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EDITORIAL

On the first Earth Day in 1970, it was appealed that we should take necessary action in the face of rapidly changing earth environment. Twenty five years after that, we are aware of that the environment surrounding agriculture has drastically changed, which also seems to suggest terrible crisis we are supposed to face in the future. It is surprising to know that total soil erosion having occured since 1970 exceeds total surface soil amount of whole land of India. More than six million hectares farm land is diminished every year by desertion, salt damage, flooding, diversion to industrial or housing use and so on. In other words almost the same size of farm land as its total in China was damaged in the past a quarter century. In the mean time the population kept increasing constantly. In developing countries many people moved from rural area to cities, which caused the serious problems such as expansion of slum areas, unemployment and waste rural area.

The problem of China which has enormous population is growing food production by about fifty million ton by the end of this century. In late years, however, China is obliged to enlarge import amount due to the depression of domestic food production. On the other hand there is an area where farm land is being restored to forest due to food overproduction like in The United States. Though the center parts of the United States is famous as granaries, considering the shortage of rainfall caused by warming weather, some researchers cast doubt whether the granaries will be able to keep present status in the future. It is really doubtful whether earth environment will warmly accept the future population burst.

In agriculture it will be needed to raise land productivity as a primary objective, which also means to raise productivity in small and medium scale farming as well as in large scale. We, working on agricultural machinery, are required to develop and spread a variety of means of mechanization to fulfill a critical need of farmers. In particular the investment to agricultural mechanization in developing countries must be considered with top priority.

Yoshisuke Kishida
Chief Editor

Tokyo, Japan
July, 1995

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Design and Development of Powered One-way Plough


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Abstract

A powered one-way plough was developed by designing the power transmission system. The design of power transmission unit was based on number of discs, spacing between two consecutive discs, forward speed of tractor and operating depth. The tractor power was computed at 28.62 hp but the design was done on 35 hp tractor because of availability. The developed plough was tested in a paddy field having Silty clay loam soil with (30.26%) moisture content (1.64 g/cc) bulk density and (8.94 kg/cm^2) cone index at the Pantnagar university farm.

The plough was operated at forward speed of 2.77, 4.31, 5.14 and 6.88 km/h with peripheral disc velocity to ground speed (PDV/GS) ratio of 2.62, 1.90, 1.77 and 1.42, respectively. Better pulverization with 43.5 mm clod mean weight diameter and 1.18 g/cc bulk density, more volume of soil worked (43.95 m^3), higher depth of cut (14.65 cm), less wheel slip (5.97%) and less draft (146.67 kg) resulted in low PDV/GS ratio. The powered one-way plough consumerd 50.76% less energy and reduced operation time by 48.64% at PDV/GS ratio of 1.42 than 2.62.

Introduction

Land preparation for wheat crop after paddy harvesting used more time and energy because the paddy field becomes stiff and tough due to puddling operations. Ultimately it looses tillage productivity. There is need for efficient machinery management system which can reduce the number of operations for land preparation. Hence the potential of meeting future requirements of tillage operations is thus centered to the idea of powering the disc gang by which the number of tillage operations can be reduced.

Little information is available on powering the disc gang. Getzlaff and Soehney (1959) worked on forces and power requirement of freely rotating and driven plough disc on hard clayey loam soil. They found 30% reduction in draft forces with a peripheral disc velocity to ground speed (PDV/GS) ratio of 1.3. The disc power requirements increased sharply with an increase in peripheral disc speed and the power consumption doubled with increase in PDV/GS ratio from 1.3 to 2.5. Soehney (1963) observed more soil pulverization with powered disc whereas large clods resulted in freely rolling disc. Young (1976) also found similar result in the case of draft and power requirement as reported earlier by Getzlaff and Soehney (1959). He also found better pulverization and excellent penetration with powered disc harrow (DYNATIL). Friesen (1977) reported the requirement of PTO horse power of 7 to 10 kW per meter width of a conventional harrow plough, operating at depth of 7.5 cm and speed of 7.2 km/h.

With the foregoing in view, the powered one-way plough was designed and developed to meet the future needs of tillage operation.

Design and Development

The powered one-way plough (**Figs. 1** and **2**) has the following components: frame, gang of plough and power transmission unit.

The frame is made of mild steel flat of 90 × 22 mm and angle iron of size 90 × 90 × 10 mm thick. The provision has been made on frame for mounting the gang of plough and power transmission unit. The three-point hitch of Categorly-I is mounted to the frame. The mounting of gang on frame was done by using three side plates of size 330 × 230 × 100 mm. The side plates were mounted on spool bearing, then mounted to frame by nut and bolt. The furrow wheel was mounted on the frame in such a way that it lies in the furrow of the last disc and remains parallel to the direction of travel.

Fig. 1 Front view of powered one-way plough.

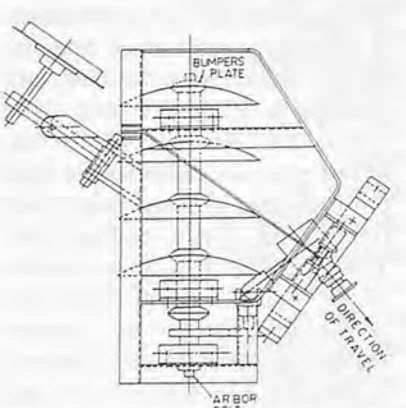

Fig. 2 Sketch of powered one-way plough.

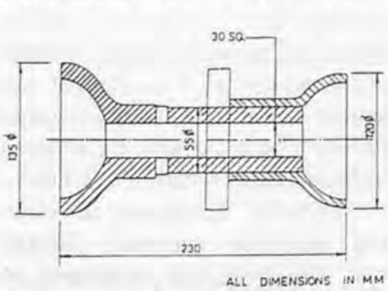

Fig. 3 Sketch of spool bearing.

The gang of plough consisted of an arbor bolt, spool bearings with side plates and disc. The arbor bolt was made of mild steel with 30 mm square section. The length of an arbor bolt was 1 130 mm. A concave bumper plate of 220 mm in diameter was provided at one end, i.e., at fixed end of an arbor bolt whereas another end was threaded for tightening the gang.

The spools of 230 mm in length and 92 mm in diameter were cast having 30 mm square hole for inserting the arbor bolt. These spools were used to maintain the spacing between two consecutive discs.

The spool bearings were cast as shown in **Fig. 3**. The self-aligned bearing was used to compensate for the manufacturing tolerance and variable deflection of supporting members.

The disc of high carbon steel was used. The stepped bevel edge was provided in the disc in order to avoid blunting. The disc had square hole of 30 mm size to accomodate an arbor bolt and 560 mm diameter with cancavity of 80 mm.

Before designing the power transmission unit, it was necessary to determine the required horse power. The powered one-way plough was designed for four discs with spacing of 230 mm. The forward speed of tractor (7 km/h) and operating depth (15 cm) was taken into consideration in determining the actual PTO horse power. The total working width of the developed plough was 92 cm. The computation for size of tractor (bhp) was done, using the following formula:

$$hp = \frac{D \times S}{4\,500} \qquad (1)$$

Where,

D = Draft of plough (kg)
= Total width of plough (92 cm) × Soil resistance (0.8 kg/cm^2)* × depth (15 cm) = 1 104 kg

S = forward speed; 116.67 m/min.

*Assumed 0.8 kg/cm^2 for clay soil.

Taking the above into consideration, the hp = 28.62

The 35 bhp tractor is easily available, hence the horse power for four disc powered of the one-way plough will be taken for 35 bhp tactor:

hence, PTO hp = 80% of 35
= 28 hp

After deciding the PTO horse

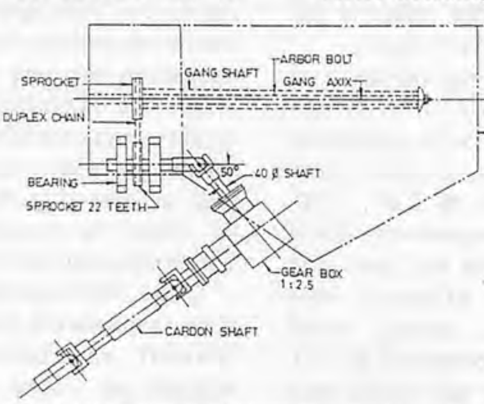

Fig. 4 Line diagram of power transmission unit.

power requirement the power transmission unit was designed. which consisted of cardon shaft; bevel gear box, auxiliary transmission shaft; sprockets and chain, and gang shaft (**Fig. 4**).

The cardon shaft is made of mild steel with square section to provide grip for rotating the cardon shaft with higher speed and torque. It was made in two parts (one hallow square and another solid square shaft) to slide in or out for automatically adjusting the length between PTO of tractor to bevel gear box as shown in **Fig. 4**. The design of cardon shaft was based on the developed torque by the PTO of tractor.

A 90-bevel gear box was used for transferring power from the tractor PTO to the disc through chain and sprocket system. The design requirements for the bevel gear box were as follows:

- Speed ratio (1:2.5);
- Speed of drive gear (540 rpm);
- PTO hp input = 28;
- number of teeth on drive and = 35 and 14, respectively, on driven gear; and
- gear material, cast steel.

The auxiliary transmission shaft was coupled to the output shaft of bevel gear box with the help of the universal joint. The universal joint was used to achieve the transmission at 30° gang angle by which transmission can be paralled to the gang of plough. The auxiliary shaft was made of mild steel and supported at both ends. The design of auxiliary transmission shaft was done by considering the developed torque only.

A chain drive system was provided to transfer the power from transmission shaft to the gang of plough because of the following reasons:

- the compact drive was necessary;
- the space was limited;
- the power loss to be limited to about 2%; and;
- requirement for simpler and cheaper power transmission system.

Table 1. Characteristics of Powered One-way Plough Parameters

Item	Series number			
	1	2	3	4
Average tractor speed (km/h)	2.77	4.31	5.14	6.88
Peripheral disc velocity (PDV km/h)	7.25	8.18	9.10	9.77
Ratio of PDV/GS	2.62	1.90	1.77	1.42
Clod mean weight dia. (mm)	54.00	51.10	48.60	43.50
Maximum clod size (mm)	94.35	84.74	82.25	79.76
Volume of soil worked in a 300 m^2 area (m^3)	41.27	41.94	43.56	43.95
Total soil worked (percent)	91.71	93.20	96.67	97.67
Bulk density (g/cc)	1.26	1.25	1.24	1.18
Fuel consumption (ℓ/h)	4.56	4.60	4.67	4.73
Energy consumption (MJ/ha)	1 220.24	891.39	765.67	619.41
Wheel slip (%)	9.35	7.51	7.03	5.97
Average draft (kg)	246.67	193.33	180.00	146.67
Average tilling depth (cm)	13.75	13.98	14.50	14.65
Effective width of cut (cm)	81	84	86	92
Total time required in a 300 m^2 area (sec.)	514	375	326	250

The design requirements for a suitable chain drive were as follows:

- PTO horse power (28 hp);
- speed of drive sprocket (216 rpm);
- speed of driven sprocket (90, 100, 120 rpm); and
- minimum centre to centre distance between sprockets.

The gang shaft consist of an arbor bolt with spools. This shaft was supported at three places. For these reasons, an empirical formula was adopted for the design of the shaft in terms of horse power transmitted and the speed of shaft rotation in revolution per minute using the following formula:

$$d = \frac{hp \times c}{rmp} \qquad (2)$$

where,

d = dia of gang shaft, cm

hp = constant with a 8 ± 0 for transmission shaft subjected to torsion only.

rpm = 110

hence d = 5.91 cm

Research Methods

The field used for the test was covered with residue of paddy which had been recently harvested by a combine. The soil was silty clay loam type and hard with the moisture content (30, 26%), bulk density (1,639 g/cc) and cone index (8.94 kg/cm^2). The field experiment was carried out at the Pantnagar University. The plough was operated by using hmt 5 911 (59 hp) tractor. The throttle lever was set at its three fourth position. The hmt tractor was used to vary the PTO speed aware that the tractor had a ground PTO (dependent PTO). The disc speed was recorded at 70, 80, 90 and 105 rpm at forward speed of 2.77, 4.31, 5.14 and 6.88 km/h, respectively. The ratio of peripheral disc velocity to ground speed (PDV/GS) was calculated at 2.62, 1.90, 1.77 and 1.42. The plots were assigned for each treatment by using randomised block design (RBD). Only one pass of plough was done for each plot. The total time, wheel slip, fuel consumption, draft and volume of soil worked were recorded for each treatments. The soil parameter such as clod mean weight diameter and bulk density were measured for each treatment. Similarly the effective width of cut, depth and forward speed were recorded.

Result and Discussions

Effective of Peripheral disc velocity to Ground Speed (PDV/GS) Ratio on various Parameters

Figure 5 shows the relationship

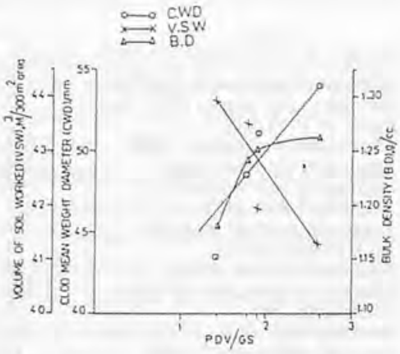

Fig. 5 Relationship between PDV/GS ratio and clod mean weight, volume of soil worked and bulk density.

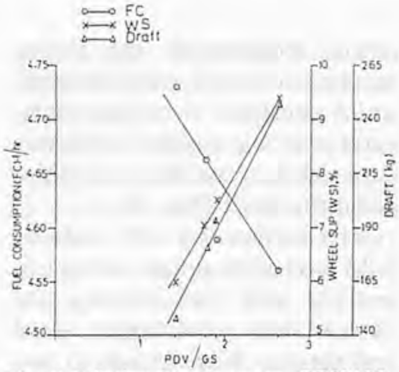

Fig. 6 Relationship between PDV/GS ratio fuel consumption, wheel slip and draft.

Fig. 7 Poor operation at improper PDV/GS ratio of 2.62 of one-way plough.

Fig. 8 Best operation at proper PDV/GS ratio of 1.42 of one-way plough.

between PDV/GS ratio and clod mean weight diameter; and bulk density and volume of soil worked. It is evident that clod mean weight diameter and bulk density increased from 43.50 to 54.00 mm and 1.18 to 1.26 g/cc, respectively, as PDV/GS ratio increased from 1.42 to 2.62. The volume of soil worked decreased from 43.95 m^3 to 41.27 m^3 with an increase in PDV/GS ratio from 1.42 to 2.62. The clod mean weight diameter and bulk density increase may be due to the throwing effect of the disc. The decrease in volume of soil worked is due to variation in tilling depth and width of cut.

Large clods were observed at higher PDV/GS ratio (2.62) than low PDV/GS ratio (1.42) while the total soil workd was found greater at PDV/GS ratio (1.42).

In similar manner, **Fig. 6** shows relationship between PDV/GS ratio and fuel consumption; wheel slip and draft. Fuel consumption per hour decreased from 4.730 to 4.533 l/h with the increase in PDV/GS ratio from 1.42 to 2.62. Wheel slip and draft increased from, 5.97 to 9.35% and 146.67 to 246.67 kg, respectively, as PDV/GS ratio increased, from 1.42 to 2.62. The reason for the increasing wheel slip and draft may be due to the pushing effect of the powered disc to the tractor in forward direction. The energy consumed per hectare was 619.14. MJ/ha at PDV/GS ratio 1.42 and 1220.29 MJ/ha at PDV/GS ratio 2.62 meaning thereby that less energy (50.76%) was consumed at low PDV/GS ratio (1.42) while fuel consumption per hour was greater at this ratio than other higher PDV/GS ratio.

The foregoing performance suggests that the powered one-way plough works well at low PDV/GS ratio (1.42) than higher PDV/GS ratio (2.62) with respect to clod mean weight diameter, bulk density, volume of soil worked, tilling depth energy consumed, draft and wheel slip.

Conclusions

Based upon the experimental results, the following conclusions are drawn:

1. The combination of peripheral disc velocity to ground speed influences the performance of the implement. The PDV/GS ratio should be kept low (1.42) for better performance.

2. Productivity in terms of tillage operation could be increased.

3. The powered one-way plough consumed 50.76% less energy at PDV/GS ratio 1.42 than at 2.62.

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Selection of Tractors for Tillage Operation Under Bangladesh Conditions

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Abstract

Fourteen tractors were tested for determining their various selection parameters. The present study dealt with the field performance parameters (effective field capacity, fuel consumption per unit time and fuel consumption per unit tilled area) of available tractors to determine the best suited tractor for tillage operation under Bangladesh conditions. The tractors were selected based on the maximum effective field capacity and the minimum fuel consumption per unit tilled area. According to the test criteria the MF-375 tractor was most suitable among the types of tractors available in Bangladesh. The effective field capacity and the fuel consumption per unit tilled area of MF-375 tractor were 0.48 ha/h and 16.00 L/h, respectively.

As the higher effective field capacity is desired by most farmers/user, the results of the present study should be helpful to them prior to the purchase of tractors.

Key words: Tractor, Tillage

Acknowledgement: The authors gratefully acknowledge the cooperation received from the Department of Farm Power and Machinery, Bangladesh Agricultural University for providing necessary facilities to accomplish the study.

Introduction

The importation of tractors into Bangladesh was started by the end of 1950s to supplement the draft power shortage in agriculture. Over 2 000 tractors were imported in 1970. The farm mechanization committee recommended to introduce 30 000 tractors by the end of 1985 to enhance farm mechanization in Bangladesh (Pakistan Govt., 1970). A list of recommended tractors available in Bangladesh is shown in **Table 1**. These tractors were imported by both the Government and the non-government organizations of Bangladesh. The samples of those tractors were tested by the National Standardization Committee of Machinery and their Power Sources, the Department of Farm Power and Machinery of Bangladesh Agricultural University, and the Bangladesh Agricultural Research Institute. These organizations are responsible for testing tractors for determining their suitability and operating conditions. However, the reports of comparative studies were not provided.

The objectives of the study were to prepare a comparative report for the selection of suitable tractors based on the maximum effective field capacity and the minimum fuel consumption at the rated nominal power of tractor during tillage operation and to recommend a suitable tractor for tillage operation under Bangladesh conditions.

Table 1. A List of Recommended Farm Tractors Available in Bangladesh

Tractor Brand	Manufacturer	Nominal Rated Power kW (Hp)	Rated Engine Speed RPM
Yanmar: YM-2700	Yanmar diesel Engine Co. Ltd., Japan	20.25 (27)	2700
Tractor: FORD-2000	Ford Motor Co. Ltd., UK	26.25 (35)	2500
Tractor: FORD-3000	Ford Motor Co. Ltd., UK	34.50 (46)	2200
Tractor: FORD-4000	Ford Motor Co. Ltd., UK	46.50 (62)	2200
Tractor: FORD-3910	Ford Motor Co. Ltd., UK	56.25 (75)	2200
Massey Ferguson: MF-135	Massey Ferguson Ltd., UK	35.25 (47)	2400
Massey Ferguson: MF-240	Massey Ferguson Ltd., UK	33.75 (45)	2400
Massey Ferguson: MF-375	Massey Ferguson Ltd., UK	56.25 (75)	2400
Hinomoto: E-18	Toyosha Co. Ltd., Japan	15.00 (20)	2500
Hinomoto: E-23	Toyosha Co. Ltd., Japan	18.75 (25)	2500
Hinomoto: E-28	Toyosha Co. Ltd., Japan	22.50 (30)	2500
Belarus Tractor: YuMz-6AM	Tractonoexport, Moscow	46.50 (62)	1750
Good Earth (Eicher): EDI-D-115/8	India	19.88 (26)	
Tractor: FIAT-480	Italy	36.00 (48)	

Source: Tractor Agencies of Bangladesh and Department of Farm Power and Machinery, Bangladesh Agricultural University.

Criteria of Tractor Selection

A number of researchers developed various methods for the selection of tractor and tillage machineries. Jangiev (1980) suggested the following equations for selection of tractor:

$$E = wS/N_e = wS/N_i \rightarrow \max. \quad (1)$$

$$C = (A_c e + B_c)/E \rightarrow \min. \quad (2)$$

where,
E = effective field capacity, ha/kW
w = width of tillage implement, m
S = effective working speed of tractor, m/s
N_e = effective power of tractor engine, kW
N_i = indicated power of tractor engine, kW
C = operating cost per ha.
A_c = combined cost components (purchase price, depreciation, fuel and oil cost, repair and maintenance cost, operator's w ages etc.) of tractor
B_c = combined cost components (purchase price, depreciation, repair and maintenance cost and shelter etc.) of tillage machinery
e = theoretical field capacity of tractor per unit energy, ha/kW
η_m = mechanical efficiency of tractor engine, decimal

Keepner et. al. (1972) expressed the effective field capacity of field machinery by eq. 3,

$$E = S\,w\,\eta_f/10 \quad (3)$$

The total cost per year for a field machine was presented by Hunt (1968),

$$A_c = F_c\%P + 10\,(RMP + L + O + F + T)/Sw\eta_f \quad (4)$$

where,
E = effective field capacity, ha/h
A_c = annual costs for operating the machine
$F_c\%$ = annual fixed cost percentage
P = initial purchase price of the machine
A = annual use, ha
S = forward speed, km/h
w = effective width of machine, m
η_f = field efficiency, decimal

Materials and Methods

The field tests of the tractors were carried out in the farm of Bangladesh Agricultural University both in dry and wet soil conditions. The farm soil belongs to the category of sandy, sandy-loam, clay and clay-loam type. The length of test fields were limited to 50 m. The implements used for different operations were mold board plow, disk plow, disk harrow and rotary tillers or rotavator. The moisture content of the soil during dry land preparation was 25-50% (d.b.). The puddling operations were done under 10-30 cm standing water. The depth of plowing and harrowing in dry soil condition were 6-12 cm and 16-24 cm, respectively. But in puddling operation the depth of tillage varied from 15-20 cm. The experiments were replicated three times for each gear positions.

The field capacity is the rate of tractor performance in terms of the area tilled per unit time. The effective field capacity was determined on the basis of actual area tilled and effective time spent by using eq. 5 (Cornelio and Roberto, 1986),

$$E = A/t \quad (5)$$

where,
E = effective field capacity of tractor, ha/h
A = area tilled, ha
t = time spend, h

The fuel tank of the tractor was completely filled up with diesel fuel before starting tillage operation and it was refilled with fuel by using a fuel measuring glass tube after tilling the desired area of the plot. The amount of fuel required for refilling the fuel tank was equal to the amount of fuel consumed by the tractor for tillage. The fuel consumption per hectare was determined by using the equation (6),

$$G = G_t/w\,l \quad (6)$$

where
G = fuel consumption, L/ha
G_t = fuel consumption for the tilled area, L
l = length of tilled area, m
w = width of tilled area, m

Table 2. Field Performance of Tractors

Tractor Brand	Effective field capacity, ha/h	Fuel consumption L/ha	Fuel consumption L/h
Yanmar: YM-2700	0.27	20.12	5.43
Tractor: FORD-2000	0.21	21.12	4.43
Tractor: FORD-3000	0.26	16.89	4.39
Tractor: FORD-4000	0.37	13.49	4.99
Tractor: FORD-3910	0.39	13.20	5.15
Massey Ferguson: MF-135	0.34	11.17	3.80
Massey Ferguson: MF-240	0.36	15.50	5.58
Massey Ferguson: MF-375	0.48	16.00	7.68
Hinomoto: E-18	0.19	13.28	2.52
Hinomoto: E-23	0.20	14.98	3.00
Hinomoto: E-28	0.33	14.47	4.78
Belarus: YuMz-6AM	0.40	19.15	7.66
Good Earth: (Eicher) EDI-d-115/8	0.25	17.00	4.25
Tractor: FIAT-480	0.35	17.20	6.02
Mean	0.31	15.97	4.98
Standard deviation	0.09	2.84	1.49

The time required for tilling a certain area of plot was recorded by a stop watch. The effective working time was determined by subtracting the loss of time from total time for a certain area. The effective field capacity of the tractor in tillage operation was determined based on the effective time and the results presented in **Table 2**.

Results and Discussion

No tractor industry has yet been developed in Bangladesh. She has to import tractors from Japan, U.K., U.S.A., U.S.S.R., Italy, India and other countries. The comparative analysis of effective field capacity and fuel consumption of presently used tractors for tillage operation are shown in **Fig. 1**. The tractors imported earlier than 1970 were not included in the analysis.

The effective field capacity of MF-375 was highest (0.48 ha/h) compared to the other available tractors. The Belarus YuMz-6AM, FORD-3910, MF-240 and MF-135 tractors possessed effective field capacity of 0.40 ha/h, 0.39 ha/h, 0.36 ha/h and 0.34 ha/h, respectively **(Table 2)**. The fuel consumption of the Ford-2000 tractor was highest (21.12 L/ha) and that of MF-135 was lowest (11.17 L/ha) among the tested tractors. The fuel consumption of MF-375, MF-240 and FORD-3910 were 16.00 L/ha, 15.50 L/ha and 13.20 L/ha, respectively **(Table 2)**. Since the fuel consumption of MF-375 was not lowest, it was not possible to conclude simply, to select the MF-375 tractor. It was evident that the MF-375 tractor possessed the highest effective field capacity and reasonably low fuel consumption.

It was noted that the effective field capacity of all the tested tractors varied from 0.19 ha/h to 0.48 ha/h and the average value and standard deviation were 0.31 ha/h and 0.08, respectively **(Table 2)**. The range of fuel consumption of the tractors tested were 11.17 L/ha (3.80 L/h) to 21.12 L/ha (4.43 L/h) and the average value and standard deviation were 15.97 L/ha (4.98 L/h) and 2.74, respectively. The fuel consumption per unit time per unit tilled area and the effective field capacity varied with nominal tractor power.

Conclusions

Fourteen tractors of various make and model were tested in the Department of Farm Power and Machinery to determine the field performance parameters (effective field capacity, fuel consumption per unit time and fuel consumption per unit tilled area), kinematic parameters (circumference of turning circle, radius of turning and speed at turning) drawbar and lugging ability (drawbar pull, drawbar power and wheel slip) and seal tests. The test results of kinematic parameters and seal tests were not included in the present study.

The analyses of the field performance parameters indicated that MF-375 was the best among the five tractors (FORD-3910, MF-135, MF-240, MF-375 and Belarus YuMz-6AM). Hence, the MF-375 tractor might be recommended for tillage operation under Bangladesh conditions.

The methods adopted in the study were simple and possessed certain shortcomings in determining the field performance parameters of tractors. Yet, the authors hoped that the results of the study might be helpful in selecting tractor prior to purchase.

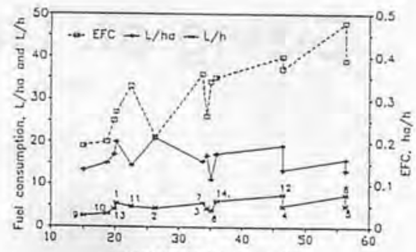

Fig. 1 Comparative results of effective field capacity and fuel consumption with nominal tractor power. (The numbers in the figure indicate the serial number of the tractors with reference to the Table 2.)

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Sizing of Tractor/Plough Combinations

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Abstract

The tractor/plough combination required on various farms is evaluated. The analyses take account of economic, husbandry and meteorological constraints. Results show that a minimum number of plough bodies is required for a given farm size but there is little cost penalty in exceeding this value. For example, a 40-ha tillage farm requires at least a 4-furrow plough while the corresponding size for a 60-ha tillage farm is 5 furrows. This approach can be applied on an individual farm basis.

Introduction

The selection of the tractor/plough combination has a critical impact on the overall operational efficiency of tillage farms. Generally, on such farms the plough is the implement with the greatest draught requirement and ploughing must usually be carried out during a restricted "time window". This paper presents an approach to plough selection that takes account of economic, husbandry and meteorological constraints. The technique presented can be used to assess the most appropriate option for a given farm.

Power Requirement

The power requirement of ploughing has been investigated and several workers (O Callaghan & Mc Coy, 1965; Oskoui et al, 1982; Gee-Clough *et al*, 1978). Plough draught requirements are notoriously variable and there is no single model that adequately defines the impact of the various parameters on plough draught, as there is considerable variation from soil to soil. In this study a statistical analysis has been done of published work on actual plough draught measurements in the field. The following model has been developed (based on field results of Oskoui *et al* (1982)):

$$Z = 7.98v + 42.085TA - 134.71CI - 8.2MC - 5.15SW + 426.8 \quad (1)$$

$$r = 0.53$$

where:
Z = specific draught (kN/m^2)
v = field speed (m/s)
TA = plough tail angle (rad)
CI = soil cone index (MPa)
MC = soil moisture content (%w/w)
SW = soil specific weight (kN/m^3)

This model accounts for only 28% of the inherent variability with a standard error of the estimate of approximately 12 kN/m^2 (see Appendix 1). Despite the inherent variability in the model, it is suitable for use as a planning tool to enable the farmer to estimate the likely plough capacity required for a given situation. Building on this model, the tractor engine brake power required to operate the plough (Tp) is given as:

$$Tp = [(Z.n.Fw.Fd/Me.Te) + (W.CRR)]v \quad (2)$$

where:
Me = mechanical efficiency of the tractor transmission system (from the engine flywheel to the rear wheels), decimal
= 0.85 (based on this author's estimate of typical values for agricultural tractors)
Te = tractive efficiency, decimal
= 0.70 (based on a maximum allowable wheel slip of 20% and using the model of Voorhees and Walker (1977))
n = number of plough bodies
Fw = furrow width (m)
Fd = furrow depth (m)
W = weight of the rig (including weight transfer from the plough) (kN)
CRR = coefficient of rolling resistance = 0.15 for typical ploughing conditions (Inns & Kilgour, 1978)

Substituting appropriate parameter values into equation 1 gives the following estimate of the specific draught (Z) for a field

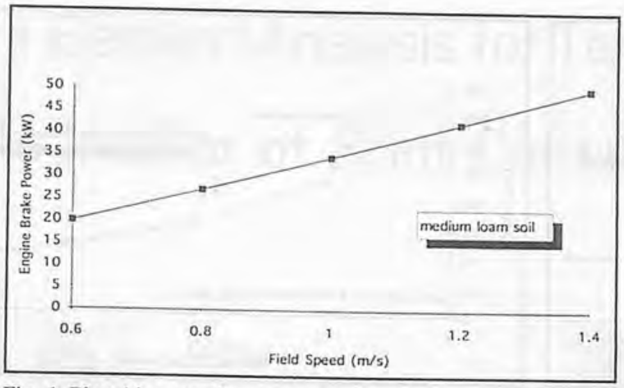

Fig. 1 Ploughing speed v. power requirement.

Table 1. Total days available during suggested ploughing periods*

Period	Probability of having good days, %				
	98	95	90	85	80
Mar 1-Apr 1	10	13	17	22	25
Mar 1-Apr 29	15	18	23	29	32
Oct 1-Nov 29	14	21	27	35	39
Sept 16-Nov 29	17	25	33	42	48

*After Frisby, 1970.

speed (v) of 1 m/s:

$$Z = (7.98 \times 1 + 42.085 \times 0.9 - 134.71 \times 1 - 8.2 \times 23 - 5.15 \times 15 + 426.8) = 72 \text{ kN/m}^3$$

Substituting this value into equation 2 gives the following estimate of the engine brake power requirement (Tp):

$$Tp = [(72 \times 4 \times 0.3 \times 0.2/0.85 \times 0.7) + 35 \times 0.15)] \times 1 \text{ kW} = 34 \text{ kW}$$

The sensitivity of Tp to field speed is given in **Fig. 1** which shows an almost linear relationship which is in general agreement with the findings of Davidson *et al* (1919).

Timeliness

Ploughing has to be carried out within a particular "time window" in order to avoid crop loss penalties associated with delayed sowing. The extent of these penalties varies with the crop mix, farm type and geographic location. The time available on a given farm is dictated by the prevailing weather conditions, which will vary from year to year. The planner must take account of this variation and assess the available time period (i.e., expected number of ploughing days available) on a probability basis. This assessment must, of necessity, be based on the historic weather and farm work records for that farm and/or area and must include an acceptable level of risk. For example, in an analysis of the weather records for Central Missouri, USA, Frisby (1970) calculated the number of expected ploughing days at different probability levels during certain periods of the year (**Table 1**). Smith (1977) evaluated the number of work days available for various soils on the basis of either 2 or 5 years in 10. For example, he found that, on average, one could expect twice as many available work days on light soil compared with heavy soil. The machinery system planner must decide on an acceptable probability level. Ward (1989) suggests that an 80% probability level is reasonable from a systems management point of view.

Applications

Once the available number of work days is known then the tractor/plough rig required can be sized. A trade off exists between rig size, on the one hand, and cost, on the other (the larger the rig the shorter the required work period hence the lower the potential crop loss penalty). Analyses of the various options available are given in **Figs. 2** to **4**, for a range of tillage areas. These show that as the tillage area increases from 20 to 60 ha, the number of plough bodies required increases from 3 to 6.

It is clear from these figures that a critical number of plough bodies exists for a given farm but, for larger farms (> 40 ha), total system costs are not sensitive to the number of bodies, beyond this critical number. For example, on a 40-ha tillage farm (**Fig. 3**) the critical number of bodies is four but there is no appreciable change in costs by having either 5 or 6 bodies. This finding is of significance as it is common practice for farmers to base the selection

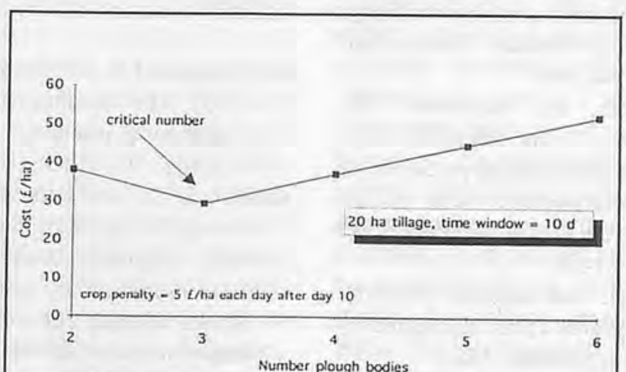

Fig. 2 Plough bodies v. total system cost.

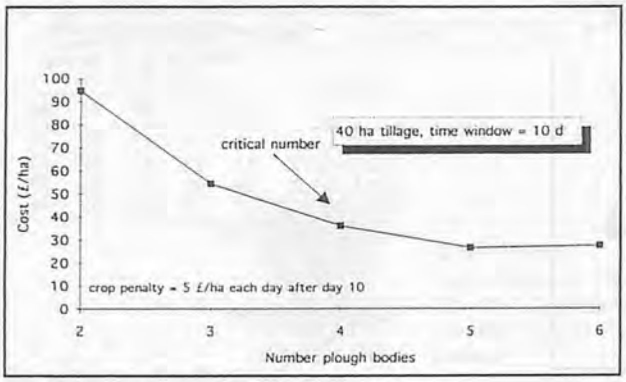

Fig. 3 Plough bodies v. total system cost.

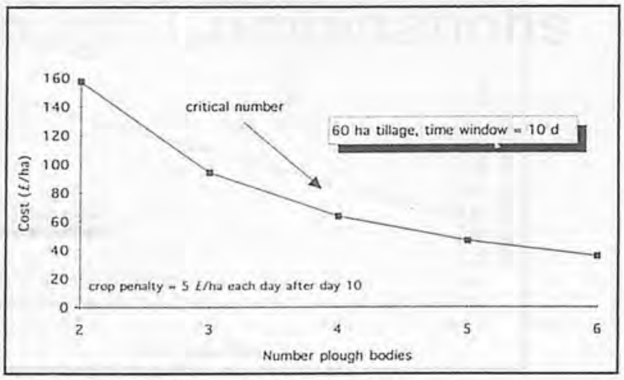

Fig. 4 Plough bodies v. total system cost.

of secondary cultivation equipment on the tractor size required for ploughing. This finding allows such farmers considerable leeway in selecting subsequent tillage implements.

The precise shape of these curves will vary depending on the particular farming situation but the trends are quite consistent. The approach presented here can be used as a basis for selecting tractor / plough combinations. The parameter values used can be altered to apply to the particular case in question hence affording the planner a tailor-made tool for each situation.

Appendix 1

Statistical model of plough draught (Z, $kN.m^2$) v. variouos parameters based on the field results of Oskoui *et al* (1982)

ANOVA Table

Source	Sum of Squares	Deg. of Freedom	Mean Squares	F-Ratio	Prob>F
Model	5394.8912	5	1078.9782	7.6384	0.000
Error	13984.4702	99	141.2573		
Total	19379.3614	104			

Coefficient of Determination	0.2784
Coefficient of Correlation	0.5276
Standard Error of Estimate	11.8852
Durbin-Watson Statistic	1.3025

Data Coefficients

		Dependent Variable: Z (kN/m^2)		
Variable Name	Coefficient	Std. Err. Estimate	t Statistic	Prob > t
Constant	426.7999	173.2314	2.4638	0.015
SW (kN/m^3)	−5.1536	2.1614	−2.3844	0.019
% H_2O	−8.1998	3.5547	−2.3067	0.023
Cl (MPa)	−134.7072	67.1884	−2.0049	0.048
Tail Angle (rad)	42.0852	8.3712	5.0274	0.000
v (m/s)	7.9775	2.9127	2.7388	0.007

Data Correlation Matrix

Z (kN/m^2)	1.000	−0.026	−0.108	0.096	0.399	0.176
SW (kN/m^3)	−0.026	1.000	−0.733	0.699	0.025	−0.065
% H_2O	−0.108	−0.733	1.000	−0.993	−0.018	0.044
Cl (MPa)	0.096	0.699	−0.993	1.000	0.017	−0.040
Tail Angle rad.	0.399	0.025	−0.018	0.017	1.000	−0.139
v (m/s)	0.176	−0.065	0.044	−0.040	−0.139	1.000

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Finite Element Analysis for Temperature Distribution in the Interior of Plant Culture Vessel

by

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Abstract

Tissue culture is an important technology for the development of agriculture and forestry in Indonesia. There are several varieties of tropical plants (seedlings) produced by using tissue culture in the country. Temperature distribution in the interior of culture vessel is one of the aspects that must be considered during plantlet cultivation. There exists such a problem that increasing light intensity which is supposed to improve photosynthetic rate of plantlet results in some negative effect to the thermal condition. This study demonstrates that the thermal problem can be solved by providing proper cooling treatments. The finite element model was used to analyze the thermal behavior of the interior of culture vessel influenced by various cooling treatments.

Introduction

Agricultural and forestry products have a big contribution to improving non-oil and gas export in Indonesia. High quality seedlings are required to produce high quality of agricultural and forestry products. Tissue culture is an important technology to produce high quality seedlings. There are several important tropical plants of which seedlings have been produced by using tissue culture. In agriculture, several Indonesian companies have been using tissue culture technology to produce seedling for oil-palm, banana and pineapple. In forestry, there are on-going research to produce high quality seedling for rattan (*manau*) and *meranti* wood.

The growth of plantlet by tissue culture depends on the micro-environment inside the plant culture vessel. The growth of plantlets that can be accomplished by environmental controls such as increase of ventilation rate of culture vessel, supply of increased amount of CO_2 into the plant culture vessel, and increase of light intensity. A simple method to increase light intensity is more light from some artificial light sources. However, air temperature of the interior of the culture vessel will be elevated when the light intensity is increased. The plantlet growth will be inhibited if air temperature inside the culture vessel is too high. The air temperature inside the culture vessel can be reduced by blowing air to the outside surface of culture vessel or by cooling down the temperature of the bottom of culture vessel. These treatments make it possible to increase the light intensity without causing the temperature problem.

Few studies have been done so far on the effect of light intensification treatment to the microenviroment inside the culture vessel. Since the temperature inside the culture vessel has a major influence on development of cultured plantlet, altering of temperature distribution due to such a treatment must be grasped. This study discusses the effect of such factors as light intensity level, velocity level of airflow over the surface of culture vessel, and forced cooling level of the culture vessel bottom on the temperature distribution inside culture vessel.

In this study the finite element model was used to analyze the thermal behavior of the interior of plant culture vessel influenced by various light intensities, velocity levels and cooling treatments.

Problem Identification

The temperature of air and culture medium (gel) contained in the culture vessel depends on the ambient temperature and the boundary condition at the surface of the plant culture vessel. **Fig. 1** shows the plant culture vessel used for this study. When the light intensity outside the culture vessel is increased, heat flow coming into the culture vessel will rise. The heat flux along the surface of culture vessel is not uniform when the artificial lamps are placed over the culture vessel. The heat flux over the top surface is larger than that over the side surface of culture vessel. Therefore, the temperature elevation of the air in the upper part is larger than that in the lower part of culture vessel. The temperature elevation can be suppressed by (1) blowing air onto the surface of culture vessel or (2) cooling the bottom of culture vessel. The air flow covering over the surface of culture vessel takes heat away from the interior of the culture vessel by the convective heat transfer between the wall of culture vessel and the air. The amount of heat flowing out from the vessel to the ambient air is a function of the velocity of airflow. The velocity effect of airflow on the rate of heat exchange can be interpreted by varying the coefficient of convective heat transfer.

What should be investigated in this study is the interactive relationship between the thermal effect of increasing light intensity, velocity of airflow along the surface of culture vessel and the bottom cooling treatment. The finite element model that can incorporate with those three factors that determine temperature distribution in the interior of the culture vessel should be developed to facilitate identifying this thermodynamic system.

Finite Element Model

The given problem can be assumed to be axisymmetric because the culture vessel is axisymmetric and the thermal conditions are also axisymmetric. It is assumed that only conductive heat transfer occurs inside the plant culture vessel. The only steady state heat transfer will be considered because plantlets are grown under steady temperature conditions. The steady state heat transfer equation for axisymmetric problem is:

$$\frac{1}{r}\left[k_r \frac{\partial}{\partial r}\left(r \frac{\partial T}{\partial r}\right)\right] + k_z \frac{\partial^2 T}{\partial z^2} = 0 \quad (1)$$

where:

k_r = thermal conductivity in r direction, kcal/(m.h.K)

k_z = thermal conductivity in z direction, kcal/(m.h.K)

T = temperature at point (r, z), K

r = radial coordinate, m

z = vertical coordinate, m.

The convective heat transfer occurs over the surface of plant culture vessel. The equation for convective heat transfer is

$$-kA\frac{\partial T}{\partial n} = hA(T - Ta) \quad (2)$$

where:

A = area, m^2

n = normal coordinate, m

h = coefficient of convective heat transfer, kcal/(m^2.h.K)

Ta = ambient temperature, K.

Besides convective heat transfer, heat also flows from outside plant culture vessel. The equation for heat flux is

$$kA\frac{\partial T}{\partial n} = qA \quad (3)$$

where:

q = heat flux, kcal/m^2.

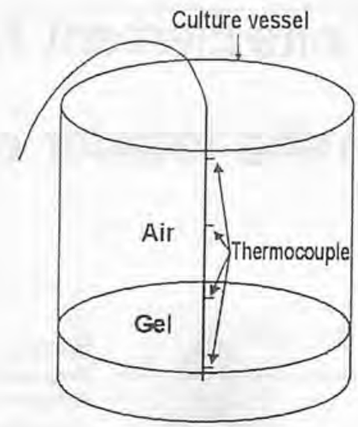

Fig. 1 Culture vessel.

Differential equation (1) and boundary condition equations (2) and (3) can be transformed into the following general finite element matrix equation.

$$[K]\{T\} - \{F\} = 0 \qquad (4)$$

where:

[K] = Global stiffness matrix

{F} = global force vector.

A computer program to solve the finite element equations was developed using Visual BASIC Ver. 3.0. The program consists of (1) inputs for vessel dimension, segmentation of domain, parameters of heat transfer, and boundary conditions; (2) grid generation; (3) stiffness matrix and force vector calculation; and (4) solution for temperature of each node. **Figure 2** shows the flow chart of computer program. Inputs for vessel dimensions were height and diameter of vessel, wall thickness of vessel and amount of gel.

One-half of the culture vessel was divided into three domains due to the coefficient of thermal conductivity for each material. The first domain was vessel domain, the second domain was air domain and the third domain was gel domain. To generate grid of finite element, each domain was divided into several segments, each segment consisting of two triangular elements. The number of node and element depends on the segmentation of each domain. The inputs for segmentation of domain were vertical and horizontal segments. After segmentation, a finite element model had fixed numbers of elements and nodes.

Thermal conductivities for vessel, air and gel were assumed constant and isotropic. The convective heat transfer occurred on the outside surface of plant culture vessel. Input parameters were coefficient of convective heat transfer and ambient temperature as convective heat transfer was assumed over the boundary. Other boundary conditions were heat flux that flows from outside to inside the plant culture vessel and specified bottom temperature. Global stiffness matrix and global force vector were calculated by using all of the inputs and used to construct finite element matrix equation. The finite element matrix was solved by using Gaussian elimination. The output of the finite element calculation was nodal temperature (T_i) (i = 1, 2, ..., n), where n was number of nodes.

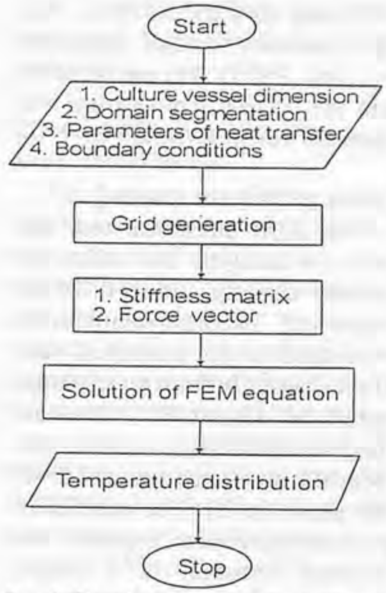

Fig. 2 Flowchart of computer program.

Experiment for Verification of Finite Element Model

The experiment was carried out to verify the developed finite element model. The dimensions of culture vessel used for this experiment were 102 mm in diameter and 100 mm in height. The thickness of culture vessel was 1 mm. Gel was placed at the bottom of culture vessel with 10 mm in thickness.

Three culture vessels were placed in an incubator where the temperature was kept at 23°C. To add more light, the fluorescent lamps were placed at 20 cm above culture vessel. In this experiment, three different intensities of artificial lighting using fluorescent lamps were applied. The intensities photosynthetic photon flux density (PPFD) were 75, 150 and 300 $\mu mol/(m^2.s)$. Temperature of air and gel were measured by copper-constantan thermocouple (0.1 mm diameter).

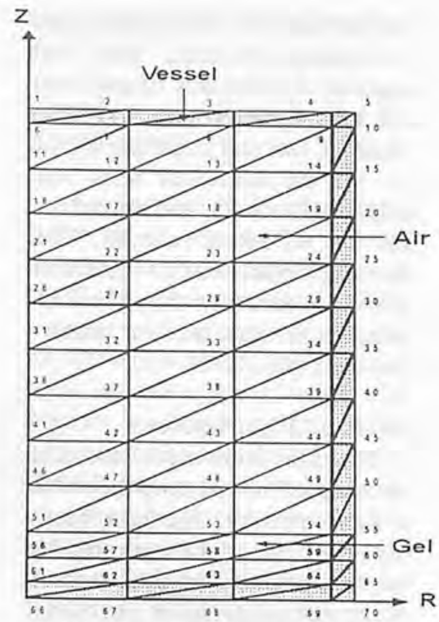

Fig. 3 Finite element model used for numerical test.

Table 1. Heat Flux Distribution over the Surface of Culture Vessel, $kcal/m^2$

Depth from the bottom, mm	PPFD, $\mu mol/(m^2.s)$		
	75	150	300
0-12	6.38	12.76	25.52
12-22	7.27	14.53	29.06
22-62	7.78	15.55	31.10
62-104	11.21	22.42	44.83
Top of vessel	34.40	68.80	137.60

Numerical Test

Fig. 3 shows the finite element model of culture vessel used for numerical tests. The vessel domain was divided into 38 triangle elements, the air domain was divided into 54 triangle elements and the gel domain was divided into 12 triangle elements. The total number of nodes was 70 and total number elements were 104. The value of thermal conductivity of air for all numerical tests was 0.03 kcal/(m.h.K), and that of the gel was 0.05 kcal/(m.h.K). The thermal conductivity of the vessel was 0.16 kcal/(m.h.K). The ambient temperature used for numerical tests was 23°C.

Effect of Light Intensity

The first numerical test was carried out for analyzing the effect of light intensity. The light intensity effect can be incorporated by varying the heat flux over surface of the culture vessel in the calculation. The amount of heat flux was calculated from measured data based on the irradiance of the light source and the energy absorption rate of vessel. **Table 1** shows the heat flux distributions over the vessel surface under three different light intensities of PPFD 75, 150, 300 μmol/(m^2.s). The greatest heat flux existed on the top of vessel. The heat flux over the vertical surface of vessel increased from bottom to the top of the vessel. The coefficient of convective heat transfer was assumed constant at 7.5 kcal/(m^2.h.K) because no air blow was applied.

Effect of Blowing Air

In the second numerical test, the effect of blowing air was analyzed by varying the value of coefficient of convective heat transfer. The coefficients of convective heat transfer were assumed uniform along the surface of culture vessel. The value of coefficients of convective heat transfer will increase, when air blow over the surface of culture vessel. Six different values of coefficient of convective heat transfer were used for this numerical test. The values of coefficient of convective heat transfer were 7.5, 10, 12.5, 15, 17.5, and 20 kcal/(m^2.h.K). The light intensity for this numerical test was PPFD 300 μmol/(m^2.s) and the bottom temperature was assumed constant at 23°C.

Effect of Bottom Cooling

The third numerical test was done to analyze the effect of bottom cooling. Four different values of bottom temperature were used in this numerical test. The values of bottom temperature were 5, 10, 15 and 20°C. The heat flux distributions over the surface of vessel was under PPFD 300 μmol/(m^2.s). The coefficient of convective heat transfer was assumed constant at 7.5 kcal/(m^2.K).

Results and Discussion

Finite Element Model Verification

Table 2 shows a comparison between finite element results and experimental results of air and gel temperatures under PPFD 75, 150 and 300 μmol/(m^2.s). The temperature, air and gel of finite element method results were close to experimental results. The maximum difference between finite element results and experimental results was 0.9°C for air, under PPFD 75 μmol/(m^2.s), and the minimum difference was 0.2°C for gel, under PPFD 300 μmol/(m^2.s). Under PPFD 300 μmol/(m^2.s), the temperature of gel from finite element result and experimental result were 27.4°C and 27.6°C, respectively. As indicated in **Table 2**, the results of actual temperature measurements show that the air temperature was always higher than gel temperature. The tested finite element model also gave the same behavior.

Effect of Light Intensity on Temperature Distribution

Fig. 4 shows the results of

Table 2. Air and Gel Temperature from Experimental and Finite Element Results, °C

PPFD, μmol/m^2.s)	Air		Gel	
	Measured	FEM	Measured	FEM
75	25.5	24.6	24.8	24.1
150	26.5	26.1	25.6	25.2
300	28.9	29.3	27.6	27.4

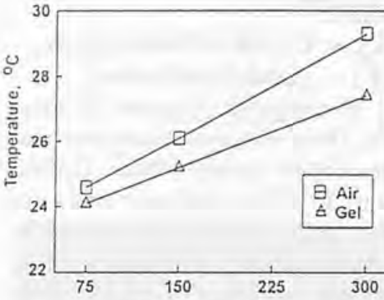

Fig. 4 Relationship between light intensity and air and gel temperature in the vessel without air blow and bottom cooling.

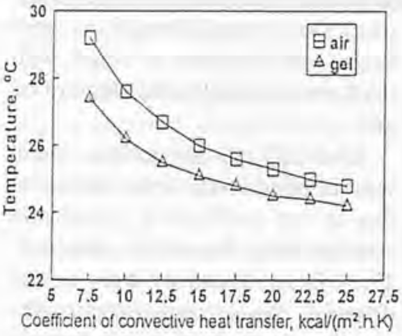

Fig. 5 Relationship between coefficient of convective heat transfer and air and gel temperature on the vessel under a constant light intensity PPFD 300 μmol/(m^2.s) without bottom cooling.

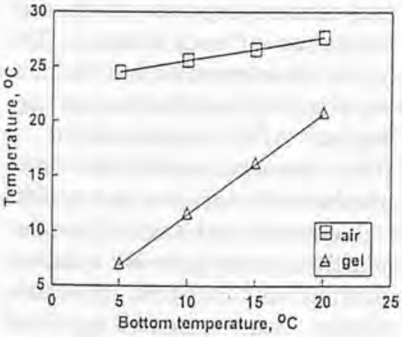

Fig. 6 Relationship between bottom temperature and air and gel temperature under a constant light intensity PPFD 300 μmol/(m^2.s), without air blow.

Data of Fig. 4. Culture Vessel Temperature at Different Light Intensities, °C

PPFD, μmol/(m^2.s)	Air	Gel
300	29.3	27.4
150	26.1	25.2
75	24.6	24.1

Data of Fig. 5. Culture Vessel Temperature at Different Coefficient of Convective Heat Transfer, °C

h (kcal/m^2.h.K)	Air	Gel
7.5	29.2	27.4
10.0	27.6	26.2
12.5	26.7	25.5
15.0	26.0	25.1
17.5	25.6	24.8
20.0	25.3	24.5
22.5	25.0	24.4
25.0	24.8	24.2

Data of Fig. 6. Culture Vessel Temperature at Different Bottom Temperatures, °C

Bottom temp.	Air	Gel
5	24.5	6.9
10	25.6	11.5
15	26.6	16.1
20	27.7	20.7

numerical test by varying light intensity over the culture vessel. Temperatures of air and gel increased with the increase of light intensity. The air temperature increased from 24.6°C to 29.3°C when the light intensity was raised from PPFD 75 to 300 μmol/(m^2.s). The gel temperature also increased from 24.1°C to 27.4°C when the light intensity was raised from PPFD 75 to 300 μmol/(m^2.s).

Effect of Blowing Air on Temperature Distribution

Fig. 5 shows the effect of convective heat transfer coefficient on temperature of air and gel on the culture vessel. Air temperature and gel temperature decreased with an increase of coefficient of convective heat transfer. This is because the amount of heat transferred from inside of the culture vessel by convective heat transfer increased due to the increase of coefficient of convective heat transfer. When the coefficient of convective heat transfer changed from 7.5 to 25 kcal/(m^2.h.K), the air and gel temperatures dropped by 4.4 and 3.2°C, respectively.

Effect of Bottom Cooling on Temperature Distribution

Fig. 6 shows that air and gel temperature decreased proportionally with a decrease in bottom temperature. The effect of bottom temperature cooling to gel temperature was bigger than the air temperature. When the bottom temperature dropped from 20°C to 5°C, the gel temperature was reduced by 13.8%, but the air temperature was reduced only by 3.3°C.

Conclusions

A numerical study of thermal behavior of the system of the culture vessel has been done using the finite element method. Finite element result agrees well with the experimental result. The effect of light intensity, air blowing and bottom cooling of culture vessel on temperature distribution inside the culture vessel can be predicted by using a developed finite element model. The results of finite element calculation showed the increasing of air and gel temperature due to an increase in light intensity which could be reduced by blowing air and cooling the bottom of vessel.

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Evaluation of Urea Super Granule Application Methods

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Abstract

An experiment was conducted in the Central farm in OUAT to evaluate the performance of urea super granule application methods in lowland transplated paddy during *kharif* season, 1991. Urea super granule (USG) was applied by hand placement, USG applicator for point placement, two-row USG applicator and USG dispenser-cum-transplanting guide. Prilled urea was applied by prilled urea applicator and conventional three split broadcasting method. The USG dispenser-cum-transplanting guide reduced the man-h requirement for line transplanting and USG application by 26.17% to 34.22% as compared to other USG application methods. The performance of the two-row USG applicator and USG dispenser-cum-transplanting guide were at par comparing the grain yield and straw yield per hectare. The benefit cost ratio of USG dispenser-cum-transplanting guide was highest among all treatments. Considering functional parameters and socio-economic conditions of the farmers, the USG dispenser-cum-transplanting guide was suitable for small-scale rice farmers in the State of Orissa.

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Introduction

In lowland paddy cultivation, the application of nitrogenous fertilizer in terms of prilled urea has been proved very inefficient which includes basal broadcasting with or without incorporation before transplanting and one or two top dressings in the flood water immediately after transplanting up to flowering stage. Numerous research reports have now indicated that only about one-third of the fertilizer N is used by the plant while the rest is lost through ammonia volatilization, denitrification, runoff and leaching.

The International Fertilizer Development Centre (IFDC) has been engaged for more than a decade for developing the USG agrotechnology, appropriate for small-scale rice farmers for use on their small paddy fields to improve fertilizer use efficiency in lowland paddy. It has the potential to increase the rice productivity of paddy fields of economically disadvantaged rice farmers without disturbing the ecological balance. It can ensure modest yield increase of 0.5 to 1.0 t/ha over the traditional method of nitrogenous fertilizer application at affordable N-rates (40-60 kg N) in all traditional irrigated as well as rainfed areas (Parbery, 1990).

Experiments conducted at OUAT, Orissa under US PL-480 project (Efficiency of Urea-based Fertilizer for Rice in India) proved the higher efficacy of deep placed USG over other modified forms of nitrogenous fertilizers and traditional broadcasting method of prilled urea application (Mishra, 1986). Normally, USG is hand-placed, one each of the centres of every four hills one week after transplanting in line transplanted paddy. This is obviously an additional, rather tedious field operation and takes about 70 to 80 man-h to cover one ha during which the worker has to insert his hand nearly 60 000 times in mud in bending posture. Moreover, hand placement of USG results in non-uniform depth of placement which ultimately affects the efficacy of USG application.

A low cost USG applicator for point placement was developed at OUAT, Orissa (Swain et al., 1992). USG applied at 5.00 cm, 7.50 cm, 10.00 cm depth by this applicator indicated that USG applied at 7.50 cm depth resulted in highest grain and straw yields. The field capacity of this applicator was 0.02 ha/h with field efficiency of 93.68%. A press wedge applicator for USG was developed at IRRI, Philippines (Khan, 1984). This applicator was tested at CRRI, Cuttack, Orissa and the performance was satisfactory under flooded water depth of less than 5.00 cm.

A two-row USG applicator was developed also, at OUAT, Orissa (Swain et al., 1992). The applicator had a cup type metering device rotated by the ground wheel through chain and sprocket mechanism. This had a pair of adjustable furrow openers to regulate the depth of placement of USG to a depth of 12.00 cm. The field capacity of this applicator was 0.064 ha/h with field efficiency of 93.97%. Hand placement of USG during transplanting was initiated at the IFDC using a simple, inexpensive bamboo device called USG dispenser-cum-transplanting guide (Savant, 1982).

Materials and Methods

The field experiments for the performance evaluation of different USG and prilled urea application methods were conducted in the Central Farm, Orissa University of Agriculture and Technology (OUAT), Bhubaneswar, Orissa during kharif season 1991. The central farm is situated 20°17' N latitude and 85°45'C longitude at an elevation of 35.0 m above mean sea level. The experiment was based on completely randomized block design with the following six treatments and four replications.

T_1: Reseacher's method
T_2: USG dispenser with transplanting guide
T_3: Two-row USG applicator
T_4: USG applicator for point placement
T_5: Prilled urea applicator
T_6: Conventional prilled urea broadcasting

The details of applicators and application methods are shown in **Figs. 1** to **4**. The area of each plot

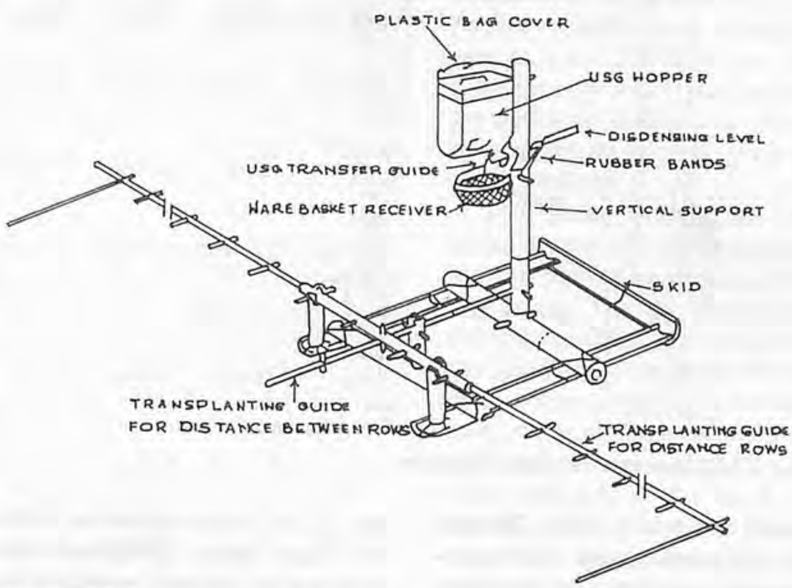

Fig. 1 USG dispencer-cum-transplanting guide.

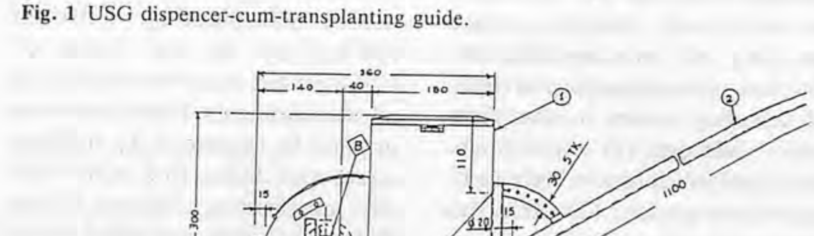

Fig. 2 Two row USG applicator.

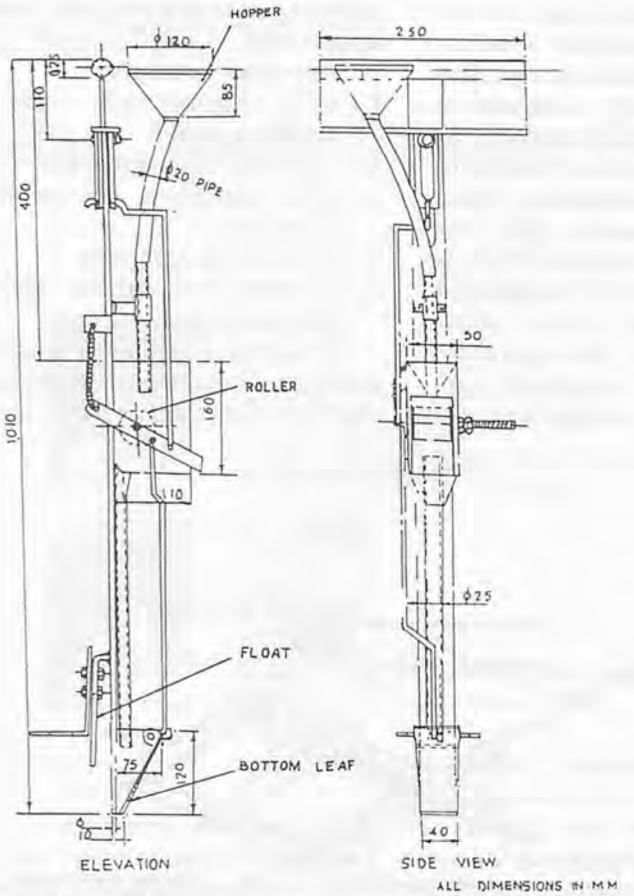

Fig. 3 USG applicator for point placement.

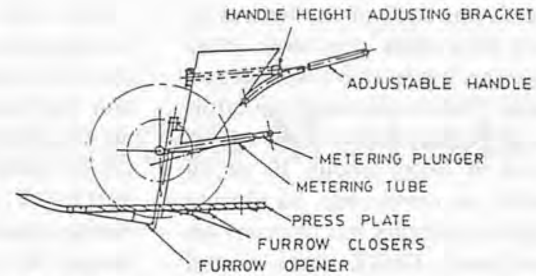

Fig. 4 Prilled urea applicator.

was 24 m^2 (6 m × 4 m). The land was prepared as per the recommended package of practices (twice bullock ploughing, once puddling and once levelling). At the time of transplanting the depth of standing water in the plots varied between 3.0 and 5.0 cm. One medium duration high yielding variety paddy, CR-1009 was selected for the trial. Line transplanting was done using a rope with knots and a pair of guides in all the treatments except in T_2. About 5.0 cm of standing water was maintained in all the plots throughout the season except the last 15 days before harvesting. Weeding was done once a month after the transplanting. No pesticide was applied as the crop was healthy throughout the growth period. The full doze of phosphorous (30 kg/ha) and potash (30 kg/ha) were applied in terms of single super phosphate and Muriate of potash, respectively, before transplanting. Nitrogen (60 kg/ha) in the form of USG/prilled urea was applied in all the treatments. Prilled urea was applied in treatment T_6 in three equal split dozes, first at the time of transplanting, second at the time of tillering and third at the time of panicle initiation.

In treatment T_1, USG was applied by hand one week after transplanting. In treatment T_2 two workers used the USG dispenser-cum-transplanting guide to transplant first two rows each with 10 hills. Then one worker had to transfer 10-12 USGs to the wire basket located below the USG hopper which were picked up by each of them and placed by hand at 7.00 to 10.00 cm depth. The workers had to move about 40 cm straight backwards, align the transplanting guide approximately and repeat the combined operation.

USGs were applied by two-row USG applicator in treatment T_3. This applicator is a continuous push type single device covering four palnt rows in one pass. USGs were applied by USG applicator for point placement in treatment T_4 (Swain et al., 1992). Prilled urea was applied in treatment T_5 by the prilled urea applicator covering four plant rows in a pass. Prilled urea is placed in continuous band at a depth of 7.5 cm by a plunger and suger mechanism in this machine. Prilled urea was applied in treatment T_6 by conventional three-split broadcasting method. The actual field capacity, grain and straw yield and cost of operation were recorded to compare the performance of the different urea application methods.

Results and Discussion

The results of the field performance evaluation of different USG/PU application methods, their economics of use and yield components in terms of average grain and straw yields/ha in each treatment are presented in **Table 1**. The highest grain and straw yields of 25.52 and 32.71 q/ha were achieved in treatment T_2 and the lowest yields of 16.67 and 20.63 q/ha were recorded in treat-

Table 1. Results of Field Evaluation of USG/prilled Urea Application Methods

Parameter	T_1 Researcher's method	T_2 IFDC USG Dispenser-cum-trans-planting guide	T_3 Two-row USG applicator	T_4 USG applicator for point placement	T_5 Prilled urea applicator	T_6 Conventional prilled urea broadcasting method
Man-h requiremeent for USG/PU application (h/ha)	80.00	384.14	15.45	50.00	14.24	24.00
Man-h requirement for line transplanting using rope and guides (h/ha)	504.82		504.82	504.82	504.82	504.82
Total Man-h requirement for line transplanting and USG/PU application (h/ha)	584.82	384.14	520.27	554.82	519.06	528.82
Cost of operation for USG/PU application (Rs./h	3.13	3.67	4.91	3.58	4.25	3.13
Rs/ha)	250.40	1 409.03	75.86	179.00	60.52	75.12
Cost of line transplanting using rope and guides (Rs./ha)	1 580.09	—	1 580.09	1 580.09	1 580.09	1 580.09
Total cost of USG/PU application and line transplanting (Rs./ha)	1 830.49	1 409.03	1 655.95	1 759.09	1 640.61	1 655.21
Cost of USG/PU (Cost of USG>PU by 10 per cent cost of PU (Rs. 3.00/kg)	430.44	430.44	430.44	430.44	430.31	391.31
Total expenditure (cost of USG/PU + cost of USG/PU appication + cost of line transplanting) (Rs/ha)	2 266.93	1 839.47	2 086.39	2 189.53	2 031.92	2 046.52
Additional Expenditure (over conventional prilled urea broadcasting method) (Rs/ha)	214.41	−207.05	39.87	143.01	−14.6	—
Grain yield CD = 0.95 0.05 (q/ha)	21.15	25.52	24.79	23.33	18.54	16.67
Straw yield CD = 1.74 0.05 (q/ha)	27.81	32.71	31.25	28.96	23.44	20.63
Additional return over control (Rs/ha) in terms of grain yield and straw yield. (grain Rs. 300/q) Straw (Rs. 40/q)	1 631.20	3 138.20	2 860.80	2 331.20	573.40	—
Net benefit over control (Rs./ha)	1 416.79	3 345.25	2 820.93	2 188.19	688.00	—
Benefit cost ratio	3.30	4.87	4.16	3.73	3.20	2.85

Note: Total return and net benefit in control was Rs. 5 826.20/ha and Rs. 3 779.68/ha, respectively.

ment T_6. The yields in treatment T_3 and T_2 were at par. The higher grain and straw yields in T_2 and T_3 may be attributed to higher fertilizer -N- use efficiency of USG. In treatment T_2 freshly puddled soil was soft at the time of transplanting which helped to close the holes at the placement sites almost immediately and automatically reducing the risks of the holes considerably which leads to eventual loss of nitrogen, being minimized (Parbery, 1990). In treatment T_3 the higher grain and straw yields may be attributed to accurate depth of placement of USG in the deep furrow opened by the tynes, later being covered by the pair of furrow covers by which higher fertilizer -N- use efficiency could be achieved.

The average grain and straw yields/ha in treatments T_1 and T_4 were at par and significantly less than those recorded in treatments T_2 and T_3. This may be due to the fact that the dissolved USG-N moved upward in the water-filled holes, left in the soil above the placement sites after hand placement of USG (Crasswell et al., 1981).

With machine deep placement of USG failure to properly close the furrows has resulted in high amounts of urea-N in flood water reducing the N-use-efficiency. Prilled urea applicator places the fertilizer as per the pre-set required rate at a soil depth of less than 5.00 cm only which may account for the lower fertilizer use efficiency reducing the average grain and straw yield/ha.

The gross returns for each method were calculated considering the prevailing cost of paddy and straw. The net benefit over control was calculated considering the additional expenditure and gross return. The highest benefit cost ratio was achieved in T_2, 4.87; followed by 4.16; 3.73; 3.30; 3.20; and 2.85 in T_3, T_4, T_1, T_5 and T_6, respectively. The average man-hour requirement for line transplanting using a rope with knots and two side guides was 504.84 man-ha. In treatment T_2, line transplanting and USG application were achieved simultaneously using the simple bamboo-made device USG dispenser-cum-transplanting guide. The average man-hour requirement by this unit was 384.14 man-h/ha. Deep placement of USG by hand in treatment T_1 indicated an average man-hour requirement of 80 man-h/ha. The total man-hour requirement for line transplanting and USG application by hand (T_1) was 584.84 man-h/ha indicating 34.35% saving in labour by using the USG dispenser-cum-transplanting guide over T_1.

The results of experiment on

USG dispenser-cum-transplanting guide through the IFDC has indicated a savings of 25 to 30% labour over traditional method of line transplanting and hand placement of USG (Savant, 1988). The average man-hour requirement for USG placement at 7.50 cm soil depth by two row USG applicator (T_3) and USG applicator for point placement (T_4) were 15.45 h/ha and 50 h/ha, respectively. In treatment (T_3) the applicator covered four plant rows in a pass and was continuous push-type machine, thus required less time to cover one ha as compared to that in treatment (T_4). In treatment (T_4) the applicator covered only two rows in a pass and was a non-continuous type machine which was to be shifted from one point of placement to the other and thus required more time.

In treatment T_5 prilled urea was applied by prilled urea applicator and the man-hour requirement was 14.24 h/ha. This applicator places prilled urea at a soil depth of about 5.00 cm. The cost of USG appliclation was highest (Rs. 6.79/h) in the case of treatment T_2 and lowest (Rs. 3.12/h) in treatments T_1 and T_6. The cost of USG application by two-row USG applicator and USG applicator for point placement was Rs. 4.91/h and Rs. 3.58/h, respectively. The cost of prilled urea application was Rs. 4.25/h through prilled urea applicator.

The total expenditure per ha was calculated. Considering the cost of line transplanting and cost of USG/PU application and cost of the nitrogenous fertilizer 60 kg N (USG/PU), the highest expenditure of Rs. 2 261/ha was incurred in treatment T_1 and lowest of Rs. 1 839/ha in the case of treatment T_2. The additional expenditure over traditional broadcasting of prilled urea (Rs. 2 047/ha) was calculated for each treatment. In treatments T_2 and T_5 the expenditure were less than that of T_6 by Rs. 207/ha and Rs. 15/ha, respectively. The additional expenditure in treatment T_1, T_3, T_4 over T_6 were Rs. 214/ha, Rs. 40/ha, Rs. 143/ha, respectively. The lowest expenditure in T_2 was due to the simultaneous completion of line transplanting and USG application by using the inexpensive bamboo-made device USG dispenser-cum-transplanting guide.

Conclusion

Deep placement of USG by two row USG applicator requires only 15.45 h/ha as compared to other methods of USG application by hand (80.00 h/ha) and by USG applicator for point placement (50.00 h/ha). Rice farmers in irrigated areas with good water control practice and line transplanting should use this applicator. Small rice farmers in rainfed areas, transplanting rice at random, should use the simple inexpensive bamboo-made USG dispenser-cum-transplanting guide as an appropriate alternative method for the proper use of USG.

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Design and Field Evaluation of a Low-cost Crop Transplanter with Multiple Seedlings Feed

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Abstract

A prototype transplanter for vegetable seedlings was designed and field tested. The planter was ground-driven and utilized a feeding belt system that made it possible for the establishment of bare-rooted or block transplants. The machine was single-row and carried by a 45-kW tractor. The speed of transplanting varied between 2 and 7 transplants/min /row and was a function of the selected variable power-train in the machine (which also affected in-the-row spacing) and tractor speed. The theoretical capacity of the machine varied between 0.09 ha/h and 0.72 ha/h (for a single row) with respective field efficiencies of 0.89 and 0.68% The machine was low-cost, simple, and manufactured from locally available parts.

Introduction

The stoop labor-labor intensive operations involved in crop transplanting have encouraged various groups and individuals to research reliable mechanical apparatus for those operations. As a result, an immense number of transplanter designs has been developed during the last 35 years (Boa, 1984 A), some of which are either patented or are commercially available (Branch, 1986, Paladino, 1982, Herbert, 1973, Holland (R), Powell (R), Mechanical Transplanter (R)). The sources of variation among those designs can generally be categorized into 5 major groups: (1) level of automation, ranging from hand-fed transplanters (Suggs, 1979, Chow et al., 1980) to high precision automation (Penley, 1981, Huang, 1983, Hwang and Sistler, 1986, Suggs et al., 1987, Brewer, 1988, Yang et. al, 1991); (2) form in which the transplant exists extending from bare root (Khan and Gunkel, 1988, Hsieh and Chen, 1989) to soil blocks (Palmer and Wilton, 1962, Moden et al., 1977, Lee et al., 1982), bandoleer and paper tape (Pretzer, 1979, Moden and Hauser, 1982), and soil plugs (Branch, 1986, De Groot, 1986); (3) type of crop including vegetables (Boa, 1984 B, Kromer, 1986), field crops (Brewer, 1978, Marshgrass (Portens et al., 1989), Sweet potatoes (Chen et al., 1982), and trees (Ardalan and Hassan, 1982); (4) seedling movement and handling, and; (5) seedling establishment in the soil.

Although transplanting technology has been markedly advancing, a number of obstacles still constrain its comprehensive adoption by farmers, especially in developing nations. Those obstacles include: (1) high cost, (2) unavailability of components and spare parts; (3) Difficulty of operation, maintenance and repair; (4) perplexity of import and assembling, and; (5) Need to establish local manufacturing facilities for machines and their components. This research has been initiated, accordingly, with the objective of developing and field evaluating a low-cost, locally manufactured, multi-feed station transplanter for vegetable crops, with the following physical and functional parameters:

1. Plant a broad range of vegetable seedlings either in a bare-root form or established in soil blocks;
2. Allow for different plants in-row and inter-row spacing along with variable planting

Note: The research was funded by a grant from the University Research Board of the American University of Beirut, Beirut, Lebanon.

depths;

3. Machine should be ground-driven and mounted on the 3-point tractor linkage system of a medium-size tractor (45-60 kW). The machine should also allow for all possible variations and component adjustments to insure prompt and comprehensive field evaluation.

Machine Development

A prototype machine was designed, developed, and tested during the period 1987-90 at the Agricultural Research and Education Center of the American University of Beirut, Lebanon (**Fig. 1**). The machine consisted of four major subsystems (**Figs. 2, 3, 4**); (1) implement chassis, (2) power transmission system, (3) transplant handling system, and (4) transplant establishment system.

Implement Chassis

The implement chassis consisted of a supporting frame (A1), a three-point hitch linkage system (A2), operator seat (A3), and the carrier of the transplant guide-rail (A4). The supporting frame was a 0.9 m × 1.3 m rectangular steel channel with cross-sectional dimensions of 85 mm × 65 mm × 10 mm. The linkage system consisted of two - 55 mm wide, 17 mm thick flat steel bars bolted to the front frame and designed to accomodate a category II three point tractor linkage system.

The carrier of the rail for the transplant-guide component was made of a 5 mm diameter steel rod (D3) welded from one end to the rail and to the frame of the transplant handling system on the other end. The rod was curved to a distance from the base of the guide that would allow transplants with a maximum height of 250 mm to pass under.

Power Transmission System

The power transmission system consisted of a driving wheel (B1) with soil engaging teeth (B2), power transmission sprockets (B3), power diversion gears (B4, B5), and sprockets (B6) for driving the transplant moving belt.

The ground-driven driving wheel was a 230 mm diameter, 120 mm wide steel wheel mounted on the machine frame by a connecting bracket. The bracket permitted the change in wheel height adjustment while maintaining the tension in the power transmission chain. To increase soil engagement and reduce slippage, 13 steel beams (40 mm × 40 mm × 3 mm) were welded on the circumference of the wheel in the form of a rail at 55 mm spacings (B2).

The wheel rotated a 20-teeth (5/8" pitch single strand) sprocket (B3) connected by a chain to a 15-teeth sprocket. Another combination consisted of a 26 - 14 teeth sprockets transmission system. The later sprocket of either combination rotated a 200 mm long, 22 mm diameter medium carbon steel rod mounted by two journal bearings on the chassis of the transplanting unit. The rod transmitted the power to 15-teeth straight bevel gears (B4, B5) having a 20-degrees pressure angle and a 1 : 1 ratio. The second bevel gear (B5) was connected to one end of a 200 mm long, 22 mm diameter medium carbon steel rod mounted by two journal bearings on the chassis of the transplanting unit (D1). This rod rotated an 18-teeth (5/8" pitch single strand) sprocket (B6) that served as the seedling-belt drive system.

Handling System of Seedlings

The seedling handling system consisted of a furrow opener (C1), pair of disc bedders (C2), and a machine depth adjustment wheel (C3). The furrow opener was mounted to the machine chassis by a 500 mm long, C-shape high carbon steel beam (64 mm × 60 mm × 6 mm). The bedders were each a 280 mm disc mounted by 500 mm long C-shape high carbon steel beam (64 mm × 60 mm × 6 mm) to a chassis extension made of a 350 mm long C-shape high carbon steel beam (75 mm × 78 mm × 7 mm). The later was mounted to the back of the machine chassis and made it possible for a three-directional adjustment of the discs. The predominant setting of the discs were at a front inter-distance of 420 mm with disc and tilt angles of 45° and 19°, respectively. This setting resulted in a 240 mm high and 190 mm wide ridge in which transplants were established.

The depth adjustment wheel was made of a 250 mm diameter, 60 mm wide rubber wheel mounted to the chassis by its bearing on a (35 mm × 35 mm × 3 mm) square steel column. The wheel counter-supported the steel ground-driven driving wheel in balancing the machine when engaged in the ground.

Transplant Establishment System

The transplant establishment system consisted of the system's frame (D1), feed belt (D2), transplant guide rail (D3), feed plugs (D4), transplant guide seat (D5), system's height adjustment (D6), transplant release (D7), and feed belt drive (D8). The system's frame was an L-shape structure the length of its sides being 840 mm and 920 mm, respectively. The frame was made of a rectangular steel column (65 mm × 45 mm × 3 mm). The chassis carried the seedling-belt drive sprockets (B6). This belt consisted of a 100 mm wide, 4 mm thick rubber belt riveted to flat steel rods (90 mm × 40 mm × 3 mm) at 200 mm spacings. The ends of each rod were, in turn, welded to

Fig. 1 A general view of the developed transplanter.

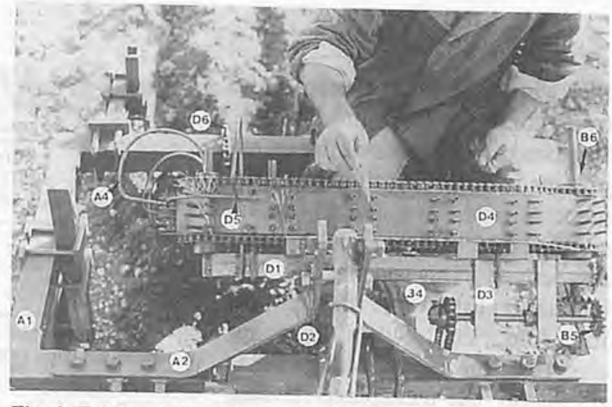

Fig. 2 Feeding belt system and other components.

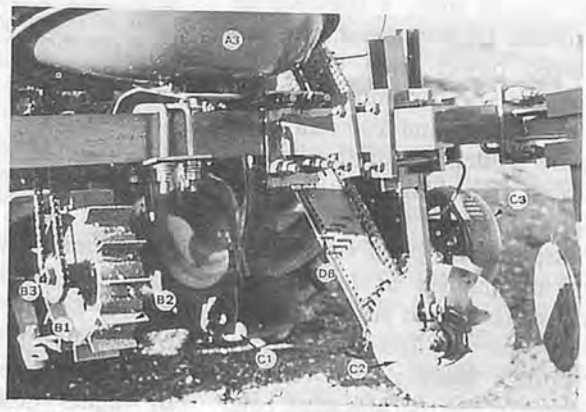

Fig. 3 Machine power system and other components.

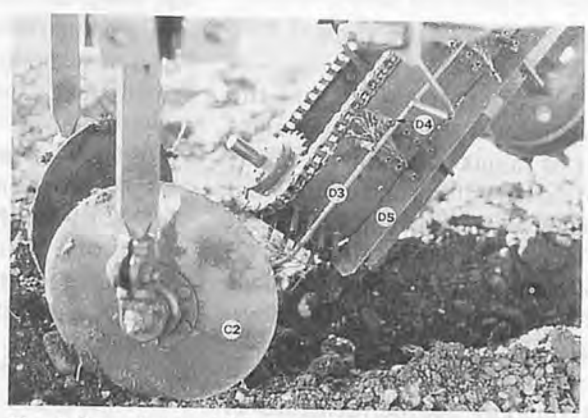

Fig. 4 Transplant establishment system and other components.

the link plates of a 5/8" pitch single strand driving chain (D8). Sets of two-rows of plastic plugs were bolted to the belt at an inter-row distance of 35 mm and a distance between two consecutive sets of 160 mm. This made it possible to have four sets for transplant feeding in front of the operator at any time. Each row consisted of 3 equidistant plastic plugs the length of each of which was 35 mm. Transplants were manually inserted on the belt between each set of plugs. Transplants were maintained at the belt by a 5 mm steel rod that served as the transplant guide, and by the transplant guide seat (D5). This seat was made of a 50 mm wide, 3 mm thick sheet-metal welded to the lower side of the system's frame just under the belt. Both the rod and the seat traced the contour of the frame and maintained the position of each transplant on the belt until it reached to the lower end of the frame where the seat was terminated and the rod was extended to a position of 100 mm away from the belt (D7). This ensured that the transplant dropped smoothly from the belt and was held up position while the discs (C2) established a ridge around it. It was possible to plant bare-root, plug type, and block transplants as a result of this system. The frame's height was adjusted through a height chain (D6) that elevated it to accommodate different transplant sizes, soil types, and ridge depths.

Machine Mode of Operation

The various mechanisms of the machine were activated by the ground-driven rotation of the driving wheel (B1). This wheel transmitted the power through one of two power train configurations: (20 to 15 teeth sprockets) and (26 to 14 teeth) sprockets. The second sprocket of each combination rotated the bevel-gear system (B4, B5) which, in turn, rotated the transplant feeding mechanism. The two power trains of the transplanter allowed for the establishment of transplants at an in-row spacing of 300 mm and 200 mm, respectively. This spacing could be increased to two-, three-, and four-fold, etc., when skipping one, two, three, etc. sets of feeders during the transplant feeding process. The speed of transplanting was, as such, a function of both the tractor speed and the selected power train (**Table 1**). The furrow opener made a 150 mm deep and 100 mm wide furrow which was adjusted according to the height of the transplants and the nature of soil. Transplants dropped via the belt feed mechanism at in-row distances that varied either through the power configuration or by skippings during the feeding process of the transplanting belt.

Table 1. Average Number of Transplants Established by the Transplanter in Every Rotation of the Drive Wheel as a Function of Tractor Speed and Power Train Configuration

Tractor Speed (KPH)	Drive Wheel (B1) Rotation (RPM)	No. of Transplants / Power Configuration*	
		Configuration 1 (300 mm spacing)	Configuration 2 (200 mm spacing)
2	0.46	1.1	1.5
4	0.92	2.2	3.0
6	1.38	3.3	4.6
8	1.86	4.5	6.1

* Configurations 1 and 2 were obtained by a 20 to 15 teeth and 26 to 14 teeth sprocket arrangement, respectively.

Table 2. Average and Standard Deviation of Missings as a Function of Speed of Transplanting

No. of Transplants per Minute	Percent of Plant Missings / Plant Spacing*	
	(200 mm)	(300 mm)
< 2	2.2 +/− 0.32 a	1.9 +/− 0.21 a
2 − 4	3.2 +/− 0.41 ab	2.1 +/− 0.11 a
4 − 6	5.4 +/− 1.36 b	2.9 +/− 1.27 b
> 6	7.2 +/− 2.12 c	5.8 +/− 1.63 c

* Means with a common letter in a column are not significantly different using a DMR test at a probability of 0.05.

Machine Performance

The performance of the machine was a function of a number of inputs consisting of inherent design criteria and operational conditions. These inputs included: (1) speed of transplant feeding; (2) soil condition; (3) inclination angle of feeder; and (4) transplant physical characteristics.

As an initial step towards understanding the performance of this machine, the contribution of speed of transplanting to transplant establishement was studied. Four different speeds of transplanting were tested. Ten runs were carried per speed where 50 model transplants were planted in each run and the number of missings counted (**Table 2**).

While the number of missings was lowest at a transplanting speed of less than 2 transplants/min/row, the most feasible transplanting rate was found to be 4-6 transplants/min/row with a tractor speed of 4.5-6 kph. Tractor speed above 8 kph caused improper transplant establishment and was hazardous to some extent. The use of higher density transplanting belt (in-row spacing of less than 10 mm), and multiple feeding belt units could raise the potential rate of transplanting 4-5 fold. Machine theoretical capacity for a single row machine varied between 0.09 ha/h at a tractor speed of 2 kph and 450 mm inter-row spacing and 0.72 ha/h at a tractor speed of 8 kph and an inter-row spacing of 900 mm. The respective field capacities were 0.89 and 0.68%.

Recommendations

The developed machine proved to be an important potential for low-cost mechanization of transplanting operations. Further research should follow to assess the performance of the machine as a function of plant physical characteristics and earth condition (soil structure, texture, and moisture content, and land leveling). Additional power train configurations should be provided for planting narrower in-row spaced transplants (less than 100 mm) such as lettuce and other similar crops.

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Performance of Water Pump Using Discarded Automobile Tire

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Abstract

Centrifugal pumps are not quite successful in pumping water using low-speed windmills. This is because the discharge is reduced by a slow revolution per minute (rpm). This means that pumps with alternative motion are more suitable than those with rotating motion.

A water pump using a discarded (used) automobile tire was constructed. Its performance was measured. The dynamic suction head of the pump was about 0.75 m. The power required to drive the pump was 90-100 W. The discharge was 20-25 liter per minute at 60-80 rpm.

Introduction

Irrigation pumps that use energy to lift water has a long history. The pump that is driven by a windmill must be compatible with the characteristics of the wind energy, i.e., the rpm of the machine must be in accord with the velocity of the wind. Centrifugal pumps with alternative motion are preferable to those with rotating motion. In recent years, alternative motion was provided by using a pump with a discarded automobile tire in order to determine the pump's performance.

Materials and Methods

A water pump using a discarded (used) automobile tire was contructed (**Fig. 1**). The tire size was 5.60-5.90/13. The lower part of the tire was rigidly fixed to eccentrical motion. The suction and discharge bores were 2 inches. The pump and valves were developed at the laboratory of the Department of Agricultural Machinery. The suction pipe was extended to the end of the discharge pipe which was jointed to a hose.

The pump was driven by an electric motor and the measurements were done at the Department's testing station. The dynamic pressure at the suction and discharge lines of the pump and revolution were also recorded. In order to measure the discharge of the pump, scale cups were used.

The efficiency of the pump (μ) was calculated by using the following formula:

$$\mu = \frac{N_1}{N_2}$$

where:
N_1: Pump drive shaft power (W)
N_2: Pump hydraulic power (W)

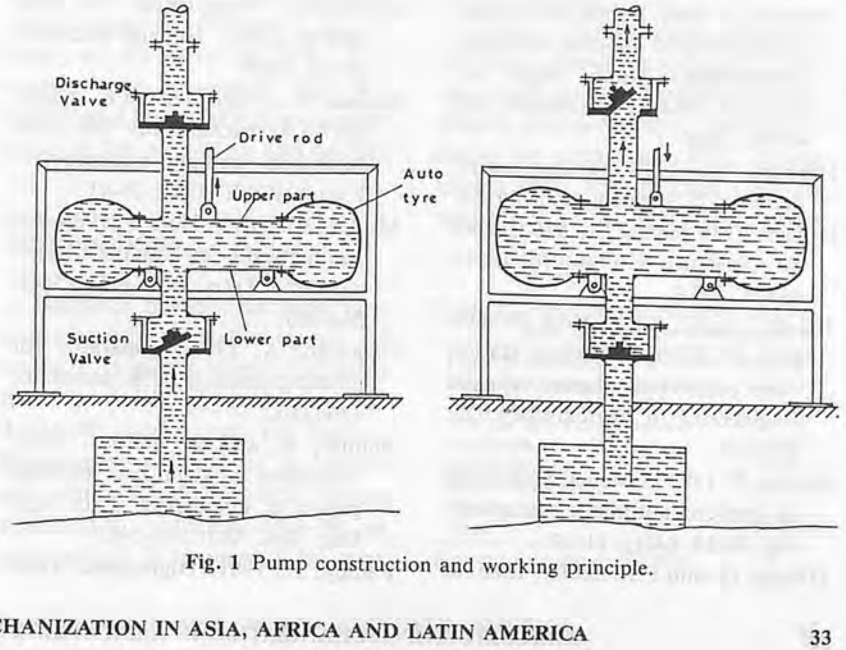

Fig. 1 Pump construction and working principle.

Result and Discussion

The pump was at 0.75 m dynamic suction head. Due to the elasticity of the automobile tire, the pump could not be used if the height exceeded 0.75 m. With the 1.75 m of the pressure line, the pump was 2.5 m in total head.

The ideal revolution of the pump per minute was 60-80. Its discharge was 20-25 liter per minute. The power required to drive the pump was 90-100 watt. The efficiency of the pump was rated at between 68 and 72 percent.

Although the pump performed creditably, it has its own disadvantage, namely: the low suction height is workable only from shallow water sources such as rivers and lakes.

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Design Development and Performance Evaluation of Onion Digger Windrower

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Abstract

The harvesting of onion crop at the proper maturity stage is essential and has to be completed within a specified period. Manual harvesting of onions is a tedious, time consuming, labour intensive and costly operation. It is, therefore, necessary to mechanize this operation. A simple low-cost self-propelled onion digger windrower was designed and developed. It is powered by a 5 hp diesel engine mounted on the wheeled frame along with the main gear box. A handle is provided for steering the entire unit. The digging unit consisting of sweeps is fitted at the front of the frame. A trapezoidal windrowing unit is fitted at the rear of the digging unit. For controlling the depth of operation a caster wheel is provided infront of the digging unit.

The field performance of this machine was evaluated in comparison with the prevalent local onion harvesting practice during different seasons at different locations in 1991-92. It was observed that the actual field capacity of the onion digger windrower varied from 0.16 to 0.19 ha/h. The percentage of damaged bulbs was from 2.63 to 3.45. The machine gave a digging efficiency in the range of 89.66 to 93.23%. The cost of the prototype was Rs. 16 000 and involved a cost of operation of Rs. 125.77 to 149.44/ha.

Acknowledgement: The workshop facilities provided by the Agricultural Engineering Research Centre, Pune of the Department of Farm Machinery and Power (MPKV) Rahuri, the cooperation given by the farmers in making their onion fields available for the testing of the machine and the finance provided for the project by the ICAR, New Delhi are gratefully acknowledged.

Introduction

Onion is one of the important commercial vegetable crops of India. It is grown over 3.055 lakh ha area with a production of 3 236.40 thousand of bulbs. Maharashtra State is a major contributor to the total onion production. During 1989-90 an area of 57.7 thousand ha was planted to onion crop in the State and total production was 780.90 thousand t representing 24% of the all-India production (Anonymous, 1990 and 1991).

At present there is no mechanization at any stage in the onion cultivation. The traditional practice of onion cultivation involves mainly the operations shown in **Table 1** with the corresponding percentage of the total expenditures required.

Onion harvesting involves different operations: digging, lifting, field curing of onions in windrows for 4-5 days, cutting at necks to separate bulbs, curing under shed and storage (Wayne and Price, 1970). Harvesting oper-

Table 1. Percentage Breakdown of Current Cost Onion Production

Land preparation	19.50
Nursery raising of seedlings	12.00
Transplanting of seedlings on the dry raised beds	14.73
Irrigation	10.07
Interculturing	12.00
Plant Protection	10.30
Harvesting	21.40
Total	100.00

Source: Anonymous, 1989.

ation cost the most (21.40%) of the total production cost.

It is important to complete the entire process of harvesting of onions within specified time limits. Any delay in the operation adversely affects the keeping quality of onions. Usually harvesting is subjected to labour scarcity problems and if delayed may cause damage to bulbs due to adverse conditions (Droll et al., 1976). In order to minimize the problems associated with the operation, to achieve timeliness and to reduce the cost of operation, a self-propelled onion digger windrower was designed and developed with the aim of:

(i) Digging out of the onion bulbs with the tops;
(ii) Separating the bulbs from the soil mass; and
(iii) Arranging the bulbs in the form of windrows in the field.

Materials and Methods

After reviewing the relevant literature and considering all the possible soil crop machine parameters, the self-propelled machine (simple in construction and operation) suitable to the recommended plant geometry was designed and developed at the Department of Farm Machinery and Power MPKV Rahuri (Maharashtra).

The digger-windrower mainly consisted of the following functional units:

(1) Power unit
  (a) Base frame with wheels
  (b) Engine
  (c) Power transmission system
  (d) Handle
  (e) Guide wheel
(2) Digging unit
(3) Windrowing unit

A brief description of each component follows:

Power Unit

Base frame — The engine and gear box of the unit are mounted on the main frame of 750 × 150 mm MS channel. The hitching arrangement of MS hollow square pipe of 920 × 45 mm and 6 mm in thickness has been provided at the front of the main frame. Two pneumatic wheels (500 mm dia) or two cage wheels (560 mm dia) can be provided on the main axle during field trials depending upon the soil type and condition of the field.

Engine — The engine specifications used as power source are as follows:

hp	: 5
rpm	: 3 600
Make	: Greaves Lambordini
Type	: Diesel
Tank capacity	: 4.5 litres
Weight	: 31 kg (with tank empty)

Power transmission — The power is taken from the engine to the main shaft of the transmission gear box with the help of 'V' belt pulley. The diameter of the engine pulley and the main shaft pulley are 100 and 190 mm, respectively. The power received from the main shaft of the transmission gear box is reduced to 490 rpm and further to 30-35 rpm at the ground wheel shaft so that it is possible to get the operational speed of 2.5 to 3.25 kg/h of the machine in the field (Tomita et al., 1978 and Razmyslovich, 1985).

Handle — A handle made of two pipes (25 mm dia) of MS 1 500 of mm length is provided for steering the entire unit similar to a power tiller. A clutch arrangement is also provided on the handle.

Guide wheel — A castered guide wheel of 125 mm diameter is provided in front of the digging unit. It is mounted on the main frame with the help of a screw so as to facilitate depth adjustment during field operation. It also helps to raise the digging blade well above the ground surface during the transport of the machine (Chesson et al., 1989).

Fig. 1 Self-propelled onion digger windrower showing different functional units.

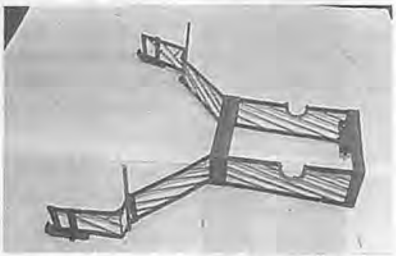

Fig. 2 Windrowing unit of onion digger windrower. The left end (wider) is connected behind the digging unit.

Fig. 3 Oman digger windrower in action.

Digging Unit

This unit consists of four sweeps each of 215 mm length, 100 mm working width and 3 mm thickness. The angle of approach and the tilt angle are 40° and 22°, respectively. The sweeps are fitted to the tines at their bottom end with the help of the nuts and bolts. The tines are of MS square bar of size 15 × 15 mm with 375 mm length. The spacing between the tines is kept as 215 mm.

Windrowing Unit

After digging the onion bulbs in the field they are separated from the soil and arranged in the form of windrows in the field. For this a windrowing unit (**Fig. 2**) is attached behind the digging unit.

The windrowing or collecting unit is fabricated in a trapezoidal shape. It is made of 6 mm diameter MS round bars. The width at the front is 800 mm and at the rear it is 300 mm. The length and height of the unit are 100 and 150 mm, respectively. The sides of the windrowing unit are closed by MS bars of 6 mm diameter to prevent spilling of onion bulbs while being arranged by the unit in the windrows. The unit is supported at both sides by two MS flats attaching it to the main frame. The windrowing unit is kept down touching to the ground all the time during the field operation with the help of the springs. These two compression springs are of 25 mm 350 mm in length mounted on 15 mm dia MS bars. This arrangement prevents any "escape" of onion bulbs from down the sides of the windrowing unit.

During the laboratory and field trials, the following instruments were used for quantifying the parameters such as draft, speed, time, weight, revolutions etc.

Tachometer (0-5 000 rpm);
Drawbar type dynamometer (0-500 kg);
Different types of tapes;
Stop watch;
Measuring cylinder (0-100 cc); and
Weighing balance (50 kg)

The field tests (**Fig. 3**) were conducted at different locations and the data were recorded as per the standard test procedure for both the onion digger windrower and the local methods.

Results and Discussions

In order to evaluate the performance of this newly developed onion digger windrower, six field trials were conducted at different locations in comparison with the local and traditional method of harvesting onion, i.e., harvesting onion bulbs by hand pulling.

With the onion digger windrower, the depths obtained were in the range of 5.1 to 6.7 cm. Onion bulbs at any depth in this range could be dug out without any damage and with an average missings of 9.07%. For the local method, the maximum depth recorded from which onions could be pulled out with hands was 7.1 cm. Unless the soil was very heavy and dry there was no possibility of missings in this conventional method of digging onions.

The average draft required for

Table 2. Field Conditions During Testing of Onion Digger Windrower

Particulars	Test I	Test II	Test III	Test IV	Test V	Test VI
General						
Date and season	5.3.92 Rabi	29.3.92 Rabi	10.4.92 Rabi	17.4.92 Rabi	21.4.92 Rabi	13.5.92 Rabi
Place	Vaduk	Kpwadi	Kalwadi	Kpwadi	Walhe	Kondapur
Tal	Haveli	Mulshi	Haveli	Mulshi	Purndar	Shirur
Dist	Pune	Pune	Pune	Pune	Pune	Pune
Name of farmer	Bondre	Kaspate	Nakate	Kaspate	Kumathe	Gaikwad
Soil type	M black	H black	M black	M black	M black	M black
Soil Moisture, %	12.4 to 14.5	14.8 to 16.4	14.2 to 15.6	12.3 to 15.5	15 to 16.2	13.4 to 15.9
Crop condition						
Crop variety		onion	N-2-4-1			
Age at harvest in days	128-130	131-133	124-127	127-130	121-125	126-132
Bulb dia, cm	5.61	5.20	4.13	6.70	5.90	5.20
Crop height, cm	54.90	31.60	32.40	37.80	33.40	28.60
Field conditions						
Plot size, m^2	380	700	590	904	765	810
Topography	level	level	level	level	level	level
Weed population	nil	nil	nil	nil	nil	nil
Atmospheric conditions						
Temperature, °C	35.90	37.40	38.80	39.50	40.30	39.90
R Humidity, %	18	65	18	44	47	25

M = Medium; H = Heavy; R = Relative

Table 3. Data of Field Tests of Onion Digger Windrower

Sr. No.	Particulars	Test I	Test II	Test III	Test IV	Test V	Test VI	Average
1.	Area covered, m^2	380	790	590	904	765	810	706.50
2.	Av depth of operation, cm	5.8	6.2	5.1	6.0	6.7	5.4	5.87
3.	Width of implement, cm	86	86	86	86	86	86	86
4.	Av draft, kgf	109.70	104.50	91.60	98.20	116.30	101.50	103.63
5.	Bubls/sq.m	127	114	116	103	107	112	113.17
6.	Missings/m^2	12	10	12	7	8	11	10
7.	Missings, %	9.45	8.77	10.34	6.77	9.26	9.82	9.07
8.	Dmg bulbs/m^2	4	3	4	3	3	3	3.33
9.	Damage, %	3.15	2.63	3.45	2.91	2.78	2.68	2.93
10.	Test duration, h	0.20	0.43	0.35	0.55	0.45	0.50	0.41
11.	Speed, km/h	2.70	2.80	2.75	2.65	2.83	2.60	2.72
12.	Theo. FC, ha/h	0.23	0.24	0.23	0.23	0.24	0.22	0.23
13.	Effe. FC, ha/h	0.19	0.18	0.17	0.16	0.17	0.16	0.17
14.	Field effi. (%)	82.61	75.00	73.91	69.57	70.83	72.72	73.91
15.	Dig. effi. (%)	90.55	91.23	89.66	93.23	92.52	90.18	91.23
16.	Yield, q/ha	281	248	227	290	243	315	267.33
17.	Fuel, ℓ	1.25	1.10	1.20	1.25	1.15	0.90	1.14
18.	Power required							
	Machine h/ha	5.26	5.56	5.88	6.25	5.88	6.25	5.85
	Man-h/ha	10.52	11.12	11.76	12.50	11.76	12.50	11.69
19.	Cost of operation, Rs/ha	125.77	132.96	140.59	148.44	140.59	149.44	139.63

Note: q/ha = quintal per ha, Effi. = Efficiency, ℓ/h = litres per h, Av = Average, Dmg = Damaged, Theo = Theoretical, FC = Field Capacity, Dig = Digging, Effe = Effective.

Table 4. Data of the Field Tests of Local Method of Onion Harvesting

Particulars	Test I	Test II	Test III	Test IV	Test V	Test VI	Average
Area covered, m^2	63.32	96	73.33	67.20	102.50	100.83	83.86
Av depth of operation, cm	4.9	5.2	5.8	7.1	6.3	5.9	5.87
Bulbs/sq.m	127	114	116	103	107	112	113.16
Missings/m^2	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Missings, %	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Dmg bulbs/m^2	1	Nil	Nil	2	Nil	1	0.67
Damage, %	0.78	Nil	Nil	1.94	Nil	0.88	0.6
Test duration, h	1.23	1.50	1.33	1.67	1.72	1.83	1.55
Dig. Effi., (%)	98.77	100	100	98.06	100	99.12	99.32
Yield, q/ha	291	252	225	317	243	325	275.50
Power required, man h/ha	194.25	156.25	181.36	248.51	167.80	181.49	188.28
Cost of operation, Rs/ha	485.63	390.63	453.40	621.28	419.50	453.73	470.70

Note: q/ha = quintal per ha, Av = Average, Dmg = Damaged, Dig = Digging, Effi = Efficiency.

Table 5. Comparative Performance Evaluation Data
Onion Digger Windrower Vs. Local Method

Particulars	Onion Digger Windrower	Local method
Average max. depth of operation, cm	6.7	7.1
Average missing, %	9.1	Nil
Bulb damage, %	2.93	0.6
Digging efficiency, %	91.23	99.32
Manual labour required man/h/ha	11.70	188.28
Cost of operation Rs./ha	139.63	470.70

operating the digger was in the range of 91.60 to 116.30 kgf at the forward travel speed range of 2.60 to 2.83 km/h. The machine could work smoothly without indicating any overloading resulting in effective field capacity of 0.16 to 0.24 ha/h and a field efficiency of 74%. The low efficiency was due to the loss of time in crossing bunds of the small basins traditionally created for planting of onions, field channels and also because of irregular rows of onions.

The digging efficiency of the onion digger windrower was from 89.66 to 93.23%. This was less than the local practice (98 to 100%) of onion harvesting as some bulbs were missed by the digger.

The percentage of bulb damage was negligible in both methods of onion digging. The machine, however, caused slightly more bulb damage (2.63 to 3.45%) than the local method (0 to 1.4%). The haphazard planting of the onions made it difficult to avoid damage to the bulbs caused by the ends of the digging blade.

The onion digger windrower reduced the man-hour requirement of the onion harvesting operation. Normally 156.25 to 248.51 man-h are required for digging of onion bulbs from one hectare by local method using small pickaxe or hand pulling method. The onion digger windrower required only maximum 12.5 man-h/ha in two of the trials (4 & 5) thus resulting in an average saving of 176.59 man-h/ha.

The machine always required less cost per ha. It was in the range of Rs. 125.77 to Rs. 149.44 (average Rs. 139.63)/ha for the digger windrower and Rs. 390.63 to 621.28 (average Rs. 470.70)/ha for the local method, an average savings of Rs. 331.07/ha.

The windrowing operation was satisfactory. However, occasionally few bulbs escaped from the windrowing unit in the fields where the soil condition was such that it produced too many clods of size bigger than the size of the onion bulbs. These clods sometimes caused lifting of one side of the windrowing unit.

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Low-cost Technology for Hulling Maize

by
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Abstract

A hand-operated abrasive machine was developed and used to study the hulling characteristics of maize grains. Two maize varieties of 12%wb original moisture content were each graded into two size fractions, small and large, and used in the study. Other factors considered were the soaking time and pressing weight. The soaking time was varied between 0 and 25 minutes in steps of 5. The net pressing weight was varied between 838 g and 2 362 g in steps of 762. Maize samples of 80 g each were used in this experiment and were hulled for 10 minutes at an average drum speed of 40 to 50 rpm. Hulled samples were each analyzed for whole kernels extracted, broken, unhulled grains, powdered material (mealy wastes), weight of flakes, coefficient of hulling, coefficient of wholeness and hulling efficiency. It was found that the soaking time had a significant effect on the whole kernels, broken, unhulled grains, powdered material, coefficient of hulling, coefficient of wholeness and hulling efficiency, but not on the flaking ability of grains. Pressing weight had a significant effect on all of the above named response variables except the coefficient of wholeness. The variety had a significant influence on all of the above response variables, except the percent unhulled grains and the coefficient of hulling. The size of grains had a significant influence on all of the response variables except the flaking ability and hulling efficiency.

Introduction

Maize is one of the three main crops in the world. It ranks third, after rice and wheat, in terms of world production. In Africa, maize is grown and consumed in Zambia, Zaire, Zimbabwe, Malawi, Kenya, Tanzania, Uganda, South East Ghana, Togo, Dahomey, West Nigeria, Cameroon and lowlands of Ethiopia (Uhlig and Bhat, 1979).

Maize is consumed in various forms depending on taste and season of the year. Some people consume it at tender age when the ears are harvested and cooked or roasted on the cob. When mature and partially dry, ears are harvested and passed through various processing stages before consumption. They may be dried and stored on the cob or may be shelled and stored as grains if consumption is not immediate. Dry grains are cooked either alone or in a mixture of other grains like beans. However, the most widespread use of maize is in the form of flour. It is cooked into a hard white or yellowish porridge (called *Ugali* in Tanzania and Kenya). Other names like *Nshima*, *Ubwali*, *Nsima* and *Ganfo* do exist in other African countries. Although flour obtained from whole maize grains is more nutritious than that from hulled grains, most consumers prefer *Ugali* made from hulled grains, mainly due to colour and palatability.

Hulling (or dehulling) entails the removal of the two outer coats of the maize grain, called the bran **(Fig. 1)**. Sometimes the germ could also be removed in order to improve the shelf-life of flour after milling (International Labour Office, 1984). It is the high oil content of the germ that causes the flour to go rancid.

A maize grain is comprised of the bran, making about 6%; the endosperm, making about 82%; the germ, making about 12% and the cap. The bran is mainly fibre, the endosperm is mainly starch and the germ is mainly oil (Chakraverty and De, 1981). Traditionally, the process of maize flour preparation has been manual by pounding in mortar and pestle. Housewives in many developing countries spend between

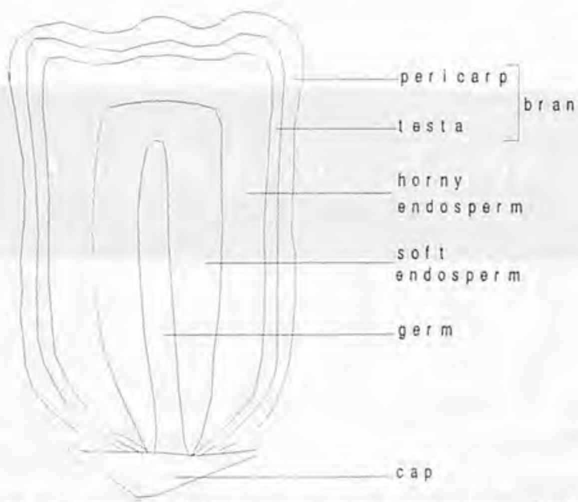

Fig. 1 Schematic of longitudinal cut of a maize grain (Uhlig and Bhat, 1979).

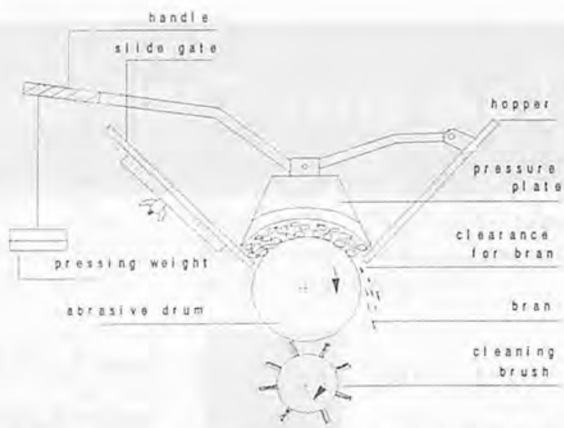

Fig. 2 Schematic representation of the maize hulling mechanism.

2 and 5 h daily pounding and processing grain for their families (Eastman, 1980). It is important, therefore, to develop a low-cost technology which is affordable in rural areas, and can be used to cut down the labour hours.

Objectives

The objectives of the study were: (a) to develop a simple hand-operated abrasion maize hulling machine suitable for technologically developing countries; (b) to test the machine; and (c) to investigate, among other things, the effects of water soaking on the hulling characteristics of maize grains.

Materials and Methods

Design of the Machine

A simple hand-operated machine was developed for hulling maize by abrasion. The basic features of the machine included: a hopper into which the grain sample is fed, a handle containing a pressure plate attached to the hopper, an abrasive drum which rotates to abrade the grains, a cleaning brush which cleans the abrasive drum, a gear-chain drive mechanism which drives the drum and the brush when the cranking handle is turned, a catch tray to catch the hulled components and a mill casing to hold the machine components in position (**Fig. 2**). The rough-surfaced abrasive drum was obtained by knurling a hardened mild steel cylinder of 126 mm length and 165 mm diameter. Other features of the machine are as detailed in Kajuna (1986).

Preparing the Samples for Hulling

Two varieties of maize were used in this study, namely; American Red No.2 from Jordan and a large dented white grain similar to Ferz 7 or 34. The moisture content of both varieties as determined by a Dickey-John grain moisture tester was 12.7% (wb). Each variety was graded into two size fractions: large and small. The large grain fraction comprised the grains which were retained on a 9 mm sieve (approximately US 3 sieve), while the small one comprised the grains that passed through the sieve. Exceptionally small grains were discarded. By trial and error, an 80 grammes sample was found appropriate to hull at a time. Each sample, except the control, was tempered by soaking in water for a short period. This softened the seed coat (Eastman, 1980) and created a difference in moisture content betweent the hull and the kernel

Fig. 3 A view of the hulling machine.

(Kuprits, 1967 and Chakravety and De, 1981). Tempering also toughened the bran and germ and facilitated the removal of the former in large pieces (International Labour Office, 1984). The soaking time was varied between 0 and 25 min in steps of 5. At the end of the soaking period, the grains were gently touched with an absorbent paper to remove the dripping water from the surface. The sample was weighed quickly to 80 g and taken to the huller.

Experimental Design

The factors that were varied in this experiment were: (a) variety (red and white); (b) size of grain (small and large); (c) soaking time

(0 to 25 min); and (d) pressing weight (838 g, 1 600 g and 2 362 g). Due to the constraint of experimental material availability, the experiment was replicated only once. The combination of all factors gave a total of 72 samples to be hulled. The hulling order was determined by using a randomization technique.

Hulling Procedure

The samples were each fed into the hulling chamber and the pressure plate guided into position. A pressing weight which was varied from 838 to 2 362 g in steps of 762 was suspended from the end of the handle (**Figs. 2** and **3**). In addition to the pressing weight, the pressure plate had its own weight of 1 282 g. The actual normal component of force (ΣF) that was pressing the grains onto the abrasive drum could be calculated as shown in the appendix.

The cranking handle was rotated clockwise at an average speed of 40-50 rpm. This was a speed which an average person could endure without tiring quickly. The drum was rotated for a short time (one min) and then reversed to turn over the grains. Reversing the drum also removed the mealy products and some of the small broken pieces. The pressing weight was always lifted before reversing (to avoid breaking the grains) and engaged when hulling was resumed. It was discovered by trial and error that 10 min was the appropriate hulling time. Longer hulling times led to too many broken kernels, especially for samples soaked for a short period, or not soaked at all.

Results

After hulling, the slide gate was opened, the drum reversed and the sample retrieved. The mealy product, both inside and outside the tray, was collected by a small brush. The whole product was graded into five categories: whole hulled kernels, unhulled grains, mealy waste (powdered material), broken pieces and the husks or flaked material (**Fig. 4**). The flaked material included large pieces of hull retained on the US 16 sieve. The mealy product included the powdered material that passed through the US 16 sieve. The mealy product included the powdered material that passed through the US 16 sieve. Each size fraction was weighed and the weight recorded.

Calculating the Efficiency of Hulling

The efficiency of hulling (η_{hull}) was calculated from the product of the coefficient of hulling (E_{hull}) and the coefficient of wholeness of the kernels (E_{wk}) as shown in equation (1)

$$\eta_{hull} = E_{hull} \cdot E_{wk} \quad (1)$$

According to Kuprits (1967) and Chakravety and De (1981) the two coefficients above could be calculated as follows:

Coefficient of hulling — The coefficient of hulling reflects the quantitative part of grain hulling. It is defined as the percent decrease in the amount of unhulled grains in the processed product and is given by

$$E_{hull} = \frac{N_1 - N_2}{N_1} \cdot 100 \quad (2)$$

or

$$E_{hull} = [1 - \frac{N_2}{N_1}] \cdot 100 \quad (3)$$

where:

N_1 = the percentage of unhulled grain before hulling.

N_2 = the percentage of unhulled grain after hulling.

E_{hull} = the coefficient of hulling.

Coefficient of wholeness of the kernels — The coefficient of wholeness of the kernels shows the proportion of whole kernels in relation to the total amount of kernels (kernels + crushed grain + mealy waste) extracted by a given system. It reflects the qualitative aspect of the hulled product. The coefficient of wholeness of the kernel represents the degree of accuracy of the hulling process. High amounts of whole kernels and, therefore, low amounts of crushed grains and mealy products indicate better hulling, which is reflected by a high coefficient of wholeness of the kernels. It is given by

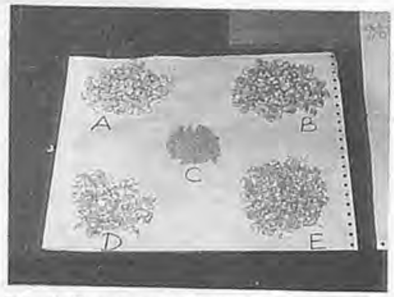

Fig. 4 Fractions recovered after hulling; A: extracted whole kernels, B: unhulled grain, C: mealy waste, D: broken, E: flakes.

$$E_{wk} = \frac{k_2 - k_1}{[k_2 - k_1] + [d_2 - d_1] + [m_2 - m_1]} \quad (4)$$

or

$$E_{wk} = \frac{k}{k + d + m} \quad (5)$$

where:

k = the yield of whole kernels extracted by the given system ($k_2 - k_1$).

k_1 = the content of whole kernels before hulling.

k_2 = the content of whole kernels after hulling.

d = the yield of crushed kernels ($d_2 - d_1$).

d_1 = the content of crushed kernels in the product before hulling.

d_2 = the content of crushed kernels in the product after

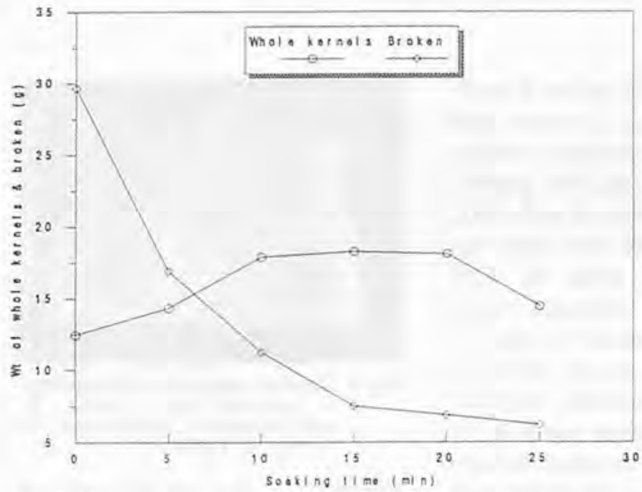

Fig. 5 Means of whole kernel extraction and grain breakage susceptibility vs soaking time.

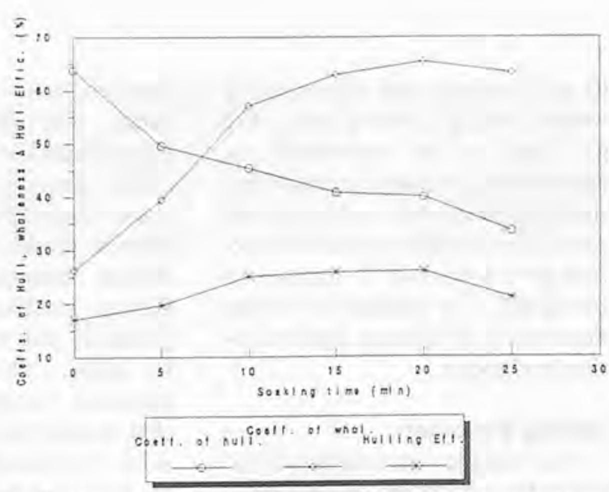

Fig. 6 Means of coefficient of hulling, coefficient of wholensss and hulling efficiency.

hulling.

m = the yield of mealy waste ($m_2 - m_2$).

m_1 = the content of mealy waste in the product before hulling.

m_2 = the content of mealy waste in the product after hulling.

All the raw data was compiled in the order of soaking time and fed into a computer for analysis. A 'GENSTAT' package (Copyright 1984 Lawes Agricultural Trust-Rothamsted Experimental Station) was used in the analysis. The means for each of the fractions were computed. The analysis of variance for each of the factors: soaking time, pressing weight, variety and grain size was carried out (**Table 5**). Also, a two-way and three-way interaction was carried out but not reported in this paper. The results of the effects of the above named factors on the hulling characteristics of maize grains are represented in **Tables 1** to **4** and **Figs. 5** and **6**.

Discussion

Most of the factors used in the study had a significant effect on the response variables-at least on an individual basis (**Table 5**). Unless stated to the contrary, the term 'significant effect' as used in this discussion should refer to significance at both 5% and 1% level.

Soaking Time

Soaking time had a significant effect on the quantity of whole kernels extracted. Initially there was a sharp incease in the quantity of whole kernels extracted as the soaking time increased. After 10 min, the increase in whole kernels extracted was at a decreasing rate up to 20 min. Thereafter it started to decline (**Fig. 5**). The zero soaking time had the least of whole kernels extracted while 15 min had the highest. Zero soaking time had the highest quantity of brokens while 25 min had the least. The tempering process applied to previously dried grains is, therefore, an effective method of reducing grain breakage (Lichfield and Okos, 1988; Gunasekaram and Paulsen, 1985). Although tempering or rehydration reduced the corn breakage susceptibility in this study, Tabil et al (1991) argued that tempering and redrying expose the grains to temperature and moisture gradients which may cause expansion and contraction resulting in internal stresses. In this study the susceptibility to breakage seemed to decrease exponentially as the soaking time increased. The exponential curve followed a trend similar to the one observed by Paulsen (1983) and Singh and Finner (1983). Unsoaked grains had a lower moisture content than soaked ones. Therefore, soaking presumably worked on the internal constitution of the grain, lending it more resilient, which reduced the shattering of the grain. While the quantity of hulled kernels was increasing with soaking time, the quantity of unhulled grain was, ironically, also steadily increasing (**Table 1**). This effect was found to be significant. One of the explanations could be that since brokens decreased with soaking, the grains that were saved

Table 1. Effect of Soaking Time Hulling Characteristics of Maize Grains

Soak time (min)	Means of the recovered fractions after hulling							
	Whole kernel (g)	Broken (g)	Unhulled grains (g)	Powdered (g)	Flaked (g)	Coeff of hull (%)	Coeff of whole (dec)	Hull efficiency (%)
0	12.44	29.65	28.95	5.89	1.56	63.81	0.26	17.05
5	14.30	16.86	40.33	4.86	1.76	49.59	0.40	19.68
10	17.87	11.25	43.69	3.34	1.71	45.39	0.57	25.03
15	18.28	7.53	47.35	3.14	1.70	40.77	0.63	25.77
20	18.13	6.87	48.05	2.88	1.41	39.94	0.65	25.93
25	14.47	6.20	53.23	2.50	1.20	33.47	0.63	20.98

Note: Each entry is a mean of 12 readings.

from breaking were shared between whole kernels and unhulled grains. Soaking had a significant effect on the susceptibility of the grains to powdering. The longer the soaking time, the less the tendency to form mealy waste and vice versa.

Flaking — the readiness of the hull to detach in flakes-did not seem to follow any significant pattern with respect to soaking **(Table 1)**. The coefficient of hulling was affected significantly by the soaking time **(Table 5)**. It dropped exponentially from 63.815 for zero soaking time to 33.47% for 25 min of soaking **(Fig. 6)**. This could be explained by the following: drier grains tend to have less coefficient of friction than wetter ones. The drier ones could, therefore, turn about more readily in the hulling chamber. In the process they were more polished than the wetter samples. Since the coefficient of hulling was calculated from the quantity of unhulled grain (equation 2) The former was going down because the latter was increasing with soaking. The coefficient of wholeness increased significantly with the soaking time. This was expected because soaking reduced the quantity of brokens and, therefore, more grains escaped unbroken **(Fig. 6)**.

The hulling efficiency was affected significantly by the time of soaking. It increased from 17.05 to a maximum of about 26% between 15 and 20 min of soaking. Thereafter, there was a tendency to drop **(Fig. 6)**. Since the hulling efficiency was a product of the coefficient of hulling and the coefficient of wholeness and the latter two were falling at 25 min of soaking, the hulling efficiency followed suit. A high hulling efficiency is expected when there is a difference in moisture content between the hull and the kernel. Perhaps very short and very long periods did not allow for this difference and the hulling efficiency tended to be low. From the results on **Fig. 6**, the appropriate time of soaking for the highest hulling efficiency was between 15 and 20 min.

Table 2. Effect of Pressing on Hulling Characteristics of Maize Grains

Press weight (g)	Means of the recovered fractions after hulling							
	Whole kernel (g)	Broken (g)	Unhulled grains (g)	Powdered (g)	Flaked (g)	Coeff of hull (%)	Coeff of whole (dec)	Hull efficiency (%)
838	11.48	9.90	51.25	3.40	1.40	35.92	0.523	17.24
1 600	16.20	12.58	44.04	3.72	1.50	44.94	0.531	22.54
2 362	20.06	16.70	35.50	4.19	1.77	55.63	0.518	27.44

Note: Each entry is a mean of 24 readings.

Table 3. Effect of Variety on Hulling Characteristics of Maize Grains

Variety	Means of the recovered fractions after hulling							
	Whole kernel (g)	Broken (g)	Unhulled grains (g)	Powdered (g)	Flaked (g)	Coeff of hull (%)	Coeff of whole (dec)	Hull efficiency (%)
red	13.63	15.37	43.39	4.16	1.42	45.75	0.45	18.98
white	18.20	10.75	43.80	3.37	1.69	45.25	0.60	25.83

Note: Each entry is a mean of 36 readings.

Pressing Weight

The pressing weight had a significant effect on the quantity of whole kernels extracted. It increased from 11.48 g for 838 g to 20.06 g for 2 362 g of pressing weight **(Table 2)**. The increase, however, was not linear. This observation was ascribed to the greater normal force (for heavier pressing weight) that was pressing the grains on to the abrasive drum, therefore, increasing the polishing effect. The quantity of brokens increased significantly with the pressing weight. The increase again was not linear. The 2 362 g had a bigger effect than the 1 600 g pressing weight. The quantity of unhulled grains increased significantly from 51.25 g to 35.5 g for 2 362 g **(Table 2)**. The more the amount of whole kernels and brokens, the less the unhulled grains. The powdering of the grains was affected significantly by the pressing weight which increased with the increasing weight. This was due to the fact that total abrazing force (ΣF) is a function of the mass of the pressing weight (equation 26). This, therefore, led to more particles being removed from the grains when larger force was applied. The pressing weight had a significant effect on the flaking ability of the grains, but only at 5% level. The coefficient of hulling of the grains increased significantly with the pressing weight. The observation came as no surprise because the quantity of whole kernels extracted was increasing and the quantity of unhulled grain was decreasing. The coefficient of wholeness did not seem to have any significant response to the pressing weight. However, it increased slightly from 0.523 for 838 g to 0.531 for 1 600 g. Thereafter, it dropped slightly to 0.518 for 2 362 g.

While the broken and mealy wastes increased significantly with the pressing weight, it is ironic that the coefficient of wholeness did not drop significantly. The hulling efficiency had a significant response to the pressing weight which increased linearly with the pressing weight.

Variety

Variety of the maize had a significant influence on the quantity of whole kernels extracted. The white variety yielded more kernels than the red one (**Table 3**). The breakage susceptibility of the grains varied significantly with variety. The red one was more susceptible than the white. The quantity of unhulled grain was not affected by variety that was being hulled. The variety had a significant effect on the quantity of mealy waste that was produced. The red variety tended to produce more powder than the white. This matched the earlier observation that the red variety broke more readily than the white. The broken pieces could, therefore, be easily crushed to mealy wastes. The white variety had more flaking ability than the red. This observation however, was significant at 5% level but not at 1%. The coefficient of hulling did not differ significantly with the variety that was being hulled. Variety had a significant effect on the coefficient of wholeness (**Table 3**). The white variety yielded more kernels than the red. Consequently, the efficiency of hulling of the white variety was significantly higher than that of the red variety.

Table 4. Effect of Size of Grain on Hulling Characteristics of Maize Grains

Size	Means of the recovered fractions after hulling							
	Whole kernel (g)	Broken (g)	Unhulled grains (g)	Powdered (g)	Flaked (g)	Coeff of hull (%)	Coeff of whole (dec)	Hull efficiency (%)
small	15.08	11.57	46.11	3.37	1.60	42.35	0.55	21.56
large	16.75	14.55	41.09	4.16	1.52	48.64	0.50	23.25

Note: Each entry is a mean of 36 readings.

Table 5. Analysis of Variance Showing the Mean Sum of Squares (MSS) for the Various Hulling Parameters Used to Evaluate the Process of Hulling

Source	df	Hull Coef	Whole Kernels	Broken	Unhull	Powdered	Flaked	Coeff. Whole	Hull Effic.
Var	1	4.5	376.2**	385.1**	3.0	11.2**	1.3*	0.45**	846.0**
Size	1	712.9**	50.7*	160.1**	454.5**	11.4**	0.1	0.04**	51.6
Soaking	5	1 320.1**	74.5**	981.6**	844.5**	20.8**	0.6	0.30**	165.2**
Press.Wt	2	2 335.8**	442.4**	281.8**	1 492.5**	3.8**	0.9*	0.00	624.0**
Var*Size	1	69.9	126.7**	2.5	45.2	5.8**	0.0	0.05**	231.8**
Var*Soak	5	37.4	4.1	25.2	24.0	2.1**	0.3	0.01*	10.3
Size*Soak	5	1.1	6.0	6.0	0.7	1.3*	0.2	0.01*	9.8
Var*Press	2	4.2	19.3	5.0	2.8	1.4*	0.2	0.02**	31.0
Size*Press	2	82.7*	32.9*	4.2	53.3*	0.0	0.3	0.01	53.7*
Soak*Press	10	17.5	6.1	6.5	11.2	0.2	0.2	0.00	11.5
Var*Size*Soak	5	9.9	4.9	11.0*	6.4	0.4	0.1	0.00	8.4
Var*Size*Press	2	8.3	3.6	1.2	5.1	0.9*	0.1	0.01*	4.5
Var*Soak*Press	10	12.2	9.2	5.8	7.8	0.3	0.1	0.00	15.1
Size*Soak*Press	10	19.5	6.8	3.7	12.5	0.2	0.1	0.00	8.0
Residual	10	14.5	5.9	2.4	9.3	0.2	0.2	0.00	10.4

** $P < 0.01$, * $P < 0.05$.
df = degree of freedom, Hull Coef = hulling coefficient, unhulled = unhulled grains, coeff. whole = coefficient of wholeness, Hull Effic. = hulling efficiency.

Size of Grain

The effect of the size of maize grain on the quantity of whole kernels extracted was significant at 5% but not 1% level (**Table 5**). Large grains yielded more kernels than the small ones (**Table 4**). The large grains had a significantly higher susceptibility to breakage than the small ones. This may be due to the larger surface area available for shearing. The size of the grains had a significant effect on the quantity of unhulled grains. The large grains hulled better than the small ones (**Table 4**). The small grains were significantly less susceptible to powdering than the large ones (**Table 4**). This was perhaps due to the fact that small grains tend to be more roundish than large ones, and as a result they rotated more freely during hulling. The size of the grain did not seem to have any significant effect on the flaking ability of the grains. The coefficient of hulling was significantly influenced by the grain size. Large grains hulled better than the small ones (**Table 4**). The coefficient of wholeness was significantly lower in large grains than in small ones. This was possibly due to the fact that the larger the biomaterial, the larger the number of tissues plus the bonding effect in the middle lamella of the cells, hence a higher possibility of failure. The hulling efficiency of the grains was not significantly affected by the size of the grains.

Conclusions and Recommendations

The increase in soaking time from 0 to 25 min decreased the susceptibility of the grains to breakage during hulling.

The red variety was more susceptible to breakage than the white variety.

The breakage susceptibility of the grains increased as the pressing weight increased from 838 g to 2 362 g.

Breakage susceptibility was higher in large grains than in small ones.

The grains gave the best hulling efficiency when the soaking time was between 15 and 20 min. Generally, the hulling efficiency of the machine based on the coefficient of wholeness and the coefficient of hulling was low. But if the conventional method of calculation of the efficiency was used (i.e. sum of weight of hulled kernels, broken and powdered divided by total weight times 100), the hulling efficiency of the machine would have been higher. It is recommended that future design should include a bigger drum and the roughness of the drum increased in order to improve the hulling efficiency. Also, more tests on the improved prototype are recommended before a final design could be recommended for mass production

APPENDIX

Derivation of the Normal Force, ΣF

Assumptions

Resistance of the brush against the drum was assumed negligible.

For practical purposes, the centre of gravity of the pressure plate was assumed to pass through A (**Fig. 7**). For academic purposes, however, force Mg where M is the mass of the pressure plate, must be considered as passing somewhere on the left of A because limb QN is longer than QB.

The frictional force in the bearings of the shaft was assumed to be negligible, i.e., assumed perfect lubrication.

If F is the individual normal force pressing one grain onto the abrasive drum, then the total force pressing all the grains is ΣF. When the drum is rotating, it is in equilibrium because there is no acceleration; and for equilibrium:

$$\Sigma M_A = 0 \quad (6)$$

$$\Sigma F_y = 0 \quad (7)$$

$$\Sigma F_x = 0 \quad (8)$$

From equation 6, considering drum and plate,

$$Wd + R_v S = R_H h + T \quad (9)$$

where T is the driving torque and W the pressing weight.

From equation 7

$$W + Mg = V + R_v \quad (10)$$

From equation 8

$$H = -R_H \quad (11)$$

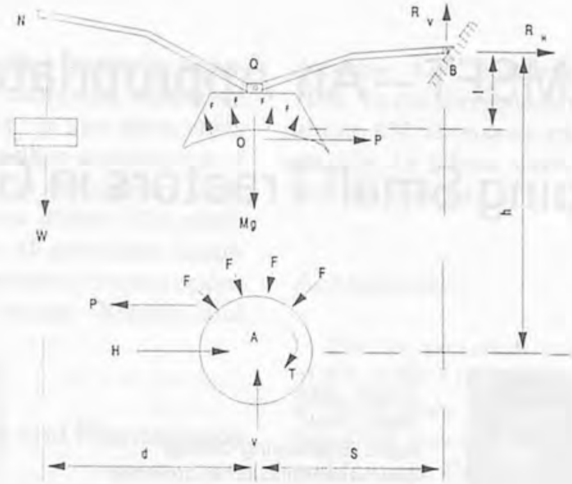

Fig. 7 Free body diagram of the analysis of the forces acting on the machine during hulling.

(for shaft alone, the drum is considered separately, and $\Sigma F = V$).

For pressure plate alone;

$$\Sigma F_y = 0$$

$$W + Mg = R_v + \Sigma F \quad (12)$$

and $\Sigma F_x = 0$

$$P = -R_H \quad (13)$$

and $\Sigma M_o = 0$

$$Wd + R_v S = R_h l \quad (14)$$

from equation 12

$$\Sigma F = W + Mg - R_v \quad (15)$$

From equation 14

$$R_v = \frac{R_H l - Wd}{S} \quad (16)$$

$$R_v = \frac{R_H l}{S} - \frac{Wd}{S} \quad (17)$$

From equation 9

$$R_v S = R_H + T - Wd \quad (18)$$

$$R_v = \frac{R_H h}{S} + \frac{T}{S} - \frac{Wd}{S} \quad (19)$$

Subtracting equation 17 from equation 19

$$0 = \frac{R_H}{S}[h - l] + \frac{T}{S} \quad (20)$$

therefore

$$T = R_H [l - h] \quad (21)$$

and

$$R_H = \frac{T}{l - h} \quad (22)$$

substituting equation 22 into equation 17

$$R_v = \left[\frac{T}{l - h}\right]\frac{l}{S} - \frac{Wd}{S} \quad (23)$$

substituting equation 23 into equation 12

$$\Sigma F = W + Mg - R_v \quad (24)$$

$$\Sigma F = W\left[1 + \frac{d}{S}\right] + Mg - \frac{Tl}{S[l - h]} \quad (25)$$

if the design of the pressure plate was such that $l = 0$, then

$$\Sigma F = W\left[1 + \frac{d}{S}\right] + Mg \quad (26)$$

and the normal force would be calculated from the known values without having to measure the driving torque, T. In the current design, the driving torque would have to be measured for every pressing weight used.

(Continued on page 48)

TTAMSFT—An Appropriate Technology for Keeping Small Tractors in Good Condition in China

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Abstract

TTAMSFT, standing for Technique for Testing, Adjusting and Maintaining Small Farm Tractors, one approach to improvement of technical state of small farm tractors, has been widely used in China since 1983. The technique is as follows: test a tractor on its actual power and fuel consumption with a mechanical meter; adjust or maintain it if it fails to meet the requirements and assure it can do so. Being simple, cheap and easy to carry, the power-fuel consumption meter can work outside and with a error of less than 3%. It was estimated that in just three years (1985-1987) TTAMSFT saved over 60 thousand t of fuel and made about 838 thousand tractors regain 824 thousand kW of power.

Introduction

China has the most small farm tractors in the world, roughly 7 million. These tractors, like other main farm machines, are tested once or twice annually in most of the country. The test results determine whether a tractor can work afterwards, must be repaired or should not be used any longer. However, before 1983 the test depended, to a large extent, on the outfit of the tractor. Measuring power and fuel consumption which represent dynamic and economic properties of a tractor, though can be easily carried out in a laboratory, proved a problem in the field. And it is simply not practically feasible to test such a great number of tractors in laboratories. To solve the problem was necessary for knowing about a engine accurately. For this purpose, a simple power-fuel consumption meter was designed and then improved.

Principle Involved

Figure 1 provides the main components of the meter and illustrated instructions for installing it. A testing scene is shown in **Fig. 2**. Before testing, they connect the meter and the inlet joint of the fuel filter of the tractor with a pipe. During testing the engine is supplied with fuel by the meter. The belt pulley of the tractor is replaced by a friction pulley. In testing, when the lever is pushed down the friction belt inside the friction hoop tightens the friction pulley so that there is a torque M loading on the engine. M is reflected by the indicator of the spring balance. That is:

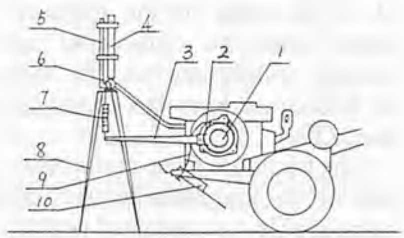

Fig. 1 Installing the power-fuel consumption meter. (1-Friction pulley 2-Friction hoop 3-Bar 4-Fuel can 5-Quantitative tube 6-Tee valve 7-Spring balance 8-Tripod 9-Steel wire 10-lever)

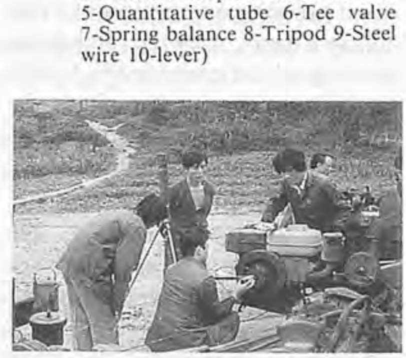

Fig. 2 A scene of testing a tractor.

$$M = (F - f) L$$

where
M = friction torque, Nm
F = reader in the spring balance during testing, N
f = reader in the spring balance before testing, N
L = length of the bar, m

Meanwhile the engine speed is measured with a tachometer and adjusted to the rated value n with the accelerator. Therefore, the actual power of the engine is:

$$Ne = 2\pi nM/60 \quad (w)$$
$$= 1.047\,(F - f)\,Ln \times 10^{-4} \quad (kW)$$

where
Ne = engine power, kW
n = rated engine speed, r/min

At the same time, they turn the tee valve and with a clock record the time for the engine's consuming a certain amount of fuel in the quantitative tube. Thus, the fuel consumption is:

$$ge = 3600G/(Ne \cdot t)$$

where
ge = fuel consumption, g/kW.h
G = a certain amount of fuel in the quantitative tube, g
t = the time for consuming G gram of fuel.

During testing water is poured into the friction pulley for taking the heat created by the friction between it and friction belt.

Application

The first test conducted in Sichuan Province, southwestern China, in 1983 provided a result which surprised tractor drivers to superior management of agricultural machinery. Of 105 tractors, most of which would be thought as in a good technical state according to conventional assessment method, were actually much deteriorated. The average power was only 78% of the rated value. Over 90% of the tractors had a power of 10-30%, even 50% less than the rated power. Fuel consumption of almost all tractors was higher than rated value. The average was 28% higher than rated. Therefore, an appeal was made to improve the technical state of small farm tractors, increase their power and decrease their fuel consumption. The power-fuel consumption meter manufactured by several factories spread in China widely and rapidly. One factory in Jiangsu Province alone sold 5836 from 1985 to 1987. In the three years about 1.67 million tractors out of 4.53 million in the country were tested with the device. The meter was found in all provinces, municipalities and autonomous regions of China except Xizang and Taiwan.

Adjustment and Maintenance

Only testing tractors cannot reach the aim of improving their technical state, but adjusting and maintaining can. With the spread of the meter, how to adjust and maintain tractors efficiently was studied and developed. Finally, the TTAMSFT was introduced, i.e., test small farm tractors with the power-fuel consumption meter; if a tractor could not meet the requirements, give it a non-disassembling inspection for fuel supply timing, fuel supply pressure, sealing property of the delivery valve, injecting pressure, injecting quality, cylinder pressure, air cleaner, valve clearance and valve timing; adjust or maintain the tractor accordingly. In one practice it was found that out of 126 tractors which failed to meet the requirements only 16.7% was up to standard in air cleaner, over 81% and 75% had problems in inlet and exhaust valve timing and 76% didn't reach the injecting standard. After adjustment and maintenance all those tractors met the standard. Normally adjusting and maintaining enable the tractors to increase power by 12% and decrease fuel consumption by 10%. In the three years (1985-87) about 838 thousand small farm tractors in China were adjusted and maintained.

Achievement

The introduction and spread of TTAMSFT in China have made a remarkable achievement and benefited greatly both the country and farmers. Firstly, the technique has made an important contribution to the country's saving fuel in the countryside. In just three years (1985-87) it saved about 60 thousand t of fuel. Furthermore, it brought about widespread application of other fuel-saving methods. Secondly, TTAMSFT ameliorated greatly the technical state of farm small tractors. A large number of tractors had an increase in power and a decrease in fuel consumption through the technique. **Table 1** compares the average power and fuel consumption of some of the country's tractors before adjusting and maintaining with those after that and illustrates the significance of the technique. Indeed it provides China a main solution to, at least at present, when there is a very large and still increasing number of small farm tractors which are scattered and owned by individuals, the problem of their technical state. Thirdly, owing to the improvement of the tractor state, the pollution resulting from abnormal engine combustion has been lowered and the working reliability of tractors increased. Fourthly,

Table 1. Comparison of Average Power (Ne) and Fuel Consumption (g)

Year	Number of Tractors Adjusted & Maintained (thousand units)	Before Adjusting & Maintaining		After Adjusting & Maintaining	
		Avg. Ne (kW)	Avg. g (g/kW.h)	Avg. Ne (kW)	Avg.g (g/kW.h)
1985	13.8	9.8	345.4	11.1	308.7
1986	228.7	9.65	340	10.9	295.1
1987	595.2	10	345.4	11	297.8
Total	837.7				

TTAMSFT demonstrated the waste of tractors caused by incorrect use, adjustment and repairs and accelerating wear resulting from dirty fuel, which taught farmer-drivers a good lesson. Finally, the technique innovated on the management of small farm tractors in China by replacing the traditional and inaccurate assessment of tractors with a scientific and quantitative method and, therefore, set a good example to management of other farm machinery.

Conclusions

1. As an appropriate technology to China, TTAMSFT has played and will play an important role in managing small farm tractors, saving fuel and lowering pollution.
2. Further studies should be made to find a suitable way to inspect small tractor chassis and improve their conditions.
3. Other farm machineries should be tested and maintained through appropriate techniques.

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(Continued from page 45)

Low-cost Technology for Hulling Maize

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Effect of Moisture Content on Thermal Diffusiveness of Grains

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Abstract

An experiment was conducted to determine the thermal diffusiveness of selected grains viz. wheat, maize, sorghum, soybean, blackgram and sesamum by using standard methods. The thermal diffusiveness of grains decreased with an increase in moisture content.

Introduction

Any process involving the heating and cooling of agricultural materials require a knowledge of their thermal properties. This is required not only for thermal process but also for designing processing systems. Many of the problems associated with drying and storing may be analyzed by using heat transfer principles. Temperature variation in a grain bin due to external and internal temperature changes may be calculated by using basic heat transfer equations. Thermal diffusiveness of grain is required for developing heat flow equations and is a function of the moisture content of the grain.

Theoretical Considerations

Assuming that the cylinder used for the determination of thermal diffusion is of infinite length, the temperature gradients parallel to the axis are non-existant and led to the following governing equation:

$$\frac{\delta T}{\delta t} = Ao$$

$$= \alpha \left(\frac{\delta^2 T}{\delta^2 \gamma} + \frac{1}{\gamma} \bullet \frac{\delta T}{\delta \gamma}\right) \quad ...(1)$$

Where,
T = temperature, K
t = time of heating, h
α = thermal diffusion, m^2/h
γ = distance from heat source, m

Considering two boundary conditions as,
$\gamma = a$ and $\gamma = 0$ both for $t > 0$
We have, $T = Ao.t = To$, for $t > 0, \gamma = a$
Thus,

$$Ao = \frac{To}{t} \quad ...(2)$$

Also, $\frac{dt}{d\gamma} = 0$, for $t > 0$, $\gamma = 0$

Substituting the above values in equation (1) and integrating for 'γ' ranging from '0' to 'a', the temperature profile and temperature gradient is given as

$$\frac{Ao.\gamma^2}{4} = \alpha\,(To - Ti)$$

$$\alpha = \frac{Ao.\gamma^2}{4\,(To - Ti)}$$

or,

$$\alpha = \frac{To.a^2}{4t\,(To - Ti)} \quad ...(3)$$

Where,
To = temperature at outside the cylinder, °K
a = radius of the cylinder, m
Ti = temperature at the inside centre of the cylinder, °K

Method and Materials

An experimental set up shown

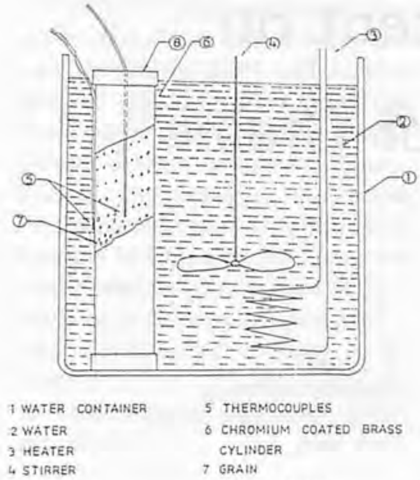

Fig. 1 Experimental set up for the determination of thermal diffusiveness.

in **Fig. 1** was used for the determination of thermal diffusiveness of the following grains:

1. Wheat (HD2189)
2. Maize (MCU 5)
3. Sorghum (Co-27)
4. Soybean (Co-1)
5. Blackgram (Co-4)
6. Sesamum (Co-1)

The experimental set up consisted mainly of a thermal diffusiveness tube (5.8 cm in diameter and 2.3 cm long), water bath, 1 500 W capacity immersion heater, variable speed stirrer, digital millivoltmeter and thermocouples. Because of the combined requirements of high thermal conductivity and rigidity, the cylindrical tube was of chromium coated and its end caps were of teflon to provide watertight and insulation. One thermocouple was fixed at the middle of the cylindrical diffusiveness tube and another thermocouple was fixed at the outside surface of the cylinder to monitor the temperature of sample at the middle as well as at the surface of the tube.

With the grain, caps and thermocouples in position the entire assembly was placed in the water-bath and the water was heated at constant rate with the immersion heater. Uniform heat distribution in water was made with the help of the stirrer. The experiment was conducted for 15 min for each grain at four different moisture levels. The outer and inner thermocouple readings were taken at an interval of 2 min using the millivoltmeter. The thermal diffusion of grain was calculated by using the equation (3).

Results and Discussion

The variation of thermal diffusion of grain with moisture content is shown in **Figs. 2** and **3**. It can be observed that the thermal diffusion of all the grains decreased with the increase in moisture content. The minimum thermal diffusion of $2.46 \times 10^{-3} m^2/h$ was observed for maize at 28.4% moisture content and a maximum of $3.77 \times 10^{-3} m^2/h$ was observed for sorghum and blackgram at 8.35% and 4.66% moisture contents, respectively.

The rate of decrease of thermal diffusiveness of grains with the increase in moisture content was almost identical for all the grains studied except for soybean for which the rate is slower than that of the other grains.

Conclusion

The thermal diffusiveness of grains decreases with an increase in moisture content and exhibits a linear negative correlation with the moisture content for all the grains studied.

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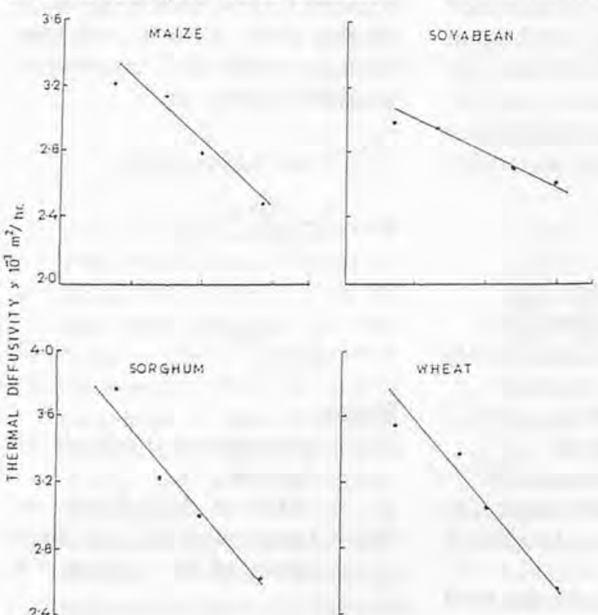

Fig. 2 Effect of moisture content on thermal diffusiveness.

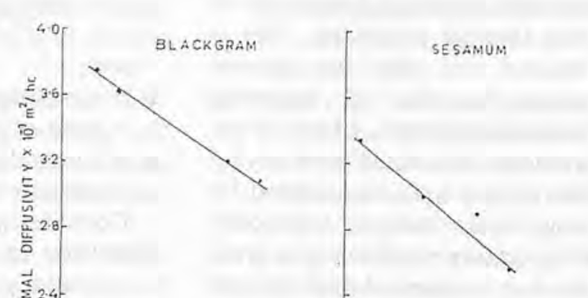

Fig. 3 Effect of moisture content on thermal diffusiveness.

Passive Water Heating in Buildings Using Exposed Surfaces

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Abstract

The roof structure of a house may be used for heating water using solar energy falling on it to provide the hot water requirements in buildings during winter season.

Introduction

In conventional solar water heating system (1,2) the solar collectors are costly affair and need regular maintenance besides space. The conventional solar collectors are generally made of iron, copper, aluminum sheets/ tubes, glass, angle iron, fibre glass insulation and wood. These collectors can be fabricated by specialized skilled persons only. The solar water heaters are suitable where water at relatively high temperature (above 50°C) is required. Cheaper methods may be adopted where the hot water at relatively lower temperature (below 50°C) is required in buildings to meet the requirements for different purposes during the day.

The structure, with some treatments, may be successfully utilized for solar heat collection for water heating. No glazing (plane glass to cover the absorbing surface) is required like in the conventional solar collectors. The existing roofs can be modified even by the mason (skilled man who constructs the house) at a little cost without adversely affecting the buildings to supply hot water. This type of solar passive water heating systems offer simple and inexpensive means to provide hot water in buildings during day time.

Acknowledgement: The author is grateful to Dr. J. Venkateswarlu, Director, Central Arid Zone Research Institute, Jodhpur for his keen interest in the present work.

Natural Water Heating System

Cement structures have been successfully used to heat up water up to moderate temperature without using glazing at the top and insulation at the back. Various experiments were carried out at the Central Arid Zone Research Institute, Jodhpur to evaluate the performance of water heating under different treatments.

For the experiment, the cement structure in the form of slabs were designed (3,4) for water heating and tested for its performance. These slabs were made from the common building materials like cement, pebbles, coarse sand (*bazri*), iron rods/wires, etc. In addition, the extra materials like aluminum and PVC pipes were used in the construction. These slabs resembled like roofs in the houses.

Few cement slabs were fabricated to test their heating performance under different conditions. A cement slab system is shown in **Fig. 1**. The absorbing surface area of each slab was 1.06 m^2 (dimensions 172 cm × 62 cm). The slabs were uniform and had thickness of 55 mm to give enough structural strength to it. The schematics of this slab is shown in **Fig. 2** and the specifications are given in **Table 1**.

For heating the water, the aluminum pipes were embedded over the top surface which acted as absorbing surface. In all, 10 aluminum pipes were used per cement slab having equal spacing 60 mm. The diameter of aluminum pipes embedded in the heating system was 18 mm. These pipes were embeded in the con-

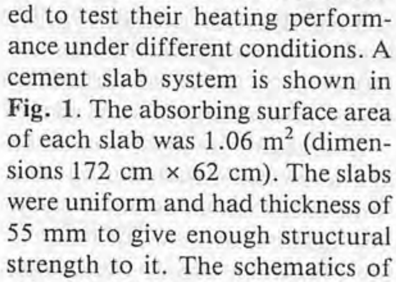

Fig. 1 Natural solar water heating system made of concrete materials.

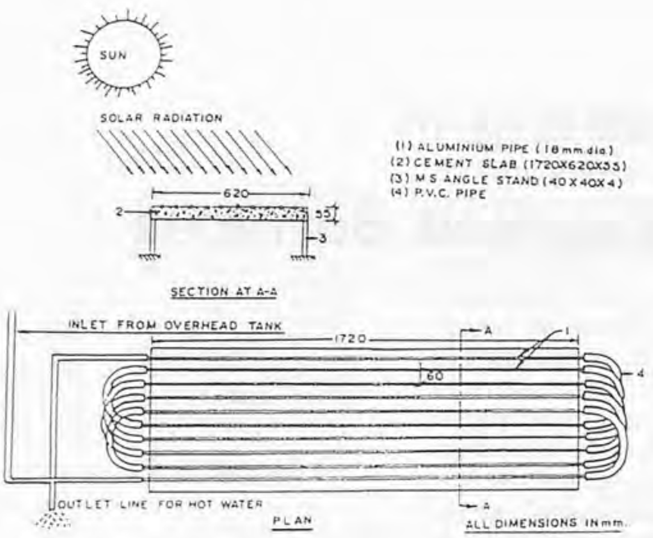

Fig. 2 Schematics of natural solar water heating system.

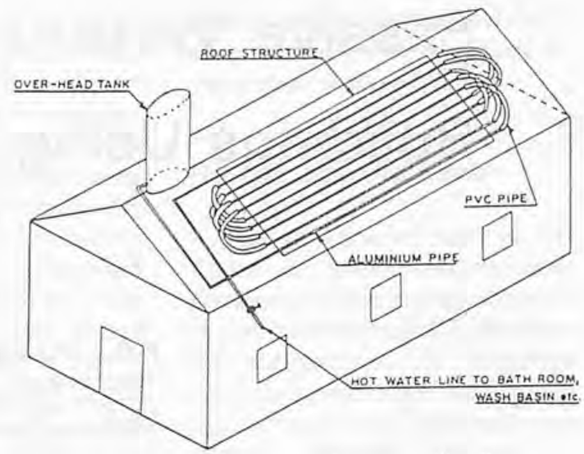

Fig. 3 View of passive water heating system in a house.

crete materials at the top of the absorbing surface such that the 70% portion of the aluminum pipes remained in the cementing material and 30% portion outside to it. In the present slabs, the length of aluminum pipe was 183 cm. But for domestic water heating the length of aluminum pipes can be increased depending on the availability of roof space.

The aluminum pipes were fixed in the concrete material so that these could not come out from it. For continuous flow of water in the aluminum pipes, these were inter-connected as shown in **Figs. 1** and **2**. One end of the aluminum pipe was connected to the overhead tank and the other end (served as outlet for hot water) can be connected to the supply pipe line to bath room, kitchen and wash basin, as shown in **Fig. 3**. The inlet of the heating system can also be connected directly to the public line to feed water into it.

The identical cement slabs of same absorbing area were constructed to test their performance for water heating at different angles. The absorbing surface was painted with black board paint (dull black, single coating) to see its effect for enhancing water heating. The black board paint absorbs the solar radiation falling on it and the temperature rise of hot water was enhanced by 4°C to 5°C. No glazing was used at the top or insulation at the base.

Table 1. Design Details of Natural Heating Systems

S.No.	Design materials/parameters	Specifications/details
1.	Heating systems made	Cement slabs
2.	Gross dimensions of one cement slab	172 cm × 62 cm × 55 cm
3.	Materials used in fabrication of cement slabs	Cement, coarse sand pebbles, iron rods/wires etc.
4.	Absorbing surface area	1.06 m^2 (172 cm × 62 cm)
5.	Absorbing paint	Black board paint
6.	Flow pipes in heating system	Aluminum pipes embedded at the top surface
7.	Aluminum pipes	
	i) Diameter	18 mm (Outer)
	ii) Length	183 cm
	iii) Number of aluminum pipes used in one heating system	10 Nos.
	iv) Spacing between two aluminum pipes	6 cm
	v) Length of aluminum pipes left on each side of slab	4.5 cm
8.	Media for inter-connection of aluminum pipes	Black PVC pipes
9.	PVC Pipes	
	i) Diameter	18 cm (Internal)
	ii) Length of PVC pipes between two aluminum pipes.	60 cm
	iii) Number of PVC pipe pieces used in one cement slab	9 Nos.
10.	Over head tank	
	i) Capacity	75 litres
	ii) Height from ground	82 cm
11.	Testing of natural heating systems	i) Horizontal plane ii) Vertical plane iii) Inclined plane 41° due south
12.	Place of testing	Jodhpur

Water Heating

The natural heating systems were tested in the solar energy yard of the Institute in the following positions :

1. Horizontal plane
2. Vertical plane
3. 41° due south (inclined plane)

The purpose of testing the heating systems at different angles was to observe the relative performance for water heating so as to evaluate the suitable recommendations to suit the convenience of users. Normally the roofs are horizontal and the walls are vertical. The third position (i.e., 41° due south) was chosen for testing as this is the optimum inclined angle due south for Jodhpur (latitude + 15°) in the winter season. The water heating studies were carried out with and without black board paint on the absorbing surface. These investigations were carried out with a view that many users may not like to blacken their roofs for water heating due to their own reservations.

All the natural heating systems were exposed to solar radiation from morning to evening. During the exposure, the aluminum pipes embedded with the heating systems were kept filled with water. For this, the valves connecting between the overhead tanks and the heating systems were kept opened and their outlets closed during testing so as to enable the aluminum tubes always filled with water.

The performance studies for water heating were carried out during the day from 10 AM to 4 PM. The observations for output hot water obtained from the natural heating systems were recorded to study the heating performance. The cold water from the over-head tanks was allowed to flow in the aluminum pipes at regular interval of time (one hour interval) at 10 AM, 11 AM, 12 AM, 1 PM, 2 PM, 3 PM and 4 PM. The hot water was collected and its temperature was recorded. Eight liters of hot water was drawn from each slab at every hour.

The water heating studies were conducted in the winter season from November to March when the ambient temperature and water temperature are quite low in this region. The result of water heating at three positions for a typical day in the month of January is shown in **Fig. 4**. In this study, no black board paint was used on the absorbing surfaces. The maximum temperature of hot water 43°C (inlet cold water temperature - 19.5°C) was recorded from the heating system inclined at 41° due south.

The temperature rise of water was increased if the absorbing surface was painted with black board paint as can be seen in **Fig. 5**. In this experiment, two similar natural heating systems were used and the study was conducted under similar environmental conditions. Both heating systems were kept inclined at 41° due south. One of these heating unit was painted with black board paint on the absorbing surface (cementing surface). From **Fig. 5**, we note that the temperature rise of cold water is enhanced by 4°C to 5°C by simply blackening the absorbing surface, the output of hot water is increased equivalent to cross hetch area as shown in **Fig. 5**. Maximum temperature of hot water at 50°C was obtained from the heating system with single coating of black board paint compared to 44.5°C obtained without blackening the absorbing surface of identical heating systems.

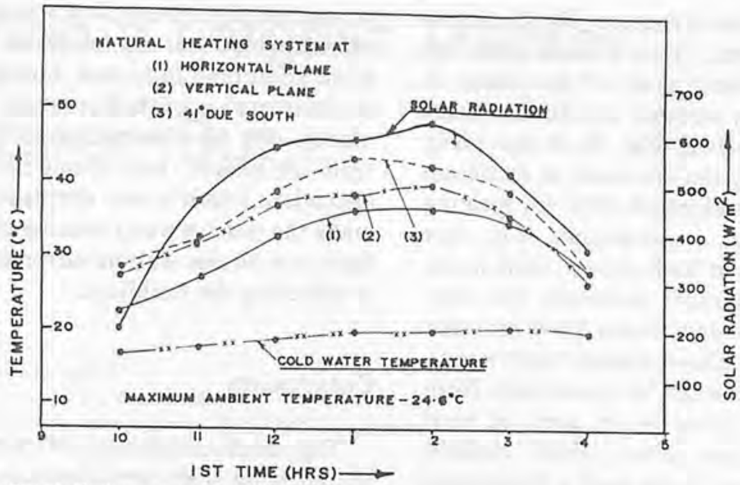

Fig. 4 Performance of water heating.

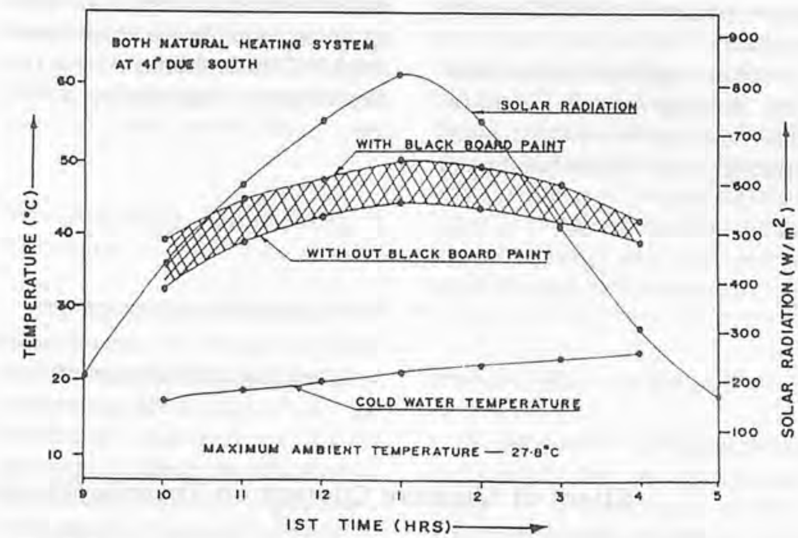

Fig. 5 Comparative performance of two identical water heating systems.

Applications

The roof structure of the house can be successfully used as passive water heating system in buildings. For this, the roof will need a little modification, e.g., embedding of aluminum pipes in the concrete structure. No glazing is required. If cold water from the over-head tank of the house is drawn through this natural heating system **(Fig. 3)**, it can easily supply the hot water at moderate temperature 35-55°C for meeting various requirements, e.g., hot water in bath rooms, dish washing, laundry purposes, etc. during the day. About 30-40 litres hot water above human body's temperature can be drawn daily from one square meter area of roof structure after slight modifications. If the roof is blackened, more output (temperature rise of water enhanced by 4-5°C) can be obtained.

In many regions, various societies, housing boards, corporations and governments build houses in bulk. These bodies can be entrusted to incorporate this solar passive water heating system at an additional little cost during the construction of the houses and money can be charged directly from the people. Individuals can also adopt it as it is very simple to make the passive water heating in their own houses without adversely affecting the buildings.

Conclusion

The roof structures of the houses, after slight modifications, can be successfully used as passive water heating system to provide hot water at moderate temperature (35-55°C) in buildings during the day without using glazing at the top.

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Effect of Moisture Content on Thermal Diffusiveness of Grains

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India: World's Largest Tractor Manufacturer, But...

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Introduction

With an annual production of 160 000 four-wheel farm tractors, India has emerged as the world's largest tractor manufacturer. The value of purchases by Indian farmers of agricultural engineering inputs, like tractors, pumpsets, fuels and equipment exceeds Rs. 20 000 crores (200 billion) per year. India now has a population of over 1.5 million (15 lakh) tractors. As a global power in the international tractor industry, India must ensure efficient utilization of such a heavy recurring investment in the agricultural engineering inputs.

The agricultural engineering programme in India should not merely aim at the supply of tractors, but should put in place the systems needed to ensure their sustainability. The systems should cover areas such as a complete range of matching implements, cost and energy efficient utilization of resources, proper supply of consumables like fuels, lubricants and spares, safety, training, logistics like insurance (of owner, equipment and the operator), prompt and efficient services (including repairs) and infrastructure for need-based research and development, testing and contracting services. Contracting services offer a big potential and need to be properly developed, so as to serve small- and medium-sized farm holdings and to ensure timeliness of farm operations.

Streamlining Government Agencies

The Agriculture Ministry of the Government of India directly concerned with the agricultural engineering discipline includes the Machinery Section at Krishi Bhawan, Engineering Division of the Indian Council of Agricultural Research, Central Institute of Agricultural Engineering at Bhopal, Training and Testing Stations at Budni, Hissar, colleges of agricultural engineering at agricultural universities and the Agricultural Engineering Division at Indian Agricultural Research Institute. The activities of all these agencies need to be reviewed, so as to ensure a comprehensive development of the agricultural engineering discipline, to meet the challenges of today and tomorrow both nationally and internationally.

Another important agency concerned is the National Bank for Agriculture and Rural Development (NABARD). financing agricultural and agro-industrial projects, including tractors, irrigation equipment with high agricultural engineering content. NABARD need not be a mere funding agency, but can channel resources and influence the pace and direction of proper development of the agricultural engineering discipline and its related logistics and infrastructure.

Human Resource Development

In agricultural mechanization, particularly the use of tractors, India is a developed country among developing countries. India has the experience and basic infrastructure. India must consolidate and improve the supporting services. The country's experience is more relevant to the needs of developing countries. India must equip itself with, fast and adequately, to offer consultancy and other services, particularly training, to international standards. India can update/set-up training institutes to offer training to developing countries. Training can be developed into a big business. India can export trainers, operators, mechanics and drivers in good numbers. The urgency is to train trainers and bring out training material, including audio-visual training aids and electronic dissemination methods. Emphasis needs to be on human resource development, including education, training and curriculum development.

India annually needs 2 lakh (200 000) trained tractor drivers, mechanics and equipment operators. Here is an opportunity to develop rural youth into a skilled work force, with employment opportunities in India and abroad. India must create awareness among farmers, provide information, training and guidelines on safety issues. Efficient utilization of high value capital intensive equipment will reduce down time and cost of operation.

Consequences of rapid tractorization in India include rising farm accidents and high cost of operation. Effective steps must be taken to ensure greater benefits from the mechanization technology to the farmers. Farm accidents need to be properly recorded and analyzed, hence the need for a comprehensive agricultural safety information system. Training on a mass scale will reduce accidents and improve productivity.

India's Role Not Appreciated

As a member of the FAO (Food and Agriculture Organization of the United Nations) Panel of Experts on Agricultural Engineering, the author attended the 12th Panel Session at Rome in October, 1994. India large-sized farm equipment industry and experience do not seem to be recognized in international forum. India's achievements and ability to assist other developing countries need to be better known internationally. India can play an active role in the agricultural engineering opportunities in countries in Africa, Asia, the Middle East, Latin America and the newly formed countries in Europe. India should also invite the 13 Session of the FAO Panel to hold its meeting in 1995-96 and make necessary preparations for it.

The FAO Panel recommendations include:

i) Greater emphasis on the need for appropriate policies and strategies in agricultural engineering.
ii) More attention to human factors in agricultural engineering, and greater a wareness of issues concerning the environment, ergonomics and safety, and gender (i.e., role of women in agriculture).
iii) Development of private sector small- and medium-scale units for machinery manufacture, distribution, repair and maintenance and contracting services, and greater integration of the elements in the supply chain, including research, testing, development, manufacture, distribution, repair, maintenance and utilization.
iv) Improvement in the availability of adequate farm power, including increased investment in domestic manufacture, credit, extension, training and research, and also engineering aspects of low input sustainable agricultural systems, soil and water conservation tillage systems and post-harvest technology.
v) Meaningful dialogue with environmental organizations, advisory/extension services, users/farmers and industry, to promote more efficient and safe application technologies for pesticides and agrochemicals.
vi) More effective dissemination of agricultural engineering information, including use of quicker and cheaper (electronics) dissemination methods.

With growing concern for environment and safety, even developed countries are seriously looking at organic, natural and safe fertilizers, pesticides and agro-chemicals. India must accelerate development of inputs like Neem based pesticides and other agro-chemicals mentioned in the Shastras, to international standards, patent them and export the technology and the products.

The FAO Agricultural Engineering Service seems to support international trade in second hand (used) farm equipment, including tractors. This business needs to be properly organized and developed, both for domestic and export markets.

Priorities

The farm equipment industry must make greater investment in research and development. India must graduate into crop specific mechanization to meet the needs of nationally important crops like sugarcane, cotton, oilseeds, horticultural crops and vegetables, plantation crops and medicinal plants, besides wheat and paddy. Mr. Chandra Mohan, Vice Chairman and Managing Director of Punjab Tractors commented in October, 1944 that:

> "With the heating-up of competition in India plus the emphasis on emissions, there has been a sea-change in the performance of Indian tractors vis-à-vis noise, operator comfort, vibration, etc. What legislatory/recommendatory steps could not achieve over the last 20 years, competition has been able to achieve in barely 5 years. The pace of improvement has also accelerated in a major fashion."

The adequate and timely provision of farm power (whether manual, draught animal or mechanical) is at least as important as the availability of land, seed, ferrtilizer and water. Ignor-

Table 1. Population of Agricultural Tractors
(Countries with a population of 500 000 and above)

Country	Population-1992
1. USA	4 810 000
2. Japan	2 003 000
3. Italy	1 470 000
4. France	1 460 000
5. Germany	1 320 900
6. Russia	1 300 000
7. Poland	1 172 140
8. India	1 136 160
9. China	774 404
10. Spain	760 000
11. Canada	740 000
12. Brazil	735 000
13. Turkey	722 550
14. U.K.	500 000
World	26 137 136

Source: FAO Year Book, 1993.

Table 2. Annual Tractor Production

Country	Quantity	Source	Remarks
1. India	160 000	Industry	1994-95
2. Japan	146 115	AMA Journal	1993
3. Belarus	96 063	ECE/ITD	1992
4. Russian Federation	72 800	ECE/ITD	1992
5. Ukraine	64 753	ECE/ITD	1992
6. U.K.	58 861	ECE/ITD	1992
7. Germany	53 217	ECE/ITD	1992
8. France	12 912	ECE/ITD	1992
9. Poland	7 976	ECE/ITD	1992

Notes: 1. Annual tractor production data in major tractor manufacturing countries of the world is not readily available. FAO year book publishes tractor population figures only, not production. UNIDO Vienna, IFC Washington, RNAM-ESCAP Bangkok, ASAE in USA, the Industry Sources in India and others were contacted on fax for this information, but in vain. FAO/AGSE made available the ECE/ITD data, which is thankfully acknowledged, as also the data received from the AMA Journal of Japan.
2. In most of the countries, tractor production has registered a decline, in contrast to the rising trend in India.

ing the need for timely and adequate power may impede farming systems to yield the potential benefits. The latest agricultural engineering equipment and techniques can significantly contribute to improving the agricultural production and productivity. There is an urgent need to update agricultural engineering infrastructure. Tractor is only one component of the system. Some of the Technology Missions established by the Government of India have yielded good results. There is a strong case to establish a Technology Mission to cover all the components of the agricultural engineering discipline.

Accelerated development of the agricultural engineering discipline will provide a firmer base for agricultural and rural development, as also for the domestic and export markets for agricultural products, inputs and services. The discipline certainly deserves a much greater emphasis by the government, the academy and the industry **(Tables 1 and 2)**.

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Recent Developments in Agricultural Mechanization in Taiwan

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Abstract

The development of agricultural mechanization in Taiwan has been in great progress in the past 20 years. Take rice production for example, almost all of the farm operations, from land preparation to harvesting, have reached a level of mechanization by 95%. This was made possible through the custom hiring services and rice nursery centers, which were widely set up throughout the island and constructed a complete service network for most of the farmers, replacing lots of farm labor.

Due to the surplus rice production, the rice diversification policy of growing upland crops instead has been in effect for more than six years and is stimulating another phase of research activities for corn pickers, peanut and soybean combines, etc. to meet the need of mechanized operations for upland crops.

Agriculture in Taiwan now is declining; all the mechanization measures can only maintain the current situation. To promote the development of agriculture, the process of farm mechanization and automation becomes essential and requires more R & D in this respect from the government. To accelerate the pace of modernization in agriculture and cut down the farm labor, the government initiated many automation programs on agricultural production, livestock production, fishery operation and agricultural transportation and services for a period of five years since 1991. This will give Taiwan another prosperous future in agriculture.

Keywords: agricultural mechanization, automation

Introduction

Ever since the restoration of Taiwan, agriculture has been developed rapidly and made the expansion of local industry and business possible. However, for the past 20 years, there has been a dramatic change in the economic structure. The original agriculture-based economy was replaced by that of industry and business due to the even faster growth of those fields and resulted in labor shortage in the countryside as well as a wide wage gap. In fact, agriculture in Taiwan is facing a dilemma nowadays. How and what to do with the agricultural structure and its production to break through the bottleneck is an urgent task. Eventually the overall mechanization and automation in agriculture will be an inevitable strategy.

Agriculture in Taiwan is restricted by its natural enviroment because of the limited land and resources. However, some countries, such as Holland and Israel whose situations are inferior to this island, can maximize the resources they have and achieve a high degree of modernization in agriculture. Therefore, how to develop what we have and make the best profits from it is the goal to strive for.

To make further developments in agriculture in Taiwan, the process of farm mechanization and automation becomes essential and requires more R & D in this respect from the government. Field crop production can be done by traditional tillage method, while the protective agricultural production system (PAPS) operated by an intensive way of cultivation might be most suitable for highly populated areas. From the viewpoint of production, the PAPS has advantages such as high production per unit area, products with good quality, etc. Whereas, from the technology side, the PAPS provides farmers with a better working environment which may provide a new prospect to the already declined agriculture.

Shortage of and Aging Labor Force

In the 1960s, 45% of the population in Taiwan were farmers. The success of land reform motivated the farmers to work harder, hence, draft cattle were in urgent need. The number was once 400 000 head in 1954 for the area of 870 000 ha. Each of the cattle should work for a land as large as 2.2 ha for the year round. As the draft cattle cannot further handle this heavy load in the field, demand for mechanized farming thus emerged and, therefore, the population of cattle decreased dramatically.

Since then, the steady growth of business and industrial sectors attracted many young people from the countryside. The population in agriculture decreased from 45% in 1960 to 18.3% in 1989. As a result, there is a shortage of labor force during busy periods, such as the transplanting and harvesting time. And the wage for the workers is climbing up accordingly, especially for the past two years. In 1990, the growth rate of wages was as high as 40.4% **(Table 1)**, although the rate tended to decrease during the past two years. Besides, the remaining agricultural population are mostly elderly people. A survey in 1991 showed 19.8 % of the farm owners were above 65 years old and 56% over 45 years old.

Table 1. Wage Growth of Male Workers, 1961-82

Year	NTD/Day	percent	Year	NTD/Day	percent
1961	35.00	100	1983	471.00	1 346
1966	41.26	118	1984	486.00	1 388
1971	70.82	202	1985	503.00	1 437
1976	193.98	554	1986	525.76	1 502
1977	213.60	610	1987	529.17	1 512
1978	254.54	727	1988	556.06	1 589 (5.1%)
1979	298.39	853	1989	649.24	1 854 (16.7%)
1980	383.24	1 095	1990	812.12	2 320 (40.4%)
1981	429.00	1 228	1991	969.32	2 769 (19.4%)
1982	461.00	1 317			

Note: Courtesy of Department of Agriculture & Forestry, Taiwan Provincial Government.

Policy and Measures for Farm Mechanization

For the government to alleviate the labor shortage, to raise labor productivity, and to save cropping cost, it is urgently necessary to promote farm mechanization. The success of agricultural mechanization in Taiwan is attributed to the sustainable support from the government. Ever since 1970, the government initiated various four-year projects such as "Measures on Accelerating Mechanization of Agriculture" (1970-1973), "Accelerating the Promotion and Application of Rice Dryers" (1975-1978) and "Fund for the Extension of Agricultural Mechanization in Taiwan" (1979-1982). Up to 1989 the fund for mechanization, which is as high as NT$5.4 billions, was set up as one of the 12 major policies that time. Another fund of the same amount came from banks and farmers' associations to make loans and subsidiary purpose of mechanization available.

From the funds, the farmers can have a low-interest loan, only 6% of annual interest, for the purchase of newly-developed farm machines. To encourage the development of new machines, the government also provides subsidies, from 10% to 50% of the market price, for farmers to purchase of the inventions for production, such as self-propelled mistblower, tree branch chopping machines, peanut combines, grain drill with listers, high crop chopper, orange cleaning and grading machines, napier harvester, pipe facilities for spraying, pea dehullers, fruits weight grader, corn sheller, etc.

Due to recent recession in agriculture, conservative farming is coming up and more efficient operations are introduced to have a better transformation of farm structure. The automation policy in electronics, machinery, plastic processing, textile and food industry by the Excutive Yuan from 1982 to 1991 proved to be very successful and encouraged the society to put more emphasis on the matter. Since 1991, agriculture, fishery, and livestock were, therefore, enlisted as part of national automation project for another ten years.

Mechanization of Rice Cultivation

Of all the country's crops, rice has reached the highest degree of mechanization. In fact, 95% of the farm operations, from land preparation, planting to drying after harvest are all mechanized. In addition, with the custom hiring services and rice seedling nursery centers being widely set up, the farmers are provided with the opportunity of using farm machines without the need to purchase any equipment. The system is very unique in Asia.

However, the total cost of NT$63,811 dollars a hectare for all operations is still expensive for production **(Table 2)** and needs to be cut down. The most costly item is the spraying operation for pest control, as very few operators will work again for this unhealthy job in the field. It is obvious that the extensive use of farm machinery hardly brings profit to the farmers. It is not only because the farmers have to pay

Table 2. Cost of Rice Cultivation in Taiwan

Item	NT$/ha	Percent
Land preparation	9 025	14.1%
Seedling	5 509	8.6%
Planting	6 587	10.3%
Fertilizing	8 311	13.0%
Drugs spraying	18 032	28.3%
Harvesting	10 274	16.1%
Drying	6 073	9.6 %
Total	63 811	100.0%

Note: Courtesy of Department of Agriculture & Forestry, Taiwan Provincial Government.

Table 3. Comparative Performance of Human/Animal and Machine Operations in Rice Cultivation

Major Operations	Workers/ha		Labor Savings (workers/ha)
	man/ animal	machines	
Land preparation	8.5	2.5	6.0
Seedling nursery	11.0	1.5	9.5
Transplanting	12.0	3.0	9.0
Harvesting	16.0	3.0	13.0
Drying	5.0	1.0	4.0
Total	52.5	11.0	41.5

Note: Courtesy of Department of Agriculture & Forestry, Taiwan Provincial Government.

the high cost of operations, but also because various options of foods for consumers are now provided and the price of paddy on the market is still intentionally maintained by the government against inflation.

However, the application of farm machinery can save labor force of 41 workers per hectare (**Table 3**). But this is only possible through a well-organized seedling nursery center and custom hiring system. Machines owned by individual farmers will result in a high-cost production. Therefore, to combine related operations into one is of a possible solution to reduce the cost. Use of herbicide has already replaced traditional weeding operations. Transplanting of rice seedling with liquid fertilizer applied underneath is another example, as it reduces a backup fertilizing process.

Transplanting has been a traditional process to make sure the healthy seedlings of equal growth stay on the growing field. By this operation, the nursery centers survive so far. However, direct seeding might become a substitute for transplanting in the future instead, although some obstacles still need to be overcome before its successful use.

In fact, since the production cost of rice is high in Taiwan, the best way to solve the surplus problem or to reduce the operation cost is to grow less rice. Rice diversification has been a policy since 1983 to alter the original rice farming partially into other crops, such as corn, sorghum, soybean or horticultural crops, or even no crop farm. It seemed a successful project at first but government officials finally realized that more work and tremendous expenses needed to be added in.

Development of Machinery for Upland Crops

The diversity of upland crops provides the domestic researchers a big room for exploration even though the local market for farm machines is rather small. In fact, majority of the machines for rice cultivation were originally from Japan. The only survived homemade machines after keen competition are power tillers and dryers. Some big companies are even willing to be the business agents for Japanese than to work out new machines of their own.

The most commonly cultivated upland crops in Taiwan are corn, sorghum, soybean and peanut. In fact, the windy and humid climate is not suitable for the crops of high stalks like corn to grow. In addition, the small, odd farms of less than 1 ha for each farming family make it even harder for mechanization.

The traditional way of acquiring farm machines for rice production were either developed by the local companies or directly imported from Japan. The Japanese machines were popular here because of the similarity of rice cultivating system in the two countries. But this experience does not apply to farm machinery for upland crops since the development of such machinery in Japan is still under way and rather few machines are available for those crops.

Grain Drills with Auxiliary Equipment

The first local grain drill was developed by the Taiwan Seed Service and quickly went into commercial channel. This was a tractor-mounted model, operated for 4 hectares a day, which can meet the needs for the drilling process of sorghum, corn, peanuts and beans. Different styles and sizes, such as the tractor-mounted models with fertilizer applicator, lister and fertilizer combined or no-till device, as well as power-tiller and cultivator-mounted models, were later developed for various applications. By 1986, the rate of utilization of planting machines was as high as 67%.

The traditional seed planters have been most suitable for corn, sorghum, peanut and bean seeds, but required more seeds per cell to guarantee a complete emergence. Thus, a thinning process is usually necessary in its later operation. A precision vacuum planter, with adjustable row width up to 45 cm and a work load of 3.4 ha a day for multiple uses, came out to the market and more than 100 sets in recent years were sold. To switch it for the seeding of another crop, the seed plate is the only part to be changed.

Vegetable Transplanter

Developing a vegetable transplanter has been as difficult as it was for the rice transplanter, but the Tao-Yuan Experiment Station has tried to make it possible for years. Now, the two-rowed vegetable transplanter is working successfully with 128 seedlings grown in the well arranged trays. This transplanter can be employed for almost all vegetable seeds with various sizes and shapes.

The vegetable transplanter will be a necessary tool in a link to the agricultural automation system, in which the vegetable seedlings can be grown in large scale both in a greenhouse-type nursery center and in the open field. Thus, the vegetable farmers must have this kind of machines to transplant the tray-formed seedlings to the field. More complicated functions are being built in by the National Chunghsin University to make it more automaticaly functioning.

Development of Harvesting Machines

To accomplish the goal of rice diversification for small farmers, the necessary equipment are harvesting machines for corn, soybeans, peanuts, etc. The American or European combines are too large for operations on small fields. Therefore, many researchers started to develop the small ones for domestic conditions. From that time on, the once-over peanut combines, corn pickers, napier harvesters, bean combines and pea harvesters, etc. had been developed by several local experiment stations within the last 10 years. Still, the performance could not meet the demands of farmers and custom services. Also, due to the small domestic market for these machines, the quantity for extension was rather limited.

The import of European models went on and helped solve the problem for the farmers that own large farms. However, this expensive machine can serve only for a limited number of farms. And due to high moisture contents of crop during harvest period, the harvested corn by the machines have sufferd an enormous loss in breakage. However, at the present time more than 150 units of European models are used by custom services for corn and sorghum harvesting.

The farming system, a combination of farmers and 350 custom hiring centers, is very unique. Since the custom hiring services are in a vantage position to assess the feasibility of new machines, the promotion work must be done in front of these custom farmers effectively. In general, the custom farmers always favor large farm machines for their great workload, the European combine is one of the example.

Corn Harvesters

Due to the success of rice combines in the past, farmers always take the once-over harvesting process for granted and hope to apply it for other grains. But for corn, the humid weather and high moisture content of kernels make the combine work unsucessful.

To overcome this difficulty, an axial-flow corn sheller with tractor p.t.o.-driven was developed and works well under humid conditions. The corn ears after harvest can directly be thrown into the sheller for threshing without need of dehusking. This sheller can be used for the threshing of sorghum, too, provided that the threshing drum is adjusted to suitable meshes. Almost 200 sets of corn threshers are used in small farms. Further studies have taken place to combine the sheller with the walking mechanism and corn cutting head, forming a mini-corn combine.

Peanut Harvester

The harvest of peanuts has troubled the farmers quite a period of time and consumes lots of labor. Many efforts have been made to develop necessary equipment and the results were still far from satisfactory.

At present, the study on the peanut harvesting is based on the principle of a grasping action to hold the stalk of peanut plants until it is threshed. This might work well only in the sandy soil, not others. Some institutes also developed a throwing-type machine which, however, does not meet the demand of users.

Two local companies are involved in the manufacture of the stalk-holding type machine. The result was positive and has passed the performance test. There are more than 30 peanut combines now in use.

Napier Harvester

Owing to its high productivity, competitiveness and taste, the napier grass has since been the important forage for dairy farm in Taiwan. Hence, the development of napier harvesters has been targeted as one of the main directions.

Some dairy farmers modified the imported corn forage harvesters and applied them for their napier grass, but the result was not so successful at the beginning. The tractor side-mounted and self-propelled ones have been developed to meet the local needs and almost 130 of them have been sold.

Soybean Combine

The crawler type bean combine, developed by the Kao-Hsiung Experiment Station for quite a long time now and redesigned by the Institute of Industrial Technology for commercial distribution is still unsuccessful.

Since the manufacturers do not have enough technical background for the dynamic chassis used in these machines, the operations and performance have not been stable. Hence, the Kao-Hsiung Experiment Station took the used chassis of rice combines made in Japan to manufacture new machines and changed the design of mechanism as well. The result has been satisfactory and can also be used to harvest other bean crops.

Automation System in Agriculture

Automation in agriculture is a combination of computer-controlled technology and agricultural mechanization through an optimizing process. To accelerate the pace of modernization in agriculture and furthermore, cut down on farm labor, the government initiated many automation programs on agricultural production, livestock production, fishery operation and agricultural transportation and services for a period of five years since 1991.

The automation in agricultural production includes pesticide-spraying application, post-harvest processing, seedling production system, greenhouse cultivation, etc. Plant factory systems might be the final form to combine some of the above subjects and become an integrated system, as the bean sprout production does. For the field cultivation, many simple greenhouse contructions were proved sucessful in a micro-climate control, especially for flower production.

The automation of seedling production program has been divided into three parts, namely; the seedling nusery, cut flower and plant flowers, such as orchids, etc. All these products are grown in a controlled environment, or in an equipped greenhouse to make mass production possible. How the greenhouse system commercially works for the tropical area is also the main subject of future research.

Related topics on vacuum seeding, growing trays collecting and discharging mechanisms are under study by the National Taiwan University and Tao-Yuan Experiment Station. The Taiwan Seeds Service, on the other hand, is responsible for a feasibility study on a Dutch-made greenhouse system. The Taiwan Sugar Company imported greenhouse facilities such as medium mixers, automatic potting machine and control units from the Netherlands for modifications.

The fishery automation focuses on the monitoring controls of ship engines and freezing equipment, controls of incinirators for fish wastes on boats, packaging facilities and pond fishing systems. Weather forcasts and collection of fishing information are also included.

Many commercialized automation systems have been employed for the livestock production. The management of milking cows through computer databases was found very efficient in controlling the feed consumption and milk production of dairy cows. Automatic egg collection systems also have its place in local layer enterprises.

The computerized auction systems have also shown prospects in the hog, flower and vegetable auction markets. Although most of the material handling systems are far from the view of automation, the data process and information flow provide buyers with a very satisfactory information. More stable market prices are thus expected.

The Perspective

In comparison with the farming systems in Asia, Taiwan has the level of mechanization of 95%, second to Japan, but far advanced than those of other Asian countries. Besides the high utilization rate of farm machines, the custom hiring services and seedling nursery centers play important roles to promote complete mechanization.

Nevertheless, the role of agriculture is declining. All the mechanization measures can only maintain the current situation. Automation in agriculture may be the answer to a breakthrough in order for the quality of farming to be further improved.

As for the upland farming, mechanization is still at a low level, especiallly on the harvesting operations for corn, peanuts and soybeans. In reality, due to the small domestic market and complexity of these machines, all the machines developed are not profitable enough for mass production. How the government gathers manpower, financial resources for R & D and encourages the manufacturing of those equipment will be the crucial task that the government is facing now.

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Establishment of Centre for Agricultural Machinery Industries

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Abstract

The Punjab Small Industries corporation (PSIC) in collaboration with the Dutch Government has established a Centre for Agricultural Machinery Industries (CAMI) at Mian Channu, Punjab, Pakistan. This centre has mandate to provide common facility and extension services, training, credit and quality raw materials to the entrepreneurs. It is also engaged in testing, designing and development of farm machinery and in generation and dissemination of information related to local farm machinery manufacturing to the entrepreneurs. The Centre is currently undertaking various steps to promote local agricultural-oriented metal industries.

Background

The PSIC, in collaboration with the Dutch Government explored the possibilities of the latter to extend help and assistance for the development of agricultural implements manufacturing industries. In 1986 it was concluded that there was a need to establish a Service-cum-Facility Centre at Mian Channu in order to provide training, advisory and technical services to the agricultural machinery and implements manufacturing industries.

After the necessary preparation the project officially started in 1989 and entered its executional operations in 1992.

Introduction

Pakistan is basically an agricultural country and the agriculture sector is a major thrust for its economic development. In order to increase agricultural production, mechanization of the agriculture sector has long been recognized as an important ingredient. With this in view, assembly and production of tractors was introduced in private and public sector. However, the production of agricultural implements remained in the domain of the private sector. As there were no proper guidelines and knowledge with the prospective entrepreneurs, a number of small units were established in different areas of the province to meet the demand for agricultural implements. This has resulted in a mushroom growth of agricultural implements manufacturing units in the country who just produce implements according to their own knowledge, without following any standards, design specifications, quality control and without using proper raw materials and manufacturing technology.

Agricultural implements manufacturing units are concentrated at Mian Channu, besides Faisalabad, Lahore, Daka and Gujranwala (3, 4, 5). The range of agricultural implements produced at Mian Channu includes cultivator, mould board plough, rotavator, disc harrow, rear blade, land leveller, scraper, cotton ridger (with and without fertilizer attachment) ridger, ditcher, border disc, seed-cum-fertilizer drill, cotton/maize planter, bar harrow, boom sprayer, maize sheller, wheat thresher and trolley (6).

Lathe, welding transformer, drill, hand shear and electric grinder are the common machines available for most of the entrepreneurs in Mian Channu. Smaller workshops are generally equipped with one or two centre lathes, bench drill, welding transformer and some have gas cutting and welding equipment. Larger units are equipped with more lathes, pillar drill and shaper. These facilities are not equipped for quality production as a result of which entrepreneurs travel to other cities for specific needs.

Mian Channu is located in the cotton belt of Punjab where cotton-wheat are the main crop rotation. Due to overlapping of harvesting and planting seasons of two crops, it was recognized that the mechanization of these two operations would facilitate the rotation of these two crops. Since there was no other major agricultural machinery production centre in the cotton belt, the industry which developed in Mian Channu in the mid-sixties, expanded in the subsequent years. Thus Mian Channu has emerged as one of the important agricultural machinery production centres in the province (3). Due to its proximity to upper Sind, the machinery manufactured in Mian Channu is also being utilized there.

At present 33 agricultural machinery production units are established in Mian Channu, representing an output value of Rs. 50 million per year (2). A large number of other industrial units, namely; cotton textile mills, cotton ginning factories, oil mills, cold storages and flour mills are also established in Mian Channu. The town of Mian Channu is located on the main national highway and railway line which connect Lahore and Karachi. Other infrastructural facilities like water, disposal system, telephone and telegraph are available in Mian Channu.

Mian Channu has, therefore, been considered as the most appropriate place for the establishment of the centre.

Objectives of CAMI

The CAMI hopes to achieve the following objectives (1).

(a) Provision of common facilities which are not yet available in the private sector;
(b) Provision of design, production and testing facilities to enhance the possibilities for product research and development;
(C) Provision of technical and managerial advice to small scale industries through extension services;
(d) Improvement of the technical know-how and skills of workers from small scale farm implement industries through training;
(e) Developing quality assurance and control system and promoting the acceptance of quality standards for new implements to be manufactured; and
(f) Provision of credit facilities for small scale agricultural machinery manufacturers/ metal industries.

Activities of CAMI

The organizational chart of CAMI is shown in **Fig. 1**. In order to achieve the above objectives, the CAMI has the following facilities.

Common Facilities

The common facilitties have a two-fold function. First, they provide production facilities needed for quality improvement, which could not be afforded by individual small entrepreneurs. Secondly, they serve as a demonstration and training opportunity for entrepreneurs who consider the installation of certain elements

Fig. 1 Organizational chart of CAMI.

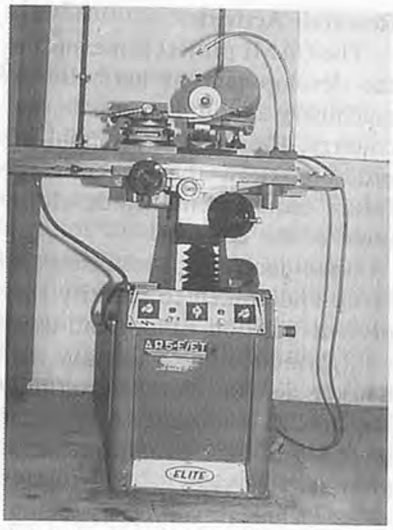

Fig. 2 Tools and cutter grinder.

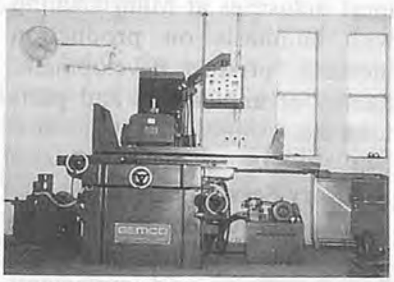

Fig. 3 Surface grinder

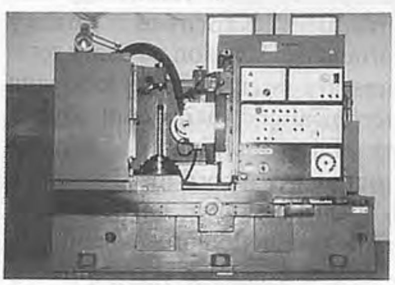

Fig. 4 Gear hobber.

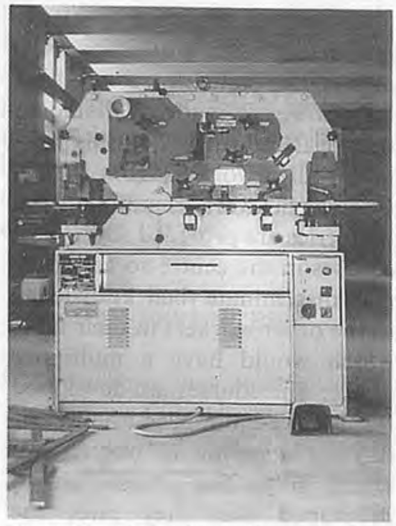

Fig. 5 Shearing and punching machine.

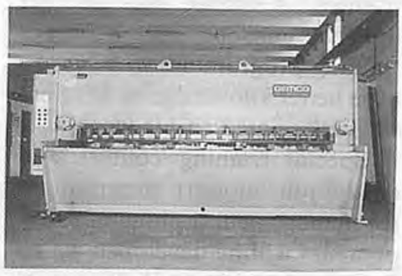

Fig. 6 Guillotine shear.

Fig. 7 MIG welding and plasma cutting machine.

Fig. 8 Automatic flame cutting machine.

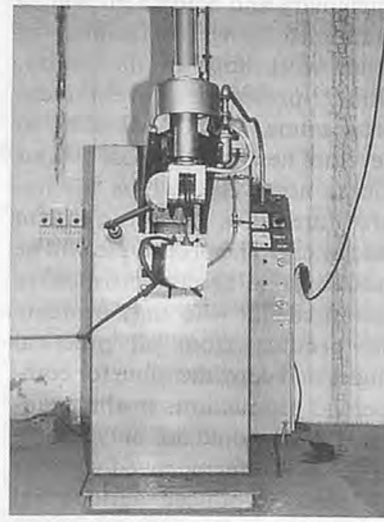

Fig. 9 Seam welding.

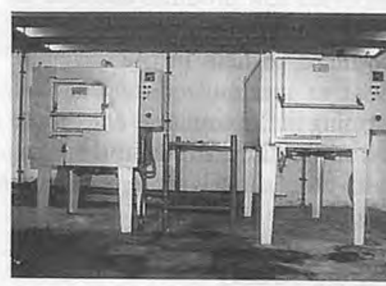

Fig. 10 View of heat treatment shop.

of the common facilities in thier own entreprises. Also, the quality assurance and control system being introduced in the common facilities may serve as a demonstration for industrialists who consider the introduction of quality assurance and control system in their own entreprises.

In providing the common facilities, the CAMI has established machine, sheet metal, welding and heat treatment shops and provided modern machinery in these shops which are not yet available in the private sector. Important machines in the machine shop are tool and cutter grinder **(Fig. 2)**, coordinate drill, surface grinder **(Fig. 3)**, shot blasting, universal milling machine and gear hobber **(Fig. 4)**. The main machinery in the sheet metal shop are shearing and punching machine **(Fig. 5)** and guillotine shear **(Fig. 6)**. The main features of welding shop are MIG welding and plasma cutting machine **(Fig. 7)**, automatic flame cutting machine **(Fig. 8)**, spot and seam welding **(Fig. 9)**. The heat treatment shop is equipped with different hardening and tempering furnaces, friction press, quenching baths and harness tester. **Fig. 10** shows the view of the heat treatment shop.

Design Office

The CAMI has established a resource centre where technical information on machines, farm implements and engineering processes and data regarding agro-economic research within the agriculture sector is stored. The centre possess learning material required for training activities. The resource centre is equipped with computers, printers and audio-visual aids.

Prototype Development

The CAMI has also established a prototype shop where prototypes of different agricultural machinery and equipment will be assembled using the facilities of other workshops in the centre. Under prototype development programme, the CAMI aims to develop new prototypes. Major focus, however, will be on improvement of existing farm machinery. The prototypes will be made available to the prospective entrepreneurs who may evaluate the product from all practical angles and copy the same for commercial production. In this manner, CAMI would not only be able to demonstrate improved versions of locally produced agricultural machinery and equipment but imported new products adopted to local conditions will also be introduced to help in the development of mechanized agricultural farming in the country. The centre has started improvement work on cultivator shovels and rotavator blades.

Testing Facility

The CAMI has established testing facilities for agricultural implements and machinery to support prototype development and provide essential information to entrepreneurs and farmers.

Under this scheme the implements and components manufactured by the local entrepreneurs is throughly tested and unbiased reports about the performance of their products is issued and improvement suggested. Testing is performed in the laboratory as well as in the field.

Training Facility

In order to introduce new technology and better production techniques, it is imperative that skilled man-power is made available to the local industry. For this purpose skilled workers from the existing agricultural manufacturing industries are provided short term courses in the centre so that they may disseminate their knowledge to the other workers in their units which would have a multiplier effect. The courses are developed for a limited number of hours per day for a period of one to two weeks only. The courses are so developed that they meet the specific requirements of the trainees. A trainee may also get himself enrolled for different training programmes in a year to have better knowledge of different subjects related to his work.

Special training courses and on-the-job support programmes for management training of entrepreneurs will be developed which may touch subjects like financial management, marketing, stock keeping, organization and planning, production control, etc.

Credit Facility

In order to provide credit facilities to small agricultural implements manufacturing industries, a revolving fund has been provided. The credit is available to those entrepreneurs who have no easy access to other financial institutions. The loan is provided to the entrepreneurs at similar conditions as PSIC's Rural Credit Programme.

It is proposed to give preference to those parties whose loan requirements are less than Rs. 1.00 lakh. The loan applications is appraised and supervised by the staff of the centre. The receipients are asked to introduce simple accounting system in their units so that they may understand their business more appropriately.

Research Activities

The CAMI project is meant for the development of agricultural machinery and implements in the country. Research is essential in order to know the present and future requirements of development of the country.

Agro-economic research is being undertaken to identify the present position of the end-user i.e., farmers, and to identify the market demand for agricultural implements and suggest suitable methods of sale promotion and after-sales services.

A technical survey is being undertaken in order to analyze the local industries at Mian Channu with emphasis on production methods, product development, quality of implements and parts used etc.

Advisory Services

In order to ensure that the existing industrial units producing farm machinery and implements adopt the latest technology and produce improved quality products, extension advisory services are essential. The following technical and managerial advisory services are rendered to improve the quality of products.

- Identification of bottlenecks in the production process and subsequent advice on remedial action;
- Advice on investment decisions and expansion of workshop;
- Dissemination of relevant modern technical know-how on dies, tools, parts and machines;
- Technical and managerial advice to entrepreneurs;
- Liaison between Pakistani and Netherlands manufacturers of agricultural implements to ensure an entrepreneur-to-entrepreneur transfer of technology and know-how, if possible resulting in joint-ventures; and
- Increase the awareness of the importance of quality and stan-

dardization.

Quality Assurance

In order to produce competitive, high-quality products and services, a high standard quality assurance system is being developed for common facilities workshops of the centre but ultimately it will be passed on to the interested individual private enterprises. This will act as a brain for the activities to be carried out in the centre. A quality hand book will be prepared which will act as a code of law for the centre.

Conclusion

In brief, the project is neither a commercial nor producing organization. It is purely a promotional project and works for the improvement of the agricultural oriented metal industries. In order to continue the activities of the project on a sustainable basis the project does not work in isolation: it rather involves other institutions as well as target group in its work and acts as catalyst.

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NOTIFICATION

The editorial staff of AMA introducing some changes in editorial policy and requests contributors of articles for publication to observe following changes in order to improve communication process. These changes will play key role in facilitating the editorial process.

Articles for publication must contain one printed copy along with one copy on 3.5 inch floppy disk and black & white photographs for the articles.

Format Guidance

The floppy disk copy must contain the following format.

a. are written in english language;
b. are written in any of these format like DOS, Word for Dos, Word Perfect, Word Star, Word for Windows, Word for Macintosh and which should be written on the surface of the disc;
c. whole article must written in same format and style;
d. the pages on floppy disk must not be numbered;
e. the tables and figures titles must be numbered;
f. the data for the graphs must also be included.

The remaining Instructions to AMA Contributors are shown in the back side of AMA.

The editorial staff of AMA realize that some contributors still have difficulty to support these changes. In this case, please contact us. Please remember the articles in the new format will be given priority for publication.

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Agricultural Mechanization with Special Reference to Kerala, India

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Abstract

There is tremendous scope for the application of engineering aspects in agriculture in the Kerala farms and expertise in agricultural engineering is urgently needed to improve farm mechanization in the State. This paper attempts to throw light on the specific idea which is of immediate interest to the Kerala farms, with the support of ample statistical data. A critical analysis of the various aspects of development of agricultural mechanization is made.

Introduction

Kerala — the "God's own land" — with its eye-catching greenary, forms a paradise for the tourists in the humid tropical regions of India. Situated between 8°18′-12°48′ North latitude and 74°52′-77°22′ East longitude, the land is blessed with moderate climatic conditions, rivers and backwaters and soil of high fertility. The area receives an annual rainfall of 3 000 mm and comprises a geographical area of 3.89 million ha which is only 1.18% of the total area of India **(Table 1)**. The area-wise classification of available land of the state is presented in **Table 1**. The operational holding sizes and the percentage distribution of the area operated by major size groups of Kerala as per the 1985-86 Agricultural Census **(Table 2)** shows that about 46.1% of cultivable land is held by marginal farmers with an average size holding of 0.18 ha. The fragmentation of holdings and hence the need for small-farm agricultural implements are supported well by the statistical data. The major crops produced in the state, and production are shown in **Table 3**.

There has been a general in-

Table 1. Land Use in Kerala, 1990-'91

Classification	Area ('000 ha)	Classification	Area ('000 ha)
Forest	1 081.51	Current fallow	44.16
Land put to non-agrl. use	297.38	Fallow other than current fallow	26.47
Barren and cultivable land	58.31	Net area sown	2 246.77
Permanent pasture	1.91	Area sown more than once	796.27
Land under tree crops	34.38	Total cropped area	3 043.04
Cultivable waste	94.61	Geographical area	3 885.50

Table 2. Operational Holdings and Percentage Distribution of Area Operated*

Class and Size of Holding	Percentage Distribution of Area Operated		No. of Operational Holdings (lakhs)		Avg. Size of Operational Holding (ha)	
	Kerala	India	Kerala	India	Kerala	India
Marginal (< 1 ha)	46.1	13.18	44.73	567.48	0.18	0.38
Small (< 1-2 ha)	21.55	15.88	2.81	178.81	1.35	1.43
Semi-medium (2-4 ha)	15.28	22.32	1.04	132.54	2.58	2.76
Medium (4-10 ha)	7.41	28.68	0.25	79.20	5.20	5.94
Large (> 10 ha)	9.66	20.24	0.04	19.25	42.25	17.20
Total	100.00	100.00	48.87	977.22	0.36	1.68

*From 1985-86 Agricultural Census, Government of Kerala.

Table 3. Gross Area, Area under Irrigation and Production of Major Crops (1991-92)

Crop	Gross Area ('000 ha)	Area under Irrigation ('000 ha)	Production ('000 t)
Arecanut	63.18	20.21	11 964
Banana	67.28	10.56	497.81
Cashew	118.04	—	105.37
Coconut	872.70	104.89	5.03 (million nuts)
Pepper	170.70	—	52.71
Rice	559.45	225.06	1 086.58
Tapioca	147.25	14.79	2 730.95

crease in the average yield of important crops during the preceding years. The production of major crops in the State like rice, coconut, arecanut, cashewnut etc. shows a steady increase during this period. The progress achieved can be attributed mainly to the increase in the area under cultivation, irrigation, and increased use of fertilizers and machinery. There has been an increase in the number of tractors, tillers and pumpsets used in the Kerala farms. The high literacy rate of 91% throws light to a better scope for extension activities among the farming population where agriculture contributes 34% of the State income.

Agriculture can be intensified, diversified and modernized in Kerala, by means of a 3-tier mechanization process that too of a selective nature, adopted on a priority basis. This can be accomplished through the rational use of:

1. Small-sized agricultural implements;
2. Tractors and tillers with accessories for tillage, sowing and harvesting operations; and
3. New innovative technologies in irrigation, drainage, soil and water conservation and scheduling.

Studies show that at present, the impact of agricultural mechanization on the agricultural development of Kerala is marginal, but the scope is tremendous. The total power availability of the State catches up to 0.22 hp/ha which proves meagre compared to the basic requirement of 0.8 hp/ha. The vast and unending potential of the State in terms of irrigation, available water resources and irrigable area are left untapped. To efficiently utilize the available infrastructure and to meet the everlasting demand for the power, there occurs an unprecedented need for mechanization.

Relevance

In Kerala, agricultural mechanization has specific relevance, particularly in farm machinery, land conservation, irrigation and renewable energy.

Farm Machinery

The use of farm machinery is very low in Kerala compared to many other States in India. Implements and tools used for carrying preparatory tillage operations like ploughing, clod crushing and harrowing have not undergone much improvement. The present status of farm machinery/implements under use in Kerala is shown in **Table 4**.

Table 4. Status of Farm Implements and Machinery in Kerala (1990-91)

Implement/Machinery	Number
Hand Operated	
Chaff cutter	4 031
Duster	9 501
Hoe	5 164
Seed drill	1 753
Sprayer	35 406
Animal Drawn	
Disc harrow	761
Paddy thresher	1 283
Leveller (wooden)	108 049
Plough	47 385
Puddler	8 085
Seed cum fertilizer drill	281
Seed drill	3 186
Power Operated	
Disc harrow	84
Harvester (self propelled)	8
Leveller	3 582
Mould board plough	1 278
Multi crop thresher	33
Paddy thresher	330
Pumpsets (electric)	74 456
Pumpset (diesel)	24 475
Spray/duster	2 085

Inspite of the small fragmented land holdings, tractors and tillers are widely replacing animal power in the ploughing and seedbed preparation operations, especially in rice cultivation. The statistics show that there are only 8 self-propelled harvesters and 33 multicrop threshers presently available in the State. Seed drills, transplanters, threshers, harvesters, etc. have to be popularized yet. State-wise sale of tractors and power tillers assesed for the year 1991-92 shows that in Kerala 440 tractors and 457 power tillers were sold. The power input to the agriculture sectors has to be enhanced considerably to meet the target of 0.8 hp/ha.

The study conducted by the Institute for Techno-Economic Studies, India, shows that there is considerable scope to develop and introduce better agricultural implements and machinery in the State. The existing ones need to be modified and new ones introduced in order to suit the requirement which needs expert personnel in agricultural engineering.

Land Conservation

The net area sown in the State is 2.24 million ha against a total geographical area of 3.89 million ha (**Table 1**). The alarming increase in population demands more and more agricultural land for industrial and building purposes. Land holdings are fast turning to "concrete jungles", giving rise to serious environmental concerns. Consequently, additional area can be brought under cultivation by adopting reclamation measures, which need engineering support in deep tillage, levelling, bunding, drainage etc.

So far, only 78 000 ha of land has been brought under soil conservation measures. There is an urgent need for bunding and formation of the land to conserve soil and water in the irrigated as well as the rainfed areas. In depth studies need to be conducted in land and water management. Intensive and creative efforts by experts (agricultural engineers, soil physicists and agronomists), with interdisciplinary approach are likely to yield the desired results.

Irrigation

Kerala is a land of rivers and back waters. With 44 rivers cutting across the land, with their innumerable tributaries and branches, the State has got an exhorbitant potential of surface and underground water for irrigation. Nevertheless, only 14.8% of the cropped are is brought under irrigation. Bringing in more land under irrigation should improve the crop production of the State. If at all the high rainfall is harvested to its fullest possible extent, successful cropping throughout the year in the State, would be a problem, only in the distant dreams to the farmers.

Indigenous methods of water lifting like swing baskets, water wheels etc. are still popular in some parts of the State. As the time goes power operated pumps are catching up and outsmarting these traditional practices. At present 74 456 electric pumps and 24 475 diesel pumps are in use (**Table 4**). More low-cost pumpsets need to be introduced to enhance irrigation. Ground water is being exploited efficiently by tube wells and filter point wells. The recent introductions in irrigation, including the drip and sprinkler systems are being widely accepted in the State. To accelerate the pace of development, the Government of Kerala is giving 50% subsidy for farmers to install the drip system.

The utilization of irrigation should be done in accordance with the potential of irrigation system which, in turn depends on water resources available, area under irrigation, cropping pattern, etc.

Renewable Energy

Agriculture is very appropriate for wind power application since it does not require continuous and bulk supply of energy and moreover requires much smaller individual systems and units. Preliminary studies conducted in the State to identify the potential places and periods for wind power application in agriculture indicate that wind power has tremendous potential for water lifting. Some windy sites could also be surveyed in the coastal areas and Palakkad District of Kerala. Wind energy can also be used effectively for generating electricity in the rural areas.

Solar energy is yet another important dependable source of renewable energy. The State has 270 days of sunlight. The vast and unending source of solar energy can be effectively tapped for drying grains and farm crops and for producing electricity for operating water pumps. The Government of Kerala has started establishing Renewable Energy Centres for maximum utilization of renewable energy sources. Scientists and agricultural engineers have to take immediate effective steps for possible maximum extraction of renewable energy in the State.

Conclusion

Agricultural mechanization in Kerala is in its early stages and needs immediate attention. The State cannot abstain from utilizing the services of agricultural engineers to enhance agriculture mechanization and hence to achieve increased crop production.

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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 Simulation Model of Psychrometric Chart: Islam, M.N., Lecturer, Dept. of Manufacturing and Quality Systems, University of Western Sydney, Macarthur, Cambelltown 2560, Australia.

A simulation model for determining the psychrometric properties of moist air was developed using mathematical equations of the moist air properties. The results generated by the model were compared with the results of the standard psychrometric chart and were found satisfactorily accurate. The model was suitable for generating and comparing any number of results up to the required interpolation within the range of dry-bulb temperature of −100°C to 200°C and wet-bulb temperature of 0°C to 70°C. The model is suitable to use in the simulation model of heat and mass transfer.

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Development of Tractor Front-Mounted Combine Harvester in India: Mehta, M.L., Senior Test Engineer; Tiwari, R.M., Foreman, respectively, Northern Region Farm Machinery Training & Testing Institute, Hisar-125001 (Haryana) India.

At present, the combined harvester density in India is just 0.01 per 1 000 ha. The wheat harvesting by combine is gaining momentum in order to prevent crop from weather hazard, for timely sowing of next crop and low grain losses as compared to other harvesting methods. Tractor side-mounted combine harvester have become obsolete and tractor front-mounted combine harvester recently developed are becoming popular as tractor can be detached after harvesting season and can be used for other field operations. Testing and evaluation of three front-mounted PTO operated combine harvester in Sonalika variety of wheat crop show that area covered ranged from 0.79 to 1.06 ha/h and fuel consumption was from 5.37 to 6.66 ℓ/ha. Total non-collectable grain losses were observed to be below 2%, threshing efficiency and cleaning efficiency found almost as per norms but grain breakage was on slightly higher side. The percent variation of total grain losses, grain breakage, threshing efficiency and cleaning efficiency ranged from −90.3 to −44.3, +9.5 to +75.0, −0.3 to +0.55 and −1.46 to +0.2, respectively, as compared to Indian Standard limits. Looking into the encouraging performance there is a great scope for tractor drawn combine harvester in mechanization of wheat harvesting as well as other crops in India and other developing countries.

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Utilization of Power Tillers in Pathum Thani Province, Thailand: Gee-Clough, D., Associate Professor; Slokhe, V.M., Associate Professor; Somton, Worasak, respectively, Asian Institute of Technology, Bangkok, Thailand.

This study was based on the data collected about utilization of power tillers in Pathum Thani Province of Thailand. Personal interviews of 79 farmers were conducted. It was found that annual use of power tiller was 490 h and they were used only for agricultural purpose. On an average 251 h were used for tilling operation which was about 51% of annual use. About 40% of total use for water pumping while 80% of total use was for transportation. The cost estimation showed that cost per hour and cost per cropped area decreased with higher annual use. About 33% repairs were done by farmers while 32% farmers got it done through local workshops. About 63% of breakdown were related to the engine.

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Breakage of Rice Grains during Milling in Existing Rice Mills in Bangladesh: Islam, M.N., Lecturer, Department of Manufacturing and Quality Systems, University of Western Sydney, Macarthur, Cambelltown, NSW 2560, Australia, and Farouk, S.M., Professor; Islam, M.R., Scientific Officer, respectively, Dpet. of Farm Power and Machinery, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Rough rice in Bangladesh is processed mainly by the farm families traditionally, and by the semi-modern and automatic rice processing mills. The lot sizes used by the farm families for parboiling are usually 50-200 kg, but for dehusking are not more than 3-5 kg. The capacities of the semi-modern and automatic rice mills are 8-12 t/batch and 9-11 t/batch, respectively.

The information on processing and milling of rough rice was collected from 32 semi-modern and 8 automatic rice processing mills. The samples of rough rice at various stages of processing (soaking, steaming, drying etc.) and the samples of milled rice were collected and were analyzed in the laboratory. Rough rice in the automatic rice mills was presteamed at 68.5 N/m^2 pressure (165°C) before soaking for 4-6 h. Soaked rough rice was steamed at 68.5 N/m^2 pressure (165°C) for 10-15 min. The steamed or parboiled rough rice was dried at 40-43°C in the LSU-type continuous flow dryer for 6-7 h. The dried rough rice was milled by rubber roll dehusker at moisture content of 14-15%. The breakage percentages of rice were 0.72% and 10.73%, after dehusking and polishing, respectively, and those were quite higher than the reported values by the rice millers. The breakage percentage of semi-modern rice mills (14.64%) was higher than that of the automatic rice mills (10.73%).

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Development and Evaluation of a Seed-cum-fertilizer Distributor in Bangladesh: Ziauddin, A.T.M., Professor; Roy, Poritosh, Graduate Student, respectively, Dept. of Farm Power and Machinery, Bangladesh Agricultural University, Mymensingh 2202, Bangladesh.

A manually operated seed-cum-fertilizer distributor was developed and tested for broadcasting seeds and fertilizers in the field. The Uniformity Coefficient of Distribution (UCD) was determined for fine urea, granular urea and wheat, and was compared with that of traditional hand broadcasting method. The distributor could spread fine urea at a field capacity of 1.06 ha/h to 1.28 ha/h, coarse urea at a field capacity of 1.49 ha/h to 1.92 ha/h and wheat at a field capacity of 1.60 ha/h to 2.02 ha/h. Normally, the UCD of traditional broadcasting system is about 30%-43% depending upon the skill. The UCD of the device for fine urea was 72.49% to 85.10%, for

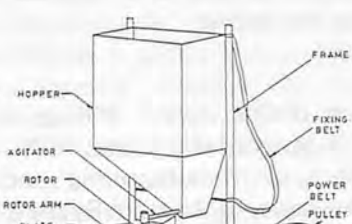

Fig. 1 The seed-cum-fertilizer distributor.

Fig. 2 Field use of the seed-cum fertilizer distributor.

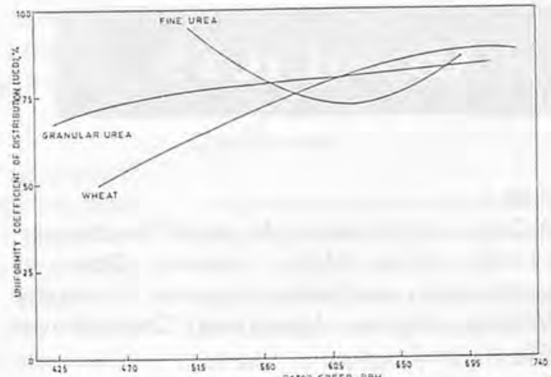

Fig. 3 Uniformity coefficient of distribution at various rotor speed.

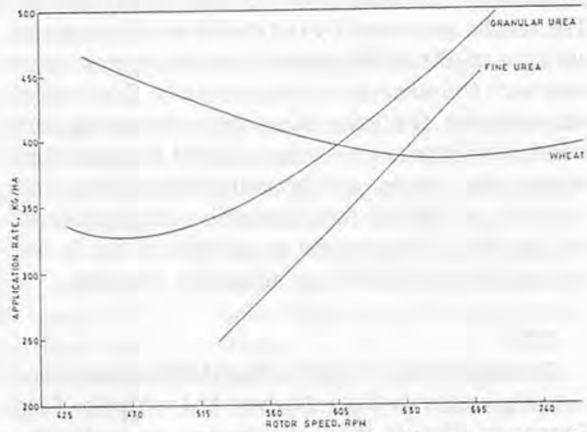

Fig. 4 Application rate of materials at different rotor speed.

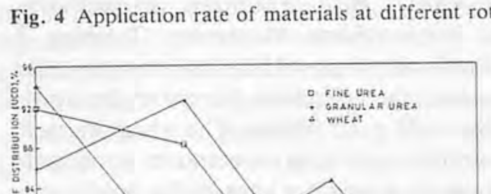

Fig. 5 Uniformity coefficient of distribution of material at different hopper openning.

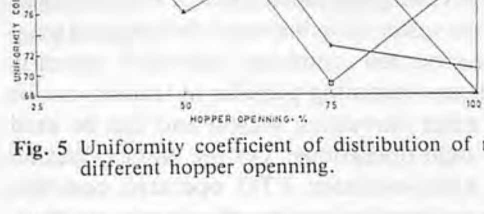

Fig. 6 Application rate of material at different hoper openning.

granular urea 69.01% to 79.65%, and for wheat it was 53.49% to 88.36%. The performance tests indicated that the developed seed-cum-fertilizer distributor could be used in the field satisfactorily.

358

Development and Performance of Manually-operated Cassava Lifter: Verma, S.R., Formerly Chief Technical Advisor; Ladeinde, M.A., Senior Agric. Engineer; Abimbola, T.O., Asstt. Director; Musa, H.L., Director, National Centre for Agricultural Mechanization, Ilorin (Nigeria), respectively.

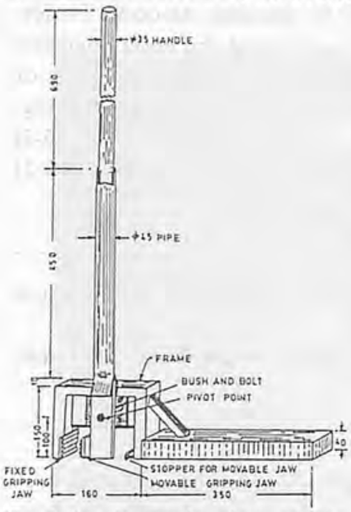

Fig. 1 An isometric view of the 'NCAM' cassava lifter.

Fig. 2 NCAM cassava lifter in operation (a) gripping the cassava stalks (b) showing uprooted cassava roots.

Harvesting of cassava is a tedious operation in Nigeria where it is an important staple food for the Nigerian people. A single-person operated cassava lifter was developed at the National Centre for Agricultural Mechanization. Its salient features included a positive gripping of the cassava stalks irrespective of their diameter, simple construction, ease of transport, low cost and ability of being fabricated by the local artisans. It required 22 to 53.44 man-hrs to harvest one ha of crop with this tool. It enabled the worker to work in a standing posture. The tool was being fabricated by the artisans and small scale entrepreneurs.

359

Sand Drying of Wet-season Paddy: Pillaiyar, P.; Singaravadivel, K.; Subramaniyan, V.; Paddy Processing Research Centre, Thanjavur-613 005, Tamil Nadu, India, respectively.

Paddy harvested amidst rain was dried in the mechanical sand roaster (0.7 T/h capacity) by maintaining various temperatures (70°-175°C). After heating the sand in the roaster to the above temperatures paddy was fed. During a traverse time of 46 sec the moisture content in wet-season paddy reduced considerably (1.5 to 8.7%). At the same time, because of a grain to grain moisture variation in the above paddy, 30-50% of grains got parboiled at high temperatures (90° to 175°C). Besides this, grain breakage also was more. At low sand temperatures, though the milling breakage was low, including the moisture content of paddy.

361

Estimation of Torque for Digging Holes for Tree Plantation: Tiwari, Vijay, Asst. Professor, Dept. of Agric. Eng., Gujarat Agric. University, Anand - 388 110, India; Ingle, G.S., Professor, Dept. of Agric. Eng., Indian Institute of Technology, Kharagpur - 721 302, India.

The forces acting on the excavating machines/tools can be determined theoretically by analyzing the conditions leading to shearing of soil. An attempt has been made to develop models based on shearing strength and on cone index/compressibility of soil to compute power/torque requirements for digging holes for tree plantation considering the fundamental relationship between the soil and tool parameters. The model developed following the cone index method is recommended as it provides torque value closer to the actual values.

362

Studies on Operators Discomfort During Interculture Operation Using Hand Hoes: Tandon, S.K., Sr. Scientist; Kumar, Adarsh, Scientist, respectively, Div. of Agricultural Engineering, Indian Agricultural Research Institute, New Delhi-110 012, India.

Three types of weeders, namely, wheel hoe, crescent hoe and "kasola" were ergonomically evaluated. The performance in respect of area coverage, overall discomfort and body part discomfort were evaluated. The data was analyzed statistically. The overall performance index of wheel hoe, crescent hoe and kasola were 8.4, 4.8 and 3.9, respectively.

IAMFE/BALTIC '95

August 8-10, 1995
Kaunas/Dotnuva, Lithuania

The Lithuanian Institute of Agriculture (LIA) and The International Association on Mechanization of Field Experiments (IAMFE) have the great pleasure of inviting you to the IAMFE/BALTIC '95, the Fourth Regional Conference and Exhibition on Mechanization of Field Experiments.

The Conference will take place on August 8-10, 1995 with paper presentations in the city of Kaunas on August 8-9 and an Exhibition and Poster Session at the LIA, Dotnuva-Akademija on August 10. At least 60 participants from 15 countries intend to participate in the conference.

Conference Objectives:

1. To arrange a conference with discussions and presentation of papers where experience and information can be exchanged between West- and East-European countries, specially in the field of Mechanization, Computerization and Methodical questions in plant breeding
2. To discuss Methodology and Techniques for Field Experiments in the Baltic and former Soviet Union countries, compared to other countries and to promote personal contacts between participants from Eastern/Western Europe
3. To present activities and products in the area of field experiments techniques of plant breeding, by means of a poster session
4. To study up-to-date field machinery at an arranged Exhibition and Field Demonstration
5. To establish a Regional IAMFE/BALTIC Secretariat

Contact: Sigitas Lazauskas, General Secretary of IAMFE/BLATIC '95, Lithuanian Institute of Agriculture, Dotnuva-Akademija, LT-5051 Kedainiai distr. Lithuania. Tel. +370-57-37789 Fax. +370-57-56996.

International Symposium on Automation and Robotics in Bioproduction and Processing

November 3-6, 1995
Kobe University, Kobe, Japan

The dates set for the International Symposium on Automation and Robotics in Bioproduction and Processing (ARBIP 95) are November 3-6, 1995, in Kobe at Kobe University.

The Symposium will cover fundamental as well as applied aspects of automation and robotics in all industrial sectors related to bioproduction and processing, e.g. agriculture, horticulture, forestry, aquaculture, animal husbandry, biotechnological product processing, biomass utilization and food industry. Papers on sensors, automatic measurement as well as control systems and robotics for farm machinery, energy and environmental aspects, greenhouse, product distribution, storage, sorting and packaging and food processing are also among areas of major interest.

Sponsored by: Japanese Society of Agricultural Machinery (JSAM)

Contact: General Registration Office, c/o Prof. Minoru Yamazaki, Chairman of Organizing Committee, Dept. of Agricultural Engineering, Kyoto University, Kyoto 606-01, Japan.

31st Annual Convention of Indian Society of Agricultural Engineers

December 28-30, 1995
Kerala Agricultural University, Trichure, India

Theme: International Cooperation in Agricultural Engineering.

Receipt of Abstract: 15th August, 1995

Communication of Acceptance: 1st September, 1995

Receipt of Full Paper: 31st October, 1995

All international participants should sent their abstract to:
Dr. V.M. Salokhe, Associate Professor, Agricultural and Food Engineering Program, Asian Institute of Technology, GPO Box. 2754, Bangkok 10501, Thailand Tel: (66-2) 5245479; 5245450, Fax: (66-2) 5246200; 5162126.

National No-Tillage Conference

January 11-13, 1996
The Adam's Mark Hotel, St. Louis, Mo. U.S.A.

No-Till Farmer brought them in by the droves in Indianapolis this year. This conference is particularly adept at attracting seasoned no-till veterans.

Contact: National No-Tillage Conference, P.O. Box 624, Brookfield, WI53008-0624 U.S.A.

ASP96 — 26th National Agricultural Plastics Congress and American Greenhouse Vegetable Growers Association Conference

June 14-18, 1996
American Society for Plasticulture, Holiday Inn Boardwalk Hotel, Atlantic City, New Jersey, U.S.A.

This year's program has been designed to take advantage of the people, growers, industry, and environment of New Jersey — the Garden State.

The theme of "Educating the Teachers of Plasticulture" pervades the entire conference. Our focus is to

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educate the participants, whether they are researchers, industry personnel, county agents, regional specialists, or newly interested colleagues, as teachers of the procedures, practices, and philosophy of Plasticulture.

ASP96 will feature the participation on individuals from a number of professional organizations with shared interests in plasticulture. The American Greenhouse Vegetable Growers Assoc. (AGVGA) will conduct a full day grower-oriented session, organized by AGVGA'ers Tim Carpenter and Rick Snyder. USDA regional research committees on Microirrigation (S-247) and Controlled Environment Agriculture (NE-164), and the Center for Controlled Environment Agriculture (CCEA) will also convene meetings.

An entire afternoon of hands-on demonstrations and lectures will take place at the *ASP Workshop*. This will occur at the Rutgers Research & Development Center, Rutger's premier horticultural research farm locxated in Bridgeton, NJ, the center of the State's vegetable and fruit production region.

The technical program of ASP96 will include a variety of topics, ranging from Drip Irrigation/Chemigation to Controlled Environment Greenhouse Systems, from Row Covers, High/Low Tunnels, and Mulches to Plastics Disposal and Recycling, and from Greenhouse Vegetable Production to Hydrogels.

The Second International Symposium on Plant Production in Closed Ecosystems: Automation, Culture, and Environment

August 26-30, 1996
Narita, Japan

The Second Symposium on A.C.E. (Automation, Culture, and Environment) System is to be held from 26-30 August, 1996 at Narita, Japan. The first A.C.E. Symposium was held in July, 1994, in New Jersey, U.S.A. concentrating on greenhouse systems. The coming symposium will cover a wider range of closed plant production systems, which are expected to become more and more important in the 21st century.

The Symposium will cover various technologies, findings, analyses, and theories related to closed plant production systems such as:

a) CBLSS (Closed Bioregenerative Life Support Systems),
b) plant cell and tissue culture systems (bioreactors, scale-up of culture systems, etc.),
c) plant factories, greenhouses,
d) transplant production systems,
e) post harvest systems, etc.

Contact:
c/o Dr. Kenji Kurata, Dept. of Agricultural Engineering, Faculty of Agriculture, University of Tokyo, Yayoi 1-1-1, Bunkyo-ku, Tokyo 113, Japan. Fax: 81 (Japan)-3-3813-2437.

Second Workshop on Sustainable Land Use Planning with Special Regard to Central and Eastern European Countries

September 4-6, 1996
University Campus, Gödöllö, Hungary

The Gödöllö University of Agricultural Sciences and the 1st Section of National Committee of International Comission of Agricultural Engineering (CIGR) have the honour to host the Workshop on Sustainable Land Use Planning in Gödöllö on 4-5-6 September 1996.

The first workshop was held at Wageningen, the Netherlands in 1992 dealing with the questions of policies, methods, information systems and projects of sustainable land use planning. The objectives of the second workshop are to search acceptable solutions for the land use in the Eastern European countries under conditions of radical change of their national economies. It is still generally accepted opinion that the main function of agriculture is to produce traditional agricultural products, mostly food staffs. Before a new investment cycle is started to replace the existing run-down production capacities it is essential to determine a clear orientation for the future functions of agriculture. It is an important question for these countries to adapt the experiences of highly developed countries, to find new farming methods for harmonization the agricultural production with nature preservation and environmental control, all this in the framework of sustainability.

Secretariat:
Gödöllö University of Agricultural Sciences, H-2103 Gödöllö, Hungary
Phone: +36-28-310-200, Fax: +36-28-310-804, E-mail: TSZALAI@FA.GAU.HU

International Conference on Evapotranspiration and Irrigation Scheduling

November 3-6, 1996
Convention Center, San Antonio, Texas

The international Conference will focus on reporting new technology, providing updates on existing technology, discuss techniques to apply a technology, and identify and prioritize future needs. Researchers, consultants, designers, instructors, extension specialists, practitioners, managers, users, and manufacturer representatives of instrumentation used for evapotranspiration and irrigation scheduling are encouraged to participate.

Sponsored by:
The American Society of Agricultural Engineers

Co-sponsors:
The Irrigation Association
International Committee on Irrigation and Drainage

For conference content information contact:
Claude Phene, Co-chair, SDI Consultant, P.O. Box 314, Clovis, CA 93613 Telephone: 209.298.0201 Fax: 209. 298.8068
Claudio Stockle, Co-chair, Washington State Univ. Biological Systems Eng. Dept., Pullman, WA 99164-6120 Telephone: 609.335.3826 Fax: 509. 335.2722 INTERNET Stockle@mail.wsu.edu

The International Ag Equipment Community will Meet in Chicago

Bringing together all participants in the farm equipment industry in one location at one time is a big idea with big results. This bulletin will provide information on the conventions and meetings in Chicago.

AIMRA

The Agricultural and Industrial Manufacturers Representatives Association Marketing Conference will be held following the NAAEC. The AIMRA Conference begins on Sunday, November 5 at 4:30 p.m. and concludes on Tuesday evening November 8. AIMRA will participate in the communication center by posting its attendees and their room numbers to ease making business appointments.

AIMRA members should mail their AIMRA and NAAEC registration form to the AIMRA office at 5818 Reeds Road, Mission, KS 66202-0174. For information contact AIMRA Headquarters at (913) 262-0317.

ASAE

ASAE is holding its annual Agricultural Equipment Technology Conference sponsored by The Power and Machinery Division, November 1-4. The group holds an exhibition and Technology Transfer Poster Session on November 2.

AECT registrants will register through the ASAE office. Those attending the NAAEC will use the separate NAAEC registration form. For information contact, Tony Kajewski, P.O. Box 8000, Waterloo, IA 50704, (319) 292-8693.

EMI

EMI members will register and reserve their hotel rooms on the NAAEC registration form. EMI members attending the Saturday meeting should check the area marked "EMI Only - Sat. a.m." There is no additional charge for this event, which will be a meeting of the EMI Farm Equipment Councils.

FEMA

Equipment manufacturers and suppliers on the FEMA mailing list will receive one reigstration form for convenient enrollment for the FEMA Fall Convention, the North American Agricultural Equipment Conference, and hotel reservations. Registration payment and hotel guarantee fees should be mailed with the registration form to the registration office in St. Louis.

People attending through the FEMA organization will have their names and room numbers posted in the FEMA Communication Center, where registrants to the NAAEC and affiliated conventions may enter to make appointments with manufacturers and their suppliers. Registrants will receive substantial discounts for registering for both the FEMA Fall Convention and North American Agricultural Equipment Conference.

NAEDA

The North American Equipment Dealers Association will hold its annual convention Nov. 2-4. NAEDA members may register for all events on one convenient form and should mail their hotel and registration fees to NAAEC, Dept 580, P.O. Box 790044, St. Louis, MO 63179-0044. (314) 821-7220.

NAEDA members enrolling will be admitted to the FEMA Communication Center, FEWA Showcase, and receive discounts for registering for both the NAAEC and NAEDA meetings.

FEWA

The Farm Equipment Wholesalers Association will be holding its Annual Convention beginning November 5, 1995, with its Industry Showcase. To enroll in the Showcase, or the FEWA Convention, call the FEWA office for registration materials at 319/354-5156. FEWA will participate in the joint communications center beginning Sunday afternoon through Wednesday, November 8.

UNACOMA General Assembly for its 50th Anniversary

June 14, 1995
The Technica Auditorium, Rome

UNACOMA celebrates the 50th anniversary of its founding with an initiative of special significance: the donation of agricultural machinery and equipment by industries in the sector to agricultural enterprises in the developing countries indicated by Caritas International. To date, 35 manufacturers have joined the initiative and others are certain to come in before the official delivery of the donations, planned for early November to coincide with the XXVI edition of EIMA.

Thus UNACOMA intended to recall its first 50 years through a gesture of solidarity, the merits of which lie especially in furthering peace among peoples and stimulating the introduction of technologies most suited to agricultural work, which is at the root of all human affairs.

UNACOMA's first 50 years are also recalled in a publication designed and compiled with the cooperation of the Accademia dei Georgofili and based on contributions from illustrious writers. These authors have covered the history of agriculture and mechanization in this period of great importance for the Italian economy and society, along with the new challenges faced and new opportunities to reap.

Starting in last place when classified with North American and European competitors, Italian industry has attained outstanding positions over these 50 years - rising to second place behind the United States in value and first in number of units produced. This industry, which exports an average of 70% of turnover, can be considered a world leader for type and range of equipment while maintaining its identity by remaining uninvolved in the phenomenon of multi-nationalization, occurring in other industrial sectors.

Even in the most recent years from 1981 to 1993, a time of a s tructural market crisis, Italian manufacturers invested in research, plant and sales networks in demonstrating their spirit of initiative and organizational capabilities.

Future prospects lie in the direction of varying forms of cooperation among enterprises for heightening ideal synergies and coming to terms with more limited demand on the market which will be, consequently, more highly competitive.

As a result of this, the 'country system' will exercise an increasingly greater influence on the industry trend because of limitations on public spending, inflation and cost factors. In addition, there is a need to speed up the application in Italy of such specific measures as the European Union's Machinery Directive, because the failure to do so creates uncertainties in the areas of forming surveillance agencies and defining sanctions for non-compliance. Moreover, financing must be considered for the technological renewal of obsolete machinery assets in connection with the new multi-year law on planned interventions in agriculture. Finally, there must be a resumption of the project for the coordination of research in the field of mechanization to bring up to date the one pursued by the National Research Council from 1976 to 1981.

VDI-MEG: The New Society of Agricultural Engineering in Germany

The former "Max-Eyth-Gesellschaft für Agrartechnik" (MEG) and the former "VDI-Gesellschaft Agrartechnik" (VDI-AGR) have been united to a new German society under the roof of the powerful "Verein Deutscher Ingenieure" (VDI). After a long time of cooperation between both societies in the different fields of agricultural engineering and after an even longer period of discussions for a unification, a new society was founded October 14, 1994 in the castle of Hohenheim to start its business from January 1, 1995 under its first president Prof. Dr.-Ing. Karl Th. Renius, head of the Agricultural Machinery Institute at Technical University of Munich.

The name of the new society is "Max-Eyth-Gesellschaft Agrartechnik im VDI" (VDI-MEG) with morre than 1 000 individual members comprising some 200 student and senior members. Beside individual membership many German associations and institutions, dealing with agricultural engineering are linked to the a ctivities of VDI-MEG - that means VDI-MEG as a society is focussing all parts of agricultural engineering in Germany. VDI-MEG took over all activities of the former societies MEG and VDI-AGR.

The new society will celebrate its foundation during its next International Meeting "Landtechnik", which will take place Oct. 12-13, 1995 in the city hall of Braunschweig. (Informations available from VDI-MEG Düsseldorf, Fax: (0) 211-6214-163).

Loyd Johnson Receives ASAE Kishida International Award

The recipient of the 1995 ASAE Kishida International Award is Loyd Johnson, P.E., in recognition of his outstanding contributions in the worldwide system of agricultural research, resulting in the post-1966 trend of increased foodgrain yields in developing countries.

Presently retired from the Rockefeller Foundation, and most recently a consulting agricultural engineer with Winrock International, Johnson devoted his efforts to the improvement of agriculture worldwide.

In the Philippines, he oversaw engineering of the research facilities for the International Rice Research Institute (IRRI). In Colombia, he engineered the facilities for the International Center for Tropical Agriculture (CIAT). He also worked on a broad range of problems in agriculture in countries including Bangladesh, Pakistan, Guatemala, Honduras, Ecuador and Ethiopia. He worked as a team member with the World Bank on projects in Sudan and Spain, and with the Ford Foundation's agricultural research team, also in Sudan. He took part in a USAID Tractor Survey in Laos.

Johnson's commitment to improving food production in developing countries was evident in his institution and personal supervision of training programs at research facilities. His teaching skills contributed to the training of future researchers and to the strengthening of the agricultural engineering programs of universities. His leadership extended to the installation of agricultural engineering research programs at IRRI, CIAT and other centers.

Johnson pioneered the concepts of energy analysis in the understanding and planning of agricultural mechanization programs and was among the early leaders in research on mechanically powered, small-scale, low-cost machines for developing country farmers.

He has authored numerous publications, including *Is Mechanization Possible Where Rice is King?* and *Rice Cultivation in the Tidal Swamps of Ecuador*. In 1983, he was recognized as Honorary Founder of CIAT.

William E. Splinter Receives John Deere Gold Medal

ASAE Fellow William E. Splinter, P.E., is the recipient of the 1995 John Deere Gold Medal in honor of his meritorious achievement in the application of scientific and engineering principles to the solution of problems in agriculture and as a scholar, educator and leader of the profession.

Noted for his significant accomplishments as a scholar, Splinter developed innovative systems and machines which have been applied in agriculture. He was one of the first scholars in the profession to make the strong connection between basic biology and engineering. His most significant contributions, however, have been in the mentoring of faculty and students, enhancing the capabilities and resources available to such individuals so they could conduct leading-edge research.

In 1975, Splinter was the recipient of the Society's Nebraska Section Outstanding Contribution to Agriculture Award. He was also awarded the 1978 Massey-Ferguson Medal. In 1977, he was honored by the Professional Engineers of Nebraska for the Outstanding Engineering Achievement Award, and was elected to the prestigious National Academy of Engineering in 1984. Splinter holds five patents (both U.S. and Canadian). Internationally recognized, Splinter has been the invited lecturer at numerous universities throughout the world. In Southern Rhodesia (Zimbabwe) and the former Rep. of South Africa, he was the invited speaker and guest at the First International Tobacco Congress. In India, he served as a consultant for the Ford Foundation at the Indian Institute of Technology. He conducted research at the University of Melbourne in Australia and visited universities and research stations in both Australia and New Zealand.

A member of ASAE since 1953, Splinter has served the Society in a wide variety of key leadership roles including that of ASAE director of publications from 1972-74, regional vice president in 1976 and ASAE president in 1978.

George J. Kriz Elected President of ASAE

George J. Kriz, associate director of the North Carolina Agricultural Research Service (NCARS) at North Carolina State University in Raleigh, has been named President of ASAE, the Society for engineering in agricultural, food and biological systems.

Kriz was inaugurated at the Society's Annual International Meeting, June 18-23, at the Hyatt Regency, Chicago. As president of the society, he is primary spokesperson for more than 9,000 members in 50 states, 10 provinces, and 110 countries. He will hold the position of president for one year, then serve on the Board of Directors for one year in the position of Past President.

Kriz came to the Department of Biological and Agricultural Engineering in 1965 and was appointed in 1969 as the associate head, the first in CALS. While in the department, he developed the CALS water management research program and initiated its animal waste management program. Since 1973, Kriz has been in the NCARS office and has been responsible for coordinating research across departments in CLAS, particularly the biennial budgets. He cultivated active interchange with the commodity organizations, many of which provide funding for CALS.

A member of ASAE since 1960, Kriz was named a Fellow of the Society in 1987. He has devoted his energies to a number of Society offices and projects. He has served as vice preisdent for projects and grants for the ASAE Foundation, as a Foundation Trustee and as director of education and research. In 1983, Kriz organized the Ad-Hoc University Administrators Group, which has since become an established committee. He served on the Steering Committee for Project 100 (1985-87), and during the same years served as ASAE's representative to the Council for Agricultural Science and Technology (CAST). ASAE's first Roundtable, "Our Biosphere, Our Responsibility," was coordinated by Kriz.

Kriz has not limited his activities to ASAE, but has served on numerous committees at national and regional levels in the Experiment Station System, particularly in the strategic planning process. Currently, he serves on the Agricultural Research Institute Board of Directors.

Allen R. Rider Named President-elect of ASAE

Allen R. Rider, P.E., vice president of operations at New Holland North America, has been named President-elect of ASAE, the Society for engineering in agricultural, food and biological systems.

He was installed at the Society's Annual International Meeting, June 18-23, at the Hyatt Regency, Chicago. He will assume the position of president for the Society next year and continue on the Executive Committee a third year as past-president.

Rider was raised on a dryland farm in Eastern Colorado. He earned his B.S. and M.S. degrees in agricultural engineering at the Colorado State University and, in 1973, earned his Ph.D. in agricultural engineering at the University of Illinois, Urbana.

Rider began his professional career as an associate professor of agricultural engineering at the Oklahoma State University before moving on to the University of Nebraska. In 1979, he joined New Holland as a senior research engineer. Since then, he's progressed through several positions with New Holland, including director of product testing, vice president of North American engineering, and vice president of product engineering.

A member of ASAE for 30 years, Rider was named a Fellow of the Society in 1986. He served for three years in the position of treasurer, and has served as director of the Power and Machinery Division, and as a member and chair of several technical and professional committees.

Osamu Kitani Elected ASAE Fellow

Osamu Kitani, P.E., professor emeritus with the Department of Agricultural Engineering at the University of Tokyo, has been elected a Fellow of ASAE, the Society for engineering in agricultural, food, and biological systems. He was honored at the Society's Annual International Meeting, June 18-23, at the Hyatt Regency, Chicago.

Election to Fellow is one of the highest distinctions an ASAE member can achieve. Elected annually by ASAE's Board of Directors, Fellows are chosen for their unusual professional distinction and extraordinary qualifications. A minimum of 20 years of active practice of engineering or teaching of engineering with demonstrated distinction in performance for at least 5 of those years is required for nomination. Election to Fellow is a distinction earned by only about two percent of the ASAE membership.

Kitani is president-elect of the International Commission of Agricultural Engineering and president of the Japanese Society of Agricultural Machinery. His distinguished career has left an impressive mark on the world of agricultural engineering. Kitani's research in soil dynamics as related to tillage machinery is widely recognized. He is considered a leader in the areas of solar energy and biomass, system and information engineering in agriculture, and international activities for small-scale farm mechanization. An outstanding tutor, Kitani's ease in communicating with people from all walks of life, coupled with his effectiveness as a leader, have greatly benefitted the profession.

Graeme R. Quick Elected ASAE Fellow

Graeme R. Quick, P.E., a consulting engineer in Queensland, Australia, has been elected a Fellow of ASAE, the Society for engineering in agricultural, food, and biological systems. He was honored at the Society's Annual International Meeting, June 18-23, at the Hyatt Regency, Chicago.

Election to Fellow is one of the highest distinctions an ASAE member can achieve. Elected annually by ASAE's Board of Directors, Fellows are chosen for their unusual professional distinction and extraordinary qualifications. A minimum of 20 years of active practice of engineering or teaching of engineering with demonstrated distinction in performance for at least five or those years is required for nomination. Election to Fellow is a distinction earned by only about two percent of the ASAE membership.

Quick is recognized internationally for his expertise, particularly in the area of grain harvesting. The publication of his highly successful *The Grain Harvesters* by ASAE, helped establish the Society as a major publisher of historical works. As former head of the Department of Agricultural Engineering at the International Rice Research Institute, he made significant contributions to the development of low cost implements for developing world agriculture. ■■

BOOK REVIEW

Physico-chemical Constituents and Engineering Properties of Food Crops

(India)

edited by R.P. Kachru, R.K. Gupta and A. Alam

The physical constituents and engineering properties of food crops are important for the design of machines and analysis of the behaviour of the product in their handling and processing. The information on the major chemical constituents, viz; carbohydrate, protein and fat content of food crops, would be helpful in making a balance diet.

Considerable research data on various engineering properties and physical as well as chemical constituents of food crops have been generated and published in scientific journals, reports etc. However, the information is not readily available to the users since the same is documented in a scattered manner.

The publication has been divided in eight chapters covering topics on physico-chemical constituents of food crops, definitions and methods for determination of physical, mechanical, thermal and biological properties of food materials. At the end of each chapter, research data on engineering properties collected from various sources have been given in the form of tables. The standard curves for various properties and instrumentation required for their determination are also given in the book. Glossary of food products with botonical and hindi names provided at the end may take it more convenient to the users.

The contents of the book are so grouped to facilitate its usage as text or reference material for students and teachers in technical universities as well as researchers in any branch of science and technology and engineers concerned with physical behaviour of food materials.

1994. 188 pages, hard cover.

Price: Rs. 450.

Published by Scientific Publishers, 5-A, New Pali Road, Post Box: 91, Jodhpur-342 001, Rajasthan, India.

Soil Physical Properties: Measurement and use in rice-based cropping systems

(Philippines)

edited by M. Wopereis, M. Kropff, J. Bouma, A. Van Wijk and T. Woodhead

Water is the major factor that determines rice production in rainfed and irrigated ecosystems. All too often the scarcity and the necessity for careful use of this resource is ignored. Efficient management of soil water, whether its source be rainfall or irrigation, is vital to global rice production.

There has long been a need to improve procedures for the measurement and management of processes related to soil hydrology and soil structure, and to characterize physical and hydrological features of rice soil that determine spatial and temporal variability in rice yield.

This comprehensive manual addresses these problems, being one of the important outputs of a joint project between IRRI, DLO-Winand Staring Centre for Integrated Land, Soil and Water Research (SC-DLO), and the Department of Soil Science and Geology of the Wageningen Agricultural University.

1994. 111 pages. 15.24 × 22.86 cm. Paperback. HDC US$7.50. LDC US$2.00 plus airmail (US$3.50) or surface (US$1.50) postage.

This book is available from Communication and Publications services, IRRI, P.O. Box 933, Manila 1099, Philippines.

Four New Books from MAW Chang Book Company, Taipei, Taiwan, ROC

(Taiwan)

edited by Liu Fu-shan

Four New books on Taiwan's amazing agricultural development that contributes to that "Taiwan Miracle" are now available in MAW Chang Book Co.

To unfold the secrets behind the success story of Taiwan in term of its rapid agricultural development in the past five decades, MAW Chang has published the following four books by Dr. Liu Fu-shan:

1. "Building An Agricultural Marketing System in A Developing Country: The Taiwan Experience";
2. "Building An Agricultural Financial System in A Developing Country: The Taiwan Experience";
3. "Building An Agricultural Extension System in A Developing Country: The Taiwan Experience";
4. "Building A Farmers' Organization in A Developing Country: The Taiwan Experience".

These four books will assuredly offer very valuable information for those who are concerned about marketing improvement, agricultural extension, farmers' organization and agricultural financial system in either developed countries or developing countries.

Dr. Liu Fu-shan, author of the four books, currently serves as Deputy Director of the Farmers' Service Development at the cabinet-level Council of Agriculture (COA), the highest agricultural administration in the Republic of China on Taiwan.

Price: Series No.1-US$35.00, Series No.2-US$35.00, Series No.3-US$38.00, Series No.4-US$40.00.

Published by MAW Chang Book Co., 9th FL., No.196, Chung Chen Road, Hsientien City, Taipei Country, Taiwan, R.O.C. 231.

Advances in Soil Dynamics Vol. 1

(USA)

The role of soil dynamics in solving problems and developing technology for things that move across and through soil is recognized as being important around the world. New crop production methods and manufactured products increasingly must rely on the technical advantages gained through the use of soil dynamics information.

This book is the first volume in a new series of monographs entitled *Advances in Soil Dynamics*. This unique series recognizes the increasing demands for qualitative and quantitative information on soil-machine interactions and physical soil-plant interactions. Volume One of this series covers state-of-the-art information on soil bins, soil physical properties and advances in soil plant dynamics.

330 pages, 6 × 9 inches, hardbound.

Member $34.00 List $42.00

Published by ASAE, 2950 Niles Road, St. Joseph, Michigan 49085-9659 USA.

On-Site Wastewater Treatment Vol. 7

Proceedings of the Seventh International Symposium on Individual and Small Community Sewage Systems

(USA)

edited by Eldridge Collins

This Proceedings is the record of the Seventh National Symposium on Individual and Small Community Sewage Systems. The previous six Symposia were held in 1974, 1977, 1980, 1983, 1987, and 1991. All were sponsored by ASAE. Many of the previous Proceedings are still available from ASAE, and serve as excellent references for this field of interest. The purpose of this Symposium is to continue the ASAE commitment toward providing opportunities for anyone holding major information on individual and small community sewage treatment to share research and discuss critical issues.

Highlights include:

- Implementing On-Site Technologies
- Septic Tanks
- Design and Performance of Constructed Wetlands
- Various Impacts of On-Site Systems
- Mechanics of Soil Based Systems
- Field Evaluations and Alternative Technologies
- Design and Evaluation of Sand Filters
- Small Community Options
- Nitrogen Removal
- Pressure Distribution Systems

600 pages, 6 × 9 inches, softbound.

Member $36.00 List $45.00.

Published by ASAE, 2950 Niles Road, St. Joseph, Michigan 49085-9659 USA.

International Mounted Units Bearing Interchange (IMUI) Guide

(U.S.A.)

Interchange, Inc. currently publishes a series of guides for cross-referencing interchangeable parts such as bearings, seals, drive belts and filters. Now the International Mounted Units Bearing Interchange (IMUI) Guide has been added to this unique selection of titles. Consisting of Pillow Blocks, Flange Units, Take-up Units, Cylindrical Cartridges and Hanging Bearings, this guide is invaluable to anyone buying, selling or using these unique bearing types. More than 32,000 worldwide producers and OEM part numbers are listed making equivalent part identification fast and easy.

Part numbers are sequenced numerically, making this mounted units guide as easy to use as a telephone book or a dictionary. The volume provides cross-references for a variety of applications and is the ideal companion to the International Interchange Guide for Bearings.

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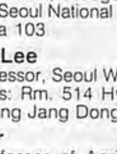
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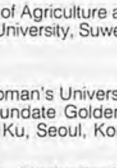
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The Updated Version of the AMA Computerized Index Available

A computerized index of technical articles in Agricultural Mechanization in Asia, Africa and Latin America has been compiled for the year 1971 through 1992. Each citation includes truncated versions of the title, first and second authors' names and four keywords. Year, issue and page number of each article are given. The citations along with software for searching the database are all included on a single computer diskette for use with IBM compatible type computers.

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