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CIRCULATION
(Tel. +81-(0)3-3291-5718)
(Fax. +81-(0)3-3291-5717)
7, 2-chome, Kanda Nishikicho, Chiyoda-ku, Tokyo 101-0054, Japan
URL : http://www.shin-norin.co.jp
E-Mail : ama@shin-norin.co.jp

FARM MACHINERY INDUSTRIAL RESEARCH CORP,
SHIN-NORIN Building
7, 2-chome, Kanda Nishikicho, Chiyoda-ku, Tokyo 101-0054, Japan
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EDITORIAL

World Peace, Where Art Thou?

The terrorists' attacks on the World Trade Center buildings in New York and the Pentagon in Washington, D.C. on September 11 sent a shiver of fear among mankind around the world. Over 6,000 lives and billions of dollars were lost during those attacks. The pain sustained by relatives of the victims will linger yet even as the United States has launched already a diplomatic, economic and military attack to bring to justice the guilty parties. May terrorism be ultimately banished from our world.

Since the maiden issue of the AMA was published in 1971, its primary objective, which holds true to this day, was to help increase food avai l ability all over the world and at the sane time improve the livelihood of farmers in developing countries through mechanization of agriculture. While farm mechanization has developed piecemeal over the last three decades, the economic gap between the developing and developed countries seems to have expanded greater than it was 30 years ago.

It is my considered view that the expanding economic gap between the rich and poor on this narrowing earth seems to exacerbate the displeasure, tension and oppressive feelings that result in regional conflicts of interests, guerrilla terrorism and protracted warfare, among other things. The poverty that it creates may be likened to a large piece of muddy land wherein mosquitoes are buzzing and breeding. And to get rid of the mosquitoes, it is necessary that the muddy land be drained and allowed to dry.

However, this dichotomy ends when we realize that terrorism cannot be totally eradicated as long as there exists an economic gap between the rich and poor. It, therefore, behooves upon us to develop a dynamic political and economic system that would reduce the economic/technological gap.

During World War II, we may recall to mind that thousands of innocent citizens were killed by the atomic bomb attacks on Hiroshima and Nagasaki cities in Japan. Not long after that event, Japan made a new start as a peace-loving nation under a new war-renouncing constitution not to take military action as a means to solve disputes and problems.

Looking back to history, however, it looks like we live in a world of endless war and retaliation that never leads to an ideal world. And where does that leave us? Regardless, AMA stands pat on its avowed objective that farm mechanization is the most essential means of giving farmers in developing countries a break for a better life. AMA wishes to contribute to that peaceful pursuit into the future.

Yoshisuke Kishida

Chief Editor

Tokyo, Japan
October 2001

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AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

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Combination Tillage Tool - II

Performance Evaluation of the Combination Tillage Tool under Field Conditions

by

R. Kailappan
Professor and Head
College of Agricultural Engineering
Tamil Nadu Agricultural University
Coimbatore- 641 003
India

K.R.Swaminathan
College of Agricultural Engineering
Tamil Nadu Agricultural University
Coimbatore- 641 003
India

N. C. Vijayaraghavan
College of Agricultural Engineering
Tamil Nadu Agricultural University
Coimbatore- 641 003
India

G. Amuthan
College of Agricultural Engineering
Tamil Nadu Agricultural University
Coimbatore- 641 003
India

Abstract

The combination tillage tool was tested in two types of soils, namely; black cotton soil at 11.7 per cent moisture content and red soil at 6.5 per cent moisture content. The conventional sliding and rotary implements of primary and secondary tillage operations were chosen either individually or in combination as control so as to fix the performance grade of the implements at appropriate ranking. The results showed that selective use of combination tillage tool after mould board or disc ploughs in black cotton or red soils promoted better moisture status in the sub-soil due to the formation of smaller size clods and their arrangements in the profile. The combination tillage tool reduced bigger size clods in the soil, improved aeration and moisture holding capacity. Performance evaluation of field ploughed with the combination tillage tool resulted in soil having medium uniformity and finer pulverization modulus. Combination tillage tool resulted in a savings of about 44 to 55 per cent in cost and 50 to 55 per cent in time when compared with different combination of other tillage implements.

Acknowledgement: The authors express their sincere thanks to Dr. R. Manian, Dr. G. Duraisamy, artisans of Zonal Research centre for their valuable help in conducting the field evaluation studies.

Introduction

The combination tillage tool performs both primary and secondary tillage operations simultaneously in a single pass. The field evaluation of the combination tillage tool was conducted in two different types of soils, namely; black cotton soil (at 11.7 per cent moisture content) and red soil (at 6.5 per cent moisture content). The conventional sliding and the rotary implements of primary and secondary tillage operations were chosen either individually or in combinations as control to fix the performance grade of the implements at appropriate ranking. In both soils, mould board plough and disc plough were used for primary tillage operations and the cultivator and disc harrow were used for secondary tillage operations. The performance in terms of soil manipulation has been studied taking into account the soil - air - moisture status obtained.

Physical Properties

The physical condition of the soil regulates the movement and retention of air and water, microbiological activity, emergence of seedlings, penetration of roots, and above all, the availability of plant nutrients which is vital for plant growth.

The physical properties studied are:

a) Clod size distribution
b) Change in total porosity
c) Change in capillary porosity
d) Change in non-capillary porosity and
e) Uniformity co-efficient

Clod Size Distribution

The clod size distribution

through sieve analysis reveal the following results:

a) A linear inverse relationship exists between clod size distribution and percentage of clods obtained in red soil when the field was ploughed by combination tillage tool (**Fig.1**).

b) A linear inverse relationship between particle size and clod fraction accumulation exists in the case of combination tillage tool alone and disc plough followed by combination tillage tool in red soil in the range less than 19 mm, similar trend in the same range of clod size was also noticed when mould board plough combinations were used in red soil (**Fig.2**).

c) Higher pulverization effect was obtained if the combination tillage tool was used after mould board plough rather than disc plough in both the soils (**Table 1**).

Porosity

Combination tillage tool effects total porosity, capillary porosity and non-capillary porosity. The soil aeration status in black cotton soil and red soil observed after using the different combinations of implements and combination tillage tool are summarised in **Table 2.**

It is observed from the above table that the total porosity was increased by the use combination tillage tool alone when compared to the combination of mould board or disc plough in combination with combination tillage tool. The level of increase was above 60 per cent in black soil and 54 per cent in red soil. Combination tillage tool ploughed field resulted in 37.5 per cent and 30 per cent capillary porosities in black cotton and red soils, respectively. In red soil no other implement combination without combination tillage tool could achieve this status of capillary porosity of 30 per cent or more.

It was also observed that in the black cotton soil, disc plough followed by the combination tillage tool produced higher non-capillary porosity exceeding 20 per cent while mould board plough followed by the combination tillage tool could yield only 19.3 per cent non-capillary porosity. However, the combination tillage tool recorded more than 30% non-capillary porosity. In red soil, combination tillage tool alone recorded more than 25 per cent of non-capillary porosity, whereas other combinations recorded lesser values.

Uniformity Co-efficient

The ratio of diameter of 60 per cent of total clods passing through the sieve of diameter of 10 per cent yields uniformity co-efficient. The results are summarised in **Table 3**.

From the table, it is clear that medium uniform soil was achieved in black cotton soil by mould board plough followed by any combination of secondary tillage tool, disc plough followed by combination tillage tool and by combination tillage tool alone. In red soil, the conventional implements combinations failed to

Table 1. Clod Size Distribution in Black Cotton Soil and Red Soil

Operation	Average percentage of clods retained in sieve sizes of					
	3/12" (38 mm)	3/4" (19 mm)	3/8" (9.5 mm)	3/16" (4.8 mm)	3/32" (2.4 mm)	<3/32" (<2.4 mm)
Mould board + combination tillage tool	0.5 (3.8)	8.5 (9.6)	15.5 (13.4)	17.8 (15.1)	9.0 (12.0)	48.7 (46.1)
Disc plough + combination tillage tool	24.6 (9.7)	8.4 (9.8)	11.6 (13.3)	11.7 (12.8)	11.4 (13.4)	32.3 (41.0)
Combination tillage tool alone	3.1 (15.8)	4.6 (15.4)	8.5 (19.7)	11.4 (17.6)	11.5 (11.4)	60.9 (20.1)

*Figures in parentheses are the values for black cotton soil.

Table 2. Porosity Status of Soil after Ploughing with Different Combination of Implements

Operation	Capillary porosity, per cent		Non-capillary porosity, per cent		Total porosity, per cent	
	Black cotton soil	Red soil	Black cotton soil	Red soil	Black cotton soil	Red soil
Combination tillage tool alone	38.0	31.4	32.3	28.5	70.3	59.7
Mould board + Combination tillage tool	41.5	30.1	19.3	24.2	60.8	54.3
Disc plough + Combination tillage tool	40.5	27.3	27.0	24.9	61.5	54.2

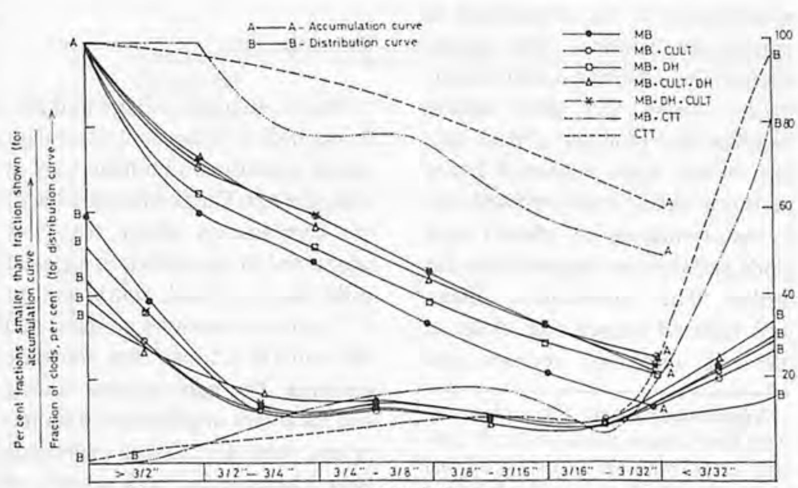

Fig. 1 Clod size distribution in red soil with combination tillage tool, mould board plough and combinations.

produce medium uniform soil. However, the combination tillage tool achieved the same.

Quality of Performance

The tillage implements by changing the structure and porosity of the soil, affected the soil-air-moisture status. Bulk density, hydraulic conductivity, infiltration rate and pulverization modulus of the soil are affected by the performance of the implements.

Bulk Density

The studies reveal that maximum loosening of the soil was obtained by the combination tool as reflected by the low soil bulk density range of 1.15 ± 0.05 g/cm^3 as against the normal 1.40 ± 0.20 g/cm^3 encountered in the conventional implements operated field. It promotes better aeration, moisture storage and root growth in the field.

Hydraulic Conductivity

From the studies, the following are the different implement combinations which recorded higher values of hydraulic conductivity.

a) Mould board plough + Disc harrow: 9.0 cm/h (Red soil)
b) Mould board plough + Disc harrow + cultivator: 10.9 cm/h (Black cotton soil)
c) Mould board plough + Combination tillage tool: 12.2 - 13.5 cm/h (Both soils)
d) Combination tillage tool alone: 16.8 - 22.4 cm/h (Both soils)

The enhanced water movement rate in the soil substrate confirms the results reflected by the enhanced porosity status already referred. This phenomenon is a desirable aspect to improve soil-moisture status in the tilled field.

Infiltration

The limiting factor for the use of combination tillage tool was its reducing infiltration rate in black cotton soil. This will enhance run-off in the field in the intensity of rainfall exceeds 2.0 cm/h. Disc plough followed by combination tillage tool improved the intake characteristics of both soils (red soil 6.13 cm/h and black cotton soil 3.18 cm/h).

Pulverisation Modulus

The results of the surface pulverisation modulus of soil obtained for different combinations of implements are summarised in **Table 4**.

Lower pulverisation modulus achieved by the use of combination tillage tool confirms the concept of Winkelblech (1961) quantifying the tilth quality. It may be inferred that combination tillage tool results in finer pulverisation in both soils

Table 3. Effect of tillage implements combination on uniformity coefficient in black cotton soil and red soil

Uniformity coefficient $V = \frac{D_{60}}{D_{10}}$	Black cotton soil	Red soil
Less than 5	None	None
5-15	a) Combination tillage tool b) Mould board + cultivator c) Mould board + Disc harrow d) Disc plough + combination tillage tool	Combination tillage tool
Greater than 15	All other implements combinations	All other implements combinations

Table 4. Pulverisation Modulus

Implements combinations	Black cotton soil	Red soil
Mould board	4.34	3.64
Mould board + cultivator	4.15	4.02
Mould board + Disc harrow	3.50	3.82
Mould board + Cultivator + Disc harrow	3.72	4.10
Mould board + Combination tillage tool	1.22	1.28
Mould board + Disc harrow + cultivator	3.28	3.90
Disc plough	5.00	5.00
Disc plough + cultivator	4.76	4.78
Disc plough + Disc harrow	5.00	5.00
Disc plough + Cultivator + Disc harrow	3.28	4.53
Disc plough + Disc harrow + cultivator	5.00	3.68
Disc plough + Combination tillage tool	2.29	1.90
Combination tillage tool	2.64	0.85

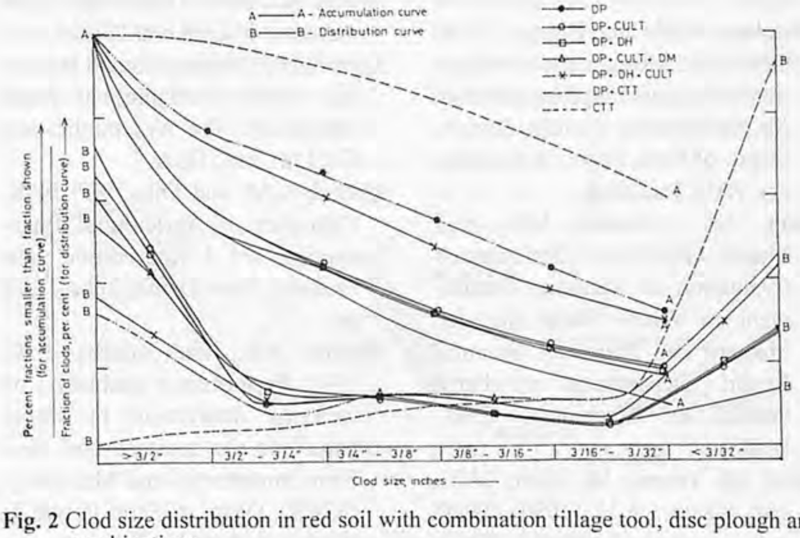

Fig. 2 Clod size distribution in red soil with combination tillage tool, disc plough and combinations.

throughout the profile.

Economics

To prepare a seed bed of one hectare $9.00 was the cost required by the combination tillage tool whereas $16 to $29 was incurred by conventional practices. Similarly, the combination tillage tool required 486 min to prepare a seed bed of one hectare whereas conventional practices required 981 to 1085 minutes. Thus here is a savings of 44 to 55 per cent in cost and 50 to 55 per cent in time per hectare, in favour of the introduction of combination tillage tool for seed bed preparation apart from lesser vehicle traffic on seed bed.

Conclusion

1. A combination tillage tool mounted on a tractor does the primary and secondary tillage operations simultaneously in a single pass.
2. Selective use of combination tillage tool after mould board or disc ploughs in black cotton or red soils promote better moisture status in the sub-soil due to clod size distribution and arrangements in the profile.
3. Combination tillage tool reduced bigger size clods in the soil and improves aeration and moisture holding capacity.
4. Medium uniformity of soil and finer pulverization modulus obtained by using combination tillage tool makes this more desirable for uniform seed bed profile.
5. Savings of 44 to 55 per cent in cost and 50 to 55 per cent in time are possible by the use of combination tillage tool for seed bed preparation.

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Performance Evaluation of Rainfed Sowing Equipment for Maize Crop, Shiwalik, Punjab

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Performance Evaluation of Rainfed Sowing Equipment for Maize Crop, Shiwalik, Punjab

by

Anil Bhardwaj
Asstt.Res.Engineer
Deptt. of Soil and Water Engg., Punjab Agricultural University,
Ludhiana
India

Harvinder Singh
Asstt.Prof.of Agril.Engg.
Deptt.of Farm Power and Machinery
PAU,
Ludhiana
India

A. M. Chauhan
Sr.Res.Engineer-cum-Head
Deptt.of Farm Power and Machinery
PAU,
Ludhiana
India

Abstract

Four rainfed sowing equipment, namely; tractor-operated adjustable furrow opener type planter (4-row); tractor-operated reversible shovel type planter (4-row); bullock-drawn single-row planter; and indigenous wooden plough, behind which seed is dropped manually (conventional method), were tested for sowing maize crop. Their performance was evaluated and compared in regard to depth of seeding, row-to-row and plant-to-plant spacing, draft requirement, germination count and yield of maize. Three replications were given with each sowing equipment in a randomized block design. The average moisture content of soil at the time of sowing was 12.23 percent. The germination count (76%) as well as the maize yield (2640.7 kg/ha) of the plots sown with bullock drawn single-row planter was significantly higher than that of all other sowing equipments (CD at 5% = 312.2 kg/ha). It required 490.3N of draft, which is about 1/3rd of the draft requirement of indigenous plough. The actual field capacity of the bullock-drawn single-row planter was observed to be 1.52 times higher and labour requirement (man-hours) 3.1 times lower as compared to the conventional method of sowing by indigenous plough. The planter weighs only 28 kg and can be moved from one field to another by a single person. The cost is also within the reach of the local farmers. Among the tractor-drawn planters although the effective field capacity, weight and costs are almost same, the reversible shovel type of planter required half the draft (1961.3N), resulted in higher germination count (59.5%) and maize yield (1920.6 kg/ha) as compared to the adjustable furrow opener type of planter.

Acknowledgement: This study was carried out under All-India Coordinated Research Project for Dryland Agriculture, funded by the Indian council of Agricultural Research. The authors are grateful to Dr.M.S.Maskina, chief Scientist and Dr.H.S.Sur. Associate Director of Research, Regional Research Station for Kandi Area, Ballowal Sounkhri, for providing the necessary physical facilities for carrying out the work.

Introduction

The border area of Northeast Punjab, India, which is popularly known as the "Kandi" area, constitutes about 10.7 percent (5.38 lakh ha) of the total area of the State and comprises mainly of the "Shiwalik" foot-hills (**Fig.1**). The production

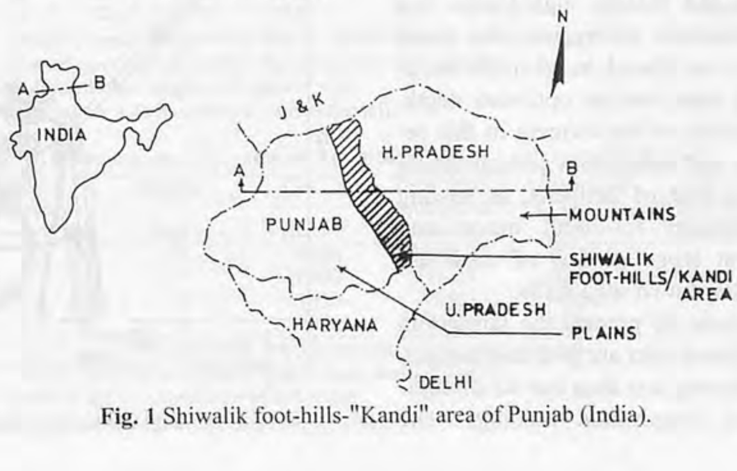

Fig. 1 Shiwalik foot-hills-"Kandi" area of Punjab (India).

problems in the area are location specific. The land is undulating and steeply sloping. About 60 percent of this sub-montane tract is cultivated much of which is rainfed with low water retentive soils of sandy loam and loamy sand texture (Suret al.,1997). The fields are terraced, small in size, some times irregular in shape and are not perfectly leveled resulting into non-uniform moisture storage in the soil. The main source of water for the crops in the region is rainfall which is quite erratic and ill-distributed in both time and space. The average annual rainfall in the area varies from 800mm to 1250mm. More than 80 percent of the rains occur in just two and a half months of monsoon season (July-Sept.). Maize in Kharif (July-Oct.) followed by wheat in the Rabi season (Oct.-March). Farmers get wide span of sowing time for wheat starting from the last week of October to the third week of November whereas maize has to be sown immediately after the first spell of monsoon rainfall, generally occurring in the last week of June or first week of July. The yields are very low (1000-1200kg/ha), even less than the national average. The main obsession in the area is to achieve the desired plant population for optimum crop production.

Sowing equipment plays an important role, along with timely sowing, optimum soil moisture, good quality seed and fertilizers in order to achieve the desired plant population and thereby high yields. For satisfactory emergence, the seeds must be placed in adequate moisture zone and at optimum depth. Majority of the farmers in this region use indigenous plough drawn by a pair of bullocks, as sowing equipment for both maize and wheat crops. A few of them use tractor-drawn seed drills.

About 80 percent the farmers in the Kandi area are poor and marginal, having less than two ha of cultivated, fragmented holdings. The capability of farmers to invest is very limited. Because of their poor economic conditions, the farmers are unable to invest on the tractor-powered implements on individual basis. Bullocks are not strong enough to pull heavy implements (Verma, 1982). In view of above, low cost and light bullock-drawn sowing equipment are needed for this region.

Verma (1982) tested and evaluated different types of rainfed sowing equipment for sowing wheat crop in the Kandi area, under, "All-India Coordinated Research Project for Dryland Agriculture." However, no study was conducted to evaluate the performance of various sowing equipment for maize. Chauhan and Dhingra (1991-93) developed a tractor-drawn adjustable furrow opener type planter for rainfed maize. Sharma and Madan (1991) and Garg et al. (1991-93), evaluated the metering attachment to the wheel-hand hoe for sowing mustard and rape seed. This wheel-hand hoe was later modified and developed as a single-row planter for maize, to be pulled by a pair of bullocks (**Fig.2**). There were also some existing and conventional sowing equipment. However, the performance of the maize planters have not been evaluated and compared under similar soil, moisture and climate, at any single location under the actual farming conditions in the Shiwalik foot-hills.

The present study, therefore was conducted to test and evaluate the performance of the existing and newly developed sowing equipment for maize crop, under the prevailing conditions in the Shiwalik foot-hills. The end in view was to suggest suitable ones which can solve the problem to a considerable extent and suit the power and economic conditions of the farmers.

Materials and Methods

The experiment was conducted for testing and evaluating the performance of various sowing equipment for sowing maize crop (variety-Megha) at the Regional Research Station in Kandi, Ballowal Sounkhari, Distt. Nawanshehr, Punjab. The climate in the region varies between semi-arid and sub-humid with a maximum temperature of 41-42 °C recorded in June

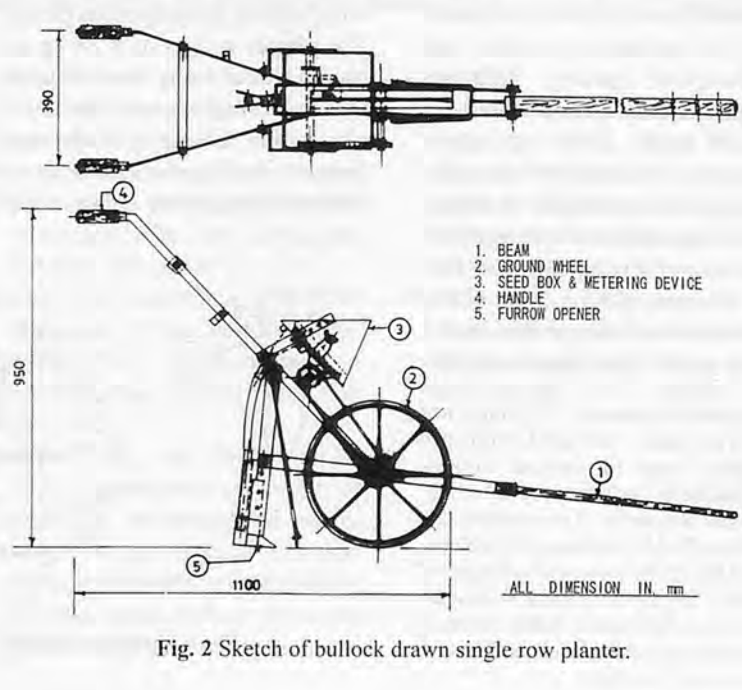

Fig. 2 Sketch of bullock drawn single row planter.

and minimum temperature (5-6 °C) in January. The type of soil was sandy loam with an intake rate of about 10.5 mm/hr. and water holding capacity of 11.5 cm/m depth of the soil.

Four sowing equipments, namely; tractor-operated, adjustable furrow-opener type (4-row) planter (T-1); tractor-operated, reversible shovel type (4-row) planter (T-2); bullock-drawn single-row planter (T-3); and indigenous wooden plough behind which the seed is dropped manually (conventional, T-4). All of them were tested and evaluated for their performance in sowing maize crop. Sowing was done in the first week of July, i.e., just at the on-set of the monsoon season. The experiment was laid out in a randomized block design (RBD), with three replications in each of the sowing equipment. The size of the plot was 180sq.m. (15m × 12m). The row-to-row spacing was 50 cm for all the treatments except sowing that used indigenous wooden plough for which it was about 30 cm as was the practice in the area. A local farmer was hired to sow the maize, seeds using an indigenous plough in order to follow and maintain the local practices. The recommended fertilizer dose was applied by following same agronomic production practices in each sowing treatment.

In order to evaluate and compare the performance of each sowing equipment, the observations in regard to the soil moisture content at the time of sowing, depth of seeding, row-to-row and plant-to-plant spacing, draft requirements of equipment, germination rate and crop yield of the maize, were recorded. The draft measurements were done with the help of a spring dynamometer as explained by Kepner et al. (1978), Michael and Ojha (1978) and Iqbal et al. (1994), at the respective ploughing speed and depth of sowing by each equipment.

Results And Discussion

The results of the experiment are summarized in **Tables 1** and **2**. The average moisture content of the soil at the time of sowing was 12.23 ± 0.22 percent which was almost the same for all treatments (**Table 1**). The observed seed rate in different treatments was adjusted according to row-to-row and plant-to-plant spacing which varied between 13.96 to 33.33 kg/ha. The seed rate was lower in case of tractor drawn planters (T-1 & T-2) as compared to the recommended seed rate of 20kg/ha. The reduced seed rate may be due to the terraced fields in the region which are not perfectly leveled and also choking of the seed delivery tubes with moist soil entering into the boot. The observed seed rate was much higher in the case of indigenous plough (33.33 kg/ha), where the seed was being dropped directly by a person walking behind the plough (T-4). Although, the seed rate with bullock-drawn single-row planter (T-3) was on the low side (18.52 kg/ha) it was quite near to the recommended seed rate.

The row-to-row spacing using the indigenous plough (29.5 cm) was observed much less than that of the recommended spacing as of planters 50 cm. The plant-to-plant spacing varied between 25.4 cm and 28.8 cm (**Table 1**). The depth of sowing was maximum in the conventional method of sowing using the indigenous plough (11.0 cm) and minimum using the bullock-drawn single-row planter (5.5 cm). The tractor-drawn maize planter delivered the seed with depths varying from 7.5 cm to 9.5 cm.

The seed germination rate in all the treatments was recorded before the thinning of the crop, a practice followed in the Shiwalik foot-hills. As the seed rate was high, thinning was required in treatment T-4, sown using the indigenous plough. The germination percentage varied from 42.8% to 76%, for different treatments (**Table 1**) which was maximum in the case of sowing using the bullock-drawn single-row planter and minimum using the adjustable furrow-opener type planter.

The maize yield of different plots sown by various sowing equipments is also given in **Table 1**. The aver-

Table 1. Observed Sowing Parameters, Germination Rate, and Yield of Maize Crop Sown using Different Sowing Equipment

Sowing equipment/ Treatment	Soil moisture (%)	Seed rate (kg/ha)	Spacing: Row to row (cm)	Spacing: Plant to plant (cm)	Depth of sowing (cm)	Percent germination (%)	Average maize yield (kg/ha)
T-1	12.01	13.96	50.0	27.3	9.5	42.8	1738.7
T-2	12.59	14.06	50.0	28.8	7.5	59.5	1920.7
T-3	12.17	18.52	50.0	25.4	5.5	76.0	2640.7
T-4	12.15	33.33	29.5	26.7	11.0	49.7	1600.0

T-1: Tractor operated adjustable furrow opener type (4-row) planter;
T-2: Tractor operated reversible shovel type (4-row) planter;
T-3: Bullock drawn single-row planter; and
T-4: Indigenous wooden plough (conventional).

Table 2. Economic and Operational Parameters of Various Sowing Equipment

Sowing equipment	Weight (kg)	Cost (Rs.)	Total draft requirement (Newton)	Actual field capacity (ha/hr)	Labour requirement (persons)
T-1	155	10800	3844.2	0.240	1
T-2	147	10000	1961.3	0.254	1
T-3	28	1050	490.3	0.058	1
T-4	16	500	1471.0	0.038	2

T-1: Tractor operated adjustable furrow opener type (4-row) planter;
T-2: Tractor operated reversible shovel type (4-row) planter;
T-3: Bullock drawn single-row planter; and
T-4: Indigenous wooden plough (conventional).

age crop yield of the plot sown using the bullock-drawn single-row planter (T-3) was 2640.7 kg/ha which was significantly higher than to the maize yield in the plots sown using all other sowing equipment (CD at 5% = 312.2 kg/ha). The average yield of the plots sown using the indigenous plough (T-4) was minimum (1600 kg/ha). The yield of maize sown using the tractor-drawn planter was also higher than that of the indigenous plough. But the difference in yield was significant only in the case of the reversible shovel type of planter. When the tractor-operated sowing equipment is compared among themselves, the reversible shovel type of planter although resulted in higher maize yield (1920.7 kg/ha) as compared to adjustable furrow-opener type of planter (1738.7 kg/ha), the difference was not statistically significant.

Rainfall which affects greatly crop production in the Shiwalik foot-hills was 127.1 cm, during the experiment which was 35.5 cm higher than the average rainfall received in the area during the same period. There were 49 rainy days during the crop period. The rainfall was above normal and uniform for the whole crop season, except in the last quarter, during which no rainfall occurred, resulting in reduction in maize yields in all the treatments.

The draft requirement, field capacity and labour requirement of the various sowing equipment are given in **Table 2**. The draft requirement of the different sowing equipment evaluated at respective depths of sowing (5.5cm-11.0cm), varied between 490.3N and 3844.2N. Among the tractor-drawn planters (4-row), the draft of adjustable furrow-opener type planter was almost double than that of that reversible shovel type planter, measured at a constant speed of 2.5 km/hr. The draft required to pull the bullock-drawn single-row planter was minimum (490.3N) and was about 1/3rd of that required for the indigenous plough (1471N) at the same speed of sowing, i.e., about 1.5 km/hr. This means that even a single bullock can pull this planter or in absence of bullock, two persons can provide the required draft easily for sowing the maize crop. Its specific/unit draft was also lower than that of the other sowing equipment which were 961.05, 490.32, 490.30 and 1471.00N/row, for adjustable furrow-opener type planter, reversible shovel type planter, bullock-drawn single-row planter and indigenous plough, respectively.

The actual field capacity of both tractor-drawn planters (**Table 2**) was almost the same (0.240 ha/hr and 0.254 ha/hr), which was quite low as compared to that measured in the plain areas (0.36-.38ha/hr). Among the bullock-drawn sowing equipment, the actual field capacity of the single-row planter was about 1.52 times higher than that of the indigenous plough. The actual field capacity of all the sowing equipment, in general, was observed to be low. This may be due to the fact that the fields in the region are terraced, small in size and, to some extent, irregular in shape, which resulted in high time loss per unit area because of greater number of turns and idle travel involved.

The labour requirement for sowing with the indigenous plough was higher than that of other sowing equipment (**Table 2**) which needed two persons while all the other planters needed only one person in sowing the crop. Also, sowing using the indigenous plough took maximum man-hours per unit area to complete the operation requiring 3.1, 12.73 and 13.65 times more man-hours/ha than that required using the bullock drawn single-row planter, tractor drawn adjustable furrow-opener type planter and the reversible shovel type of planter.

The weight and cost of the sowing equipment are also shown in **Table 2**. The cost as well as the weight of two tractor drawn planters were almost similar. There is only a marginal difference of Rs.800 in cost and 8 kg in weight. Although the cost of the bullock-drawn single row maize planter (Rs.1050) is higher than that of the indigenous plough (Rs.500), if is well within the buying capacity of the local farmers. Also, its weight (28 kg) is such that a single person can very easily lift and transport it from one field to another.

Conclusions

Keeping in view the poor economic conditions of the farmers, low power availability and other existing problems in rainfed farming in the Shiwalik foot-hills, the bullock-drawn single-row planter seems to be the right type of sowing equipment in sowing maize crop. Its performance was the best amongst all the sowing equipment tested and evaluated in this study and is relatively inexpensive, costing only Rs.1050 hence affordable to most farmers in the area. The germination rate as well as the maize yield in the plots sown using the bullock-drawn single-row planter was highest. Maize yield was 65% higher than the conventional method of sowing using indigenous plough and 37% to 51.8% higher than tractor-operated planters. Also, its draft requirement of 490.3N was minimum which suits the power available in the form of bullocks, at the majority of the farms in the region. Its labour requirement is also lower as compared to conventional method of sowing maize using the indigenous plough. Among the tractor-drawn planters, the reversible shovel type of planter performed better than the adjustable shovel type of planter.

(Continued on page 12)

Performance of a Manually Operated Fertilizer Drill for Already Established Row Crops in Semi-arid Regions


by
N. A. Aviara
Lecturer
Department of Agricultural Engineering
University of Maiduguri,
Maiduguri,
Nigeria

J. O. Ohu
Professor of Agricultural Engineering and
Dean, Faculty of Engineering
University of Maiduguri
Nigeria


M. A. Haque
Associate Professor and Head
Department of Agricultural Engineering
University of Maiduguri
Maiduguri,
Nigeria.

Abstract

A manually-operated fertilizer drill for already established row crops was designed, constructed and tested in a semi-arid environment. The drill, which applies fertilizer along the two rows bordering the furrow through which it is pushed, is fitted with flow rate control and row distance adjustment units. It is calibrated to deliver varying application rates for granular fertilizers, and for use in fields with crops of different row spacings.

Tests showed that application rates varied from 25 to 420, 35 to 500, 32.5 to 450 and 30.6 to 435 kg/ha for calcium ammonium nitrate, urea, single superphosphate, nitrogen phosphorus and potassium, respectively. For these types of fertilizer, metering efficiency decreased and conveying efficiency increased with increase in gate opening up to a certain point and thereafter remained nearly constant.

The work rate varied from 0.32 to 0.34, 0.35 to 0.40 and 0.25 to 0.27 ha/h for maize, millet and sorghum, respectively. The drill consistently places fertilizer at a distance of 5 cm from the plant to a depth of 3 cm into the soil at 30° rake angle. The row distance within which it can operate is from 45cm to 90cm.

Introduction

In agricultural lands, soil movements resulting from run-off, compaction and wind erosion lead to loss of soil nutrients (Schwab et al 1981). Excessive leaching also deprives the soil of its nutrients and renders it unfavourable to plants.

An example of the above phenomenon is obtained in the semi-arid region of Nigeria where soils are susceptible to erosion because the land is left bare, loose and exposed. Heavy soil losses recorded in this region have contributed immensely to the depletion of plant nutrients, and this has rendered the soil incapable of sustaining crops throughout the growing season. Nutrient deficiency results in yellowing of leaves and moulting on already established row crops. This situation has necessitated the use of fertilizer in supplementing lost nutrients to sustain productivity. Commercial fertilizers are normally used for this purpose and their application form is an essential operation in crop production in the region. Fertilizers may be applied to the soil before the seeds are sown, as the seeds are being sown or when the seeds have germinated and become established. For some tropical crops, the split method, that is application of fertilizer during planting and after germination, has been recommended.

Most of the available fertilizer applicators work on single rows and carry out pre-planting and pre-emergence application. Igbeka (1981) designed, developed and tested a simple single-row land-wheel driven fertilizer applicator which took between 4.2 and 4.5 hours to cover a hectare of maize and between 10.5 and 10.8 hours for that of rice. Abubakar and Adeoti (1989) designed, fabricated and tested a portable hand-jab fertilizer applicator with discharge range lying between 7.7 and 23.5g per punch for calcium ammonium nitrate (CAN) and between 5.9 and 21.6g per punch for urea. Oni (1982) modified a four-row fertilizer applicator to a two-row one, evaluating its flow rate and draft, while Unadi and Gupta (1994) developed a two-wheel tractor-operated seed-cum-fertilizer drill that can deliver between 5 and 130kg/ha of fertilizer. Other tractor-operated fertilizer applicators are employed in applying liquid fertilizer between rows (Smith and Wilkes, 1984). All these applicators so far are not suitable for use in applying granular fertilizer by side dressing to already established row crops. Moreover, the passage of tractors through the field can inflict injuries on the crops. As a result, fertilizer application to already established row crops is normally carried out manually. Farmers find it difficult carrying out this operation as it is not only laborious and time consuming but also wasteful.

This paper evaluates the performance of a fertilizer drill, designed and fabricated for applying fertilizer to already established row-crops. The work also aims at mechanizing the split fertilizer application method usually practised in the irrigated agriculture of the semi-arid region.

Description and Operation of the Fertilizer Drill

(a) Some Fundamental Design Considerations

In designing the fertilizer drill, physical properties of various fertilizer types were examined. Some of the properties were found to affect drillability and they include:

Hygroscopicity which was found to be temperature dependent; particle size and shape which varied from coarse to fine and from granular to irregular; specific gravity found to range from 0.63 to 1.06; dynamic angle of repose which is 40^o (Mehring and Cuming 1930). These properties were factors considered in the design of machine components and mechanisms, and in the selection of materials for construction.

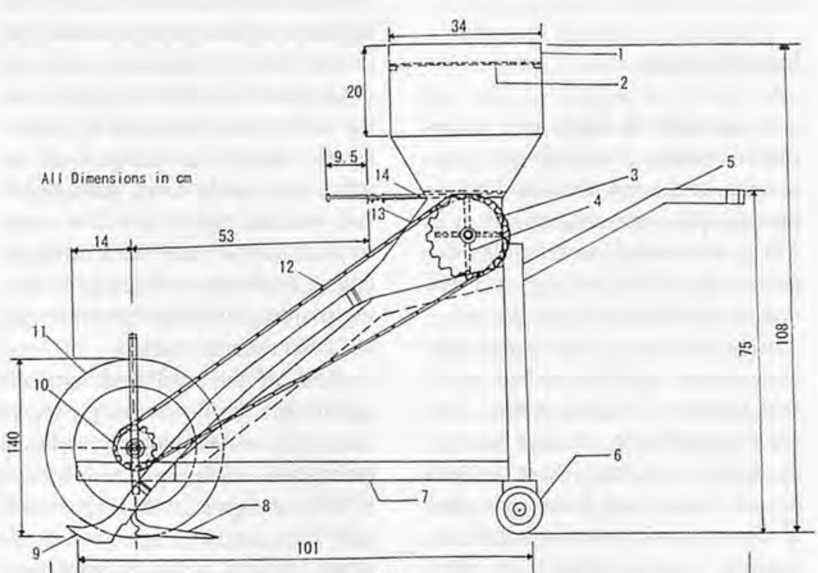

Fig. 1a Fertilizer drill assembly (front view).

Crop fertilizer requirements were also considered and the machine was designed to apply the recommended quantities with minimum losses.

(b) Fertilizer Drill Description

The fertilizer drill consists of a feed hopper, hopper flow rate controls, metering unit, conveying unit, furrow openers, soil coverers, row distance adjustment unit, tool frame and power transmission system comprising of handles, drive wheel and chain and sprockets. The drill assembly drawings and part list are shown in **Fig. 1** (a, b, c) and **Table 1**, respectively.

The hopper (1) is rectangular at the top to a depth of 20cm and pyramidal from that point to the base. It holds between 21.45 and 35.65 kg of different types of granular fertilizer, when filled with the flow rate controls in closed position. It is mounted on the metering unit (13) which is a chamber divided into two compartments. In each compartment, the metering devices of paddle feed agitators (4) are coupled to a horizontal drive shaft (18) which runs through and out of the chamber. A sprocket (3) is keyed to the shaft and used in driving the metering mechanism from the ground wheel (11), by means of chain (12) and sprocket (10). The metering unit carrying the hopper, is mounted on the tool frame (7). Two spouts (17) to which the fertilizer conveying tubes (15) are connected, branch out from the base of the left and right hand compartments. There are two flow rate control devices (14) located between the hopper and metering unit. These devices are graduated and used in regulating the amount of fertilizer flowing from the hopper into each of the compartments. The fertilizer tubes made of flexible plastic hose, run curvilinearly from the spouts of the metering unit to the ground where they are each coupled to a furrow opener (9) on either side of

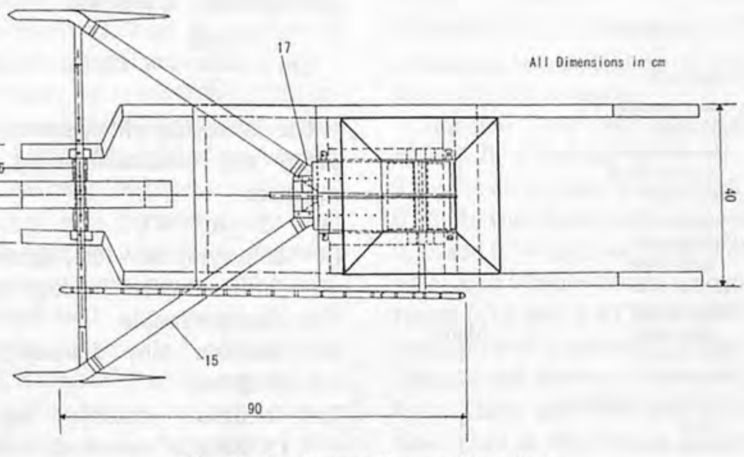

Fig. 1b Fertilizer drill assembly (plan).

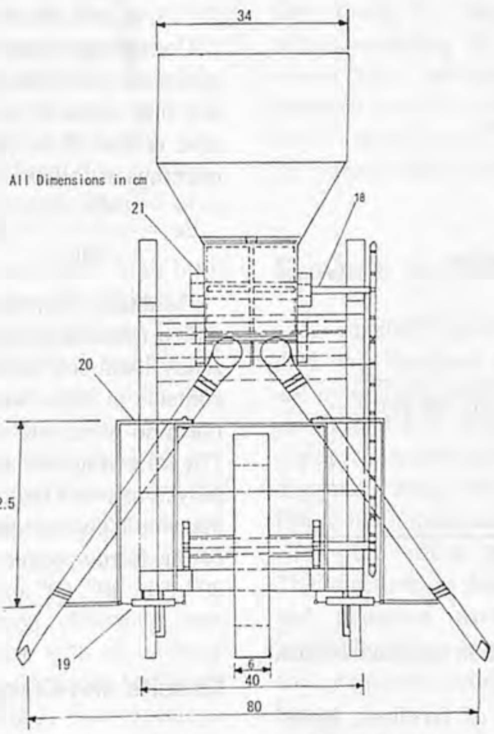

Fig. 1c Fertilizer drill assembly (end view).

the drive wheel. The soil coverers (8) are attached to the furrow openers. The row distance adjustment unit (20) is made of a spring loaded mechanism, graduated and used in determining distance between the furrow openers. This also makes the openers steady and able to absorb shock or ride over obstacles during operation. It is coupled to the furrow openers and adjusted at the top of the drive wheel.

(c) Fertilizer Drill Operation

To operate the drill, the hopper gate openings are closed using the flow rate controls. A wire mesh (2) is placed in position and used to detect the presence of clods, and the hopper is filled with fertilizer. The desired discharge gate opening is selected and the row distance adjusted. The machine is then pushed along the furrow between the two rows on which application is to be made. As the drive wheel runs, it drives the shaft of the fertilizer metering device via the chain and sprocket arrangement. This rotates the paddle feed agitators in the metering unit compartments and enables each of them to carry the fertilizer fed on it, from the hopper to the discharge spout serving the fertilizer tube, while the next feed agitator is being charged. The fertilizer entering the tube is conveyed down into the furrow cut by the opener and the soil coverer running over, covers it. Since the machine is manually operated by hand push, its speed is governed by that of the operator.

Performance Evaluation

The prototype fertilizer drill was tested to determine the application rate of four fertilizers, namely; calcium ammonium nitrate (CAN), urea, single superphosphate (SSP) and nitrogen phosphorus and potassium (NPK). This was carried out by filling the hopper with fertilizer using the flow rate control to set the gate opening and running the machine through a distance of 75m at constant speed. Ten different gate openings were used and for each test, five runs were made. The amount of fertilizer dropped in each run was collected and the average per hectare was calculated for maize, millet and sorghum.

The flow of fertilizer from the hopper through gate openings to the metering paddle feed was calculated using the Deming and Mehring (1929) equation for the flow of fertilizer and other comminuted solids through funnels as cited by Mohsenin (1986). The equation is given as:

Equation 1

Q_h = flow rate, g/min

B = gate opening size, mm

W = Density of fertilizer, g/cm^3 (Av. of 1g/cm^3 assumed, ASAE 1982)

ϕr = angle of repose, 40^o

Table 1. Fertilizer Drill Part List

S/N	Component Description and Specification	Material	Quantity
1.	Fertilizer Hopper (34cm × 34cm × 34cm)	Mild steel sheet guage 18	1
2.	Wire mesh (32cm × 32cm)	Mild steel	1
3.	Metering Device Drive Sprocket (ϕ18.5cm).	Aluminimum coated steel	1
4.	Paddle feed Agitator (60cm × 7cm × 1cm	Steel sheet guage 18	8
5.	Drive Handle (ϕ2.5cm × 54cm)	Cylindrical steel pipe	2
6.	Rear wheel (ϕ10cm)	Rubber tyre	2
7.	Tool Frame (Varied)	Rectangular steel pipe	Many
8.	Soil coverer (18cm × 5.4cm)	Mild steel	2
9.	Furrow opener (10cm × 2cm)	Mild steel	2
10.	Drive wheel sprocket (ϕ10cm)	Aluminium coated steel	1
11.	Drive wheel (ϕ40cm)	Rubber tyre	1
12.	Drive chain (90cm × 1.5cm)	Steel chain	1
13.	Metering chamber (30cm × 16cm × 15cm)	Steel sheet guage 18.	1
14.	Hopper flow rate control (37cm × 8cm)	Steel sheet guage 18	2
15.	Fertilizer tube (ϕ4.0cm × 68cm)	Plastic hose	2
16.	Drive wheel shaft (ϕ2.5cm × 30cm)	Mild steel	1
17.	Metering Unit spout (ϕ4.0cm)	Guage 18 steel sheet	2
18.	Metering device drive shaft (ϕ2.5cm × 32cm)	Mild steel	1
19.	Row distance adjustment unit spring (ϕ0.5cm × 8cm)	Mild steel	2
20.	Row distance adjustment unit (varied)	Flat mild steel bar	2
21.	Bearing Housing (Varied)	Cylindrical steel pipe	4

$$Q_h = \frac{100B^{2.5}W}{\tan \phi r\,[(34.6 + (67.4+444 \sin \tfrac{1}{2}\Theta))(+\,0.13-0.161 \tan \phi r)]}$$

Equation 1

$$Qd = \frac{WD^{2.93}}{(6.29\tan\Theta_i + 23.16)\,(d+1.89) - 44.9}$$

Equation 2

Θ' = cone included angle, 45°

d = particle diameter, mm (variable)

The Franklin and Johanson (1955) equation for flow of granular materials through horizontal orifices, corrected for inclined orifices was used in calculating the flow of fertilizer through the discharge orifice into the conveying tube.

Results obtained were converted to the S.I. Unit. The equation is stated as follows: **Equation 2**

This was corrected to give

$$Qdß = Qd \frac{(\cos \Theta i + \cos ß)}{\cos\Theta i + 1} \quad (3)$$

Qd = flow rate in horizontal orifice, kg/min

Qdß = flow rate in inclined orifice, kg/min

W = Density of fertilizer, kg/m³ (Av. of 1000kg/m³ assumed ASAE 1982)

D = size of discharge orifice, cm (3.81cm)

d = particle diameter, cm (variable)

Θi = angle of internal friction (assumed equal to dynamic angle of repose, 40°)

ß = angle of orifice inclination, 15°

Metering efficiency (Em,%), was determined as a ratio of flow rate at the metering unit discharge orifice to the hopper flow rate at various gate openings, as follows:

$$Em = \frac{Qdß}{Qh} \times 100 \quad (4)$$

The conveying unit operating capacity was calculated using the equation:

$$Qc = 15\ \_\ d_o^4\ WV \quad (5)$$

Qc = conveying flow rate, kg/min

= fertilizer tube loading efficiency, variable

do = fertilizer tube diameter, m (0.038m)

W = fertilizer density, kg/m³ (1000kg/m³ assumed, ASAE 1982).

V = machine operating speed, m/s (Av. of 0.86m/s)

Conveying efficiency (Ec,%) was evaluated as a ratio of the conveying unit capacity to the metering unit orifice flow rate at all gate openings as follows:

$$Ec = \frac{Qc}{Qdß} \times 100 \quad (6)$$

Field tests were also conducted in maize, millet and sorghum fields of a sandy loam soil at 6.38% moisture content, in order to determine the machine work rate on these crops. The following rake angles were employed to select the minimum value that would give adequate penetration of the furrow opener into the soil: 20°, 30°, 40°, 60° and 65°.

Results and Discussion

Results of application rates obtained for the four fertilizers at various gate openings for maize, millet and sorghum are presented in **Tables 2**, **3** and 4, respectively. These varied from 25 to 420, 35 to 500, 32.5 to 450 and 30.6 to 435 kg/ha for CAN, Urea, SSP and NPK, respectively. For all these fertilizers, the application rate increased with an increase in gate opening. Gate opening No. 1 gave the smallest rate while gate opening No.10 gave the largest rate for all the fertilizers. In most cases, it was found that gate openings beyond No.7 did not have significant effect on the quantity of fertilizer applied per meter.

At gate No.1, the flow of fertilizer through the metering unit orifice was higher than that of the hopper. All metered fertilizers were discharged into the conveying tube. From gate No.2 to No.10, metering efficiency was found. This decreased with an increase in gate opening up to gate No.8 and after this, it remained nearly constant for all the fertilizers as can be seen from **Fig. 2**. It was expected that decrease in metering efficiency would result in the undelivered fertilizer remaining in the metering chamber to cause clogging. This situation was not observed possibly because the paddle feed agitators acted as plugs. This must have given rise to intermittent flow of fertilizer from the hopper instead of a continuous flow.

The NPK which has a high flow characteristic, gave the highest metering efficiencies of 99 and 77.5% at gate openings No.2 and No.10, respectively, while Urea which was particularly difficult to drill because of its low flow and high hygroscopic characteristics, gave the least metering efficiencies of 95.5% at gate opening No.2 and 63% at No.10.

The conveying efficiency was found to increase with an increase in gate opening for all the fertilizers as shown in **Fig.3**. Gate openings beyond No.7 in most cases did not have marked influence on the conveying efficiency. The increase with gate opening may be due to increase in fertilizer tube loading efficiency resulting from increase in the quantity of fertilizer discharged into it. The fertilizer left within the tube is distributed along its length and eventually discharged into the furrow cut as the application operation continues. For these reasons, the metering and conveying efficiencies at all the gate openings for all the fertilizers tested were considered acceptable. They were, therefore, taken as parameters for measuring the drillability of fertilizer using the machine.

Machine work rate in a maize field with a spacing of 75cm × 25cm, at an average travel speed of 0.86m/s was found to lie between 0.32 and 0.34 ha/h, for millet with a spacing of 90cm × 30cm, it was between 0.35 and 0.40 ha/h, and for sorghum with a spacing of 60cm × 30cm, it was between 0.25 and 0.27 ha/h. These take into account the time taken in stopping to refill the hopper and carry out occasional adjustments. These rates are far better than those for hand application which according to Igbeka (1981) would take between 40 and 60 hours to cover a hectare. The rake angle which gave 3 cm depth for the furrow opener was 30^{o}.

Summary and Conclusion

A manually-operated fertilizer drill was designed and tested for use in applying fertilizer to already established row crops in semi-arid regions. The tricycle build and handles make it easy to park when refilling the hopper and easy to push with little effort, when operated. The machine is easy to fabricate and materials used are readily available. It has a compact design and requires minimum maintenance.

At an average travel speed of 0.86m/s it will cover a hectare of maize within 3.14 hours, hectare of millet within 1.82 hours and a hectare of sorghum within 4.03 hours. It can be calibrated to deliver the required amount of fertilizer with acceptable metering and conveying efficiencies, and work within row spacings lying between 45cm and 90cm. It applies fertilizer at a distance of 5cm from the plant and a depth of 3cm into the soil, along the two rows bordering the furrow through which it is pushed. Its use will eliminate the tediousness of applying fertilizer by hand to already established row crops in semi-arid zones, and mechanize the split method of fertilizer application being practised in the region.

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Table 2. Application Rate of Fertilizer at Various Gate Openings for Maize (Standard Deviation in Parentheses)*

Gate Opening	CAN	SSP	UREA	NPK
1	-	37.5 (0.08)	40.5 (0.02)	35 (0.04)
2.	-	104 (0.003)	120 (0.001)	100.5 (0.001)
3	-	150 (0.12)	185.5 (0.03)	150 (0.02)
4	-	208.5 (0.04)	220.7 (0.085)	205 (0.013)
5	-	260 (0.07)	270 (0.004)	251 (0.043)
6	-	314 (0.18)	335.5 (0.01)	295 (0.013)
7	-	365 (0.025)	380 (0.02)	350 (0.025)
8	-	406.5 (0.3)	425 (0.18)	382 (0.1)
9	-	420 (0.11)	437 (0.003)	395.7 (0.12)
10	-	430 (0.002)	441 (0.013)	410 (0.017)

*Application rate is kg/ha.

Table 3. Application Rate of Fertilizer at Various Gate Openings for Millet (Standard Deviation in Parentheses)*

Gate Opening	CAN	SSP	UREA	NPK
1	25 (0.001)	32.5 (0.002)	35 (0.004)	30.6 (0.12)
2	57 (0.12)	70 (0.01)	75 (0.05)	65.5 (0.005)
3	95 (0.046)	138 (0.007)	140 (0.25)	100 (0.15)
4	125 (0.008)	195 (0.12)	200 (0.23)	142 (0.11)
5	140 (0.06)	220 (0.11)	260 (0.03)	200 (0.061)
6	180 (0.015)	248 (0.1)	320 (0.03)	240 (0.025)
7	225 (0.01)	280 (0.25)	360 (0.06)	286 (0.087)
8	236 (0.09)	312 (0.004)	370 (0.11)	338 (0.142)
9	245 (0.001)	345 (0.125)	375 (0.1)	345 (0.13)
10	250 (0.054)	360 (0.08)	380.5 (0.2)	350 (0.1)

*Application rate is kg/ha.

Table 4. Application Rate of Fertilizer at Various Gate Openings for Sorghum (Standard Deviation in Parentheses)*

Gate Opening	CAN	SSP	UREA	NPK
1	40 (0.52)	45 (0.3)	50 (0.14)	42 (0.2)
2	97.5 (0.006)	125 (0.013)	150 (0.013)	95 (0.04)
3	150 (0.31)	200 (0.001)	230 (0.21)	160 (0.34)
4	200 (0.00)	281 (0.12)	312 (0.16)	200 (0.001)
5	250 (0.215)	335 (0.024)	360 (0.05)	280 (0.063)
6	315 (0.5)	390 (0.01)	450 (0.3)	322 (0.12)
7	370 (0.11)	425 (0.36)	470 (0.002)	400 (0.1)
8	405 (0.45)	430 (0.38)	484 (0.02)	415 (0.03)
9	415 (0.2)	442 (0.17)	495 (0.061)	420 (0.17)
10	420 (0.38)	450 (0.001)	500 (0.108)	435 (0.1)

*Application rate is kg/ha.

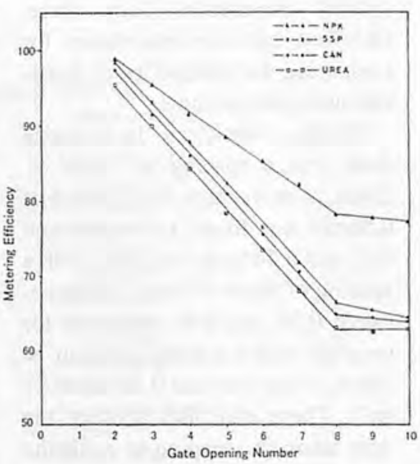

Fig. 2 Metering efficiency at different gate openings and average travel speed of 0.86m/s for four fertilizer types.

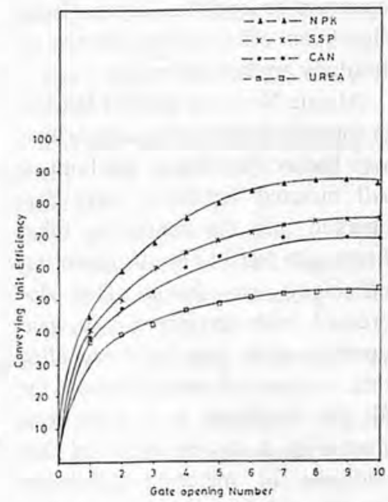

Fig. 3 Conveying unit efficiency at different gate openings and average travel speed of 0.86m/s for four fertilizer types.

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Design of a Pressure Regulator for Lever-operated Knapsack (LOK) Sprayers

by
Ricardo F. Orge
Sr. Science Research Specialist
Rice Engineering and Mechanization Division
Philippine Rice Research Institute
Maligaya, Muñoz, Nueva Ecija
Philippines

Abstract

A pressure regulator was designed to improve accuracy in applying pesticides of commercially available lever-operated knapsack (LOK) sprayers. It operates by maintaining the output pressure regardless of excessive pumping of the operator.

The design features a diaphragm that deflects at varying magnitudes depending on the magnitude of pressure of the liquid where it is subjected to. The displacement due to deflection was then used to control the opening and closing of an inlet when the minimum and the maximum operating (output) pressures are attained, respectively.

This paper discusses the theory on how the design functions and also describes the performance of the three fabricated pressure regulator prototypes.

Introduction

Environmental and economic concerns dictate that agricultural pesticide application accuracy be improved. Since pesticides are expensive and are undesirable in the environment for many reasons, they must be applied precisely on the target at the correct amount.

Although there have been dramatic advances in pesticide application technology in the past decades, the LOK sprayer is still the principal tool used by our farmers today in the Philippines and in Southeast Asia. Design features and quality of sprayers available vary considerably. Some have shortcomings which affect performance and user safety (Hastings and Quick, 1992).

For LOK sprayers to precisely apply pesticides on the target at the correct amount, the following factors should be satisfied: constant operator's walking speed, uniform width of swath, constant nozzle discharge, and appropriate spray droplet size. Except for the first, all of the factors mentioned are affected, either solely or partly, by the operating pressure of the sprayer. Evaluations have demonstrated that a constant pressure setting produces the best results in pesticide application (Bohmont, 1990). The reason is that, a constant pressure results in a uniform spray discharge and width of swath. At desired magnitude depending on the kind of nozzle used, it would also eliminate, if not minimize, drift-prone (too fine) or drip-prone (too large) spray droplets which may contaminate the operator and/or the environment

This study aimed to design and develop a pressure regulator which could be coupled to LOK sprayers and could maintain a constant operating pressure regardless of the frequency of pumping of the operator.

Materials and Methods

Design Criteria

The pressure regulator was primarily designed to maintain a uniform, or with at most 10% variation, output pressure of desired magnitude at the nozzle regardless of excess, and fluctuating pressure at the sprayer's compression chamber. Other major considerations in designing were as follows:

1. *Compatibility with existing LOK sprayers*. The device can be easily attached to existing knapsack sprayers with little or no modification of the sprayer parts;
2. *Ease of fabrication*. The design allows easy fabrication even in small machine shops and utilizes commercially available standard parts;
3. *Durability*. The design makes use of corrosion resistant materials like plastic, brass, and stainless steel. It should be able to withstand pressure so as to prevent leaks or sudden failures (bursting) which may expose or contaminate the operator to harmful chemicals.

The Operating Concept

The idea was to regulate pressure by opening and closing an inlet

(**Fig. 1**) to maintain a certain range of pressure (minimum and maximum output pressure) of liquid inside and coming out of the designed device. Through the movement of a diaphragm, which deflects at varied intensities (depending on the magnitude of pressure acting on it), automatic opening of the inlet at minimum output pressure and closing at maximum output pressure is made possible.

The device operates within the bounds of the following fundamental equation:

$F = P \times A$ .... equation 1

where:

F = force due to pressure;

P = pressure exerted by the liquid on a surface;

A = area subjected to pressure.

When the inlet is closed, the valve is acted upon by forces shown in **Fig. 2**. One of the these forces is the one transmitted by the control pin, F_p, which plays a vital role in pushing the valve to open the inlet. At equilibrium condition, the following relationship exists:

$F_1 = F_p + F_b + 2R_y$.... equation 2

where:

F_p = reaction force at the control pin;

F_b = force acting at the bottom of the valve due to the pressure of the liquid inside the controlled pressure chamber (CPC);

R_y = vertical component of the reaction force, R, at the rim of the inlet which is in contact with the valve;

F_1 = downward force acting on the valve due to pressure of the incoming liquid.

The relationship neglects, among others, the weight (in water) of the valve and the control pin. At an instant when the inlet starts to open, or when it has just closed, the reaction force, R, at the rim of the inlet becomes zero. Under this condition ("R=0" condition), applying equation 2 with further simplifications, results to the following:

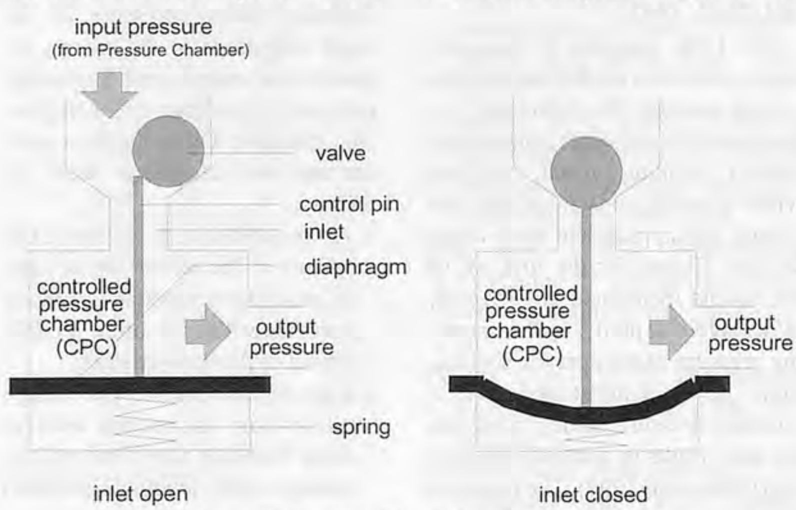


Fig. 1 Schematic diagram of the designed pressure regulator.

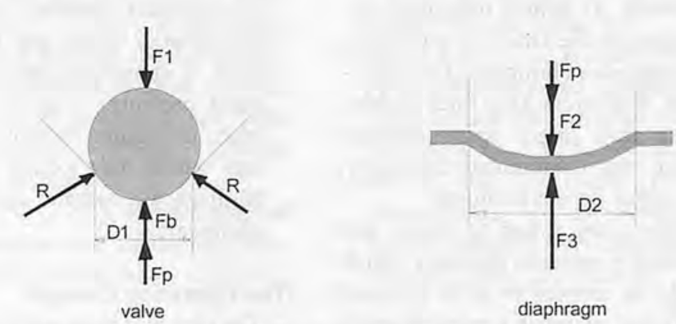


Fig. 2 Free-body diagram of the valve and the diaphragm.

$F_3 = F_1 + F_2 - F_b$ .... equation 3

where:

F_3 = force exerted by the spring;

F_2 = force acting on the diaphragm due to the pressure of liquid inside the CPC.

Open-to-close condition. When the inlet is open, liquid freely flows into the CPC and no distinct difference in pressure exists between the incoming and the outgoing liquid, especially if the input pressure (P_1) starts from zero. The maximum output pressure (P_{2max}) is attained once the force F_2, acting on the upper side of the diaphragm is already enough to counteract the force exerted by the spring (F_3), causing the diaphragm to deflect downward. As a result, the control pin which freely rests on the diaphragm moves down by gravity enabling the valve to completely close the inlet thereby blocking the entry of liquid. At this instant, "R=0" condition again exists and the input pressure, P_1, is equal to the maximum output pressure, P_{2max}, hence, the following relationship (basing from equation 3) holds true:

$F_3 = P_{2max} (A_2)$......... equation 4

where:

P_{2max} = output pressure at an instant the inlet is closed;

A_2 = effective area of the diaphragm.

When the valve is already closed, the liquid at the CPC is isolated from that of the incoming liquid. With continuous pumping of the operator, F_1 increases, therefore, increasing the reaction at the rim of the inlet (R>0). Under this condition, the flow of the liquid coming out of the device is solely governed by the output pressure, P_2, which decreases with time.

Close-to-open condition. With the valve still closed and with continuous pumping of the sprayer, the input pressure, P_1, rises while the pressure of the "isolated" liquid at the CPC drops. This continues until the minimum output pressure P_{2min}, is reached and "R=0" condition again exists. At this instant, basing from equation 3,

$$F_3 = P_1A_1 + P_{2min}(A_2 - A_1) \quad \text{................................ equation 5}$$

where:

A_1 = area of the inlet;

P_{2min} = liquid pressure at the CPC at an instant the inlet starts to open.

At this instant, the reaction force at the control pin, F_p, has increased due to the decrease in F_2 until such time that, when combined with F_b, it can already overcome F_1 to push the valve up and open the inlet. This enables the pressure at the CPC to rise until P_{2max} is again attained.

Design of Inlet and Diaphragm

If equations 4 and 5 are combined and simplified further, the following relationship could be established:

$$P_{2min} = \frac{P_{2max} - P_1(D_1/D_2)^2}{1-(D_1/D_2)^2} \quad \text{................................ equation 6}$$

where:

D_1 = diameter of the inlet

D_2 = effective diameter of the diaphragm

Equation 6 requires that $P_1 >= P_{2max}$ and $D_1/D_2 < 1$. This equation reveals that the ratio of the diameter of the inlet and the diaphragm plays a significant role in the performance of the designed pressure regulator. **Figure 3** shows the graph of equation 6 when P_{2max} is set at 20 psi (selected based on the operating pressure of nozzle used). As shown, the ratio between the diameter of the inlet and the diaphragm affects the minimum output pressure (P_{2min}) of the device. At higher D_1/D_2 ratio, the device is more sensitive to the input pressure hence resulting to a significant decrease in P_{2min} as the input pressure increases. A good design is when the difference between P_{2max} and P2min is kept to minimum even at high input pressures. This is only attained by keeping the D_1/D_2 ratio as small as possible. The lower this ratio, the closer to horizontal is the boundary line for P_{2min} and the more uniform is the output pressure of the device. A compromise, however, is necessary since a very small D_1/D_2 ratio would require a relatively large diaphragm and perhaps to be complemented by a big spring which will make the design bulky and more expensive. Frankel (1990), however, reported that the variation of pressure for hydraulic sprayers should not exceed 10%. **Figure 3** shows that maximum variation in the output pressure (i.e., the difference between P_{2max} and P_{2min}) occurs at the highest possible input pressure. For Taiwan and other existing knapsack sprayers, the highest attainable pressure with manual pumping is about 70 psi. Hence, considering a 10% pressure variation, a D_1/D_2 ratio of at most 0.2 was considered.

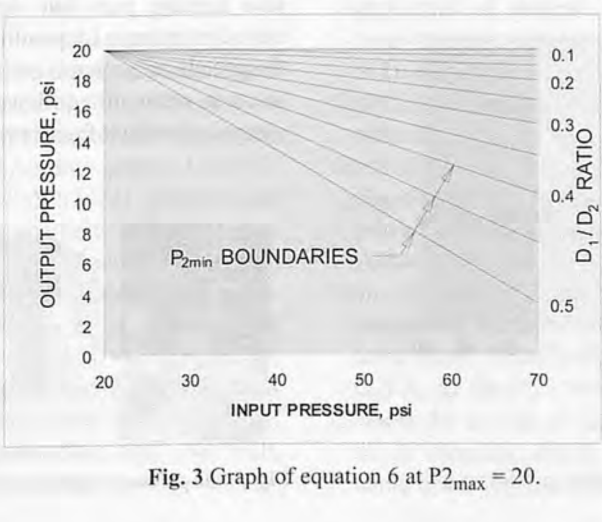


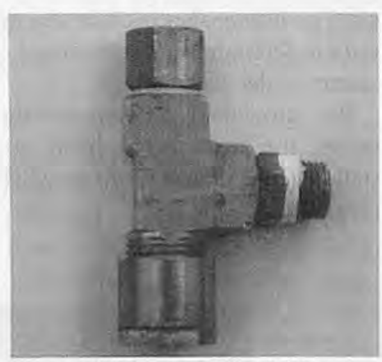
Fig. 3 Graph of equation 6 at $P2_{max}$ = 20.

Results and Discussion

The Test Prototypes

The first prototype. The first prototype features a commercially available 6mm diameter brass tee which served as the device's main body (**Fig. 4**). Other parts were fabricated and fitted into it to complete the whole assembly. In this prototype, the ratio of the diameter of the inlet and the effective diameter of the diaphragm was estimated at 0.08. Test results show that the pro-

Fig. 4 The pressure regulator prototype 1.



a. without pressure regulator

b. with pressure regulator

Fig.5 The pressure regulator prototype 2.

totype yielded an output pressure of 10 psi (relatively low because of difficulty in finding appropriate size of spring) which remained constant up to an input pressure of 70 psi. Although no further test was conducted for higher output pressure, the result confirmed the workability of the concept.

The second prototype. The second prototype utilized components similar to that of the first. However, the diaphragm was replaced with a smaller one whose size was dependent on the size of the cap which was fitted at the same location where the diaphragm in the first prototype was installed (**Fig. 5a**). With this prototype (D_1/D_2 ratio ~ 0.2), it was found that with two layers of 2mm thick rubber sheet (from inner tube of used car tires) used as diaphragm, the spring was no longer necessary to attain an output pressure of 30 psi. Basing from test results, the decrease in the output pressure at increasing input pressure was observed (**Fig. 6**). Theoretically, with a maximum input pressure of 32 psi, the minimum output pressure should only be about 30 psi. This discrepancy could be due to error in determining the effective diameter of the diaphragm.

By providing an appropriate holder, the prototype could be installed in the Taiwan made sprayers (**Fig. 5b**).

The third prototype. The third and latest prototype was designed to be fitted to a new LOK sprayer design developed at PhilRice. The same operating principle as in prototypes 1 and 2 was applied however, a mechanism to block the flow of liquid when the pressure is below the desired operating pressure (i.e., zero nozzle discharge for pressures below operating pressure) was incorporated in the design. As shown in **Fig. 7**, the prototype utilized a PVC fitting as its main body. A brass tube was attached at the side to connect it to the sprayer's lance. It is equipped with a 2mm thick rubber diaphragm (D_1/D_2 ~.1.5) underneath which is a compression spring which sets the output pressure at about 20 psi, the operating pressure of its complementing nozzle. Performance test showed that the device's output pressure ranged from 18 to 24 psi (**Fig. 8**). No liquid flow was observed at the nozzle when the device was operated starting from zero up to just before 20 psi input pressure. This flow was cut-off when the input pressure was allowed to fall down to 10 psi.

Limitations

The pressure regulator which was designed has the following limitations which may need further studies to overcome them:

Gravity dependent. The pressure regulator needs to be positioned vertically with the diaphragm below the inlet in order for it to function. This is because the downward movement of the inlet valve and the push pin is fully dependent on their weight. This makes the device not fit to be installed on the lance of the sprayer but only on a fixed location where it could be positioned vertically.

Insufficient control for input pressures below the set output pressure. The prototype can work only for input pressure equal to or more than the output pressure set for it to limit. Although the third prototype tried to address this problem by blocking the flow of the liquid when the input pressure is below the desired output pressure, the resulting cut-off pressures for starting and stopping nozzle discharge were not the same.

Summary and Conclusion

A pressure regulator was designed and developed for LOK sprayers with a view to improving their efficiency and accuracy in pesticide application.

The device operates by controlling the opening and closing of its inlet so as to maintain a certain range of operating pressure (output pressure). The inlet opens at minimum output pressure and closes at maximum output pressure. It has a diaphragm which serves as its pressure sensing part that deflects at varied magnitude (depending on the magnitude of pressure acting on it) so as to maintain equilibrium. The control pin which freely rests on the

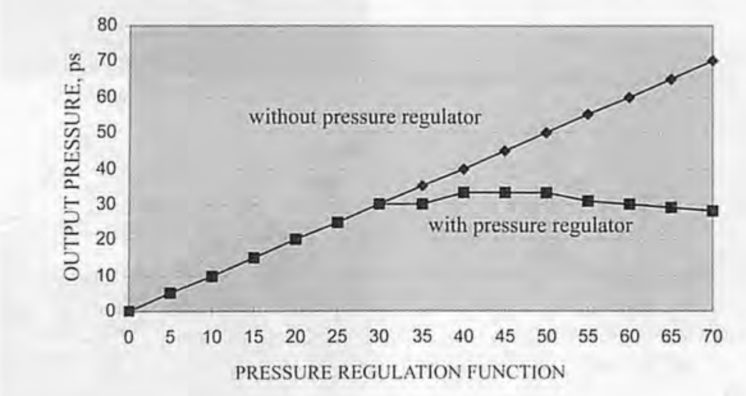


Fig. 6 Performance curve of the pressure regulator prototype 2.

Fig. 7 The pressure regulator prototype 3.

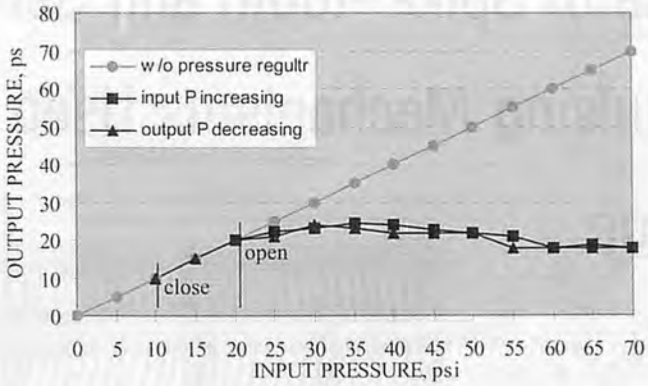


Fig. 8 Performance curve of the pressure regulator prototype 3.

diaphragm, transmits this deflection to the push valve, therefore, automatically controlling the opening and closing of the inlet.

Three prototypes were fabricated and tested. Results confirmed the workability of the concept where the following conclusions could be drawn:

1. The difference between the maximum and minimum output pressure of the device is governed by the ratio of the diameter of the inlet and the diaphragm. The smaller the ratio, the smaller is the difference between the minimum and maximum output pressures, and the more efficient is the device in maintaining the output pressure; and
2. The magnitude of the output pressure is dependent on the resistance of the diaphragm to deflection. Higher resistance means higher output pressure.

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Evaluation of a Reciprocating Peanut Sheller

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Relative Performance of Spike -tooth and Serrated -tooth Type Bruising Mechanisms Used in Wheat Straw Combine

by

Manjeet Singh
Assistant Professor Agricultural Engineering
College of Agricultural Engineering
Punjab Agricultural University, Ludhiana
Punjab
India 141004

S. S. Ahuja
Senior Agricultural Engineer
Deptt. of Farm Power and Machinery
Punjab Agricultural University, Ludhiana
Punjab
India 141004

V. K. Sharma
Additional Director Research (Engineering)
Punjab Agricultural University, Ludhiana
Punjab
India 141004

Abstract

Wheat straw combine is used to collect and bruise the straw and stubbles left in grain combine harvested field. The performance of a straw combine with spike-tooth type bruising mechanism was determined on the basis of net specific fuel consumption and straw quality. The optimum combination with spike-tooth type mechanism was for concave bar spacing (C) 11 mm, cylinder speed (S) 30.83 m/s and feed rate (F) 21.5 q/h. The performance of straw combine with serrated-tooth type bruising mechanism was compared with the performance of straw combine having spike-tooth type bruising mechanism. Serrated-tooth type bruising mechanism was requiring 6-8% less net specific fuel consumption as compared to the spike-tooth type bruising mechanism. But splitting of the straw was better for spike-tooth type bruising mechanism as compared to the straw splitting obtained for serrated tooth type bruising mechanism.

Introduction

Punjab, agriculturally the most advanced State has highest intensity of farm mechanization in India. The mechanization of wheat harvesting and threshing operation is almost complete in Punjab. Of 3.3 million hectares area under wheat crop about 1 million hectares area of the crop is now harvested by grain combines. Wheat straw combine is used to collect and bruise the straw and stubbles left behind after wheat crop harvested by grain combines. Wheat straw, a very valuable product used as a cattle feed for milch animals in India and other countries.

Experiments conducted on threshers revealed that in the threshing system, 62% power was consumed for bruising the straw only. These wheat threshers with spike-tooth type threshing mechanism, not only produce clean grain but also process the wheat stalk into a finally bruised straw. Several alterations of bruising mechanisms for a straw combine are being tried by the researchers and local manufacturers. The views of serrated-tooth type bruising drum and spike-tooth type bruising drum are shown in **Figure 1**. The major advantage claimed by the use of serrated tooth type bruising system was its considerably low energy requirement. A study was conducted to investigate the performance of straw combine with serrated-tooth type bruising mechanism (1). In continuation with that study, present study is to investigate the performance of straw combine with spike tooth type bruising mechanism. Performance of a straw combine with optimized serrated tooth type bruising drum as in previous study (1) was also compared with the performance of straw combine with spike-tooth type bruising drum. Performance of the straw combine was determined by net specific fuel consumption of the prime mover and straw quality, judged by average

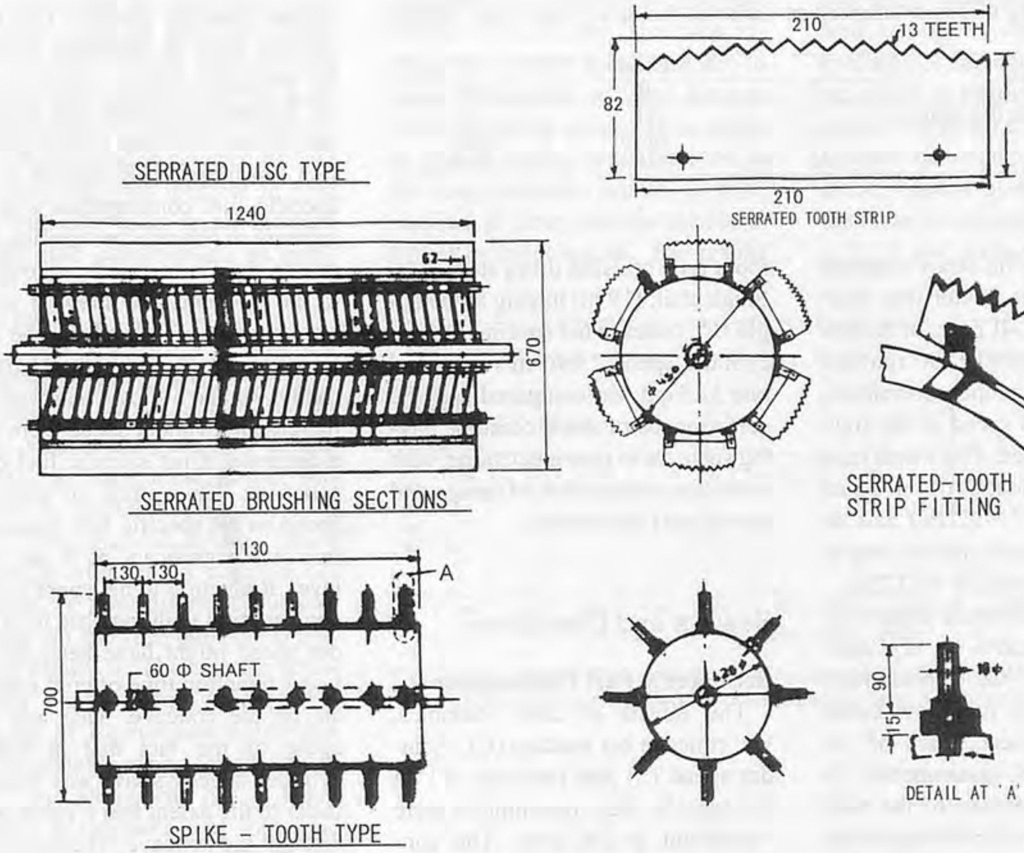

Fig. 1 Different types of straw bruising mechanisms used on straw combines.

length & splitting percentage of the straw.

Rajan et. al.(1995) compared the performance of a thresher with serrated-tooth type and spike-tooth type threshing systems. For the similar experimental conditions, the serrated-tooth type threshing system was requiring 10-25% less power as compared to the spike-tooth type threshing system. The serrated tooth type thresher was capable of handling the maximum feed rate of 9.3 q/h as compared to only 8 q/h in case of spike-tooth type system with similar dimensions and experimental conditions.

Singh et. al.(1998) studied the effects of various design and operational parameters like blade angle(6° to 10°), concave bar spacing (8 mm to 14 mm), cylinder speed(23.96 m/s to 30.83 m/s) and feed rate (15 to 21.5 q/h) on the performance of serrated –tooth type bruising mechanism. These experiments indicated an optimum combination of blade angle 10 °; concave bar spacing 11 mm; cylinder speed 23.96 m/s; and feed rate 21.5 q/h. The optimization of results was considered in terms of net specific fuel consumption and straw quality determined on the basis of average straw length and split straw percentage.

Procedure for Field Testing of Straw Combine.

The basic parameters of straw combine such as overall dimensions of cutter bar and reel, blower (size and location), diameter and width of bruising drum and concave clearance (front 21 mm and rear 20 mm) were kept constant during the experiments. The straw bruising drum (diameter 64 mm) consists of spike-tooth type drum with a closed concave. In bruising system the straw was not allowed to escape from the top of the concave as in a grain combine. The whole length of the straw passes through the concave which after bruising is reduced in size. The finally bruised straw is blown by a blower into the trolley which is hooked at the back of the machine. The trolley is covered with a canvas cloth that is tethered with trolley to collect the straw. The machine was operated by SWARAJ-855 tractor of SAE 55 hp. The levels of different independent variables selected for spike tooth type bruising drum are given in **Table 1**.

V-pulleys of sizes 16.51 cm, 20.32 cm and 24.13 cm with transmission ratios 2.38:1, 1.95:1, and 1.62:1 were selected to vary the speed of the rotation of the bruising cylinder. The feed rate was also varied by changing the forward travel speed of the tractor. The selected forward speeds were 2.0, 2.5 and 3.0 km/h for evaluating the ef-

Table 1. Levels of Different Independent Variables for Spike-tooth Type Bruising Drum

Variables	Level		
	I	II	III
Concave bar spacing (C) (mm)	8	11	14
Cylinder speed (S)	23.96	28.98	30.83
Feed rate (F) (q/h)	15	18	21.5

m/s - meter/seconds.
q/h - quintals/hour.

fect of feed rate on straw combine performance. The tractor was operated in L-I and L-II gears at throttle speed between 1400-1800 rpm according to the proper correlation between forward speed of the tractor and drum speed. The wheat crop had an average length of cut equal to 223 mm (C.V =15.8%) and an average stalk density of the crop at 412 stubbles/sq.m (C.V. = 11.2%).

The average moisture content of the straw was 6.33% on dry basis (C.V. =13.2%). Fuel consumption was measured by fuel flow meter attached to the rear guard of the tractor. Net fuel consumption is equal to the difference of the total fuel consumption for the operation of straw combine minus the fuel consumed during the idle run (no cut). The net specific fuel consumption is the ratio of net fuel consumption to the average feed rate. Straw quality was determined on the basis of average straw length and split straw percentage. Samples collected from the trolley for each experiment were thoroughly mixed.

The mean length (mm) and standard deviation were recorded for each sample which is the average straw length. Straw sample (Approx. Wt. 100-200 g) was sorted manually for unsplit straw to determine the split straw percentage. The average length of straw < 25 mm with C.V. < 40% together with splitting of straw > 92-95% with C.V. <40% was considered acceptable quality. The feed rate (kg/h) of the crop was the product of wt. of crop per unit area (kg/sq.m), effective width of cut (1.83 m) and forward travel speed (m/h).

The performance of the straw combine with optimized serrated-tooth type bruising drum studied by Singh et.al. (1998) having blade angle 10^{o}, concave bar spacing 11 mm, cylinder speed 23.96 m/s and feed rate 21.5 q/h was compared with the performance of straw combine having spike tooth type mechanism with optimum combination of design and operational parameters.

Results and Discussion

Net Specific Fuel Consumption

The effects of three variables, viz. concave bar spacing (C), cylinder speed (S) and feed rate (F) on net specific fuel consumption were significant at 5% level. The concave bar spacing was the most significant parameter affecting the net specific fuel consumption followed by cylinder speed and feed rate.

The results of net specific fuel consumption as affected by the concave bar spacing (C) at different cylinder speeds (S) and feed rates (F) are given in **Figure 2**. At highest cylinder speed 30.83 m/s, there was steep fall in net specific fuel consumption when concave bar spacing was increased from 11 mm to 14 mm. This may be due to that higher cylinder speeds, result in quicker flow of materials through the enlarged concave area. In general, increased concave bar spacing resulted in reduction in net specific fuel consumption. Reduction in net specific fuel consumption with an increase in concave bar spacing was due to the lesser resistance offered to the movement of straw at wider opening size which allows the materials to pass through relatively easily. **Figure 3** shows that with the increase in cylinder speed there was a decrease in net specific fuel consumption. This effect of cylinder speed on net specific fuel consumption was significant at 5 per cent level. Reduction in net specific fuel consumption with increase in cylinder speed might have been due to lesser retention time of crop materials on the concave. This was because of the fact that at higher cylinder speeds straw was bruised faster to the extent that it could pass through the concave. The results of net specific fuel consumption affected by feed rate (F) at different concave bar spacing (C) and cylinder speeds (S) are given in **Figure 4**. At cylinder speed of 23.96 m/s and concave bar spacing C2 11 mm, net specific fuel consumption decreased from 2.282 to 1.953 cc/kg as feed rate was increased from 15 q/h) to 21.5 q/h. Reduction in net specific fuel with feed rate was less pronounced for the concave bar spacing 14 mm. **Figure 4** is showing clearly that with the increase in

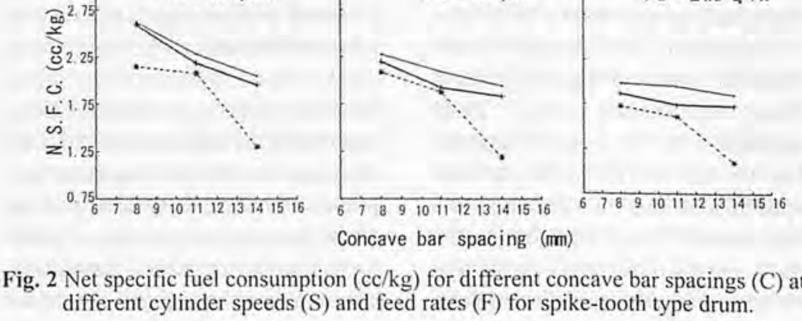

Fig. 2 Net specific fuel consumption (cc/kg) for different concave bar spacings (C) at different cylinder speeds (S) and feed rates (F) for spike-tooth type drum.

feed rate, net specific fuel consumption was reduced. This effect of feed rate on net specific fuel consumption was statistically least significant at 5 per cent. Reasons for this decrease in net specific fuel consumption with increase in feed rate was due to the lesser increase in net fuel consumption as compared to the relative increase in feed rate.

Average Straw Length

Concave bar spacing was the most significant parameter affecting the average straw length, followed by cylinder speed and feed rate. The result of average straw length as affected by concave bar spacing (C) at different cylinder speeds (S) and feed rates (F) is given in **Figure 5**. The average straw length obtained for concave bar spacing of 14 mm was not within the acceptable range (straw length < 25 mm along with c.v. < 40%). **Figure 5** indicates that increased concave bar spacing results in increase in average straw length. This effect of concave bar spacing on average straw length was statistically significant at 5 per cent level. The reason for the increase in the average straw length with increase in concave bar spacing was due to the fact that larger straw could pass through the openings at larger spacing between the bars. The results of average straw length as affected by cylinder speed (S) at different feed rates (F) and concave bar spacing (C) are given in **Figure 6**. At concave bar spacing 14 mm and feed rate 18 q/h, average straw length was 45.04, 40.78 and 38.35 mm at three cylinder speeds 715 rpm, i.e. 23.96 m/s, 865 rpm, i.e. 28.98 m/s and 920 rpm i.e. 30.83 m/s, respectively, which was not within the acceptable range of straw size (< 25 mm with c.v. < 40%). Increased cylinder speed had resulted in reduction of average straw size. This effect of cylinder speed on average straw size is significant at 5 per cent level. The reasons for a reduction in average straw size with increase in cylinder speed was due to more cut/impacts per unit time at higher cylinder speed. Thus, higher impact energy was imparted to the crop materials which, in turn, resulted in finer straw available at higher cylinder speeds. The results of average straw size as affected by feed rate(F) at different concave spacing (C) and cylinder speeds (S) are given in **Figure 7**. At cylinder speed 715 rpm i.e., 23.96 m/s and concave bar spacing 8 mm average straw reduced by only 0.62mm as feed rate was increased from 15 q/h to 21.5 q/h. Reduction in average

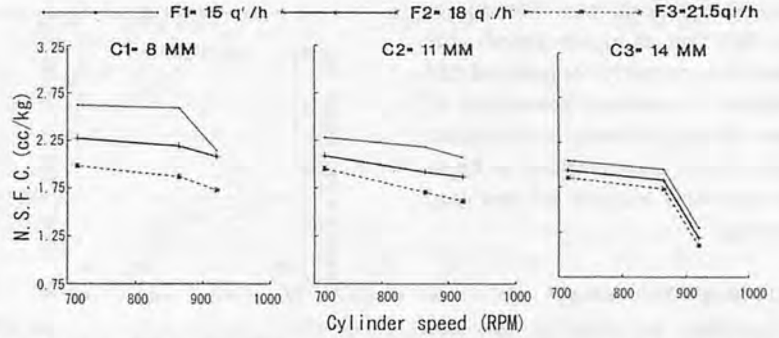

Fig. 3 Net specific fuel consumption (cc/kg) for different cylinder speeds (S) at different feed rates (F) and concave bar spacings (C) for spike-tooth type drum.

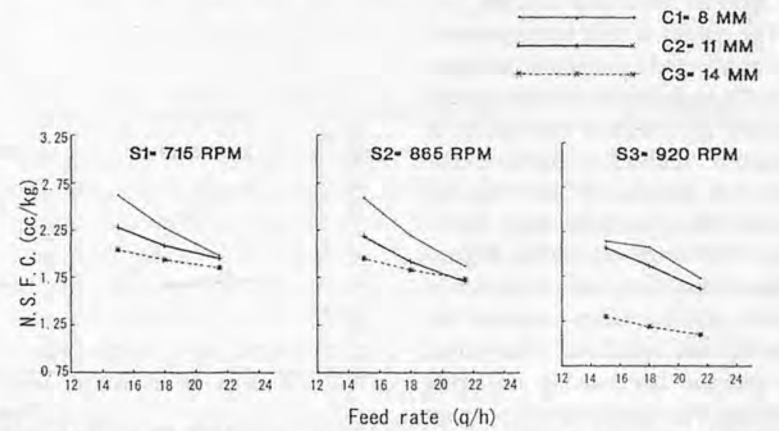

Fig. 4 Net specific fuel consumption (cc/kg) for different feed rates (F) at different concave bar spacings (C) for cylinder speeds (S) for spike-tooth type drum.

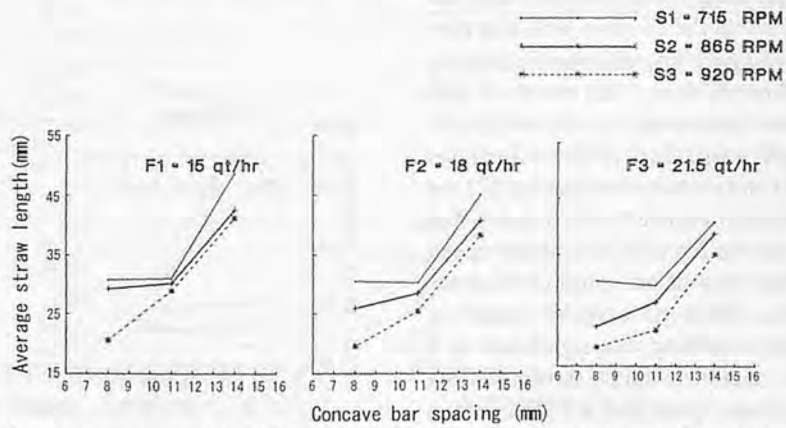

Fig. 5 Average straw length (mm) for different concave bar spacings (C) at different cylinder speeds (S) and feed rates (F) for spike-tooth type drum.

straw size was more pronounced for concave bar spacing 14 mm. This reduction was up to 8 mm with the increase in feed rate from 15 q/h to 21.5 q/h. **Figure 7** showed that increased feed rate reduced average size of straw. This effect of feed rate on average straw length was significant at 5 per cent level. The reason for this reduction in straw size at high feed rates was due to the fact that at higher speeds, the straw was properly compressed and resulted in minimal movement of straw. Energy transfer to a compact mass would also be greater at higher feed rates because of less crop slippage.

Split Straw Percentage

Concave bar spacing was the most significant parameter affecting the split straw percentage followed by cylinder speed and feed rate.

The results of split straw percentage as affected by concave bar spacing (C) at different cylinder speeds (S) and feed rates (F) are given in Figure 8. Splitting of straw at concave bar spacing 14 mm was not within the acceptable range (splitting > 95% with c.v. < 40%). **Figure 8** shows that there was a reduction in straw splitting when concave bar spacing was increased. This effect of concave bar spacing on straw splitting was significant at 5 per cent level. The reasons for the reduction in straw splitting at high spacing were due to less retention time of the straw on the concave such that they could pass through concave opening relatively faster. The results of split straw percentage as affected by cylinder speed (S) at different feed rates (F) and concave bar spacing (C) are given in **Figure 9** which shows that with the increase in cylinder speed there was better splitting of straw. This effect of cylinder speed on straw splitting was significant at 5 per cent level. Straw splitting at low cylinder speed and at high concave bar spacing, was not within the acceptable range (splitting> 95 per cent with c.v. <40%). The reasons for the better splitting were due to high impact levels imparted by the bruising cylinder at high cylinder speeds. The results of split straw percentage as affected by feed rate (F) at different cylinder speeds (S) and concave bar spacing (C) are given in **Figure 10**. At cylinder speed 920 rpm i.e. 30.83 m/s and concave bar spacing 8 mm, there was slight reduction in straw splitting from 98.98% to 98.58% when feed rate was increased from 15 q/h to 21.5 q/h. **Figure 10** shows that, in general, straw splitting increased with an increase in feed rate. This effect of feed rate on splitting of straw was

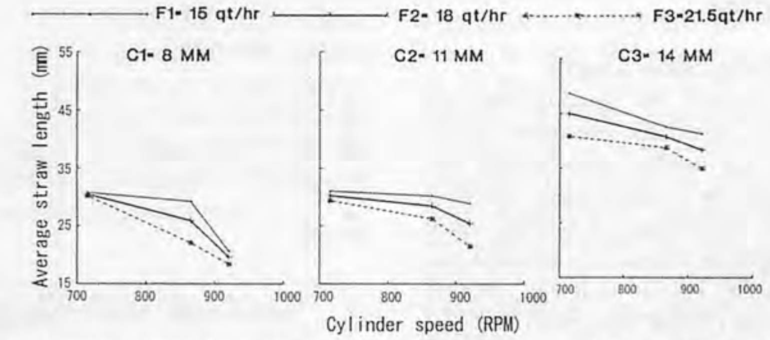

Fig. 6 Average straw length (mm) for different cylinder speeds (S) at different feed rates (F) and concave bar spacings (C) for spike-tooth type drum.

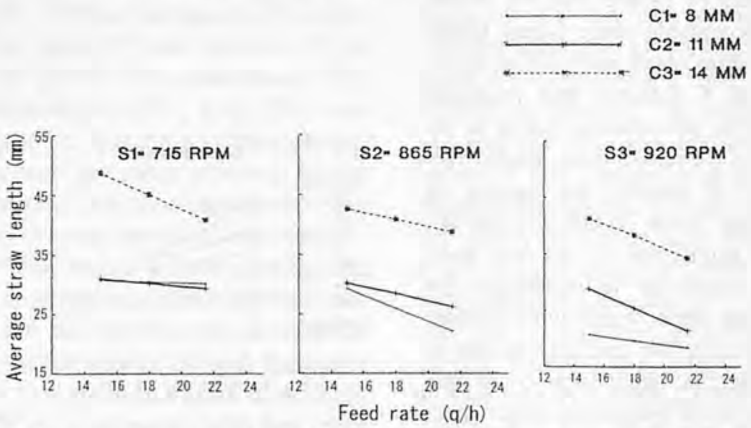

Fig. 7 Average straw length (mm) for different feed rates (F) at different concave bar spacings (C) cylinder speeds (S) and for spike-tooth type drum.

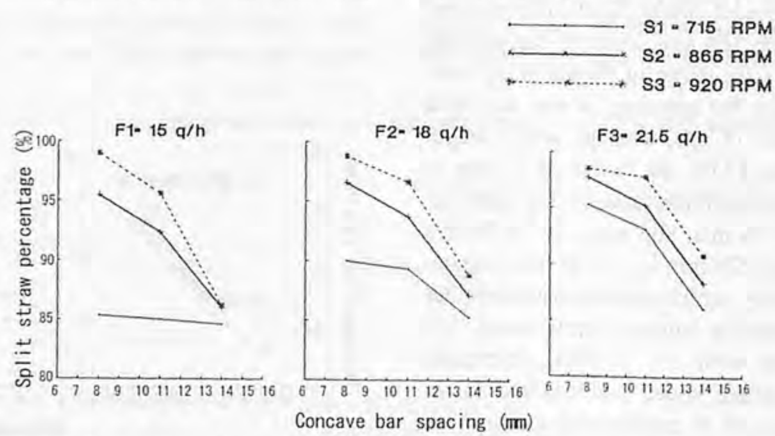

Fig. 8 Split straw percentage (%) for different concave bar spacings (C) at different cylinder speeds (S) and feed rates (F) for spike-tooth type drum.

significant at 5 per cent level. Better splitting at high feed rate was due to the vigorous rubbing and agitation amongst different layers of the straw at high feed rates.

Optimum Combination for Spike Tooth-type Bruising Mechanism

The optimum combination for different independent variables, viz, concave bar spacing (C), cylinder speed (S) and feed rate (F) was for minimum net specific fuel consumption and better straw quality. The results of different dependent variables (net specific fuel consumption, average straw length, split straw percentage) as affected by different independent variables are shown in **Figures 2** to **10**. Hence, from the above discussion it can be concluded that optimum combination for spike-tooth type bruising mechanism was at concave bar spacing 11 mm, cylinder speed 30.83 m/s and feed rate 21.5 q/h.

Relative Performance of Serrated -tooth and Spike-tooth Type Bruising Mechanisms

In this section the two bruising mechanisms -- serrated-tooth type as optimized by Singh et. al (1998) with concave bar spacing 11mm, cylinder speed 23.96 m/s and feed rate 21.5 q/h and spike-tooth type optimized in the present study were compared on the basis of their performance. The dependent variables were net specific fuel consumption (cc/kg), average straw length (mm) and split straw percentage (%). Serrated-tooth type bruising mechanism having blade angle 10 degree was compared to the spike-tooth type bruising mechanism. The comparison was made only in the range where straw quality was acceptable for both systems. The bruising system is the most energy consuming unit. Hence, a major part of the fuel is consumed for the operation of the cylinder.

The net specific fuel consumption for serrated-type bruising mechanism was 2.02, 1.73 and 1.49 cc/kg at concave bar spacing 11 mm and cylinder speed 715 rpm i.e. 23.96 m/s at three feed rates 15 q/h, 18 q/h and 21.5 q/h, respectively. The net specific fuel consumption for the optimized setting of spike-tooth type drum at concave bar spacing 11 mm and cylinder speed 30.3 m/s were 2.07, 1.87 and 1.61 cc/kg at three feed rates 15 q/h, 18 q/h and 21.5 q/h, respectively. This plot of net specific fuel consumption for serrated-tooth type drum and for spike-tooth type drum is

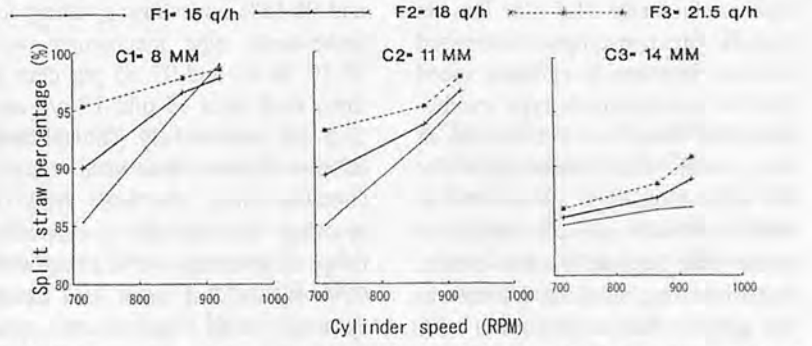

Fig. 9 Split straw percentage (%) for different cylinder speeds (S) at different feed rates (F) and concave bar spacings (C) for spike-tooth type drum.

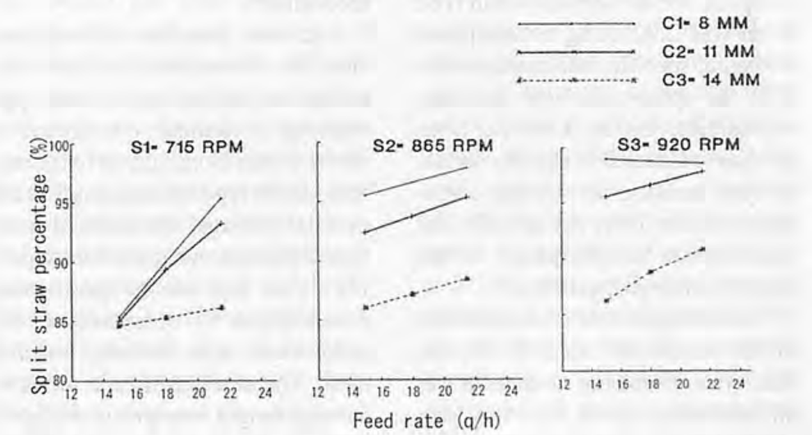

Fig. 10 Split straw percentage (%) for different feed rates (F) at different concave bar spacings (C) and cylinder speeds (S) for spike-tooth type drum.

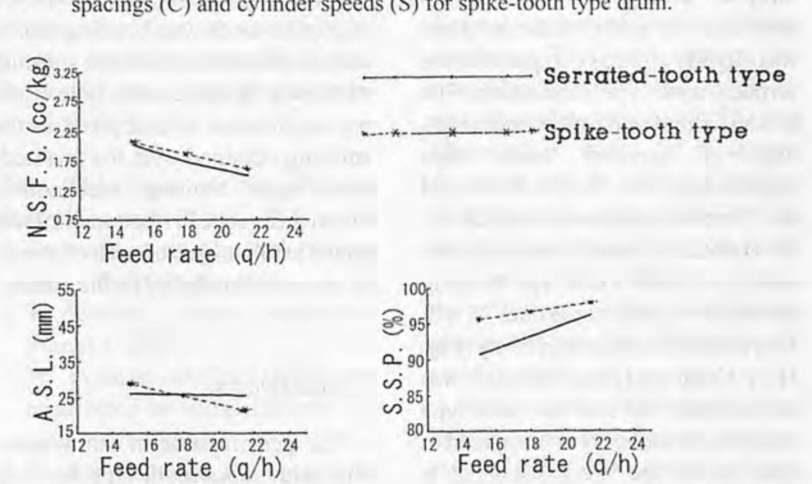

Fig. 11 Comparison of overall performance of straw combine with serrated-tooth and spike-tooth type bruising mechanism.

given in **Figure 11**. It is evident from this figure that in the all cases the net specific fuel consumption was higher for spike-tooth type bruising mechanism as compared to the serrated-tooth type bruising mechanism. The net specific fuel consumption for both types of bruising mechanisms were minimum at feed rate 21.5 q/h. The net specific fuel consumption increased with an increase in cylinder speed for the serrated-tooth type mechanism but there was a reduction in net specific fuel consumption for the spike-tooth type system due to relatively more impacts caused by spikes than serrated blades. Hence, faster bruising, resulting decrease in net specific fuel consumption with the increase in cylinder speed. The maximum net specific fuel consumption for the serrated-tooth type drum was 2.02 cc/kg as compared to the net specific fuel consumption 2.07 for spike-tooth type bruising mechanism. Hence, it is clear from the above discussion that the serrated type bruising mechanism corresponds to the lower net specific fuel consumption as compared to the spike-tooth type mechanism.

The average size of straw was within the acceptance range of size for both type of bruising mechanisms at all treatments except the straw size available for concave bar spacing 14 mm). The average size of straw available from the spike-tooth type drum was slightly more as compared to the serrated-tooth type mechanism. The average straw size for optimized setting of serrated tooth type mechanism was 25.57, 25.96 and 26.17 mm as compared to the 28.87, 25.45 and 21.47 mm for the optimized setting of spike tooth type bruising mechanism at three feed rates 15 q/h, 18 q/h and 21.5 q/h, respectively (**Fig. 11**). At high feed rates, the straw size available for the serrated-tooth type mechanism was more as compared to spike-tooth type mechanism but it was within the acceptable range (straw length < 25 mm with c.v. < 40%).

The results of split straw percentage for the optimal setting of serrated-tooth type bruising mechanism and spike tooth type bruising mechanism are also given in **Figure 11**. The straw splitting obtained for the serrated-tooth type bruising mechanism at were 90.67, 93.20 and 96.15% and straw splitting for spike-tooth type mechanism was 95.59, 96.63 and 97.,85 per cent at three feed rates 15 q/h, 18 q/h and 21.5 q/h, respectively. The splitting of straw obtained was within the acceptable range for both type of bruising mechanism (acceptable range of splitting >95% along with C.V. 40.%). But there was better splitting with spike-tooth type bruising mechanism as compared to the serrated tooth type bruising mechanism.

It is clear from the above discussion that the net specific fuel consumption for the spike-tooth type bruising mechanism was greater at all feed rates as compared to the serrated-tooth type mechanism. For the optimal settings, the serrated-tooth type bruising mechanism was requiring 6-8 per cent less net specific fuel consumption as compared to the spike-tooth type bruising mechanism. The straw quality in terms of average length was not significantly different for both types of bruising mechanisms viz., serrated-tooth type and spike-tooth type bruising mechanisms. But there was better splitting of straw with spike-tooth type bruising mechanism as compared to the splitting obtained with the serrated-tooth type bruising mechanism. Small difference in straw quality was due to small projected area of serrated strips as compared to the spikes.

Conclusions

The performance of straw combine with spike-tooth type bruising mechanism was determined on the basis of net specific fuel consumption and straw quality judged by straw length and splitting. The optimum combination for the minimum net specific fuel consumption and better straw quality was for concave bar spacing 11 mm, cylinder speed 30.83 m/s and feed rate 21.5 q/h. When the performance of straw combine was compared for the optimal settings of spike tooth type and serrated tooth type bruising mechanisms. It was observed that serrated tooth type bruising mechanism was requiring 6-8% less net specific fuel consumption as compared to the spike-tooth type bruising mechanism. The straw quality in terms of average straw length available from serrated-tooth type mechanism was not significantly different as compared to the straw length obtained from spike-tooth type bruising mechanism. But splitting of straw with the spike-tooth type bruising mechanism was better as compared to the splitting of straw with serrated tooth type bruising mechanism.

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Evaluation of a Reciprocating Peanut Sheller

by
M. A. Helmy
Professor
Ag. Eng., Ag. Mech. Dept.,
Fac. of Ag., Kafr El-Sheikh,
Tanta University
Egypt

Abstract

The present study was carried out to evaluate the performance efficiency of a reciprocating peanut sheller at various shelling box speeds of 1, 1.4, 1.7 and 2 m/s, feed rates of 60, 80, 100 and 120 kg/h, air velocities of 4.43, 6.25, 8.37 and 10.11 m/s and peanut moisture contents of 11.6, 17.12 and 23.52%. The shelling efficiency, mechanical damage and unshelled seeds (total losses), sheller productivity, unit energy consumption, seed recovery and degree of cleanliness were estimated. The results showed that these indices were 95.44%, 5.55%, 4.56%, 70×10^{-3} Mg/h, 3.36 kW.h/Mg, 99.67% and 96.1%, respectively, at shelling box speed of 1.4 m/s, feed rate of 80 kg/h, air velocity of 8.37 m/s and peanut moisture content of 17.12% (d.b.) as an optimum condition of the peanut sheller. The lowest cost to produce one megagram of shelled peanut seeds was 64 L.E.** at the same operating conditions. The shelling efficiency of the reciprocating sheller increased by 3.45% comparing to drum-sheller at the same operating conditions approximately.

Introduction

Oil crops are considered important sources of nutrition for millions of people all over the world. Peanuts are one of the major cash oil crops in the world. It occupies the fourth place, in regard to cultivated area, among other oil crops spread at the world level *(Abou El-Kheir and Shoukr, 1993,FAO, 1986)*. Egypt produces about 3150 Mg peanut per year from 26000 feddans*** with an average of 1211 kg/fed *(Younis et al., 1997)*. It is expected that peanut production will increase in the near future, specially in the newly reclaimed lands. Shelling is the most important process before handling peanut. Shelling minimizes size of packing to save transportation cost and facilitate handling for further processes. For hand shelling, farmers shell and separate the peanut kernels from the broken shells at the same time, mainly for seed purposes. Construction of a peanut sheller is important for farmer use. Sheller design, operation parameters and the conditions of peanut affect mechanical shelling.

The Objectives of the Present Study Are as Follows:

1. To study some physical properties of the peanut crop.
2. To develop a simple constructed peanut sheller.
3. To evaluate shelling efficiency as affected by some different operation conditions.
4. To determine out the energy requirements to overcome the shelling operation.
5. To compare the reciprocating sheller and drum-shellers.
6. To state the production cost for a megagram of shelled peanut seeds by using the reciprocating sheller.

Review of Literature

Ibrahim et al. (1975) studied the effect of some operating factors such as clearance, speed and number of beaters on damage and efficiency for shelling peanuts. They used six levels of clearance (11,15,20,25,30 and 35mm), five levels of speed (100,140,180,220 and 260 rpm) and three sets of number of beaters (4,6 and 8). The results showed that the clearance was the most significant factor that affected both shelling damage and efficiency. Generally, the millibility as well as the different types of damage decreased by increasing clearance. The total damage increased as the number of beaters increased at clearance level of 11 and 15mm. For levels of clearance above 20 mm the effect of number of beaters was negligible. Shelling milliblity decreased as the clearance increased. In almost all cases, the efficiency of the 6-beaters set was lower than the other sets of 4- and 8-beaters.

Singh and Thongsawatwong (1983) used two peanut shellers, one of them was manual and the other was power operated. They were modified to make them easy

** One US dollar = 3.42 L.E. (Egyptian pound) according to prices of 1999.
*** One feddan (fed.) = 4200.83 m^2

to operate and improve their performance. The improved manual peanut sheller has a mechanism to adjust the clearance, and round tooth shelling bars. The modified manual peanut sheller, operated by two men, has a capacity of 32 kg (seed)/h with breakage of about 4.8% and shelling efficiency of 96%. For the power- operated peanut sheller, a feeding mechanism and a blower were designed. The modified sheller has a capacity of about 175 kg (seed)/h at shelling bar speed of 145 stroke /min and clearance of 2 cm. The machine has shelling efficiency of 97%, breakage of 4.7%, blower loss of 0.2%, cleaning efficiency of about 98.3% and the power consumption of about 2.2 kW.

Gore et al. (1990) classified the groundnut shellers depending on their power source to manually-operated and power-operated. Based on shelling action, the shellers could be classified into reciprocating type and continuous or rotary type. The manually-operated groundnut shellers could be classified into three subclasses; a) semi-rotary type sheller, b) hand-operated sheller with shelling cylinder which was rotated by hand; and c) foot-operated sheller.

Abou El-Kheir and Shoukr (1993) studied the effect of some operating parameters of sheller and natural properties of crop material shelling efficiency. The increase in the number of drum beaters from 4 to 8 increased the number of hits per unit time and increased the shelling efficiency from 74 to 80.6% at drum speed of 1.83 m/s and from 87 to 92.5% at drum speed of 4.58 m/s. Shelling efficiency using rubber drum was less than that of both steel and wooden drum.

Singh (1993) tested two types of concave in manual sheller, the first was wire mesh concave and the second was slotted grate. Shelling capacity with wire mesh concave was higher (86 kg/h) compared to that of slotted grate (60 kg/h). This is due to increased opening area. For wire mesh concave the shelling efficiency ranged from 83 to 89% compared to the slotted type which ranged from 82 to 84%. Also, the percentage of breakage ranged from 3.7 to 6.7% and from 8.4 to 12.6% for warmish and slotted grate, respectively.

Younis et al. (1997) developed a peanut sheller. Results of the modified sheller evaluation indicated that breakage was reduced from 57 to 54%, cleaning efficiency increased from 67 to about 96%, and separation efficiency increased from 28 to 93% compared to the original sheller. The total loss was also reduced from 57% to about 4% compared to the original sheller.

Materials and Methods

The present study included construction of a reciprocating peanut sheller (**Fig. 1**). It was constructed in the Agric. Eng. Workshop, Fac. of Agric., Kafr EL-Sheikh Governorate, Egypt. The machine is a reciprocating sheller type. It is powered by 4 kW (5hp, 3-phase, 1425-rpm) electric motor. The sheller has two function units for shelling and cleaning. The following points were taken into consideration during the construction:

1. All parts from local materials.
2. The constructed sheller should have a simple mechanism.
3. Ease of operation, adjustment, repairs and maintenance.
4. Low cost manufacture (prototype cost reached about 750 L.E.) so that small farmers can afford it.

The main parts of peanut sheller are shown in **Fig. 1**. The sheller consists of the following parts:

1. Feeding and shelling box were constructed from wood and steel sheets. The two walls of the box were adjusted to obtain the proper slope for the samples to slide smoothly toward the feed opening. The feed rate of sample could be controlled through two gates fixed on the sides of the feed box walls. The bottom section of the shelling box was provided with fixed wooden strips for shelling process. The shelling box was driven by using a crank having a radius of 5 cm. That results in a box stroke length of 10 cm. Meanwhile, the box speed was changed by using different pulleys varying in their diameters. To determine the reciprocating speed of the shelling box, the crank rotational speed was mea-

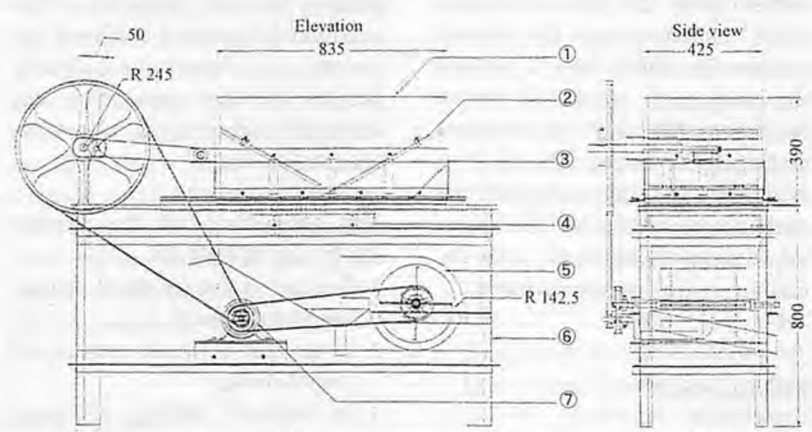

Fig. 1 Elevation and side view of the reciprocating sheller.

sured by a tachometer (model 3632) in rpm, and it converted to a liner speed (m/s).

2. The separating screen was fixed under the feed box and the clearance between the feed box and separating screen could be adjusted by using four bolts moving the screen in perpendicular direction. The screen has 45 cm length and 35 cm width and made by using a number of wooden strips with the dimensions of 2 × 3 × 30 cm (**Fig. 2**).
3. The blower fan (centrifugal type) has four straight blades and two inlets opening. The inlet openings have a circular shape of 28.5 cm diameter while the outlet opening has a rectangular shape of 16 × 39 cm. On the two inlets, there were two gates for controlling the airflow rate. Air velocity was measured by using the hot-wire type anemometer (model SATO-SK-73D) which gives the velocity in m/s.
4. The frame was constructed from wood, steel angles and steel sheets.

Figures 3, **4** show the distribution frequency curves of the peanut crop used in all experimental tests, during summer season 1998. This variety was two seeds for each pod. Whereas, the dimension of pods and seeds forms are considered important as limiting factors in passing the seed and the hull between the screen strips grate holes and in determination of the clearance between box bottom and separating screen. For all experiments, this clearance was selected at a constant value of 18 mm according to a study of the physical properties of peanut pods and seeds. On the other hand, the main experimental procedure were carried out to study the effects of following operation variables on the sheller productivity, shelling efficiency, seed damage, unshelled seeds, total losses, energy consumption, degree of cleanliness and seed recovery:

1. Four box speeds of 1, 1.4, 1.7 and 2 m/s.
2. Four feed rates of 60, 80, 100 and 120 Kg/h.
3. Three moisture contents of 11.6, 17.12 and 23.52%.
4. Four separating air velocities of 4.43, 6.25, 8.37 and 10.11 m/s.

Three replications were carried out for each experiment. Each peanut crop sample was weighed and dropped into the feeding box. The moisture content of peanut pods samples was calculated and measured by using the oven method at temperature of 105 deg for 24 hours of drying. It was determined on dry basis (d.b.). The technical indices in the present investigation were determined as follows:

1. Totals shelling losses defined as the sum of the percent damage and unshelled seeds. They were determined according to relations used by *Gore et al. (1990)*:

Damage Percentage =

$$\frac{Weight\ of\ damage\ seed}{Total\ weight\ of\ seed} \times 100,\% \quad .... 1$$

Unshelled seed Percentage =

$$\frac{Weight\ of\ unshelled\ seed}{Total\ weight\ of\ seed} \times 100,\% \quad .... 2$$

2. Shelling efficiency was determined according to the formula used by *EL-Sayed (1992)*:

Shelling efficiency = 1-

$$\frac{Weight\ of\ unshelled\ seed}{Total\ weight\ of\ seed} \times 100,\% \quad .... 3$$

3. Ameter and voltameter were used for measuring the current

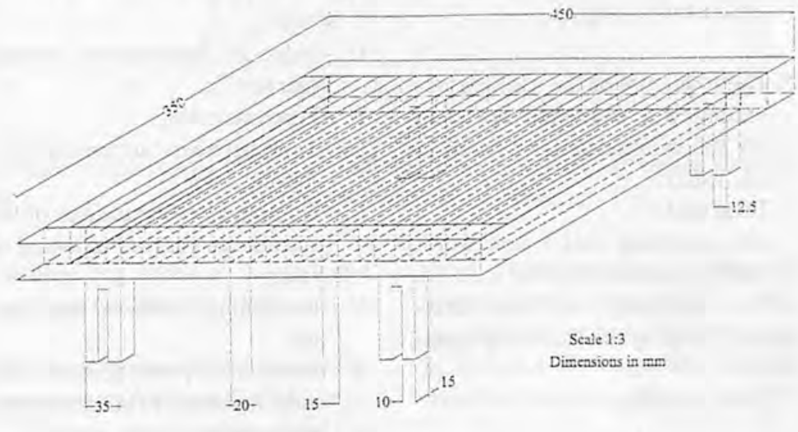

Fig. 2 Separating screen.

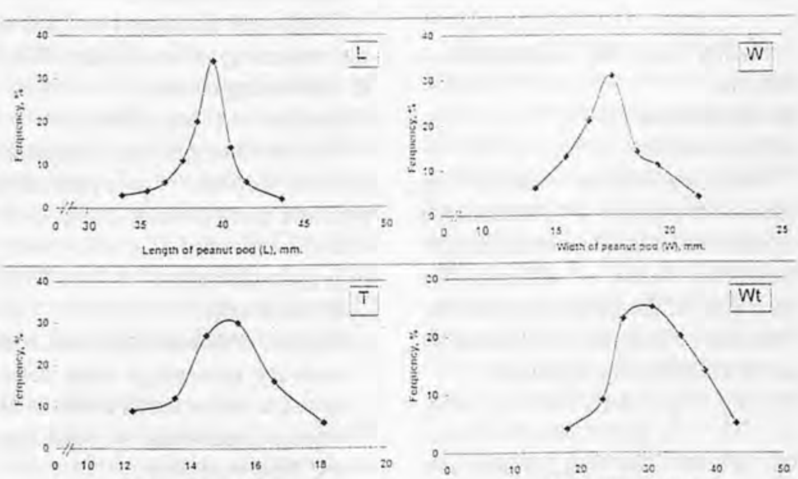

Fig. 3 Frequency percentages against length, width, thickness and weight of peanut pods.

strength and potential difference, respectively. Readings of amperes and volts were taken before and during each treatment. The power consumption was calculated by using the following formula *(Lockwood and dunstan,1971)*:

Power consumption =

$\sqrt{3}$I. V. Cosθ. η, Watt 4

Where:

I = Current strength, amperes;

V = Potential difference, Volts;

Cosθ= Power factor, decimal (being equal to 0.71) and

η = Mechanical efficiency of motor assumed 80 %.

4. The unit energy requirement was calculated by using the following equation:

Unit energy requirement =

$$\frac{Power\ consumption\ (kW)}{Productivity\ (Mg/h)}, \text{kW.h/Mg} \quad ....5$$

5. The total cost of the shelling operating was estimated by using the following equation *(Awady et al., 1982)*:

Total cost =

unit operating cost + unit worth of shelling losses, L.E./Mg 6

Unit operating cost was determined by using the following equation:

Unit operating cost =

$$\frac{Sheller\ cost(L.E./h)}{Productivity(Mg/h)}, \text{L.E./Mg} \quad ....7$$

Sheller cost was determined as follows:

A. Fixed costs:

1).Depreciation:

Declining balance method was used to determine the depreciation *(Hunt, 1983)*. In this method the depreciation value is different for each year of the machine's life. Depreciation value was determined by using the following equation:

$D = V_n - V_{n+1}$, L.E./Yr. 8

$$V_n = P\left(\frac{L-X}{L}\right)^n, \text{L.E./Yr} \quad .... 9$$

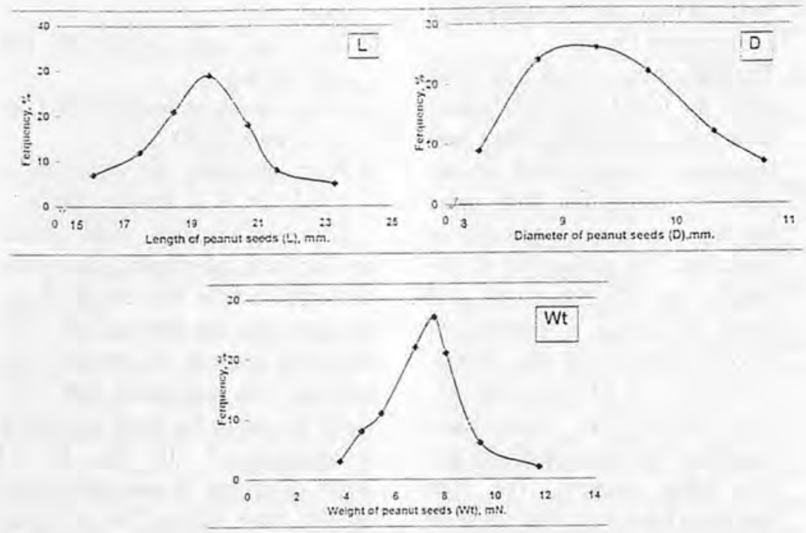

Fig. 4 Frequency percentages against length, diameter and weight of peanut seeds.

$$V_{n+1} = P\left(\frac{L-X}{L}\right)^{n+1}, \text{L.E./Yr.} \quad . . 10$$

Where:

D =Value of depreciation charged year (n+1);

P =Purchase price;

L =Time between buying and purchasing, Yr.;

n =Number representing age of the machine in year at beginning of year;

V =Remaining value at any time and

X =Ratio of depreciation rate for used machine (The maximum rate is =1.5).

2.)Interest on investment, shelter taxes and insurance:

They were estimated as 12% of the remaining value *(Awady, 1978)*.

B. Operating costs:

1).Repairs and maintenance:

For machinery, repairs and maintenance is about 7% as a percent of purchase price *(Awady, 1978)*.

b) Electric cost.

c) Lubricant cost.

d) Labor cost.

6. Degree of cleanliness and seed recovery percentage were determined at four various levels of air velocity according to Kashayap and Pandya (1965):

$$D_s = \frac{a}{a+c} \times 100, \% \quad .... 11$$

$$R_s = \frac{a}{a+b} \times 100, \% \quad .... 12$$

Where:

D_s = Degree of cleanliness of seed recovered in product, %;

R_s = Seed recovery in the product,%;

a = Mass of seed recovery in the product, kg;

b = Mass of material other than seed recovery in the product, kg and

c = Mass of seed in the reject, kg.

Results and Discussion

Effect of Some Performance Parameters on Shelling Losses

Shelling losses, including damaged and unshelled seeds, are more sensitive to various parameters such as shelling box speed, feed rate and peanut moisture content.

By increasing box the speed from 1 to 2 m/s, at feed rate of 80 kg/h and moisture content of 17.12%, seed damage increased from 3.8 to 7.61% (**Fig. 5**). Also, by increasing the feed rate from 60 to 120 kg/h at box speed of 1.4 m/s and moisture content of 17.12%, seed damage increased from 5.12 to 7.13% (**Fig. 6**). **Figures 5** and

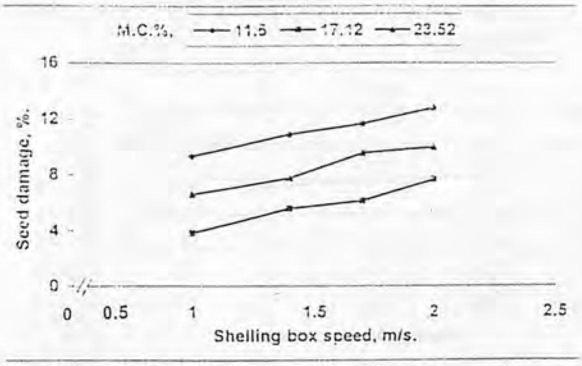

Fig. 5 Effect of shelling box speed on seed damage at various moisture contents (feed rate of 80 kg/h).

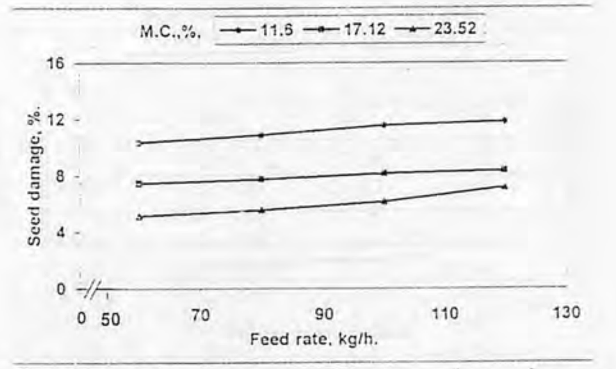

Fig. 6 Effect of feed rate on seed damage at various moisture contents (box speed of 1.4 m/s).

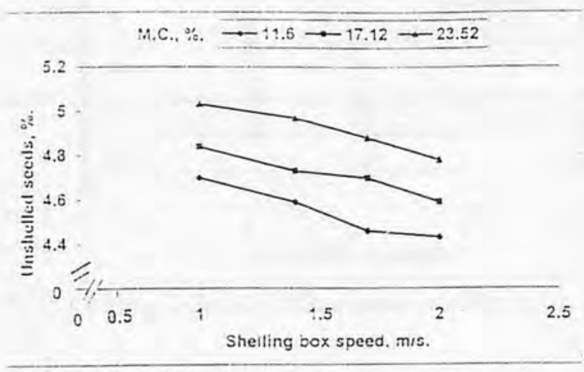

Fig. 7 Effect of shelling box speed on unshelled seed at various moisture contents (feed rate of 80 kg/h).

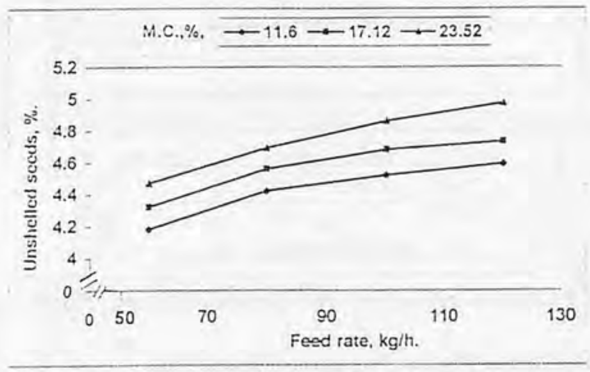

Fig. 8 Effect of feed rate on unshelled seed at various moisture contents (box speed of 1.4 m/s).

6 also illustrated that the minimum seed damage was obtained at a moisture content of 17.12% for the increment of both box speed and feed rate.

By increasing the box speed from 1 to 2 m/s, at feed rate of 80 kg /h and moisture content of 17.12%, unshelled seeds decreased from 4.63 to 4.31% (**Fig. 7**). **Figure 8** shows that by increasing the feed rate from 60 to 120 kg/h at box speed 1.4 m/s and moisture content 17.12%, unshelled seeds increased from 4.32 to 4.73%. By increasing the peanut moisture content from 11.6 to 23.52 at box speed of 1.4 m/s and feed rate of 80 kg /h, unshelled seeds increased from 4.42 to 4.69% (**Figs. 7** and **8**).

In order to establish the optimum operating conditions, **Figure 9** illustrates that shelling losses (total losses) and productivity as affected by shelling box speed. It is seen that minimum total losses were obtained at a feed rate of 80 kg /h, shelling box speed of 1.4 m/s and moisture content of 17.12%.

Effect of Some Performance Parameters on Shelling Unit Energy

The box speed increase from 1 to 2 m/s, at feed rate of 80 kg / h and moisture content of 17.12%, increased unit energy from 3.29 to 3.61 kW.h/Mg (**Fig. 10**). Also, the feed rate increase from 60 to 120 kg/ h, at box speed of 1.4 m/s and moisture content of 17.12% increased unit energy from 3.13 to 3.68 kW.h / Mg (**Fig. 11**). By increasing moisture content from 11.6 to 23.52 at box speed of 1.4 m/s and feed rate of 80 kg/h, unit energy increased from 3.12 to 3.61 kW.h/Mg (**Figs. 10** and **11**).

Cost Analysis

Table 1 summarizes the economical cost for producing one Mg of peanut seeds. The total cost was deduced to determine the least operating conditions. It can be concluded that the lowest value of total cost 64 L.E./Mg was obtained at box speed of 1.4m/s, feed rate of 80kg/h and average moisture content of about 17.12%.

Effect of Some Performance Parameters on Degree of Cleanliness and Seed Recovery

In regard to the degree of cleanliness, results show a remarkable increase in the degree of cleanliness percentage, at any moisture content, as the air velocity increased and the vice versa was noticed of seed recovery (**Fig. 12**). The air velocity increase from 4.43 to 10.11 m/s, at moisture contents of 17.12% increased the degree of cleanliness from 88.37 to 98.87%. But the air velocity increase from 4.43 to 10.11 m/s, at moisture content of 17.12% decreased seed recovery from 99.89 to 99.47%.

In order to establish the optimum

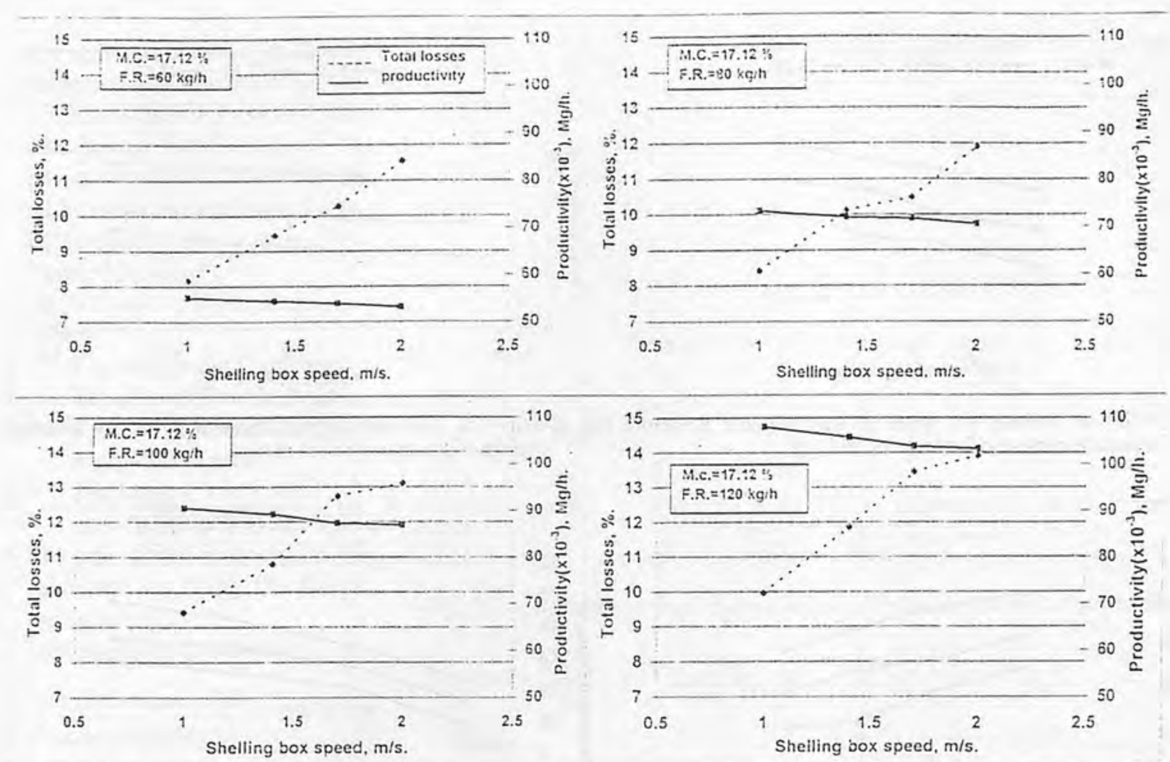

Fig. 9 Effect of shelling box speed on total losses and productivity at a fixed moisture contents and various feed rate (F.R.).

Table 1. Some Physical Properties of Peanut Pods

Length			Width			Thickness			Mass and weight				
									Class				
Class (mm)	Av. (mm)	F (%)	Class (mm)	Av. (mm)	F (%)	Class (mm)	Av. (mm)	F (%)	g	mN	Av. (g)	Av. (mN)	F (%@)
<35	33.89	3	<15	14.07	6	<13	12.25	9	<2	<19.60	1.83	17.94	4
35->36	35.40	4	15->16	15.44	13	13->14	13.54	12	2->2.4	19.60->23.52	2.37	23.23	9
36->37	36.48	6	16->17	16.47	21	14->15	14.49	27	2.4->2.8	23.52->27.45	2.68	26.27	23
37->38	37.57	11	17->18	17.46	31	15->16	15.46	30	2.8->3.2	27.45->31.37	3.11	30.49	25
38->39	38.46	20	18->19	18.57	14	16->17	16.58	16	3.2->3.6	31.37->35.29	3.54	34.70	20
39->40	39.44	34	19->20	19.46	11	>17	18.10	6	3.6->4.0	35.29->39.21	3.91	38.33	14
40->41	40.51	14	>20	21.29	4	-	-	-	>4.0	>39.21	4.39	43.03	5
41->42	41.46	6	-	-	-	-	-	-	-	-	-	-	-
>42	43.63	2	-	-	-	-	-	-	-	-	-	-	-
-	-	100	-	-	100	-	-	100	-	-	-	-	100
X*	38.880			17.320			15.010				3.070	30.100	
Sx**	1.796	-	-	1.667	-	-	1.486	-	-	-	0.185	1.821	-
V, %***	4.619			9.624			9.900				6.026	6.049	

air velocity, it is seen that the maximum degree of cleanliness and seed recovery (96.1%, 99.67%, respectively) were obtained at air velocity 8.37 m/s for peanut moisture content of 17.12% (**Fig. 12**).

Comparison Between Reciprocating Sheller and Shelling Units (drum + beater by Ibrahim et al., 1971 and Abou EL-Kheir and Shoukr, 1993).

Figure 13 shows the shelling efficiency percentage of the reciprocating sheller at various box speeds for three peanut moisture contents of 11.6, 17.12 and 23.52% and feed rate of 80 kg/h. The shelling efficiency increased from 95.5 to 95.81%, from 95.37 to 95.69% and from 95.17 to 95.56% as box speed increased from 1 to 2 m/s for moisture contents of 11.6, 17.12 and 23.52%, respectively. It may also be noticed that the highest shelling efficiency was 95.81% at shelling box speed of 2 m/s (**Fig. 13**) while it was 92.5% at shelling drum speed of 4.2 m/s (**Fig. 16**). This is an advantage to reduce the consumed unit energy at relatively low speed.

Figure 14 shows the seed damage percentage of the reciprocating sheller at various box seed for three peanut moisture contents of 11.6, 17.12 and 23.52% and feed rate of 80 kg/h. The minimum seed dam-

Table 2. Some Physical Properties of Peanut Seeds

Length			Diameter			Mass and weight				
Class (mm)	Av. (mm)	F (%)	Class (mm)	Av. (mm)	F (%)	Class g	Class mN	Av. (g)	Av. (mN)	F (%@)
<17	16.07	7	8.0->8.5	8.27	9	<0.4	<3.92	0.38	3.72	3
17->18	17.46	12	8.5->9.0	8.78	24	0.4->0.5	3.92->4.90	0.47	4.60	8
18->19	18.45	21	9.0-9.5>	9.29	26	0.5->0.6	4.90->5.88	0.55	5.39	11
19->20	19.51	29	9.5->10.0	9.75	22	0.6->0.7	5.88->6.86	0.69	6.76	22
20->21	20.68	18	10.0->10.5	10.33	12	0.7->0.8	6.86->7.84	0.77	7.54	27
21->22	21.56	8	10.5->	10.78	7	0.8->0.9	7.84->8.82	0.82	8.03	21
>22	23.27	5	-	-	-	0.9->1.0	8.82->9.80	0.96	9.41	6
						>1.0	>9.80	1.20	11.76	2
-	-	100	-	-	100	-	-	-	-	100
X*				9.41				0.71	6.96	
Sx**		-	-	0.71	-	-	-	0.064	0.631	-
V, %***				7.545				9.01	9.01	

*Arithmetic mean ** Standard deviation *** Coefficient of variation @ Frequency distribution

Table 3. Effect of Moisture Content on Total Cost at Box Speed of 1.4 m/s and Feed Rate of 80 kg/h

M.C., %	Feed rate kg/h	Box speed m/s	Sheller productivity Mg/h	Sheller operating cost L.E./h	Unit operating cost L.E./Mg	Unit shelling losses, L.E./Mg Unshe.	Dama.	Total	Total cost L.E./Mg
11.6	80	1.4	0.06777	2.8	41.32	7.07	34.78	41.85	83.17
17.12	80	1.4	0.07191	2.8	38.94	7.3	17.76	25.06	64.00
23.52	80	1.4	0.07006	2.8	39.97	7.5	24.77	32.27	72.24

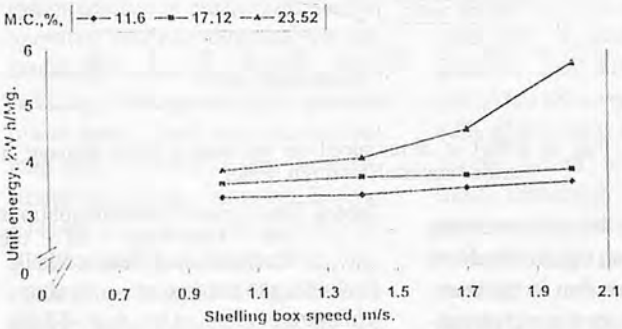

Fig. 10 Effect of shelling box speed on unit energy at various moisture contents (feed rate of 80 kg/h).

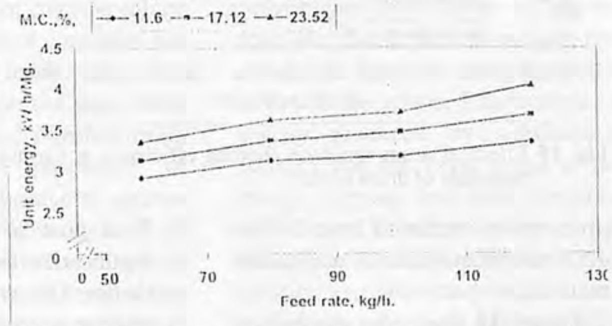

Fig. 11 Effect of feed rate on unit energy at various moisture contents (box speed of 1.4 m/s).

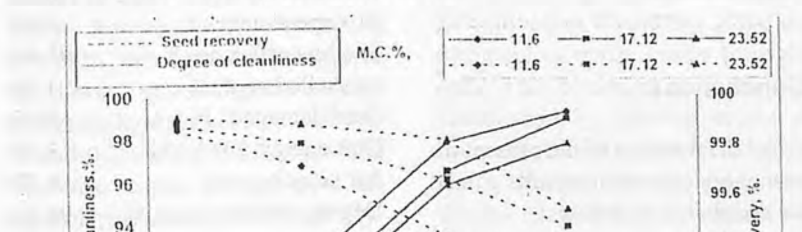

Fig. 12 Effect of air velocity on degree of cleanliness and seed recovery at various moisture contents (feed rate of 80 kg/h).

age was obtained at moisture content of 17.12%. The mechanical seed damage increased from 3.8 to 7.61% by increasing box speed from 1 to 2 m/s, respectively, at moisture content of 17.12% and feed rate of 80 kg/h. It may also be noticed that the seed damage was relatively high with reciprocating sheller (**Fig. 14**) comparing to drum-sheller (**Fig. 16**) which can be avoided by using rubber coated strips instead of wooden strips.

Figure 15 shows the shelling efficiency percentage at various drum speeds for three materials of drum beater (steel, wood and rubber) and beaters number of 8 as obtained by *(Abou EL-Kheir and Shoukr, 1993)*. In all cases, this efficiency increased by increasing drum speeds. Whereas, the shelling efficiency increased from 80.6 to 92.5%, from 71.6 to 88.1% and from 67.1 to 84.5% as

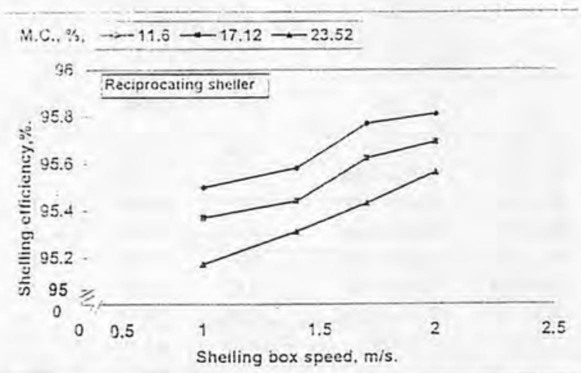

Fig. 13 Effect of shelling box speed on shelling efficiency at various moisture contents (feed rate of 80 kg/h).

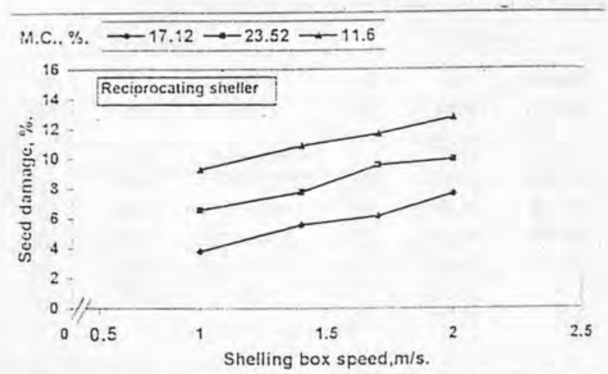

Fig. 14 Effect of shelling box speed on seed damage at various moisture contents (feed rate of 80 kg/h).

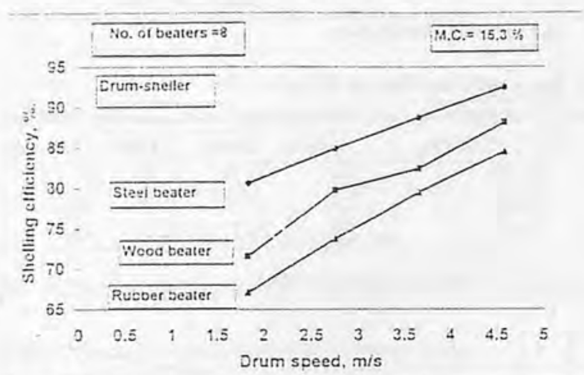

Fig. 15 Effect of drum speed on shelling efficiency at various materials of drum beater.

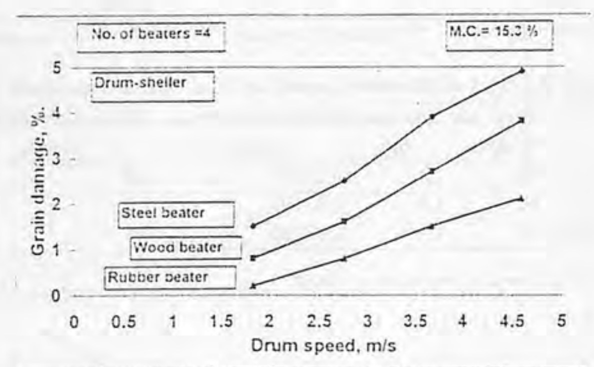

Fig. 16 Effect of drum speed on mechanical grain damage at various materials of drum beater.

drum speed increased from 1.83 to 4.58 m/s for steel, wood and rubber material, respectively.

Figure 16 shows the mechanical seed damage percentage at various drum speeds for three materials of drum beater (steel, wood and rubber) and beaters number of 4 as obtained by *(Abou EL-Kheir and Shoukr, 1993)*. It is clear that grain damage increased proportionally by increasing drum speed. Whereas, mechanical grain damage increased from 1.5 to 4.9%, from 0.8 to 3.8% and from 0.2 to 2.1 by increasing drum speed from 1.83 to 4.58 m/s for steel, wood and rubber material, respectively. Therefore, the reciprocating sheller is recommended for the following reasons:

1. Shelling efficiency of reciprocating sheller is more than that for the drum sheller. This was due to the highest friction action caused by the largest friction area for the reciprocating sheller.
2. Total cost of the reciprocating sheller is less than that for the drum sheller. This was due to the manufacturing cost for the reciprocating sheller was less than for the drum sheller.

Conclusions

For the duration of the present investigation, the main results gained are concluded as follows:

1. The applied recommendations for operating of the reciprocating peanut sheller may be concluded in **Table4**.
2. Increment of shelling efficiency of 3.45% was achieved comparing to the drum-sheller.
3. The lowest value of total cost of 64 L.E./Mg was obtained at box speed of 1.4 m/s, feed rate of 80 kg/h and average moisture content of 17.12%.

Table4. The Applied Recommendations for Operating of the Reciprocating Peanut Shelle

Performance parameter	value
Moisture content (d.b.), %	17.12
Feed rate, kg/h	80.00
Clearance, mm	18.00
Box speed, m/s	1.40
Shelling efficiency,%	95.44
Unshelled seed, %	4.56
Seed damaged , %	5.55
Unit energy, kW.h/Mg	3.36
Air velocity, m/s	8.37
Degree of cleanliness, %	96.10
Seed recovery, %	99.67

4. *Recommendations for further study:* The seed damage effect of the shelling wooden strips should be reduced through a modification and improvement of the shelling unit. The wooden strips should be replaced by coated-rubber strips.

(Continued on page 27)

Effect of Threshing Methods on Maize Grain Damage and Viability


by
A. Dauda
Lecturer
Department of Agricultural Engineering,
Faculty of Engineering,
University of Maiduguri
Maiduguri, Nigeria


A. N. Aviara
Lecturer
Department of Agricultural Engineering,
Faculty of Engineering,
University of Maiduguri.
Maiduguri, Nigeria

Abstract

A study was undertaken to investigate the effect of five maize threshing methods, namely; bare hand threshing, hand-held manually operated tool sheller, stick beating, pounding in mortar and tractor, operated machine threshing on the threshing output, grain damage and seedling emergence of planted maize grain. Tests were carried out with these methods using three varieties of maize, namely; Hybrid 8341-6, TZESR-Y and TZESR-W. Results obtained show that machine threshing gave significantly higher threshing output on all the varieties used than other methods.Its average output was 626.67 kg/hr. Among the five threshing methods, bare hand threshing gave the lowest percent grain damage (0.5% on hybrid, 0.3% on TZESR-Y and 0.2% on TZESR-W), while the stick beating method gave the highest percentage (4.0%) on Hybrid 8341-6 2.0% on TZESR-Y and 1.0% on TZESR-W. Grain viability, determined on the basis of percent seedling emergence of planted maize, was found to be high for products of the threshing methods except that of stick beating. Threshing method and variety of maize were found to have significant effect on output, damage and viability of grains obtained from the threshing operation.

Introduction

Maize (Zea mays L), otherwise known as corn, is one of the most important cereal crops in Nigeria. It is mainly grown for grain or silage with only a limited quantity fed green or used as fodder crop. Oni and Ali(1986) reported that about 80% of this crop is harvested for its grains which are processed for food, industrial products, animal feed and alcoholic beverages.

Harvesting and threshing or shelling of maize have posed a major problem to the crop's production in Nigeria, especially with the recent increase in the land area under its cultivation. Threshing is the detachment of maize grains from the cobs. This operation is usually accomplished by rubbing action or exertion of shear pressure, stripping and impact. The rubbing action occurs when maize is shelled by hand threshing and the stripping occurs when the cone shaped manually operated sheller is used. Impact action takes place when stick beating, pounding of cobs in a mortar and tractor or motor operated machine are employed.

In Nigeria, the common methods of threshing maize are bare hand threshing, threshing hand held manually operated tool, stick beating and the pounding of cobs in mortar. Mechanical threshing using tractor, engine or motor operated machines is becoming popular due to the recent increase in the establishment of large scale farms in the country.

Bare hand threshing (**Fig. 1**), involves the detachment of grains from the maize cobs by picking the cob in one hand and using the other to detach the grains. This method is widely practiced by subsistence farmers and has been found to be energy sapping and time consuming. Output is influenced much by the physical characteristics of the cob and kernel.

Threshing by hand held-manually operated tool (**Fig. 2**) is practiced by farmers whose holdings are beginning to increase in size and number. It involves the use of a lo-

Fig. 1 Bare hand threshing method.

cally made hand sheller in carrying out the threshing operation. This sheller is a hollow conical, metallic tool with the inner wall lined with teeth in such a way as to leave a space into which the maize cob is fitted during the threshing operation. To achieve the threshing of maize using this tool, it is picked up and held in one hand and with the other hand of the operator, the cob to be threshed is fitted into the space between the teeth on the inner wall of the tool. The fitted cob is given a twisting movement and the tool teeth engage the grains and detach them from the cob. During threshing a large quantity of maize is either lost or damaged. Damaged grains have low test quality, constitute the unusable portion and cause reduction in market value.

The stick beating method of threshing maize (**Fig. 3**), involves the loading of cobs in to a hessian or jute bag, dropping the bag on a concrete floor and having it beaten with stick until the threshing of the

Fig. 2 Hand held manually operated tool sheller method.

Fig. 3 Stick beating method.

content is achieved. Damages to the grains are incurred in the application of this method.

Pounding of maize cobs in mortar (**Fig. 4**), to thresh them is widely practiced and is associated with large scale breakage of the grains depending on their moisture condition. Whole cobs are poured into a mortar and pounded with pestle until they are broken down to small particles. The grains are obtained when the chaff is winnowed off by tossing the pounded cob against the direction of wind.

The mechanical threshing method (**Fig. 5**), involves the use of a motor engine or tractor-operated threshing machine. Oni and Ali (1986), investigated the factors influencing threshablity of maize in Nigeria and showed that field drying, maize varieties, ear size, cylinder speed and feed rate all had significant influence on the performance of threshing machines. Goel and Nanda (1994), reported that the important factors affecting mechanical threshing of ground nut are pod moisture content, peripheral speed of machine and type of threshing element. Similar results were reported by Ige (1978) on the threshing of cowpea. Moisture loss in maize has

Fig. 4 Pounding in mortar method.

Fig. 5 Tractor operated machine threshing method.

been shown to be variety and location dependent, and to decrease with time. It has been suggested that for maximum weight, kernels must remain on cobs during the drying process, as moisture migration from cob to kernel could result in the transport of solubles which would increase the dry matter content of the kernel (Oni and Ali 1986). Miah et al (1994), investigated the performance of four rice threshing methods and showed that pedal thresher gave the highest output, while manual treading gave the least grain damage. Information on various maize threshing methods and equipment is important to farmers as it enables them to select the proper thresher.

This study was undertaken to investigate and compare the effect of existing methods of threshing maize in Nigeria, on the damage and viability of the grains.

Materials and Methods

The five common methods of threshing maize in Nigeria were selected for the study. The experiments were conducted at the farm centre of the Borno State Agricultural Mechanisation Authority (BOSAMA), Maiduguri. Three maize varieties namely; Hybrid 8341-6 TZESR-Y, and TZESR-W were used. For each method of threshing mentioned earlier on, five hundred maize cobs from each of the three varieties were randomly selected and used in carrying out the threshing test. The mechanical thresher was operated by an MF375 tractor at a PTO speed of 540 rpm. Threshing experiment on each method was replicated four times for each of the maize varieties. For each replication, the threshing time was recorded using a stop watch and from this, the output capacity of the method employed was calculated. Percent damage on grains was also computed and the average values were taken.

Seed viability tests were also conducted.Four maize grains from the products obtained using each method of threshing on each variety, were selected and planted at a uniform depth of 40mm using randomised block design, on a plot of land in the University of Maiduguri research farm. Water was applied on daily basis to supply the amount of water required for seedling emergence and growth.

Seedling emergence was monitored and observed on daily basis from the fourth day of planting to the tenth. Percent emergence of seedlings on each day of observation was computed and recorded.

Results and Discussions

The performance of the different maize threshing methods and equipment, namely; bare hand threshing (BT), hand held manually-operated tool sheller (HT), stick beating threshing (SB), pounding in mortar threshing (PM), and mechanical threshing (MT), in terms of threshing output on the various varieties of maize are shown in **Table 1**.

The average threshing out puts of BT, HT, SB, PM and MT were 10.567, 16.5, 63.167, 25.667 and 626.667 kg/hr, respectively. The analysis of variance (ANOVA) presented in **Table 2** shows that both the threshing method and maize variety have significant effect on the threshing output at 1 and 5% levels, respectively. Multiple range analyses of the threshing output for both methods and variety are presented in **Tables 3** and 4. These show that the MT method gave the highest output on all the varieties of maize, compared to the other methods. This may be due to the machine's high operational speed and feed rate. The output of all the threshing methods on Hybrid 8341-6 variety appears to be higher than the output on TZESR-Y and TZESR-W, respectively. However, no significant difference appears to exist between their output on TZESR-Y and TZESR-W varieties at 95% confidence intervals.

The average percentage grain damage incurred from each threshing method on the maize varieties are presented in **Table 5**. The average grain damage varied from 0.2 to 4.0%. The analysis of variance (ANOVA) presented in **Table 6** shows that both method of threshing and variety of maize have significant effect on grain damage at 5% level. The multiple range analysis of grain damage for both method and variety presented in **Tables 7** and **8**, show that the damage incurred from the SB method was significantly higher than that of HT and BT. This may be due to the excessively high impact forces which must have been exerted on the grains during threshing with SB method. The damage inflicted on Hybrid 8341-6variety was significantly higher than those of the TZ-ESR-Y and TZESR-W varieties, whereas no significant difference

Table 1. Effect of Threshing Method and Variety on Threshing Output (kg/hr)

	Out put on varieties			
Method	Hybrid 8341-6	TZESR-Y	TZESR-W	Mean
BT	11.50	10.20	10.00	10.57
HT	18.50	15.50	15.50	16.50
SB	65.00	62.50	62.00	63.17
PM	26.50	25.00	25.50	25.67
MT	630.00	625.00	625.00	626.67

Table 2. Analysis of Variance (ANOVA) of the Threshing Output (kg/hr) of the Five Methods of Threshing Maize Varieties

Source of variation	Sum of squares	d. f.	Mean square	F-ratio	Sig. level
Main effects	862412.26	6	143735.38	1000.000	0.0000
Methods	862388.31	4	215597.08	1000.000	0.0000
Varieties	23.95	2	11.97	15.010	0.0020
Residual	6.3813333	8	0.7976667		
Total (CORR.)	862418.64	14			

Table 3. Multiple Range Analysis of Threshing Output (kg/hr) for Methods

		Confidence intervals = 95 percent					
Method	Count	Average	Homogeneous group				
BT	3	10.567	*				
HT	3	16.500		*			
PM	3	25.667			*		
SB	3	63.167				*	
MT	3	626.667					*

Table 4. Multiple Range Analysis of Threshing Output (kg/hr) for Varieties

		Confidence intervals = 95 percent	
Variety	Count	Average	Homogeneous groups
TZESR-W	5	147.600	*
TZESR-Y	5	147.640	*
Hybrid	5	150.300	*

Table 5. Effect of Threshing Method and Variety on Maize Grain Damage (Unit: Percent)

	Damage on variety			
Method	Hybrid 8341-6	TZESR-Y	TZESR-W	Mean
BT	0.5	0.30	0.2	0.330
HT	1.0	0.80	0.6	0.800
SB	4.0	2.00	1.0	2.330
PM	2.0	1.00	1.0	1.330
MT	2.0	0.85	0.8	1.217

Table 6. Analysis of Variance (ANOVA) of grain damage (1%) for the five different Methods of Threshing Maize Varieties

Source of variation	Sum of squares	d. f.	Mean square	F-ratio	Sig. level
Main effects	10.463000	6	1.7438333	5.451	0.0159
Methods	6.640667	4	1.6601667	5.189	0.0233
Varieties	3.822333	2	1.9111667	5.974	0.0259
Residual	2.559333	8	0.3199167	-	-

appears to exist between the damage inflicted on these two varieties, all at the 95% confidence intervals. The results of head count on seedlings emergence and the percentage final emergence at the end of ten days for grains of each maize variety obtained from the products of the threshing methods are shown in **Tables 9**, **10** and **11** for Hybrid 8341-6, TZESR-Y and TZESR-W, respectively.Grains from the BT method achieved 100% emergence within 6 days except for the Hybrid 8341-6variety where 100% emergence was achieved in 7 days. Grains of the TZESR-W variety obtained from every one of the threshing methods gave 100% emergence at the end of 10 days. Similar results were obtained from the Hybrid 8341-6and TZESR-Y varieties except for grains from the SB method which gave 50 and 75% final emergence, respectively, and for the MP method which gave a 75% final emergence on Hybrid. 8341-6 The high grain damage and low seedling emergence obtained from the SB method on the Hybrid 8341-6and TZESR-Y varieties show that the method is an suitable means of threshing maize.

Conclusions

The study shows that the tractor operated threshing machine performed better than the other methods in terms of output. Its low damage on grains and high seedling emergence makes it a commendable method for maize threshing. Cost is, however, an important factor in the application of this method. Farmers could form themselves in to co-operative groups and pool their resources together in order to procure the equipment. The services of the ADPs (Agricultural Development projects) and Tractor Hiring Units could be utilised and this would make the use of the machine to become popular. Although the hand held-manually operated tool sheller gave a lower average output when compared to stick beating and pounding in mortar, the significantly lower grain damage and high seedling emergence makes it rank next to mechanical threshers and could be used by subsistence farmers to ease off the rigours of bare hand threshing.

Table 7. Multiple Range Analysis of Grain Damage (%) for Methods

	Confidence intervals = 95 percent		
Method	Count	Average	Homogeneous groups
BT	3	0.3333	*
HT	3	0.8000	*
MT	3	1.2167	* *
PM	3	1.3333	* *
SB	3	2.3333	*

Table 8. Multiple Range Analysis of Grain Damage (%) for Varieties

	Confidence intervals = 95 percent		
Variety	Count	Average	Homogeneous groups
TZESR-W	5	0.720	*
TZESR-Y	5	0.990	* *
Hybrid 8341-6	5	1.900	*

Table 9. Head Count of Seedling Emergence from 4-10 Days after Planting for Hybrid 8341-6 Maize Threshed Using Different Methods

	Head count per number of days after planting							
Method	4	5	6	7	8	9	10	% Final emergence
BT	2	3	3	4	4	4	4	100
HT	1	1	2	3	4	4	4	100
SB	0	1	1	2	2	2	2	50
PM	0	0	2	2	2	3	3	75
MT	1	1	2	3	3	4	4	100

Table 10. Head Count of Seedling Emergence from 4-10 Days after Planting for TZESR-Y Maize Variety Threshed Using Different Methods

	Head count per number of days after planting							
Method	4	5	6	7	8	9	10	% Final emergence
BT	2	3	4	4	4	4	4	100
HT	2	2	3	4	4	4	4	100
SB	0	2	2	3	3	3	3	75
PM	1	2	3	3	4	4	4	100
MT	2	2	3	4	4	4	4	100

Table 11. Head Count of Seedling Emergence from 4-10 Days after Planting for TZESR-W Maize Variety Threshed Using Different Methods

	Head count per number of days after planting							
Method	4	5	6	7	8	9	10	% Final emergence
BT	2	2	4	4	4	4	4	100
HT	2	3	3	4	4	4	4	100
SB	1	2	2	3	3	4	4	100
PM	1	1	2	3	3	4	4	100
MT	2	3	3	4	4	4	4	100

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Design, Construction, and Performance Evaluation of a Manually Operated Cowpea Thresher for Small Scale Farmers in Northern Nigeria

by
A. Dauda

Lecturer
Department of Agricultural Engineering,
Faculty of Engineering,
University of Maiduguri
Maiduguri, Borno State
Nigeria

Abstract

A manually hand-operated cowpea threshing machine was concepted, designed, constructed and tested. The thresher was tested for three commonly grown cowpea varieties taking into consideration the range of seed sizes (large medium and small). The varieties are Kanannado, Borno Brown and Aloka local.

Results obtained gave a threshing effectiveness of 85.9%, 84.6% and 84.1% for Kanannado, Borno Brown and Aloka local, respectively. Seed damage was 1.8%, 2.3% and 1.9% for Kanannado, Borno Brown and Aloka local, respectively.

Winnowing efficiency at 372 rpm fan speed was 92.75%, 92.5% and 92.35% for Kanannado, Borno Brown and Aloka local, respectively. Throughput capacity was 95.4 kg/h, 93.5 kg/h and 92.8 kg/h for Kanannado, Borno Brown and Aloka Local, respectively, and is not statistically different at 5% significance level.

Introduction

Cowpea Vigna unguiculata L. Walps is grown commonly in Northern Nigeria and used for food throughout the country. It is widely eaten in various forms as boiled whole beans, mixed with corn, rice or millet, ground and fried into bean cakes (akara) or steam moulded in tins or leaves (moyin-moyin).

Majority of cowpea growers are small-scale farmers whose plots are less than one ha each (Suleiman, 1986). On such a scale of farming, all the operations, from field preparation to harvesting and threshing are done manually. Traditional cowpea threshing in Northern Nigeria is normally done by: (a) getting the whole cowpea and striking by sticks, on bare ground or mats; (b) pounding in a mortar by pestle; and (c) opening the pods by hand. In the first two methods, severe damage is caused to the seeds resulting in low germination. On the other hand, the method of opening pods by hand is tedious and time consuming. Therefore, the traditional method is rather labour intensive and time consuming (Ige, 1977). Michael and Ojha (1978) reported the performances of different sources of power for threshing beans and gave capacity of threshing by hand beating to be 17-29 kg/h, while engine operated capacity was 500 kg/h. Cowpea threshing machines are not common, most especially to small-scale farmers, since most of the available ones are government owned and are very few. The objective of the design of this cowpea sheller are as follows:

(a) Minimum cost compatible with efficiency;
(b) Ease and safety of operation and inspection;
(c) Availability of local materials;
(d) Higher threshing output compared to manual threshing;
(e) Ability to achieve high throughput at low level of damage to seeds; and
(f) Durability.

Mechanical threshing machines include the following categories (Lazaro and Simalenga, 1994):

(a) Drum and concave (spike tooth, rasp bar and the angle bar types).;
(b) Double belt type; and
(c) Cylinder and concave made of rubber.

Materials and Methods

A rasp bar cylinder, drum and concave type was concepted, designed and constructed. The cylinder was constructed of 25 mm iron rod frame and covered with 16 gauge iron sheet. Along the cylinder, thin strips of wood 350 mm long × 25 mm width × 15 mm thickness covered with rubber of 5mm thickness were bolted to the cylinder at an interval of 60 mm all round the circumference. The woods could be easily replaced when worn out. Threshing is completed by the rasping action between the cylinder bars and the solid concave below the cylinder. Drum and concave clearance is made adjustable from 8-19 mm from specification as given by Kepner et al (1978).

Galvanized sheet gauge 18 was used for the hopper, concave, screens and housing (All dimensions are as on design drawing). The main frame was constructed from angle iron 50 mm × 50 mm. Heat treated (case hardened) mild steel of (based on design analysis) 40 mm diameter was used for the transmission shaft. The belt chosen is rubber impregnated with leather, while the ball bearing used was chosen according to ASAE Standard as given by Hall et. al (1980).

The winnowing mechanism was designed from the principle by Joshi (1981) and constructed using an 18 gauge mild steel. The fan was constructed from a 30 mm mild steel driving shaft (case hardened) and 200 mm × 150 mm curved metal sheets to form the fan blades. The fan housing was made from galvanized steel plate and fixed in such a way that the clearance between it and blade is 60 mm. An air duct from the fan was inclined at 25^{0}. Above the duct a screen with 12 mm holes was placed. The screen was located 200 mm below the drum.

The fan was driven from the same power drive shaft as that of the drum. Test procedure was adopted after the method of Lazaro and Simalenga (1994). Three cowpea varieties Kanannado, Borno Brown and Aloka local at moisture contents of 25% (w.b) were used to test the thresher. The time taken to thresh each sample was measured using a stop watch. After threshing, the seeds which were completely separated from the pods were collected and weighed. Unopened pods, thumb opened and the collected seeds were weighted separately. The ratio of the opened seeds to the total seeds in the sample was calculated to determine threshing effectiveness.

From the threshed cowpea, a handful of seeds was randomly taken and weighed. The ratio of the damaged seeds to the total seeds on the sample was calculated to determine percentage seed damage.

The performance of the winnowing mechanism was tested on the three cowpea varieties, at 25% moisture content using a 1 KW electric motor with variable pulley diameters so that the fan speed could be varied. Fan speed was measured using a tachometer while air velocity was determined using hot wire anemometer.

A one-kg mixture of hand-threshed seeds and chaff were allowed to fall from the threshing mechanism while the fan is rotated. After the operation, the material in the seed collector was weighed. The chaff in the container was separated by hand and weighed. Likewise, blown off material was collected on a mat and weighed. The seeds contained in the chaff were sorted and weighed.

The effectiveness of separation was then calculated as winnowing index from the relationship (Lazaro and Simalenga, 1994).

$I = (a/(a+c)) (d/(b+d))$

where

a = weight of seeds in the seed collector (kg)

b = weight of chaff in the seed collector (kg)

c = weight of seeds blown off with chaff (kg)

d = weight of chaff blown off.

Results and Discussion

Table 1 shows the effectiveness of threshing (89.5%, 84.6%, 84.1%) and throughput capacity (95.5, 93.5, 92.8 kg/h) of the thresher for the three varieties of cowpea. (Kanannado, Borno Brown and Aloka-Local, respectively).

From the results obtained, it

Table 1. Effectiveness of Threshing and Throughput Capacity of the Thresher

Variety	Opened (kg)	Unopened (kg)	Total (kg)	Threshing effectiveness (%)	Throughput capacity (kg/h)
Kanamado	0.561	0.920	0.653	85.9	95.4
Borno Brown	0.482	0.088	0.570	84.6	93.5
Aloka-local	0.481	0.091	0.572	84.1	92.8

Table 2. Performance of Cowpea Seed Damage for the Three Local Varieties

Variety	Weight of sample (gm)	Damaged seeds (gm)	Percentage damage (%)
Kanamado	50	0.9	1.8
Borno Brown	50	1.05	2.1
Aloka-local	50	0.95	1.9

Note: each sample is replicated four times

Table 3. Winnowing Mechanism Performance

Fan speed (m/s)	Air velocity (m/s)	Air flow rate (m^3/s)	Winnowing parameters based on 1kg mixture				Winnowing Index (%)
			a (gm)	b (gm)	c (gm)	d (gm)	
433	13.3	1.066	705.6	23.8	5.1	269.6	83.36
405	12.4	0.994	692.8	20.4	62.1	224.7	84.25
397	12.2	0.979	714.2	15.0	55.3	215.5	74.23
384	11.8	0.941	595.9	75.0	41.0	288.1	74.23
372	10.3	0.827	560.4	22.5	12.0	405.1	92.75
358	8.3	0.663	630.7	125.6	10.6	233.1	63.91
330	7.4	0.589	620.3	158.6	10.0	211.1	56.19

could be observed that Kanannado cowpea variety is the easiest in threshing since they (the varieties) were all at the same moisture content. This is followed by Borno Brown and Aloka-local;

For the seed damage level, the lowest percentage seed damage 1.8% was recorded for the Kanannado followed by Aloka local (1.9%) and then Borno Brown 2.1%. This could be attributed to the Kanannado to resist abrasion than the other two. **Table 3** shows the performance of the winnowing mechanism. It was observed that the best performance was obtained at 372 rpm fan speed. This fan speed recorded an air velocity of 10.3 m/s, at this air velocity, the winnowing index was 92.75. The lower index at higher air velocities was due to some seeds being blown off with the chaff as the velocity was exceedingly higher than the seed's terminal velocity except of course with the air velocity at 11 m/s with a fan speed of 384 rpm.

At low air velocity on the other hand, the low index was due to chaff falling into the seed collector, that is, air velocity was not adequate enough to blow off the heavier chaff particles.

During winnowing 12 seconds were adequate to complete the operation of 1 kg of the material. This gives a throughput capacity of 300 kg/h for the three varieties.

Conclusion

A manually operated cowpea thresher has been designed and constructed to serve the needs of small scale farmers and the performance evaluation was satisfactory compared with traditional method of threshing.

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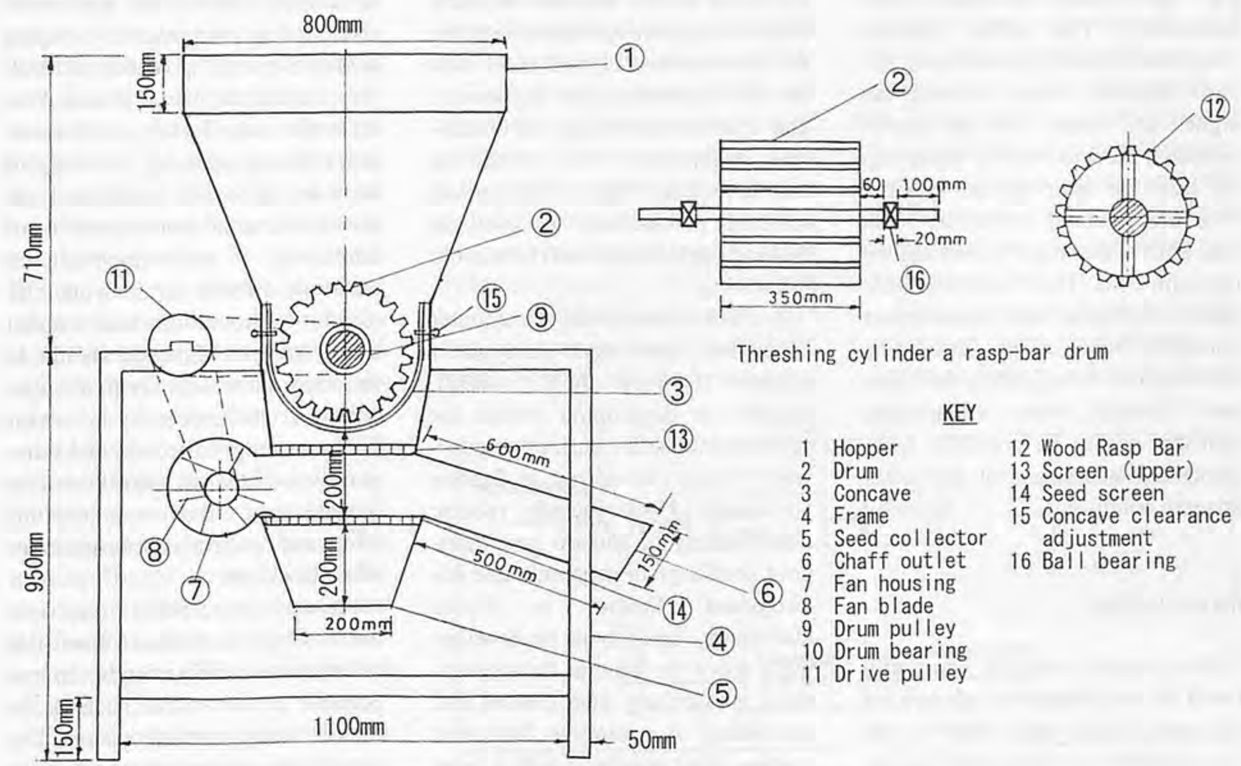

Fig. 1 Manually Operated Cowpea Thresher.

Design and Fabrication of Robot for Oil Palm Plantation

by
Wan Ishak Bin Wan Ismail
Ph.D., P.Eng.
Associate Professor
Faculty of Engineering
University Putra Malaysia
43400 Serdang, Selangor Darul Ehsan
Malaysia

Mohd. Zohadie Bardaie
Ph.D., P.Eng.
Professor/Deputy Vice Chancellor
University Putra Malaysia
43400 Serdang, Selangor Darul Ehsan
Malaysia

Abstract

A new technology of designing harvesters and collectors using new concept of robotic and automation technology was introduced for the oil palm plantation. By introducing the automation and robotic technology in oil palm plantation, it is envisaged that more manpower can be reduced, lighten the burden, increase productivity as well as making agricultural activities more interesting. The robot systems, computer control systems and circuit diagrams were studied, designed and tested. With the use of interface card to receive input signal from the computer and transmit it to the solenoid valve, the robot was able to automate in picking the oil palm FFB. The 'Hydraulic Simulation Software' used as computer controller required no installation of electrical wiring along the robot arm. Typically, robot for plantation industry has to be portable, withstand bad weather, dust and other adverse conditions.

Introduction

One major problem currently faced by the plantation industry for oil palm, cocoa and rubber is the unavailability or inadequate labour supply. It is envisaged that increasing the productivity of existing labour through the use of machines or modern technology can reduce the effect of labour shortage. Developing countries with agriculture as their main economy like Malaysia, should follow the examples of countries like USA and Japan in successfully modernizing and mechanizing their agriculture sector. Both countries are able to achieve such a high status of mechanization simply because they employed engineering technology for the development of their machineries. By introducing the automation and robotic technology in Malaysia's plantation, more manpower can be reduced, lighten the burden, increase productivity as well as making agricultural activities more interesting.

A robot is essentially a computer controlled mechanical manipulator system (Douglas R.M., 1992). Studies on developing robots for agricultural use are currently underway. Works carried out at Purdue University, USA include robotic transplanting of tomato and marigold seedlings in a greenhouse environment. Studies in Kyoto University, Japan focus on developing a robot for general field operations, particularly pest control and harvesting. A prototype fruit harvesting robot equipped with a large manipulator was developed for trial to harvest fruits on large scale (Zohadie et al., 1995). Kondo et al., (1996) developed a cucumber harvesting robot. The basic mechanism of the robot and the details of the robot components were based on the physical properties of the tomato plants and on the environmental conditions. A cherry tomato harvesting end-effector was also developed so that the robot can be made multi-purpose. Monta et al., (1995) developed a harvesting robot, consisted of a manipulator, a visual sensor, a travelling device and end-effector for the berry plants. Four different end-effectors for harvesting, thinning, spraying and bagging were developed for this robot. From the experimental results in field and laboratory, it was observed that each end-effector could work efficiently. Automation and robotic technology in Malaysia should be introduced immediately in the agriculture sector, especially in solving the harvesting, collection and transportation of the oil palm fresh fruit bunches and cocoa pod, and tapping and collection-transportation of rubber latex.

An agriculture robot or agro-robot is simply a machine consisting of cranes or a robot arm driven by a portable power source such as hydraulic and pneumatic system. The complexity of designing and developing agro-robots are that they must be portable, able to carry out heavy tasks and able to withstand bad weather, dust and other adverse conditions. The complexity also arises from the detection of agricultural products with a significant biological variability and complex biological environments.

The objective of the present project is to mechanize the agricultural operations in order to increase productivity and to solve the acute labour shortage problem in plantations. This project is expected to come up with an agro-robot that harvests, collects and transports agricultural products such as oil palm FFB and cocoa. Financial support for the project Design and Development of Agricultural Robots for Plantation Crops is provided by the National Scientific Research Council Malaysia (MPKSN) under IRPA 1997.

Literature Review

In the present system wherein harvesting of oil palm ffb is done manually (and the harvested ffb is on the ground), a team of workers is responsible for collecting and transporting the oil palm ffb from the field to the collection point at the roadside. There are several ways in which this bunch is collected and transported. These methods include carrying on the shoulder, using cart, bicycle and wheel barrow. Picking and transporting oil palm ffb techniques have been improve by using machine like jackpack, forklift, mini-tractor, FFB picker, dumper and grabber. To improve the productivity, grabber (a mechanical handling equipment for loading ffb into a trailer) was modified with the objective to automate the functions for picking and loading of oil palm FFB (Wan Ishak et al., 1997).

Many agricultural machines are already partly automated to perform repetitive tasks. In order to automate a process completely, it is necessary to develop computer systems that are capable of comparing the desired set of results with actual results and of taking corrective action. This is the essence of closed-loop computer control or feedback control. In a computer control system, the computer simply observes the process via an interface card that is capable of detecting physical signal such as analogue voltage, converting it to digital signal, and converting digital words into meaningful binary information for computer processing. In recent years control systems have assumed an increasingly important role in automation technology. The control system for the agricultural robot design is based on a closed loop control system. The components consist of input signal or external signal applied to a control system, control element or controller plant or controlled system, control output and feedback element. The agro-robot requires computer control system, sensors, interface card and relay card to receive and send messages from computer to the robot and vice versa (Mohd Saufi, 1998).

The hydraulic control system, on the other hand is the application of hydraulic oil to the actuators such as hydraulic motors and hydraulic cylinders, converting the hydraulic energy to mechanical energy. In the hydraulic system, a small force can be applied to do heavy work. Hydraulic power produced by the tractor is able to handle the heavy work that operates the agricultural machines. Unlike the mechanical method of power transmission, the relative position of the engine and work site remains nearly constant. With the flexibility of hydraulic lines, power can be moved at almost all position. In the robot system, the hydraulics were the accepted means to power the movement of robot arms. Hydraulic driven robots have proved more suitable, notably for lifting and carrying out heavy tasks, hence suitable for plantation operations.

Methodology

The project involves the design and fabrication of a prototype agro-robot for harvesting and collecting of oil palm FFB. The hydraulic from the tractor or portable hydraulic power pack will be used as a power source for the operations of the robot. The manipulators consisting of an arm, hand and fingers are powered by the hydraulic through the use of double-acting cylinders, hydraulic motors, relief valves, flow control valves and solenoid valves. The movements of the robot arm are automated with the use of computer control system, sensors, interface cards and relay cards to receive and send messages from computer to the robot and vice versa.

The agro-robot consists of various important components as shown in **Figure 1**. Four hydraulic

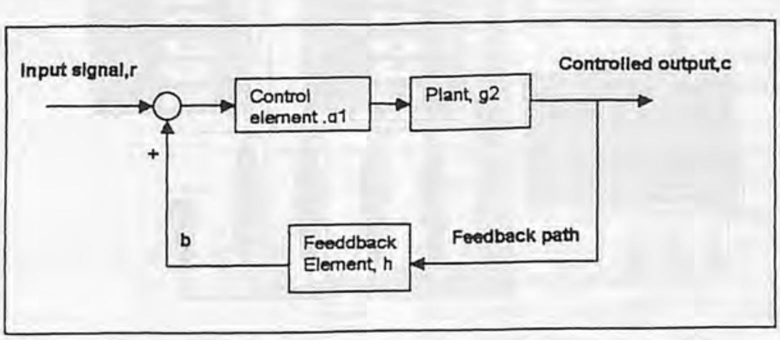

Fig. 1 Grabber closed control system.

cylinders were installed to the robot arm. The function of the hydraulic cylinders is to change the hydraulic energy to the mechanical energy in order to execute work. Double acting cylinder produce stroke in either direction to push or pull the arm of the robot. Cylinder A operates to turn the robot arm in the x axis, cylinders B and C were used to move the robot arm in Y axis and Z axis to locate the oil palm FFB. Cylinder D was attached to the fingers or grippers of the robot arm, to pick and collect the oil palm FFB to be transported to the mill. These hydraulic cylinders were controlled by the relief valves, flow control valves and 4/3 solenoid control valves. The relief valves were used to control and limit the oil pressure whereas the flow control valves were used to control the movement speed of the robot arm. The solenoid control valve is the distribution center of automation, used to direct the oil flow to the respective arm as directed by the computer control system.

The design of the agro-robot control system was based on a closed-loop system (**Figure 2**) whereby the input will signal the switch or camera vision. The control element or controller will be the computer control program software. In this case, either the Genie Computer Control Software or the Hydraulic Simulation Software was used. The control system will be the solenoid valves and the control output will be the hydraulic cylinders of the robot arm. The limit switches acted as the feedback element. The design of the automation system for the agricultural robot consisted of relays as the center of communication between the control components such as solenoid valves, limit switches and sensors. The relays directed and distributed the automation process through the solenoid valves to activate a particular hydraulic cylinder to carry out its function. Limit switches were used to limit the movement of the cylinders either during extension or retraction to depict the arm movement. The limit switch sends electrical signal to the relays, so that the movement of the arm will be in sequence. The Hydraulic Simulation Software had an advantage which required no installation of the electrical wiring, including limit switches along the robot arm. The resulting hydraulic circuit drawing in the computer takes the place of much of the external wiring required for control process. The light sensor was attached to the gripper to identify the presence of the objects. The light sensors sent messages to the relays so that the solenoid valve will activate the particular hydraulic cylinder to grab the oil palm FFB.

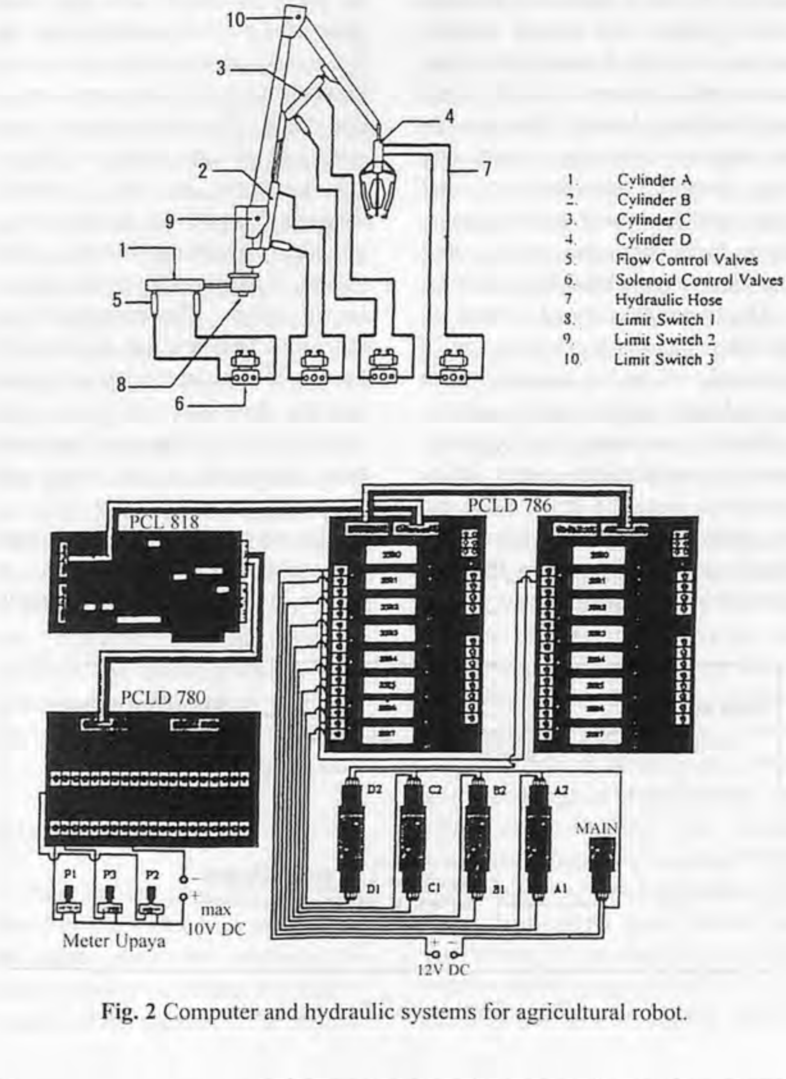

Fig. 2 Computer and hydraulic systems for agricultural robot.

This project concentrates on the design of the automation system with the interfacing of the Hydraulic Simulation Control Software or Hydraulsim and the agro-robot. The application of the hydraulsim requires the design of the hydraulic circuit and ladder diagram. Once the circuit and ladder diagram are designed, they can be tested using the simulation mode of the program before being transferred to the actual hardware or robot arm. The hydraulic circuit was important in determining the sequence of the robot arm's movement by actuating the solenoid valves to move the hydraulic cylinders. To move the agro-robot automatically and the hydraulsim software needed to be interfaced with the robot arm using interface and relay cards. The interface card received the input signal from the computer and transmitted it to the relay card whereby the relay interface card then sends the signal to the solenoid valves of the agro-robot to move the robot arm. The signal actuated the solenoid valves that permitted the hydraulic oil to flow to the respective hydraulic cylinders of the robot arm. Limit switches were the feedback components that limit the hydraulic cylinder movement. The signal from the limit switch was fed back to the control component and generated another signal to move the hydraulic actuators. The limit switches were available in the hydraulic circuit of the hydraulsim.

Operation of Agro-robot

Figure 3 shows an example of hydraulic circuit for the movement of the agro-robot arm. **Figure 4** shows an electrical circuit or ladder diagram to actuate the automation of the agro-robot movement. The hydraulic circuit of the agro-robot was activated with a push button to generate the electric current flow which activated the relay. The relay then actuated the solenoid valve to permit the hydraulic oil to enter the hydraulic circuit.

There are six switches (push button) to operate the hydraulic circuit of the agro-robot. Switch IN0 used to start the hydraulic circuit, IN4 was to set the robot arm at the rest or original position and IN5 was used to stop the hydraulic circuit. Switches IN1, IN2 and IN3 were used to pick the oil palm FFB in three different locations. These switches were activated automatically through the use of the solenoid valves of the hydraulic circuit.

To start the operation switched 'on' switch IN0. The electric current activated the relay C1 which actuated the solenoid valve OUT0 to permit the hydraulic oil to enter the hydraulic circuit.

To pick the oil palm FFB in one particular position, switch IN1, IN2 or IN3 must be activated either manually or automatically. A transducer, sensor or camera vision can be used to identify the location of the object. A signal from the manual control, transducer, sensor or camera vision will be sent to the solenoid valve through the interface and relay cards, to activate the switch. This switch will activate the relay C2 and later actuate the solenoid valve OUT3 to move the cylinder B to raise the robot arm B. Cylinder B stopped when it touched the limit switch L2.2. Limit switch L2.2 activated the relay C3 which stopped the current flow to relay C2. This process will actuate the solenoid valve OUT5 and move cylinder C to raise the robot arm C. The cylinder C stopped when it touched the limit switch L3.1. Limit switch L3.1 activated the relay C4 which stopped the current flow to relay C3. This process will actuate solenoid valve OUT1 and move the cylinder A to move the robot arm A to the right hand side.

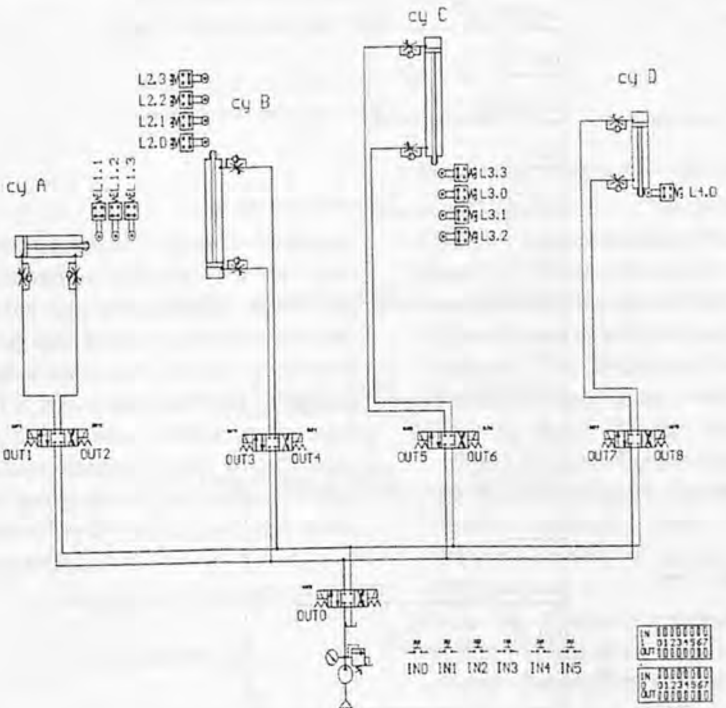

Fig. 3 Hydraulic circuit for agro-robot.

Cylinder A stopped when it touched the limit switch L1.2 which activated relay C5 that stopped the current flow to relay C4 that actuated solenoid valve OUT4 to move cylinder B to lower the robot arm B. The cylinder B stopped when it touched the limit switch L2.0 which activated the relay C6 that stopped the current flow to relay C5 that actuated the solenoid valve OUT6 and moved the cylinder C to lower the robot arm C. The cylinder C stopped when it touched the limit switch L3.0. The limit switch L3.0 activated relay C7 which stopped the current flow to relay C6 that actuated solenoid valve OUT10 and moved the cylinder D to grab the oil palm FFB.

The cylinder D stopped when it touched limit switch L4.0 which activated the relay C8 that stopped the current flow to relay C7 hence actuated the solenoid valve OUT3 and moved the cylinder B to raise the robot arm B. Cylinder B stopped when it touched limit switch L2.2. The L2.2 activated relay C9 which stopped the current flow to relay C8 that actuated solenoid valve OUT2 and moved the cylinder A to move robot arm to the center position. Cylinder A stopped when it touched limit switch L1.1 which, in turn, activated relay C10 that stopped the current flow to relay C9 hence actuated the solenoid valve OUT4 and moved cylinder B to lower the robot arm B. Cylinder B stopped when it touched limit switch L2.1. The L2.1 activated relay C11 which stopped the current flow to relay C10, actuated the solenoid valve OUT7 and, in turn, moved cylinder D or the fingers of the robot to drop the oil palm FFB into the container.

In this project, an initial three different locations were designed and set in the hydraulic circuit. The sequence of operations of the other two positions were the same as described above using different relay and limit switches available in the hydraulic circuit design. Switch IN5 was used to stop the oil flow to the hydraulic circuit, when the operation was completed. Switch IN4 was used to set the robot arm in the rest or original position.

Conclusions

Automation and robotics technology is widely used in manufacturing and technology related industry. Industrial robots have been developed through the use of already available sensing and actuating arrangements. Robotics technology in agriculture related industry is still new, hence still under research and development. The agricultural robot designers have a constraint due to the complexity of the sensors, actuators and their working environment. An agro-robot was designed and fabricated at the Department of Biological and Agricultural Engineering, University Putra Malaysia, to be used to collect and harvest oil palm FFB. Portable hydraulic power source was used to power the movement of the robot arm. With the application of the interface card and relay card, interfacing between

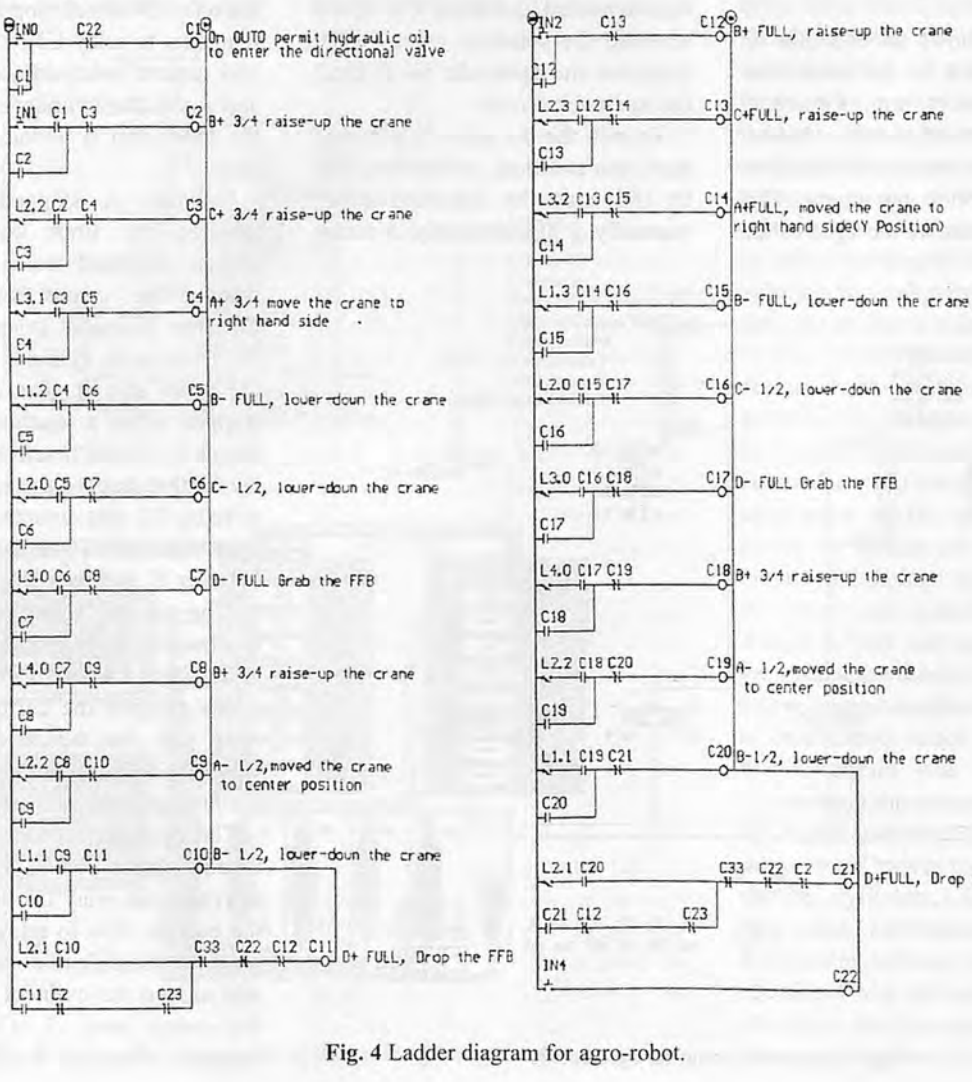

Fig. 4 Ladder diagram for agro-robot.

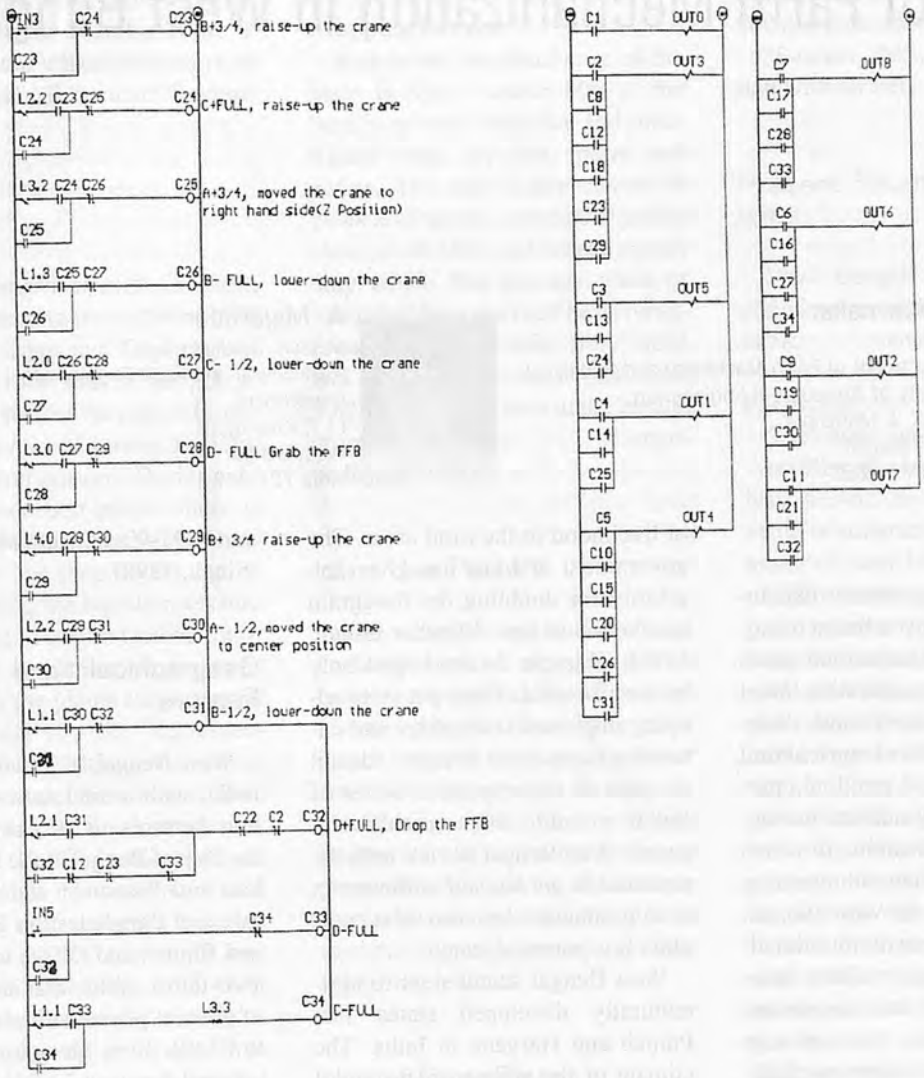

Fig. 4 Ladder diagram for agro-robot.

the Computer Control Hydraulic Simulation Software and the agro-robot was successfully carried out. The agro-robot can be operated automatically and picking of oil palm FFB was made easier as compared to the manual system. In the near future, camera vision will be used to recognize the oil palm FFB for the robot to harvest and pick automatically.

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Status of Farm Mechanization in West Bengal, India

by

S. Karmakar
Lecturer
Department of Farm Machinery and Power,
Faculty of Agricultural Engineering,
B C K V, Mohanpur
West Bengal
India 741 252

A. Majumder
M.Tech. Student
Agricultural and Food Engineering
Department,
I I T, Kharagpur
West Bengal
India 721 302

Abstract

In a developing country like India, whose economy is based on agriculture, farm mechanization needs to be given due consideration. West Bengal, though significantly contribute in the national agricultural production, does not stand in a perspective way in agricultural mechanization, the application of which could utilize the natural resources with full efficacy. In West Bengal, yet cultivation is mostly traditionally. So, in this paper, efforts have been made to speculate the present farming system, it's shortcomings and scope of sustainable mechanization.

Introduction

Agriculture, an unorganized sector, is the mainstay for the vast rural area where not less than three fourths of the Indian population still live. Agricultural growth can be considered as the major means of converting India's status from "*developing country*" to "*developed country*". This implies that India should attain 'self sufficiency' in meeting demand of the expanding population. Now agriculture contributes 28% of gross national product (GNP), about 60% of the employment and is primary source of livelihood in the rural areas. The government of India has given top priority for doubling the foodgrain production in next 10 years (Singh, 1996). This can be envisaged only by the all-round efforts put in developing improved technology and extending them to the farmers. Also, it dictates all the respective States of India should be agriculturally sound. West Bengal has not only the potential to get her self sufficient in food production but also to support other not-potential states.

West Bengal stands next to agriculturally developed states like Punjab and Haryana in India. The climate of the state is in favour of agriculture. Despite positive features, West Bengal cannot highlight it as an agriculturally developed State. In last few decades technology has given us many solutions to our emerging problems. Efficacy of agricultural inputs and natural resources, seeds, fertilizer, chemicals, power, land and water can be increased through the adoption of appropriate equipments and machineries. Insufficient use of implements in our fields may be a reason, which necessitates the well acceptance of farm mechanization in the state. The field operations done by farmers with tractors and driven implements increased productivity from 6.509 q/ha during 1983-84 to 28 q/ha or 330.75% during 1991-92 in Bundelkhand area (Singh, 1998).

Geographical and General Feature

West Bengal is situated in East India, with a total area of 8.8 million hectares. It is surrounded by the Bay of Bengal in the South, Sikkim and Bhutan in the North, Assam and Bangladesh in East, Nepal and Bhutan and Orissa in the West. Two-thirds of the total area consists of alluvial plains with elevation below MSL 30 m. Geographically, location is between 21°31′ and 27°14′ North Latitude and 85°51′ and 89°53′. With only 2.7% of the geographical area of India, West Bengal supports 8% of the country's population. (Gangopadhyay, 1995). According to the census of 1991 population density was about 766 heads per square km. Area of cultivable land was 5.45 m. ha and the total number of farmers was 6.13 millions. The average land holding capacity was 0.88 ha. Gross cropped area was 7.6 m. ha giving a cropping intensity of 140%. Gradually this small land is also getting fragmented and causes difficulty in investment for perspective farm mechanization. Soils of West Bengal can broadly be classified as Brown Hill soils, Terai soils, Red soils, Laterite soils, alluvial soils and coastal saline soils. **Table 1** shows the land utilization pattern of West Bengal (Economic Review, 1997-98).

Climate

The averages rainfall is about 1750 mm ranging from 2500 – 3500 mm in the Duars and Terai regions to 1200 – 1800 mm in the plains. Some 75 – 80% of the rain falls during four months of June to September (monsoon season). During pre- and post-monsoon period there is erratic rainfall. Thus in rainfed condition only one crop a year can be raised. During the high temperature spell during March to October minimum and maximum temperatures recorded in the plains range around 16-26 °C and 30 – 40 °C, respectively. In the hill during this period minimum temperature ranges from 7 – 15 °C and the maximum varies from 15 – 20 °C. In the plains in winter months the maximum and minimum temperatures recorded are 27°C and 10°C and in hill area the same are 11°C and 3 °C. Over the year the minimum and maximum humidity ranges from 40 to 93%. Sunshine hours range from 8.5 to 9.5 on days in winter to 4.5 to 5.5 hours a day in cloudy monsoon. (Gangopadhyay, 1995).

Agro Climatic Zones

Based on rainfall, temperature, soil types and topography of land, West Bengal can be designated into 6 agro climatic zones, viz – Hill zone, Terai zone, Old alluvial zone, New alluvial zone, Laterite and red soil zone and coastal saline zone covering one district, four, nine, seven, three, two districts of the state respectively. New alluvial zone is the largest zone comprising 28, 277 km^2 and Hill zone, the smallest of 3, 115 km^2.

Cropping Pattern

Rice is the dominant crop of the State. In Kharif season 80% of the land is covered with rice and other Kharif crops are jute, maize and pulses. The area under cereals is 78.44% of which coverage of paddy alone if 93.18% and wheat covers only 6.3%. The average yield of paddy is 2.8 mt per ha. The coverages of pulses, oilseeds, fibre crops and cash crops are only 4.63, 7.96, 5.82 and 4.70%of area under annual crops, respectively. (Gangopadhyay, 1995).

Land Use Pattern

The utilization of land is shown in **Table 1** which suggests that in last 10 years only 3.5% of increase in cultivable area have been taken place. There is no change in forest area. Also no change in area not available for cultivation in a decade implies that there has not been any proper attempt to bring about intensive cultivation and there is lack of earthmoving equipment and deep tillage implements.

Use of Farm Power

It has been found that mostly agriculture in West Bengal depends on bullock power and human labor. Approximately one power tiller is for every 10 to 15 farmers each having more than 2 ha of cultivable land i.e., only about 22% of farmers hold a power tiller and one tractor there is in a village comprising of not less than 300 marginal farmers*.

*Source: Personal communication with farmers.

Present Situation and Problems

West Bengal is facing one or combination of the following problems:

Farm Size

The area under cultivation in West Bengal has gone down by at least 67,462 ha since 1990-91as a result of urbanization and fragmentation of land holdings. Large and medium holdings are also decreasing in number while there has been a steep increase in the number of marginal holdings. According to the sixth agricultural census launched in the State in 1995-96, 95% of the total holdings belonged to the marginal (less than 1 ha) and small (1-2 ha) categories and represented 72% of the cultivated area of 5,588,228 ha. On the other hand, there has been a drop in the percentage of semi-medium (2-4), medium (4-10) and large (more than 10 ha) categories by 14, 11 and 3%, respectively, (HT correspondent, 1999). Land holding size (Kharif, 1996-97) of the State is shown in **Table 2.** Due to

Table 2. Land Holding Size

Land Sizes	% of land of this category
Upto 1 ha	41.89
1-2 ha	36.66
2-4 ha	18.41
4 and above	3.04

Table 1. Land Utilization in West Bengal

Classification	1985-86		1996-97	
	Area, (000ha)	percentage	Area, (000ha)	percentage
1. Net sown area	5262	59.50	5463	62.80
2. Current fallows	65	0.70	213	2.40
3. Forests	1186	13.40	1195	13.70
4. Area not available For cultivation	1730	19.60	1659	19.10
5. Other uncultivated land excluding current fallows	606	6.80	166	2.00

this small and scattered land holdings of farmers, they are unable to perform intensive cultivation and is the major constraint for mechanized farming.

Irrigation Facilities

West Bengal is not potentially resourceful in terms of irrigation facility. Irrigation utilization in the State was 1.15 m ha in 1997-98, 1.09 m ha in 1990-91 and 1.01 m ha in 1980-81 (Economic Review, 1997-98). Increase in irrigated land in a decade is only 13.8%. Net sown area of the state in 1997-98 was about 5.463 m ha. So. only about 21% of the cropped area are irrigated. In Rabi season 90% of the land remain barren due to lack of irrigation facilities (Gangopadhyay, 1995). To improvise the inadequate irrigation facility, much emphasis has been given in developing major irrigation, in general, and minor irrigation, in particular. The important schemes under minor irrigation are deep tube well (high, medium and low capacity), river lift irrigation, shallow tube well, tank irrigation, lift irrigation, open dug well etc.

Climate and Machinery

Intensive rainfall may cause soil instability and encourage soil erosion, particularly on slopping grounds. Erosion could be reduced to 0.02 t/ha/month from 1 t/ha/ month when maize crop is sown by no-till method, a mechanized farming practice in place of conventional cultivation (Choudhary, 1985). In semi-arid countries, where crops are completely removed by harvesting and grazing between crops, traditional tillage methods are encouraging erosion and nutrient losses.

Present Pattern of Cultivation

Paddy is the major crop in the state. It is grown as pre kharif or *Aman* (January-April), kharif or *Aus* (April-July) and rabi or *boro* (December –March)-crop. In some districts like Midnapore, only two crops, viz, Aman and Aus are raised extensively. The field is plowed by bullock-drawn indigenous plow (**Fig. 1**). In some cases and also for vegetable crops, the field is plowed by spade or *kudali* (**Fig. 2**). Then it is leveled by a bamboo made leveler or ladder *(moi)* (**Fig. 3**) pulled by a pair of bullock and the leveler is made heavy for proper effect with a child sited on it or the labor operating the bullocks standing on it. Finger combing cleans weeds. Paddy seedlings are transplanted by conventional manual system in puddleded soil. Pesticides are sprayed by hand operated low-pressure knapsack sprayers (**Fig. 4**). Matured paddy is harvested by serrated sickle (**Fig. 5**). In some perspective farming family, threshing is done by pedal thresher (**Fig. 6**) and, in general, it is done by conventional trampling operation. For vegetable harvesting spade is mostly used.

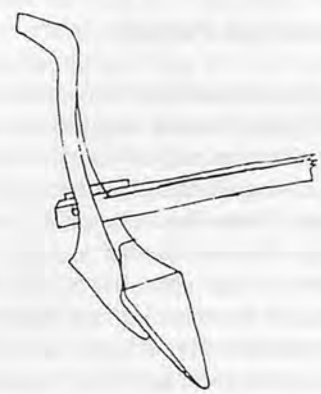

Fig. 1 Indigenous plough.

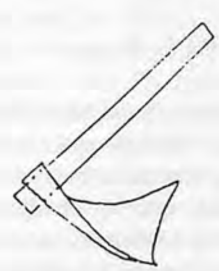

Fig. 2 Spade.

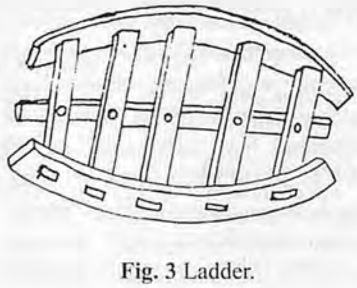

Fig. 3 Ladder.

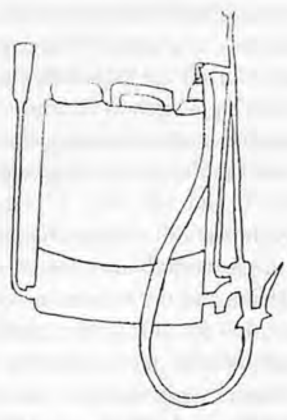

Fig. 4 Knapsack sprayer.

Fig. 5 Serrated sickle.

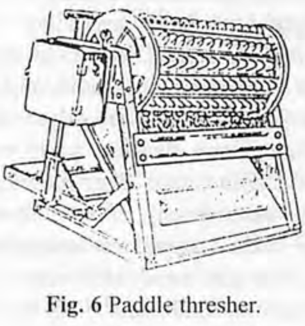

Fig. 6 Paddle thresher.

Need and Scope of Mechanization

West Bengal has a good potential for crop production. Yield of few crops in the state is more than the average yield in the country. In 1996-97, West Bengal produced 2,179 kg/ha of rice as against 1,879 kg/ha in the country, the figures in gram is 862 kg/ha as against 810 kg/ha, in Jute 2,178 kg/ha as against 2,008 kg/ha, in potato 27 tonnes/ha as against 19 tonnes/ha. The contribution of West Bengal to all India production for rice 15.5%, sesame, 14.1%, Jute and mesta, 68.9% potato 33.8%, Tea 21.2% in 1996-97 (Economic Review, 1997-98). It is seen (**Table 3**) that there is no appreciable correlation between the increase in yield with the increase in area of cultivation and increase in production for respective crops in a decade length time period. In case of cereals, there is an increase in production of 53.3% while that in yield is 35%; in case of winter paddy, with area increment of 106%, the production increased by 131.1%, but surprisingly the yield increment is mere 11.9%. For pulses, increase in yield is 17.2% though there is decrement in production of 34.5% because of cut short in land sown. For oilseeds 37% increase of area has given 83.7% of increase in production with 33.4% increase in yield. Extensively growing jute gave 19.5% increase in yield for 15% decrease in area with 1.6% increase in production. In case of sugarcane, 100% increase in area gave 123% increase in production with only 8% increase in yield. Potato gave 207% increase in production with 127% increase in area for 35% increase in yield in this modern era.

In order to raise the land production in West Bengal, modern agricultural production methods are necessary. In the fields of West Bengal, high yielding varieties of crops, improved fertilizer, modern irrigation method (to some extent) are being used. But, these all inputs will have their efficient use only when the soil which is the room for all these inputs and the future crops to be raised, is processed properly and treated to the required quality for respective crops. This dictates the use of agricultural implements and machineries in the field.

It has been found that field plowing in the State with a conventional indigenous plow costs about Rs. 1800/ha, while the cost of plowing with a power tiller (hired) in the same location is only Rs. 675 /ha, less by more than 35%. Transplanting of seedlings by manual labor costs about Rs.1700/ha while if the same operation is done by mechanical transplanter (six row), then the operational cost is Rs.569 to 610/ha (Datt, 1995) and can be accomplished within 3.3 times less than that taken by manual transplanting. Harvesting by conventional method of sickle cutting costs about Rs. 1000/ha while if it is done by vertical conveyer reaper it costs only Rs. 665/ha (Pandey, 1998) and threshing by traditional trampling or beating paddy stalk on bars costs Rs. 750 while by paddle or power thresher it costs from Rs. 500 to 600/ha. For all the mechanized implements which have been cited in this paragraph as alternative measures will not be facing land holding size and economy of the State as constraints.

The coverage of oilseeds is 7.96% of the area under annual crops. It is grown in the districts of Hoogly, Bankura, Birbhum, Burdwan and Malda mostly which constitutes 20% of the state area. It is Laterite and Red soil zone where cropping intensity is 120% (Patel, 1999).

Table 3. Area, Production and Yield of Some Principle Crops in West Bengal

Crops	Area (000 hectares)		Production (000 tonnes)		Yield (kgs/ha)		PIP in 10 years
	1985-86	1996-97	1985-86	1996-97	1985-86	1996-97	
Cereals	5481.30	6212.3	8863.6	13584.90	1617	2187	53.3
Rice	5078.00	5800.6	7991.00	12636.00	1575	2179	57.9
(i) Aus	481.30	461.7	540.6	775.50	1123	1680	43.5
(ii) Aman	4083.30	4282.5	6023.2	8566.40	1475	2000	42.2
(iii) Boro	512.30	1056.4	1427.2	3294.90	2787	3119	131.1
Wheat	305.10	351.1	738.7	839.00	2420	2390	13.5
Barley	17.50	5.4	16.2	5.10	926	944	(-)68.7
Maize	56.30	34.5	103.4	83.50	1840	2441	(-)19.1
Other cereals	23.70	20.7	14.3	20.50	603	1000	43.3
Pulses	421.00	234.6	264.4	172.90	627	735	(-)34.5
Gram	68.70	29.0	59.8	25.00	882	862	58.3
Tur (arhar)	15.50	3.4	14.00	2.70	903	794	(-)78.6
Mung	42.30	16.3	23.8	6.10	571	374	(-)75.0
Masur	93.00	51.3	50.1	43.20	538	843	(-)14.0
Khesari	99.00	26.7	63.5	32.20	636	1185	(-)49.0
Other pulses	102.50	107.9	53.1	63.70	520	592	20.6
Oilseeds	371.00	509.1	233.6	428.10	630	841	83.7
Rapseed and Mustard	231.60	319.5	163.3	248.80	706	780	52.7
Linseed	48.80	10.6	13.00	2.70	265	255	1.8
Sesame	74.80	142.5	44.00	99.70	587	704	127.0
Sunflower	1.30	1.1	0.8	0.30	615	273	(-)62.5
Other	14.50	37.7	12.5	40.60	862	1079	233.0
oilseeds	773.30	631.8	7633.2	7582.9	9875	12016	(-)0.6
Fibre	730.70	620.1	7389.8	7506.0	10123	12106	1.6
Jute	44.40	9.2	234.9	66.7	5341	7283	(-)71.4
Mesta	2.10	2.3	8.5	10.3	4048	4478	17.6
Other fibres							
Other crops	12.90	24.9	812.1	1810.30	67667	72400	123.1
Sugarcane	138.40	314.3	2757.6	8472.30	19978	26980	207.3
(gur)	98.00	102.0	157371.0	165375.0*	1606	1621	5.1
Potato							
Tea							

* = In thousand kilograms.
PIP= percentage increase in production.

(Continued on page 63)

Role of Farm Mechanization in Rural Development in India

by

S. Karmakar
Lecturer
Department of Farm Machinery and Power,
Faculty of Agricultural Engineering,
B C K V, Mohanpur
West Bengal
India 741 252

C. R. Mehta
Scientist
Central Institute of
Agricultural Engineering
Nabi Bagh,
Bhopal
India 721 302

R. K. Ghosh
Dean
Faculty of Agricultural Engineering,
B C K V, Mohanpur
West Bengal
India 741 252

Abstract

Real India is rural India. Nearly 76% of the population lives in the rural area and 69% depends on agriculture for livelihood (Singh, 1992). The principal motivating force of rural development program is to escalate this vulnerable section of people and to raise social, psychological and cultural status, which will increase social activities. A real breakthrough in productivity has come and is expected to elevate in recent future because of the extensive application of mechanization in Indian farms. In this paper, an attempt is made to cite the need for farm mechanization for elevating rural life.

Introduction

The concept of rural development was born in the context of agriculture, and it remained, for a long time, coterminous with agricultural development in India (Maheshwari, 1995). The World Bank defines rural development as "A strategy designed to improve the economic and social life of a specific group of people - the rural poor. It involves extending the benefits of development to the poorest among those who seek a livelihood in the rural areas. The group includes small-scale farmers, tenants and the landless".

The core task of rural development consists in the use of local resources and skills, modernization of farming, regeneration of agricultural and allied activities, eradication of development problems and improvement in health and education (Singh, 1996,[b]). Rural development and agricultural products are interrelated. High agricultural production with the use of improved farming techniques, new implement, new farm powers can bring about economic transformation of the village - rural India.

The agriculture sector today contributes approximately 30% of the gross domestic product (GDP) and 70% of the population earns it's livelihood directly or indirectly from agriculture (Paroda, 1997). Around three million-hectare crop area is predicted to shift from foodgrains to non-food grains. To meet the growing domestic and export needs, the average yield at national level is required to be improved by 30 to 50% for various commodities by the end of the Ninth Five-Year Plan (2001-02). To attain self sufficiency, India should attain a per hectare yield of 2.2 mt for rice, 2.9 mt for wheat, 1.1 mt for coarse grains, 0.84 t for pulses, 1.1 mt for oilseeds, 0.34 mt for cotton, 80 mt for sugar cane, 17.7 mt for vegetables, and 16.8 mt for fruit by 2001-2. It requires an annual yield growth of about 2.5% for foodgrains, 4.5% for pulses, 3.9% for oil seeds, 3.8% for cotton, 3.5% for vegetables, 6% for fruits, 3.1% for sugarcane. To achieve food security, a strong regulatory tool is obvious and highly necessary. This can be envisaged by *farm mechanization*.

Only high yielding varieties of crops will not help to increase the yield of crops. For the timeliness in field preparation, proper soil condition and thriving atmosphere should exist which can be achieved from appropriate farm mechanization. It is not difficult to see, even at the more basic levels, that the use of indigenous agricultural implements reflects ignorance and illiteracy among the farmers in terms of modern agricultural development (Choudhary, 1985). Several scientists have shown that because of the technical innovation there had been overall increase in output of crops, increase in net farm income, improvement in the level of living, changes in the social structure, level of education, changes in attitudes and values of rural people and increase in contact with urban areas and extension agencies (Mishra, 1992).

This paper gives an insight into the importance of farm mechanization in the upliftment of the living standard of rural people.

Areas of mechanization

Agricultural economic development is highly correlated with the amount of energy used. Developing countries have 70% of the world population while their energy share is only 17% of the total energy consumption (Choudhary,1985). It clearly shows the poor productivity of the developing countries and dictates the use of machinery thereby consuming more power in the farm.

Mechanization of agriculture has two forms connected with farm jobs, viz., job requiring traction work, i.e., mobile mechanization which attempts to replace animal power for tillage work, hauling, transplanting, interculture operation, harvesting; and the other one is of stationary type required for irrigation, winnowing, threshing etc.(Muthuraman, 1996).

Agricultural mechanization embraces the design, manufacture, distribution and operation of all types of tools, implements and machines, including equipment for agricultural land development, farm production, crop harvesting and primary processing. To cope up with the need for producing required foodgrains, farm operations should be carried out intensively in the following ways:

1. Tillage by tractors and power tillers in respective regions of acceptance as substitute to conventional bullock power.
2. Cultivation by soil working equipments, viz., disc plough, mould board plough, disc harrow, rotavator, roto tiller, puddler, leveller in place of spade, deshi plough, and bhakar.
3. Conventional sowing, fertilizer application devices like broadcasting, dibbling, behind plough method can be replaced by mechanical transplanter, pneumatic planters, seed drill, seed cum fertilizer drill, potato planter, and sugarcane planter.
4. Primitive irrigation devices like leather bag, swing basket, chain pump, Persian wheel etc. can be replaced by centrifugal pump, drip irrigation, sprinkler irrigation, and axial flow pump.
5. Khurpi, spade, plough, traditional plant protection equipments can be replaced by hand weeders, cultivators, rakes, rotary tillers, sprayers and dusters.
6. Sickle, khurpi, spade etc. conventional harvesting, digging equipment can be made obsolete by serrated sickle, reaper, combine and digger.
7. Beating, rubbing, animal treading, and olpad threshing can be replaced by paddle threshers, power threshers, combines, and decorticators.

Advantages of Farm Mechanization

The important advantages of farm mechanization are:

1. It helps to have timeliness in operation, reduces operational period and labour in farming operations (**Table 1**), thereby reducing the drudgery of farm labour.
2. Work becomes efficient which will enhance the overall agricultural production. Increased production will create scope for additional employment by re-deployment of labour into different areas of agricultural operations and thus rural life upliftment will tale a momentum because of low operational cost (**Table 1**).
3. Cost reduction in farm operation (Singh, 1996[a]) because of mechanized cultivation in few major crops are shown in **Table 2.**
4. Mechanization brings about land reclamation of barren and useless lands and can be made cultivable, thus resulting in better utilization of lands.
5. It leads a subsistence to capitalis-

Table 1. Advantages of Mechanized Cultivation Related to Specific Implements

Implements	Percentage savings in comparison to conventional method		
	Labour	Operating time	Cost of operation
Animal drawn puddler	66 – 88	66 – 88	66 -82
Manually operated rice transplanter	65	65	45
Self propelled weeder	59	92	48
Self propelled vertical conveyor reaper	52	90	52
Manually operated mustard drill	-	-	50
Tractor mounted cultivator seed planter	91	91	48
Tractor mounted ridger type sugarcane cutter planter	85	85	60
Tractor mounted potato digger	40	45	35
Tubular maize Sheller	66	66	70
Groundnut cum castor dicorticator	98	98	89
Multicrop plot thresher	71	71	65

Table 2. Cost of Cultivation by Conventional and Mechanized Method

Crop	Cost of cultivation, Rs/ha		% Reduction in cost
	Conventional	Mechanized	
Paddy	1127	853	24.31
Wheat	1099	979	11.00
Fodder	1155	950	17.75
Gram	948	785	17.20
Sugar cane	2032	982	51.67
Vegetables	1481	1038	30.20

tic form of agriculture and helps search for international markets for farm production.

6. It improves the standard of living of rural people by freeing the farmers from much laborious, tedious hard work.
7. It generates surplus manpower for non-agricultural purposes.
8. Mechanization encourages better management of farm enterprises and makes it possible by providing more free time for planning and study.
9. For winter crops as wheat, use of improved bullock drawn implement as mould boar plough and disc harrow save 31 to 37% of energy as compared to conventional practices (Dey, 1998).

Future Strategy

Despite it's long inception, notions of mechanization have not yet been achieved up to the level of satisfaction. There has been much development in farm machinery engineering, but these have not reached the land extensively. It is reported that in Indian agricultural universities, research work is conducted to the extent of 39.5%, whereas, field extension work is done only for 2.6% (Annual Report, 1995-96, Applied Manpower Resource). This is really an impediment to the farm mechanization. This scenario demands that future down-to-earth approach and extension work needs to gain momentum.

The Krishi Vigyan Kendras (KVK's) under State agricultural universities and Indian Council of Agricultural Research (ICAR), and State extension department are given responsibility to disseminate developed technology to the rural poor. The various steps that may help in faster acceptance of farm mechanization are:

1. A committee of experienced engineers should be formed to identify types of machines to be popularised based on requirements, availability, quantity, performance, reliability, capacity and cost.
2. A package of 3-4 implements should be taken and extension workers should perform method and result demonstration for popularization.
3. Standardization and availability of different parts of agricultural implements, equipments and machinery. This may help in faster repair, maintenance and reliability of farm machinery.
4. Spare parts of machines and implements should be made sufficiently available in rural stores in the absence of which procurement time, depreciation cost of machines, down time etc. are increased, even in worst cases agricultural season.
5. Extension officers should organise regular radio and TV programmes highlighting the development of machines, and their benefits.
6. Extension agencies should assess the requirement of credit for the purchase of big machines, such as combine, and sugarcane harvester. which a farmer cannot afford to own. They should also approach State Governments/ Banks for loans and subsidy.
7. Custom hiring of big machines should be encouraged.
8. Know-how training for the farmers should be organised in different levels for teaching them the skill of operation, repair and maintenance of agricultural implements.
9. Field and Farmers' Day should be organised and agricultural machine exhibitions should be conducted to encourage the farmers to know about the largest changes in machines.
10. Low level of machine delivery mechanism, procedural drills, regulation and laws affecting the agricultural system needs improvement for users' convenience.
11. Demand for machines, service stations, workshops, and fuel supply stations should be raised which are non-existent in rural areas.
12. Light weight prime-movers and matching implements which are of low cost, should be encouraged for multipurpose use to suit Indian rural economy.

Conclusions

Serious consideration should be given to the foregoing strategies. The pattern of investment of human effort and labour has to be remodelled in the light of advanced technology. Rural people should developed confidence in using and operating the improved implements. The impact of mechanization in farming practice depends on the purchasing capacity of it's users. So, resource mobilisation at the grass root level has to be given importance.

It is a good sign that RNAM network had advocated the establishment of National Farm Mechanization Committees in member countries exclusively to advice governments in this important area (RNAM News Letter, 1995). The Government should encouraged farmers to adopt improved technology by way of financial incentive "Farmers Agri-Credit Card" facility.

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Mechanical Performance of Indigenous Agricultural Machinery in Multan Division, Pakistan

by

Tahir Tanveer
Project Incharge
Centre for Agricultural Machinery Industries
Punjab Small Industries Corporation
G.T.Road, Mian Channu, Punjab
Pakistan

Dr. Hayat M. Awan
Professor and Dean
Faculty of Commerce
Law and Business Administration
Bahauddin Zakariya University
Multan, Pakistani

M. Saleem Bhutta
Project Director
Metal Industries Development Centre
Punjab Small Industries Corporation
Allama Iqbal Road,Sialkot Cantt
Pakistan

Toseef Azid
Associate Professor
Department of Economics
Bahauddin Zakariya University
Multan
Pakistan

Abstract

This study is based on a survey conducted in the Multan Division of Pakistan. Multan was selected for the study because of the presence of maximum number of tractors and allied machineries. One hundred fifty tractor owner farmers were interviewed to evaluate the mechanical performance of farm implements and to identify the scope for new and improved machinery. The mechanical performance of farm implements was adjudged from the replacement parts requirements, repair and maintenance frequency, material handling ability, labor requirement and user opinion on implement quality. The study concludes that the introduction of quality parts and safety devices should get first attention. The development and commercialization of efficient machines to replace the present clumsy seed drill, sprayer, wheat thresher, and trolley are important. The consumer protection and awareness should receive immediate attention to shift from supply-push to demand-pull market character.

Introduction

A number of studies are available in the literature relating to the mechanization in agriculture in developed as well as developing countries. These attempts have covered the different dimensions of subject, especially with reference to the developing countries, e.g., comparative studies on mechanization by Binswanger, one on tractors in South Asia(1978), and on comparative historical aspects(1984), on mechanization in Latin America by Abercrombie(1972). Africa-oriented perspective by Clayton(1983), related to Pakistan by Base and Clark(1979), Gotsh(1973), Agarwal(1981), Gill(1983), Lingard(1984), Khan, et.al. (1986), and Mc Inerney and Donaldson(1975) discussed the substitution view of tractors with the help of empirical evidences. Mathur and Kapp(1961) discussed the direct and indirect effect of mechanization in India. Rudra(1987) reviewed the technology policies including mechanization in India. Schmitz and Secklar (1970) set out clearly the producer and consumer analysis of a labor saving mechanization innovation.

Agricultural mechanization is recognized around the world as a climacteric constituent influencing farm productivity both directly and indirectly. Farm mechanization started in Pakistan with the introduction of tractors in the country. In 1947, there was about 500 tractors in Pakistan (Ansari and Raza; 1984). The population expanded to 35333 tractor in 1971-72 (NCA 1988).

As per the Pakistan Census of Agricultural Machinery, 1984 it is important to note that of the 204,846 tractors imported into the country up to 1983-84, only 155,047 tractors were actually operating at the farms. Of the balance some have been written off or lying unserviceable and others were working in the non-farm sector.

The role of tractors in farm mechanization is just to function as a source of power and give propulsion to the attached implements/ machinery. It is the implement which has direct bearing on crop production. So far, Pakistan has experienced only selective mechanization featuring ease and speed of operations previously dependent on manual and bullock power (Razzaq, et al;1990).

Agricultural implements/machinery are manufactured all over the country but the major production centre is in Mian Channu besides Faisalabad, Lahore, Daska and Gujranwala (Khan et al. 1986, Sargana et al. 1986a, Sargana et al. 1986b).The implements/machinery manufactured at these centre are of poor quality because these are produced according to manufacturers own knowledge without following any standards, design specifications, quality controls and without using proper raw material and manufacturing technology. The range of agricultural implements produced at Mian Channu and other centre includes cultivators, mould board plough, chisel plough, rotavator, disc harrow, rear blade, land leveller, scraper, cotton ridger, ridger, ditcher, border disc, seed-cum-fertilizer drill, cotton/maize planter, bar harrow, boom sprayer, maize sheller, wheat thresher and trolley (Tanveer et al. 1992). The implement produced at these centres are of similar qualities.

The Punjab Small Industries Corporation (PSIC) in association with the Netherlands Government, established a centre for Agricultural Machinery Industries (CAMI) at Mian Channu. The major objective of the CAMI is to improve the quality of agricultural implements by assisting the agricultural machinery/implement manufacturers. CAMI conducted this study to identify the quality improvement areas in agricultural implements/machinery of the same type as manufactured in Mian Channu and scope for new and improved machinery with the following objectives:

1. To find out the wear and tear of agricultural machinery/implement.
2. To determine the operational breakdowns of agricultural machinery.
3. To determine the labour requirements of agricultural machinery.
4. To collect the information about input specification.
5. To assess the farmers' satisfaction about quality of implements.
6. To identify the scope for new and improved farm machinery.

Fig. 1 Cultivator.

Methodology

Multan was selected for the study due to presence of numerous/tractors and allied machineries. The information relating to the objectives of the study was collected through on site interviews of the stratifield sample of users of farm machineries and implement. A sample comprising of 150 owners and users of at least one farm implement made in Mian Channu was drawn from amongst the 440,000 farmers operating throughout the six districts of Multan. A questionnaire was developed for this study. In order to test the validity and completeness of the questionnaire it was pretested and necessary changes were incorporated.

The owners/operators of implements were interviewed in depth by qualified and experienced agricultural engineers. The information supplied by the user was ascertained by the interviews team to be the candid opinion before entering into the questionnaire.

Results and Discussions

Mechanical Performance

The mechanical performance of farm implements is adjudged from the replacement parts requirements, repair and maintenance frequency, material handling ability, labor requirement and user opinion on implement quality.

Wear and Tear

The wear and tear is the rate of weight reduction of the component. During operation the moving parts lose weight as a result of material removed from its surface due to abrasion. The average time of replacement of wearing parts of the implements similar to the type made in Mian Channu is given in **Table 1**. The cultivator shovel, springs, rotavator blades, sprayer nozzle, pipe and seed drill tubes

Table 1. Average Time of Replacement of Wearing Tractor Part

Type of Part	Name of Implement	Average Time of Replacement
Shovels	Cultivator	50 Hours
Spring	Cultivator	50 Hours
Tine	Cultivator + Ridger	150 hours
Blades	Rotavator	50 Hours
Universal joint	Rotavator	150 Hours
Gears	Rotavator	150 Hours
Bearing	Rotavator	100 Hours
Seed tubes	Drill	50 Hours
Marker	Drill	100 Hours
Metering units	Drill	100 Hours
Chain drive	Drill	100 Hours
Pump	Sprayer	60 Hours
Nozzles	Sprayer	50 Hours
Pipes	Sprayer	50 Hours
Cutter	Thresher	100 Hours
Tyres	Trolley	300 Hours (Used Tyres)
Axle bearing	Trolley	Quite Often
Hitch	Trolley	Quite Often

had the minimum life. The cultivator shovels are not hard enough to withstand the abrasive action of soil and gone out of shape in 50 hours of use. The cultivator spring is not heat treated for increased spring constant and thus loosened after 50 hours of operation. The sprayers nozzles and rubber pipe do not adapt very well to the high pressure operation. The seed tubes requires frequent cleaning and crude dechoking and cracked due to hot and dry climate.

The wear and tear of parts in Multan was high due to mismatch between parts and working condition requirements. The service life of the wearing parts is reduced considerably when put to the conditions for which it was not designed for such was case of rotavator blade used for ploughing in the cotton stick and stubble. The high rate of wear and tear noticed in the case of sprayer pump was its poor adaptability for handling corrosive insecticides and as such lasted only for one season, i.e., 60 hours of operation. The wearing parts had low hardness due to lack of heat treatment.

The absence of over-load protection devices on safety features also contributed to fast wear and tear due to greater dynamic stresses and strain during operation. The critically short service life of bearings and tyres had its origin in making use of used parts to lower the sale value of implements.

Operationl Breakdown/Delay

The implement breakdown during operation is emphatically examined due to its direct affect on the timeliness, field efficiency and cost of use. The operational breakdown reflected poor operational capabilities as well as design/construction. The frequent operational breakdown is reported in cotton drill, sprayer, cultivator, trolley and wheat thresher. The nature of malfunctioning differed.

The cotton seed drill registered 76 percent of the 30 hours of annual use on a 20-ha farm with 65% area planted to cotton as operational breakdown/delay. The major reasons reported are blockage of seed metering mechanism and seed tubes. The seed box and metering mechanism do not suit the seed characteristics. The seed tubes blocked due to soil sticking at the seed delivery end due to improper seed placement device design.

The boom sprayer clocked seventy five percent of 33 hours of use on a 20 ha farm with 65% area under cotton as operational breakdown.

The sprayer parts malfunctioning are due to high operating pressure and corrosive action of chemicals. The pump reportedly requires replacement every year failed due to corrosion. The rust in the pipes develop due to their lack of rust proofing. The nozzles leakages could be attributed to the poor fittings of the parts. There are cases of rubber pipe bursting for want of pressure regulators.

The operational breakdown in the case of cultivators are not excessive and are reported to be ends spring loosening, tines and frame deformity. The loosening of spring is due to lack of heat treatment. The tines and frame deformity could be both because of improper material and operational disqualifications.

It was observed that breakdowns of axle, bearing and hitch of trolley are frequent. The axle and bearing are neither destined for use on tractor trolley nor are new. The hitch breakdown is due to push-pull during sudden stoppage for want of over-run brakes.

The operational breakdown reported in the case of the wheat thresher is loosening of welded and bolted joints due to rattling of the machine and the chocking of threshing cylinder due to uneven and or moist crop feeding. The relatively dry and hot season when the wheat thresher is used help in reducing the operational difficulties. The rattling of the machine is excessive due to lack of balancing of the oscilating cleaning mechanism and poor parts fitting. In general implements receiving sufficient repair and maintenance attention before the start of the season

Fig. 2 Cotton ridger.

Fig. 3 Rotavator attached with tractor.

Table 2. Labour Requirements for Various Implements

Implement	Skilled	Semi-skilled	Unskilled
Cultivator	1	-	-
Rotavator	1	-	-
Cotton drill (seed-cum-fertilizer)	1	1	-
Cotton sprayer	1	-	-
Boom sprayer	1	1	-
Wheat thresher	1	5	-
Trolley	1	-	-

registered low operational breakdown.

Labour Requirements

The poor design and construction of cotton drill, sprayer and thresher leads to increased labor requirement. The cotton drill required extra semi-skilled person to ensure the flow of seed through the seed (**Table 2**). The skilled person is required to operate the tractor.

The sprayer operation is also reported to be needing an extra person walking behind to observe clogged/malfunctioning of nozzles. Such an arrangement not only added to the cost but also exposed the man walking behind to the hazardous/chemical spray.

The labour requirements of the wheat thresher are, on the average, one skilled and five semi-skilled persons. The skilled person operates the tractor, two semi-skilled person operates the feeding of thresher and two others handled the output and one is used as relief and observing the thresher performance.

Input Specification

The specification of agricultural materials input plays a major role in the mechanical performance of farm machinery. The most common cotton seeds sold in Multan is not properly graded, delinted and dry which clogged the seed metering mechanism/seed tubes and stuck to the wall of the gear box.

The insecticide powder or emulsifiable concentrate when mixed with water made colloidal solution which requires constant stirring to keep the chemical particles suspended.

The on-going practice of delinting cotton seed with inert material such as ash and or sulphuric acid and later soaking the seed for acid removal make the seed too moist to be dry up in a day or two. The tendency has been to process the moist cotton seed through the drill resulting in blockage of seed metering mechanism. Similarly, insufficient stirring of insecticide concentrate or use of dirty water for mixing insecticide caused poor pump and nozzle performance.

Quality of Implements

The overall quality of implements is reported to be fair (**Table 3**). The user expressed dissatisfaction over the paint quality. The poor paint quality coupled with predominant open storage synergized the rusting of implement and thereby short its troublesome service life.

The quality consciousness of the respondent is neither fully developed nor is there any compassion available in the project area. The expression of satisfation on the material parts and fabrication quality does not match the high operational breakdown reported, especially for cotton drill and sprayer.

The dependence of quality of implements on the manufacturing source is checked by applying chi-square test to the data listed in **Tables 4** and **5**. The overall quality difference between various implements

Fig. 4 Seed drill.

Fig. 5 Tractor trolley.

Fig. 6 Wheat thresher.

Table 3. User's Perceptions Regarding Quality of Implements of all Manufacturers (Unit: Percent)

Quality Parameters	Rotavator	Cultivator	Cotton Ridger (9tine)	Cotton Ridger (21 tine)	Rear Blade	Cotton Drill	Boom Sprayer	Wheat Thresher	Trolley
Material and Part									
Good	31	55	54	43	51	44	34	56	53
Fair	40	38	40	57	34	42	51	32	40
Poor	29	7	6	-	15	14	15	12	7
Fabrication									
Good	28	62	58	43	58	45	36	61	52
Fair	43	32	35	57	30	41	52	31	43
Poor	29	6	7	-	12	14	12	8	5
Paint									
Good	26	25	41	29	26	30	32	34	31
Fair	48	40	34	71	38	40	56	41	40
Poor	26	35	25	-	36	30	12	25	29

manufactured in Mian Channu was insignificant. The similarities in design, common sources of material and parts purchases and similar manufacturing skill and facilities become the reasons for negligible quality difference.

Scope for New and Improved Machinery

The Multan division offered tremendous opportunities in improvement and promotion of farm machinery of the same and better types manufactured in Mian Channu.

Improvements

The farm machinery improvements are needed in design and construction. The design improvements entails matching the input specifications and agricultural recommendation on a cost effective way. The farmers in Multan are price conscious. The price of the machine has a significant role in the sales. The improvements in the machine are, therefore, to be conceived such that performance improved without any noticeable price increase. The objective can be achieved by reducing the weight of the machine without sacrificing its strength and performance through the introduction of special steel and heat treatment technology. The introduction of quality wear parts such as cultivator shovels, springs, tines and wheat thresher cutter held great promise. The rotavator with L shaped blades are unsuitable for handling cotton sticks and stubble. Instead new diamond section straight blades are recommended. The hardware (nuts and bolts) used on fastening wearing part needs heat treatment for extra tensile strength and wear resistance.

The sprayer pumps improvements are needed by incorporating corrosion resistant parts and building extra-precision. The nozzle design and variety must be increased. The boom configuration is required to be redesigned for better strength and full crop canopy coverage and efficient transport position. The use of hard plastic materials for nozzles, pumps parts, joints and light weight channel frame could improve sprayer performance and cost.

The tractor trolley needed complete new dead axle assembly development with mechanically actuated over run brakes. The bed height of the trolley could have been lower for easier loading and unloading. The addition of ramp or winch rollers could add more versatility to the tractor trolley.

The use of good quality paint, safety devices such as overload cut off, belt, chain covers, road mark-

Table 4. User's Perceptions Regarding Quality of Implements Manufactured in Mian Channu (Unit: Percent)

Quality Parameters	Rotavator	Cultivator	Cotton Ridger (9tine)	Cotton Ridger (21 tine)	Rear Blade	Cotton Drill	Boom Sprayer	Wheat Thresher	Trolley
Material and Part									
Good	-	55	50	-	38	38	31	49	50
Fair	43	40	42	100	52	40	50	40	36
Poor	57	5	8	-	10	22	19	11	14
Fabrication									
Good	-	60	52	-	47	36	38	51	46
Fair	43	36	40	100	48	42	50	42	47
Poor	57	4	8	-	5	22	12	7	7
Paint									
Good	-	27	42	-	10	14	22	35	29
Fair	43	53	30	100	43	44	62	49	32
Poor	57	20	28	-	47	42	16	16	39

Table 5. User's Perceptions Regarding Quality of Implements Manufactured other than Mian Channu (Unit: Percent)

Quality Parameters	Rotavator	Cultivator	Cotton Ridger (9tine)	Cotton Ridger (21 tine)	Rear Blade (Karah)	Cotton Drill	Boom Sprayer	Wheat Thresher	Trolley
Material and Part									
Good	40	55	58	50	58	51	37	63	55
Fair	39	37	37	50	24	43	52	26	42
Poor	21	8	5	-	18	6	11	11	3
Fabrication									
Good	36	63	63	50	63	55	33	70	55
Fair	43	29	32	50	21	41	56	21	42
Poor	21	8	5	-	16	4	11	9	3
Paint									
Good	32	24	40	33	30	41	30	35	32
Fair	50	34	38	67	34	35	48	32	42
Poor	18	42	22	-	36	24	22	33	26

ings, emergency stop, noise and vibration reduction features deserve serious considerations. The use of weather resistant paints would specially benefit a large majority of farmers who store the implements in the open.

New Introductions

The Multan farmers are beginning to feel the benefits of deep ploughing. A good quality mould board or disc plough could be introduced. The disc plough could be more versatile as it can handle the cotton sticks and sugar cane stubble as well.

Precision planter could be introduced along with good quality delinted dry cotton seed.The precision planter would save subsequent laborious thinning and replanting operations to achieve desired plant population.

The cotton and potato inter-culture equipment are outdated and inefficient. The alternate in the form of powered inter-row rotary hoe with and without fertilizer would be more cost effective. Potato and sugar cane planters already available in the other parts of the country need to be promoted in the project area. A two-row potato digger and shaker design being produced in Okara could satisfy the Multan division market. Sugar cane harvesting is difficult and expensive proposition. Sugar cane whole stalk cutter with partial stripping features had been developed in USA and Brazil on a specially converted tractor costing nearly Rs.2.0 million could work satisfactorily in Multan. Plant protection equipment need re-engineering to shape it for achieving complete plant coverage, low drift and ease of adjustment.

The introduction of double axle tractor trolley with over run safety brakes and with or without tipping backward, side or both features for handling bulky material such as cotton and sugar cane could be good market introduction.

The wheat thresher is an inefficient and unsafe machine. A suitable replacement having low energy input and less labour requirements without any loss of capacity would find acceptance. The preferable cleaning system of the thresher would be aspirating type, which is environment friendly.

Recommendations

Wearing Parts and Paint

Quality wearing parts for the cultivator, chisel, rear blade, drill, cotton ridger and wheat thresher should be introduced. The rotavator blade design should be changed if it is to be continued to be used for cotton sticks and stubble handing. A good quality paint should also be introduced.

Tillage Implements

Multan agriculture can greatly benefit from deep ploughing. The introduction of disc plough would favour due to it all kinds of crop residues handling ability. The rotavator is getting popular in Multan. The gears, shafts, bearing being used in its manufacturing are purchased used and the machine lack overload protection device as well. The rotavator break down had thus been significant. The development and standardization of rotavator parts should be undertaken.

Seeding and Planting

Line sowing of cotton is universal in the project area. The equipment and the seed quality is poor. There has to be strong emphasis on the simultaneous introduction of precision planter and quality seed for cotton and maize.

Inter-cultuure and Ridging Equipment

The inter-row rotary hoe should be developed and introduced in the project area. The cotton ridging operation can be avoided if deep ploughing is practised.

Sprayer

The boom sprayer in use for cotton need complete re-designing to make the machine more reliable, efficient and light. A wide range of nozzles in sizes and varieties should be introduced. Modern concepts of ultra low volume should also be kept in mind.

Harvesting Equipment

Whet harvesting should be fully mechanized. Mechanical reapers popular in Central Punjab should be developed in the Multan division and introduced. Wheat thresher is energy guzzling, dangerous and labour intensive machine. A completely new designed wheat thresher which is efficient and safe must be introduced.

Transport Equipment

Variety in tractor trolley does not exist in Multan. Only box type design in different sizes are made. The bigger box trolley had single axle double rim wheels. There was a strong case for introducing a well designed trolley with adequate number of axles for efficient off road work. The development and introduction of 6 and 10 tons capacity dead axles with over run brakes would drastically reduce road accidents. Special features on the trolley such as high side and tail board moving bed, ramps, tipping mechanism would be great market success.

Post-harvest Equipment

The introduction of seed cleaners, driers, tractor operator devices for handling bags and boxes and graders for potatoes would be useful.

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Investigation on Tractor Repair Costs under Tanzanian Conditions

by
Dr. Sylvester Mpanduji
Dept. of Agric. Engineering
Sokoine University of Agriculture
P. O. Box 3003
Morogoro,
Tanzania
Email: smmpanduji@yahoo.com

Dr. agr. Georg Wendl
Institute of Agric. Engineering
Technical University Munich
Voettinger Str. 36
85354 Freising,
Germany

Dr. Hamis O. Dihenga
Dept. of Agric. Engineering
Sokoine University of Agriculture
P. O. Box 3003
Morogoro,
Tanzania

Dr. E. L. Lazaro
Dept. of Agric. Engineering
Sokoine University of Agriculture
P. O. Box 3003
Morogoro,
Tanzania

Abstract

The repair costs of tractors in Tanzania were investigated using data collected from large-scale farms. The results show that the average annual repair costs varies significantly with the tractor age. Extremely higher repair costs occur from year 10 of ownership than during the early ages. The accumulated repair costs of tractors are higher in Tanzania than that in Europe and the USA for the 2WD tractors. However for the 4WD tractors they are almost equal to those of Germany models.

Introduction

Tanzania has 45 million ha of arable land but only 10% of these are currently under cultivation (MOA, 1991). To utilize this enormous potential, the country needs to expand and improve mechanized agriculture at all levels of farm power production. However, tractorization has been observed to be limited by several problems. Among them, the frequency of repair has been observed to be one of the major problems. For example, about 45% and 60% of tractors in the country were out of use due repair problems in 1983 and 1994, respectively, (UNIDO, 1984; FAO, 1995)

This problem could be influenced by lack of information on the part of tractor owners regarding prediction of repairs and their costs that are likely to occur or to be encountered at different periods of ownership. This has also been aggravated by the lack of published literature on the subject in Tanzania.

This work was, therefore, undertaken in order to solve the problem and to provide the necessary information for estimating the costs of using tractors in Tanzania. This information will be also important for plans and budgets required for mechanization in the country. The objectives of this work were:

1. To determine the annual repair costs of 2WD and 4WD tractors for different consecutive years of ownership,
2. To develop mathematical prediction functions based on the relationship between accumulated repair costs and cumulated hours of use, and
3. To compare the results of this study with the data established in other countries.

Material and Methods

Data were collected from 12 large-scale farms in five regions in Tanzania, namely; Morogoro, Iringa, Tanga, Kilimanjaro and Arusha regions. The data collected includes tractor make, model, type and year of purchase. Other data were tractor purchase price, power, repair history, costs and hours of use. Much of the data were extracted from farm records which were stored as tools for accounting and management systems of the farms.

In order to have a better con-

Acknowledgement: The authors grateful acknowledge the Germany Academic Exchange Service (DAAD) for funding this study.

cept, on which group components of the tractor consume more in terms of repair costs, the repairs were classified into the following tractor groups assembly:

1. Engine;
2. Transmission system including tyres and tubes;
3. Hydraulic system;
4. Electrical system; and,
5. Others for unspecified components.

The classification into the above mentioned groups was done during data collection in conjunction with the respective maintenance technicians and sometimes using the service manual available at the farms.

Data from 121 tractors were collected of which 2WD tractors were 102 and the remaining tractors were 4WD ones. The average power rating of the tractors was 60 kW and 89 kW for the 2WD and 4WD tractors, respectively.

Repair costs are defined as those expenses necessary to restore or maintain technical soundness and reliability of the machine (Morris, 1988; Wendl, 1991). They include the sum of spare parts and labour costs. However data collected in this study was for the costs of spare parts only because data on labour costs was not available. During the data collection, most farms estimated labour costs to be about 6% of the spare parts' cost. This value was reasonably equal to the value of 4% established in Burkina Faso (Kando and Larson, 1990).

Repair costs of tractors could be best established by studying each tractor over a period of time. However, using such method would require to observe each tractor for a number of years in order to obtain the historical data before the repair cost functions are reliably established. Since the repair costs of tractors were to be determined within a time limit frame, the method used by Ward *et al*., (1985) and Wendl (1991) was used in data processing. This is because the method has an advantage of establishing the repair cost information within a short time span. The method involves the following steps. First, tractors are grouped accordingly (in this case, 2WD and 4WD). Secondly, tractors in each group are classified into different tractor age. Then for each age the average annual hours of use and average repair costs are computed. Thereafter, the series of average accumulated

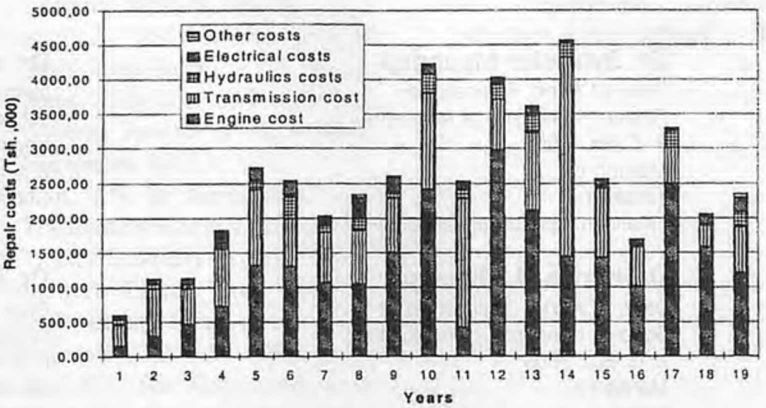

Fig. 1 Average annual repair cost s of the 2WD tractors for 19 years of ownership.

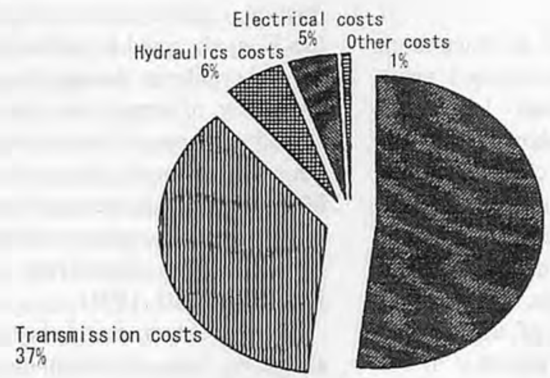

Fig. 2 Distribution of the accumulated repair costs of the 2WD tractors at the end of year 19.

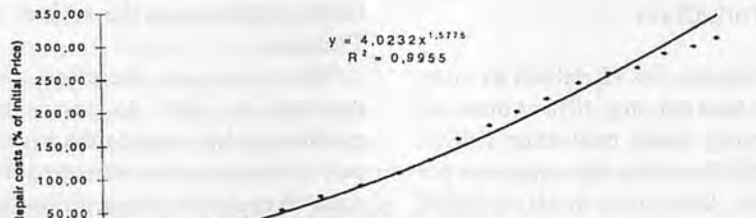

Fig. 3 Relationship between the total accumulated repair costs (% of initial price) against the cumulated hours of use for the 2WD tractors.

hours of usage and the accumulated repair costs for each group of tractors are determined. In the end, curves indicating the relationships between the average accumulated repair costs as the percentage of the initial purchase price of the tractors versus the average cumulated hours are plotted. The mathematical prediction functions for the repair costs are then determined from the plotted curves.

Results and Discussion

The results show that some of the tractors were used for more than 18 years. The average annual repair costs for the 2WD tractors (**Figure 1**) increased with the tractor age for the first 5 years of ownership and then there were significant variations in the annual costs as the tractors ages increased. However, higher repair costs occurred from year 10 and above. The average annual repair costs of the 4WD tractors (**Figure 4**) also varied with tractor's age. Nevertheless higher repair costs occurred during year 5 within the first 11 years of ownership and thereafter every two to three years.

The engine and the transmission groups assembly accounted for 88% of the total accumulated repair costs when 19 and 18 years of ownership of 2WD and 4WD tractors were considered, respectively (**Figures 2** and **5**).

A regression analysis of the data showed a power function relationship between the total accumulated repair costs (expressed as a percentage of the initial price) against the cumulated hours of use. The function for the 2WD tractors (**Figure 3**) is expressed by:

$$y = 4.0232x^{1.5776}$$
$$R^2 = 0.9955$$

and for the 4WD tractors (**Figure 6**) as:

$$y = 3.7388x^{1.4724}$$
$$R^2 = 0.9879$$

Where x is cumulated hours of use per thousand.

The comparison of these results with the prediction functions established from previous work in other countries showed that the function for the 2WD tractors (**Figure7**) is consistent with the result obtained in Burkina Faso (Konda and Larson, 1990). How-

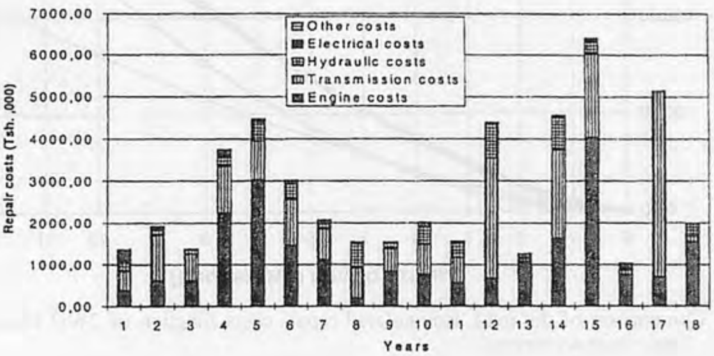

Fig. 4 Average annual repair costs of the 4WD tractors for 18 years of ownership.

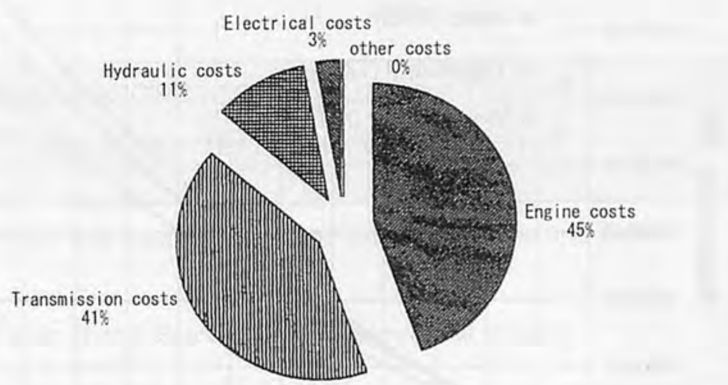

Fig. 5 Distribution of the accumulated repair costs of the 4WD tractors at the end of year 18.

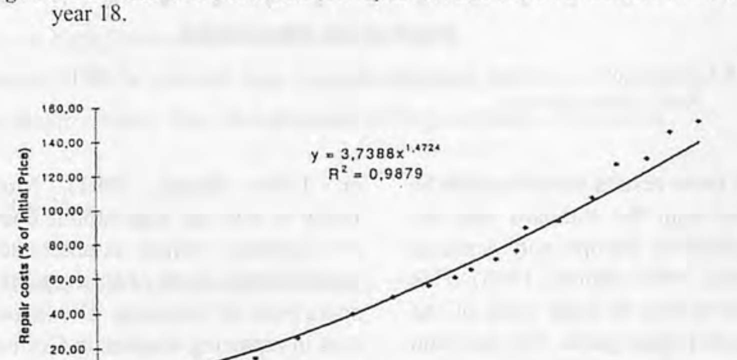

Fig. 6 Relationship between the total accumulated repair costs (% of initial price) against the cumulated hours of use for the 4WD tractors.

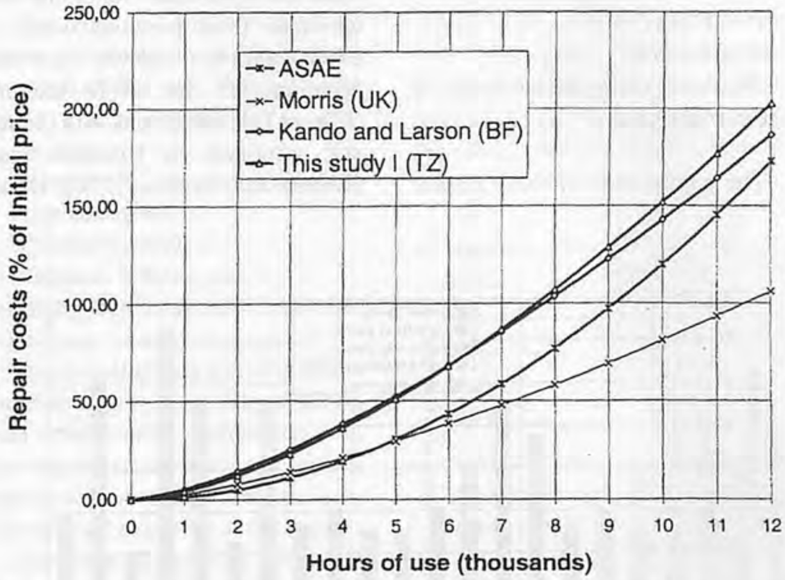

Fig. 7 Comparison of the total accumulated repair costs function of 2WD tractors from various sources.

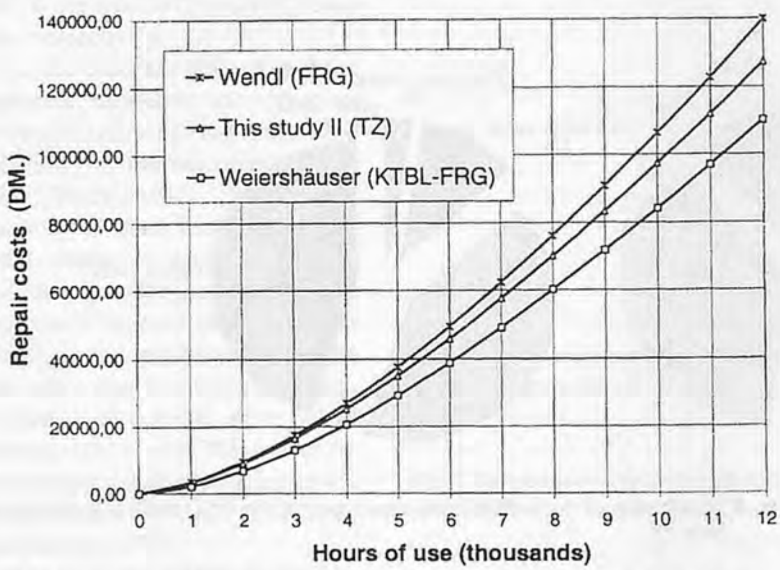

Fig. 8 Comparison of the total accumulated repair costs function of 4WD tractors from various sources.

ever, these results were found to be higher than the standard data established in Europe and America (ASAE, 1990: Morris, 1998). This could be due to high costs of the imported spare parts. The function developed for the 4WD tractors in this study showed a similar trend with the prediction functions developed in Germany (Weiershaeuser, 1989; Wendl, 1991). Most likely it was the high labour costs in Germany which counteracted with the high costs of the imported spare parts in Tanzania. The labour cost in repairing tractors in Germany is about 35% of the total repair cost (Wendl, 1991) compared to 6% in Tanzania.

Conclusions

The repair costs of 2WD and 4WD tractors under Tanzanian conditions were investigated. The results showed that some of tractors in Tanzania are owned for at least 18 years. The average annual repair costs varied significantly with the tractor age. High repair costs occurred from year 10 of ownership and above. The engine and transmission groups' failure accounted for more than 85% of the total accumulated repair costs. In that case these groups offer a potential for repair costs saving, if strict maintenance schedule is adhered to in order to prevent primary damages. The mathematical prediction models were found to be similar to those developed elsewhere. However, the model established for the 2WD in this study was found, on one hand to predict higher magnitude of repair costs than the models developed in USA and Europe, and on the other, they were consistent in magnitude with the model developed in Burkina Faso. The model of the 4WD tractors was found to predict similar results as the models developed in Germany.

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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.

932

Exhaust Emissions of Unmodified Diesel Engine Fuelled with Bio-diesels: **Ravinder S. Chhina**, Department of farm power and machinery, College of agricultural Engineering, P. A. U Ludhiana-1410004. **S. R Verma**, Same.

Linseed, rice-bran, gobhi sarson (Brassica napus), sunflower and jatropha curcas oils were trans-esterified to convert them into bio-diesels. The kinematic viscosity values of these bio-diesels were measured and compared with petro-diesel. The kinematic viscosity values were 1.2 to 1.8 times that of petro-diesel and were used as alternate fuels in a 3.67 kW, direct injection, CI engine and their exhaust emissions, viz. nitric oxide (NO), carbon-monoxide (CO). The combustible concentrations were monitored and compared with petro-diesel. The tests were conducted at four different loads, i. e. 25, 50, 75 and 100% of the rated load. Bio-diesels exhibited lower CO and combustible emissions and higher NO emissions as compared to the petro-diesel.

933

Design, Development and Testing of a Small Pea Depodding Machine: **B. L. Mandhyan**, Res. Engineer, AICRP on Post Harvest Technology, Dept. Of Post Harvest Process and Food Engg., J. N. Krishi Vishwa, Vidyalaya, Jabalpur MP, Pin-482 004. **V. K. Tiwari**,Asstt. Res. Engineer, Same. **D. K. Jain**, Asstt. Res. Engineer, Same.

A small depodding machine for peas was designed and developed. The machine employs an abrasive roller-concave assembly for separating the pericarps from the kernels. This separation takes place in two stages. The machine has a capacity of 55 kg/hr and a depoddig efficiency of 96.45%. The separating efficiency is 91%. The machine can be operated by a half horse power motor.

937

Investigation and Hierarchical Structure Analysis of Grain Post-production System: **He Yong**, Professor and Head, Agric. Engineering College, Zhejiang University, Hangzhou 310029, Zhejiang, P.R. of CHINA.

On the basis of a comprehensive investigation and analysis synthetic the present situation of grain post-production system in Zhejiang Province. Analytic Hierarchy Process (AHP) were applied to determine macroscopically ways and measures in which the function of grain post-production system can be improved so as to reduce losses and increase the effectiveness of grain.

938

Design of Steel Wheel for Improved Bullock Cart: **Dr. C. N. Gangde**, Associate Professor, Farm Power and Machinery, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola-444 104, India. **Dr. K. P. Pandey**, Professor, Agril. Engg. deptt. I.I.T. Kharagpur-721 302, INDIA.

The design details of different parts of a steel wheel for improved bullock cart such as rim section, spoke and hub are studied considering the pay load capacity of bullock cart as 20,000 N.

942

Maize Seeder with Watering Device: Gao Zhongdi, Senior Engineer, Baicheng Academy of Agri-Mechanization Science, 50, Haiming West Rd, Baicheng City, Jilin, P. R. CHINA. **Liang Xiuli**, Deputy Research Assistant, Same. **Gao Yuan**, Engineer, Same.

This paper is a study on the optimum mechanization operation process of watering-sowing of maize in the West drought region of Jilin Province. The authors designed and manufactured a maize seeder with watering device which was attached to 8.8 ~ 11kW four-wheel tractor. It can carry out a combination of furrow opening-watering-sowing and manuring-closing soil and rolling. This machine adopted a special operating method of the front-mounted furrow opening-watering and rear mounted sowing-manuring device. It solved the problems that otherwise seeds float on the water surface. Now, the water flows out of furrow very well. The test has shown that all its technical parameters are satisfactory and suitable for watering-sowing the maize seeds.

957

Enhancing Pulse Yield through Mechanical Sowing: **Abdul Razzaq**, Senior Subject Matter Specialist (Engg.), Adaptive Research Farm, Sheikhupura, PAKISTAN. **Liaqat Ali**, Assistant Research Officer, Adaptive Research Farm, Sheikhupura, PAKISTAN.

The study was conducted to observe the influence of mechanical sowing on mung bean (Vigna radiata) a prospective pulse crop. Manual broadcasting plus mechanical ridging and straight and cross-drilling of mung bean seeds were tested. Drilling was observed to increase mung bean yield significantly over broadcasting and was also found economically viable, registering 829.82kg/ha yield with 26.49 percent increase and contributing CBR of 1:27.90. Mechanical straight drilling proved to be the best method of sowing mung bean to enhance production. ■■

Compost Utilization in Horticultural Cropping Systems

(USA)

by Peter J. Stoffella, Brian A. Kahn

The first book to establish a composite of the existing scientific knowledge on the us of compost in commercial horticultural enterprises, Compost Utilization in Horticultural Cropping Systems gives you a comprehensive review of the production, use, and economics of compost.

Consider these statistics:

* Americans generate about 200 million megagrams of municipal solid waste per year.
* The agricultural market for compost could reach over 680 million cubic meters per year.
* Two horticultural areas together account for over 50% of compost use: landscaping (31%) and food crop production (25%)

Now consider this:

* Proven benefits of compost use, including plant disease suppression, better moisture retention, supplying nutrients, and building soil organic matter.
* Increased pressure on peat supplies and wider availability of compost products
* Creation of composting enterprises by the horticultural industry in response to its own needs, rising disposal fees for organic waste, and consumer demand for compost at retail centers

Compost Utilization in Horticultural Cropping Systems covers production methods, compost quality and the parameters associated with its measurement, and biological, chemical, and physical processes that occur during composing. Rather than searching for information in various places, now you can find all the information you need in one convenient source.

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Application of Distinct Element Method to Analyze Machine-soil Interaction

(Japan)

by Akira Oida

Introduction

Remarks on current project

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

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

Professor, Dr.Akira Oida
Lab. Agricultural Systems Engineering, Graduate School of Agriculture, Kyoto University
Tel:+81 75 753 6150
Fax:+81 75 753 6173 ■■

NEWS

Agricultural Equipment Technology Conference 2002

February 20-23, 2002
Kansas City, Missouri, USA

This seventh Agricultural Equipment Technology Conference (AETC 2002) is again being sponsored by the Power and Machinery Division of ASAE. AETC 2002 will bring together engineers, managers, researchers and other professionals in the agricultural equipment industry to exchange information, discuss opportunities and address challenges for production agriculture in the 21st century.

AETC 2002 will focus on machinery and machinery systems for agricultural production. Invited speakers will address issues such as precision farming, autonomous vehicles, sensors and electronics in agricultural machinery. An industry exhibit will feature leading-edge products and systems while poster sessions will present the latest

in academic and applied research.

Each year ASAE and Resource magazine select and honor companies that have developed new products for advancing engineering technologies in agricultural, food and biological systems and related areas.

The Power and Machinery Division of ASAE will pay special tribute to many of these companies and their representatives on Thursday, February 21, at a special Awards Program from 5:30pm until 6:30pm. A reception will immediately follow the presentations. All AETC registrants are invited to this very special event.

For AETC 2002 Information, Contact:

David W. Smith
Deere & Company Technical Center
3300 River Drive; Moline, IL 61265 USA
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Email: SmithDavidW2@JohnDeere.com

2002 ASAE Annual International Meeting/ CIGR XVth World Congress

July 28-July 31, 2002
Chicago, Illinois USA

Organizational Structure

This meeting of ASAE and CIGR is comprised of technical groups managed largely by committees within or closely related to these Divisions (ASAE) or Sections (CIGR). They are:

ASAE Divisions

* Power and Machinery (PM)
* Soil and Water (SE)
* Information & Electrical Technologies (IET)
* Structures and Environment (SE)
* Food and Process Engineering (FPE)
* Biological Engineering (BE)
* Emerging Areas (EA)
* Other Areas

CIGR Sections

* Land and Water Use (CIGR-I)
* Farm Buildings, Equipment, Structures and Environment (CIGR-II)
* Equipment Engineering for Plant Production (CIGR-III)
* Rural Electricity and Other Energy Sources (CIGR-IV)
* Management, Ergonomics and Systems Engineering (CIGR-V)
* Processing (CIGR-VI)
* Information Systems (CIGR-VII)

Deadlines:

Presentation proposal forms due to Session Organizers-December 21, 2001

Notification of acceptance mailed to presenters-January 7, 2002

Speaker/Presenter instructions updated on ASAE Web site March 1, 2002

Full Written Paper Presentation due to Headquarters-April 22, 2002

Further information
http://www.asae.org/meetings/

AAAE International Agricultural Engineering Conference (IAEC)

November 28-30, 2002
Shanghai, China

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

These conferences have attracted a wide cross-section of senior researchers, extension workers and planners from over 30 countries. They received an overwhelming response and were very successful. The next IAEC 2002 will be held in Shanghai, China.

Topics:

Papers are invited in the following areas and special topics:

* Agricultural engineering education
* Agro-industry
* Agricultural waste management
* Agricultural systems engineering
* Electronics in agriculture
* Energy in agriculture
* Environmental engineering
* Ergonomics
* Food engineering

* New materials and emerging technologies
* Postharvest technologies
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* Soil and water
* Terramechanics

Special Topic:

* Development and utilization of wild, green & special food resources

Call for papers;

Abstracts in English, not exceeding 500 words, should be submitted with the information form before 1st January, 2002. Each abstract will be reviewed and decision of the Editorial Board will be conveyed to each author by 1st March, 2002. The final papers must be submitted by 1st July, 2002. Instructions for writing papers will be forwarded along with the acceptance letter. Only papers of authors, who pay the registration fee or attend the conference will be published in the conference proceedings. Therefore, pre-registration is encouraged.

Important dates:

Submission of information form and abstract-1st January, 2002.

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Abstract and completed information form should be sent to:

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School of Food Science & Technology

Southern Yangtze University

214036 Wuxi, China

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UPDATED FINDER SYSTEM FOR TECHNICAL ARTICLES IN AMA AND OTHER AGRICULTURAL ENGINEERING PERIODICALS

A computerized index of technical articles appearing in 13 agricultural engineering periodicals, including Agricultural Mechanization in Asia, Africa and Latin America since it's beginning in 1971, has been updated through the end of 1999. The index database comes with it's own MS-DOS-based search engine.

There are four ways to get this free-of-charge index system:

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Those who have access to the Internet may search on-line an expanded agricultural engineering finder system index by TELNETing to SWEETPEA. ENGR. UCDAVIS. EDU (or **169.237.204.225**), and when the prompt: "Username:"appears, type: SEARCH tenter). No password is required, and there is no charge.

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Professor, Escuela de Agricultura de la Region, Tropical Humeda(EARTH), Apdo. 4442- 1000, San Jose, COSTA RICA
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Hipólito Ortiz-Laurel
Head of Agric. Engineering and Mechanization Dept. / Postgraduate College, Iturbide 73, Salinas de Hgo, S.L.P., C.P. 78600, MEXICO
TEL(+52)-496-30448,FAX(+52)-496-30240

S.G. Campos Magana
Leader of Agric. Engineering Dept. of the Gulf of Mexico Region of the National Institute of Forestry and Agricultural Research, Apdo. Postal 429. Veracruz, Ver. MEXICO

William J. Cnancellor
Professor Emeritus, Bio. and Agr. Eng. Dept., Univ. of California, Davis, CA, 95616, U.S.A.
TEL(+1)-530-753-4292,FAX(+1)-530-752-2640, E-mail:wjchancellor@ucdavis.edu.

Megh R. Goyal
Prof./Agric. Engineer, Dept. of General Engineering University of Puerto Rico, P.O.Box 5984, Mayaguez PR, 006815984, U.S.A. TEL(+1)-787-265-4702,E-mail:m-goyal@rumac.upr.clu.edu

Allan L. Philips
General Engineering Dept., University of Puerto Rico, P.O. Box 9044, Mayaguez, Puerto Rico 00681-9044, U.S.A.

Graeme R. Quick
Leader, Power & Machinery Section, 200 Davidson Hall, Agricultural and Biosystems Engineering Dept., Iowa State University, Ames, Iowa, 50011-3080 U.S.A.

-ASIA and OCEANIA-

Shah M. Farouk
Professor(Retd.),Farm Power & Machinery Dept., Bangladesh Agricultural University, Mymensingh 2200, BANGLADESH TEL(+880)-91-5695ext.2596, FAX(+880)-91-55810,E-mail:smf@bdcom.com

Mohammed A. Mazed
Director General, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, BANGLADESH

Manbahadur Gurung
Store Officer, Bhutan Fruit Products Limited, Samtse, BHUTAN TEL(+975)-65369

Wang Wanjun
Past Vice Director and Chief Engineer/Chinese Academy of Agricultural Mechanization Sciences, 1 Beishatan, Beijing, 100083, CHINA
TEL(+86)-(0)83-001-6488-2710,FAX(+86)-(0)83-001-6488-2710,E-mail:wwj@isp.caams.org.cn

A.M. Michael
1/64, Vattekunnam, Methanam Road,Edappally North P.O., Cochin, 682024, Kerala State, S. INDIA

T.P. Ojha
Director General(Engg.) Retd., ICAR, 110, Vineet Kung Akbarpur, Kolar Road, Bhopal, 462 023, INDIA TEL(+91)-755-290045

S.R. Verma
Prof. of Agril. Engg. & Dean Engg.(Retd), 14, Good Friends Colony, Barewal Road , Via Ayoli Kalan, Ludhiana -142027 Punjab, INDIA
TEL+91-(0)161-463096, E-mail:srverma@hotmail.com

Sarath Ilangantileke
Regional Representative for South and West Asia, International Potato Center(CIP), Regional Office for CIP-South & West Asia, IARI(Indian Agricultural Research Institute) Campus, Pusa, New Delhe-12, 110002, INDIA
TEL(+91)-11-5719601/5731481,FAX(+91)-11-5731481,E-mail:cip-delhi@cgiar.org

S. M. Ilyas
Director of Central Institute of Post Harvest Engineering and Technology (CIPHET), Ludhiana P.O.:P.A.U. Ludhiana - 121004, INDIA
Tel:(+91)-161-808669, Fax:(+91)-161-808670, E-mail: ciphet@satyam.net.in

Soedjatmiko
President, MMAI(Indonesian Society of Agricultural Engineering and Agroindustry), Menara Kadin Indonesia Lt.29 Jl. HR. Rasuna Said X-5/2-3 Jakarta, 12940, INDONESIA
TEL(+62)-(0)21-9168137,7560544,FAX(+62)-(0)21-5274485,5274486,7561109

Mansoor Behroozi-Lar
Professor, Agr. Machinery, Ph.D, Tehram University Faculty of Agriculture, Karaj, IRAN
TEL(+98)-21-8259240,E-mail:mblar@chmran.ut.ac.ir

Jun Sakai
Professor Emeritus, Kyushu University, 2-31-1 Chihaya, Higashi-ku, Fukuoka city, 813, JAPAN
TEL+81-(0)92-672-2929,FAX+81-(0)92-672-2929,E-mail:junsakai@mtj.biglobe.ne.jp

Bassam A. Snobar
Professor and Vice President, Jordan University of Science and Technology, P.O.Box 3030 Irbid, 22110, JORDAN
TEL+962-2-295111,FAX+962-2-295123,E-mail:snobar@just.edu.jo

Chang Joo Chung
Emeritus Professor, Seoul National University, Agricutural Engineering Department, College of Agriculture and Life Sciences, Suwon, 441-744, KOREA
TEL+82-(0)331-291-8131,FAX+82-(0)331-297-7478,E-mail:chchung@hanmail.net

Chul Choo Lee
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TEL+82-(0)2-446-3473,FAX+82-(0)2-446-3473,E-mail:ccsslee@chollian.net

Imad Haffar
Associate Professor of Agric. Engineering, Faculty of Agricultural Sciences, United Arab Emirates University, Al Ain, P.O. Box 17555, UAE
TEL+971-506436385, FAX+971-3-632384, E-mail : haffar96@emirates.net.ae

Muhamad Zohadie Bardaie
Professor and Deputy Vice Chancellor (Development Affairs), Chancellory, Universiti Putra Malaysia, , 43400 UPM, Serdang, Selangor, Darul Ehsan, MALAYSIA
TEL+60-39486053,FAX+60-3-9426471, E-mail:mzbd@admin.upm.edu.my

Madan P. Pariyar
Consultant, Rural Development through Selfhelp Promotion Lamjung Project, German Technical Cooperation. P.O. Box 1457, Kathmandu, NEPAL

David Boakye Ampratwum
Associate Professor, Dept.of Bioresource and Agricultural Engineering, College of Agriculture, Sultan Qaboos University, P.O. Box 34, Post Code 123, Muscat, Sultanate of Oman, OMAN
TEL+968-513866,FAX+968-513866,E-mail:davidamp@squ.edu.om

ElTag Seif Eldin
Mailing Address: Dept. of Agric. Mechanization, College of Agriculture, P.O. Box 32484, Al-Khod, Sultan Qaboos University, Muscat,Sultanate of Oman, OMAN

Nawaf A. Abu-Khalaf
Engineer, the Project Directorate in Palestinian Agricultural Ministry, P.O.Box 405, Hebron, PALESTINE, Telfax: 972-2-2227846/7, E-mail: abukhalaf @ hebronet.com


I Haffar


M Z Bardaie


M P Parriyar


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J Kigour

Allah Ditta Chaudhry
Professor and Dean Faculty of Agric. Engineering and Technology. University of Agriculture, Faisalabad, PAKISTAN

A.Q.A. Mughal
Vice Chancellor, Sindh Agriculture University,Tandojam, PAKISTAN

Rafiq ur Rehman
Director, Agricultural Mechanization Reserch Institute, P.O. Box No. 416 Multan, PAKISTAN

Bherulal T. Devrajani
Professor and Chairman, Faculty of Agricultural Engineering, Sindh Agriculture University, Tandojam, Sindh, PAKISTAN TEL+92-2233-5594

Reynaldo M. Lantin
Professor, College of Engineering and Agro-Industrial Technology University of the Philippines Los Baños, Laguna 4031, PHILIPPINES TEL+63-(0)49-536-2792,FAX+63-(0)49-536-2873, E-mail:rmlantin@mudspring.uplb.edu.ph

Ricardo P. Venturina
President & General Manager, Rivelisa publishing House, 215 F. Angeles St. cor Taft Ave. Ext., 1300 Pasay City, Metro Manila, PHILIPPINES

Saleh Abdulrahman Al-suhaibani
Professor, Agricultural Engineering Dept.,College of Agriculture, King Saud University,P.O. Box 2460 Riyadh 11451, SAUDI ARABIA

Ali Mufarreh Saleh Al-Amri
Associate Professor, Dept. of Agric. Engineering, Colleg of Agricultural and Food Sciences, King Faisal University, Al-Ahsa,SAUDI ARABIA

Sen-Fuh Chang
Professor, Agric.-Machinery Dept. National Taiwan University, Taipei, TAIWAN

Tieng-song Peng
Deputy Director, Taiwan Agricultural Mechanization Research and Development Center. FL. 9-6, No. 391 Sinyi Road, Sec. 4, TAIWAN

Surin Phongsupasamit
Professor of Agricultural Engineering, Dept. of Mechanical Engineering, Faculty of Engineering, Chulalongkorn University, Phyathai Road, Patumwan, Bangkok 10330, THAILAND

Chanchai Rojanasaroj
Research and Development Engineer, Dept. of Agriculture, Ministry of Agriculture and Cooperatives, Gang-Khen, Bangkok 10900, THAILAND

Vilas M. Salokhe
Professor, AFE Program, Asian Institute of Technology, P.O. Box 4, Klang Luang, Pathumthani 12120, THAILAND
TEL:(+66)-2-5245479, FAX:(+66)-2-5246200, E-mail:salokhe@ait.ac.th

Gajendra Singh
Professor, AFE Program, Asian Institute of Technology, P.O. Box 4, Klongluang, Pathumthani 12120, THAILAND

Suraweth Krishnasreni
Senior Expert in Agricultural En-gineering, Department of Agricul-ture, Chatuchak, Bangkok 10900, Thailand.
Tel. 5792153, 5794497, 5798520 Ext. 124, Fax:9405791, E-mail:Suraweth@doa.go.th

Yunus Pinar
Professor, and Head, Agric. Machinery Dept, Faculty of Agriculture, University of Ondokuz Mayis, Kurupelit, Samsun, TURKEY

Pham Van Lang
Director, Vietnam Institute of Agricultural Engineering, A2-Phuong Mai, Dong Da Hanoi, VIET NAM

Abdulsamad Abdulmalik Hazza'a
Associate Professor and Head of Agricultural Engineering Department, faculty of Agriculture, Sana'a University, P.O.Box 12355, Sana'a YEMEN
Tel:+967-1-250501, Fax:+967-1-2511585

--EUROPE--

Anastas Petrov Kaloyanov
Professor & Head, Research Laboratory of Farm Mechanization, Higher Institute of Economics, Sofia, BULGARIA

Pavel Kic
Vice-Dean/Technical Faculty, Czech University of Agriculture Prague, 16521 Prague 6-Suchdol, CZECH
Tel:+420-2-24383141, Fax:+420-2-20921361, E-mail:KIC@TF.CZU.CZ

Henrik Have
Prof. of Agric. Machinery and Mechanization at Institute of Agric. Engineering, Royal Veterinan/-and Agricultural University, Agrovej 10DK2630 Tastrup, DENMARK

Giuseppe Pellizzi
Director of the Institute of Agric. Engineering of the University of Milano and Professor of Agric. Machinery and Mechanization, Via G. Celoria, 2-20133 Milano, ITALY
Tel:+30-02-23691922, Fax:+30-02-23691499, E-mail:giuseppe.pellizzi@Unimi.it

Aalbert Anne Wanders
Staff Member, Dept. of Development Cooperation, Netherlands Agricultural Engineering Research Institute (IMAG), Wageningen,NETHERLANDS

John Kilgour
Senior Lecturer in Farm Machinery Design at Silsoe College, Silsoe Campus, Silsoe, Bedford, MK45 4DT, UK

Milan Martinov
Full Professor on Agricultural Machinery, University of Novi Sad, Faculty of Engineering, Institute of mechanization and machine design, TRG D. Obradovica 6, 21 121 Novi Sad, PF55, YUGOSLAVIA
TEL+381-21-350-122(loc.298), FAX+381-21-350-592, E-mail:mmartog@uns.ns.ac.yu ■■


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