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EDITORIAL

Shin-Norinsha Has Come a Long Way

The story behind the success of a threesome, namely; the Chugai-Norinsha, founded in 1933 and later renamed Shin-Norinsha; the Farm Machinery Research Corporation established in 1971 as a subsidiary company; and the quarterly journal so-named AMA then as now, also founded in 1971, is a study in expanding communication.

This year, 2003, marks the 70th anniversary of the Shin-Norinsha which indeed has come a long way. Sans any birthday celebration about reaching age 70 years, we cannot but look back with pride and look forward to with hope that the celebrant promises to do more than what it has already accomplished in expanding communication. No less remarkable has been the role of the Farm Machinery Research Corporation in supporting the efforts of AMA in disseminating worthwhile information and knowledge via the printed medium. Early on, the then Chugai-Norinsha's newspaper was the Chugai Agriculture and Forestry now known as the weekly Agricultural Machinery News.

Whereas the early efforts of the same threesome on the promotion of agricultural machinery was initially addressed largely to Japan's medium-and small-sized farms, the expanding communication has progressed by leaps and bounds as AMA's readership also expanded in area and coverage. The rather unexpected enthusiasm of numerous contributors/editors of articles for AMA publication has been instrumental in this development. As of the last count (AMA's Spring 2003 issue) there was a total of 82 cooperating editors/contributors from 52 countries: 18 and 12 in Africa; 14 and 8 in the Americas; 41 and 23 in Asia and Oceania; and 9 and 9 in Europe.

For another, the rice transplanter and head feeding combine that Japan developed have revolutionized transplanting and harvesting rice not only in Japan but also in many rice producing countries where these machineries proliferated in large numbers.

In conformity with Shin-Norinsha's high resolve to forge ahead in its serious mission of promoting agricultural mechanization and expanding communication, the Farm Machinery Industrial Research Corporation stands ready, willing and able to continue to support the AMA in its endeavor - even if it takes another 70 more years.

Yoshisuke Kishida
Chief Editor

Tokyo, Japan
July 2003

CONTENTS

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

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Effect of Different Seedbed Preparation Methods on Physical Properties of Soil

by
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Abstract

A comparative study was carried out with four different seedbed preparation methods to determine the effect of different seedbed preparation methods on physical properties of soil. The methods were: Method I: chisel + disc harrow + float; Method II: mouldboard plough + disc harrow + float; Method III: mouldboard plough + rotary cultivator + float; and Method IV: chisel + rotary cultivator + float. In comparison with other methods, using rotary cultivator in Methods III and IV reduced the soil moisture content more rapidly and the penetration resistance of the soil at the depth of 5 and 10 cm. The minimum decrease in soil moisture content was observed at Method I during seven days. The least bulk density and highest porosity values were determined at Methods III and IV.

Introduction

The aim of soil tillage is to prepare a proper growing condition in the soil for the seed. Several studies on seedbed preparation have been made. Saglam et al. (1996) determined the effect of various tillage methods on the growth of plants and yield. Özarslan et al. (1999) reported the best soil tillage method by considering the relation of seed, fertilizer, fuel, time consumption and yield. For this purpose they used four different soil tillage methods: Method 1: mouldboard plough + disc harrow; Method 2: chisel + rototiller; Method 3: rotary cultivator; and Method 4: mouldboard plough + (cultivator + rotary harrow). Karaca et al. (1999) studied a suitable seedbed preparation for ridge planting that has some advantages according to the conventional seedbed preparation in cotton production. Pinar et al. (1992) compared 6 seedbed preparation methods used currently in Samsun region in terms of soil compaction, soil segmentation, bulk density and porosity.

This study aimed at determining the effect of different seedbed preparation methods on physical properties of the soil. Four different seedbed preparation methods were also used: Method I: Chisel + Disc Harrow + Float; Method II: Mouldboard Plough + Disc Harrow + Float; Method III: Mouldboard Plough + Rotary Cultivator + Float; and Method IV: Chisel + Rotary Cultivator + Float.

Acknowledgements

This project was supported by the Research Fund of Akdeniz University which is hereby gratefully acknowledged.

Materials

The research was undertaken on the facilities of Akdeniz University, Faculty of Agriculture, and Aksu Research and Application Land. The soil is composed of 38.1% sand, 26.0% silt, 35.9% clay and classified as silty-loam soil.

A general specification of seedbed preparation equipment is given in **Table 1**. In the choice of soil tillage equipment used in the research, especially the ones used commonly in the Antalya Region were preferred.

In Methods II and III the plowing depth was normally 20 cm. In Methods I and IV chisel depth was 25-30 cm and in Methods I and II disc harrow was passed twice for seedbed preparation.

The soil compaction was measured by a standard cone penetrograph. As can be seen in **Fig. 1**, the penetrometer consist on a handle, a compression bar with a compression helical spring, a recording pen, a card controller, helix bar with its support and conic penetration tip. During the penetration process, data were recorded on scaled paper. Data were converted into the

Table 1. Tillage Equipment Used in Seedbed Preparation

Equipment	Working width, cm	Specification
Mouldboard plough	107	4 furrows made
Disc harrow	205	18 discs used
Chisel	210	6 furrows made
Rotary cultivator	200	24 blades used
Float	214	Tractor mounted

cone indexes using calibration curve of penetrograph.

Method

The experimental design was organised according to randomised plot design using four replications. Four seedbed preparation methods were compared; Method I: chisel + disc harrow + float; Method II: mouldboard plough + disc harrow + float; Method III: mouldboard plough + rotary cultivator + float; and Method IV: chisel + rotary cultivator + float.

In order to characterize the physical properties of the soil after the seedbed preparation process the followings were measured: a) Penetration resistance of the soil (MPa); b) Soil moisture measurements at the depth intervals of 0-10 and 10-20 cm; c) Bulk density of the soil (g/cm^3); and d) Porosity of the soil (%).

Soil samples were taken from the depth of 0-10, and 10-20 cm to determine bulk density and porosity of the soil. Cylinders with diameter of 5 cm and volume of 100 cm^3 were used to take soil samples. The soil samples were kept in 105 ^oC for 24 hours and weighed again to determine the moisture content.

Results and Discussion

The effect of different seedbed preparation methods on soil moisture content during seven days are given at **Figs. 2 and 3**.

The least soil moisture content was obtained at Methods III and IV during seven days after the seedbed preparation process. The decrease in soil moisture content was observed 3.8 %, and 3.6 % for Method I, 5.6%, and 5.9% for Method II, 7.7%, and 7.4% for Method III, and 8.4%, and 8.5% for Method IV at the depth of 0-10 cm, 10-20 cm intervals, respectively. The use of rotary cultivator for seedbed preparation at Methods III and IV reduced the soil moisture content more rapidly than other methods.

As shown in **Table 2** the least bulk density and highest porosity values were in Methods III and IV. Previous studies have found that the rotary cultivator causes a lower bulk density as well as higher porosity values as compared to the other tillage applications (Önal and Aykas, 1999; Özarslan et al., 1999).

Although slight differences exist between the means of penetration resistance of the soil, it is statistically not important. When the values of the penetration resistance of the soil depth of 5 cm and 10 cm were examined, penetration resistance was reduced using the rotary cultivator at Methods III and IV (**Table 3**).

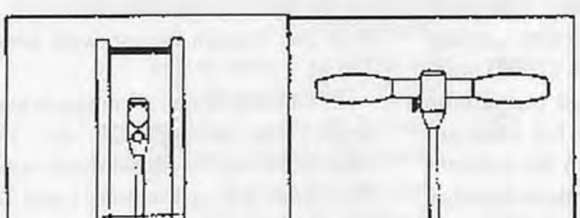

Fig. 1 Sketch of penetrometer used.

Table 2. Bulk Density and Porosity of Soil

Seedbed preparation methods	Seeding depth (cm)	Bulk density (g/cm^3)	Porosity (%)
I	0-10	1.10	53.5
	10-20	1.20	49.4
II	0-10	1.08	54.4
	10-20	1.21	48.9
III	0-10	1.02	57.1
	10-20	1.17	51.4
IV	0-10	1.01	57.9
	10-20	1.18	51.1

Table 3. Soil Penetration Resistance

Soil depth	Penetration resistance (MPa)				
(cm)	I	II	III	IV	Significance
5	1.4a^y	1.3a	0.7b	0.8b	*
10	1.4a	1.4a	0.9b	1.0b	*
15	1.5	1.8	1.8	1.7	NS
20	1.8	1.8	2.0	2.0	NS
25	2.0	2.0	2.3	2.0	NS
Mean	1.56	1.68	1.62	1.56	NS

^{y} Means within a group followed by the same letter are not significantly different at probability P=0.05, by Duncan's multiple range test.
* Significant at P ≤ 0.05.
NS, Nonsignificant at P ≤ 0.05

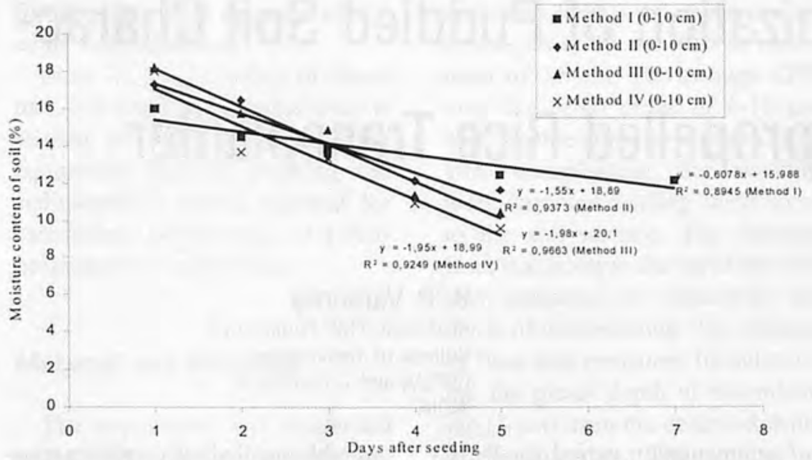

Fig. 2 Changing of soil moisture content of soil at the depth of 0-10 cm during 7 days.

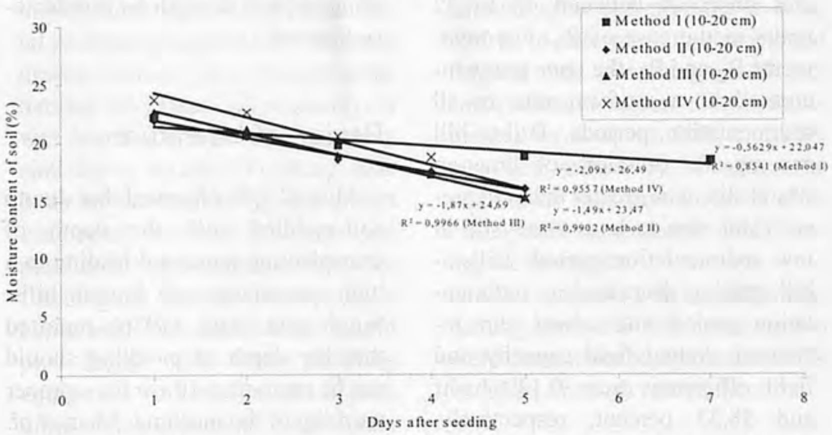

Fig. 3 Changing of Soil moisture content of soil at the depth of 10-20 cm during 7 days.

Conclusion

Based on this study, the following conclusions have been reached:

(1)In comparison with other methods, the use of rotary cultivator reduced the soil moisture content more rapidly including the penetration resistance of the soil depth of 5 and 10 cm.

(2)The minimum decrease in soil moisture content observed at Method I during seven days.

(3)The least bulk density and highest porosity values were determined at Methods III and IV.

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Studies on Optimization of Puddled Soil Characteristics for Self-propelled Rice Transplanter

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Abstract

Studies were undertaken in silty clay loam soil to identify optimum puddled soil condition for self-propelled rice transplanter. The experiment was conducted with three types of puddler, namely; rotary puddler (R), peg type puddler (P) and cultivator (C) with two levels of puddling viz. twice (2) and thrice (3). Transplanting was done using a Chinese-made self-propelled rice transplanter (Model: 2ZT-238-8) at sedimentation periods of 24, 48 and 72 hours. The results indicate that the depth of puddling and hardpan was in the range of 10-15 cm and 19-22 cm, respectively. The sinkage of the traction wheel was well into the hardpan thereby providing sufficient traction to propel the transplanter and hence no mobility problem was observed. Buried and floating hill percentage was considerably high after 24 hours of sedimentation period leading to high mortality. Buried hill, floating hill and hill mortality decreased with an increase in sedimentation time. At 48 hours of sedimentation period, the buried and floating hill percentage was within 2-3 percent and the hill mortality was within 4 percent in the case of P_2, C_2 and C_3. This indicates an ideal condition for transplanting. For other treatments (R_2, R_3 and P_3) ideal condition was obtained after 72 hours of puddling. The cone index values increased at a faster rate between 24 to 48 hours of sedimentation period for P_2, C_2 and C_3. But the same phenomenon was observed between 48 to 72 hours in the case of R_3. For treatments R_2 and P_3, the cone index increased at a uniform rate in all sedimentation periods. Hill-to-hill spacing, a function of traction wheel slip, was greater than the preset value due to less wheel slip at low sedimentation period. Hill-to-hill spacing decreased as sedimentation period and wheel slip increased. Actual field capacity and field efficiency were 0.149 ha/hr and 58.32 percent, respectively. Mat feeding time consumed 25.35 percent of total time of operation.

Introduction

Self-propelled rice transplanter has problems of poor traction, sinkage and steerability like all other wet land machinery. Since self-propelled rice transplanter works on puddled soil, the topsoil must have sufficient bearing capacity to minimize sinkage of the equipment. At the same time the hardpan must be sufficiently hard and not too deep to provide necessary traction to propel the transplanter. Both bearing as well as traction capacity are a function of shear strength of soil (Knight and Freitz, 1962). Usually a vehicle is immobilized by concurrent failure in bearing and traction. It is not possible to separate these two effects. A self-propelled rice transplanter requires a suitable puddled soil condition *vis-a-vis* depth of puddling, degree of puddling and soil strength for satisfactory function.

Review of Literature

Mori (1975) observed that due to soft-puddled soil, the depth of transplanting increased leading to a high percentage of buried hills. Singh and Garg (1976) reported that the depth of puddling should not be more than 10 cm for a proper working of the machine. Khan *et al.* (1979) found that there should be proper settlement of puddled soil before transplanting could be done. Depending upon soil texture, sedimentation period may differ from 1-10 days. Soft-puddled soil gives poor anchorage to seedlings. The flow of mud along with the float increases buried hill percentage (Singh *et al.*, 1981 and Singh *et al.*, 1985). High water level increases floating hill percentage (Singh *et al.*, 1985). Singh *et al.* (1981) found that water level should be within 1 to 2 cm to reduce excessive float drag force, which leads to bogging down of the transplanter. Kanoksak *et al.* (1988) found that soil mechanical properties like cone index and shear strength influence the transplanter performance in terms of buried and floating hills. Mufti and Khan (1995) observed that the depth of transplanting, transplanting angle, buried and floating hill percentage were affected by field condition.

From the above review of literature, it is felt that a detailed study is needed on the type of puddling equipment, level of puddling and sedimentation period required for satisfactory performance of a self-propelled rice transplanter.

Material and Methods

The experiment was conducted in the field with silty clay loam soil by using mat type seedling grown in polythene sheet. The experimental plot was ploughed with a tractor drawn vertical disc plough after harvest of wheat. Subsequently, it was harrowed twice and was leveled by a scraper. Puddling was done by three puddling equipment viz., rotary puddler (R), peg type puddler (P) and cultivator (C) after flooding the field for 24 hours. The experiment was laid out in a split plot design with three puddling equipment, and two levels of puddling which accounted for six main plot treatments. Sedimentation period of 24, 48 and 72 hours were taken as sub-plot treatment. Each experiment was replicated thrice. Transplanting was done by a Chinese-made self-propelled transplanter (Model: 2ZT-238-8).

Observations were taken on depth of puddling, hardpan depth and its hardness, cone index, depth of transplanting, sinkage of float, buried and floating hills, hill mortality, traction wheel slip, hill-to-hill spacing and hill population per sq. m.

The hardness of hardpan depth was measured by a cone penetrometer. The penetrometer was gradually pushed into the soil till there was no further penetration with maximum applied load. The corresponding depth represented hardpan depth and its cone penetrometer resistance represented its hardness. Cone penetrometer resistance (CPR) was measured up to a depth of 15 cm with an increment of 2.5 cm. The average CPR over the depth range of 0-15 cm was considered as cone index. Just after transplanting, the seedling were uprooted holding them close to the soil surface. The distance from that point to the tip of the root was measured to determine the depth of transplanting. The sinkage of float was measured by subtracting the preset depth of transplanting (3 cm) from the observed depth of transplanting. The number of hills buried and floating were counted after transplanting in a sq. m area to determine the buried and floating hill percentage with respect to total numbers of hills transplanted in a sq. m. Hill mortality was determined by counting the number of hills that survived after 15 days of transplanting (DAT) using the **Formula**.

Field capacity, field efficiency, turning time and fuel consumption were determined in a plot size of 24 × 81 sq. m. with two replications.

Results and Discussion

The effect of puddling by different puddling equipment on the depth of puddling, hardpan depth and its hardness are shown in **Table 1**. There was no appreciable variation in sinkage of traction wheel under different sedimentation periods. Hence it was pooled together to represent the sinkage in each main plot treatment (**Table 1**).

Maximum depth of puddling (14.36 cm) was obtained in the case of a rotary puddler with three passes (R_3), which was significantly higher than that of other treatments. The lowest puddling depth (10.72 cm) was recorded for cultivator with two passes (C_2). There was no significant difference in depth of puddling between treatments C_2 and P_2 and treatments R_2, P_3 and C_3, respectively. High depth of puddling in the case of R_3 may be due to higher level of puddling (3 passes) and more weight (240 kg) of the puddler. However, with peg type puddler and cultivator at the same level of puddling (3 passes), the depth of puddling was lower than that of the rotary puddler (R_3) which may be due to low weight of puddling equipment. The hardpan depth and its hardness varied within 19-22 cm and 1022-1123 kPa, respectively. There was no significant difference in hardpan and its hardness among all treatments. The

Formula

$$\text{Hill mortality, \%} = 1 - \frac{\text{No. of hills survived 15 DAT per sq.m}}{\text{Total no. of hills transplanted per sq.m}}$$

Table 1. Effect of Puddling by Using Different Puddling Equipment on Depth of Puddling, Hardpan Depth, Hardness of Hardpan and Traction Wheel Sinkage.

Puddling equipment	Treatment	Depth of puddling, cm	Hardpan depth, cm	Hardness of hardpan, kPa	Traction wheel sinkage, cm.
Rotary puddler twice puddling	R_2	12.23	21.92	1082.01	23.16
Rotary puddler thrice puddling	R_3	14.36	22.47	1123.14	24.50
Peg type puddler twice puddling	P_2	11.14	20.17	1115.12	22.86
Peg type puddler thrice puddling	P_3	12.79	22.00	1097.88	24.19
Cultivator twice puddling	C_2	10.72	19.08	1022.44	22.50
Cultivator thrice puddling	C_3	12.14	20.50	1030.69	23.62
	SEm ±	0.373	-	-	-
	CD(0.5%)	1.175	NS	NS	NS

traction wheel penetrated into the hardpan and thereby produced the necessary traction to propel the transplanter. Hence, no mobility problem of the transplanter was encountered during experimentation.

Cone index was measured to study the strength characteristics of puddled soil and its effect on transplanting parameters. The cone index values measured over a depth range of 0-15 cm at different sedimentation periods are presented in **Table 2**. It was observed that cone index was lowest (109.34 kPa) in the case of treatment R_3 at 24 hours of sedimentation period (S_1) with a reduction of 74 percent over that of saturated unpuddled soil. There was no significant difference in cone index between R_2 and P_3 at S_1. The maximum cone index of 248 kPa was observed in the case of C_2, which was significantly higher than other treatments. Cone index increased significantly for all treatments as sedimentation period increased. There was a faster rate of increase from 48 to 72 hours in case of R_3 contrary to a uniform rate of increase for treatments R_2 and P_3 for all sedimentation periods. But the rate of increase was high for C_2, C_3 and P_2 between 24 and 48 hours of sedimentation period indicating faster settling of soil compared to other treatments.

Table 2. Effect of Puddling by Using Different Puddling Equipment at 3 Levels of Sedimentation Period on Cone Index (0-15 cm). Cone Index of Saturated Soil: 421.56 kPa.

Puddling equipment	Treat-ment	Cone index, kPa		
		Sedimentation period, hrs		
		24	48	72
Rotary puddler twice puddling	R_2	150.27(64.35)	219.55(47.91)	289.96(31.22)*
Rotary puddler thrice puddling	R_3	109.34(74.06)	143.66(65.92)	241.35(42.95)
Peg type puddler twice puddling	P_2	207.56(50.76)	275.20(34.72)	324.76(22.96)
Peg type puddler thrice puddling	P_3	141.07(66.54)	204.81(51.42)	272.91(35.26)
Cultivator twice puddling	C_2	248.82(40.97)	338.14(19.79)	410.41(2.64)
Cultivator thrice puddling	C_3	202.51(51.96)	280.97(33.39)	328.76(22.01)

* Values in parenthesis show the percentage decrease of cone index w.r.t. saturated soil.

C.D. (0.05%) 1 2 3 4
14.51 4.94 12.10 17.55

The transplanting performance in terms of sinkage of float depth of transplanting, buried and floating hills, mortality, traction wheel slip, hill-to-hill spacing and hill population per sq. m are given in **Table 3**. The sinkage of float was significantly higher in the case of R_3 than those of other treatments at S_1. The lowest float sinkage (1.98 cm) was found in the case of C_2. As sedimentation period increased, the float sinkage decreased significantly for all treatments. At 72 hours of sedimentation period, the float sinkage was less than 1 cm for all treatments except R_3. Greater sinkage at S_1 might be due to soft-puddled soil (low cone index). With an increase in sedimentation period, the soil gained strength and can support the weight of the transplanter thereby resulting in low sinkage.

The depth of transplanting was set at 3 cm. It is clear from **Table 3** that the depth of transplanting in all treatments is more than 3 cm for all sedimentation periods. Maximum depth of transplanting (6.15 cm) was observed in the case of R_3 at S_1. Greater depth of transplanting than the preset depth was due to the sinkage of float on the soft-puddled soil, which was more pronounced at S_1. Depth of transplanting gradually decreased as sedimentation period increased.

Buried and floating hill percentage were considerably high at S_1 for treatments R_2, R_3 and P_3 compared to P_2, C_2 and C_3 which were statistically at par. As sedimentation period increased, the buried and floating hills percentage decreased significantly for all treatments with exception of C_2 where at S_3 there was higher floating hill percentage (3.00) compared to S_2 (1.28). This may be due to hard soil where there was a problem of penetration in transplanting finger into the soil. This situation was noted where there was a patch without water due to unleveled field condition. The high percentage of buried and floating hills at S_1 may be due

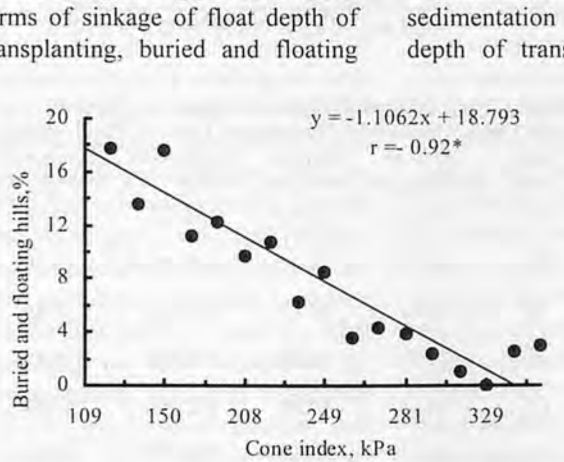

Fig. 1 Relationship between cone index and burried and floating hills.

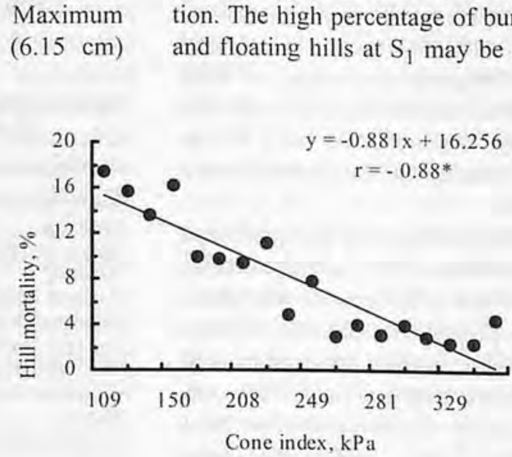

Fig. 2 Relationship between cone index and hill mortality.

to poor anchorage of seedling in the soft soil and movement of mud along with the float because of high float sinkage. High depth of transplanting might have also contributed towards the buried hill percentage. These results corroborate with the observations made by Singh *et al.* (1980) and Singh *et al.* (1985). There is a good negative correlation (r = -0.92*) between cone index and buried and floating hills percentage indicating that with an increase in cone index, buried and floating hills percentage decreased (**Fig. 1**).

Hill mortality followed a similar trend as that of buried and floating hills. It was observed that buried and floating hills did not contribute solely towards hill mortality. Some of the buried and floating hills might have survived and in some cases there might be mortality due to mechanical damage to root and stem. A good negative correlation (r = -0.88*) was found between cone index and hill mortality (**Fig. 2**).

Traction wheel slip was within 2.58 – 4.28 percent at S_1 and gradually increased with sedimentation period. A maximum wheel slip of 13.59 percent was recorded in the case of C_2 followed by C_3 (12.71 %) and P_2 (12.59%) at 72 hours of sedimentation period (S_3). High wheel slip at S_3 might be due to high drag force at hard soil (more cone index) and low water level (less than 1 cm) which is in agreement with the findings of Mori (1975) and Singh *et al.* (1981).

Hill-to-hill spacing was greater at S_1 and decreased significantly with sedimentation period. At S_3 the hill spacing was closely equal to the preset spacing of 12 cm for R_2 and P_3. But, for P_2, C_2 and C_3 the spacing was 5.42, 7.5 and 5.42 percent less than the preset spacing. Higher hill spacing at lower sedimentation period might be due to low traction wheel slip than the designed slip. As sedimentation period increased, wheel slip increased and, consequently, the hill spacing decreased. Similar observation was also made by Mori (1975).

Hill population per sq. m increased with sedimentation period for all treatments because of low mortality. For treatment R_3 at S_1 hill population per sq. m was higher than that of R_2 inspite of higher mortality because of lower missing hills (4.17%). Similarly, although the mortality was higher for C_2 at S_3 compared to S_2 the hill population was higher at S_2 due to low missing hills (3.67%). It is found that mortality alone does not influence the hill population. Missing hills, which are dependent on seedling density and uniformity, also affect hill population. The average missing hill percentage in the study was 7.04 percent (S.D. = 2.64). High missing hill percentage was due to non-uniformity of the seedling in the mat.

The transplanter performance with respect to field capacity, field efficiency and fuel consumption were studied in a plot size of 21 × 81 sq. m. Actual field capacity was observed at 0.149 ha/hr at an average working speed of 1.34 km/hr. The maneuverability of the transplanter was quite satisfactory. The average turning time was 20.50 sec. Field efficiency was observed at 58.32 percent. Mat feeding consumed 25.35 percent of total time of operation. Fuel consumption was recorded as 0.40 l/ha.

Conclusion

Table 3. Effect of Puddling by Using Different Puddling Equipment at 3 Levels of Sedimentation on Transplanting Parameters.

Puddling equipment	Treatment		Sinkage of float, cm	Depth of transplanting, cm	Buried hill, %	Floating hill, %	Mortality, %	Traction wheel slip, %	Hill-to-hill spacing, cm	Hill population, sq. m
Rotary puddler twice puddling	R_2	S_1	2.82	5.83	9.98	7.68	16.124	2.58	12.48	24.0 (10.99)*
		S_2	2.02	5.02	5.17	5.64	11.06	4.43	12.18	25.20 (11.12)
		S_3	0.95	3.95	1.00	1.31	3.97	7.158	12.02	28.47 (5.21)
Rotary puddler thrice puddling	R_3	S_1	3.15	6.15	11.09	9.56	17.38	2.55	12.59	25.33 (4.17)
		S_2	2.24	5.24	7.51	6.14	13.56	4.00	12.46	25.20 (9.95)
		S_3	1.50	4.50	3.59	2.69	4.93	5.22	12.29	28.20 (6.60)
Peg type puddler twice puddling	P_2	S_1	2.43	5.43	5.10	4.60	9.46	3.72	12.29	27.49 (5.00)
		S_2	1.23	4.13	2.20	2.15	3.94	7.16	11.88	29.13 (6.09)
		S_3	0.51	3.51	0.00	1.08	3.00	12.59	11.35	28.93 (12.08)
Peg type puddler thrice puddling	P_3	S_1	2.90	5.90	9.71	8.00	15.62	2.72	12.54	24.66 (7.46)
		S_2	2.20	5.20	6.32	5.87	9.71	4.46	12.36	26.67 (7.64)
		S_3	0.98	3.98	1.37	2.26	2.89	7.03	12.04	28.67 (9.40)
Cultivator twice puddling	C_2	S_1	1.98	4.98	4.44	4.00	7.78	4.28	12.11	27.67 (6.19)
		S_2	1.06	4.06	1.30	1.28	2.49	9.46	11.62	29.67 (7.70)
		S_3	0.46	3.46	0.00	3.00	4.50	13.59	11.10	31.53 (3.63)
Cultivator thrice puddling	C_3	S_1	2.26	5.26	6.18	5.07	9.94	3.48	12.23	27.20 (5.49)
		S_2	1.38	4.38	2.31	1.51	3.19	6.58	11.98	31.00 (3.54)
		S_3	0.66	3.66	0.00	0.00	2.42	12.91	11.35	31.53 (5.20)
	CD(0.05)	1	0.1160	0.117	0.64	0.753	2.24	1.350	0.6190	
		2	0.0519	0.068	0.61	0.331	0.78	0.430	0.0935	
		3	0.1270	0.165	1.49	0.811	1.91	1.060	0.2290	
		4	0.1560	0.179	1.37	1.000	2.73	1.607	0.6470	

* Values in parentheses represent missing hill percentage.

From the above study, it is concluded that the transplanter could be operated satisfactorily without any mobility problem up to a puddling depth of 15 cm. Buried and floating hills and, subsequently, hill mortality decreased as the sedimentation period increased. There is good correlation between cone index and buried and floating hill percentage and between cone index and hill mortality. As far as transplanting performance is concerned, ideal condition for transplanting could be obtained at 48 hours of sedimentation period (S_2) for treatments C_2, P_2 and C_3 and 72 hours of sedimentation period for treatments R_2, R_3 and P_3, respectively, for silty clay loam soil. There was no maneuverability problem of the machine. Actual field capacity and field efficiency was 0.149 ha/hr and 58.32 percent, respectively. Mat feeding consumed 25.35 percent of total time of operation which needs to be reduced.

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Minimizing Error in Row-spacing While Drilling Seeds

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Abstract

The expected value of seed and hence plant distribution pattern of those seeds which are drilled need not coincide with the passage line of the centre of seed discharge tube thereby giving an impression of poor row-to-row spacing. A technique to minimize error in spacing rows for a given; seed, seed rate and a seed-drill is described.

Optimum agro-technical requirements is one of the major objectives for better growth of plants. The requirements nevertheless aim at providing optimum air, light, nutrients, water etc. to every plant. One agro-technical requirement is to distribute seeds evenly. Seed distribution or seeding is classified as: (a) broadcasting; (b) drilling; (c) precision planting; and (d) check row planting (1).

Solid seeding or regular drilling or (simply) drilling is carried out by pouring a stream of seeds (like wheat, jowar, some of the pulses) within the furrow opened by the soil-opener and then providing the seed with adequate soil-cover, and simultaneously or separately pressing or compacting the soil to a required degree. The stream does not consist of a single seed placement in a line or a row. Rather the stream has a finite width referred to henceforth as bandwidth. The seeds are scattered in a random manner in both directions, viz transverse or band-width wise and longitudinal or along the rows.

Row-to-row spacing, while using drills, is normally maintained at the main frame, the unit to which the soil-opener assembly along with seed and fertilizer tubes arrangement is attached. Either there are holes for mounting ordinary bolts or U-bolts on the frame to help achieve the required spacing. However, maintaining required spacing at the main frame need not ensure the targeted row-to-row spacing. A difference of 2 to 3 cm in between the centre of furrow openers is not uncommon for an even-setting at the main frame. Even if the centre of furrow openers are spaced evenly, the centre of seed exit-tubes will not be equally spaced. This is all due to non-standard techniques being adopted by the manufacturers. In the absence of good workmanship, the only alternative left is to maintain required spacing between the centre of seed exit-tubes. Even if this is implemented, the seeds upon germination exhibit a picture of non-uniform row-to-row spacing. When a seed leaves the end of discharge tube has a random exit velocity and space-orientation. Further, it enters into an undefined recently disturbed or still under disturbance soil regime – the interaction decides finally the settlement of the seed.

It is apparent, therefore, that seed distribution across bandwidth is not going to be similar from row to row.

Methodology

The centre of exit of seed-tubes (COST) were spaced at 20 cm. Wheat seeds were sown in a plot at a fixed notch setting and constant forward speed of the tractor. The passage of COST of three consecutive tubes were known. The tests were restricted to germination count only. The entire bandwidth of each row was divided into classes or intervals of 1 cm and longitudinal distance was kept 1 m. The germination count in each segment of 1 × 100 cm was made.

Results and Discussion

The random variable X was band-width while its quantification viz x_i in cm pertain to the location of segment with respect to the centre of exit of seed-tube. Since the attention was focussed on three rows, they were designated as COST 1, COST 2 and COST 3. Probability mass function pmf or $p(x_i)$ for each segment was computed (**Figs. 1** to **3**). Using the relationship:

$$E[X] = \sum_{\forall i} x_i p(x_i)$$

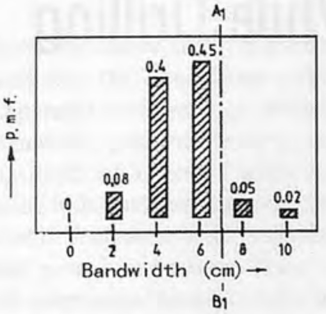

Fig. 1 p.m.f. v/s bandwidth for row-1 A_1B_1 is passage line of COST1.

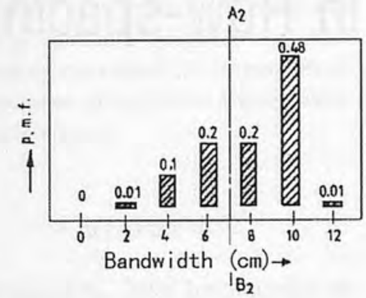

Fig. 2 p.m.f. v/s bandwidth for row-2 A_2B_2 is passage line of COST2.

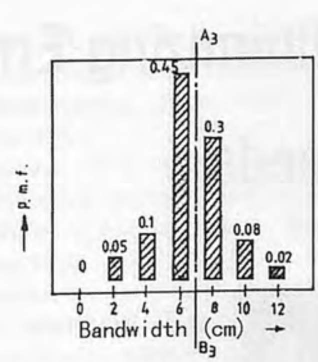

Fig. 3 p.m.f. v/s bandwidth for row-3 A_3B_3 is passage line of COST3.

where, E [X] stands for expected value of X.

the expected values for rows 1,2 and 3 were found as :

E [X1] = - 1.94 cm

E [X2] = +1.14 cm

E [X3] = - 0.36 cm

It is obvious that the expected values and COSTs do not coincide. One gets the impression that row-to-row spacing was not properly maintained. If E[X] is taken as the basis for spacing one must so space COSTs that distance between E[X1] and E [X2] = 20 cm = distance between E [X2] and E [X3]. This would imply that before drilling is done the spacing between COST1 and COST2 should be 16.92 cm and between COST2 and COST3 = 21.5 cm and not 20 cm, presuming that this shift would not affect the seed distribution pattern. It may be noted that there is a difference of 4.5 cm between consecutive COSTs.

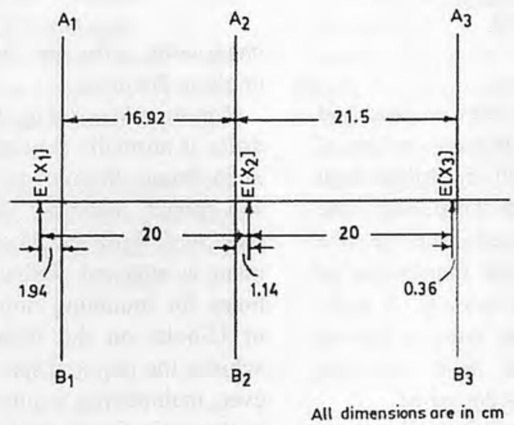

Fig. 4 Final spacing between the passage lines of COSTs to have equal spacings between E[X] values.

Farmers using the same drill season after season can be trained to adjust spacings on the main frame provided that information on the crop sown earlier is known. If not, a small trial run to see seed germination can be made to get the required information on x_i and $p(x_i)$.

Conclusions

In order to minimize error in spacing rows for crops wherein drilling of seeds is practiced, the spacings of soil-opener cum seed and fertilizer tube assembly on the main frame should be based on x_i and $p(x_i)$ information with respect to the required seed to be sown and the drill to be used.

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Improvement and Evaluation of Crop Planter to Work on Ridges in Irrigated Schemes of Sudan

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Abstract

Manual sowing is the traditional method to grow crops on the top of 80-cm spaced ridges in irrigated schemes. No seeding machines are available to perform this job. Improper crop geometry in farmers' fields is considered as a main factor in reducing yields. This work was carried out to improve the workability of tractor-mounted 4-row crop planter to place seeds in the middle of ridges top without slipping-off or swinging. The improvement comprised assembly of furrow wheels to maintain planter stability. Furthermore, the roll pins and the three-point hitch were replaced by stronger units. Then the improved planter was evaluated and compared with manual sowing for sunflower, sorghum and cotton.

Results indicated that the required time of manual sowing was 95, 19 and 19 times the requirement of planter sowing for sunflower, sorghum and cotton, respectively. Compared to manual sowing, planter sowing reduced operation cost for sunflower, sorghum and cotton by about 50, 18 and 29%, respectively, and reduced the seed rate of sunflower and cotton by about 17 and 40%, respectively.

Manual sowing resulted in significantly wider spacing between plants for sunflower and sorghum while planter sowing resulted in significantly narrower spacing for cotton. Planter sowing resulted in insignificant greater yields of sunflower and cotton but significant increase in sorghum yield. Hence, the improved planter could be recommended for crop sowing on top of ridges and the recommended seed rate and spacing between plants for manual sowing should be revised with the use of planter.

Introduction

The main rotational crops that are grown in irrigated schemes in Sudan are groundnut (*Arachis hypogea* L.), sorghum (*Sorghum bicolor* L.), cotton (*Gossipium hirsutum* L. and *G. barbadense* L.) and wheat (*Triticum aestivum* L.). Moreover, sunflower (*Helianthus annus* L.) is one of the promising cash crops that has been introduced recently to be grown as a winter crop in the period November-March. Its sowing date coincides with two field intensive labor operations, which are groundnut harvesting and cotton picking. Therefore, sunflower commercial production had been faced with shortage of hand labors for manual sowing, which necessitates the use of seeding machines.

All crops raised on surface irrigation system are grown on top of ridges 80-cm apart to facilitate irrigation and to avoid the risk of water logging in the central clay plain of Sudan. Field crops rather than wheat are sown using dibbling method. In this method, a long walking stick, with plain and pointed heart-shape metal attached to the lower end of it is used for preparing holes. This manual seeding tool is available from local markets. The seeds are then dropped into the hole manually and covered by loose soil. This manual sowing method results in variable distance between holes, variable number of seeds per hill and high number of uncovered seeds by the soil to grow. Hence, an optimum plant population with optimum spacing between plants (crop geometry) could not be achieved in farmers' fields. Therefore, the improper crop geometry of all crops in farmers' fields is considered as one of the main reasons behind reduced crops yields in irrigated farms.

A report prepared by the Department of Social Planning and Economics Studies (1999) for comparison of farmers' practice with the research recommendations, indicates that farmers practice for sorghum resulted in 52, 67 and 127% for the number of holes/ha, number of plants/ha and number of plants/hole, respectively. For cotton the parameters were 88, 98 and 119%, respectively. This indicates wider spacing between holes and higher number of seeds/hole, high competition of plants/hole, and consequently, low crop yields per unit area. Therefore, machine sowing is of vital importance for all field crops to attain the intended plant population per unit area with recommended spacing between plants for high crop yields. However, no seed drills or planters are available in the irrigated farms for field crops sowing except for wheat. Moreover, the designed seeding machines were manufactured to work on flat lands and not on the top of ridges.

A tractor-mounted 4-row 12MX Multiflex planter was provided to the station by the ARETP (Agricultural Research, Extension and Training Project). It is American make. It has no gauge wheels. It was observed to slip-off the top of the ridges when attached to tractor of untied chain of lower links. Moreover, excessive tillage tools used in dry and heavy clay soil results in the breaking of tractor lower-links chain. This is why practically no tractor with proper adjustable links chain for adjustment of mounted agricultural tools is found in local farms. The objectives of the present study are to improve the sowing operation performance of the planter for successful operation on the top of ridges without slipping-off or swinging; and to evaluate its effects on irrigated field crops in comparison with the traditional method of manual sowing.

Materials and Methods

The Required Planter Characteristics

The planter should satisfy the following requirements for crop sowing on the top of ridges:

1. A tractor-mounted planter should mitigate the breaking down of the ridges;
2. Placing the seeds in the middle of the top of ridges;
3. Placing the seeds to the required depth; and
4. To attain proper spacing between seeds and the required number of seeds per hill.

One of the prerequisites for operating a planter to sow the seeds on the top of the 80-cm spaced ridges is the proper setting of ridges to the specified distance.

Main Features of Selected Planter

The planter consists of four adjustable seeding units on a tool bar. They were placed 80-cm apart to match the requirements of irrigated field crops. Each seeding unit performs the sowing operation independent of the other. The seed metering device consists of rotating gears and plates which are powered through two fixed halves of the ground wheel (gear side half wheel and plain side half wheel). The ground wheel passes on top of the ridge and transmits its rotating power to the driven shaft to which a seed distance gear is connected to rotate the gear inside the seed hopper. The hopper, in turn, rotates the plate with seed cells. The regulation of seed rate is carried through selection of proper tooth gear number (seed distance gear) and a plate with suitable number of seed cells. The planter can be used for sowing wide range of field crops by just changing the gears and the plates.

Planter Improvement

In order to maintain the stability of the planter in placing the seeds in the middle of the ridge without slipping-off and to eliminate its side swinging, two furrow wheels were assembled, which were provided from scraped groundnut planter. Each wheel consisted of two parts that connected to each other by a joint. The purpose of the joint was to permit the free movement of the wheel in vertical direction so as to follow the undulations and to override the scattered soil clods in the bottom of the furrow without changing the planter height and depth of seeds. At the same time the wheel restricted the movement in horizontal direction so as to keep the position of seeding units on the top of the ridges. Moreover, the presence of furrow wheels would eliminate planter side thrust on links-chain via planter side swinging or displacement. At the lower side and to the rear of the joint connection, a metal bar was welded to support the furrow wheel from reaching the ground surface when the planter turns at the end of the swath or for transportation. Each of the two assembled wheels was bolted to the planter tool-bar using two V-blocks at a distance of 40 cm from each outer seeding unit to enable planter to run in the middle of the furrows. The improved planter is able to perform properly the sowing of sunflower, sorghum and cotton. The rear of the plnater showing the location of the four seed hoppers is seen in **Fig. 1**.

Field Test

The experimental work was carried out at the New Halfa Research Station in New Halfa scheme, which is between latitudes 15° 05' S (approx.) and 15° 30' N. The Atbara River forms the eastern boundary. The clay layer is about 2 m thick. The clay content is 45 – 60% (Blokhuis, 1962).

The research recommendations (Technical packages, 1991) for manual sowing of various field crops on top of the spaced ridges are as follows:

a. Sunflower: 30 cm between holes and 2 seeds/hole then to be thinned subsequently to 1 plant/hole.
b. Sorghum: three plants per hole at a spacing of 30 cm or 1 plant per hole at 10 cm apart.
c. Cotton: drop 5-7 seeds/hole at a spacing of 50 cm between holes for July sowing. The germinated seeds should be thinned to just three plants/hole some four weeks after sowing. For late sowing in August the spacing should be reduced to 30 cm between holes.

A suitable seed metering device for the planter to perform the sowing of each crop was selected (**Table 1**).

A comparative evaluation of the performance of improved planter sowing and manual sowing method on-farm sunflower and sorghum experiments was conducted in randomized complete block design with three replications on a 2.1 ha farm. Two experiments were farmer-managed trials. Sunflower hybrid seeds (Hysun 33) was sown in prepared land with the use of disk plow + offset disk harrow + 80-cm spaced ridges. The sorghum (local variety White Milo) was sown in prepared land with the use of 4-body ridger only for setting up 80-cm spaced ridges. Subseuently, the improved planter was used for commercial sunflower sowing in large-scale area of 88.2 ha in the 1999/2000 season.

The cotton experiment was undertaken at a research station farm because farmers tended to sow fuzzy seeds of medium stable cotton (local variety Barac 67). This type of seeds is not applicable to be sown by the planter. Therefore, the seeds of cotton were sown manually with concentrated sulfuric acid to remove the fuzz. No mechanism in the country is available to perform this chemical process of cottonseeds. The experimental land for cotton was prepared using disking + harrowing + leveling + 80-cm ridges. The experiment layout was a randomized complete block design with five replications. Because of the availability of only one plate with seed cells for cotton sowing, only one seed hopper was used. Delinted seeds were sown with the use of the planter for a comparison with the manual sowing of linted seeds. No thinning was done to the crop so as to represent the farmer's practice. The crop was irrigated fortnightly and fertilizer of 143 kg N/ha was applied after four weeks from crop germination. The crop was sprayed by insecticides when necessary using knapsack sprayer. Subplot size was 4.8 × 15 m (6 rows × 15 m) and the manually picked area was 3.2 × 10m (4 rows × 10m).

Experimental Collected Data

For each crop, the required time for completing the sowing of 1 ha with the use of planter and hand laborers was calculated. The cost of planter sowing was considered to be US$ 4.6 per ha that is similar to the cost of wide level disc harrow with a seeder box for wheat sowing in New Halfa scheme. Manual sowing cost for each crop was recorded according to the current hand labor rates. The seeds of sunflower and cotton rather than sorghum were weighed before and after sowing to enable a comparison to be made betweeen the planter's performance and that of the manual sowing method.

For sunflower and sorghum experiments, 10 random readings were taken 21 days from crop germination for a distance of three meter long to measure the spacing between plants and to count the number of plants. For the cotton experiment, three random readings per subplot were taken for the same distance length.

Results and Discussion

Pattern of Crop Growth

The expected number of seeds per hill for different field crops is shown in **Table 1**. The crop growth reveals the effect of drilling of seeds in turns of the distance between plants. This was due to the design of the rubber seed spout, which was a spiral shape to facilitate vertical extension and contraction. The seed spout corrugation caused the seeds to fall separately as they are dropped. Therefore, the planter performs the sowing operation as a seed drill which sugests that, in the measurement of spaces between plants, those with a distance of up to 10 cm apart are considered as the number of plants/hill.

Operational Data of Sowing Methods

The required average time of the planter sowing cotton was considered as spent in sowing sunflower and sorghum (0.5 machine-h/ha) with the use of the four seed hoppers. However, manual sowing of sunflower, sorghum and cotton requirs an average time of 47.6, 9.5 and 9.5 man-h/ha, respectively, which is about 95, 19 and 19 times the average requirement of planter sowing (**Table 2**). The highest average time requirement for sunflower manual sowing was due to the introduction of the crop for the first time to the New Halfa scheme. This means that the farmers and laborers are not adept at sowing the seeds with limited quantity. Expensive imported hybrid seeds to cover the required area at optimum spacing between holes and with only two seeds per hill, especially with light weight may be blown down by the wind during sowing. This situation causes the farmer or laborer to bend in dropping the required number of seeds into the hole.

Using the planter to sow the seeds reduces the operation cost by about 50, 18 and 29% for sunflower, sorghum and cotton, respectively, saving about 0.8 and 8 kg/ha of sunflower and cotton seeds, which is about 17 and 40%, respectively, in comparison with manual sowing method (**Table 2**). Savings in sorghum seeds was not recorded. However, the total sown area of cotton in irrigated schemes is about 204,000 ha (El-Awad, 2000). The savings in cottonseeds would be equal to about 1,632 tons which could be used for oil production and the byproducts of cakes could be used for animal feeds. Additionally, saving in seeds could reduce the cost of handling, storage and transportation of cottonseed stock for sowing. Hence, planter sowing of cottonseeds would be economically feasible with the use of chemical delinted cottonseeds.

Crop Growth Performance

Based on agronomic research recommendations (Technical packages. 1991), the optimum holes and plants number per 3m long for sunflower, sorghum and cotton is 10 and 10, 10 and 30 and 6 and 18, respectively. The obtained results of spacing between plants and number of plants for various crops are shown in **Table 3**.

For the sunflower sowing with the use of the planter resulted in optimum spacing between plants (31 cm) and 13 plants of 1 – 2 plants per hill to give a high plant population of 30% more than the recommended quantum. Manual sowing results in an optimum plant population (10 plants/3m long), but with significantly ($P = 0.05$) wider spacing between holes (42 cm) to result in about 7 holes only with 1 – 2 plants/hole. This number of holes was about 30% lower than the optimum which means using about 70% of the cultivated area. Despite the small increase in crop yield obtained using the planter for sowing is still preferable against manual sowing.

Manual sowing of sorghum seeds resulted in significantly wider spacing ($P > 0.05$) between plants (43 cm), while planter sowing resulted in significantly ($P > 0.05$) lower plants/3m long (21 plants). Here again, manual sowing resulted in about 7 holes/3m long, which was 30% lower than the recommended sowing. Hence, only 70% of the cultivated area was used for sorghum sowing. Although the obtained number of plants in manual sowing seemed to be around the optimum (32 plants/3m long), but it was in an average of 4 – 5 plants/hole. This has to be thinned to only 3 plants/hole with extra cost. Unfortunately, farmers do not perform thinning.

With regard to cotton growth using planter and manual sowing, a significant difference ($P = 0.05$) between the two sowing methods was evident only for spacing between plants. A significant narrower spacing (24cm) was obtained for the planter sowing. Manual sowing resulted in an average of 46 cm between plants to give 7 more holes/3m long, which is just 17% higher than the recommended and 37 plants with an average of 5 – 6 plants/hole, which was double the intended plant population. In comparison, using the planter for sowing resulted in 20-plants/3m long. This plant population was approximately similar to the optimum or just 11% higher than the recommended spacing.

The use of distance gear and number of cells in the plate in cotton sowing anticipates a result of 38 cm between hills and 3 – 4 seeds per hill (**Table 1**). The obtained results indicated that the average distance between plants was 24 cm with 1 – 2 plants/hill. The seed germination test for 50 seeds replicated 3 times was 75%, which could be a reason for the reduction in the number of plants/hill. Using the planter for sowing resulted in insignificant

Table 1. Selected Planter Seed Metering Device for Various Irrigated Field Crops

Crop	Distance gear	Number of cells in plate	Distance between hills (cm)	Expected number of seeds per hill
Sunflower	10-tooth gear	12	31	1 – 2
Sorghum	8-tooth gear	16	28	2 – 3
Cotton	8-tooth gear	12	38	3 – 4

(After Powell Manufacturing Company, Inc.)

Table 2. Operational Data in the Sowing Method for Various Field Crops

Sowing method	Required time (h/ha)	Sowing operation cost (US$/ha)	Seed rate (kg/ha)
		Sunflower	
Planter sowing	0.5	4.6	4.0
Manual sowing	47.6	9.3	4.8
		Sorghum	
Planter sowing	0.5	4.6	/
Manual sowing	9.5	5.6	/
		Cotton	
Planter sowing	0.5	4.6	12
Manual sowing	9.5	6.5	20

Table 3. Effect of Sowing Method on Growth of Various Field Crops

Sowing method	Spacing between plants(cm)	No. of plants/ 3m long	Crop yield (kg/ha)
		Sunflower	
Planter sowing	31	13	1011
Manual sowing	42	10	960
Means	37	12	986
SE ±	3.4 (*)	2.6 (NS)	44.9 (NS)
		Sorghum	
Planter sowing	25	21	1301
Manual sowing	43	32	1032
Means	34	27	1167
SE ±	2.0 (*)	1.9 (*)	69.1 (*)
		Cotton	
Planter sowing	24	20	2030
Manual sowing	46	37	1722
Means	35	29	1876
SE ±	5.3 (*)	4.7 (NS)	263 (NS)

(NS) = Not significant.
(*) = Significant at 5% significance level.

Fig. 1 The shape of the improved crop planter with attached assembled furrow wheels.

increase in cotton yield in comparison with manual sowing methods (**Table 3**).

Conclusion

1. The assembled furrow wheels with vertical free movement and horizontal restricted movement required an adjustment in the planter to sow the crop in the middle of the top of the ridges without slipping-off or swinging.
2. The use of the improved planter for sowing various field crops saved much time, reduced the operation cost and a better seed rate compared to manual sowing method.
3. In addition to the insignificant increase in sunflower and cotton yields, a significant increase in sorghum yield was obtained with the use of the planter but not with the manual sowing method.
4. This study demonstrated the necessity to recommend a revision of the crop seed rate and spacing between plants when mechanical sowing is adopted.

Recommendation

The planter could be recommended for field crop sowing on the top of ridges in the Sudanese irrigated schemes. However, the agronomic recommendations of seed rate and spacing of various field crops should be revised when using the planter.

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(Continued from page 26)

Development of a System for Analyses of Nozzle Spray Distribution for Students and Applicators' Education

Typical result of height effects is illustrated in **Fig. 5** for flat nozzle at operating pressure of 3 bar and a discharge height of 50, 75 and 100 cm. This result showed improved distribution as the mounting height increased. The distribution pattern from two cone nozzles working at a 3 bar pressure and 100 cm height is illustrated in **Fig. 6**, with a polynomial fitting of degree 6 for the collection volume with respect to distance from centerline, the R^2 for this fit 0.89.

Conclusions

The apparatus, instrumentation and procedure developed as a result of this research fulfills the objective to develop a system which rapidly and accurately measures and analyzes spray distributions from nozzles. The results obtained from several tests with the system were consistent and replicable. The spray distribution patterns obtained with this method were generally comparable to the patternator results.

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Development of a System for Analyses of Nozzle Spray Distribution for Students and Applicators' Education

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Abstract

A system for analysis of nozzle spray distribution was developed to demonstrate for students and applicators' spray distribution patterns across a spray table at various nozzle operating conditions. The system consists of three major components: a table consisting of "V shaped" channels, pumping system of hoses, pressure regulator and 220-volt a.c. pump and a wheeled frame that carried the spray table pump and a cubic water tank 50 × 50 × 50 cm. The unit allows for easy transport and set-up at any locations. The unit provides a mean of evaluating effects of several variables on spray distributions. The distribution patterns and coefficient of variation results obtained with this method were consistent, replicable and the results generally were extremely comparable to results in the spray table.

Introduction

The effectiveness, cost and safety of any pest control program are often greatly influenced by the distribution of the pest control agent. Many pest control applications are made with little knowledge of the variation in distribution of the pest control agent on the target. To improve pest control applications, instrumentation is needed to accurately and rapidly determine the distribution of sprays across the swath for various nozzle operation conditions.

Several different types of equipment and methods have been used for measuring spray distribution patterns. Liljedahl and Strait (1959) and (Roth et al., 1979) measured fluorescence of deposits containing a fluorescent tracer on long strips of paper with a photocell and fluorometer, respectively. Solie and Gerling (1985) modified the system developed by Roth to more accurately measure fluorescence at selected locations. Smith (1983) and (Carpenter et al., 1983) analyzed the amount of tracer of chemicals on targets placed at various positions across the swath. Others, including (Azimi et al., 1985) and other researchers have used a spray table ("patternator") with troughs to measure the distribution across the sprayed swath from single nozzles. Carpenter et al. (1988) modified the system used by Azimi to more accurate computerized weighing system for analyses of nozzle spray distribution.

Proper application of agricultural chemicals has received considerable attention by industry, regulation agencies, producers, scientists and the general public in western society. On the contrary, Jordan and other developing countries do not have any enforced regulations to control the applications. Farmers are not qualified or trained to handle these chemicals safely and properly, which lead to increase toxic residual in fruits and vegetable and even the scarce water resources.

Education plays a major role in providing accurate and helpful information to students and operators in hope of reducing many of the potential risks involved with chemical application. The objective of this work is the development of an affordable system for analyzing factors affecting spray distribution from a single and multiple nozzles.

System Description

The system for analysis of nozzle spray distribution consists of three major components: a spray table consisting of "V shaped" channels, pumping system of hoses and pressure regulator and 220-volt a.c. pump and a wheeled frame that carried the pump, the patternator table and a cubic water tank 50 × 50 × 50 cm.

The "Patternator" (Spray Table)

Figs. 1 and **2** show the patternator table and the test stand constructed to measure the spray distributions of nozzles typically used to apply pest control agents. The patternator table consists of a 0.5 mm galvanized metal sheet 2.20 m long and a width of 1 m. The "V shaped" channels, consists of forty one, 5 cm wide (peak to peak), and 4 cm deep to keep water from splashing into adjacent channels. The patternator has adjustable back stand to get the required tilt angle; to direct the water toward a collection unit at the end of the table. The nozzles mounting mechanism in the back of the patternator allowed for desired height, tilt angle and position of the nozzle(s) with respect to the patternator. Adjustable screws are provided for easy adjustment of boom height and nozzle spacing

Forty-one, 50-mL bucket were positioned at the lower end of the table, each corresponding to one of the channels. After each test the collected liquid from each bucket is measured by using graduated cylinders.

Pumping System

The pumping system consists of a centrifugal 220-volt a.c. pump, 3-m sets of flexible hoses, hydraulic agitator, pressure regulator and necessary plumbing. A bypass flow type, pressure regulator was used to maintain the desired pressure at the nozzles and to return excess flow to the tank. The system was so set up that a valve could be opened and the pump operated to rapidly remove the mixture from the tank. All electrical controls were mounted on the frame of the test stand.

Wheeled Frame

To allow for easy transport and set-up of the system, 4-wheels are attached to the legs of the supporting system stand which carries a cubic tank 50 × 50 × 50 cm (125 L) and the centrifugal pump. Five-swirl agitation jets (10 mm diameter) spaced uniformly along the centerline of the tank to provide thorough agitation of the tank contents. Permanent agitation line plumbed into the pressure feed from the pump before it reaches the regulator. This ensures that even when there is no return flow from the regulator, a small degree of agitation is maintained to keep tank mixes in suspension.

Research and Training Activities

The system can be used to demonstrate the most common method of applying pesticide to protect field crops with emphasis on safe and efficient use. The influence of several variables on spray distribution can be studied conveniently under laboratory conditions. The following is a brief description of some of the activities that can be demonstrated:

Pre-application inspection: This includes checking of sprayer, pump, gages, filter, strainer, lines, fittings and spray tips prior to filling and operating the system.

Spray tip selection: To demonstrate the importance of proper spray tip selection and its effects on spray coverage patterns and discharge rate required.

Spray mixture application rate: To provide information that can be used to accurately determine the required spray mixture application rate. This determination depends on several variables such as spray tip selection and spacing, operating pressure and ground speed.

Chemical formulations: To show typical chemical formulations that are available and sprayer configurations that are needed for effective application of the various formulations.

Tank mixing of chemicals: To emphasis the importance of suitable tank mixing procedures required to form a desirable spray suspension. Proper concentration and combination of chemicals and carriers are necessary to insure adequate chemical effectiveness.

Effect of nozzle spacing on spray pattern: To assess spray uniformity, overlap and skips in spray patterns.

Effects of boom height on spray pattern: To illustrate the effects

Fig. 1 Nozzle "patternator" test stand.

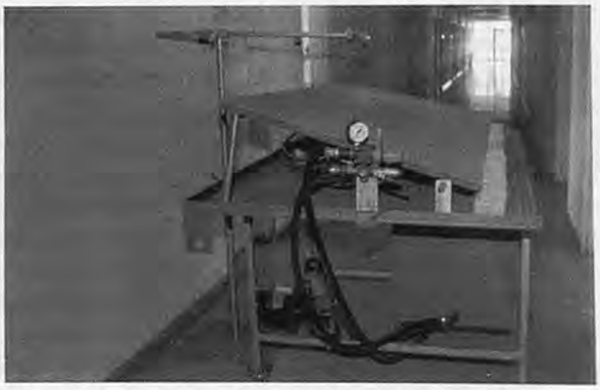

Fig. 2 Side view of nozzle spray distribution test stand showing nozzle holder and pressure regulator.

of nozzle height above the target on spray distribution and uniformity. Spray nozzle close to the target may result in poor coverage while excessive boom heights result in drift problems in the presence of wind.

Effects of nozzle wear on spray pattern: To compare spray patterns from new and worn nozzles which results in inadequate application coverage.

Pressure variation effects on spray pattern: To show the effect of operating pressures on spray pattern for the same nozzle.

Patternator Testing

To evaluate the spray distribution from an individual and multiple nozzles under a predetermined set of operating conditions, the nozzle distribution pattern was measured on a patternator. To prevent any clogging and reduce the nozzles wear; distilled water was used as a working fluid. The pumping system re-circulates the clean distilled water through a nozzle mounted over the patternator table. After each test, the collected liquid in each bucket under the channels was measured using a graduated cylinder. The system works for 30 seconds for each test, the collected water returned back to the tank through a by-pass in the patternator table. The nozzles which are used for these tests deliver flat and cone spray patterns. The nozzles are made of plastic.

Results and Discussion

The objective was to develop a system for rapidly measuring and analyzing spray distributions. Several experiments were performed with various nozzles and operating conditions to verify the accuracy of the system. **Fig. 3** shows the collected fluid across the swath of the patternator from a flat nozzle working at a pressure of 2 bar, the nozzle height was 50 cm above the centerline of the patternator. The distribution pattern follows the bell shaped normal distribution. To check that the replicable characteristic of the measurements exists, each test was replicated three times (rep. 1, rep. 2 and rep. 3). **Fig. 4** shows the collected volume as a function of distance from a centerline of the patternator for three replications of flat nozzle working at a pressure of 2 bar and a height of 75 cm, the figure indicates that the function is replicable.

(Continued on page 23)

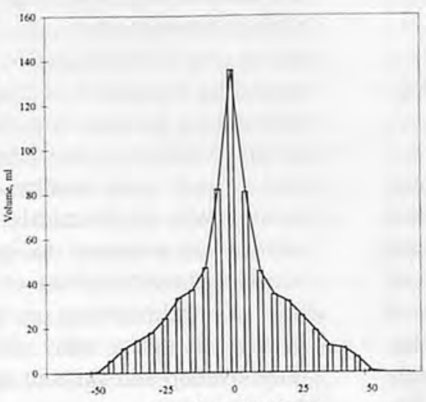

Fig. 3 Sample distribution pattern from a flat nozzle with plastic core at 50 cm height and 2 bar.

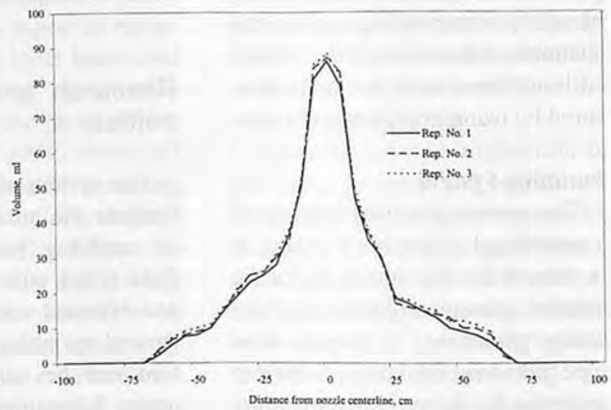

Fig. 4 Resutlts of three pattern replicates at 75 cm height and 2 bar.

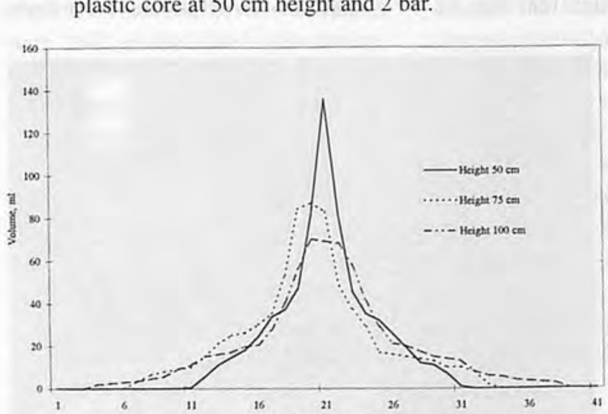

Fig. 5 Height effect at 3 bar pressure.

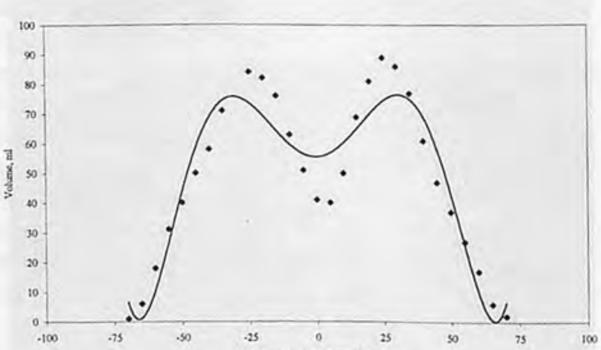

Fig. 6 Distribution pattern from two cone nozzle at 100 cm height and 3 bar pressure.

Comparative of Weeding by Animal-drawn Cultivator and Manual Hoe in EN-nohoud Area, Western Sudan

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Abstract

The study was conducted in EN-nohoud area, Kordofan State, Western Sudan, in 1999-2000 to compare an animal-drawn cultivator with the traditional hand hoe for weeding groundnut. It was found that the average field efficiency and effective field capacity of the animal-drawn implement were higher than those of the manual hoe by about 4% and 162% respectively. The crop yields per feddan (0.42ha) for the areas weeded by the animal-drawn cultivator were greater then for the manual hoes by 87%. Using the animal-drawn cultivator also reduced the cost of weeding by 64% as compared to the manual hoe and, consequently therefore, increasing the returns from groundnut production.

Introduction

Power source is one of great importance in determining the level of mechanization and agricultural development in any country. There are three main sources of power in agriculture: human, animal, and motorized power (Fashina, 1986).

In the rural areas of developing countries farmers use simple implements and tools utilizing human and animal powers. In spite of many trials for mechanizing the small-scale traditional agricultural system, the general recognition is that sophisticated and expensive technology will never be a suitable solution for small farmers. Therefore, the intermediate technology may suit these areas instead (Milles, 1982).

Many developing countries like Nigeria, India, and Spain besides some developed countries like USA and UK are formulating national policies and plans for adopting intermediate technology to encourage and promote local manufacture of the necessary tools (Starkey, 1992).

Introducing animal-drawn implements as intermediate technology for small farmers is becoming increasingly necessary, especially for some critical operations like weeding. It is important for increasing the cultivated lands and crop production (Wohab *et al* , 1997).

Animal draught implements compared to manual tools have positively affected the crop production factors through improving field efficiency, increasing crop yield and reducing costs of production (Olukosi, 1986; Stevens, 1992; Wohab *et al*, 1997; Dash, 1998 and Actul, 1998).

Farmers in most parts of Western Sudan grow different types of crops such as millet, sorghum, groundnut, water melon and cowpeas in small areas as traditional agriculture (Edward, 1981). they use various types of small agricultural tools and implements in different stages of crop production. Animal-drawn implements are used by some farmers in western Sudan mainly for weeding of groundnut (Kinsey, 1986).

The agricultural service units in EN-nohoud areas have played a vital role in training framers and their animals, introducing credit services and supporting the adoption and use of animal-drawn implements.

The introduction of this technology, especially for weeding groundnut (the most important cash crop in the area) was observed to increase the cultivable land, reduce the total costs of production and improved the general standard of living of the people (Starkey, 1992; Oscar, 1997).

The main objectives of the present study are:

1. To test the performance of a modified animal-drawn cultivator under field conditions and compare it with the manual hoe; and
2. To evaluate crop productivity and costs of cultivator weeding as compared to the hand hoe.

Materials and Methods

The experiments were conducted at EN-nohoud area, Western Sudan, 850 km southwest of Khartoum (the capital).

The area is generally of low rainfall, semi arid Savanna zone with an average rainfall of 200 mm in the northwest and 500 mm in the southeast. The land is flat to undulating with some seasonal channels (*khors*). The soil is sandy to sandy loam with clays in the seasonal channels (Abdel Rahman 1987). The main crops are groundnut, watermelon and karkadi (*Hibiscus*) as cash crops, and millet, sorghum, cowpea as food crops. All these crops are completely grown in small farms in rainfed areas.

Experimental Sites

Four sites were selected according to annual rainfall distribution which is the main crop production-limiting factor in the area. Two sites were located in the North where rainfall is low while the other two sites in the South where the rainfall is higher. Ten farmers in each site were randomly selected and every farmer was allotted two plots of about 36m^2 each.

Horses were trained to be draught animals and each horse was guided by two men to carry out the weeding operation.

Tools and Implements for Weeding

A locally-made manual hoe was used as a traditional tool for weeding. It consists of a front blade and a 1.5 m long wooden beam. The front part could be made in different shapes depending on the soil type but the most popular in the area is the one which is locally called *Um sidair* (**Fig. 1**).

The animal-drawn cultivator is locally produced and called *Misra.* It is made of a metal frame with five tines in two rows, three in the front and two in the back row with a total width of 1.0 m. The implement, as shown in **Fig. 2**, has two driving wheels to facilitate when being drawn by horses, camels or donkeys.

During weeding the implement is linked to the animal at two points on the harness (collar) by means of two metal rods or ropes, two meter long. The harness was made from locally available materials, e.g., wood, leather or metal (**Fig. 3**).

The selected farmers planted groundnut in their plots but for each farmer, one plot was weeded manually by the hand hoe while the other plot was weeded at the same time by the animal-drawn cultivator (*Masra*).

During the weeding operation, field efficiency in percentage and field capacity in fed/hr were measured. At harvest the crop yield in kg/fed was recorded.

Table 1. Details of Cost Items

Animal/implemnt	Purchase Price (SD)	Expected life (yr) + annual use (hr)	Deprec.+R&M (% pp)	Feeding and medicalcare(%pp)
Horse	46,000	6 (1,000)	10 (depreciation)	3%
Cultivator	1,000	10 (500)	10	-
Manual hoe	500	1 (250)	-	-

* Labour costs for animal-drawn cultivator = 36.0 SD/hr
* Hiring labour for hand hoe + labour feeding = 40.0 SD/hr
pp.= purchase price
R& M= Repair and Maintenance
SD = Sudanese Dinar (0.04 US $)

The costs of weeding operation by the two methods were also calculated as follows:

The costs of weeding by the animal drawn cultivator included the implement the draught animal, and labour costs as shown in **Table 1**. However, the interest rate, taxes, insurance, shelter costs were not considered since the implements were distributed by a cooperative project on a credit basis and they were kept under tree shelters within the vicinity. Depreciation, repair and maintenance costs of the implement were taken as 10% of the purchase price as suggested by Atul (1998). Depreciation, feeding and medical care of the animals were taken as 10% and 3% of purchase price, respectively.

Costs of using manual hoe for weeding included the costs of the hoe and the costs of hiring and feeding of one labour as shown in **Table 1**. The life span of the hoe was assumed to be one year and used for 250 hours.

Results and Discussion

Field Performance

The performance rate showed sig-

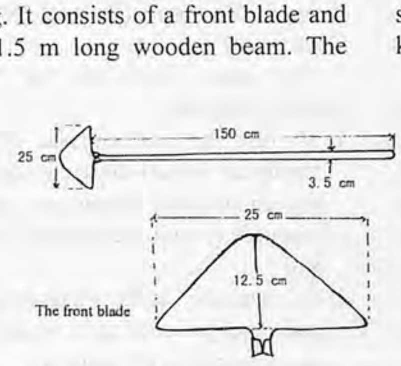

Fig. 1 The manural hoe (Um sidair).

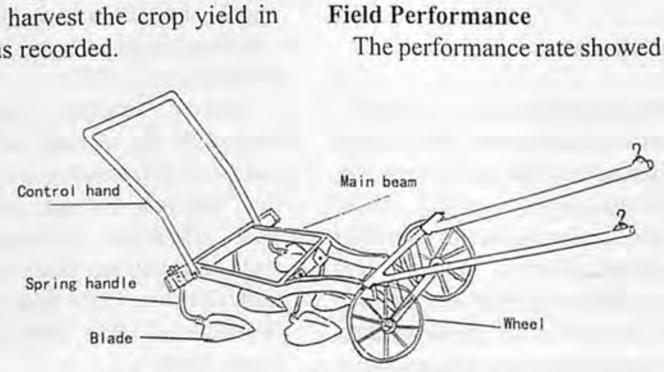

Fig. 2 The modified cultivator (Masra).

Table 2. Analysis of Variance for the Different Parameters

Source of variation	F. tabulated 5%	F. tabulated 1%	F. calculated F.E.	F. calculated F.C	F. calculated Crop yield
Site	2.68	4.88	66.31**	26.23**	227.94**
Treatment	4.11	7.39	18.97**	1,614.38**	1,506.37**
Site × treatment	2.68	4.88	2.9*	18.71**	11.16**
C.V.			2.27	10.91	7.68

F.E.= Field efficiency
F.C.= Field capacity
C.V= Coefficient of variation
* Significant at 0.05 level
** Significant at 0.01 level

Fig. 3 The implement linked to the animal at the harness.

Table 3. Average Field Efficiencies for the Cultivator and Manual Hoe in the Four Sites

Treatment	Site A	Site B	Site C	Site D	Mean ±SE
Cultivator	82.7^{d}	84.8^{f}	75.0^{h}	70.0^{i}	78.1±1.27
Hoe	79.7^{e}	79.0^{g}	75.0^{h}	63.0^{j}	74.2±1.27
Mean	81.2^{a}	81.9^{a}	75.0^{h}	66.5^{c}	76.2

* Means with the identical letter symbols are not significantly different.

Table 4. Average Field Capacities of the Animal-drawn Cultivator and Manual Hoe in the Four Sites

Treatment	Site A	Site B	Site C	Site D	Mean ±SE
Cultivator	0.23^{c}	0.24^{e}	0.19^{g}	0.18^{j}	0.21±0.05
Hoe	0.08^{d}	0.08^{f}	0.08^{h}	0.08^{j}	0.08±0.05
Mean	0.16^{a}	0.16^{a}	0.14^{b}	0.13^{b}	0.15

* Means with the identical letter symbols are not significantly different.

Table 5. Average Crop Yield in (kg/fed) of the Animal-drawn Cultivator and Manual Hoe for the Four Sites

Treatment	Site A	Site B	Site C	Site D	Mean ±SE
Cultivator	259^{d}	250^{f}	335^{h}	364^{j}	302±2.0
Hoe	120^{e}	110^{g}	184^{i}	232^{k}	161.5±2.0
Mean	189.5^{a}	180^{a}	259.5^{b}	298^{c}	231.75

* Means with the identical letter symbols are not significantly different.

nificant differences between the two methods of weeding and among the four selected sites (**Table 2**).

It is clear that field efficiency of the animal-drawn cultivator is generally higher than that of the manual hoe. The differences between the two treatments are 3.7%, 6.8% and 10% for sites A, B and D, respectively. These differences were highly significant as shown in **Table 3**.

The higher field efficiencies obtained in the animal-drawn implement in all sites may be attributed to the better utilization of time in the field when performing the work.

The field efficiencies in sites A and B are higher than that of sites C and D possibly due to the sandy loose soil condition in these sites.

In all sites the field capacity of the animal-drawn implement was higher than that of the hand hoe. The average difference between the two treatments is 0.13 fed/hr (**Table 4**). The higher field capacities of the cultivator is attributed to the reduced time loss in the field and the longer width of cut used. This is in agreement with the findings of Olukosi (1986), and Rahma (1993).

It can be observed also that the field capacities of the animal-drawn implement are higher by 21% at sites A and B than those of sites C and D. The differences between the treatments in all sites were highly significant at 1% level.

Crop Yield

The yield measurements of the two treatments in the four sites indicte that the animal-drawn implement out-yielded the manual hoe in all sites. The differences in ground nuts production between the two treatments were 139 kg/fed, 140 kg/fed, 151 kg/fed and 132 kg/fed for sites A, B, C, and D respectively. These differences at all sites are highly significant (**Table 2**). The average crop yield recorded in the animal-drawn implement is higher than that of the manual hoe by 87% (**Table 5**). The results are in line with the findings of Fashina (1986).

The crop yield of sites C and D are higher than those of sites A and B for both treatment. This could be due to the higher rainfall and the better soil type at these sites.

Weeding Cost Estimation

The cost items presented in **Table 1** were used for calculating the total cost of weeding one feddan by the two studied methods of weeding. It was found that the cost of weeding one feddan by the animal-drawn cultivator and hand hoe were SD 338 and SD 525, respectively (**Table 6**).

Although the cost per hour is higher for the cultivator as compared to the manual hoe method, the required time for operating one feddan is less.

Using an animal-draught implement reduces the weeding cost by 64%, this may be a positive indicator to encourage using this method for weeding large areas. These findings agreed with those Norman (1976) Atul (1998) and Starkey (1992).

Table 6. Comparative Cost between the Two Weeding Methods

Weeding method	Total hourly cost (SD/hr)	Required time (hr/fed)	Total costs (SD/fed)
Animal-drawn cultivator	71.0	4.76	337.86
Manual hoe	42.0	12.50	525.0

Conclusions

The following conclusions may be drawn from the present study:

1. The performance rate of the animal-drawn implement is higher than that of the manual hoe.
2. The animal-drawn cultivator increases the average crop yield by 87% as compared to the manual hoe.
3. The total cost per feddan for the hand hoe weddings is higher by 55% as compared to the animal draught implement. Hence the time required and cost for the cultivator can be considered economically visible and socially acceptable particularly for larger areas.

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'Tapak-tapak' Pump: Water Lifting Device for Small Scale Irrigation and Rural Water Supply for Developing Countries

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Abstract

Farmers and rural communities obtain irrigation and drinking waters, some of the priority needs of humans, through open wells, ponds and streams. Inefficient supply of such waters contributes to a decrease in agricultural production and most of the diseases that afflict the people in rural areas. Water lifting device, like the 'Tapak-tapak'* pump, can best answer some of the small-scale irrigation and rural water supply problems. This is because it is easy to construct, the materials are locally available, easy to dismantle and reassemble, easy to carry around, less expensive and could be handled by both women and children.

The pump with a slight modification on the suction pipe (made 'gradual' instead of 'sharp' bend) of the original design was constructed and tested. The performance of the pump was evaluated by making it lift water from a pond of 0.55m deep, low static head (LSH) and 3.10m deep, high static head (HSH), and a pipe length of 0.95m and 3.50m, respectively. Two types of up and down movements of the legs - fast (FS) and slow (SS) speeds at each static head were used. At the LSH, the mean FS and SS were 41 and 33 cycles/min. while at the HSH, the mean FS and SS were 42 and 35 cycles/min, respectively.

The mean discharge at the LSH with FS was 125.2 l/min. and LHS with SS was 83.7 l/min. The values at the HSH with FS and HSH with SS were 106.8 l/min. and 69.2 l/min., respectively. At the HSH the friction losses in the pipe were 5.86 cm and 2.51 cm for the FS and LS, respectively. The corresponding friction losses at the LSH were 2.19 cm and 1.08 cm. The hydraulic efficiency ranged between 92% and 98.9% depending on the speed and value of the static head. The lower the speed, the higher the hydraulic efficiency, and the higher the static head, the higher the hydraulic efficiency. The volumetric efficiency was as low as 57% at HSH with SS speed and as high as 90% at LSH with FS. The average flow rate reduction of LSH(FS) and LSH(SS) was 33.3%; HSH(FS) and HSH(SS) was 35.3%; LSH(FS) and HSH(FS) was 14.7% and LSH(SS) and HSH(SS) was 17.3%

The construction cost, excluding machinery and power used, was US$68.61.

*For want of an appropriate name for the pump which IRRI designed, the motion of the standing operator's legs of alternate up and down movement to lift water from the source, the IRRI engineers must have christened the pump "Tapak-tapak" by the Tagalog word which conveys a repetitious stepping by the foot.

Introduction

Farmers and rural communities in developing countries depend mostly on open-wells, ponds and streams for irrigation and drinking purposes. Countries in Africa are heavily dependent on their agriculture to feed the population and to provide capital and impetus for other forms of development (Rowland, 1993). Despite a modest growth in total food production throughout sub-Saharan Africa in recent years, World Bank (WB) (1990) figures show that per capital production fell by about 6% between 1979/81 and 1986/88. Apart from not producing enough food, Africa is unable to earn adequate income from its cash crops

(WB, op. cit.). According to the WB (op. cit.), the size of land devoted to cash crops is decreasing throughout the continent as farmers attach more importance to securing their own food requirement.

In arid and semi-arid areas, where even water harvesting has strictly limited application, irrigation is usually the only means of producing crops, and therefore, has become attractive as a way of increasing and stabilizing yield (Rowland, 1993). Traditional irrigation systems have been in operation for a long time in some parts of Africa, but it was only recently that large-scale, centralized, technology-driven schemes have been attempted (FAO, 1986; Rowland, 1993). The performance of large-scale irrigation schemes have been disappointing, giving, in most cases a very poor return on investment (FAO, 1986). This is due to various technical constraints, including equipment often being too difficult to maintain, too dependent on imported fuel and spare parts, and not standardised. Chambers (1969) noted that complex projects involving a great deal of administrative control and long-term involvement by controlling agency are less likely to succeed than smaller scale programmes that require low levels of initial capital investment and provide maximum independence to the settler (farmer). Lack of small-scale irrigation schemes in most developing countries has rendered some crops like maize, rice and tomatoes which could have been produced throughout the year as seasonal crops. It is, therefore, important that small-scale farmers in Africa be encouraged and supported to use small-scale irrigation schemes that use simple pumps in order to increase their crop production to feed the rapid growing population. Devices for pumping water for irrigation range from age-old indigenous water lifts to highly efficient but costly pumping units (Michael and Khepar, 1989).

Semi-arid areas in developing countries depend on reservoirs (ground reservoirs, farm ponds, etc.) for their water conservation (Shahin, 1993). Runoff and seasonal stream waters are collected in these reservoirs for both domestic and livestock usage. To avoid contamination of the waters, governments, non-governmental organizations and individuals must provide safe and convenient supply of water to poor rural communities whose economic clout is so negligible that they cannot command a share of water supply resources from a return on investment point of view. Also, considering the diverse rural settlement pattern, socio-cultural and economic status and agro-ecological conditions, manually operated pumps should be considered the most appropriate and economic means of water lifting device to small rural habitations spread over a geographical vast area. Such pumps should be able to draw water from ponds, streams and shallow wells. They are easy to operate and sturdy enough to be handled by even women and children. The components of the pump are simple in construction, materials are locally available and use common shop tools to construct, thereby reducing cost and simplifying maintenance and repair.

Considering the above criteria, Tapak-tapak is the appropriate pump to be adopted for small-scale irrigation and rural water supply. The objectives of the study were: (1) to construct Tapak-tapak pump using locally available materials; and (2) to evaluate the cost and performance of the pump.

The Tapak-tapak Pump

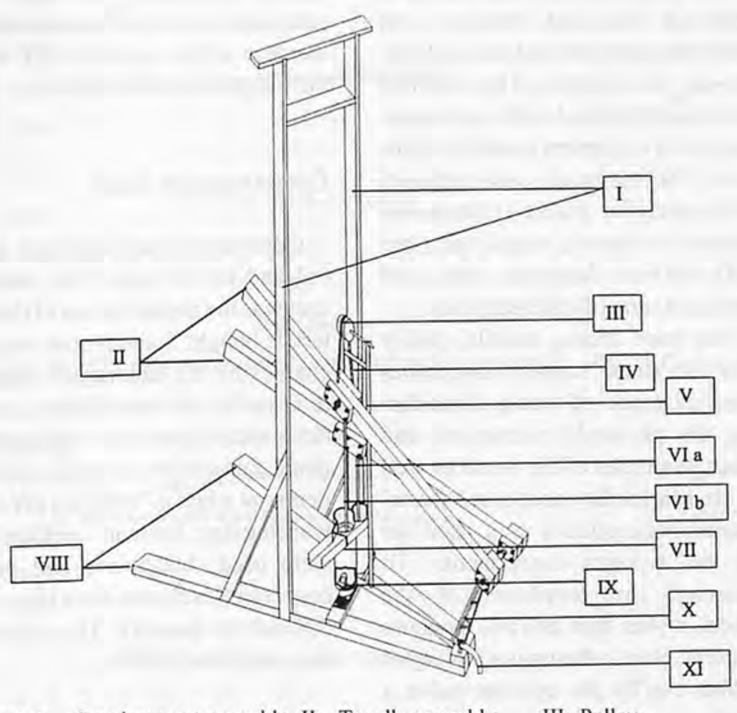
The pump is based on the design developed in Bangladesh by the Rangpur Dinajpur Rehabilitation Service (IRRI, 1990) and adopted by the International Rice Research Institute (IRRI). The pump is a twin cylinder, foot operated double displacement, capable of producing continuous discharge of water. It is operated by a man standing on the plank and moving the legs up and down. The pump is ideal for rural water supply from ponds and for small-scale irrigation schemes where engine-driven pumps are generally too expensive and bucket-lifting by hand is unhygienic, and also limited to very small areas because of its high labour requirement (IRRI, 1990). The advantages of the pump are:

- The use of body weight and leg muscles during operation and, therefore, less tiring than conventional pumps which use arm and back muscles;
- Can be portable or stationary;
- Suitable for open-pit wells, ponds or reservoirs, canals, lakes and rivers;
- No priming is required for depth as great as 5m;
- The capacity is higher than most low cost manual pumps due to the effective use of the body weight and the twin cylinders; and
- Simple to construct, easy to dismantle and reassemble.

The Tapak-tapak pump is a reciprocating pump, which works by the action of up and down movements of two pistons (plungers), in twin cylinders (**Fig. 1**). The pump has a two-stroke arrangement in which two pistons, VIa and VIb, each moves in one of the twin cylinders in opposite direction as shown in **Fig. 1**. During operation, the operator stands on a two-foot-rest (treadle) and moves the body from one side to the other, thereby relaxing the legs one after the other. When a piston moves up, a piston valve closes and there is a reduction of pressure below the piston valve thereby creating a vacuum in the corresponding cylinder. This makes a foot valve in the cylinder open and thus water is sucked into the cylinder. When a piston moves down, the foot valve closes and the piston valve opens as a result of an increase of pressure below the piston valve. This makes water already collected in the cylinder pass through and settles on the piston valve. With the second upward movement of the piston, the water collected on the piston valve is brought to the spout to be discharged. These two processes continue but in the opposite manner as the operator moves the body from one side to the other. Unlike one-stroke deferential plunger arrangement in which flow is intermittent, the Tapak-tapak pump provides steadier, smoother and continuous flow, as it is a two-stroke, twin cylinder pump.

The salient features of the pump are (**Fig. 1**):

i) The stand support assembly, which the operator holds for firm support during operation;
ii) The treadle assembly on which the operator stands during the operation;
iii) The pulley assembly a circular wood over which the rope connected to the piston passes;
iv) The pulley stand assembly holds the pulley;
v) The plunger assembly, which consists of metal rod, connected to two metal discs, in between which, is the rubber or leather cup to form the piston valve. The plunger assembly brings the water from the cylinder to the discharge spout;
vi) The main cylinder assembly which houses the foot valve and the plunger (piston) valve and through which water is sucked and discharge from the water source. The assembly consists of twin cylinders connected to one discharge spout;
vii) The foot valve assembly, which opens and closes as the piston moves up and down for water to be sucked into the cylinder; and
viii) The base frame assembly, which holds the whole pump and is placed on the ground during installation.



Legend: I: Stand support assembly II: Treadle assembly III: Pulley
IV: Nylon rope V: Pulley stand assembly VI: Plunger assembly
VII: Main cylinder assembly VIII: Base frame assembly IX: Foot valve assembly
X: Pivot shaft and frame assembly XI: Suction pipe

Fig. 1 Schematic diagram of the Tapak-tapak pump.

Theory

The expected or theoretical volume of water, V_t, to be discharged from one cylinder (per 1/2 cycle) is calculated using the relation,

$V_t = V_c + V_p \ (m^3)$ 1

where, V_c is the volume of water column in the cylinder and V_p is the volume of space occupied by the piston rod in the water column.

But $V_c = V_i + V_{ii}$ 2

where, V_i is the volume of water column above the leather cup and V_{ii} is the volume of water in the leather cup.

$V_i = \eta D^2 (h-h_1)/4, (m^3)$ 3

where, D is the internal diameter of the cylinder, h is the height of the water column and h_1 is the internal height of the leather cup.

The shape of the leather cup is like a frustum, therefore the formular of the volume of a frustum (Perry and Perry, 1986) is used to calculate V_{ii}.

$V_p = \eta \ d_p^2 h/4 \ (m^3)$ 4

where, d_p is the diameter of the piston rod.

The expected volume of water, V_T, per cycle is thus,

$V_T = 2V_t \ (m^3)$ 5

The volumetric efficiency, η_v, is calculated as;

$\eta_v = V_A \times 100\%/V_T$ 6

where, V_A is the actual volume of water collected per cycle.

The discharge, Q, of the pump was determined using the relation,

$Q = 3600Vn/T \ (m^3/\ hour)$, ...7

where, V is the volume of water discharged (m^3), n is number of cycles and T is time (s).

Applying the Bernoulli equation between suction and discharge ends,

$P_1 / \rho g + v_1^2 / 2g + H_r - (h_b + h_p)$
$= P_2 / \rho g + v_2^2 / 2g + h_s$,..............8

where, $P_1/\rho g$ and $P_2/\rho g$ are the pressure heads for suction and discharge ends respectively (m), and

$v_1^2/2g$ and $v_2^2/2g$, the velocity heads at the suction and discharge ends respectively (m). H_r, h_b, h_p and h_s are the theoretical, friction loss at the bend, friction loss in the pipe and static heads respectively (m).

Equation 8 is based on the assumption that water is frictionless and of uniform density, and the flow is in steady state (Massey, 1989).

But $v_1 = v_2 =$ negligible (v_1 and v_2 are very small compared to v) .9

where, v_1, v_2 and v are the velocities at the suction and discharge ends, and in the pipe respectively.

And $P_1 = P_2$ (atmospheric pressure).............. 10

where, P_1 and P_2 are the pressures at the suction and discharge ends respectively.

Equation 7 is then reduced to;

$H_r = h_b + h_p + h_s$. 11

The friction losses are calculated using the relations:

$h_b = K_b v^2/2g$ 12

and $h_p = 4fLv^2/2gd$,...............13

where K_b is the coefficient of friction, f, the friction factor of the pipe, L, the length of the pipe, d, the diameter of the pipe and v, the velocity in the pipe.

Rearranging and applying continuity equation to equations 12 and 13, h_p, h_b and H_r are then calculated, taking f = 0.005 and $K_b = 0.45$ for 45^o bend,.

Hydraulic efficiency, η_h, is calculated as: $\eta_h = H/H_r$ 14

where, $H = H_r - H_L$ is the effective head of the pump (m), and H_L is the head loss through friction (m).

The mechanical efficiency, η_m, was not determined as a result of lack of instrument to measure the power put in by the operator. Hence, the overall efficiency, η_o, = $\eta_m \times \eta_v \times \eta_h$, was not calculated.

Materials and Method

Both wood and metal were used for the construction or fabrication of the pump. The construction was based on the design from the International Rice Research Institute (IRRI, 1990) except that the rectangular shape of the groove was made U-shaped to suit the shape of the nylon rope used. Also, the 'sharp' bend of the suction pipe was made a gradual bend (**Fig. 1**). This is because the sharp bend can cause 'pitting' in the pipe that would enhance corrosion and also can create eddies that will reduce the output pressure gradient thereby reducing delivery rate. The construction was done in accordance with the specification of the design drawing, at the University of Science and Technology (UST), Kumasi.

The materials for the metallic parts, especially for the cylinder assembly, should be tough, strong, smooth on the surface, and resistance to abrasion and corrosion. Considering these properties, stainless steel, cast iron, brass or even galvanised steel plate should have been used (Fraenkel, 1989). However, mild steel plate which satisfies all the properties but susceptible to corrosion was used, because of its relatively low cost and its availability on the market. The metallic parts were painted with anti-corrosion paint to prevent possible corrosion. The materials used included mild steel flat plates (1.0mm and 3.0mm thickness), round bar (iron rod) 14.0mm diameter, nails, and bolts and nuts of different sizes.

The base frame, treadle, pulley and the stand support assemblies were all made of wood. Considering the physical, mechanical and other properties of the wood as well as its availability and cost, 'kusia' (naucles diderrichii) was used for all the wooden components. To maintain the properties of the wood, it was kept at 15% moisture content. Due to the unavailability of rubber cup for the cylinder valve, a leather cup was used.

The pump was tested also at the University using one of its ponds as the source of water. It was operated by an operator of 58kg weight. A bucket of 14-litre capacity was used to collect the discharge. The number of cycles made by the operator and the time to fill the bucket was noted. One cycle was left and right upward movement of the operator's legs. In all, three people were involved: one operating, one counting the cycles and one timing. With this method, the time taking and the number of cycles to fill one bucket, up to fifty buckets were noted.

The pump was first placed on the floor near the pond with the vertical distance of 0.55m from the water level to discharge end (Low static head) (LSH) and two sets of tests were made. One set was when the operator was relaxed and moved the legs up and down normally (slow speed) (SS) and the other set was when the operator moved the legs faster (fast speed) (FS). The pump was taken to a cemented roof of 3.10m high (High static head) (HSH) and of the same horizontal distance from the pond like when it was on the floor. Two tests were also made of similar movements of the legs of the operator like when the pump was on the floor.

Construction Cost

Construction cost involved material and labour costs. The material cost was the market prices of the materials bought. Labour cost were the charges by the technicians engaged to assist in the construction. In all, three technicians were engaged for metal fabrication, welding and carpentry at a rate of US$2.13 per man-working day. Ten man-working days were used. Machinery and power costs were excluded since they were difficult to quantify. The construction cost was US$68.61.

Results and Discussions

The characteristics of the pump are shown in **Table 1**. The table indicates that at the LHS, the FS and SS were on the average, 41 cycles/min. and 33 cycles/min respectively, while at the HSH, they were 42 cycles/min and 35 cycles/min. The theoretical or expected volume of water to be released by the pump per cycle was 3.40×10^{-3} m^3. However the actual volume of water collected per cycle were 3.06×10^{-3} m^3 for LSH with FS, and 1.95×10^{-3} m^3 for HSH with SS. Both LSH and HSH with SS and FS respectively, had the same volume of 2.52 $\times 10^{-3}$ m^3 per cycle.

The friction loss in the pipe, h_p, however, increased with an increase in static head (**Table 1**). This indicates that the length of the pipeline had great effect on the h_p in agreement with the relationship, $h_p = \gamma L$ (Massey, 1989), where L is the length of the pipeline and γ is constant and equals $32fQ^2/g\pi^2d^5$ with symbols having the usual meanings.

Table 1. Characteristics of Tapak-tapak Pump When Operated by a Person of 58.0kg Weight

	LSH = 0.55m		HSH = 3.1m	
	FS	SS	FS	SS
Number of cycles/min.	40.90	33.21	42.37	35.38
Volume of water discharged/cycle $\times 10^{-3}$ (m^3)	3.06	2.52	2.52	1.95
Flow rate (l/min)	125.17	83.67	106.83	69.17
Friction loss in the pipe (cm)	2.19	0.96	5.86	2.51
Friction loss at the bend (cm)	2.59	1.16	1.88	0.79
Hydraulic efficiency (%)	92.00	96.26	97.56	98.94
Volumetric efficiency (%)	90.10	74.06	74.11	57.06

All values are averages

Generally the hydraulic efficiency, η_h, which expresses reduction in effective head due to frictional losses, was high at SS (**Table 1**). This indicates that at slow speed (SS) friction losses were less. However, at HSH, even though friction losses were high, hydraulic efficiency, η_h, was higher compared to the corresponding speed at LSH with less friction losses (**Table 1**). The reason could be that at HSH, the effective head was so high that a friction loss effect on it was negligible whereas at LSH, the effective head was greatly influenced by a slight friction loss. In general, the high hydraulic efficiency ranging between 92.0% and 98.9% at all levels indicate that there was not much reduction in effective head due to friction losses. The volumetric efficiency, η_v, ranged from as low as 57.1 % at HSH with SS to as high as 90.1 % at LSH with FS (**Table 1**). At HSH

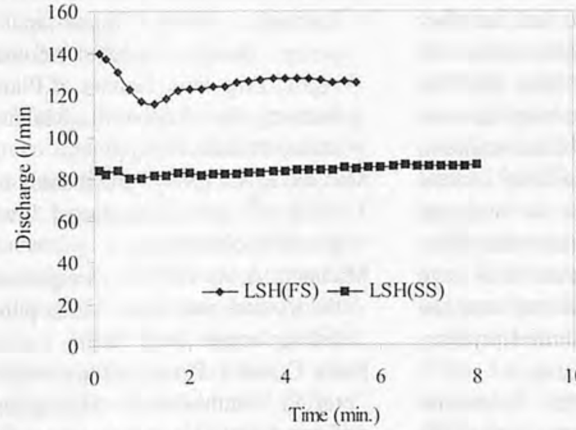


Fig. 2a Discharge at low static head with fast and slow speeds.

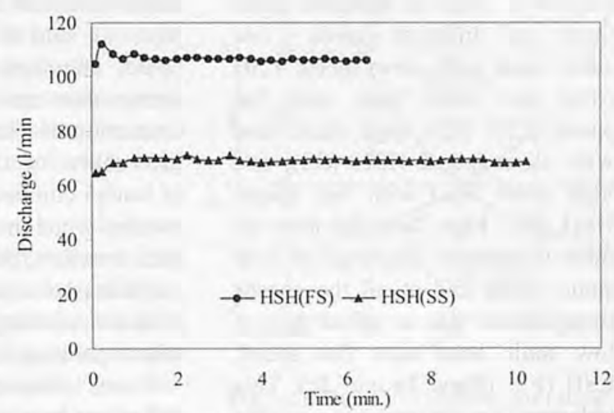


Fig. 2b Discharge at high static head with fast and slow speeds.

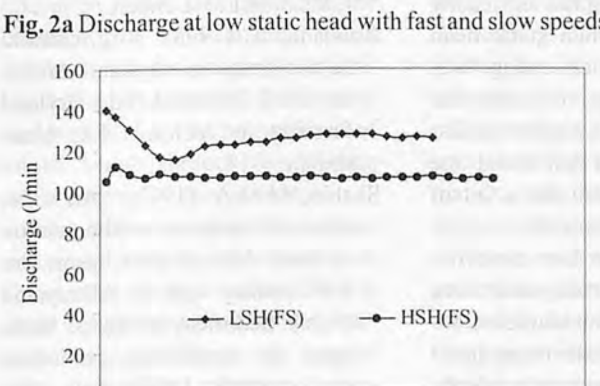


Fig. 2c Discharge at low and high static heads with fast speed.

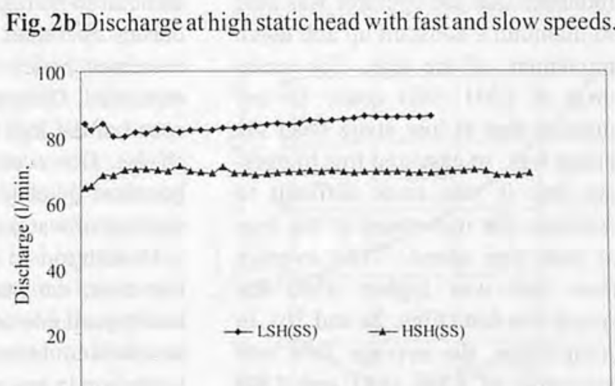


Fig. 2d Discharge at low and high static heads with low speed.

with SS water losses through leakage was high and, therefore, discharge was reduced, hence low volumetric efficiency, η_v.

The maximum discharge obtained in the study was 7.5 m^3/hr. Even though this is lower than the quoted value of 10.8 m^3/hr at 2m static head in IRRI (1990), the two discharges are not comparable as the discharge of the pump is relative to the weight, age and sex of the operator. However, it is hoped that if the same operator were to operate the two types (sharp and gradual bend of suction pipe pumps), the one constructed in this study (gradual bend) would produce greater discharge than the design one (sharp bend). This is because the gradual bend of the suction pipe eliminates eddies and pressure gradient, which will in turn cause flow separation.

Figs. 2a to **2d** show a comparison of discharge of the pump with respect to time at different static heads and different speeds - low static head with slow speed, LSH (SS); low static head with fast speed, LSH (FS); high static head with slow speed, HSH (SS); and high static head with fast speed, HSH (FS). **Figs. 2a** to **2d** show almost a constant discharge at both static heads and at all the speeds though there was an initial drop at low static head with fast speed, LSH (FS) (**Figs. 2a** and **2c**). This indicates that the operator was able to maintain a constant up and down movement of the legs. The initial drop at LSH (FS) could be explained that at low static head the pump was so easy and free to operate that it was more difficult to maintain the movement of the legs at that free speed. The average flow rate was higher when the speed was fast (**Figs. 2a** and **2b**). In comparison, the average flow rate reduction of LSH (FS) and LSH (SS) was 33.3%; HSH(FS) and HSH(SS) was 35.3%; LSH(FS) and HSH(FS) was 14.7% and LSH(SS) and HSH(SS) was 17.3%. However, at fast speed, the operator got tired early and also there was a lot of water wastage through spillage on the floor. **Figs. 2c** and **2d** showed that for the same speed, the flow rate was higher at LSH than at HSH. The friction loss at the bend, h_b, increased with an increase of flow rate.

It took 10 man-working days to construct the pump assembly. The construction cost, including labour, was $68.61 USD. This cost excluded power and machinery used. This is much lower than other pumps of the same capacity.

Conclusion

The construction cost was reasonably cheap compared to other water lifting devices. This cost could be reduced when constructing on mass scale because some of the metal materials were left, as they were not sold in smaller pieces. It could, therefore, be said that the construction cost was even an over estimation. It would be advisable to use rubber cup if available instead of leather cup because the latter got swollen when in contact with water and, therefore, the need for a large clearance between the cup and the cylinder resulting in initial priming when operating the pump.

It was observed that it became difficult to be raising the legs easily during operation when static head increased hence much energy was expended. Generally, the faster the speed of the legs the higher the discharge. However, at fast speed one got tired quickly and also a lot of spillage of water occurred.

In addition to the low construction cost, the materials used were easily available on the market. Construction could be done in any small workshop in any community whether rural or urban. Replacement of any component was easy since the pump could be dismantled and reassembled with ease. Again, the pump produced continuous flow of water because it had a double cylinder. A critical look should, therefore, be taken to adopt the pump in small-scale farming and rural communities to save them from over-reliance on fluctuated natural rainfall as their source of crop water requirement, and diseases from contaminated water, respectively.

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Improved Harvesting of Straw

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Abstract

The present article shows the results of experiments using harvesting machines (КИР-1,5 and КПИ-2,4) for picking up and shredding straw for cattle feed. The straw harvesting machine (КПИ-2,4) for cutting and harvesting straw uses a rake for picking up the non-grain part of a crop that is better than the mower-shredder КИР-1,5.

Introduction

The increasing growth in sowing areas and the introduction of new grades of high crop of grain cultures poses a sharp a question of harveting a hay crop with the least losses in optimum agrotechnical terms. This is particularly interesting in the Republic as modern, high-duty grain harvesting combines "Case" (USA) and "Claas" (Germany) are delivered in the country. But unfortunately, these combines are not adapted to cleaning the straw, which is a necessary component for the preparation of mixed rough forages for feeding cattle especially during winter.

Take into account a usual situation and material opportunities in Uzbekistan farms, it is expedient to clean non-grain parts of a crop harvested by machines. A special straw harvesting machine is purchased from the point of view of profitability.

It is known, shredded straw increases the appetite of farm animals by 30 %. And in order to supply cattle with shredded straw, it is necessary to conduct cleaning the straw simultaneously with shredding. It is in this connection in technological process of harvesting machines (КИР-1,5 and КПИ-2,4), that the process of straw shredding is investigated.

Results and Discussion

Based on a comparative experience in an experimental farm in UzMEI, after cleaning the wheat straw of grains using a harvesting combine, the qualitative parameters of the "Case" machineare analyzed.

The change in soiling (Зc) and loss (Пc) straw is depicted on a kind of the schedule (**Figs. 1a** and **1b**).

As it is visible from the schedule (**Fig. 1a**) with a increase in the height of installation of a rotor КИР-1,5 losses are increased, and the soiling of a straw decreases. Within the limits of height of installation of a rotor of 90 ...120 mm of loss make 12 ...14.5 %, and content of soil in a straw is 2 ...4 %, that exceeds the allowable norm of the zootechnical requirements.

It was observed that the blunting and breakage of a rotor's knives are caused by accidents on the ground resulting in infringement of technological process.

Thus, the mower-shredder КИР-1,5 corresponds not only to the requirements of mechanized cleaning of a straw but also to the zootechnical requirements.

Results of experiment with the КПИ-2,4 show (**Fig. 1b**), that with a increase in the height of the installation of the pick upper's fingers in limits from 60 up to 180 mm losses were increased, but the soiling of straw does not exceed of the zootechnical requirement.

And so, the pick upper - shredder КПИ-2,4 satisfies the zootechnical requirements (0.3 %) by parameters

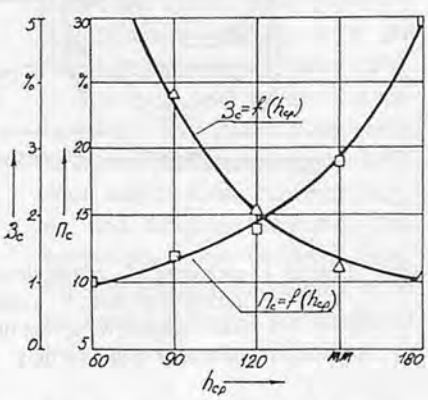


Fig. 1a Soiling (Зc) and loss (Пc) straw versus height of installation of КИР-1,5.

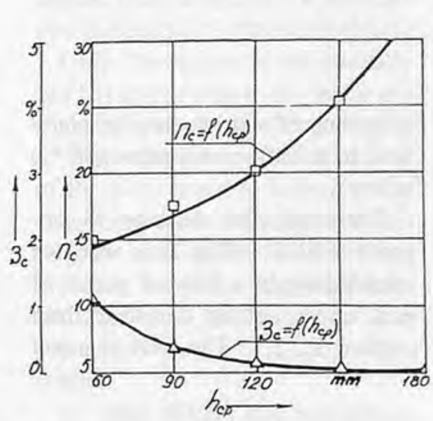
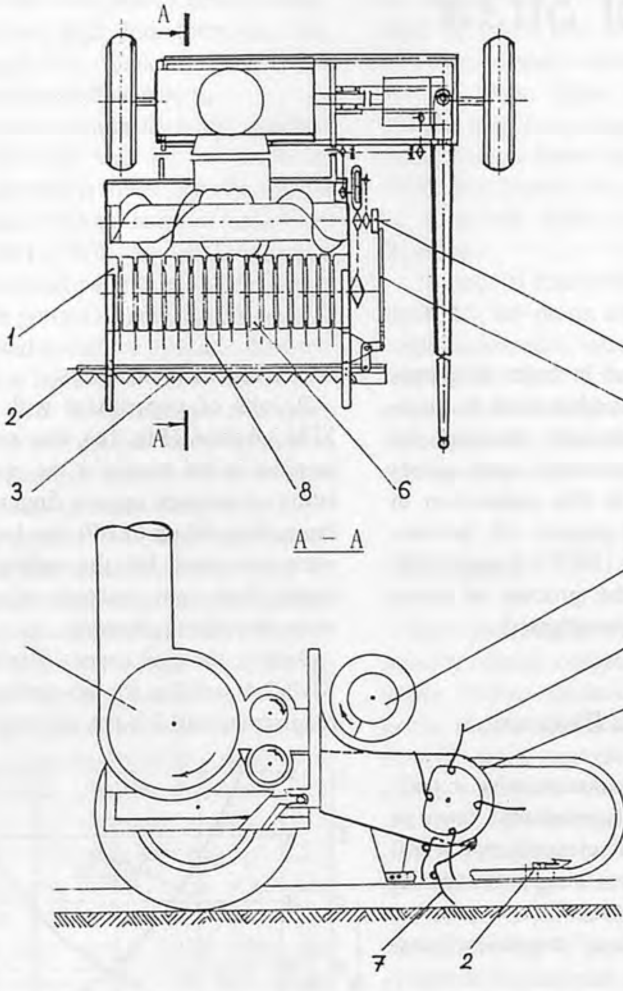


Fig. 1b Soiling (Зc) and loss (Пc) straw versus height of installation of КПИ-2,4



Legend: 1 - pick upper; 2 - cutting device; 3 - segment knife;
4 - intermediate shaft; 5 - a cranc-rod gear; 6 - rings – slopes;
7 - rake – fingers; 8 – spring fingers; 9- screw;
10 – shredder (cutting drum)

Fig. 2 Advanced pick upper - shredder КПИ-2,4.

of soiling of a straw, but completeness of selection of a straw (83 %) is low.

Therefore, the decision to improve КПИ-2,4 (**Fig. 2**) is accepted establishing in a forward part 1 of pick upper cutting device 2 from mower КС-2,1. The drive segment of knife 3 is executed through a intermediate shaft 4 of pick upper, by means a cranc-rod gear 5.

In addition to the bottom part of the rings, slopes 6 are installed on the hinged rake - fingers 7 for raking up straw on accidents between rows. By the work of the machine,

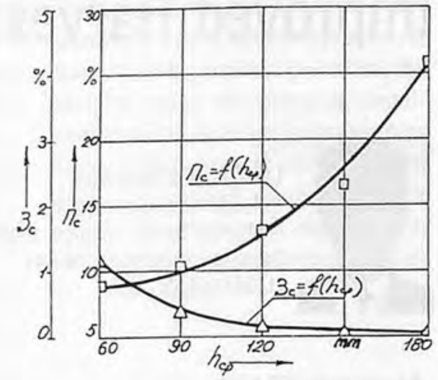


Fig. 3 Effect of proper height of installation of cutters.

segment knives cut of the stubble and cutting parts of stalks together stacked in mows of straw are gathered by the rake – fingers. These are then selected by the pick upper's fingers 8, and further directed through screw 9 in the shredder 10. From there the straw is transported in shredded form to a trailer.

Experiments conducted with the advanced pick upper-shredder (**Fig. 3**) show, that with an increase in height of the installation of cutters losses on non-grain parts of a crop are increased. It is important to note, that by cutting and raking of stubble it has managed to raise a complete selection of a straws up to 90 % and thus pollution of a straw by soil equally 0.3 ...0.4 %, that does not exceed the zootechnical requirement.

Thus, for harvesting of straw from mows, the most preferred machine is the straw harvesting machine КПИ-2,4 with adaption for cutting and selection with the rake upping of non-grain parts of the crop, being the best parameters in the operation. ■■

Design and Development of Multi-fruit Grader

by
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Abstract

A multi-fruit grader was designed on the principle of weight basis and developed for grading spherical fruits like apples, pears, peaches, orange, mousmi, and pomegranates. The main components of the grader are: frame, roller conveyor, fruit carrier, weighing unit, power transmission unit and chain sprocket drive. The performance of the grader was evaluated at 5 (0.029 m/s), 10 (0.058 m/s), 15 (0.086 m/s), 20 (0.115 m/s), 25 (0.144 m/s) and 30 (0.173 m/s) rpm of fruit carrier on four fruits, namely; apples, oranges, mousmi and pomegranates. The performance was satisfactory at the carrier speed between 12 and 15 rpm. The capacity ranged from 150 to 200 kg/h depending upon the fruit type and variety. The overall grading efficiency was close to 96%.

Introduction

India has varied climates and soils on which a wide range of tropical, subtropical, temperate and arid zone fruit crops are grown. India produces about 41.5 million tonnes of fruits over an area of 3.3 million hectares (NHB, 1998). Post-harvest losses of fruits vary between 20 and 30 percent amounting nearly to Rs. 3000 crores annually (Anon, 1995). This may be due to lack of efficient post harvest technologies related to their collection in major producing areas, short term storage and cold chain in the entire post-harvest handling operations.

The normal practice in India is to grade fruits manually. Manual grading is carried out by trained operators who consider a number of grading factors and separate fruits according to their physical quality. Manual grading is costly and the operation is affected due to low availability of labours during peak seasons. It has also been reported that the weight of spherical fruits like apples, pears and citrus is proportional to the cube of its characteristics dimensions (Ryall and Lipton, 1972).

Grading fruits is a very important operation as it fetches high price to the grower and improves packaging, handling and causes an overall improvement not only in the marketing system. During the grading operation, the infected, deformed and rotten fruits are removed. The fruits are graded according to size, shape and colours. However, none of the existing graders grade fruits by weight. Graded fruits have better export market and reduce handling losses during transportation.

Weight sorting based on a catapult principle is used to sort apples accurately and without damage (Maggs, 1973). Generally, eggs are sorted by weight (Brennan et al., 1976). Weight grading is capable of more precise separation than is dimensional grading. It reduces labour cost, damage, time and power consumption and improves efficiency and accuracy.

Considering the need of the grader, however, the Department of Post Harvest Process and Food Engineering, College of Technology, G.B. Pant University of Agriculture and Technology, Pantnagar, has carried out an extensive research to design, develop and test a fruit grader working on the principle of weight basis for major fruits like apple, orange, mousmi and pomegranate.

Design and Constructional Details

The main components of the grader are frame, roller conveyor, fruit carrier, weighing unit and power transmission system (**Fig. 1**). The multi-fruit grader was designed for its various components viz. bevel gear, transmission shaft, chain and sprocket, conveyor, hopper, and weighing assembly. The components were designed using standard formula. The details of the procedures followed for design of these components are as follows:

1. Design of the Hopper

The feed hopper was designed to contain fruits for grading. It was constructed using M.S. sheet of thickness 1.5 mm. The hopper is fed manually and has a provision to discharge the fruit one by one on a roller conveyor.

a. Wall thickness - The thickness of the M.S. sheet to construct the sides must bear the fruit load carried by side walls, as bulk load pressure is given (Spinvakovsky and Dyachkov, 1972) as:

$$p = K_1 \times h \times \gamma \qquad (1)$$

where,

p - value of bulk load pressure on the vertical walls, kg/m^2

h - vertical distance from the surface of the load, m

γ - bulk density of the material, kg/m^3

K_1 - flow factor

where, $K_1 = (1 - \sin\varphi) / (1+\sin\varphi)$

Assuming

φ = angle of repose 20° for most fruits

h = 0.2 m (used in fabrication)

γ = 400 kg/m^3 (highest value among the fruits considered)

the value of K_1 was obtained as :

$K_1 = 0.49$

Substituting the values of K_1, h and γ in equation (1) the value of bulk load pressure: p = 39.2 kg/m^2

The standard steel table indicates that 1 mm thickness of M.S. sheet can bear the load of 46 kg/m^2. Therefore, the thickness of 1 mm was used for fabrication owing to its availability in the market.

b. Discharge opening of hopper - Based on the size of the fruits and angle of repose, Spinvakovsky and Dyachkov, 1972 proposed the following equation to determine the size of the opening :

$b = k (80 + a`_{max}) \tan\varphi$, mm (2)

where,

k = empirical factor (2.4 for unsorted fruit)

$a`_{max}$ = size of the largest fruit, mm (80 mm for largest fruit)

φ = angle of repose (20° for selected fruits)

Substituting the values of k, $a`_{max}$ and φ in the equation (2), the value of b is obtained as :

$b = 2.4 (80 + 80) \tan 20°$

b = 13.9 cm = 15 cm with a factor of safety

2. Design of the Roller Conveyor

The fruit roller conveyor was designed to convey fruits at the rate of 900 pieces per hour. The space between the rollers was kept in such a manner so as to accommodate only one fruit without jumping during its movement.

a. Capacity of the conveyor - The capacity of the conveyor was determined using the Spinvakovsky and Dyachkov, 1972 formula:

$Q = (3600qv) / 1000$ ....(3)

where,

Q - capacity, tons per hour

q - weight of the fruit per metre of the conveyor length, kg/m

v - linear speed of the conveyor, m/s

Assuming

q = 1.5 kg/m and v = 0.14 m/s

we get design capacity,

Q = 0.756 tons per hour

b. Resistance to motion factor - When a conveying machine serves to lift Q tons per hour to a height of H metres, the effective power spent on lifting the load will be:

$N_{eff} = (1000\,QH) / (3600 \times 75)$ hp ....(4)

If the weight of the load is q kg per metre of the conveying machine, the path L metre and the friction w, the weight of the load conveyed will be qL and the frictional resistance will be:

$W_{fric} = qL\omega$ kg....................(5)

The power required to overcome frictional resistance is:

$N_{fric} = (W_{fric}\,v) / 75$ hp.......(6)

The total power consumption is:

$N = N_{eff} + N_{fric}$

$N = (QH) / 270 + (QL\omega) / 270$ hp ....(7)

where, H = 0.2 m, lift height,

L = 1.0 m, path length and

ω = friction factor (0.1 for fruit conveyor)

Substituting the values in Equation (7), the total power obtained was:

N = 0.00084 hp

The value of friction factor was chosen from the table (Spivakovsky and Dyachkov, 1972) as 0.1 for the fruit conveyor.

c. Chain and sprocket for conveyor – The power to be transmitted is 0.00084 hp and the speed of drive sprocket is 30 rpm. The velocity ratio (V_r) is:

$V_r = N_1 / N_2$ ....(8)

where,

N_1 - number of teeth on smaller sprocket

N_2 - number of teeth on larger sprocket

V_r = 30/30 = 1:1

The chain pitch (p) is:

P = C / (20-30) ....(9)

where,

C = centre to centre distance between two sprockets, mm

= 500 mm kept for design

p = 500/20 to 500/30 for a low speed drive

= 25 to 16.66 mm

The standard pitches in this range were 19.05 and 25.40 mm. Therefore, a higher value of chain pitch, 25.04 mm was selected as the load was variable and easily available.

The chain speed (V) is given by formula:

$V = pnz/60 \times 1000$ m/s…(10)

where,

p - pitch of the roller chain, 25.4 mm

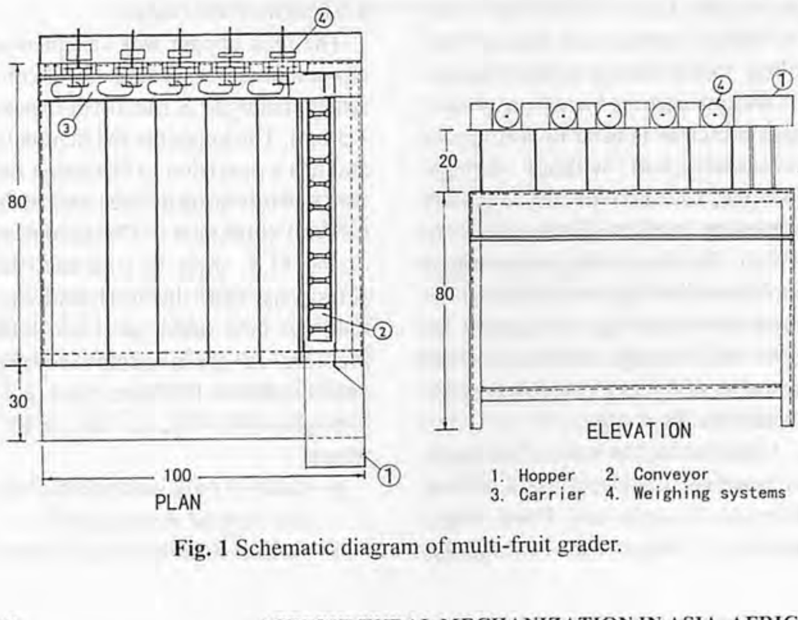

Fig. 1 Schematic diagram of multi-fruit grader.

n - speed of sprocket, 30 rpm (0.173 m/s)

z - number of teeth in the sprocket, 18

Putting the values in equation (10) we get: V = 0.228 m/s

The total circumferential/driving force acting on chain (F_u) is:

$F_u = (2\Pi \times 1000 \times T) / zp$.(11)

where, T is torque to be transmitted by motor i.e. 5.96 kg-f. The value of F_u is obtained as:

F_u = 147.43 kg-f = 1444.81 N

The chain tension due to centrifugal force of inertia (F_c) per unit chain length was neglected due to the low speed of the chain.

The tension due to sagging (F_f) is:

$F_f = K_f \times W \times C$ ....(12)

where,

K_f - chain drive arrangement coefficient considering the value as 2.0 for centre line inclined at an angle up to 45 degrees

C - centre to centre distance between two sprockets, 50 cm and

W - average weight N/m, (27 N/m or 2.755 kg-f from table)

Therefore,

F_f = 2.755 kg-f (26.99 N)

The total load on driving side (tight side) of the chain (F_o) is:

$F_o = F_u + F_f$

= 150.185 kg-f (1471.813 N)

The breaking strength of the chain (F_b) is:

$F_b = F_o \times$ factor of safety

Say, the factor of safety is 7 (Sharma and Agrawal, 1996)

= 1051.295 kg-f (10302.691 N)

As per desired, the chain speed, pitch, designed load and factor of safety, a simple roller chain with 25.4 mm pitch (16-B-3) was selected as per IS-2403-1975.

3. Design of the Weighing Assembly

The weighing assembly, fabricated from 10 mm circular M.S. rod, functioned as fulcrum to act as a lever. At one end of the rod the weights (50, 100, 150, 200 & 250 g) were mounted and the other end was used as carrier for holding the fruit. The forces acting at the ends of the rod and fulcrum are shown in **Fig. 2(a)**. The bending moments are shown in **Fig. 2(b)**. The design of the assembly is given as below:

a. Bending moment (M_b) – The maximum bending moment (M_b) at point O in **Fig.2 (b)** is given by the formula:

$M_b = F \times l_1$ ....(13)

where,

F - load at point A , Say for example a load of 250g is considered

l_1 - distance between fulcrum point and load point, 100 mm for this case

Then, M_b = 0.25 kg-f-m

b. Allowable bending stress (f_b) - For any kind of lever the allowable bending stress was given by:

$f_b = M_b / z$.........................(14)

where, z - modulus section of lever

The modulus section of lever for circular section is given as :

$z = \Pi d^3 / 32$

where, d - diameter of the lever rod (taken as 5 mm for weighing unit)

Then the value of fb obtained is:

$f_b = (M_b \times 32) / \Pi d^3$

$f_b = 2.037$ kg/mm^2

c. Resultant at the fulcrum (R) – The formula is:

R = F + P ....(15)

where,

F - load on one end (0.250 kg), i.e., at load point

P - load on other end (0.250 kg), i.e., at the centre of fruit carrier

The value of resultant (R) obtained is: R = 0.50 kg.

d. Allowable shear stress (f_s) -

$f_s = (M_b \times 4) / (2\Pi \times d^2)$.(16)

$f_s = 0.6366$ kg/mm^2

The ratio of f_s/f_b is equal to 0.31 which was higher than the permissible value (as 0.25) for bending stress (Sharma and Agrawal, 1996).

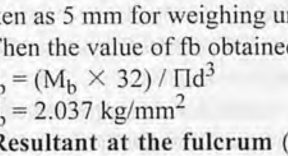

Fig. 2a Principle of the weighing unit.

4. Design of the Power Transmission System

The power was transmitted to the fruit carrier through a 90° bevel gear and chain-sprocket drive. It was designed for an input power of 0.5 hp. The torque input, T is:

$T = (hp \times 4500) / (2\Pi \times N)$. (17)

where,

N - speed of the fruit carrier, (60 rpm)

T = 5.96 kg-m

a. Pinion shaft – The maximum tangential load (F_o) is:

$F_o = F_t/C_v$ ....(18)

where,

F_t - tangential force,

C_v - velocity factor, and

F_o = 25.04 N

The torsional moment due to F_o on the pinion shaft (M_t)

$M_t = F_o d_p / 2$......................(19)

= 1.50 N

Normal load on the shaft (F_n)

$F_n = F_o / \cos\phi$

= 26.64 N

The pinion shaft was supported between two bushings spaced at 20 cm apart. Neglecting the weight of pinion for design purpose, the bending moment (M_b) is given as:

$M_b = F_n L / 4$ ....(20)

= 1.332 N-m

Equivalent torsional moment (Mt_e)

$Mt_e = \sqrt{Mt^2 + Mb^2}$ ....(21)

Mt_e = 2.0 N-m

The diameter of pinion shaft (d) was calculated as:

$d = \sqrt[3]{\frac{Mt_e \times 16}{\Pi \times fs}}$ ....(22)

Considering designed shear stress, f_s as ($0.18 \times f_{at}$) and substituting the value of ultimate shear stress (f_{ut}), f_s was obtained as

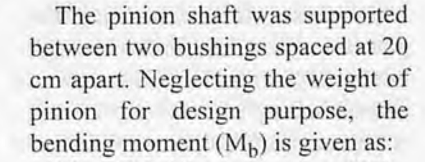

Fig. 2b Bending moment of the weighing arm.

253.80 MN/m^2.

The pinion shaft diameter (d) was obtained as 0.034 m or 34 mm.

b. Gear shaft - The transmission ratio between the pinion and gear was 1:1. This means that the torque on the gear shaft would be same. Therefore, the diameter of the gear shaft (D) was determined as:

D= $\sqrt[3]{\text{increased torque}}$

D= $34\sqrt[3]{1}$

= 34 mm

Hence, a diameter of 34 mm was selected for gear shaft.

c. Bevel gear - A bevel gear with 90 degree shaft angle and transmission ratio 1:1 was designed and fabricated. It was checked and found to be safe against bending stress, dynamic loading and contact stress. The designed dimensions of the gear is given in **Table 1**.

d. Chain and sprocket – The maximum power to be transmitted is 0.5 hp and the speed of the drive sprocket is 60 rpm. A roller chain was selected for transmitting the power to the fruit carrier through the bevel gear. Various factors were determined as:

Velocity ratio (V_r):

$V_r = N_1 / N_2$ ....(23)

where,

N_1 - speed of pinion, rpm

N_2 - speed of sprocket, rpm

V_r = 60/60 = 1:1

A sprocket with 12 teeth was selected due to low speed.

Chain pitch (p):

The pitch of the roller chain was calculated using following empirical equation:

p = C / 20 ....(24)

where,

C = centre to centre distance between two sprocket (400 mm)

p = 400/20 = 20 mm

A chain pitch, 25.40 mm was selected as the load was variable (Sharma and Agrawal, 1996).

Chain speed (V):

V = pnz / (60 × 1000) ....(25)

where,

p - pitch of the roller chain 25.4 mm,

Table 1. Detailed Design Dimensions of a Bevel Gear Used in Grader

Particulars	Pinion	Gear
Pitch cone angle (d)	45^o	45^o
Number of teeth (t)	24	24
Pitch circle diameter (d)	12.0 cm	12.0 cm
Cone distance (R)	8.48 cm	
Face width (f)	2.82 cm	
Normal pitch (p_n)	1.57 cm	
Addendum (h_a)	0.50 cm	
Dedendum (h_d)	0.60 cm	
Outside diameter (OD)	12.99 cm	
Gear material	Case Hardened Steel	

n- speed of pinion, 60 rpm

z - number of teeth of pinion, 24

Therefore, V = 0.609 m/s.

The total circumferential/driving force acting on chain (F_u) is

F_u = (2Π × 1000 × T) / zp...(26)

where,

T = torque to be transmitted by motor, i.e., 5.96 kg-m

Force F_u = 61.43 kgf = 602.01 N

The chain tension due to centrifugal force of inertia (F_c) per unit chain length was disregarded due to low speed of chain.

The tension due to sagging (F_f) formula is:

$F_f = K_f \times W \times C$ ....(27)

where,

K_f - chain drive arrangement coefficient (2.0 for centre line inclined at an angle up to 45 degree)

C - centre to centre distance between two sprockets, 400 mm

Therefore,

F_f = 2 × 8.007 × 0.40 = 62.76 N

The total load on the driving side (tight side) of the chain (Fo) is:

$F_o = F_u + F_f$ = 602.01 + 62.76 = 664.77 N

The breaking strength of the chain (F_b) is:

$F_b = F_o$ × factor of safety

= 664.77 × 8.35 (approx.)

= 5550.82 N

The factor of safety was chosen as per recommendation (Sharma & Agrawal, 1996) was 8.35. The desired chain speed, pitch, designed load and factor of safety for a simple roller chain with 25.4 mm pitch (16-B-3) was selected as per IS-2403-1975. The minimum breaking load, F_b of this chain was 43.10 kN, which was more than

Table 2. Effect of Speed on Grading Efficiency of Different Fruits

Speed, rpm	Overall Grading Efficiency, %			
	Apple	Orange	Mousmi	Pomegranate
5	100	99	99	100
10	96	100	100	100
15	93	100	99	98
20	92	97	98	98
25	90	98	98	93
30	85	95	97	93

the calculated breaking load of the chain. Hence, the chain design was found safe against breakage.

Experimental Procedure for Performance Evaluation

Five kg samples of each fruit were taken for the experiments. The samples were fed into the grader and separation efficiency was calculated for each grade (A, B, C and D) where grade A means more than 200g, grade B, 150-200g, grade C, 100-150g and grade D is less than 100g. The speeds of the fruit carrier were kept 5, 10, 15, 20, 25 and 30 rpm. Three observations of separation efficiency were taken for each speed and for each fruit. The overall separation efficiency of the grader was calculated by taking the average of the separation efficiency of each grade for that speed. The data collected during the tests of the grader were analysed. In order to test the significance of the parameter such as speed and its interactions with separation efficiency, the appropriate computer programmes for regression analysis were used.

Results and Discussion

The grader was operated at 5, 10, 15, 20, 25 and 30 rpm. The grading efficiency at various speeds for apple, orange, mousmi and pomegranate is shown in **Table 2**.

(Continued on page 52)

Development and Construction of a Machine for Waxing Fruits and Horticultural Products

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Abstract

Due to the variability and importance of agricultural products produced in Mexico, like prickly-pear, vegetables, fruits, etc., a machine for cleaning and waxing such products was developed and built. The quality of the work done by the machine must be satisfactory for market conditions and its cost must be adequate for the economical conditions of Mexican producers. It was intended that the machine could be applied to a broad variety of crops produced in Mexico, by taking into account the conditions of quality in appearance and texture of crops. The result was a simple, low-cost machine which is currently working efficiently with crops such as tomato, cucumber and green pepper. The observed work capacity with tomato and cucumber was 5 tons per eight-hour working period, and 1.5 tons for the same period, with green-pepper crops.

Introduction

The production of vegetables in Mexico is an important activity which stands out, in the order of importance, crops like tomato, potato, green pepper, onion, watermelon, melon and green tomato. Common operations like plowing, fertilization and sanitary treatments are highly mechanized. This is due to the fact that the machines used for these operations are the same, or very similar, to the ones used in the production of corn, beans or grains, as there are no particular problems to adapt this kind of machines to every crop. Substantial advancements have also been achieved in the sowing and transplanting operations. In the latter, the use of mechanical transplanting machines is widely extended. This type of machines require a worker for every one or two plantation rows; they are adaptable to small surfaces, abut they do not substitute manpower at a significant level. Therefore, work is currently undertaken to achieve an integral mechanization of the transplanting operation, i.e., machines that do not require manual positioning of plants.

There is a wide variety of agricultural products with different characteristics among them. Approaching this preliminary idea, specific machines associated to each crop are developed, each with a low rate of use. This causes the cost per hour of using the machine to be high. This factor combined with those associated to infrastructure, socio-economic character and adequate varieties have slowed down the mechanical harvesting of horticultural products and their post-harvest handling. Ruiz (1989) mentioned that the introduction of harvesting machines requires a change in varieties, cultivation methods and herbicide handling, with the purpose of achieving the required adaptation of production to the harvesting machine. In many cases a selective, mechanical harvesting has been suggested. To do this, the machine must be able to select fruits to be recollected as a function of several attributes like color, size, shape and consistency. For post-harvest handling, Kader (1992) pointed out that, for wholesalers and distributors, the most important attribute of agricultural products is the quality in terms of appearance, firmness and a long stocking time; while for consumers the agricultural products have a good quality when they have good looking, firm and when they have a good taste and high nutritive value. The harvesting of fresh fruits must be performed at the time of physiological maturity in order to minimize damages during harvest, storing, packing and transferring, ensuring in this way an acceptable quality when the products are marketed. An indicator of fruit maturity is the firmness of pulp (Delwiche and Sarig, 1991; Macías, 1996).

There are different attributes taken into account in order to select agricultural products, like size or quality. The physical separation of products can be made either pneumatically, electronically or by density. This separation can also be made manually, by detecting those products with mechanical damage, physiological disorders like germination or damage produced by insects (Baumgarner, 1992). This author also mentions that not all products can be waxed, however, as after brushing the fruits, they are susceptible to water loss and withering. The execution of an efficient selection depends on a careful and critical selection of several components of the equipment and the development of a suitable supervision scheme. Adequate spacing must be available for the selection equipment, which depends on the degree of diversity of the fruit, on the number of divisions or required separations, and on the relative size of the fruit to be selected. In addition to the required space, the equipment must have a way to control the speed of the band carrying the fruit which depends on the variations on fruit characteristics like quality, size, etc. Each worker must have a specific responsibility which involves assigning specific areas within the packing line and the identification of specific tasks to be performed by the worker (Baumgarner, 1992).

The objective stated for this project consists of developing and building a machine for waxing agricultural products, whose performance quality could be accepted for the market conditions and whose acquisition cost could be adequate to the economical possibilities of low income Mexican producers.

Materials and Methods

Taking into account the importance that fruits and vegetables have in Mexico, a waxing machine that could be afforded by Mexican producers with low income level was projected. The following characteristics of the fruits were considered:

Appearance:

1. Size: Dimensions, weight, volume.
2. Shape and Geometry: Diameter/depth ratio, softness, solidity.
3. Color: Uniformity, intensity.
4. Brightness: Wax.
5. Defects: External, internal.
   a. Physiological mechanical (dryness, damages).
   b. Physiological (rotting).
   c. Pathological (caused by fungus, bacilli or virus).
   d. Entomological (caused by insects).
6. Texture.
   a. Firmness, hardness, softness.
   b. Succulence, juiciness.
   c. Sandy, gummy.
   d. Toughness, fibrous.

In the development of this project, the following methodology was considered:

First of all, a bibliographical revision was performed with the purpose of finding existing machines used to remove spikes from the prickly-pear and also for waxing fruits and vegetables. This effort was made in order to take advantage of useful ideas used in such machines that could be incorporated in this project.

Secondly, taking into account the results of the bibliographical review, a list of agricultural products to be tested with the machine was made. Next, the general systems that will be integrated with the machine were proposed. A list and a brief description of such system follow:

1. Selecting the agricultural product.
2. Cleaning and waxing rollers. In the upper part of these rollers, a wax deposit is placed, which is kept liquid with the help of heat generated by light bulbs. Guides were considered in order to control the aperture of rollers as a function of the size of fruits.
3. Plain belt conveyor. Once the fruits are cleaned and waxed, they go to the conveyor where they are grouped according to their size, color, and external defects. The belt is 10 meters long and 80 centimeters wide which lays on top of several smooth rollers. This is driven by a 2.24-kW electric motor. The cleaning rollers are also driven by an additional 2.24-kW electric motor.

Conceptual Design of the Machine

As with any design work, this project started by identifying a need in order to generate a solution that corresponds to a real problem. In this case, the need consisted of simplifying and making more efficient both the process of removing spikes from a prickly-pear and the process of cleaning and waxing fruits and vegetables, in order to add value to such products.

Once the problem was identified, a detailed planning of this problem was developed with a proper identification of input and output variables, restrictions and design criteria.

Input: a prickly-pear with spikes, different-sized fruits (dimensions, weight and volume), color, shape, geometry and defects (external and internal).

Output: a spike-free prickly-pear, fruits with no mechanical damage, selected according to size, color, form and geometry, and without defects.

As the machine is being developed it is expected that once the product is selected, this will not have mechanical damages, with a 100% percentage of cleanliness but most importantly, that the machine could be adapted to accept different crops as a function of size and shape.

Restrictions

The development of a new technology must offer all possible advantages. However, in order to solve the problem, the design will have both economical and technical restrictions. These restrictions are frequently imposed by the clientele.

In general terms, not all restrictions can be satisfied at the same time or at the same level; therefore, some of them will be discarded in order to have an economically fea-

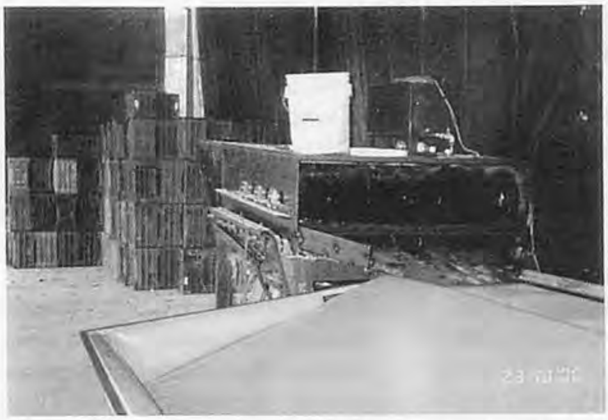

Fig.1 Machine for waxing fruits and horticultural products.

Fig. 2 Machine during operation (waxing tomatoes).

sible design.

The compulsory restrictions or requirements for this project are:

1. The design must satisfy the quality requirements related to the removal of spikes of the prickly-pear and, in general, the final appearance of the products must be satisfactory.
2. Safety and hygiene during machine operation.
3. Must fulfil with noise and vibration standards.
4. The machine must be able to perform the work that is ordinarily performed by four workers.

The optional restrictions or requirements for this case are:

1. The machine must be simple and easy to operate.
2. The cleaning and maintenance work must be easy to perform.
3. The cost of the machine must be affordable, as compared to other existing machines.
4. The machine must have a compact design in order to facilitate its transportation.

Results and Discussion

Figs. 1 and **2** show, respectively, the projection of the machine and the machine during operation (cleaning, waxing and tomato selection). The machine was designed to work with crops such as prickly-pear, tomato, cucumber, onion, green pepper, apple, melon, pear, potato, sweet potato, avocado, peach, apricot, pumpkin, watermelon, mangoes, orange, pomegranate, lemon, grapefruit and eggplant. When the machine is used to remove spikes from prickly-pear, care must be taken in order to completely clean the machine and change the rollers when other products are cleaned.

The machine has been adequately working with tomato, cucumber and green pepper, but problems were experienced with wax supply, as this gets solidified. In order to solve this problem, a heat source was installed along the dosing tube.

Conclusion

There exist in Mexico machines with a large capacity for waxing agricultural products. The working capacity of these machines is about 15 to 20 tons per eight-hour working period which is suitable for large producers.

The machine described in this paper is adequate for producers with a low income level. Such machine is simple and with a low cost (in the order of US$900.00) and has been tested successfully with tomato, cucumber and green pepper. The measured working capacity of this machine is about 5 tons per eight-hour working period in the case of tomato and cucumber crops, and 1.5 tons during the same period, for the case of green pepper crop. Such working capacity makes this machine a convenient technology for low-income producers.

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Comparative Grain Storage in India and Canada

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Abstract

Farmers and traders often have to store cereal grains and oilseeds because of the variations in the market demand and production. The grains undergo quality and quantity losses during long periods of storage. Abiotic (grain temperature, moisture content and intergranular gas composition) and biotic (insects, mites and fungi) factors interact to damage the stored grains. Proper storage facilities and management practices are essential for safe storage of grains. Selection of grain storage facilities and the management practices depend on the grain to be stored, local weather conditions and the availability of construction material and labour. This paper discuses and compares the grain storage facilities used and the management practices in India and Canada. India experiences losses of about 7 to 10% of her production in storage while the storage losses in Canada are less than 1%. Bag storage is common in India whereas grains are handled and stored in bulk in Canada. The reasons for such variations and the possible strategies to be followed for reducing the storage losses in India, based on the experience of Canada, will also be outlined.

Introduction

World food production has grown substantially in the past 20 years. The most rapid growth has been in the developed countries (such as Australia, Canada and the USA) where grain production has increased by about 4% a year over the past two decades compared to the growth rate of 2.8% a year world-wide (Thalwitz, 1981). The human population, however, has also increased substantially. It is projected that the world population will touch 7 billion mark within the next 25 years. The increase in population in the developing countries is more than twice the percentage increase in the developed countries (Pino et al., 1981). For example, the annual rate of population increase in Asia is 1.8% as against 0.7% in North America (Kemball, 1985). As a result, particularly in the developing countries, the per capita availability of food will become critical in the years ahead. The following solutions have been suggested to cope with the future food demand: (i) slowing down the population growth and (ii) augmenting food supplies by expanding food production per unit cropped area by applying more fertilizer and water. The success of these programs primarily depends on the socio-economic conditions of the nation. Another vital solution to improve the food availability is conserving food grain by reducing losses during and after harvest. The Food and Agricultural Organizations (FAO) of the United Nations has estimated a worldwide loss of over 200 million tonnes of food grain in the post harvest operations and found that much of the loss occurs in the developing countries (FAO, 1989).

Most of the developing countries in Asia and Africa are characterized by high density population and inefficient post harvest grain handling and processing techniques. The FAO estimates the annual losses of grains as approximately 10% of the total production with peaks for some countries reaching as high as 30 to 50% (FAO, 1989). The main reasons for such high losses are: lack or inadequacy of storage facilities, permitting free access to insects, rodents and birds to the products, influence of high humidity air or even rain causing mold growth, and in general, poor storage practices. The sophisticated on-farm storage facilities used in the developed countries such as in Canada may not be suitable for developing nations because of the cost of construction, operation and maintenance, and different climatic conditions.

Effectiveness of any storage practice depends on the climatic conditions of the region (Atwal, 1974; Sinha, 1973). For example, Sinha (1973) reported that in a temperate climate mites are more dominant than insects and microorganisms. In a tropical humid climate, primarily insects, and to a lesser extent, microbial species are the casual factors than mites. In a dry climate, insects are dominant rather than mites and fungi, and in a subtropical climate all 3 types of organisms are equally abundant. The losses to stored grain are also influenced by the type of grain and harvesting, drying and storing practices, seasonal variations of the weather, and the socio-economic traditions in the region.

Thus, the grain storage problems and the grain storage practices a farmer should follow to save grain differ greatly between a temperate (Canada) and a tropical (India) countries, and between developed (Canada) and developing (India) countries. This report explains various grain storage practices used in India and Canada.

Objectives

The objectives of this paper are:

1. To report on various grain storage facilities and practices used in Canada and India; and
2. To discuss the ways of reducing stored grain losses in Indian storages based on the experience of Canada.

Canada

An Overview

Climate, landform and soils have limited Canada's agricultural land to 68 million ha (Kreuger and Corder, 1982), which is only about 7% of the total land area. Of the total population of 27.3 million people, only about 3% are engaged in agriculture (Anonymous, 1994). The average farm size in the Canadian prairies is larger than 260 ha (Kreuger and Corder, 1982; Kemball, 1985). The average annual production of grains, oilseeds and pulses was 60 million tonnes between 1984 and 1993 (Anonymous, 1994). The major cereal crops grown are wheat, barley, oats and corn, and the major oilseeds are canola and flax seed. Of the average annual world production between 1984 and 1993, Canada produced 5.0% of wheat, 7.2% of barley, 7.3% of oats, 1.4% of corn and 16.5% of canola (rapeseed). Canada shared 21% of the world exports (Veeman and Veeman, 1984). The total agricultural exports of the country account for about 7.2% of the total exports.

On-Farm Storage

Much of the harvested grain goes to farm storage before being moved for marketing to commercial facilities. The grains are handled and stored in bulk. The most common storage structures on Canadian farms are the freestanding corrugated, galvanized steel bins of 60 m^3 capacity (Muir, 1986). Several small, freestanding wooden bins of 40 m^3 capacity are used along with few larger multiple structures constructed from wood or steel. The number of bins used on a farm depends on the number of crops grown in a crop season, the area of the farm and harvest of each crop.

On the farmstead the grain is usually transferred to and from storage with portable screw augers. Considerable harvested grain is dried using mechanical dryer or by forcing ambient air through the grain to safe moisture levels before storage. With the introduction of on-farm drying and larger farms, more integrated and planned handling systems are being installed using bucket elevators to deliver the grain into the bins and dryer.

The major problem encountered in the storage bin is the moisture migration which occurs because of convection currents due to temperature gradients caused by changes in outdoor air temperatures. In the process, the moisture content of the grain near the top center of the bin in winter, or near the bottom center in summer is raised above the safe limits. This causes development of mold growth and subsequent heating of the grain and eventually may result in the outbreak of insects when the temperature levels near the hotspot are optimum. In order to avoid this problem the farmers usually aerate the grain mass (force air at 1-2 (L/s)/m^3 of grain). The forced ventilation not only cools the grain, thus controlling moisture migration, but also removes 0.5 to 1.0 percentage point moisture from the grain (Friesen and Huminicki, 1987). If heating of the grain occurs, farmers turn the grain or cool it using aeration fans.

Emergency Storage Structures

When lack of storage structures occurs most farmers resort to emergency storage structures that can be constructed easily and less expensively than permanent structures. Some farmers temporarily store their grain in open piles. A new type of emergency storage structure, called Quick Bin, is commonly used by the farmers. The capacity of these bins is up to 180 m^3.

Off-farm Storage

Various types of off-farm commercial facilities such as elevators, are used in Canada. Depending on the purpose served these storage facilities are classified as follows (Halter, 1973):

Country elevators - These facilities are also known as primary elevators. Wood, steel and concrete constructions are used. The grain is received at the country elevators from farms in trucks and wagons, weighed, put through some preliminary cleaning and grading, stored and shipped by rail. The storage capacity of an elevator is more than 10,000 tonnes. There are 1409 country elevators in the country with a total capacity of 6.7 million tonnes (Anonymous, 1994).

Terminal elevators - These constitute rail-ship interface. The principal use of these facilities is to receive grain after official inspection, to weigh, clean and store grain prior to shipping. Shipment from these elevators is mainly by water but rail or truck shipment is also used to local markets. There are 18 terminal elevators in Canada with a total storage capacity of 3.3 million tonnes (Anonymous, 1994). These facilities handle a wide variety of grains and grades.

Process elevators - These facilities are specialized for processing a specific crop for a specific industrial purpose. They receive grain by trucks, rail or ship depending on the geographic location. These elevators have storage and blending provisions, specialized cleaning and grading equipments and dryers. There are 25 process elevators with a total capacity of 0.52 million tonnes (Anonymous, 1994).

Transfer elevators - These are elevators in the western or eastern division, the principle use of which is the transfer of grain that has been officially inspected and weighed at another elevator to ocean-going vessels or to rail and receiving, cleaning, and storing of foreign grains. Thus their function is limited to unloading, storing, and shipping. There are 15 transfer elevators in the country with a total storage capacity of 2.4 million tonnes (Anonymous, 1994).

India

An Overview

India is primarily an agricultural country. The agriculture sector is the mainstay of the national economy accounting for almost half of the national income. During the last decade, the country has turned to a position of surplus in food grain production from a position of deficit. Of the total population of 1 billion people 63% derive their livelihood from farming. The average land holding size is 2.6 ha, while one-fourth of the rural households own lands less than 0.4 ha and another one-fourth of them are landless (Singh, 1983). There are two crop seasons in the country, khariff, the crops raised in the summer and rabi, those raised in the winter. India produced 193.1 million tonnes of food grains during 1997-98, in the total cultivated area of 115 million ha (Venkataramani, 1999). The major cereal crops grown are rice (30% of the total cropped area), wheat, sorghum and maize, and the major oilseeds grown are groundnut, castor seed, sesame, rapeseed, linseed, safflower and cotton seed. Of the world production from 1984 to 1993, India shared 9.4% of wheat, 1.8% of corn, 18.4% of sorghum, 20.3% of rice, 32.0% of groundnut and 17.8% of rapeseed (Anonymous, 1994).

On-farm Storage*

About 70% of the grains is stored on the farm where maximum losses occur in terms of mass, quality, and nutritive value. Good storage practices and improvement of the existing storage structures on the farm is very important. The various on-farm storage facilities used in rural India can be classified as traditional or improved storage facilities.

Traditional Storage Facilities

The existing traditional storage practices are called by different names in different parts of the country, but the construction and operation of these structures are almost similar in any part of the country.

Primitive types - These pots, made from mud, cannot be made airtight, so the moisture accumulation cannot be avoided even as each of these containers hold 10 to 15 kg of grains.

Bamboo baskets - The baskets are plastered with mud to contain 20 to 200 kg of grain.

Mud structures - These structures, holding 100 to 400 kg each, are made of unburnt clay mixed with straw or dry grass. The common shapes are oval, rectangular, and circular with thickness of 1.5 to 8 cm. A big hole on the top is used for filling and a small hole on the bottom is used for emptying them.

Straw bins - These are used for storing paddy in the eastern humid zones. Dried paddy straw is used for making temporary structures which, after filling, are further reinforced from outside with paddy straw ropes around the whole structure. Each bin normally holds up to 600 kg of grains.

Underground bins - These are made bricks, concrete or mud each holding up to 8,000 kg capacity. These types of structures are found in low water level areas. Cylindrical or rectangular in shape, they hold grain to a height of 5.0 m with a hole in top for filling the grains. A layer of straw is placed on all sides of the grain bulk at the time of filling; often it is noticed that about half a meter of the grain layer at the periphery adjoining the walls turns black due to rotting. Insect infestation is low except in top layers. Unloading grain from such underground structures is very laborious.

Surface bins - These are rooms made of bricks with or without plaster. Their capacities are up to 3,000 kg. Cleaning of these structures is difficult because of the construction and darkness.

Drums - Empty or used made of sheet metal come with a lid and spout. Capacities range from 200 to 800 kg.

Bag storage - This is the most common grain storage in rural India. Bags are usually stored in the same house where people live. The grain brought from the threshing yard is sieved for weed seeds and foreign material, and heaped loosely in the house for 1 to 2 wk for aeration and cooling. Then it is stored in jute or woven polythene bags of 50 to 100 kg capacity each. The stored grain is periodically removed from the stor-

* From Girish et al. (1972).

age for household consumption and for marketing. The grain is occasionally examined for infestation, and if appreciable infestation is noticed it is exposed to the sun, sieved and re-stored. Highly infested grain is usually sold for animal feed.

Improved Storage Facilities

Cover and plinth storage (CAP) - Successful in some parts of African and Middle East countries, this system is suitable for arid areas with low rainfall. In this system, the bags are stored on wooden platforms and covered with 1,000-gauge polythene sheet. Three tier perforated duct tubes approximately 30 cm in diameter (one on top and the other two near the floor) permit free circulation of air. This facility has proven to be good against rainwater, rats, and insects. About 1.5 million tonnes of food grain are stored in this manner.

Welded wire mesh - This is an indoor structure specially used for high moisture grains. The capacity of the structure is 4.0 m^3. The bin is fabricated using welded wire mesh with hessian cloth lining inside to allow for free circulation of air. The structure is mounted on prefabricated steel elevated base to prevent entry of rats. A gas tight rubberized cloth cover is provided on the outside to make the structure moisture proof and airtight for fumigation.

Plastic bin - This is a low-cost structure suitable for indoor storage of grain. It has tube-shaped metal base with a provision for placing bamboo sticks vertically all around, inside the metal base. A cylindrical rubberized fabric hung inside is filled with the grain. Unloading is done either from the top or through the sliding door at the bottom of the metal base.

Prefabricated steel bin with hopper bottom - This is a strong, durable outdoor structure with a sloping roof, a hole in the top for filling and a hopper bottom with sliding door for emptying of grain. The bin stands on firm support with a clearance of 60 cm from the floor. Perforated tubes are provided at the center for free air movement.

Mud wall storage bin or Pusa bin - This is a conventional mud bin with polythene lining to make the structure airtight. This bin is easy to construct, very simple and within reach (not expensive) of an average farmer.

High moisture storage bin - This is an outdoor bin of 5.0 m^3 capacity that bin is erected on brick masonry columns with two concentric shells. The inner shell, made of galvanized perforated steel sheets, holds the paddy and allows for the movement of air, while the outer shell, made of plain steel sheets offers protection for the grain from moisture. The bottom of the bin is also made of galvanized perforated steel sheets for draining the excess moisture. Due to the free movement of air in the annular space, the moisture content of paddy is reduced from 23% to 14% in five months without any deterioration and discolouration.

Concrete masonry bin - This is a weatherproof structure with multiple compartments. The structure is constructed on a 60 cm platform with a flight of steps at the side for filling. A hole on top is provided for filling the grain and a spout on the inclined floor helps in emptying. The sidewalls are of reinforced concrete or brick construction with cement plastering on both sides.

Off-farm Storage

The urban storage structures are maintained by various agencies like the Food Corporation of India (FCI), State Warehousing Corporations, State Food and Civil Supplies Departments, and traders. Common urban storage facilities are:

Bag storage facilities - Buildings used for bag storage were constructed for general purposes, with corrugated metal or concrete roofs and mud or brick walls. Normal capacity of these structures is up to 6000 tonnes. The stack patterns are standardized to 9.3 m × 6.2 m with a walking space in between stacks. The grain in the bottom layers of the stacks is usually damaged due to seepage and condensation of moisture due to diurnal variation in temperature. To avoid this problem the stacks are placed on wooden platforms of 10 to 12 cm heigh. These platforms also help in free circulation of air underneath. In the absence of wooden platforms, a layer of polythene sheet is provided.

Flat bulk storage structure - This structure has a capacity up to 2,600 tonnes each. The internal dimension of the structure is 36.6 m × 19 m × 13.4 m. It has a mechanical bulk grain handling capability, and an aeration duct and a portable fan for forced air ventilation. Temperatures of the grain are constantly monitored by placing thermocouples in the grain bulk. The structure is adequately rat- and moisture-proof.

Modern silo plant - The capacity of these silos is between 500 and 10,000 tonnes each. They are provided with mechanical bulk grain handling system, a portable forced ventilation system, and thermocouples for measuring grain temperatures. In addition, they have the facilities to receive grain from road trucks and rail wagons for mechanical unloading of trucks, for cleaning, mechanical drying, automatic weighing and stitching, and a control room. Silo plants of 0.1 million tonnes capacity are being constructed at five locations in the country.

Aluminum bins with in-bin drying - These facilities are similar to those used on Canadian farms. The capacity of each bin is 66 m^3. A perforated metal floor, and a fan and heater assembly are provided for drying purposes.

Discussion

India suffers a loss of about 7% of her total grains in the storage (about 12.7 million tonnes). Krishnamoorthy (1972) quantified the losses caused by different agents as: 2.5% due to rodents, 0.9% due to birds, 2.5% due to insects, and 0.7% due to moisture. Storage loss in Canada is less than 1%. The following paragraphs explore the reasons for such high losses in Indian storages and suggest few ways of minimizing losses.

Unattended Grain

Indian farmers leave their grain on the threshing floors from a few days to a few weeks for drying purposes. The 0.9% loss caused by birds occurs here. In Canadian farms, mechanical threshers are used for quick threshing of the grains. Canadian farmers use mechanical dryers for quick drying and aeration fans for cooling the grain in the storage bin. In this way they avoid leaving the grain unattended in the fields. If mechanical threshers and dryers, to speed up the operations, could be used on Indian farms also the 0.9% loss could be avoided. However, owing to their financial situation many or most Indian farmers cannot afford to buy and use mechanical threshers and dryers. One possible solution for this problem could be that the government buys the mechanical threshers and dryers, and rent them to the farmers.

Extension

Indian farmers use traditional storage structures like the mud pots, bamboo baskets, kerosene drums, while their Canadian counterparts use modern and sophisticated storage facilities. Most Canadian farmers are well informed of the problems and losses that could occur in storage (through extension bulletins and user manuals), and take precautionary measures well in advance to save their grain. On the other hand, an Indian farmer is not aware of the losses. Neither his traditional feeling nor his economic condition permits him to adopt modern developments on his farm. Even though many improved storage structures have been developed by the research stations at Hapur and Mysore, their adoption by the farmers is poor. Extension wings of the Government Agricultural or Agricultural Engineering departments should publish simple extension bulletins explaining storage problems and losses and distribute them to farmers, conduct short term courses to teach the farmers about modern storage practices, and demonstrate new storage structures and practices on the farms.

Bag or Bulk Storage?

Bag storage is commonly used on Indian farms and in commercial storage facilities. In Canada only bulk storage is practiced. The main reason for this could be the availability of farm labourers in India. About 516 million people work on the farms in India, while only 1.1 million Canadians are engaged in agriculture. Lambeck (1989) states that maintaining quality and controlling rodent and insect activity is difficult in a bag storage system.

Can post-harvest losses be minimized? - There is no doubt that each system has its own advantages and disadvantages. For example, the advantages of a bag storage system are: (a) ease in manual handling, (b) easy segregation of infested bags, (c) less sweating problems, (d) many types and grades of grain can be stored in the same facility, and (e) it does not require special equipments. But a bag storage facility requires substantially more space than a bulk storage facility and insect and rodent problems are greater. The peripheral exposed surface area per unit mass of grain is much less in a bulk storage than in a bag storage, and hence less damage occurs from external elements in the bulk storage. The ability to handle bulk grain more rapidly than when it is in bags, improves the availability of grain supply in food deficit areas.

Lambeck (1989) further states that in a well-managed bulk storage system grain losses are often less than 0.5%. Thus, it is clear that a well-maintained bulk storage system is better than a bag storage system. But, is it suitable for India? Bulk storage requires specialized equipment, often imported ones (for Indian conditions). Also, it requires high initial investment, which is beyond the reach of a poor Indian farmer. Adopting bulk storage system from bag storage will replace manpower which is not desirable with the high level of unemployment problems in India. Instead, following ways to handle the situation efficiently are suggested:

On-farm - An average Canadian farm is 100 times larger than an average Indian farm (260 ha against 2.6 ha). Therefore, Canadian farmers can afford to use large storage bins with mechanical grain handling systems. But it is not necessary that a bulk storage system be large and sophisticated to get the full benefits out of it. Indian farmers can use small aluminum bins for storing grain instead of jute bags, which they have been using for many years. They should clean the bin, and apply insecticides before storing the grain. Proper ventilation should be given to avoid heating of the grain, and they should inspect their grain more often than what they are doing now, and should treat it if necessary to avoid losses.

Off-farm - Although newly constructed off-farm storage structures are bulk storage facilities, still a large quantity of grain is stored in bags which should be made rodent proof, and airtight for fumigation. Proper management by trained personnel is essential in reducing losses. The grain should be inspected at regular intervals. Jute bags used for storing grain may be lined with plastic sheets to make them moisture proof.

Underground Storage or Above-ground Storage?

Indian farmers use underground storage structures made of brick, concrete or mud. In Canada, only the above-ground storage is practiced. The grains stored in underground structures are often free from seasonal fluctuations of temperature and humidity. But, aeration and inspection of the grain for spoilage are difficult. Also, adequate sealing should be provided to avoid seepage of water, especially when the mud pots are used for storing grain underground when the penetration of moisture causes considerable losses. To avoid this, the mud pots could be lined with polythene sheets. An Indian farmer does not give proper ventilation to the stored grain. If the above-ground storage with proper ventilation is used instead of underground storage, the unnoticed losses in underground storages can be minimized. Grain in the above-ground storage can be inspected easily, kept under hygienic conditions and turning is easy.

Co-operative Storage

The production from small pieces of land holdings in India is very little (about 1,601 kg/ha, (FAO, 1989)). When the farmer stores this small quantity of grain, he often does not take interest in adopting new developments, nor does he care for them. If there is noticeable deterioration, he immediately sells the grain at a lesser price to avoid further monetary losses. This situation could be improved if cooperative storage is practiced instead of individual on-farm storage. For instance, if 100 farmers join together to form a cooperative society, then the total land area will be around 250 to 300 ha, and the quantity of grain that need to be stored also will be large. In a group of 100 farmers few can be educated easily on the grain storage problems and practices. These few farmers can manage the storage facility. If all the farmers grow the same crop in every crop season, then a bulk storage system can be used, otherwise a bag storage system should be suitable for this type of cooperative storage. The operational costs and the losses, if any, should be borne by every farmer in the society.

Conclusions

The common way of storing grain on an Indian farm and in commercial storage facilities is in bags, whereas in Canada only bulk storage system is used. India experiences a loss of 7% of her total production in the grain storage with less than 1% in Canada. Some means of minimizing post-harvest of grain in India are:

1. Farmers should use mechanical threshers and dryers to avoid leaving the grain on threshing floors that give free access to birds, rodents and insects.
2. Farmers should be educated on the problems of storage and new developments in storage.
3. Small bulk storage bins should be used on the farms and the existing commercial bag storage facilities should be managed efficiently to reduce the losses.
4. An above-ground storage should be a better alternative for an Indian farmer than the traditional underground storage structures.
5. Cooperative storage should be explored in order to get the full benefit of a bulk storage system.

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(Continued from page 42)

Design and Development of Multi-fruit Grader

The table shows that the grading efficiency decreased with an increase in grader speed for all the fruits. However, various mathematical models were tried to fit the efficiency data through a curve fitting program showing was found that the apple and pomegranate had a linear trend while orange and mousmi showed a quadratic relationship between speed and efficiency. The coefficient of correlation (R^2) and standard errors were 0.98 and 1.13, for apple; 0.89 and 1.12 for orange; 0.91 and 0.56 for mousmi; and 0.92 and 1.29 for pomegranate. The efficiency ranged between 85- 100, 95-100, 97-100 and 93-100% for apple, orange, mousmi and pomegranate, respectively. The decrease in efficiency with the increase in grader speed may be due to the effect of offset and impact on fruit holder.

Conclusion

The multi-fruit grader was designed and developed successfully. Based on the experimental results, its performance was satisfactory at the carrier speed of between 12 and 15 rpm. From the results obtained, it could be concluded that the overall grading efficiency is about 96%.

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Design Guidelines for Tractor Operator's Entry and Exit

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Abstract

The operating efficiency of the man-machine system and the performance of the operator can only be affected in an indirect manner due to the improper design of the entry-exit system. A good access system was found to reduce the chance of accident taking place. Work schedules are, therefore, less likely to be disrupted by an operator's absence due to injury. Twenty subjects were chosen to represent 5^{th} to 95^{th} percentile of the standing height based on anthropometric survey of the tractor driver's population and all the subjects were acclimatized with the experimental protocol. Subjective assessments made by the experimental subjects proved a reliable measure when they were asked to differentiate between relatively poor and good entry-exit of the tractor models used in the study. A Z-bend passageway should be avoided or entrance should be as possible to the gap between the seat and steering wheel. The passageway width should be as large as possible within the track width of the vehicle. This paper reveals the present status of entry-exit system on leading Indian tractors and the research study conducted at College of Agricultural Engineering and Technology, Junagadh on the design guidelines for entry-exit system.

Introduction

Tractorization started in India sometimes during 50s with annual sales of tractors of a few thousands units across the country when only the important models of tractors were available. The existing Indian tractors are yet to fall in line with the world trend regarding operator workplace because very little attention is given to the entry-exit system in designing a tractor. The tractor being an off-road vehicle is a very important source of farm power. The Indian tractor industry has touched an all time new record sale of around 2.21 lacks of tractors with India securing prestigious position of being the largest tractor manufacturing country in the world (Singh & Doharey, 1999). China and India are the two biggest nations of the world which could become important with their tractor productions using "medium technology" and units of low power level achieving high annual growth in domestic sales (Renius, 1994). In almost all designs of man-machine system human comfort and operator safety without affecting the cost of machines is gaining considerable importance (Babbs, 1979). However, in the case of tractors there seems to be no place for human comfort for economic reasons. The increasing awareness on the potential benefits of good ergonomic design has resulted in a steady improvement of the operator's workplace (Yadav, 1995).

The design and location of a tractor operator's workplace is frequently comprised because of conflicting requirements for the limited space available (Yadav, 1997; Yadav *et al.*, 2000). The need to consider the whole access system is emphasized because of the interactions between the size and location of steps, handholds and workplace arrangement. The need for easy access is particularly acute in the case of tractors because of the frequency with which drivers must get in and out during work. Difficult access is not only annoying and uncomfortable but can lead to accidents, both directly and indirectly by rendering the driver to be tired, irritable and less vigilant (Oborne, 1982). The workplace should not seriously hinder the movement of the operator in getting on and off the tractor and should allow easy and unhindered access to various controls (Yadav, 2000). However, accident statistics from tractors suggests that further improvements are necessary in the design of operator's entry-exit system.

On many agricultural tractors the driver climbs up into the workplace just in front of large driving wheels and the seat is positioned approximately over the rear axle. This results in Z-bend in the access path that makes entry and exit difficult (Yadav and Tewari, 1998). Steps and handholds need to be considered in conjunction with each other in order to provide safe ascent and descent. During both entry and exit, it should be possible for an operator to maintain a 3-point contact at all times (Couch and Fraser, 1991). The design of handholds is, therefore, as important as steps and need to be considered in conjunction with step design.

Methodology

A total of 20 subjects (tractor operators) were selected for this study following the sampling procedure given by Roebuck et al. (1975). The subjects were only male tractor operators because in India no female operators are employed for tractor driving task in field operations. In all three body dimensions viz. height, weight and step height were measured for each of the subjects. An anthropometer, bathroom weighing scale (0 - 100 kg) with an accuracy of 1.0 kg and measuring scale were used for the measurements. The collected data were analyzed and values for 5^{th}, 50^{th} and 95^{th} percentile were calculated by using equation 1:

$$P = L + [R (P-U) / (C-U)] \quad ....(1)$$

Where,

P = Percentile value, per cent

L = Adjacent lower range of class, cm

R = Class range, cm

U = Cumulative percentage of adjacent upper class, per cent

C = Cumulative percentage of this class, per cent

Five popular models of different leading tractor manufacturers were randomly selected viz. Farmtrac, T_1 (Escorts Ltd.); Mahindra 475 DI, T_2 (Mahindra and Mahindra Ltd.); Swaraj 735 FE, T_3 (Punjab Tractors Corporation Ltd.); HMT 3522 EDI, T_4 (Hindustan Machine Tools Ltd.) and MF - 35, T_5 (Tractor And Farm Equipments Ltd.). The different parameters measured for all the five tractors were step (height, arrangement and size), handholds (type, arrangement and size), passageway (location, size and shape) and operator workplace. These parameters were then used to study the shape of the entry-exit system.

A physiological and subjective assessment can also help in determining the proper entry-exit system. Hence assessment of workplace in terms of heart rate was carried out. The selected subjects were used in each part of the experiment when each parameter or combination was varied. Each subject was chosen to represent a group of percentile of the height range of the tractor driver's population, giving a total coverage from 5^{th} to 95^{th} percentiles. In each experimental session the subjects got in and out of the tractor for five minutes. The experimental procedure was explained to the subjects at the beginning of the session. Each time the subject climbed to the workplace, sat on the seat for 35 seconds, stood up and climbed out backward. Each subject was asked to walk round the tractor before climbing in again. Heart rate was measured by stethoscope before climbing in after getting down. A 150 mm long lined labeled scale was developed with 'great difficulty' at the right end and 'little difficulty' at the left end to assess the ease of access in terms of subjective evaluation. Care was taken in designing the experiments to minimize bias by asking the subjects for only one assessment for each experimental combinations tested, evaluating results as the preferred rank order rather than in absolute terms of 'good' or 'bad' and using mean results for each group of subjects.

Results and Discussion

When the accommodation of the population within the whole tractor workplace is considered, interactions occur within design dimensions. It is then convenient to treat the design in relation to the two extremes of a small (5^{th} percentile) and tall (95^{th} percentile) subject. Therefore, in all three dimensions of 36 randomly selected tractor operators were measured for each of the subjects. The data was compiled and grouped in 3 cm interval. The 5^{th}, 50^{th} and 95^{th} percentile values of the stature of tractor operators were found to be 156.75, 163.50 and 175.50 cm respectively. It was then confirmed analytically by using equation 1. The same procedure was then repeated for finding out the percentile values for weight and step height (**Table 1**).

Entry-exit System for Different Tractor Models

An entry-exit system for a particular design needs to be considered as a whole because there are interactions between individual components. The specification of a single system that is applicable to all machine designs is, therefore, not practical. So it was necessary to measure the parameters related to entry-exit system for all the leading tractor models in India. Giving emphasis on passageway shape, handholds, step-height and operator's workplace, plans for tractor models T_1, T_2, T_3, T_4 and T_5 were prepared and different aspects were also discussed.

Models T_1, T_2, and T_3 have a Z-bend, which is not desirable. T_5 was found to have comparatively better passageway shape. T_4 is found to be having the best passageway without any Z-bend and has a much wider platform width (**Fig. 1**). So in terms of passageway shape T_4 model has a favorable entry-exit system. The factor that determines whether the system has good or indifferent access can also be considered through the design's point of view in relation with operator's seat in the workplace. Ideally the gap between the seat and steering wheel should be opposite to the point of entry of the tractor (Bottoms, 1983). Where this is impractical the pathway between the door and seat should be straight since right angle turns in confined space are undesirable.

It is difficult for an operator to get in and off from a tractor with a workplace platform height more than some standard value. Up to the present time, there is no standard workplace platform height defined by the BIS and no guideline available on entry-exit system especially for Indian tractors. Therefore, this was confirmed with the BIS that for agricultural machinery the acceptable height of workplace platform should be 400 mm. If the workplace platform height is more than this in the case of high hp machinery, it can be corrected by providing steps. In tractor models considered T_1, T_2 and T_5 did not have steps with a platform height of 52.8, 58.0 and 48.0 cm, respectively. Model T_3 and T_4 have steps at a height of 49.0 and 41.0 cm, respectively and with a platform height of 69.8 and 59.6 cm, respectively. Among all the tractor models T_4 has a step at minimum height, i.e., 41.0 cm, which is very close to the standard value, whereas T_2 does not have a step in spite of 58 cm workplace platform height. In the case of Escort 340 and Mahindra 575 DI step height was 50.4 and 48.4 cm whereas the height of platform was 63.8 and 72.8 cm, respectively. Dismounting was also found more hazardous and hence more difficult than getting in (Niaz and Leslie, 1988). This suggests that the problems of getting out of the tractors need to be given at least equal attention as the problems during entry. Steps should be clearly visible from the top while egressing from the tractor. In the case of T_3 the step is only partially visible from the top which can lead to accident while egressing. Step should be arranged so that they are approximately at right angles to the access path.

Steps and handholds should be arranged in a manner, which will encourage the operator to dismount by climbing out backwards since this is considered to be generally a safer way of dismounting. During both entry and exit it should be possible for the operator to maintain a 3-point contact at all times (Vollmer *et al.*, 1980). The design of handholds is, therefore, as important as steps and needs to be considered in conjunction with step design. Usually the steering wheel is frequently used as an alternative for handhold particularly when getting in and out, which can lead to accidents and discomfort to the operator. A handhold each was found in T_1, T_4 and T_5 whereas for the T_2 model, the seating envelope

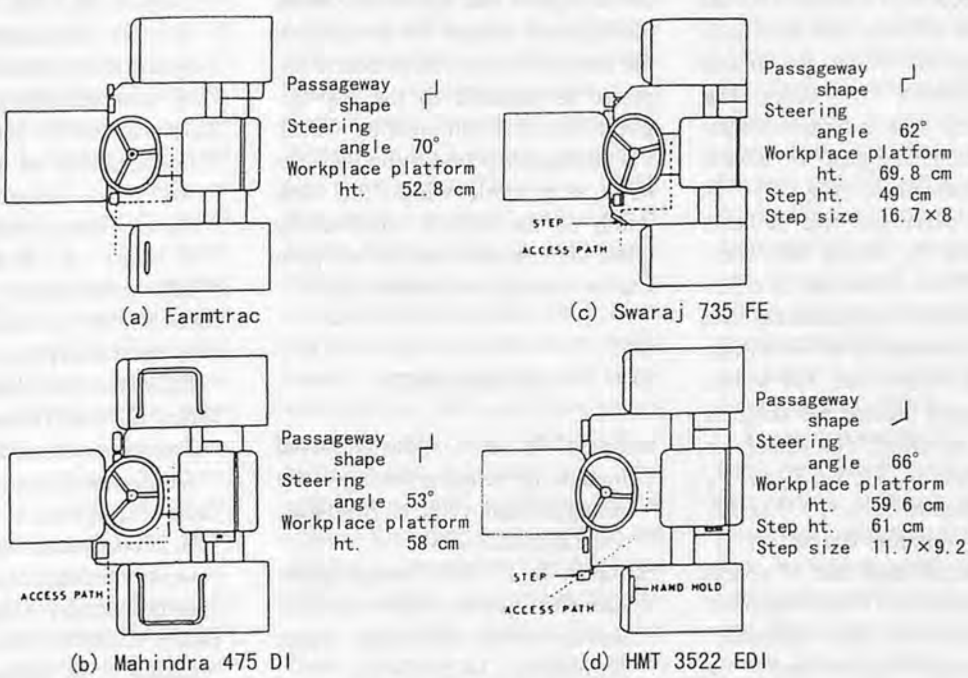

Fig. 1 Schematic diagram showing entry-exit system.

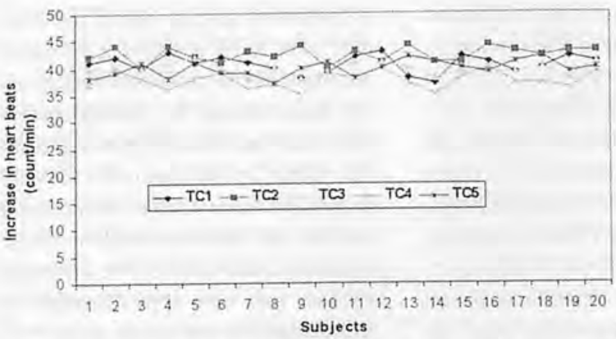

Fig. 2 Physiological evaluation in terms of heart rate for different tractor models.

Table. 1 Percentile Values of Different Body Dimensions of the Male Tractor Operator's Population.

Particular	Mean	S.D.	Mini-mum	Maxi-mum	Percentile value 5th	50th	95th
Stature, cm	165.68	5.79	155.00	182.00	156.75	163.50	175.50
Weight, kg	61.67	2.81	65.00	70.00	57.30	61.30	67.60
Step height, cm	42.44	1.95	40.00	51.00	40.10	41.50	44.00

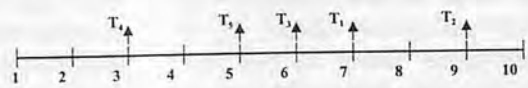

Fig. 3 Mean subjective assessment score.

on the mudguard was used as handhold. The T_3 did not have both a handhold. There should be a clear pathway between the entrance to the work area and operator's seat into which controls the tractor. Other obstacles must not impinge since their presence makes access difficult and creates hazards.

Physiological and Subjective Assessment

Twenty male subjects were chosen, each representing one-tenth percentile of the height range of tractor driver population giving a total coverage from 5^{th} to 95^{th} percentile, designated as S_1, S_2, ... S_{20}. The heart beat was measured for all the subjects initially and then each of them was allowed to get in and out of the tractor for 5 times. The physiological data in terms of heart rate was then analyzed for tractor models considered (**Fig. 2**). T_2 shows the maximum rise in heart rate whereas T_4 shows the minimum rise. Since heart rate is effectively a power measurement, this score is an assessment of work done in climbing in and out. The scores were averaged among the subjects to provide a rating. The rating for tractor models T_1, T_2, T_3, T_4 and T_5 was calculated to be 4, 5, 3, 1 and 2, respectively (smaller the better).

The subjects rated ease of access for each tractor on 15 cm long lined labeled scale with "great difficulty" at one end and "little difficulty" on the other end. The assessments were analyzed by scoring the distance of the mark from the "little difficulty" end on a designed scale from 1 to 10. The scores for all the subjects were averaged to provide a rating for each tractor (**Fig. 3**). Tractors T_1, T_2, T_3, T_4 and T_5 were rated as 7, 9, 6, 3 and 5, respectively. Thus tractor T_4 with lowest score is supposed to have the best entry-exit system among the five tractor models considered.

Conclusions

A step should be provided if the workplace platform height is more than 40 cm. The provision of handholds should be there to assist drivers to ingress and egress. A Z-bend passageway should be avoided or the entrance should be as nearly opposite as possible to the gap between the seat and steering wheel. The passageway width should be as large as possible within the track width of the vehicle, particularly when the entrance can not be opposite the steering wheel-seat gap.

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Physical Energy Input for Maize Production in Zambia

by

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Abstract

Production of maize, which is the main crop in Zambia, requires optimization of energy at all stages of production. The energy used in carrying out field operations in production is derived from human, animal and mechanical power. Farming has been classified as small, medium or commercial scale depending upon the sources of power and size of cultivated land. The study conducted in Zambia has shown that the energy input per hectare of small, medium and large scale farming is in the ratio of 1:2:11. The energy input for small scale farming is 211 MJ per hectare. The average energy output/input ratio is 27. It was also found that 26%, 7% and 67% of the total physical energy input was from human, animal and mechanical power, respectively.

Introduction

Maize (*Zea Mays*) is the staple food crop in Zambia and indeed in most of the countries in the SADC region. It is the principal food crop for over 70 million people (Blackie, 1994). Maize crop in many ways dominates Zambian agriculture, and is planted in well over half the cultivated area in the country. It is a major cash crop and subsistence crop in many areas. Furthermore, it is the basic input for poultry, intensive beef, dairy and pig production. Maize stalks, silage and bran help carry cattle through long dry seasons. In Zambia, maize is particularly important in the Eastern, Southern, Central, Lusaka and Copper belt provinces. Northern, Western and Luapula provinces also grow maize (Chipasha, 1996). The planted area and production of maize from 1982 to 1995 are shown in **Fig. 1**.

Agricultural households in Zambia are categorized into three types, namely; small, medium and large-scale (JICA, 1995). All farmers engaged in small scale farming systems utilize of hand hoe, ox-cultivation, and produce maize mainly for home consumption and employ low-level technology. These farmers predominantly depend on family labour for most farm operations. Medium scale farmers are engaged in semi-intensive farming systems that involve partial mechanization, extensive use of draught power, mixed farming, or less specialized farming and employ medium input level technology. Commercial farmers are engaged in large scale intensive farming systems that often include extensive mechanization, specialized farming and use of high level of technology (SACCAR, 1991).

The majority of the farming population is smallholders. In spite of this, they are responsible for 70 % of the maize production. There are more than 600,000 small scale farmers with limited access to capital, credit and markets, which are prerequisites for modern agriculture (Lungu and Chinene, 1993). The average maize grain yield from small scale farms is 1.5 t/ha, while commercial producers average 5-6 t/ha (Yerakun, 1995).

Energy is used mainly for agricultural operations such as seedbed preparation, planting, fertilizer application, harvesting and transportation. However, some energy is also used indirectly by way of fertilizers and pesticides and general maintenance. Energy input resources can be categorized into three groups: (a)

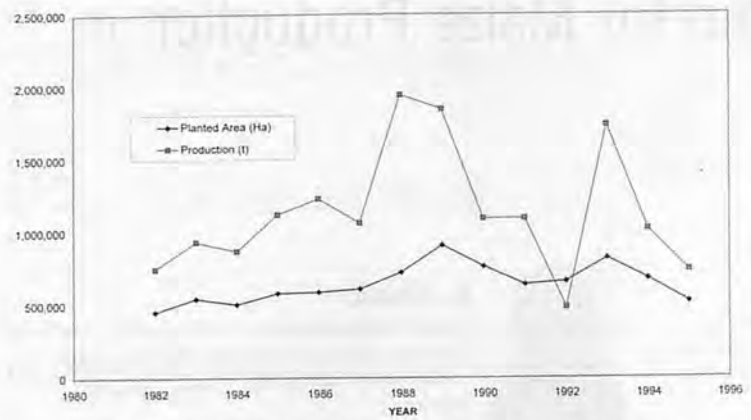

Fig. 1 Area planted and corresponding production for maize.

physical energy resources, i.e., human, animal and mechanical/electrical prime movers; (b) chemical energy resources, i.e., fertilizers and agro-chemicals; and (c) biochemical energy resources i.e., seeds and hormones (Singh et al., 1994). The present study was concerned only with the physical energy inputs for maize production in Zambia.

Materials and Methods

The major stages of production were identified as those which are essential and are performed every season for the production of maize. These are seedbed preparation, planting, fertilizer application, crop production and harvesting. Farmers involved in maize production are grouped according to the source of power for the agricultural activities and the area cultivated. It was assumed that small scale farmers depend only on human labour carrying out all field operations in maize production. They use only hoes for cultivation and can plant from 0.5 ha to 5 ha each. Medium scale farmers depend mostly on animal draught power for energy and normally plant between 5 ha and 20 ha each. Commercial farmers use mechanized equipment such as tractors, combines, and power tillers and plant units more than 20 ha (CSO, 1994).

In order to calculate the energy utilization, the following assumptions were made: (a) one hour work by a human being was assumed to be equivalent to 0.0746 kWh energy; (b) one hour work by a pair of bullocks was assumed to be equivalent to 0.746 kWh energy (Makungu and Dihanga, 1994); (c) one man-day was equivalent to 7 h work (Jonsson, 1977); (d) the power of a tractor is equal to the estimated power needed for a particular activity; (e) energy output of a driver was negligible as compared to the energy input of a tractor; (f) the units for maize production were square fields and were larger than 2 ha. Based on these assumptions, the human, animal and mechanical energy components were estimated.

Table 1. Labour Requirements for Crop Using Hand Cultivation and Animal Power

Operation	Technology		
	Hand cultivation	Animal draught power	
	Man-days	Man-days	Ox-days
Land preparation	42	8	8
Planting and basal dressing	6	-	-
Weeding 1st and top dressing	12	6	4
Weeding 2nd	12	4	4
Harvesting, shelling etc	40	-	-

Results and Discussion

Energy Requirements for Small Scale Farmers

Table 1 shows the time required in man-days to perform a particular operation in maize production (Moll and Kahokola, 1993). Values from this table were used to arrive at energy requirements for small scale farmers shown in **Tables 2** and **3**.

Energy Requirement for Commercial Farmers

In commercial farming, the tractor is used as the main source of power for farm operations (**Table 4**).

Proportions of Different Sources of Energy

Most of the work for both the small scale and medium scale farming is done by human labour. In small scale farming, all the operations are done by human power. In medium scale farming, only plant-

Table 2. Time and Energy Requirements for Small Scale Farming Operations

Item	Time required		Energy required	
	Man-day/ha	h/ha	hp-h/ha	MJ/ha
Land preparation	42	294	29	79
Planting and basal dressing	6	42	4	11
Weeding 1st and top dressing	12	84	8	23
Weeding 2nd	12	84	8	23
Harvesting, shelling etc	40	280	28	75
Total	112	784	78	211

Table 3. Time and Energy Requirements for Medium Scale Farming Operations

Item	Time required		Energy required	
	Man-day/ha	h/ha	hp-h/ha	MJ/ha
Land preparation	8	56	56	150
Planting and basal dressing	6*	42	4.2	11
Weeding 1st and top dressing	6	42	4.2	113
Weeding 2nd	4	28	28	75
Harvesting, shelling etc	40*	280	28.0	75
Total	64	448	120.4	425

* No oxen used for the operation.

ing, basal dressing and harvesting operations are performed by humans, the remaining being done by animal power. The total energy is, therefore, the sum of both components. Commercial farming involves the use of tractor power in all the field operations. The total physical energy consumption in maize was 3.8×10^8 MJ, which was comprised of 26 % human, 7 % animal and 67 % mechanical power.

Energy Output/input Ratio

The ratio of the energy output of the crop to the physical energy input for its production is an important indicator of the efficiency of production. Food energy yield of maize is assumed to be 15.1 MJ/kg (Makungu and Dhienga, 1994). The energy output/input ratio of maize in Zambia since 1982 is shown in **Fig. 2**. The average energy output/input ratio is 27.

It is seen from **Fig. 2** that crop production increased as the energy output/input increased and vice versa. It is noticed that a linear relationship between maize production and physical energy output/input can be established as shown in **Fig. 3**.

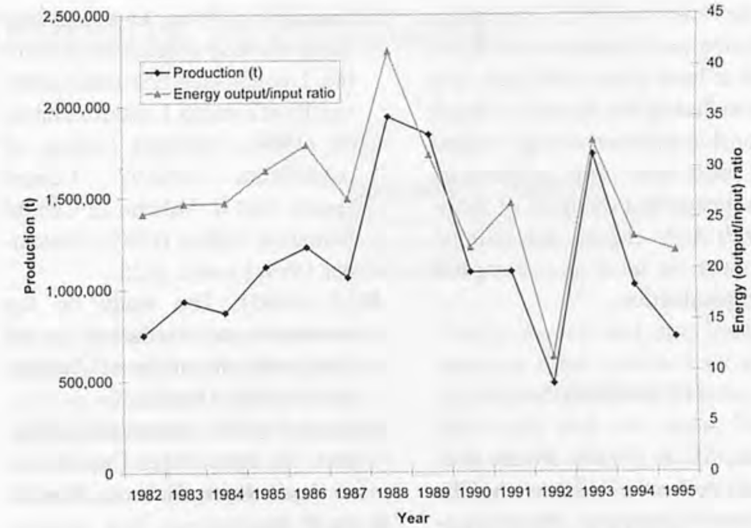

Fig. 2 Production of maize and energy output/input ratio.

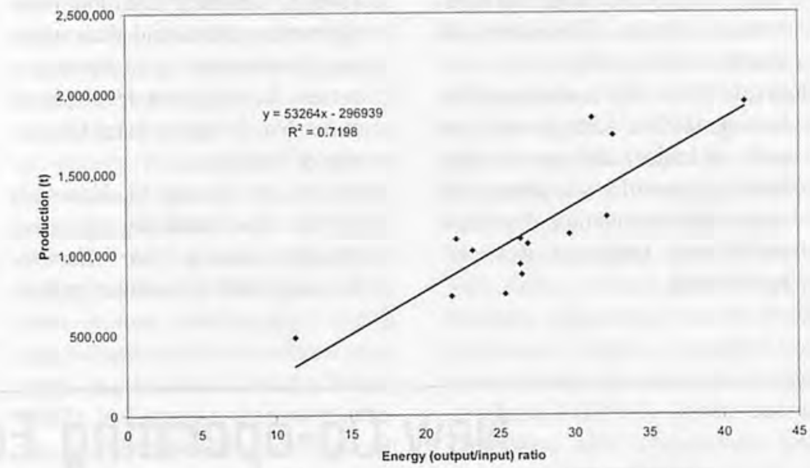

Fig. 3 Linear plot between energy output/input and production.

From the linear plot as above,

$Y = 53264\,X - 296939$

and $R^2 = 0.72$

where, X = energy output/input ratio, and Y = production of crop, t and R is the correlation coefficient.

Conclusions

Increased demand for maize requires optimization of energy at all the stages of maize production. This study is a step forward in contributing information on the energetics to the maize production in Zambia.

From the results the energy input per hectare for small, medium and commercial scale farming are 211, 425 and 2304 MJ, respectively. These are in the ratio of 1:2:11. The results also show that mechanical power has the highest percentage share of energy input in the maize production, followed by human power and lastly by animal power.

These results are based on production data from 1982 to 1995. It is also observed that energy output/input ratio went as high as 41 in 1988 and dropped to as low as 11 in 1992. The average figure was, however, 27 over the years of study. The annual variation in production may be partly due to rainfall variation. It is also noticed that commercial farming operations were growing and touched all time high in 1988 and dropped thereafter

Table 4. Time and Energy Requirements for Commercial Farming Operations

Item	Machine and type	Power source (minimum) type and size in hp	Time required for a square field >2 ha (h/ha)	Energy required hp-h/ha	Energy required MJ/ha
Land preparation		Tractor			
(i) Ploughing	plough 3 discs	60	4	240	645
(ii) Harvesting	disc harrow, 1.2m	40	2.2	88	236
Planting	planter 3 rows	60	2.5	150	403
Weeding	cultivator 3 rows	40	3	120	322
Fertilizer application	fertilizer spreader 8m	40	0.5	20	54
Harvesting	Combine 2 rows	60	4	240	645
Total		300	16.2	858	2,340

with the lowest in 1992. The pattern of farming and production does not appear to have since stabilized. It is also concluded that there is a linear relationship between energy output/input ratio and crop production, which means that methods of farming with high energy output/input ratio must be used to accomplish greater production.

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Farm Tractor Conditions in Botswana

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Summary

Tractor owner characteristics and tractor conditions in the Southern Agricultural Region of Botswana have been studied using questionnaires. It was found that 24%, 32%, and 44% of tractor owners were between 31 and 40 years, between 41 and 50 years and over 50 years, respectively, with 62% having primary or no education. The tractors had an average age of 21 years and engine power range of 25 to 110 kW. All of them were used for ploughing. The study further revealed that out of the tractors studied, 32% were bought new, 80% were either Massey Ferguson or Ford, 28% had headlights, 12% had turn signal lights, 4% had parking lights, 6% had brake lights, 58% had good tyres, 62% had good brakes, 84% had PTO shaft protector guards, 78% had mounting steps, 42% had good bodies and 34% had good seats. All of them have dashboard light. The operator workplace dimensions allow him enough space. Levers, pedals and controls were conveniently located in 90% of the tractors. Tractor noise levels were found to be above EC limits. The noise when ploughing at a speed of 6.5 km/h ranged from 98.6 to 104.1 dB(A) for engine power range of 20 to 100 kW. Maintenance and repair were irregular due to lack of education, information and money.

Introduction

Most tractors in Botswana are bought used or second hand, and they do not have maintenance books. Hence the maintenance history is often unknown making it difficult to assess the actual tractor condition. Safety and ergonomics have become very important in industry and agriculture, but in Botswana, these are often neglected mainly due to lack of legislation, information and education. Good safety practice in product production and farm machinery operation and regular maintenance of farm machinery reduce farm accidents and extends machine life. In comparison, in Britain alone, with about 1.3 million people employed in agriculture, an adult dies every three or four working days due to agricultural machinery related accidents (Agricultural Training Board, 1987). In Germany, there were a total of 1,065 tractor accidents in 1985 (Hammer, 1991). Mufti et al (1989) reported that tractor accounted for 31% of 104 farm machine injuries in Pakistan in 1987. Whitney (1995) stated that cleaning and periodic maintenance of tractors is very essential in enhancing their service life, while Bukhari et al. (1987) posited that if due attention is not given to proper and timely repair and maintenance of a tractor, it will naturally not give the desired service. Statistics for tractor accidents due to tractor condition are not readily available in most developing countries. Nevertheless, it is believed that the situation may even be worse due to the high percentage of illiteracy in developing countries compared to developed ones.

Many farms in Botswana are family owned and run. Most tractors are often operated by owners or owner's relatives. Tractors comprise old and new ones. Tractors that are old and not well maintained may be dangerous on the road and on the farm and unsafe for the operator and other vehicle users. If the operator's seat and workplace are uncomfortable and tractor controls are not within operator's reach, he will perform below optimum, incur excessive stress and fatigue resulting in possible increase of accidents and loss of money. Operators may also be exposed to harsh climatic and working conditions like heat, noise, exhaust gasses, and vibrations, subjecting them to stress, premature fatigue, accidents and occupational diseases. According to Hornick (1961), environmental conditions like temperature, relative humidity and dust seriously affect the performance of tractor operators.

Tractor conditions in Botswana have not been studied extensively. The study presented in this paper utilises questionnaires to survey tractor owners' characteristics and working conditions in the Southern Agricultural Region of Botswana. The survey will alert the Government, agro-industrial companies, schools and farmers about present tractor conditions and what to do to improve the conditions.

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Materials and Methodology

The study was carried out on 50 tractor owners and 50 tractors in the Southern Agricultural Region of Botswana, with the help of agricultural extension officers who identified the tractors and tractor owners. Data was obtained through a two-part questionnaire. The first part was composed of close-ended questions on the personal characteristics of the tractor owners covering age, gender, marital status, education, and training in tractor operation. The second part comprised open-ended questions on the tractors covering tractor characteristics (like make, type, engine power, year of registration, main dimensions); utilisation characteristics (like type of operation, type of maintenance, work duration, main repairs carried out); conditions of tyres, lighting system, brakes, controls (like steering wheel, levers, pedals); condition of safety protective devices; noise level; operator's comfort (like seat, reach of controls, access and exit conditions). Open-ended questions were used on the tractors because they allowed the researcher to pose follow up questions in order to obtain detailed or specific responses. The questions were tested on 20 tractor owners and tractors. They were modified to remove misunderstandings, ambiguities and mistakes before the questionnaires are used for the study.

Tractor engine idling, moving and ploughing operation noise levels were determined using Quest Technologie Impulse Sound Level Metre model 2700 with 20 to 140 dB(A) range, equipped with model OB-50 octave filter set. Noise levels were measured 1 m from the engine and at operator's ear. Steering tests were conducted using a Hoffmann dynamometer steering wheel. Breaking tests were achieved by measuring the distance covered by tractor before coming to a stop from a speed of 5 km/h on a firm untarred ground after brake application.

Results and Discussion

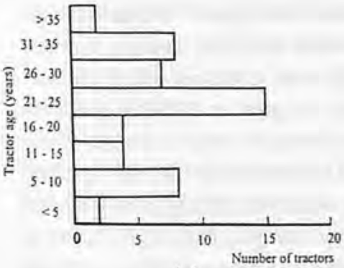
Table 1 shows some personal characteristics of the tractor owners indicating that none of the tractor owners was below 31 years of age, 24% were between 31 and 40 years, 32% between 41 and 50 years and 44% above 50 years. The highest percentage of tractor owners was those above 50 years because younger people do not have enough savings to buy a tractor, neither are they often credit worthy to borrow from banks to purchase tractors. People below 31 years are often working, schooling or unemployed. All the owners were male and married with 4 to 10 children.

Thirty-six percent of the tractor owners were illiterates, 26% had primary school education, 22% had junior secondary school education and 16% had senior secondary school (O-LEVEL) education. Nobody had more than secondary school education. The educational level of the owners was, therefore, generally low. Thirty-two percent had tractor operation training and 26% had attended servicing management training. The rest learnt to operate tractors privately on their farms. In contrast, studies in India show that only 12.5% of the farmers studied were trained in the use and maintenance of tractors (Balasankari and Salokhe, 1999).

Table 1. Some Characteristics of Tractor Owners

Age	Number	Percentage
below 31	0	0
31 - 40	12	24
41 - 50	16	32
above 50	22	44
Total	50	100
Education	Number	Percentage
None	18	36
Primary	13	26
Junior secondary	11	22
Senior secondary	8	16
Total	50	100

All of the tractors examined were diesel of which 32% were bought new and the remaining 68% were bought second hand. Furthermore, all the tractors were not insured but they had road licence. The popular make of tractors owned were Massey Ferguson and Ford with 46% and 34% ownership, respectively. This is so because there are dealers who sell and service these makes locally, so farmers do not travel long distances to buy or service them. The remaining 20% were of other makes such as John Deere, Landini, Fiat, and Mahindra which were bought from South Africa. The tractors surveyed were manufactured between 1963 and 1996. The age and power characteristics are shown in **Fig. 1**. The average age was 21 years and 64% were over 20 years. Only two each were less than 5 years and more than 35 years old. According to Febo and Pessina (1995), the management of old tractors is often uneconomical and they may be dangerous on the roads and unsafe for the driver and other vehicles, mainly because of deterioration of their performance. The power ranged from 25 kW to 110 kW with only one above 100 kW. Tractors with 25 kW to 60 kW power made up 74% of the total. The survey revealed that 94% of the



(a)

(b)

Fig. 1 Tractor age and power characteristics.

tractors had road licence and only 10% were insured. Since the machines are mostly used off the highway the owners did not think it was important to insure them. This is not advisable because accidents occur on the farm and off the highway too and it may occur during the few times they are on the highway. According to Shippen et al (1987), each year there are many farm accidents on or about farms when people are killed or injured, due to carelessness, ignorance and lack of proper maintenance of farm machinery. Hammer (1991) reported that 34% of all the tractor accidents in 1988 in Germany were off the farm.

All the tractors were used for ploughing. In addition, 42% were used for planting, 30% for cultivation and 58% for transportation of farm products to market or storage centres. The average time taken to plough and plant per day were 8.5 hours each. Cultivation was done by 6% of the farmers who had cultivating implements. The average area covered by each tractor per annum was 75 ha which means they are underutilised.

Other characteristics were as follows: (1) number of forward and reverse gear speeds ranged from 6 to 8 and 1 to 2, respectively; (2) maximum forward speeds ranged from 20 to 30 km/h; (3) all of the tractors had PTO rotational speed of 540 rpm; (4) 15% had mechanical brakes, while 85% had hydraulic brakes; (5) all of the tractors had hydraulic steering; (6) all of them had mechanical hand brakes.

Table 2 shows the lighting condition of the tractors, while **Table 3** displays the presence of lighting as a function of tractor age. None of the tractors had parking and brake lights, 46% had headlights, 24% had turn signal lights and all of them had dashboard lights. The headlight, turn signal light and dashboard light conditions are shown in **Table 2**. A Likert scale of 1 to 5 is used for the figure with 1 = very good, 2 = good, 3 = moderate, 4 = poor and 5 = very poor. **Table 2** indicates that 43% had very good or good dashboard lighting, while 46% had poor or very poor dashboard lighting; 16% had very good or good headlights, while 36% had poor or very poor headlights; 8% had very good or good turn signal lights, while 16% had poor or very poor ones. The lighting conditions, in general, made the tractors prone to accidents. Tractors without headlight were more than 24 years old. **Table 3** shows that the tractor lighting condition, in general, deteriorated with age. This should not be the case if the tractors were maintained regularly. Poor lighting conditions were mainly due to neglect and lack of education and money. Some dashboard lighting had varying degrees of dimness. Some headlights were dim, had no high or low beam, had cracked glass cover or had no glass cover. Poor and very poor turn signal lights were dim, had broken glass cover or had no glass cover.

The tyre conditions were better than lighting conditions because 58% were in very good and good condition, while 26% were in poor or very poor condition. The rest were moderate. Tyres with at least 75% of original lug height remaining were classified as very good and good. Those with 25% or less of the original lug height remaining were classified as poor and very poor. The increase in tyre wear and hours of work was linear. Tyre wear also increased with tractor age but in a non-linear manner. This agrees with findings by Febo and Pessina (1995) on some Italian tractors.

Sixty-two percent of the tractors had very good and good brakes, while 38% had very poor and poor brakes. Tractors with very good and good brakes stopped within 2 m from a speed of 6.5 km/h when brakes were applied. Those with poor and very poor brakes stopped in 4 m or more under the same conditions. The rest had moderate brakes. Sixteen percent of the tractors had no brake pedal locking devices to ensure even braking and simultaneous brake application of left and right wheels. These were completely missing or broken. There was no special pattern between missing or broken locking device and tractor age, but the tractors with poor brakes were all more than 18 years old.

Eighty-four percent of the tractors had PTO shaft protector guards on them. Of this, 78% were in good condition and 22% were cracked or twisted. Half of those without guards had the guards missing while the other half did not have them at the time of second hand

Table 2. Lighting Conditions

Lighting type	1	2	3	4	5
Headlight	4(8%)	4(8%)	2(4%)	10(20%)	8(16%)
Turn signal light	2(4%)	2(4%)	0(0%)	5(10%)	3(6%)
Parking light	50(100%)	0(0%)	0(0%)	0(0%)	0(0%)
Brake light	50(100%)	0(0%)	0(0%)	0(0%)	0(0%)
Dashboard light	4(8%)	13(26%)	5(10%)	10(20%)	18(36%)

1 = very good; 2 = good; 3 = moderate; 4 = poor; 5 = very poor.

Table 3. Presence and Absence of Lighting

Tractorage (years)	Headlight		Turn signal light		Parking light		Brake light		Dashboard light	
	P	A	P	A	P	A	P	A	P	A
Less than 5	2	-	2	-	2	-	1	1	2	-
5 - 10	8	-	6	2	2	6	3	5	8	-
11 - 15	4	-	2	2	-	4	1	3	4	-
16 - 20	4	-	1	3	-	4	1	3	4	-
21 - 25	10	5	1	14	-	15	-	15	15	-
26 - 30	-	7	-	7	-	7	-	7	7	-
31 - 35	-	8	-	8	-	8	-	8	8	-
Over 35	-	2	-	2	-	2	-	2	2	-
Total	28	22	12	38	4	46	6	44	50	0

P = present, A = absent.

purchase. These did not correlate with tractor age. Febo and Pessina (1995), however, found these to correlate with tractor age in Italy.

Mounting and dismounting steps were found on 78% of the tractors of which 16% were twisted or cracked. Half of those without mounting and dismounting steps were not provided with steps by manufacturer because of the tractor size. These had the platform for the feet, which also acted as the first step, at a height of 50 to 65 cm with a mean of 58 cm. The other half had theirs completely missing of broken. Seventy-four percent had one step and 4% had two steps between the ground and the platform for the feet. The distance between the ground and the step was 47.5 to 55.8 cm with a mean of 52.6 cm for those with one step. Those with two steps had the first step between 52 and 56 cm with a mean of 54 cm, and the second step was 78 to 86 cm with a mean of 82 cm above the ground with an interstep distance of 25.4 to 31.8 cm and an a mean of 27.2 cm. Location of steps is very crucial in reducing mounting and dismounting accidents. Hammer (1991) reported that 49% of tractor accidents in 1985 in Germany were related to mounting and dismounting. Tractors without mounting and dismounting steps make operators jump off tractor when dismounting making them prone to accidents. Hammer posited that the height of the first step above the ground should not exceed 40 cm and the interstep distance should lie between 12 and 30 cm to enhance safety and reduce accidents. The length and width of the steps ranged from 21.5 to 36 cm with a mean of 27.6 cm and 10 to 22 cm with a mean of 12.7 cm, respectively. Hammer (1991) suggested that the length of the step must be at least 40 cm.

None of the tractors had a cab for the operator. Operators were, therefore, exposed to the scorching sun, dust, exhaust gasses and noise. This is the situation in most other African countries, while in the developed countries the majority of tractors are furnished with cabs (Baryeh, 1982). It was found that 42% had very good or good bodies, 24% had slight body dents and 34% had poor or very poor bodies (with some rusty and/or torn parts). Those with very good or good bodies were less than 22 years old, while those with poor or very poor bodies were over 33 years old. Nevertheless, 88% had good mudguards. Those without good mudguards had rusty and/or cracked portions.

Eight percent had no seat suspension. The rest had spring suspension. All seats had synthetic material covering. Seat adjustment was not working in 80% due mainly to lack of lubrication and rust. Most of them had the same operators for several years so the seats were often not adjusted. It was established that 34% had very good seats which were not torn, 24% had moderately good seats with patches and stitches and 42% had poor or very poor seats which were torn with bits of the seat plastic foam missing. All tractors with poor or very poor seats were over 22 years old. The seat dimensions ranged from 43 to 47 cm in width with a mean of 45 cm and 31 to 39.5 cm in depth with a mean of 34.5 cm. The back rest dimensions ranged from 25 to 34 cm in height with a mean of 29.6 cm and 37 to 46 in width, with a mean of 40.8 cm. According to Gite and Yadhav (1989) the dimensions of seat and location of controls are useful in designing the tractor workplace. The locations of the controls should be such that these are accessible to the operator from his safety and comfort viewpoint (Arude et al, 1999). Seventy percent had good steering while 30% had steering with some backlash. Levers and pedals were good in 78% of the tractors while 22% had worn out pedals and pedals which exhibited some play. The older tractors were in the category with poor levers and pedals. Pedals in 60% of the tractors were stiff due to old age and lack of regular maintenance. All the tractors had levers and pedals in place, contrary to the findings of Febo and Pessina (1995) in which 8 out of 96 tractors studied in Italy had some levers and pedals of some important controls reduced to stumps.

The operator workplace dimensions are displayed in **Fig. 2** and **Table 4**. The table gives the minimum, mean and maximum values of the dimensions indicated in **Fig. 2**. The dimensions are compared where possible with International Standards Organisation (ISO) standards 4252-4253. The mean dimensions compare favourably with the ISO standards provided. They also compare favourably with values reported by Arude et al (1999) for some Indian tractors. About a third of them also agree with results reported by Febo and Pessina (1995) on some Italian tractors. These do not correlate with tractor age. There is a difference of 21 cm or more between the maximum and minimum values of dimensions 1, 5, 6, 7, 8, 9 and 17. The rest have disparities of below 17 cm. The distances for the gear levers were variable because there were two levers with 18% located beside the seat, 28% in front of the seat and 54% between the operator's legs. Steering wheel diameter varied from 35 to 48 cm with an average of 36.5 cm. Steering column angle with the horizontal varied from 55° to 65° with a mean of 60.5° comparing favourably with the average of 62.8° reported in India by Arude et al (1999). The steering wheels of 58% the tractors required an effort of 70 to 95 N to turn when the mass on the steering axle is 1.5 t because of age and irregular maintenance. In comparison, a new tractor requires a force of 25 to 40 N for same mass on steering axle (Febo and Pessina, 1995). The operator workplace was generally spacious enough. Steering wheel, hydraulic lever, brakes, clutch and accelerator pedals were generally conveniently placed in 90% of the tractors. The remaining 10% had some of these pedals located too close to the central longitudinal plane of the tractor.

The tractor noise level when stationary, when moving at 6.5 km/h and when ploughing at 6.5 km/h are shown in **Fig. 2** which also gives the noise of new tractors and EC limits for comparison. The used tractor noise level for both stationary and moving situations were always higher than those of a new tractor. The used tractor noise for stationary and moving situations vary linearly from 89.4 to 90.4 dB(A) and 91.6 to 94.5 dB(A), respectively, as the tractor power changes from 20 to 100 kW. When the tractor is ploughing it changes linearly from 98.6 to 104.1 dB(A) for the same power range. These levels are a bit higher than those reported by Febo and Pessina (1995) but compares with those reported by Pazzona and Murgia (1993) both on Italian tractors. All noise levels recorded in this study are above the EC limits and normal hearing level. Hence prolonged tractor operation may affect the hearing of an operator. **Fig. 3** displays tractor noise as a function of tractor age. The figure reveals that tractor noise increases as it ages. The increase is gentle up to 15 years for ploughing noise and then increases more rapidly with increase in age thereafter.

One tractor each had a faulty starter and a dead battery. It was found that 74% of the tractor owners serviced their tractors at home or on the farm. The remainder serviced theirs at the dealer's or tractor garages. Studies in India show that 45% of the farmers carry out tractor repairs and maintenance at the dealer's garage (Balasankari and Salokhe, 1999). Servicing frequency was, however, very erratic in 86% of the tractors due to lack of education, information and money. Most of the owners were illiterates or semi-illiterates who did not attach great importance to servicing, or could not write down servicing dates and schedules in order to follow them. Some did not know the importance of regular maintenance. Lack of money, education and information made them do the minimum maintenance that will enable the tractors function, neglecting regular care and maintenance of the tractor and the devices fitted to prevent accidents or to guarantee efficient ergonomic performance. Some left tractors running until they quit before they attended to them. Other researchers have also found uneducated and very lowly educated farmers to be negligent with machine maintenance and servicing (Taiwo, 1987; Bhutta et al, 1997). It was found that 50% had oil leakage around the engine and oil sump. All these were tractors that were over 10 years old. Most of the older tractors which had no oil leakage had engines which had been overhauled. The most frequently repair problems encountered by the owners were those related to the hydraulics, ignition switch, starter, injection pump and

Table 4. Dimensions of Operator Workplace

Dimension	Measured (cm)			ISO limits (cm)	
	Minimum	Average	Maximum	Minimum	Maximum
1	51.0	62.3	72.0	57.5	67.5
2	8.0	15.3	18.5	5.0	-
3	15.0	18.5	20.2	np	np
4	16.0	18.0	23.0	np	np
5	39.0	41.0	55.0	np	np
6	44.0	47.0	52.0	np	np
7	53.0	72.0	84.0	np	np
8	48.0	68.0	75.0	np	np
9	57.0	68.0	83.0	np	np
10	33.0	38.0	45.0	-	40.0
11	28.0	36.3	45.0	-	40.0
12	24.0	27.8	36.0	7.5	30.0
13	15.0	22.2	24.0	7.5	-
14	26.0	28.0	35.0	-	30.0
15	0.0	2.0	8.0	-	35.0
16	44.0	45.0	48.0	45.0	-
17	65.0	74.0	90.0	np	np
Steer	35.0	36.5	48.0	np	np

np = not provided.

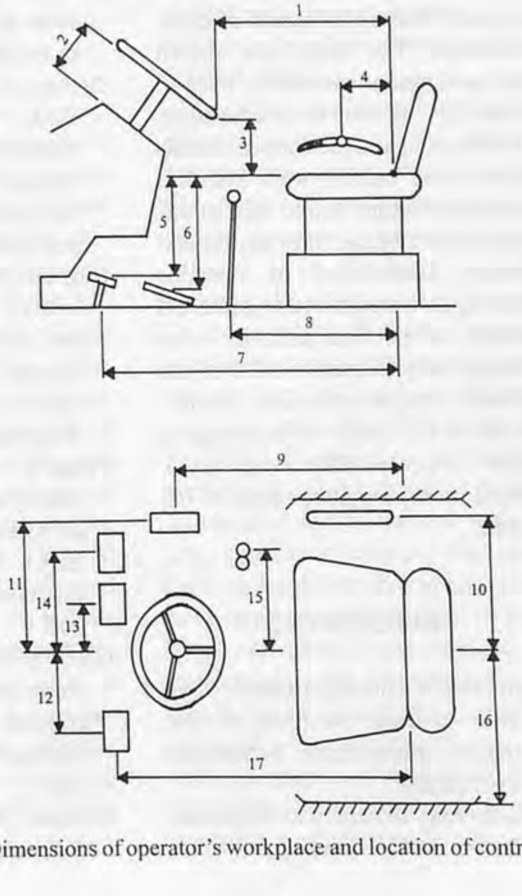


Fig. 2 Dimensions of operator's workplace and location of controls.

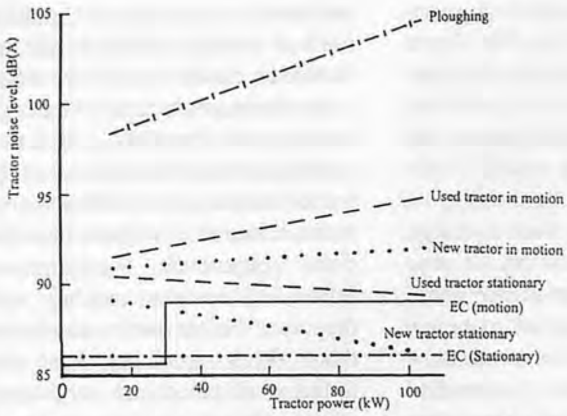


Fig. 3 Tractor noise level variation with tractor power (New tractor noise level copied from Fedo and Pessina, 1995).

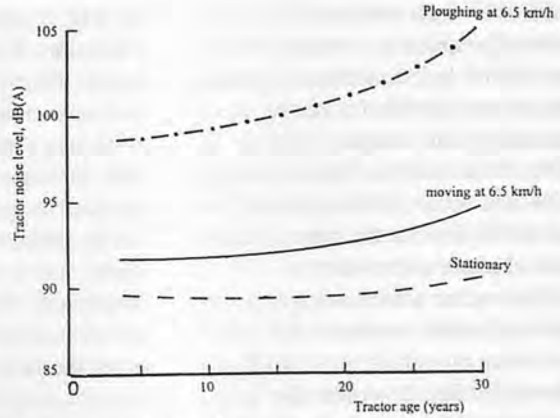


Fig. 4 Tractor noise level variation with tractor age.

engine in descending order of frequency. These problems were more common with tractors that were over 16 years old.

Conclusions

The characteristics of 50 tractor owners and conditions of 50 tractors in the Southern Agricultural Region in Botswana have been successfully studied by means of questionnaires. The study has shown that most tractor owners are over 40 years old with little or no education. The physical and mechanical conditions of the tractors were found to be unsatisfactory due to lack of education of owners, information and money. Dimensions of operator workplace were generally good and pedals, levers and controls were conveniently located in 90% of the tractors. Tractor noise was generally above EC limits with ploughing noise between 98.6 and 104.1 dB(A) for a ploughing speed of 6.5 km/h.

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An Energy Modeling Analysis of the Integrated Commercial Biodiesel Production from Palm Oil for Thailand

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Abstract

In this study, an integrated palm oil methyl ester production modeling was developed and its process energy was analyzed. The results show that with various commercially methyl ester productions, the energy ratios of palm oil methyl esters would be approximately ranged from 4-15, which was higher than rapeseed and soybean methyl esters. A value of 4,428 MJ/ a ton of oil mill products as an energetic performance indicator was credited to the commercially chemical conversion. The system energetic analysis also showed that, with the improved technology on chemical conversion, fresh fruit bunch harvest would become the largest part of process energy consumption. Fertilizer production occupies around 70% of the process energy uses in this part.

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Introduction

In Thailand, approximately 90 % of crude oil for petroleum productions is imported. Within the final modern energy consumption produced from crude oil, diesel fuel consumption was around 32 Ml/ day, which was around 49% of total petroleum products (NEPO, 2002). Moreover, Tickell (2000) also reported that if the worldwide rate of consumption increased by 2% each year and at the current amount of 24 billion barrels of oil per year, we would run out of oil in 2040. At some point between 2010 and 2025, all fuel from fossil oil will be too expensive for the average Western consumers to afford. It is around 65% of world oil proven reserves occupied by the Middle Eastern Nations (Schwaller and Gilberti, 1996 and ESCAP, 1999). Before 2025, as worldwide production dwindles, the Middle Eastern share of oil production will then rise to 50%; therefore, exactly when the time comes, the world oil market will depend largely on the actions of Middle Eastern countries (Tickell, 2000).

In order to secure and sustain the energy supply and reduce financial risk and trade deficit of the country, the systems of renewable resources within the country have to be developed. With the high potential ability and suitably available lands for palm oil production, Thailand would be able to benefit in various aspects from its locally established biodiesel production (Vanichseni et al., 2002). Biodiesel is not only acceptable to substitute diesel fuel in unmodified diesel engines without any significant effects, but both field trials and bench emission tests have been proved that most of polluted parameters were reduced in comparison with the conventional diesel (Knothe and Dunn, 2001). Generally, the energy analysis is a tool for policy formulation and might lead to public policies discouraging or courageous the production or consumption; moreover, it is able to provide a basis for energy conservation and guidelines for economic consideration and management decisions (Stout, 1990).

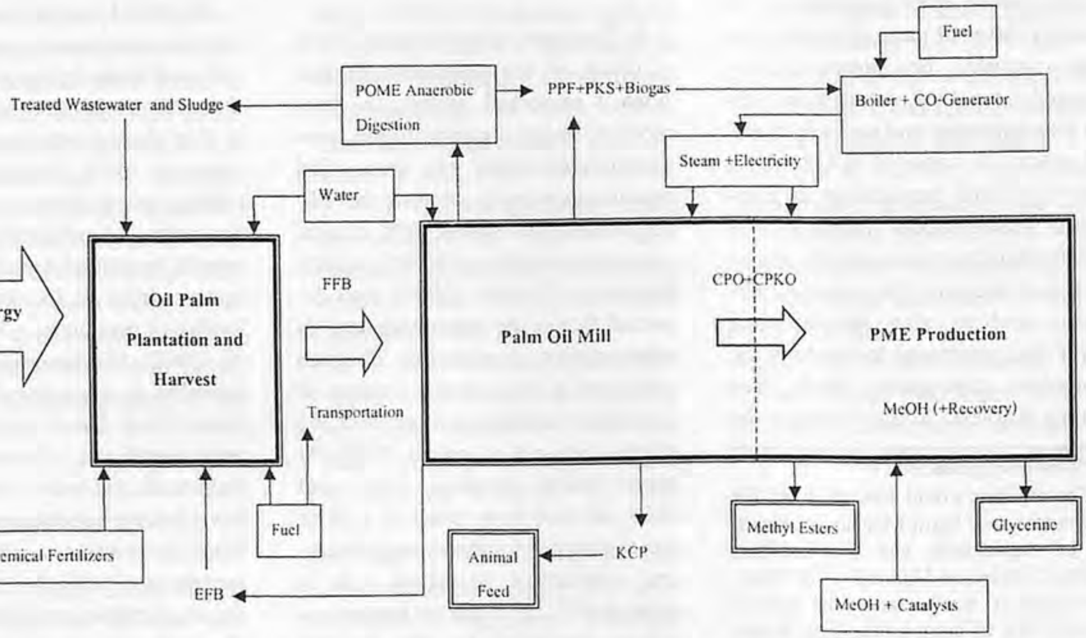
In this study, the energy systems in biodiesel production from palm oil are reviewed, analyzed and optimized. The processes start from oil palm plantation/harvesting to oil mill and then transesterification. Basically, the purpose of this study is to simulate and analyze the energy required in each main processes and overall ratio. The results would be compared with other studies and to measure the performance indicator for the energy efficiency of technology development.

Methodological Approach

The Principle

An integrated system of biodiesel production in this study comprises of oil palm plantation/harvesting, palm oil mill and a chemically conversion process called transesterification. All of these processes were connected and supposed to work continually. The amount of fresh fruit bunch (FFB) production from harvesting areas supposed to match with the capacity of oil mil plant in the most appropriated economic aspect. While both crude palm oil and kernel oil (CPO and CPKO) were utilized as raw materials for methyl ester (biodiesel) production (transesterification process). **Fig. 1** shows a developed material and energy flow model for this study.

The model was assumed that FFBs had been carried by trucks to the standard oil mill which had the capabilities to extract both CPO and CPKO. The transesterification process was also located at the same location, where the steam and electricity produced from oil mill boiler/co-generator, fueled by palm press fiber, palm kernel shell and biogas from anaerobic digestion, was able to be connected. In the energy input classification of this study, the concept of and information from life cycle inventories (LCIs), especially raw material, energy consumption and product inputs and outputs were adopted and modified for the study purposes. Generally, an LCI is an ecological profile that consists of all steps from agricultural production ('cradle') and processing leading up to chemical production ('factory gate'), are taken into account, in which a functional unit of the concerned parameters in the process of aggregation are all calculable and measurable units. These functional units are as kg, joule and 1,000 kg of product, respectively (Hirsinger, 2001). In addition, the input and output data in this analysis would be taken from the acceptable published literatures. The major concerned inputs are process energy, which is limited to energy inputs in the life cycle exclusive of the energy contained in the feedstock unless the feedstock is also fossil energy or considered as non-renewable material resources. Nonetheless, primary energy means all raw materials extracted from the environment can contain energy.



Remark: CPO = Crude palm oil; CPKO = Crude palm kernel oil; EFB = Empty fruit bunch; FFB = Fresh Fruit Bunch; KCP = Kernel cake and pellet; MeOH = Methanol; PKS = Palm kernel shell; POME = Palm oil mill effluent; PPE = Palm press fiber.

Fig. 1 A developed material and energy flow model of commercial biodiesel production from palm oil.

Table 1. Energy Summary of FFB Production for CPO and CPKO (MJ/1,000 kg of CPO and CPKO)

Process energy		Transport energy		Energy of material resource		Total	
(MJ)	(%)	(MJ)	(%)	(MJ)	(%)	(MJ)	(%)
2,240	4.8	150	0.3	44,400	94.89	46.79	100.00

Remark: Energy of material resources assigned to FFBs = 14.91 MJ/kg.
Source: Modified from Hirsinger *et al.*, 1995a.

Energy Utilization in Oil Palm Plantation and Harvest

Oil palm is one of the highest yields of oil among oil crops in the world. In Thailand, most of oil palm plantation area located within the southern part of the country because the environment of this area is suitable for oil palm plantation (Sarakoon, 1996). However, it was found that there were also oil palm plantation areas well established in the Eastern of Thailand. The production yields of these areas are compatible with of those in the Southern. Recently, there are around 277,000 hectares (ha) of plantation areas. Moreover, the plantation areas are expanded around 15,500 ha each year (Korawis *et al.*, 2002). Normally, oil palm plantation and harvest within the suitable lands of Thailand have the production capability of 3 tons-FFB/rai[1)]/year (19.5 tons-FFB/ha/yr) (Sarakoon *et al.*, 1998). This energy modeling study was assumed that EFB (Empty Fruit Bunch) and treated wastewater and sludge of palm oil mill effluent (POME) from oil mill factory were applied along with chemical fertilizers to oil palm plantation.

For the analysis of energy requirements for FFB production, Hirsinger *et al.* (1995a) investigated and analyzed the resource and energy requirements for FFB production in Malaysia. In this analysis, they assumed that FFBs were produced on plantations of approximately 5,000 ha (32,500 rais) containing approximately 130 to 140 palms per ha (20-22 palms per rais) and a production rate of 18, 000 kg per ha (2.78 tons/rai/year). They also assumed that the total fertilizers required are purchased fertilizer plus the additional fertilizer value of land-applied POME and its sludge, EFB, and other organic sources. Some other additional assumptions (works) were included as plantation/replanting, harvest, land clearance, irrigation, drainage, and general works. The energy summary of FFB production for CPO and CPKO shows in **Table 1**.

1) 1 hectare = 6.5 rais

Energy Utilization in Oil Mill Process

Recently, there was around large 18 oil mill factories (standard process) with 30-60 tons-FFB/hr capacity in Thailand. Most of these are separation processes. The others, around 24 oil mill factories, are considered small factories, where most of them are conglomeration processes. Reviewed data of percentage of energy solid material composition in FFB show that in FFB normally contains 21% of CPO (Hirsinger *et al.*, 1995a), 3% of CPKO (Mattsson *et al.*, 2000), 14% of PPF, 6% of PKS (Mahlia *et al.*, 2001). POME effluent from oil mil was an average figure of 0.87 m^3 / ton FFB, in which the potential production of biogas was 12 m^3/m^3 effluent (Prasertson and Prasertsan, 1996). To estimate the energy utilization in the processes, weight of the compositions of the energy material resources of 1,000 kg of CPO and CPKO production are 4,170 kg of FFB, 584 kg of PPF, 250 kg of PKS and 44 m^3 of biogas.

Mahlia *et al.* (2001) calculated the gross calorific value of the PPF and PKS based on their chemical compositions using the Dulong formula. The gross calorific value of 35% wet and 65% dry PPF is 11,324 kJ/kg and of 10% wet and 90% dry PKS is 17,516 kJ/kg. The formula for calculation of the potential energy conversion from the PPF and PKS is:

$$E_p = M_f\ LHV_f + M_s\ LHV_s$$

Where:

E_p = potential energy conversion from PPF and PKS (kJ/kg)

M_f = PPF production (kg); LHV_f = lower heating value of PPF (kJ/kg)

M_s = PKS production (kg); LHV_s = lower heating value of PKS (kJ/kg)

Therefore, the potential renewable energy from PPF and PKS of 1,000 kg of CPO and CPKO production are 10,992,216 kJ.

Generating biogas from POME in Thailand is not commonly practical because most of POME treatment processes are conventional pond. To efficiently generate biogas (methane) from POME, an anaerobic digestion process is required; moreover, anaerobic treatment efficiency is normally greater than 90% of COD/BOD removal within a certain period of time (Prasertsan and Prasertsan, 1996: Borja *et al.*, 1996). As the results, in this study, a steam cycle system for electricity and steam generation was introduced; while, a cubic meter of biogas is referred to 0.023 GJ (Hirsinger *et al.*, 1995a). Therefore, the potential renewable energy from POME biogas of 1,000 kg of CPO/CPK is 44 × 0.023 = 1 GJ or 1,000,000 kJ. The total potential renewable material resource from oil mill of 1,000 kg of CPO/CPK is 11,992,216 kJ.

Additionally, Mahlia et al. (2001) reported that to process 1,000 kg of FFB to CPO required electrical energy about 20 kWh and to generate 1 kg of steam at 20 bars required energy of 2,590 kJ while a kW of electricity required 30 kg of this steam. The process of a ton of FFB to CPO required 500 kg of steam. Moreover, Hirsinger et al. (1995b) reported that the production of 1,000 kg of CPKO required process energy of 1.05 GJ (referring to mechanical extraction using single or double high-pressure screw pressing). With a boiler efficiency of 80%[2)], therefore, the available energy to raise steam is; $E_r = \eta_b \times E_p = 0.8 \times 11{,}992{,}216$ kJ = 9,593,773 kJ. Where E_r = energy to produce steam (kJ); η_b = boiler efficiency (%). The total potential steam generated is $m_o = E_r / 2{,}590$ = 3,704 kg. Therefore, the process energy (electricity) obtained is (3,704/30) = 123 kWh. The steam required to generate 1,000 kg of CPO and CPKO is 500 kg/ton-FFB × 4.170 ton-FFB = 2,085 kg. The electricity required for 875 kg of CPO and 125 kg of CPKO production are 4.170 ton-FFB × 20 kWh/ton-FFB = 83 kWh and (1050 MJ/1,000 kg) × 125 kg = 131 MJ or 36 kWh.

As the results, to produce 1,000 kg of CPO and CPKO, the potential renewable energy material resources from the oil mill process are able to produce steam and electricity more than the process requirement around 1,600 kgs and 4 kWh, respectively. It would be summarized that palm oil mill industry was over self-sufficient energy requirements. It was assumed that 1600 kg of steam at around 3 bar @ 150 ℃ and 4 kWh from oil mill would be utilized in transesterification process. With specific internal energy of 2,571 kJ/kg[3)] of steam and 311 MJ of 4 kWh's process energy, there is around 4,428 MJ credited in the next process.

Energy Utilization in Transesterification Process

Noureddini *et al.* (1998) and Knothe and Dunn (2001) summarized that tranesterification is currently the most common and effective method or process for transformation of the triglyceride molecules into smaller, straight-chain molecules, reducing the high viscosity of fats and oils to a range close to that of conventional diesel. In principle chemistry of the transesterification of vegetable oils is the stoichiometry of the overall reaction, which requires 1 mol of triglyceride for 3 mols of alcohol to give 3 mols of esters and 1 mol of glycerol. This reversible reaction, which is either acid- or alkaline-catalyzed, involves stepwise conversions of triglyceride to diglyceride to monoglyceride to glycerol producing 3 mols of esters in the process (Freedman *et al.*, 1986). Theoretically, the activation energies of the refined soybean oil transesterification reactions ranged from about 6,400 to 20,000 cal/mol (Noureddini *et al.*, 1997). Nevertheless, Vanichseni *et al.* (2002) reviewed that, in commercial scales, excess methanol and alkali-catalyst are normally used in the processes. Mainly, patents or technologies on transesterification are able to divide into two groups. One is batchwise and the other is continuous process. However, the continuous process is practically well suited for large capacity requirements and using unrefined oils as feedstock. Moreover, the unit can be designed to operate at various pressure or temperature or at atmospheric pressure and slightly temperature. Recently, there were approximately 85 biodiesel plants around the world; whereas, there is only one in Malaysia using CPO and CPKO as feedstock. This pilot plant with 3,000 tons/year capacity has been successfully operated and done on field trial tests of its products. Therefore, its commercial scale would be constructing as a commercial scale as 500,000 tons/year capacity of biodiesel.

In this paper, since the energy information of a commercial scale of CPO and CPKO transesterification process for biodiesel production was not available, the transesterification processes of CPO and CPKO to methyl esters in oleochemical alcohol productions, rapeseed and soybean methyl esters were obtained as the energy information sources. Normally, the quality of methyl esters from these processes is purifier than of biodiesel production and suitable for detergent-grade alcohol production (Schafer, 1998). The process energy used for palm oil methyl esters in this paper was surveyed and analyzed. From that 77% of the methyl ester was produced by high pressure and temperature systems using CPO and CPKO, while the remaining 23% was produced by low pressure systems using refined oil. Recently, the yield of methyl ester from most of transesterification processes generally reached 95-99%. The process energy consumed in transesterification processes of unrefined rapeseed oil methyl ester (RME), crude palm oil methyl ester (PME) and unrefined soybean oil methyl ester (SME) are shown in **Table 2**. The process energy obtained in **Table 2** varies because of the different technologies used. SME process energy was analyzed using the validated Aspen Plus® (simulation model result, in which 90 ℃ , atm pressure and sodium methoxide catalyst were designated conditions.

Table 2. Energy Summary of Methyl Ester Production from unrefined vegetable oil (MJ/1,000 kg)

Process Energy	PME[a]	SME[b]	RME[c]
Methanol	4,174	2,903	3,333
Transesterification	6,800	2,669	906

a: Modified from Hirsinger *et al.*, 1995b.
b: Modified from Sheehan *et al.*, 1998.
c: Modified from Hovelius and Hansson, 1999.

Therefore, the process energy required, inclusive methanol used, for production of 1,000 kg of methyl ester using CPO and CPKO is 10,974 MJ. However, the remaining steam and electricity from oil mill can be credited in the process. As the results, PME production re-

2) Up to date of new boiler efficiency (Hee, 2000)
3) Superheated vapor water: 3 bar @ 150 ℃ : specific volume = 0.63388; enthalpy = 2760.95 kJ/kg (Sonntag, 1998)

quired more energy of around 6,546 MJ. Otherwise, if the process for SME and RME were assumed for PME production, the required more energy would be around 1,144 and 519 MJ/1,000 kg of biodiesel, respectively.

Results and Disscussion

In **Table 3**, the energy summary of the model in this study was identified. For various transesterification processes, energy of raw material resources, PME production and FFB harvest accounted as ranges of 83-94%, 1-12% and 4-5%, of total energy uses, respectively; while, for total energy uses in FFB harvest included raw material resource accounted as ranges of 87-99%. Moreover, 100 % of energy raw material resource accounted as FFB, which considered as C-assimilation by green plants via photosynthesis. All compositions of FFB are renewable energy resources, which can be reproduced within a short period of time; whereas, the fossil energy is non-renewable resource, which acquires more than a hundred million year for reproduction.

Recently, from the communication with a few standard oil mill plants in Thailand and with the capacity of at least 30 tons-FFB/hr, their existing electricity demands are less than a half of their existing boilers/co-generators' capability. Normally, with 60 tons-FFB/hr, the designated boilers/co-generators' capacity is 1.2 MW; therefore, only around a half of PPF has been used as fuel. The remaining PPF are usually used as fertilizer for oil palm plantation. PKS, with its higher LHV, is usually sold as fuel for a commercial power plant. At the moment, EFB has been sold as material for mushroom cultivation. Only small amount has been used as fertilizer for oil palm plantation. With the conventional pond, no biogas production while POME sludge is disposed as land fill.

Fig. 2 shows the process energy uses for PME production from oil palm. The results of analysis identified that the transesterification process for methyl ester in oleochemical industry, which produces purifier product than the others, is the major process energy consumption. The line of credited energy from oil mill shows as a threshold limit for biodiesel energy efficiency development. If PME production's energy demand was less than this threshold limit, with the macroscopic viewpoint, it would be assumed that the process energy consumption of biodiesel production from oil palm/palm oil was equal to that consumed by FFB harvest. As the results, in PME milder processes, FFB harvest would become the major process energy consumption. Once, the development of PME production are dynamic, Yoo et al. (1998) reported the successful results of a production technology invention of palm diesel, which used two stages reactors (esterification and transesterification) for free fatty acid elimination and methanolysis purposes. This process could be operated at 70 - 80 ℃ at 3 kg/cm^2 (around 3 bars) and the yield could be achieved to more than 97%. Moreover, in esters purification section, the development of esters/glycerol separation without high temperature distillation was successfully implemented, however, its partial glycerols in product are still higher than in DIN 51606 standard. Nevertheless, the field tests of this product had been successfully done without any major problems, it would be because of the difference among saturated compositions of palm oil and rapeseed and climate of this tropical and cold areas.

In development of PME production technology, May and Basiron (1998) reported a successfully research on enzyme-caltalysed reactions on transesterification of CPO and CPKO with regardless of free fatty acid. The use of Candida cylindracea/rugosa and lipase 3A were successfully carried out both batchwise or in continuous modes under various conditions using the free enzyme, enzyme dispersed in Florisil and enzyme immobilised on acid treated Florisil. At optimum conditions, a > 90% yield has been achieved. The enzymatic transesterification takes place at ambient temperature of 30 ℃ and atmospheric pressure requires less energy. With the mild process conditions, the reaction can also preserve the thus, resulting endor-

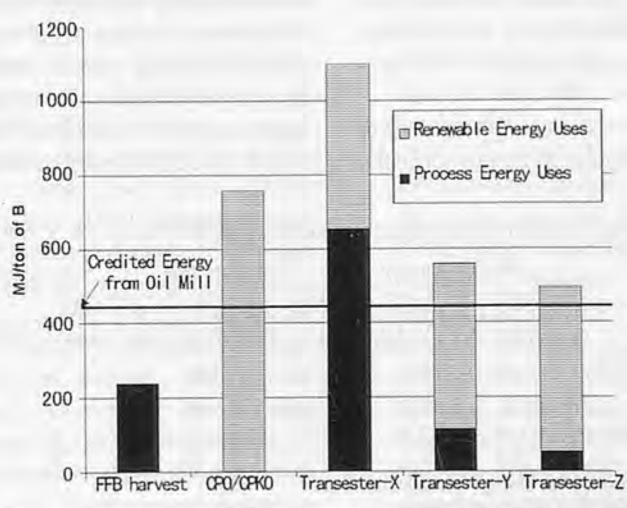


Fig. 2 Process energy uses of FFB harvest to PME production; X- PME from Hirsinger et al. (1995b), Y-SME from Sheehan et al. (1998), Z-RME from Hovelius and Hansson (1999).

geneous valuable minor components, i.e., carotenes, vitamin E and sterols in the product, i.e., esters. With the improved technologies, energy uses in FFB harvest will potentially become the highest among the process activities in the model. In South East Asia, Piggott (1990) summarized the expenditure on the individual operations from the start of clearing until palms are brought into regular harvest and are mature. The results show that fertilizer is the highest percentage among them. The main nutrients used in palm oil plantation normally are N, P_2O_5 and K_2O. Nithedpatrapong et al. (1996) did the application of EFB and nutrients for oil palm in the Southern of Thailand and found that chemical fertilizer grade 15-10-30, 2.875 kg/palm/year with 150 kg/palm/year could produce average yield of oil palm (5-8 years old) 2,936 kg/rai/year. As the results, it is assumed that for 1,000 kg of PME production it would require 13.4 kg of N, 8.9 kg of P_2O_5 and 26.7 kg of K_2O. For energy requirement for fertilizer sector, Mudahar and Hignett (1987) summarized the estimates of average energy requirements for N, P_2O_5 and K_2O; consequently, **Table 4** shows the estimated energy requirements of nutrients in FFB harvest. The figures in **Table 4** also mean that total energy in nutrients occupy around 70% of total energy inputs of FFB harvest.

Moreover, the energy input from N is 67% of total energy in nutrients. Therefore, to minimize the energy inputs in FFB harvest, the reduction of N consumption or other alternatives should be focal points. The N2 fixation by legume would be an optional as a solution. Comparison among the crops production energy inputs, from the works of Hirsinger *et al.* (1995a), Sheehan *et al.* (1998) and Hovelius and Hansson (1999), the results of FFB, soybean and rapeseed are as 2,390, 17,946, and 8865 MJ/1,000 kg of biodiesel, respectively. As the results, it is possible that, because of being a perennial crop, oil palm plantation, therefore, requires the minimum average energy inputs during its 20 years of harvest period.

For the energetic efficiency of the processes, a characteristic value of the energy output/input ratio is one of measure indicator. Although, many literatures analyzed the ratios for RME and SME, but many of them were criteria in different scenarios. For instance, the output-input ratios for RME production were reported as 2.14 for main products and 3.18 for the energy balance of all the involved production (El Bassam, 1996); moreover, Williamson and Badr (1998) and McKendry (2002) also reviewed the figures from various investigations institution and improved production, which resulted in ranges from 1.5 to 3. However, in this study, with the classified energy uses in RME production in Sweden, Hovelius and Hansson (1999) concluded the ratio as 2.4. The SME energy ratio in the United States was 1.9 (calculated from data in Sheehan *et al.* (1998) and US Department of Energy [DOE] (2000). On the other hand, the diesel production energy ratios, which calculated from the life cycle inventories of US domestic and foreign diesel fuel production reported by Sheehan *et al.* (1998) and US diesel properties' standard in DOE (2000), were 0.27 and 0.28, respectively. Nontheless, the energy modeling of PME production calculation results in this study and the gross heating value data from May and Basiron (1998), the process energy ratios, with considering of only main product, were able to be ranged from 4.6 to 14.5.

In the transesterification process, methanol is the most important energy input. Currently, most of methanol productions use natural gas and crude oil for their feedstock and process energy inputs. McKendry (2002) projected the energy ratio of methanol production from wood as 6-12, which is foreseen as possible in the longer term, while the projection based on improved technologies and low-input, high-yield crops for ethanol production can possibly be as between 2 and 3. Therefore, with the current and improved process efficiency development and threshold limit in **Fig. 2**, the process energy ratios of CPO and CPKO and PME are possibly become infinite.

Table 3 Energy Summary of Biodiesel Production from CPO and CPKO (MJ/1,000 kg of Biodiesel)

Item	Process energy		Transportation		Raw material resource		Total energy uses		Credited energy system	
	MJ	%	MJ	%	MJ	%	MJ	%	MJ	%
FFB harvest	2,240	$4.2^X/4.6^Y/4.7^Z$	150	$0.28^X/0.31^Y/0.31^Z$	44,400	$83.2^X/92.6^Y/93.9^Z$	46,790	$87.7^X/97.6^Y/98.9^Z$	*	-
CPO and CPKO production	0	0	0	0	0	0	0	0	**	-
Transesterification^X	6,546	12.27	0	0	0	0	53,336	100	4,428	8.3
Transesterification^Y	1,144	2.4	0	0	0	0	47,934	100	4,428	9.2
Transesterification^Z	519	1.1	0	0	0	0	47,309	100	4,428	9.4

*: Credited renewable energy system included.
**: Over self-sufficient energy system.
X: Process with high pressure and temperature; Hirsinger *et al.*, 1995b.
Y: Process with atm pressure and 90 ℃ temperature; Sheehan *et al.*, 1998.
Z: Process from Hovelius and Hansson, 1999.

Conclusion

Regarding the scarcity and unreliability of oil resources in the near future, Thailand as a dependent crude oil importer will be obviously faced with the risk and insecurity in primary energy supply, especially fuel for transportation, which is the largest consumption sector in the country. However, with a high potential in agricultural production, the country has a feasible opportunity to develop a commercially liquefied fuel production from oil crops. An integrated energy model in this study showed the high energy ratios of PME production. With the recycling of renewable material energy resources in the system, oil mill process is able to provide the excess energy for transesterification. An energy value of around 4,428 MJ/1,000 kg of CPO and CPKO production would be supplied to the next process. This value is also a performance energy efficiency indicator (threshold limit) for CPO and CPKO commercially chemical conversion process. With the improved technology development, the energy required in chemical conversion process would feasible to be lower than that threshold limit. This means the major process energy required for PME production would be FFB harvest. Within the FFB harvest's total energy uses, fertilizers' production acquires more than 70%, of which N is 67% of total energy uses in nutrients. Therefore, to minimize the energy inputs in FFB harvest, the reduction or other alternatives of chemical fertilizers, especially as N should be significantly considered. One of the optional solutions might be N_2 fixation by legume.

Comparison among the commercial oil crops for 1,000 kg of biodiesel production, as oil palm, rapeseed and soybean, the energy required for plantation cultivation and harvest are briefly around 2,390, 17,946 and 8,865 MJ, respectively. Among energy uses of SME, RME and PME production development, the results showed the highest potential advantage of PME over the others. The commercial PME production's energy ratios would be able to reach from 4-15 or more depends on the technologies used in oil palm nutrition, boiler and co-generator efficiency and transesterification processes. Furthermore, with the improvement of energy efficiency and bioenergy development technologies, the trend of PME process energy ratio is potentially become close to infinite, in which, as considering as primary energy uses, the major one will be solar energy.

Table 4. Estimated of average energy requirements of nutrients in FFB harvest.

Nutrients	Production[A] and PTA[B] (MJ/kg)	Nutrients required [C] (kg/1,000 kg of PME)	Total (MJ/1,000 kg of PME)
N	78.13	13.4	1,046.94
P_2O_5	17.45	8.9	155.31
K_2O	13.70	26.7	365.79
Total energy in nutrients			1,568.04

A: based on the average North American practice; Mudahar and Hignett, 1987.
B: PTA stands for packaging, transportation of raw material and product, and application; Mudahar and Hignett, 1987.
C: Fertilizer grade 15-10-30, 2.875 kg/palm/year plus EFB 150 kg/palm/year; Nithedpatrapong *et al.*, 1996.

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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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Effect of Tyre Inflation Pressure and Forward Speed of Powertiller on Energy Cost of Operator. K. Kathirvel, Associate Professor, Department of Farm Machinery, College of Agricultural Engineering, Tamil Nadu Agricultural University, Coimbatore 641 003, INDIA. R. Manian, Professor and Head of the same Department. C. Divaker Durairaj, Associate Professor of the same Department.

For achieving functional effectiveness of power tillers used in farm operations and for maintaining or enhancing the human comfort by appropriate design features, the capability of the power tiller operator was evaluated in terms of energy expenditure. Five subjects were screened for normal health with medical investigations, standardized and calibrated by indirect calorimetry. Two commercially available power tillers with varied design features were chosen for operation in dry and wetlands. The energy expenditure of the subjects while operating the power tillers at three levels of forward speeds and at three levels of tyre inflation pressure was estimated and the energy cost of work was graded. The influence of forward speeds and tyre inflation pressure on energy expenditure was analyzed. The human energy expenditure of 7.46 kW power tiller for rotary ploughing operation varied from 13.15 to 18.58 kJ/min at different forward speeds of operation. For roto-puddling it varied from 14.82 to 21.92 kJ/min at different forward speeds of operation. The energy cost of power tiller operation can be graded as moderately heavy. The wet puddling operation is generally heavy in nature when compared to dry ploughing as 12.7 to 28.0 per cent of additional energy is required for the same. With the increase in forward speed of operation, weight of power tiller and tyre inflation pressure there is a significant increase in DHR and DVO2. The investigation indicated that roto-puddling is strenuous activity in comparison to rotray ploughing as it involves higher energy cost. For continuous operation rest pauses are needed to compensate the additional demand of energy to avoid discomfort to the operator. The effect of weight of power tiller, type of operation, forward speed of operation and tyre inflation pressure on the energy expenditure is highly significant.

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Ergonomic Evaluation of Direct Paddy Seeder. K. Kathirvel, Associate Professor, Department of Farm Machinery, College of Agricultural Engineering, Tamil Nadu Agricultural University, Coimbatore 641 003, INDIA. K. P. Vidhu, PG Student of the same. R. Manian, Professor of the same. S. S. Sivakuamr, Assistant Professor of the same.

Poorly designed equipment, implements, or products often require workers/users to compensate or exert themselves unnecessarily. All too often, such over exertion lead to both job related errors and an increased level of risk. The stresses transmitted onto the workers directly reduce their ability to do their job safely and effectively. Ergonomical evaluation of farm equipment can provide a rational basis for recommendation of methods and improvement in equipment design for more output and safety. The sowing operation with direct seeder demands higher energy expenditure of subjects in rice cultivation. Three subjects were selected for the study based on the age and screened for normal health through medical investigations. The parameters used for the ergonomical evaluation of all the selected implements include heart rate and oxygen consumption, energy cost of operation for all the selected implements, acceptable work load, endurance time, work rest cycle, discomfort ratings and force measurement for manually operated implements. Based on the analysis of the results the following conclusions are drawn. The mean value of heart rate of the three subjects for direct paddy seeder was 141.92 bpm and the corresponding oxygen consumption was 1.254 lit min-1. Based on the mean oxygen consumption, the energy expenditure was computed as 25.85 kJmin-1 or 6.15 kcal min-1. The operation was graded as "heavy". The heart rate lies in the range of 140 to 170 bpm for about 75 per cent of the operating time for direct paddy seeder, necessitating the higher energy demand of the operation. Two operators in cyclic system have to be employed for seeding to enhance the comfort of the subjects and to maintain the efficiency of the implements. The work rest cycle for achieving functional effectiveness of the seeder 15 minutes of work followed by 8 min rest with two operators. Based on the over all discomfort rate (ODR) of 14.7 obtained for seeding with direct paddy seeder and the subjective response, a handle grip with a soft material was suggested to improve the gripping comfort of the operator. The force required for pulling the direct paddy seeder was 196.96 N. ■■

NEWS

No need to search - just click

Germany

VDI software is revolutionising bolt calculations based on VDI 2230
Free demo version at www.vdi-software.de
Editor: VDI Verein Deutscher Ingenieure
(The Association of Engineers), VDI Society for Development, Design and Marketing
Price: from EUR 498,00
Released in German and English Language.
Available from: Beuth Verlag GmbH, D-10772 Berlin,
Phone: +49 (0) 30 26 01-22 60
Fax: +49 (0) 30 26 01-12 60
www.beuth.de

New software from the VDI Society for Development, Design and Marketing (VDI-EKV) is introducing a revolution to day-to-day bolt calculations: a click is all that is required instead of having to search for and copy data manually.

The elaborate and delaying process of using a pocket calculator and having to consult tables, standards and guidelines is no longer necessary. Alternatives are calculated and presented in graphical form in seconds using multi-variant analysis. Results can therefore be rapidly analysed and documented. The software is bilingual English and German.

The tool, based on the guideline VDI 2230 Part 1, reduces the time needed for traditional manual calculations by about 80 percent, according to tests by experts. A tutorial program gives users an overview of the functions of the user interface and how to do calculations. The VDI software provides all its Help in the form of text or graphics. A free demo version can be ordered directly from www.vdi-software.de for trial purposes.

The 7th China International Agricultural Machinery Exhibition and China International Livestock and Poultry Exhibition 2003

Concurrently with China Agricultural Machinery Fair
16 to 18 October 2003
Nanjing, China

Venue: China Nanjing International Exhibition Center

Organizers: China Agricultural Machinery Distribution Association, China Association of Agricultural Machinery Manufacturers, China Huaxing Agricultural Machinery Limited Corporation, Technology Clearinghouse of China.

Supporters: The Ministry of Agriculture, the People's Republic of China, The Ministry of Science and Technology, the People's Republic of China, Agricultural Bank of China.

China International Agricultural Machinery Exhibition and China International livestock and Poultry Exhibition

Classification of the Exhibition for Details: Sect. 1 Tractors, Sect. 2 Agricultural trailers and transport vehicles, Sect. 3 Machinery and equipment for working the soil and plant care, fertilizing, Sect. 7 Machinery and equipment for sprinkler irrigation, irrigation and drainage, Sect. 8 Machinery and equipment for grain harvesting (incl. grain maize and rape), forage harvesting, harvesting root crops, Sect. 11 Machinery and equipment for the conditioning, handling, conservation and storage of harvest products, Sect. 12 Machinery and equipment for fruit growing, horticulture, viticulture, and field vegetable farming as well as for special crops, Sect. 13 Machinery and equipment for municipal applications, Sect. 14 Forest technology, Sect. 15 Farm inputs, Sect. 16 Components, spare parts, accessories, Sect. 17 Renewable industrial raw materials and renewable energy sources. Sect. 18 Direct marketing, Additional sources of income, Sect. 19 Management, Services, Sect. 20 Information, special shows, consultancy services, Sect. 21 Hatching equipment, egg grading and packing equipment, Sect. 22 Livestock & poultry breeding technology and equipment, Sect. 23 Animal semen and embryo technology and equipment, Sect. 24 Milking machinery, dairy keeping and processing equipment, Sect. 25 Installing and air conditioning of animal housing, Sect. 26 Supervisory equipment of animal housing, Sect. 27 Depollution & animal waste treatment, Sect. 28 Feed addictive technology, Feed preparation and distributing equipment, Sect. 29 Feed processing machinery and equipment, Sect. 30 Cleaning and disinfecting equipment, Sect. 31 Slaughtering, cutting and processing equipment, Animal care equipment

The Schedule of the Exhibition

Opening time to the exhibitors: from 8:00 am to 17:00 pm, 16th-18th, October 2003

Visiting time: from 8:30 am to 16:00 pm, 16th-18th, October 2003

The Relative Activities: The Forum of Chinese Agricultural Machinery, The Second Summit of Asian Agricultural Machinery Associations, The Press conferences of New Technology and Products

Exhibition Contact

China Agricultural Machinery Distribution Association

Address: No. 26, Yuetan South Street, Beijing, China

Ctc: Mr. Henry Xiao

Tel: 0086-10-68596444, 68596442

Fax: 0086-10-68526910

E-mail: huibang@camtf.com.cn,
or Henrybeijing@yahoo.com.cn
Website: http://www.camtf.com.cn

International Workshop 2003 Agricultural Engineering and Agro-products Processing toward Mechanization and Modernization in Agriculture and Rural Areas

10-11 December 2003
Hanoi, Vietnam

In order to meet the demand of increasing growth rate in agricultural development and to promote the application of appropriate technologies in agricultural production with increased output and improved quality, the issues on developing agricultural engineering and machinery appropriate to the producing condition have become indispensable measures for better quality and stable production.

In this situation, Vietnam Institute of Agricultural Engineering (VIAE), under Ministry of Agriculture and Rural Development (MARD) is a key scientific and technological institution in agricultural engineering for agricultural production, processing of agro-products and rural development. In recent years, VIAE has organized international workshops on agricultural engineering. These workshops are to provide opportunities for scientists engaged in agricultural engineering from various countries to exchange ideas and learn from one another as well as to discuss issues on common interest.

This proposed workshop would be organized on the subject: " Agricultural Engineering and agro-products processing toward mechanization and modernization in agriculture and rural areas".

Calling Papers Focus on:

1. Technologies and equipment for agricultural production (farm power; tractor for hill and slopeland; relation between land and machine; water saving irrigation; harvesting of rice, corn, fruit)
2. Technologies and equipment for agro-products storage and processing (drying; storage of fruit and vegetables by cold stores; primary processing; processing; etc.).
3. Utilization of new energy resources.
4. Policies promoting agricultural engineering development in regional and international integration.

Language

The official language: English.

Time And Venue

December 10th - 11th, 2003 in Hanoi, Vietnam.

Registration

Registration fee is 200 USD/person.

This registration fee includes the cost of proceedings and Visa procedures in Vietnam.

Deadlines To Remember

* Pre-registration: before 15th August 2003

* Receipt of the paper: not later than 15th September 2003

(Papers are suggested not to be longer than 10 pages)

Official Invitation Letters will be sent to the participants 3 weeks before the commencing day of the Workshop.

Contact Persons

Mr. Vu Dao Tue, Mr. Nguyen Thai Duong, Ms. Le Thi Viet Lam

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ISMAB 2004
The 2nd International Symposium on Machinery and Mechatronics for Agriculture and Bio-systems Engineering (ISMAB2004, Japan)

Sept. 21-23, 2004
Kobe, Japan

This symposium is organized by Japanese Society of Agricultural Machinery, and co-sponsored by Korean Society of Agricultural Machinery and Chinese Institute of Agricultural Machinery, Taiwan.

This assembly will be provided for exchanging ideas and results, and transmitting scientific information from East Asia to the world.

Place: Kobe University (Kobe City)

Tentative Schedule:

Day 1st: Opening session & Reports of general sessions, Kobe Univ. Centennial Hall

Day 2nd:: General sessions (poster) and Organised sessions (oral)

Day 3rd: Technical Visit & Excursion to local Town, Port Kobe, view from Kobe Univ.

Topics

ISMAB2004 topics include, but are not limited to: Bio-systems Engineering, Bio-mechatronic, Biological Engineering, Bio-energy & Alternative Energy, Power & Machinery, Post harvest Technology, Food and Processing Engineering, Precision Farming and Agriculture, Automation in Agro-industry, Robotics in Agriculture, Agricultural Informatics, Information and Communication Systems, Bioinformatics, Environmental Technology, Nano technology.

Organized Sesions

Mechatronics in Bio-systems Engineering Chaired by Prof. Ikeda, Zoro-emission Engineering in Bio-systems Engineering Chaired by Prof. Kawamura, Concurrent Engineering in Agricultural Machinery Chaired by Prof. Umeda.

Conference Contact
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SIEMSTA 2004
The 7th Seoul International Exhibition of Machinery, Science and Technology for Agriculture 2004
November 12 - 17, 2004
Seoul, Korea

Frequency : Biennial
Date : November 12 - 17, 2004
Opening Hours : 10:00 - 17:00
Venue : Pacific Hall, IndianHall, Atlantic Hall, COEX (Convention and Exhibition)
159 Samseong-dong, Gangnam-gu, Seoul, Korea
Organized by : Ministry of Agriculture and Forestry
Managed by : COEX, Korea Agricultural Machinery Cooperative(KAMICO)
Exhibits Profile

Agricultural Machinery - Tillage Implement, Soil Improvement Implement, Seeding / Transplanting / Harvesting / Dry Machinery, Safety Cap and Device, Seeding and Plant Nursery Machinery, Crop Security Machinery, Pest Controlling Machinery, Transportation Machinery, etc.

Agricultural Materials - Seed, Fertilizer, Agricultural Chemicals, Agricultural Covering Materials, etc.

Orchard / Horticultural Materials and Facility - Soil Improvement Implement, Crop Security Machinery, Pruning Machinery, Pest Controlling Machinery, Seeding / Harvesting / Transportation Machinery, Manure Spreader, Forage Crops Harvesting Machinery, Forage Crops Processing and Transportation Machinery, Irrigation and Watering Facility, Nutrient Supplying Facility, Environment Controlling Facility, CO2 Generator, Plant Nursery Facility, Hydroponics, Medium Environment Measuring Equipment, Green House, etc.

Agricultural Products Circulation and Processing - Washing and Grading Facility, Processing / Wrapping / Tying / Drying Facility / Conveyor / Quality Inspection System, Pre-chilling Facility, Low Temperature / Controlled Atmosphere Storage, Complex Grain Processing Facility, Meat and Poultry Processing / Dairy Products Processing Facility, Fruit and Vegetable Processing Facility, etc.

Livestock Machinery and Materials - Feeding and Watering Facility, Milking Facility, Egg Collect and Grading Facility, Ventilating / Lighting Facility, Thermo Keeping Facility, Disease Sensing / Disinfection System, Conception Diagnosis System, Weight Measuring System, Feeding and Management S/W, Farm Waste Purification Plant, Farm Waste Compost Controlling Facility

Forestry Equipment and Machinery - Forest Road Equipment, Forest Caring Equipment, Reforestation Equipment, Logging Equipment, Engines, etc.

Package and Material Handling Standardization Packaging Material and Equipment, Loading and Unloading Machine, Agricultural Products Distribution Information Network System and Service

SIEMSTA 2004 Management: COEX
Address: World Trade Center, Gangnam-gu, Seoul 135-731, Korea
Tel 82-2-6000-1054, 1057
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Korea Agricultural Material Industry Association
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Tel (02)3431-7900(404)
Fax (02)3431-4492
E-mail: hzsong@kamico.co.kr
Application Information
Application Deadline: September 30, 2004

World Bioenergy 2004
Conference and Exhibition on Biomass for Energy
2-4 June 2004
Jonkoping, Sweden

World Bioenergy 2004 focuses on the lessons learnt and the experiences gained from the world on the usage of biomass for energy.

In addition to the special Pre and Post Study Tours, there will be short Study Tours included in the Conference. Here the participants will see different bioenergy-related facilities, such as bundling, chipping and transport of wood and agricultural residues, small and medium-scale Central Heating Plants and the use of wood and wood pellets for family houses. Visits to sawmills and pellet-and briquette factories will be included.

Topics: Politics for improving sustainable energy (invited speakers), Raw material resources, Fuel production including refining, Logistics and distribution, Equipment/combustion, The international markets.

Call for Papers - The organizers are currently soliciting papers for World Bioenergy 2004. If you are interested in presenting a paper at one of the sessions, please see submission guidelines, or contact Ms Karin Haara (karin.haara@svebio.se) by e-mail or phone +46 (0)8 441 70 80.

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About the Fair - World Bioenergy 2004 forms an exclusive and very attractive marketplace for suppliers, manufacturers and buyers of products, equipment, technology and know-how within the international bioenergy sector. Furthermore the exhibition hall is directly linked to the conference rooms and the lunch restaurants making it the strategic choice for exhibitors.

Club of Bologna strategies for the development of agricultural mechanisation

68 experts from 35 countries and representatives from FAO, CIGR, AIT and UNIDO took part in the 13th Club of Bologna meeting, subdivided into two separate sessions held respectively on 27 - 28 July 2002 in Chicago, in conjunction with the ASAE Annual International Meeting and the 15th World CIGR Congress, and on 16 - 17 November 2002 in Bologna on the occasion of the 33rd EIMA show.

The general subject - common to both sessions - was: Mechanisation and traceability of agricultural productions: a challenge for the future.

Conclusions and Recommendations

- considering the growing importance of traceability as a tool for assuring the healthfulness of plant and animal food products by tracking their history, utilisation and sources, for the protection of consumers;
- recalling that the widespread adoption of traceability will require the involvement of the various governments and countries, to identify and define specific directives aimed at safeguarding the health of citizens;
- reasserting the consequent need to: develop specific informational processes on a large scale to: identify the crucial links within the various agri-food chains; promote drafting of international standards for the various productions, as well as techniques for tracking and recording the material and energy flows which characterise each production and distribution system;
- reaffirming the need for traceability to be defined within the wider context of the certification of farms;
- identifying in mechanisation the key element for documenting the history of the individual productions that leave the farm, enter the agri-food chain and ultimately reach the consumer's table.

The CAD Guidebook A Basic Manual for Understanding and Improving Computer-Aided Design (Mechanical Engineering series / 150)

(USA)

by Stephen J. Schoonmaker

This text/reference presents fundamental principles and theories in the function, application, management, and design of 2- and 3-D CAD systems-illustrating troubleshooting procedures and control techniques for enhanced system operation and development.

Offers an extensive glossary of key terms and concepts, as well as useful end-of-chapter review questions.

The CAD Guidebook provides surefire strategies to alternate among, and become comfortable with, a wide range of CAD systems, construct appropriate design processes, predict hardware and software interactions, monitor CAD environments, create and analyze 3-D CAD assemblies, surfaces, and components, plan efficient approaches for part modeling, effectively utilize and allocate available resources, translate models to alternate system formats.

The CAD Guidebook is an essential reference for mechanical, manufacturing, industrial, software, computer, design, quality, and reliability engineers, and an excellent text for undergraduate and graduate students in these disciplines.

S. J. Schoonmaker
Grove Worldwide, Shady Grove, Pennsylvania, U.S.A.

November 2002 / 344 pp., illus. / ISBN: 0-8247-0871-7 / List Price: $150.00

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