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EDITORIAL

Restoration of Agricultural Machinery Researches and Educational System in Advanced Nations

With the fall of farming population and for other reasons, the number of students studying in agriculture related departments of universities is falling off in advanced nations. For the students graduated from those departments, it is not so easy to find employment. In any agricultural engineering department in the universities of advanced nations, some vacancy was born in their research and educational capacity. That situation urged many universities to change the research and educational system of agricultural engineering department, even to change the name of the department. That is to assure the position of the teaching staff, for the reasons of their own rather than social demand.

In most universities in Japan and in many advanced nations, the terms “agricultural engineering” or “agricultural machinery” have disappeared. Instead it became popular to use the terms like “resource”, “environment”, ”biology” for the name of new departments. Nevertheless “agricultural machinery” is a clear key-word for us involved in agricultural mechanization. We can no longer find that key-word in most universities. The term “agriculture”, however, is still the most essential and clear key-word in developing nations, where agricultural engineering and agricultural machinery continue to take an important part both in researches and education. The problem is that the situation in advanced nations makes it difficult to transfer valuable experiences, knowledge, know-how of advanced nations to developing nations.

I have often mentioned the definition of agriculture, that is, “agriculture, in broad sense, is an inter-action for human beings to seek good harmonization with other life systems on earth”. Agriculture is the most essential and important activity for human beings to be sustainable for a long time in future on this planet. I strongly hope that the term “agriculture” will be rising again in advanced nations, and that the terms like agriculture, agricultural machinery, agricultural engineering will be restored in universities and public institutions. We should never forget a large number of people involved in farming. They are waiting for new machines and the benefit of agricultural engineering researches. AMA wishes to play a role in connecting such farmers and agricultural engineering researches.

Yoshisuke Kishida
Chief Editor

Tokyo, Japan
May 2005

CONTENTS

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

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Para-Ploughing Effect on Soil Moisture Retention

by

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Abstract

Field experiments on moisture conservation effect of para-plough were conducted during the year 2002 in an area of 0.6ha. The physical properties of the soil such as bulk density, hydraulic conductivity and porosity were measured. The effect of moisture conservation using a para-plough* was observed along with chisel plough and control. It was found that para-ploughing loosened the soil 25% more at 30 to 45cm depth, whereas, chiseling could achieve 18% over the control. The hydraulic conductivity of the soil increased in both chiseled and para-ploughed land to the extent of 0.58 and 0.72cm^{h-1}, respectively, over the control. Total porosity has increased by 4% in the para-ploughed treatment followed by chisel-ploughing (3%). The para-ploughed treatment could maintain almost the same moisture status up to 45cm depth on different days of observation, whereas the chisel-ploughed treatment conserved more moisture at 60-90cm depth.

*A unique kind of plough so-named para-plough that functions like a chisel plough shattering the sub-soil without disturbing the top soil. An illustration is sketched in **Fig.1**.

Introduction

Land and water are the two basic inputs for agriculture. Sustainable agricultural production under tropical rainfed condition is possible only through the adoption of scientific conservation tillage practices. In India, about 69% of the total cultivated area depends entirely on rainfall for crop production. In Tamil Nadu, about 65% of the area is under dry land agriculture. The semi-arid tropics of India are characterized by rainfall, which is extremely variable in quantity, distribution and intensity. The mean annual rainfall

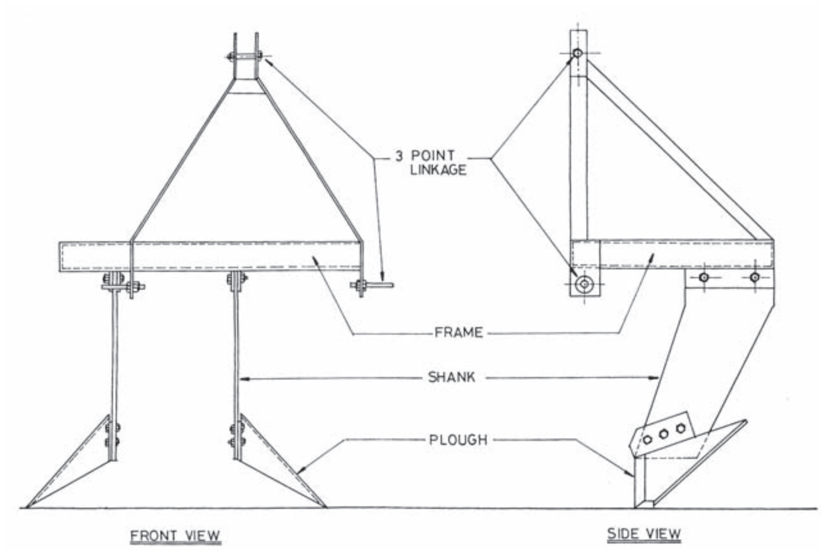

Fig.1 Para Plough

Treatment	Bulk density ($g\ cm^{-3}$)		Hydraulic conductivity ($cm\ h^{-1}$)		Total porosity (%)	
	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
Chiseling	2.17	1.77	0.33	0.91	30.12	33.00
Para ploughing	2.15	1.62	0.29	1.01	30.50	34.10
Contorol	2.16	2.14	0.36	0.37	29.62	29.68

Table 1. Soil physical properities

of the country is about 1194mm contributing about 400 million ha m of water of which 125 million ha m is lost as runoff, 70 million ha m as evaporation and the remaining 200 million ha m infiltrates into the soil including percolation loss (Balasubramanian, 2001). In Tamil Nadu about 45.5% of net sown area is irrigated. This implies that about 55% of the net sown area still depends on rainfall. Thus the conservation of the rain water in dry land areas obviously provides the key for successful crop production.

Rainfall received in arid and semi arid regions can be conserved in the soil by improving soil moisture storage. The various soil and water conservation measures include construction of run-off impeders, bench terracing, contour cultivation, and allied cropping and conservation tillage practices. But of which, the construction of run-off impeders is costly, whereas conservation tillage practice is cheap and can be manipulated according to the forecast of rainfall.

The various conservation tillage practices are the formation of broad bed and furrows, basin listing, chiseling and para-ploughing. Among these, chiseling and para-ploughing manipulate the soil without much disturbance to the top soil and increase the water holding capacity during precipitation. In conservation tillage, para-ploughing is a new concept and its effect on moisture conservation is yet to be investigated in India. Hence a study was conducted to evaluate the moisture conservation effect of para-plough in comparison with chisel plough and control.

Materials and Methods

The experiment was conducted in sandy clay soil consisting of 39.33% clay, 9.6% silt, 26.96% fine sand and 21.47% coarse sand. The apparent specific gravity of the soil varied from 1.21 to 1.35 and infiltration rate from 1.0 to 1.8cm^{h-1}.

Layout of Experiment

An area of 0.6ha was selected for the study. The field was divided into three plots of 0.20ha each. The effect of moisture conservation using para-plough was observed along with chisel plough and control.

Chiseling

Deep chiseling was done to a depth of 30 to 40cm with a heavy duty chisel plough which consisted of a shank of 640mm length and 170mm width with 12mm thick flat iron bar. The share is 150mm length with an inclined angle of 20 degrees. Provision was made for mounting the unit to a three-point hitch of the tractor. The depth of operation of the unit was controlled by the tractor hydraulic system. A safety pin was also provided as an overload protection in the unit. Ploughing with the chisel plough involved ripping the soil upto 40cm depth without inversion. Chiseling was done at an interval of 1.5m both in longitudinal and lateral directions.

Para-Ploughing

Ploughing using para-plough was done to a depth of 35cm. This shattered the sub-soil making it loose without disturbing the top soil. The para-plough (**Fig.1**). consisted of two shanks fixed opposit to each other at a distance of 37cm. Shares were fitted in the shank at an angle of 37.5 degrees. The interfacial area of the plough is 375cm^2. A mounting frame was provided to attach the unit to the three-point hitch of the tractor. The depth of operation was controlled by a tractor hydraulic system. Paraploughing was done continuously.

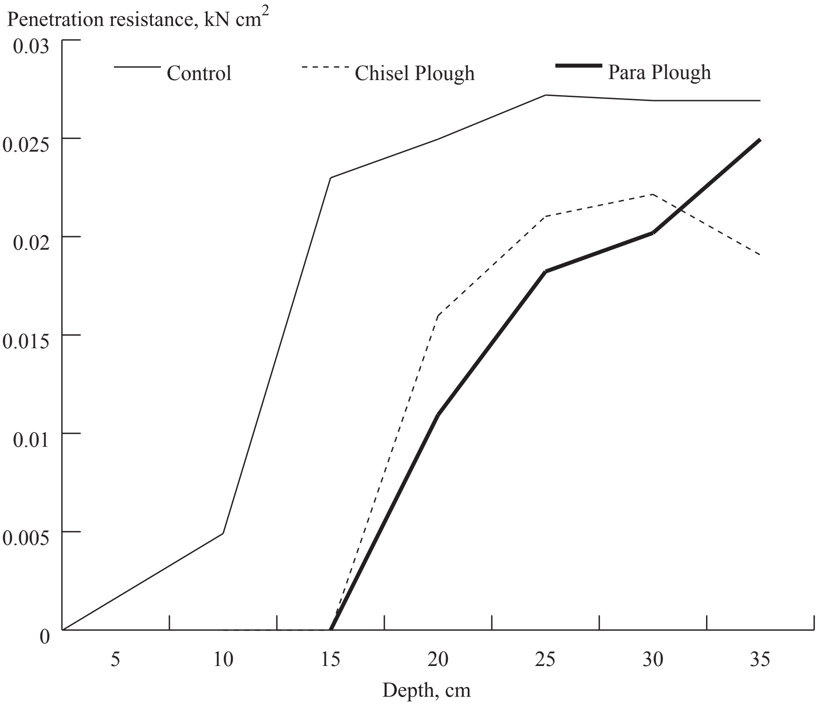

Fig.2 Penetration resistance

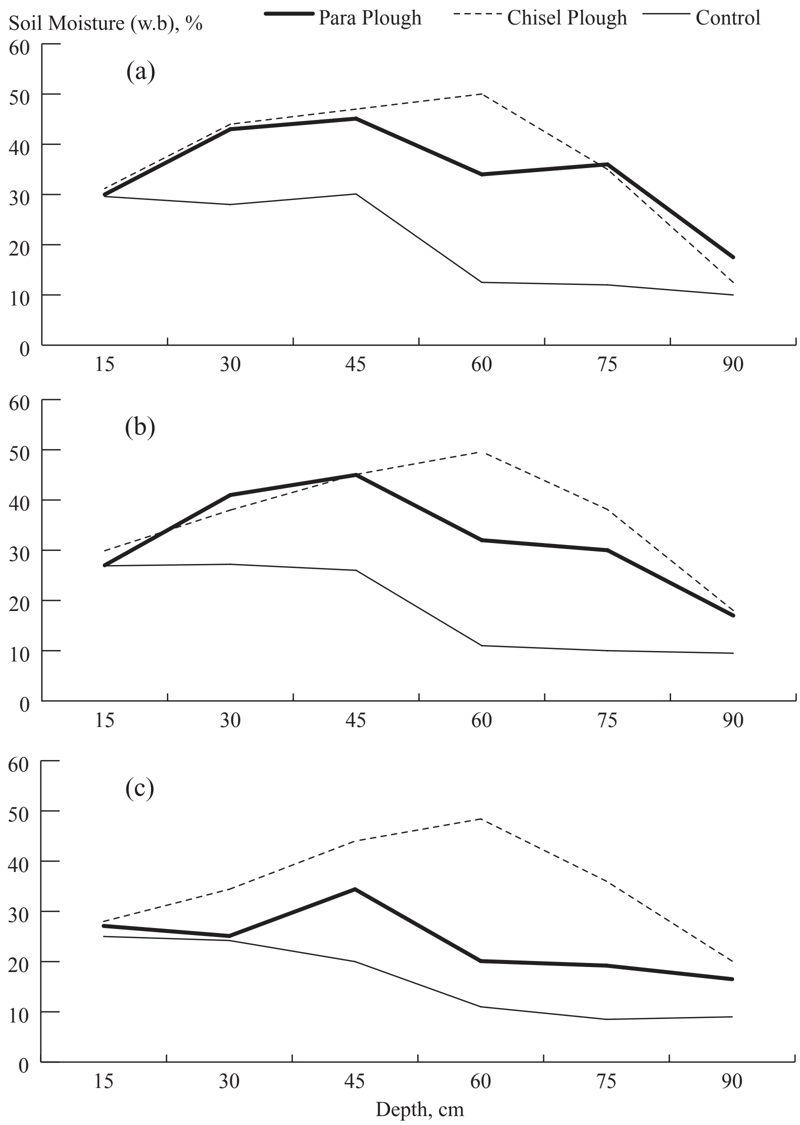

Fig.3 Soil moisture status after 161mm rainfall
(a) after 1st day, (b) after 4th day, (c) after 7th day

Determination of Physical Properties

Bulk Density

The bulk density of the soil was observed by core cutter method (Punmia, 1994)

Hydraulic Conductivity

The hydraulic conductivity of the soil was measured by constant head method (Baruah and Barthakur, 1999). The out flow water was observed by collecting it in a measuring jar until constant outflow was obtained. From the observations, the hydraulic conductivity was calculated.

Total Porosity

Undisturbed core samples were taken from the experiments site at three random locations and immersed in a water tub for 24 hours for saturation. These samples were taken out and weighed. The experimental set up consisted of a vacuum flask and a graduated cylinder connected by means of a rubber tube. A funnel was placed over the vacuum flask. The gradated cylinder was filled with water. A filter paper was placed in the funnel and the saturated soil core samples were transferred to it. The required tension (50cm) was applied by adjusting the level of the graduated tube which was allowed to equilibriate. The equilibrium condition indicated was monitored by cessation of water dropping from the graduated cylinder. Core samples were weighed and dried in a hot air oven for 24 hours. The dry weight of the sample was observed. The core samples were then discarded and an empty cylinder weight was noted. The total porosity was noted before and after the treatments.

Penetration Resistance

A proven ring cone penetrometer with a 30-degree angle was used to measure the penetration resistance of the soil. The unit was pushed vertically downward at random locations and the penetration resistances corresponding to different depths were observed. The experiment was repeated at different locations of the experimental plot and the corresponding penetration resistances were taken from the calibration graph.

Soil Moisture Measurement

A neutron probe was used to measure the soil moisture at various depths of 15, 30, 45, 60, 75 and 90cm at five locations in each treatment. Two-inch GI pipes of 120cm length was used as access tubes. Five access tubes were installed in each treatment at random locations to a depth of 90cm leaving 30cm above the soil surface.

Results and Discussion

Soil Physical Properties

The physical properties such as bulk density, hydraulic conductivity and total porosity of the soil were observed before and after enforcing the treatments and the average value is summarized in **Table 1**.

Bulk Density

The results infer that the soil ploughed using a para-plough gave rise to the least bulk density of

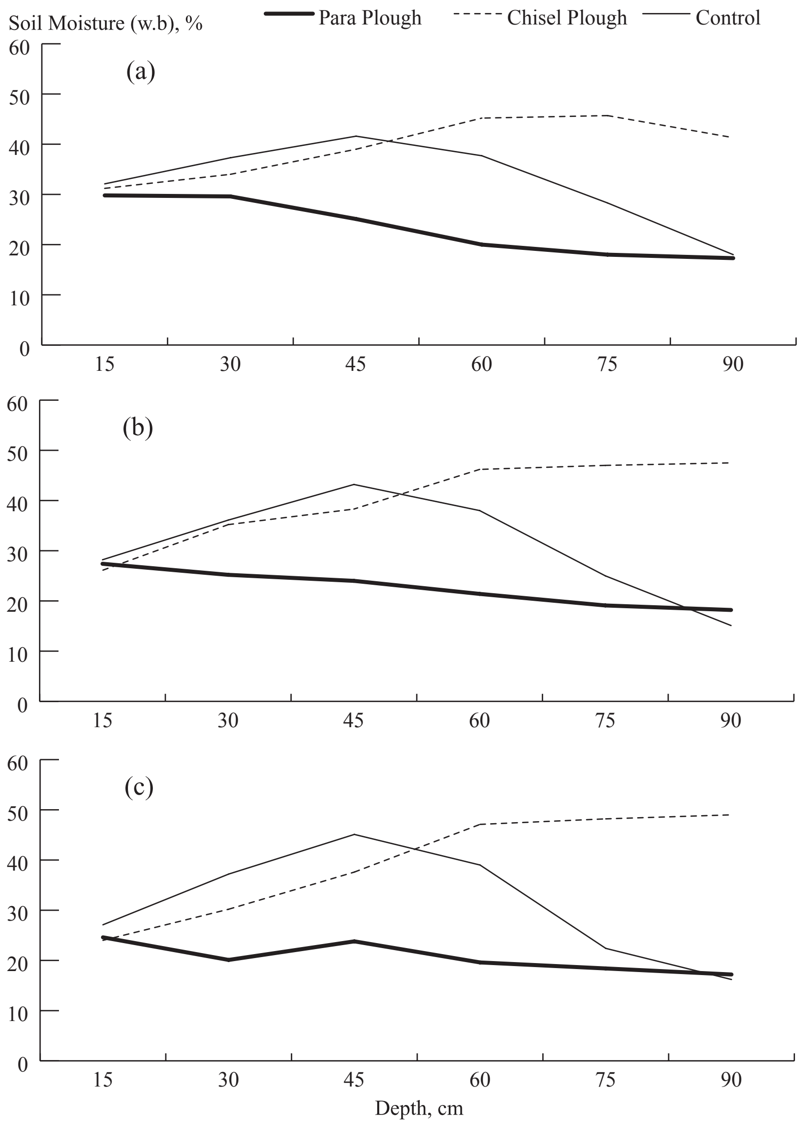

Fig.4 Soil moisture status after 47mm rainfall
(a) after 1st day, (b) after 4th day, (c) after 7th day

1.62g cm^{-3} followed by chiseled plot (**Table 1**). The bulk density which is an indicator of soil compaction showed that para-ploughing loosened the soil by 25% more at 30 to 45cm depth, whereas chiseling could achieve 18% over untreated plot (Srivastava *et al*., 1994). This is advantageous in increasing the moisture holding capacity of soil, thus the moisture retention.

Hydraulic Conductivity

The hydraulic conductivity of the soil was found to increase in both chiseled and para-ploughed land to the extent of 0.58 and 0.72cm h^{-1}, respectively, over the untreated plot. The improvement in hydraulic conductivity of the soil will help in increasing the water movement deep into the soil quickly, thus reducing run off and enhancing the soil moisture (Datiri and Lowery, 1991).

Total Porosity

The observations summarized that the total porosity has increased by 4% in the para-ploughed treatment followed by chisel-ploughing (3%). This is due to disturbance of macro-pores (Beven and Germann, 1972). From the results of porosity, it was concluded that the pore space created by the ploughing treatment is conducive to retaining more moisture than the control during precipitation.

Penetration Resistance

The penetration resistance observed in the three treatments is shown in **Fig.2** showing that the penetration resistance of untilled soil was higher than the para-ploughed and chisel-ploughed plots. In the para-ploughing treatment, the penetration resistance at 15 to 30cm depth was relatively lower than that of the chisel-ploughing but after 30cm depth the resistance was higher than the chisel-ploughing. This infers that the soil loosened by the para-plough was comparatively higher up to 30cm depth than the chisel plough.

Soil Moisture Status

The average soil moisture content observed before the treatments was 15.95%. The soil moisture status observed after 161 and 47mm rainfall are summarized in **Figs.3** and **4**, respectively. From **Fig.3 (a)**, it was observed that the moisture status in the para-ploughed and chisel-ploughed soil was almost constant up to 45cm deep. At 45 to 75cm depth, chisel plough had retained higher moisture than the para-ploughed soil (15%). After 75cm, the moisture retention was observed to be the same for both treatments. As expected, the unploughed land retained lower moisture from 30 to 90cm depth. After four days of rainfall, the moisture status up to 45 cm depth in para-ploughing and chisel-ploughing remained constant (**Fig.3 (b)**). In the para-ploughing, the moisture content decreased by 3 to 5% at 45 to 75cm depth. But there was no moisture depletion in the chisel-ploughed land. At 90cm depth, the moisture content again remained constant. There was a gradual decline in moisture content in the unploughed land in all layers (Jones *et al*., 1990). The decrease in the moisture content in the para-ploughed treatment may be due to

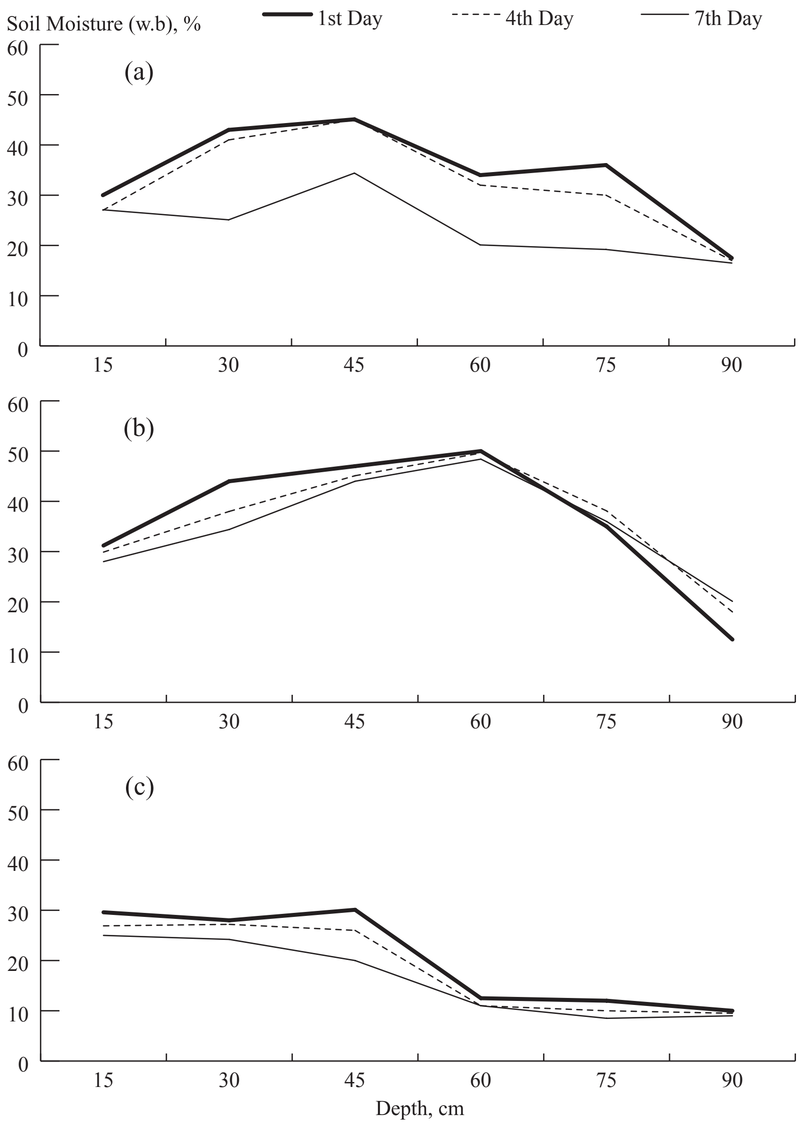

Fig.5 Moisture depletion pattern after 161mm rainfall
(a) para plough treatment, (b) chisel plough treatment, (c) control

greater moisture evaporation up to 45cm depth because of the loose nature of the soil. These moisture contents might have been supplemented from 60-75cm depth due to capillary rise. After seven days of rainfall, the moisture status of the para-ploughed land was low compared to the chisel-ploughing (**Fig.3 (c)**). The chisel-ploughed treatment could retain the moisture absorbed during the rainfall at 45 to 75cm depth, even after seven days.

The moisture status observed after the 47mm rainfall is shown in **Fig.4** which implies that the moisture status in the para-ploughed and chiseled land was almost equal up to 45cm deep. The chisel-ploughed plot replenished higher moisture than the para-ploughed treatment. When more rainfall was received, the chisel-ploughed land was capable of enriching more moisture from 45 to 90cm deep (**Fig.4 (a)** and **Fig.4 (b)**). The para-ploughed treatment could maintain almost the same moisture status up to 45cm deep on different days of observation (**Fig.4 (c)**). This might have been achieved due to capillary movement of moisture from the deeper zone to the surface.

Moisture Depletion Pattern

The soil moisture pattern in the three treatments after 161mm of rainfall is presented in **Fig.5**. The moisture observed in the para-ploughed treatment on the first and fourth day at different depths was almost identical except at 75cm (**Fig.5 (a)**). In that depth the moisture has depleted by 16%. On the seventh day, the moisture has depleted by 41% at 30 and 60cm depth. At 45 and 75cm depth, it was 23 and 47%, respectively. It was concluded that more moisture has been depleted at 30cm depth due to evaporation since the soil is low in bulk density. The depletion at 45cm was low since it was supplemented from 60 and 75cm depth by capillary action. In the chisel-ploughed treatment, the moisture depletion observed at 30cm depth was only 23% between the first and seventh day, compared to the para-ploughed treatment (41%) (**Fig.5 (b)**). Since the soil is not disturbed at 0 to 30cm depth, the moisture depletion might have been lower (Doty and Reicosky, 1978). In the control plot, the moisture depletion pattern between the first and seventh day at 15,30, 45cm depth was 13, 14 and 33%, respectively (**Fig.5(c)**). At 60, 75, 90cm depth, the depletion was negligible.

The moisture depletion pattern after the 47mm rainfall is shown in **Fig.6** showing that the moisture depletion pattern between the first and seventh day in the para-ploughed treatment and controlled treatment was almost identical (**Fig.6 (a)**). Only at 15cm deep had the chisel-ploughed treatment 7% more depletion than the para-ploughed treatment (**Fig.6 (b)**). In the control plot the maximum moisture depletion of 31% was 30cm depth (**Fig.6 (c)**). At 15cm depth, the depletion was 5% lower than that of the chisel-ploughed treatment. The moisture depletion pattern at 45 to 90cm depths in the control treatment was negligible. It was concluded that the para-ploughed treatment conserved more moisture up to 45cm depth whereas the chisel-ploughed treat-

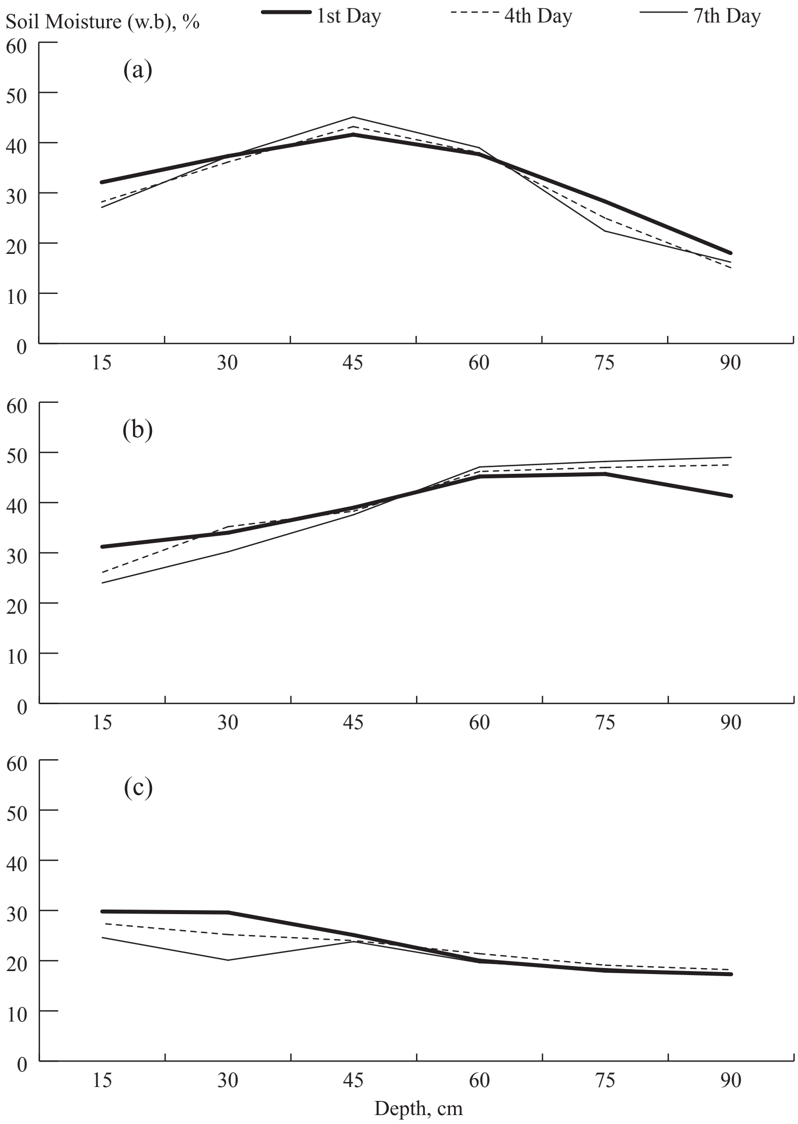

Fig.6 Moisture depletion pattern after 47mm rainfall
(a) para plough treatment, (b) chisel plough treatment, (c) control

ment conserved more moisture at 60-90cm depth.

Conclusions

The para-ploughing loosened the soil 25% more at 30 to 45cm depth. The chisel-ploughing could achieve 18% more over the control treatment. The hydraulic conductivity of the soil was found to increase in both chiseled and para-ploughed land to the extent of 0.58 and $0.72cm^{h-1}$, respectively, over the unploughed land. Total porosity has increased by 4% in the para-ploughed treatment followed by the chisel-ploughing in the soil (3%). In para-ploughing, the penetration resistance up to 15 to 30cm depth was relatively lower than that of the chisel-ploughing and after 30cm depth, the resistance was higher than that of the chisel-ploughing. The para-ploughed treatment conserved more moisture up to 45cm depth whereas the chisel-ploughed treatment conserved more moisture at 60-90cm depth.

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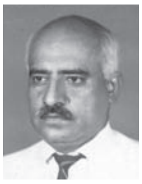
Effect of Storage Conditions on Emergence of Helthy Seeding of Soyabeen

by



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Abstract

Experiments were conducted at the Agriculture University Peshawar, Pakistan to study the effect of seed storage conditions on the emergence and health of soyabean seedlings (Cv. Lee) under field conditions. The storage treatments were: seed placement cloth bags, plastic bags, gunny bags, pitchers, tin cans, pods and in a refrigerator. Each treatment was replicated three times in a randomized complete block design. Data revealed that field emergence was significantly different for different sampling dates as well as for different storage containers. Seed emergence was greater for early sowing of the crop and for seed stored in pods and in the refrigerator, respectively. Further, data demonstrated that storage container type significantly affected the percentage of healthy seedlings. The seed stored in pods and in refrigerators had 51.6% and 52.8% healthy seedlings, respectively.

Introduction

Soyabean seed viability and stand establishment are major constraints in soyabean production because a considerable amount of the seed becomes useless due to improper storage. Longevity of seed viability is increased by controlling seed moisture content and storage temperature. Thomas, (1980) reported that a suitable combination of factors for safe storage of soybean seed was a moisture content below 12% a temperature less than 10ºC and a 70% relative humidity. Radhakrishnan, (1983) reported that seeds stored in air-tight glass containers maintained 40% germination for 4 months and in gunny or polythene bags for 2 months. He further reported that soyabean seed lost viability more rapidly than did small seeds. Delouche, (1974) reported that high quality seed lots maintained germination above 80% for the full carry-over period under warehouse conditions. Ohta *et al*., (1979) reported that stored seeds at 15, 25 and 35ºC at 60, 70 and 80% relative humidity had observed variation in germination capacity. Godoy *et al*., (1976) stored large, medium and small seeds at 25ºC and 35% relative humidity, and they found that germination was proportional to seed size and decreased with storage time. Holman and Carter, (1952) reported that at moisture contents below 12% germinability will remain good for up to two years. Storage of seed at low moisture levels in vapor-sealed packages prolonged viability Ashraf and Gregge, (1971), Amaral *et al*., (1948) stored seed with initial moisture contents of 11.4 and 13.4% in Jute, Polythene and multi-layer paper bags from April to December and found no difference in seed vigor resulted. Bogolepove, (1981) reported that seed when seed was stored at constant temperature and humidity, the best results were obtained with seed stored in plastic bags. Ravalo *et al*., (1980) reported that seeds with an initial moisture content of 8.6% in sealed bags at 12ºC had minimum loss in viability and 85% germination after eleven months. Srivastava, (1975) and Tonne *et al*., (1978) reported that germination was the highest in seeds stored at 8.6% moisture content in metal cans rather than in bags. Delouche, (1977)reported that soyabean seed could be stored at 15-18ºC and 60% relative humidity or at 9% moisture content in vapor proof packaging. Keeping in view the above findings, therefore, it was decided to study the effect of seed storage conditions on seeding emergence and health for soyaeans under field conditions.

Material and Methods

The experiment was conducted at the Agriculture University Peshawar to study the effect of seed storage conditions on the emergence and health of soyabean seedings under field conditions. The treatments were storage in; cloth bags, plastic bags, gunny bags, pitchers, tin cans, pods and a refrigerator. Each treatments was replicated three times in a randomized complete block design. Seeding emergence tests were conducted with a split plot arrangement in four replications on a silt clay loam soil.

For determination of field emergence and seedling health, groups of 100 seeds from each treatment were planted from April 1st and onwards when the soil temperature was high enough to stimulate germination. Seedlings with cotyledons free of the soil surface were counted until no more seedlings were recorded as having emerged for three consecutive days. The number of healthy seedlings was recorded as the number of those seedlings appearing to be free of diseases, discoloration and abnormalities. Data were analyzed according to the appropriate design, and means were compared according to Duncan's New Multiple Range Test Leclarge *et al*., (1962).

Results and Discussion

Field emergence was significantly different for different sampling dates as well as for different storage containers (**Table 1**). However, for, three out of the ten sampling dates, significant differences among the means for the various containers were not detected. The entire source of difference due to container type was due to reduced emergence for seed stored in tin cans, when averaged across the various planting dates. Emergence declined from 86.8% in April to 42.1% in August, with noticeable reduction from the middle of the May and onwards. Seedling emergence increased on August 15 irrespective for the storage container type except type for seeds stored in the refrigerator. Similarly, Hatam and Jamro, (1991 and 1992) reported that emergence was higher in April and May than in June. Furthermore, they reported that highest emergence was recorded in cool months while emergence gradually declined to a minimum in the hot dry season, followed by increased emergence again during the monsoon season. Further, Burris, (1980) reported that seeds stored in a refrigerator at 6^{o}C had higher germination than those plastic bags although the moisture was same for both seed lots.

Storage containers types and storage period significantly affected the germination percentage of healthy seedlings. A minimum of 37.8% and 42.3% healthy seedlings were recorded in tin cans and plastic bags, respectively No significant reduction in the percentage of healthy seedlings (**Table2**) was observed for up to 135 days of storage. However, reduction in germination proceeded subsequently with a greater rate up to the end of storage period, reaching a minimum valve of 30.6% in July followed by 32.1% in August. The number of healthy seedlings increased during the last fifteen days of storage in the two above-mentioned containers.

Seed moisture content declined due to post-harvest ripening in storage and to decreases in relative humidity. The loss and re-absorption of moisture in unsealable containers was different than in air-tight containers (tin cans, plastic bags). The rise in seed moisture content was mainly because of re-absorption of moisture in the high-humidity monsoon season. Re-absorption of moisture by seeds was high and rapid in some containers as compared with others. In the case of the unsealable containers, seeds which were hygroscopic, absorbed moisture until the vapor pressures of seed moisture and atmospheric moisture were in equilibrium. In the tightly sealed containers the seeds already had enough moisture and the equilibrium was reached very soon quickly.

Noticeable reduction in germination was observed with rise of temperature from April and onwards. This trend was more pronounced with certain types of speed containers. The reduction was greatest in seed stored at high moisture (tin cans, plastic bags) and those with both high temperature and high moisture levels (tin cans, plastic bags). Both high temperature and

Container	Apr 1	Apr 15	May 1	May 15	June 1	June 15	July 1	July 15	Aug 1	Aug 15	Mean
Cloth bag	86.0abc	80.7	75.0d	62.7	53.3	42.7b	45.0c	56.7a	49.0a	58.7ab	61.0ab
Plastic bag	94.7bc	75.0	83.8ab	58.3	48.0	45.0b	47.0b	47.3a	46.0ab	69.3a	61.5ab
Gunney bag	88.0ab	78.0	82.0bc	56.3	52.3	46.0b	46.0b	54.3a	42.3b	61.7ab	61.1ab
Pitcher	68.7ab	81.0	75.7cd	60.0	53.0	50.3b	50.3b	51.7a	42.0b	65.3ab	63.4a
Tican	82.7c	84.0	82.3bc	57.3	49.7	44.0b	44.0b	29.3b	34.3c	34.3c	54.2b
Pods	86.7ab	86.7	82.7bc	63.3	54.3	72.3a	72.3a	62.3a	53.3b	53.3b	66.4a
Refrigerator	89.0a	89.0	90.0a	64.7	54.0	52.7b	52.7b	61.7a	53.7b	53.7b	67.2a
Mean	86.8a	81.1	81.6b	60.4	52.1e	50.4c	60.9c	51.9c	42.1f	65.6d	

Table.1 Effect of Storage Containers on Field Emergence of Soyabean (Cv. Lee)
(Values with the same column followed by a common letter are not significantly different (P=0.05) according to Duncan's New Multiple Range Test)

high moisture are reported to be detrimental to germination Ashraf and Gregg, (1971), Goldovskil and Smolyak, (1984) and Burris, (1980). Seeds stored in a refrigerator at 6ºC had higher germination than those in plastic bags, althrough the moisture content was the same in both cases. The seeds in pods were exposed to ambient temperatures and humidity as was the case with storage in most of the other containers, but germination was the highest because individual seeds in the pod cavity may have been provided with a different micro-environment which protected them against dumping of seeds on other seeds as may have taken place in other types of containers.

Field emergence could have been affected by high ambient temperature, fluctuations in relative humidity and by soil-borne diseases. The loss of soil moisture influenced by relative humidity and temperature, during the emergence period may also have been a cause of low emergence. Emergence increased again during mid- August when relative humidity increased and daily evaporation decreased which conditions were different from those in the laboratory where there was a constant decrease in germination. Germination and emergence percentages were directly proportional to the percentages of healthy seedlings. However, the reduction in germination in February was not linked with a reduction in the number of healthy seedlings, suggesting that these two were independent phenomena.

Conclusion and Recommendations

Field emergence was significantly different for sampling dates and for seed stored in different types of containers.

Emergence decreased as planting dares become later.

Seed germination percentages and numbers of healthy seedlings had consistently similar responses under all storage conditions.

Germination and emergence percentages were greater for seeds stored in pods and those stores in the refrigerator.

Healthy seedling percentages were directly proportional to those for germination and emergence.

The storage of seeds at ambient temperature levels as is usually done by farmers, was found to be a practice that allowed deterioration of germination and emergence characteristics.

Storage at a low temperature (6 ºC) or in pods appeared to be ideal with regard to retaininig in maximum germinability.

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(Continued on page32)

Container	Apr 1	Apr 15	May 1	May 15	June 1	June 15	July 1	July 15	Aug 1	Aug 15	Mean
Cloth bag	60.0b	61.7bcd	60.0b	47.7	34.7bc	31.7b	27.7	31.3ab	37.0a	40.0	43.2b
Plastic bag	61.7b	65.0bc	63.0ab	44.7	33.7c	28.3b	29.0	26.7b	33.3a	37.3	42.3bc
Gunney bag	59.7b	60.0cd	60.0b	45.7	42.0a	33.0b	31.7	30.0ab	32.0a	41.7	43.8b
Pitcher	59.3b	57.7b	61.7ab	42.7	39.7ab	33.0b	35.0	31.3ab	34.0a	43.3	43.8b
Tican	59.7b	66.3bc	60.0b	46.7	31.3c	29.3b	31.7	14.0c	10.7b	28.0	37.8c
Pods	73.3a	67.3b	66.7a	51.0	45.0a	50.7a	41.7	40.7a	36.3a	44.0	51.6a
Refrigerator	70.7a	74.7a	66.7a	53.0	45.0a	49.3a	51.0	41.0a	41.3a	46.0	52.8a
Mean	63.5a	64.6a	62.6a	47.7	38.3cd	36.5de	34.0ef	30.6g	32.1fg	40.1bc	

Table.2 Effect of Storage Containers on Percentage of Healthy of Soyabean in Field (Cv. Lee)
(Values with the same column followed by a common letter are not significantly different (P=0.05) according to Duncan's New Multiple Range Test)

Development of a Check Valve Mechanism as an Attachment to a Power Tiller Operated Seeder

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Abstract

Field evaluations were conducted on a power tiller operated cup feed seeder, developed in the Department of Farm Machinery, Tamil Nadu Agricultural University, India to assess the uniformity of seed spacing in the row. Even though the seeder could maintain the row to row spacing, the uniformity of plant spacing in the row was poor as indicated by a wide frequency distribution of plant spacing. So, a check valve system was contemplated to be incorporated with the cup feed seeder, so that the hill to hill drop distance (the plant spacing) could be maintained properly. The concept of the check valve system was to accumulate the seeds coming through the delivery tube at the tube end and to drop them collectively at pre-determined intervals or spacing. It had a flap valve toggled by a pegged disc mounted on the ground wheel. Field trials were undertaken sowing black gram and maize, to compare the seeder's performance with and without the inclusion of the hill dropping system. The observed spacing distribution of the crop planted using the check valve equipped seeder was almost that of a normal distribution, with the peak frequency aligning exactly at the desired hill spacing in the row. The filled capacity of the seeder with check valve was lesser by 11.2 to 34.5% than that of the seeder without the check valve. However, the hill spacing improved the plant geometry so much that all the ensuing operations for the crop were efficient. The mechanical lag of the check valve was a serious constraint on the planting speed of the seeder. An improved valve design or pneumatic valve actuation would definitely enhance the operating speed of the system.

Introduction

Agriculture is the foundation of Indian economy both in terms of its share in the Gross Domestic Production (GDP) and the number of workers it can employ. More than 70% of the agricultural land holdings are medium and small farms (less than 2ha). As mechanical power of some form always enhances productivity

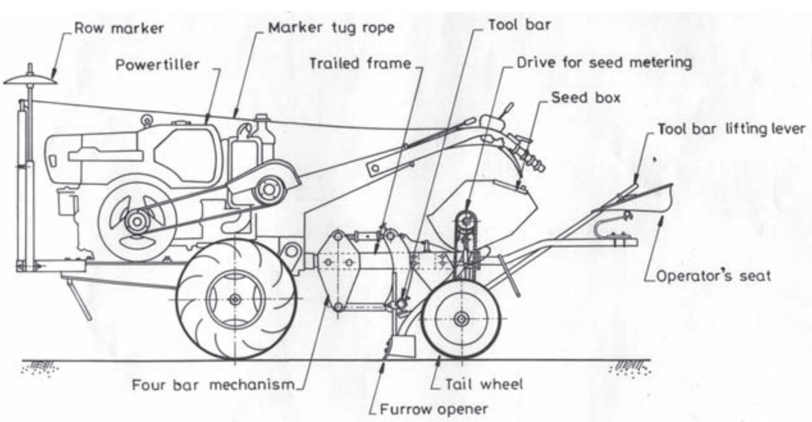

Fig.1 Power tiller operated cup feed type seeder

by ensuring timely field operations, a suitable power source for the medium and small farm is the need of the hour. In this respect, the power tiller is the most suitable power source in all aspects. But the main disadvantage is the non-availability of proper matching implements to use with the power tiller. So, considering the suitability of the power tiller to the Indian farming scenario and also the fact that all post-planting operations depend on proper plant geometry, a power tiller operated cup feed seeder (**Fig.1**) was developed in the Department of Farm Machinery, College of Agricultural Engineering, Tamil Nadu Agricultural University during the 1999-2000.

The major components of the seeder are: (a)the trailed frame; (b)the ground wheel, from which the power is transmitted to the cup feed rotors through chain and sprocket; (c)the main shaft, where the cup feed rotors are mounted; (d)the seed metering mechanism comprised of cup feed rotors with 16 cups, suitable for a wide range of seeds from green gram to groundnut; (e)the seed funnel which collects and directs the seeds to the seed tube; (f)the seed box to hold the seeds; (g)the hoe type furrow openers opening the furrow for proper placement of seeds at desired depth; (h)the tool bar lifting mechanism to engage and disengage the cup feed rotors with the help of a dog clutch; and (i)a set of row markers to align adjacent seeding passes in the field.

Need for the Check Valve System

Field evaluations were conducted on the machine to assess the uniformity of seed spacing in the row. The field trials were conducted in farmers' fields in the Coimbatore district, Tamil Nadu, India, for the sowing of black gram in an area of 0.2078ha. The RNAM test code was used as the standard test format for evaluating the seeder. The occurrence of different plant spacings as observed in the row were measured and recorded. A histogram (**Fig.2**) relating the frequency of each range of plant spacing was plotted. The seed spacing frequency as measured for the germinated crop showed a wide range of spaces commencing from 1cm onwards to 20cm. Even though the seeder could maintain the row to row spacing, the uniformity of plant spacing in the row was very poor as indicated by the wide frequency distribution of plant spacing valves. This poor uniformity of distribution resulted mainly because of multiple pick up of seeds by the metering mechanism.

The resulting type of spacing distribution in the row demanded excessive thinning operations to achieve a suitable crop stand. Choosing the plants to be thinned in the row so as to obtain the required uniform plant spacing, was also difficult. Reduction of the number of cups might have resulted in further widening of the spacing obtained, implying the need for a space filling operation rather than for thinning. This situation obviously could be remedied only by resorting to an improved sowing method, either precision planting or hill dropping at an exact hill to hill spacing.

The term "precision planting", is widely used and means the accurate, even-spaced in the row placement of seeds at uniform depth (Khan and McColly, 1971). Precision planting saves seeds, utilizes fertilizer to the best advantage and increases yield by enabling good cultivation practices. It involves singulated placement of seeds at precise spacing in the row, which is a complex process.

Wilkins and Lenker (1981) developed and tested a microprocessor-controlled planter for precision sowing. Laboratory tests proved that the unit metered raw lettuce seeds with fewer errors. Parish *et.al*., (1999) developed a belt-metering seeder for soybeans for precision seed spacing and compared its performance with that of commercial seeders equipped with fluted wheel, brush, or finger-type metering systems. They observed that at ground speeds of 3.2 to 9.6km^{h-1}, it was able to me-

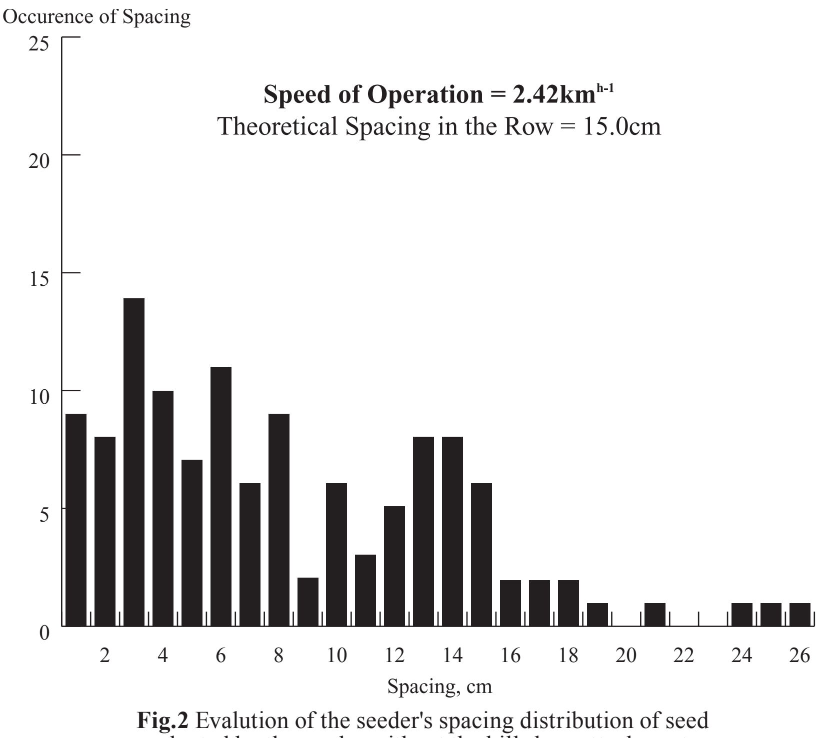

Fig.2 Evalution of the seeder's spacing distribution of seed planted by the seeder without the hill-drop attachment

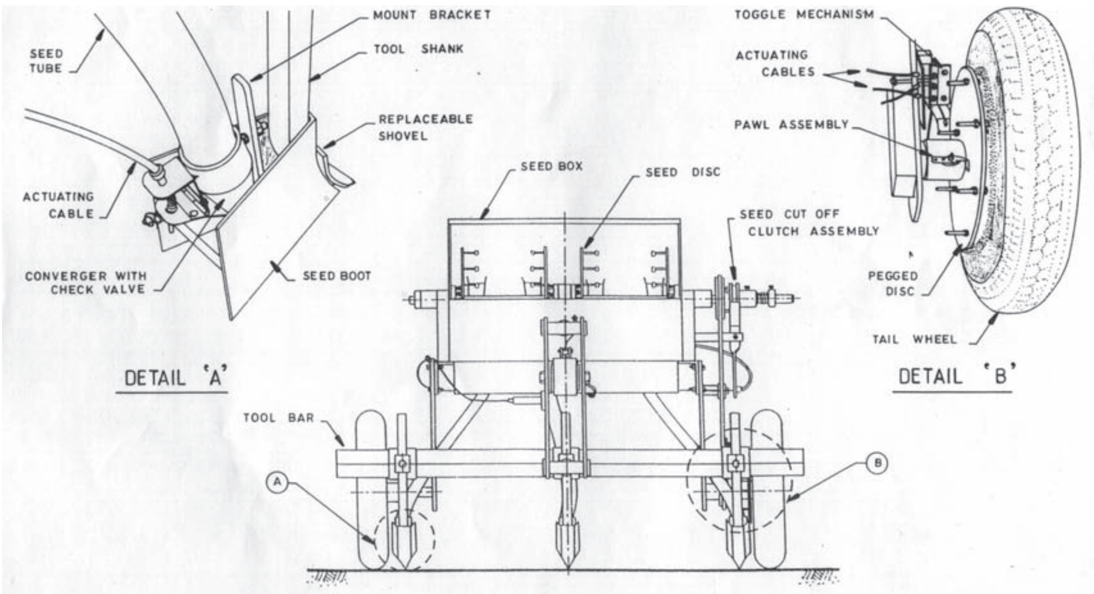

Fig.3 Check Valve Attachment

ter soybeans with a mean spacing of 23 to 30mm for a normal spacing of 24mm with a quality of feed index of 38 to 46%.

To avoid the complexity and the associated cost of a precision planter, the best alternative appeared to be a hill drop planter. Ahmed and Gupta (1994) developed a single-row manually operated electrostatic planter for small seeds. Hill to hill spacing could be changed by varying the number of pick up pins on the rotating wheel. To overcome the problem of scattering of seeds in a hill, Ryu and Kim (1998) developed the roller type metering device. Experimental results showed that the newly developed metering roller had better performance with regard to seed placement than did the previous one.

From the results of the field trials with the cup seeder, it was observed that it could not maintain the uniformity of spacing between plants in the row, not only because of the external and field parameters, but also because of the inherent irregularity of the seed metering device. But, the main factor causing irregularities was the time lag during the seed trajectory through its path from the point of seed release to the tube end. However, the irregularities of the field, bouncing of seeds on the seedbed and scattering of seed were some other problems affecting the uniformity of spacing. So, it was deemed that a hill dropping system would be a viable solution for neutralizing the non-uniform spacing obtained. A check valve system was contemplated to be included to the existing cup feed seeder, so that the hill to hill drop distance (the plant spacing) could be maintained properly. The objective of this work was to develop and evaluate such a system.

Check Valve System

The concept of a check valve system (**Fig.3**) is to accumulate the seeds coming through the delivery tube at the tube end and to drop them collectively at pre-determined intervals or spacing.

Check Valve Assembly

The check valve is a simple hinged door closing the tapered mouth of a seed converger (**Fig.4**) and mounted on the end of the seed tube. The valve is hinged freely with respect to the fixed frame of the

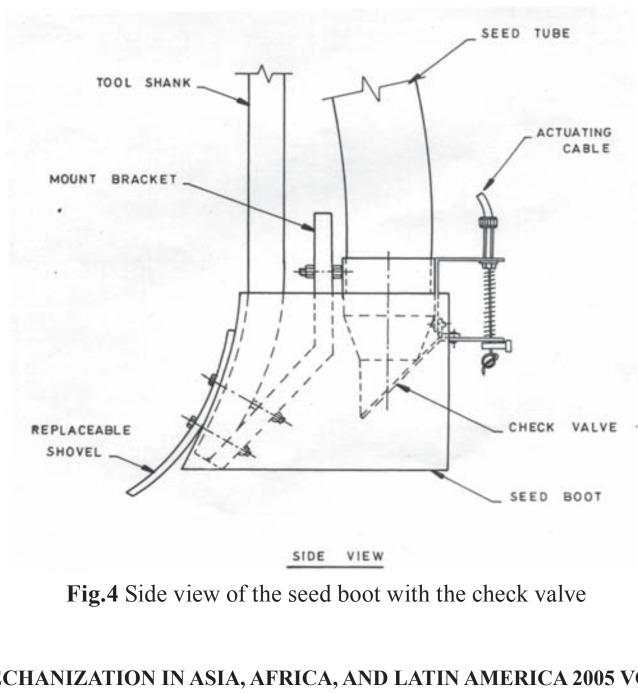

Fig.4 Side view of the seed boot with the check valve

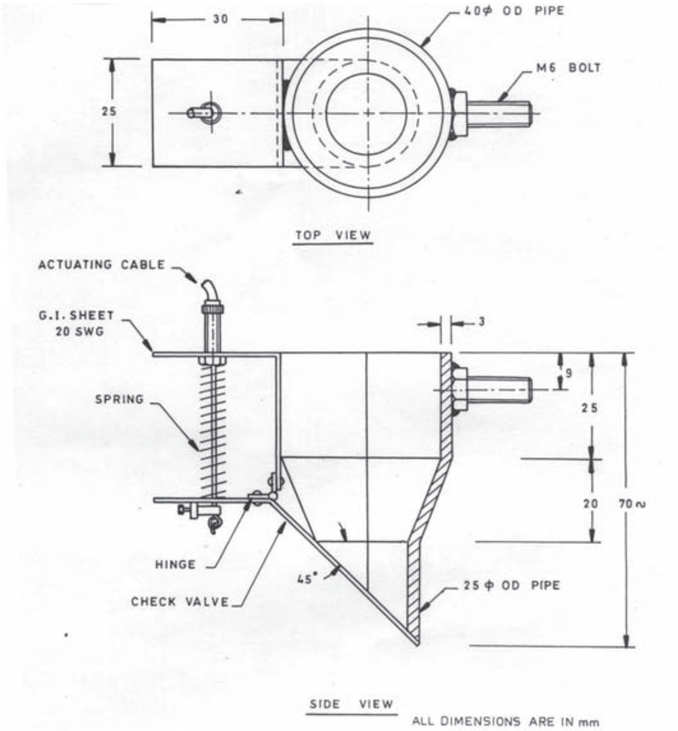

Fig.5 Converger with check valve

assembly so that it closes or opens the tube end with ease. Normally, the valve is kept in the closed position because of the spring provided between the lower arm at the back and the chassis. A cable rest-screw is provided on the fixed frame of the valve assembly to adjust the tension of the spring, so that the pressure of closure could be adjusted. One end of a cable was fixed on the valve (**Fig.3**) as inserted through the screw and spring. The other end of the cable was connected to a valve-actuating toggle mechanism.

Converger

The converger was made of steel (**Fig.5**) and placed at the end of each seed tube inside the seed boot. The main objective of the converger is to accumulate the hill of seeds so that seeds are clustered in placement, as well to provide a proper seating for the check valve itself. The degree of taper of the inside hole was made in such a way that it was greater than the angle of repose of the seeds so that the seeds would flow easily without interruption. The delivery side of the converger was cut at an angle of 45 degrees, so that positive seed clustering would be achieved and the bouncing back of seeds by the check valve would be minimized. Because of this particular shape, seeds accumulated at the bottommost part of the converger, where the check valve opening was the greatest. Hence, scattering of seeds due to the check valve opening motion was controlled.

Toggle Mechanism

A toggle mechanism was provided to open the check valves in all the furrow openers at a pre-determined interval, with respect to the travel of the seeder's ground wheel. The mechanism pulled the valve cable and hence actuated the valves. The mechanism mainly consisted of a "L" shaped flap, which was hinged to the wheel drop frame of the seeder (**Fig.3B**). The cables from the valve assembly were connected to the flap through the holes provided on the main frame. The other side of the flap was in a position to become activated by "pegs" provided on the periphery of a rotating pegged disc mounted on the ground wheel. When the pegs pushed the flap, the cables were pulled resulting in the opening of the check valves. After toggling the valves open, the pegs disengage automatically from the flap and the valves return to their closed position. This action of the valves clusters the seeds fed from the cup-feed metering system at the tube end and allows them be dropped as a hill whenever the valve opens. Valve toggling is repeated with respect to the number of pegs on the disc and thereby the hill to hill spacing on the row is achieved.

Pegged Disc

The pegged disc was mounted on the wheel hub, so that it could rotate freely over the hub. Pegs were provided on the periphery of the disc at uniformly spaced intervals (**Fig.3B**) and the inter-peg distance could be changed to effect the desired hill spacing. The pegged disc was engaged to the ground wheel hub through a pawl and ratchet mechanism.

Pawl and Ratchet Mechanism

A pawl and ratchet mechanism was provided to prevent the toggling of the valves, while the power tiller operated seeder was reversing. It is a simple free wheel mechanism that actuates the valve toggling mechanism only in the forward direction and not in the reverse direction. The ratchet mechanism hinges in one direction with respect to its axes and is spring loaded (**Fig.3B**). It doesn't fold in the other direction. While the seeder moves forward the ratchet mounted on the ground wheel hub, locks with the lock provided on the pegged disc and the two elements rotate together. This leads to the rotation of the disc along with the ground wheel hub, and thereby valve toggling becomes actuated. This in turn pulls the cables and results in opening of the valves and subsequent dropping of seeds. However, when the wheel reverses, the ratchet slides over the pawl (lock) on the hub preventing rotation of pegged disc. This permits the seeder to reverse without check valve actuation.

Results and Discussion

Field Trials on the Check Valve System

Field trials were undertaken sowing black gram (*Vigna mungo*) on a 0.6ha plot and maize (*Zea mays*) on a 0.56ha plot, essentially to compare the seeder's performance with and without the inclusion of the hill dropping system. It was observed that in both cases of the seeder operating without the hill dropping mechanism, a wide and poor distribution of plant spacing in the row was observed (**Figs.6a & 7a**). The occurrence of multiples i.e., a seedling spacing range of 1 to 3cm was predominately higher in both the aforementioned cases. This was a clear indication that, the cup-feed seeding mechanism inherently was a drilling mechanism rather than a planting mechanism. It was also clearly seen that, even when the cup configuration was intricately modified to suit the exact size of the specific seed, the cups actually picked up multiples. When the seed cup was sized to grip each seed tightly the metering mechanism exhibited too many misses of seed pick up and hence this size of seed cup was not chosen to be used in the trials.

When the check valve was added at the bottom of the seed tube to collect and drop a hill of seeds at a specific plant spacing, the situation was observed to have improved greatly. The system was operated at a slower speed of 1 to 1.3km^{h-1}, so that the valve would have enough time to place the seeds in a bunch at the specified spots. Here, the resulting hill spacing distribution was found to be nearly that of a normal distribution with the peak frequency aligning exactly at the desired hill spacing in the row (**Figs.6b & 7b**). The distributions were only approximately normal, because of the scattering of hills, due to valve inertia, mechanical lag, impact of the seed hill on the furrow bottom and the inefficiency of furrow closing. Although the seeder without the check valve could maintain the plant population, depth of seeding and row to row spacing according to the preset levels, the hill spacing in the row could be achieved only by the seeder with check valve attached.

Economics of Using the Check Valve System Developed

The field capacity of the seeder with check valve (0.06ha^{h-1}) was lesser by 11.2 to 34.5% than that of the seeder without check valve. This was because of the lower speed of operation (1.0 to 1.3km^{h-1}) adopted in order to reduce the effect of valve lag and scattering of seed hills.

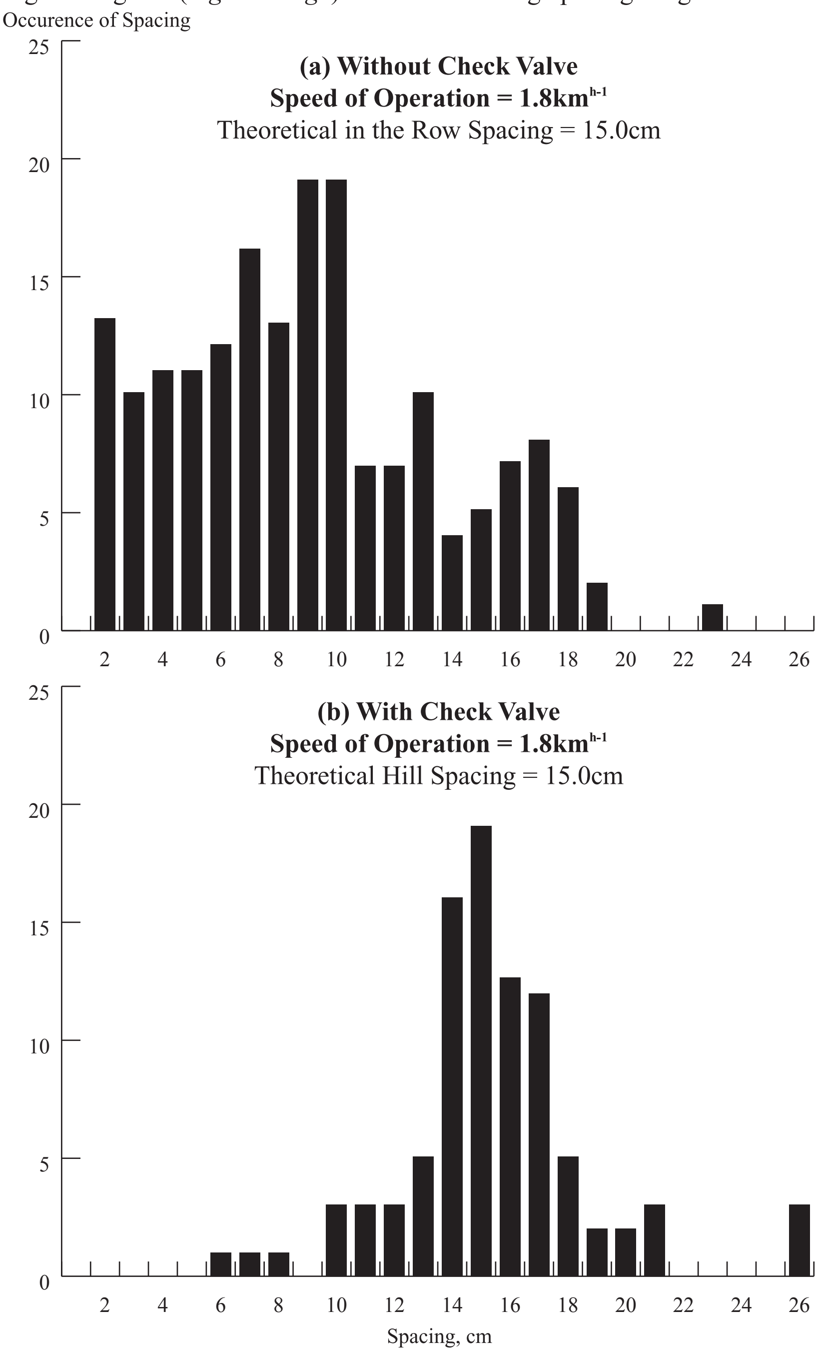

Fig.6 Distribution of in the row spacing for black gram

Particulars	Change in percent relative to the system without check valve	
	Trial sowing black gram	Trial sowing maize
Loss in time	12.62	18.10
Loss in labour	12.62	18.10
Increase in cost	20.47	21.66

Table 1 Cost economics of the seeder with check valve in comparison to those without check valve

The field efficiency of the seeder with and without the check valve was about the same, at ground approximately 70 to 75%. The reduced field capacity due to lower operation speed caused a loss in time and labour and an increase in cost (**Table 1**) as compared to these valves for the seeder operation without the check valve. However, the hill spacing improved the thinning efficiency and the in-field, plant-stand geometry so that all the ensuing operations with the crop were less cumbersome and more cost effective. The checked rows provided easy intercultural operations by way of cross blocking.

From the observations made in the field and the results of the field experiments, it was understood that the mechanical lag of the check valve was a serious constraint on the planting speed of the seeder. Improved valve design or pneumatic valve actuation would definitely improve the operating speed of the system.

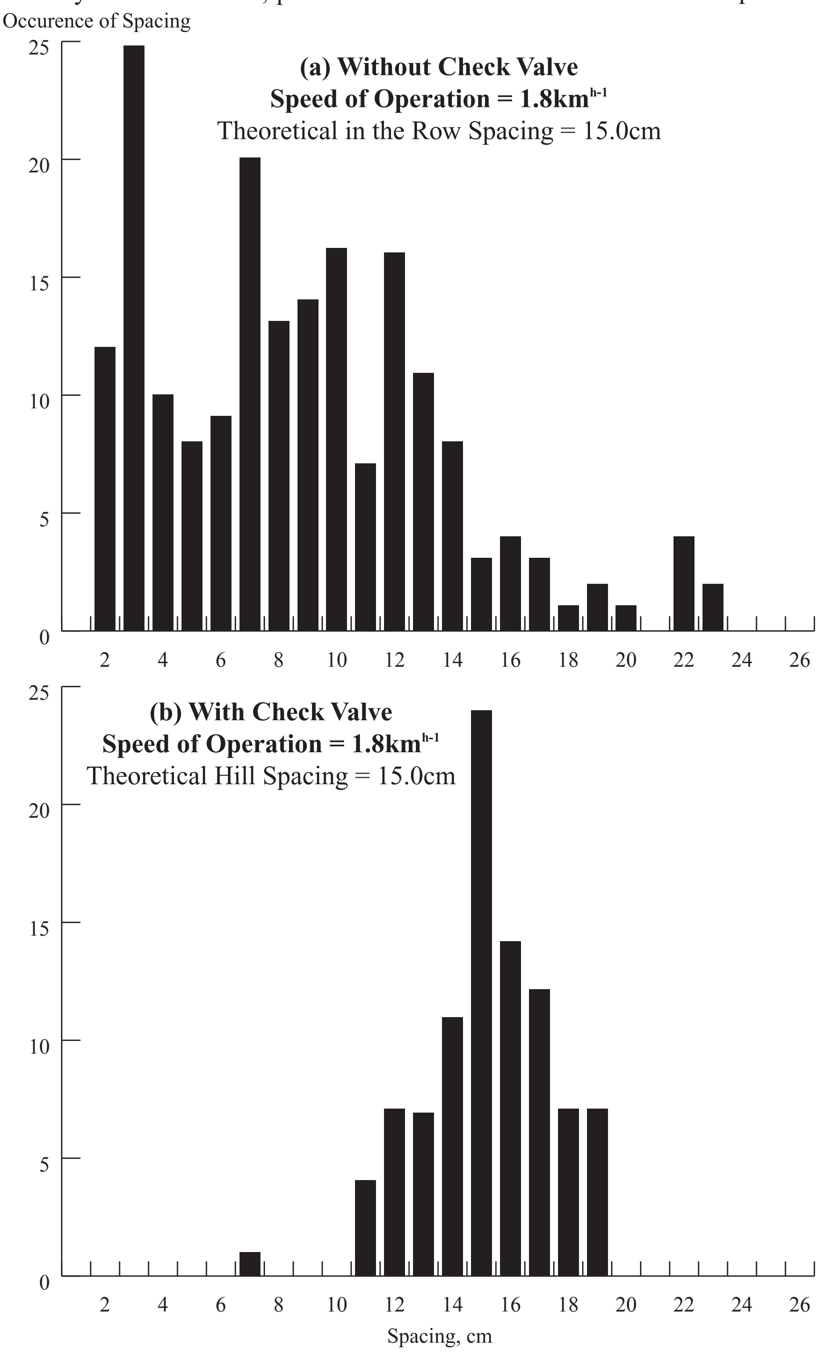

Fig.7 Distribution of in the row spacing for maize

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Freely Rear Converging Linkage System for No-Till Planter

by

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Abstract

Research was conducted on the kinematic performance of front and rear converging linkages (RCL) in comparison with the performance of parallel linkages (PL), both as might be applied to individual precision planter units. The mathematical model developed predicted the tine weight transfer required for soil penetration with an accuracy of 90% for the RCL based on comparisons with experimental results obtained under laboratory conditions. It was observed that the weight transfer from the main frame to the planter unit depended mainly on the magnitude of the draft force (F_x), and on the height of the virtual hitch point (VHP). This weight transfer represented only 50% of the total weight required for the planter unit to reach the desired planting depth as compared with the weight transfer provided by the (PL) system. Although the (PL) system required an additional tensile spring to achieve the required weight transfer-this system was shown to be more stable with regard to planting depth performance in comparison with the (RCL) system.

Introduction

Most of the work related to the analysis of converging linkage systems has been done in order to improve the tractive performance of the tractor, that is to say to add some weight from the implement to the tractor rear axle. In the case of minimum tillage planters it is required either to reverse this situation or to add some dead weight to individual planter units in order to provide enough weight to reach the to permit plunter opener to the appropriate planting depth in trashy and undisturbed soil conditions. The use of rear and front freely rotating converging linkages on seed drills was described by Abo El Ees (1978). He found by analysis of the two linkage geometries, and for specific conditions, that better weight transfer and greater depth of penetration for the same planter-unit weight, were achieved by the rear converging linkage rather than by the front converging linkage.

One of the disadvantages of Abo El Ees's RCL design was the tendency of the frame to tilt towards the front under dynamic conditions. Also it did not allow for soil surface irregularities to be accommodated without having an adverse effect on the orientation of the planter frame with respect to the horizontal. This could result in a undesirable performance, and under certain conditions, could affect significantly the final planting depth, and therefore, reduce the resulting crop stand.

The planting depth of a tractor mounted precision planter is normally controlled by a combination of gage wheels and the linkage system connecting the planterunit to the main frame. These have to be arranged and designed in such a way that allows the individual planter units to follow the soil irregularities. This is an important feature to be considered when a precision row crop planter is being developed, but if is even more important when the planter is to be employed in minimum tillage operations.

Literature Review

Two types of hitch linkages are common on present-day tractors. One type is the parallel-link hitches, which are employed extensively for front-mounted cultivators and for rear-mounted precision planters. The second type is the rear-mounted hitches which are of the rear converging-link type. Each of these types can be operated with the hitch member acting as a free link in the vertical plane or with the links restrained by means of the lift mechanism of the tractor (Kepner *et al.*, 1980). In this respect Clyde (1961) mentions that force relations for mounted or semi-mounted implements in a given soil condition are determined primarily by the design of the hitch linkage and of the implement, as well as by the method used for controlling implement depth, other than by hitch adjustment. Normally, in designing a system for mounted tillage implements for the rear of the tractor the following factors are considered (Kepner *et al*., 1980) :

1. Effect of the implement upon the tractive ability of the tractor weight transfer.
2. Uniformity of tillage depth as the tractor passes over ground-surface irregularities.

According to Johannsen (1954), the three-point hitch arrangements for rear mounted implements can be classified into two groups:

1. Restrained-link operation of three-point hitches.
2. Free-link operation of three-point hitches.

In restrained-link operation the implement gets all its vertical support from the tractor, the hitch links being free only when the tool is entering the ground. As soon as the tool reaches its working depth, it is held by the hydraulic system.

With free-link operation depth is sometimes controlled by gage wheels on the implement frame. With this system the convergence of the links in the vertical plane provides a virtual hitch point or instantaneous centre of rotation (VHP). The virtual hitch point can readily be changed by modifying the arrangement of the links In this respect, Kepner *et al*., (1980) mentioned that gauge-wheel-controlled free-link operation gives more uniform depth than either automatic position control or automatic draft control when the field surface is irregular and the soil resistance varies substantially. Due to the similarities of soil conditions with minimum tillage, this last comment supports the choice of the free rotating system for the planter prototype.

Parallel Linkage

Hitches with parallel arms are used on many mounted implements, such as precision planters and front mounted cultivators, and are usually used in situations where a floating system is required. In this system the depth of work can be controlled either by a lifting mechanism or with a depth control wheel. A free link operation is required to achieve precision control of the depth of the planter in a manner completely independent of the soil surface irregularities and of soil strength variations. The most common way to achieve this desired performance is by the use of gauge wheels rather than the restrained-link system. Kepner *et al*., (1980) notes that the virtual hitch point for a parallel free-link system is at infinity. Therefore, the direction of pull, in the vertical-longitudinal plane, must be parallel to the link arms. The magnitude of the vertical reaction forces, acting through the gauge wheels can be changed by changing the slope of the link arms. Moving the depth control wheels has no effect on the magnitude of the reaction forces acting upon them. Abo El Ees (1978) derived a mathematical expression,

$$NW = W/[1 + K Tan\beta]$$

where, (NW) is the net weight left for penetration and is equal to F_y, (W) is the total weight of planter unit including any added ballast weights, (K) is the ratio F_x/F_y and (ß) is the angle of the arm with respect to the horizontal. F_x is the horizontal force applied to the planter. Once the geometry of the links, is known the net penetration weight can be determined. This penetration weight is basically the vertical soil reaction acting through the implement and depends on the soil properties and conditions as well as on the implement design characteristics.

Rear Converging Linkage

The standard three-point hitch system on actual tractors includes on upper link and two lower links the latter of which converge towards the front and are free to move laterally within certain limits (Kepner *et al*, 1980). They may also be locked so they are laterally rigid. This is a desirable feature in most position control operations, such as mechanical weed control, secondary fertilizing applications, tractor mounted spraying etc. The upper and lower links converge vertically towards the front of the tractor. This particular feature of the restrained or free-converging link system allows for additional downward-acting

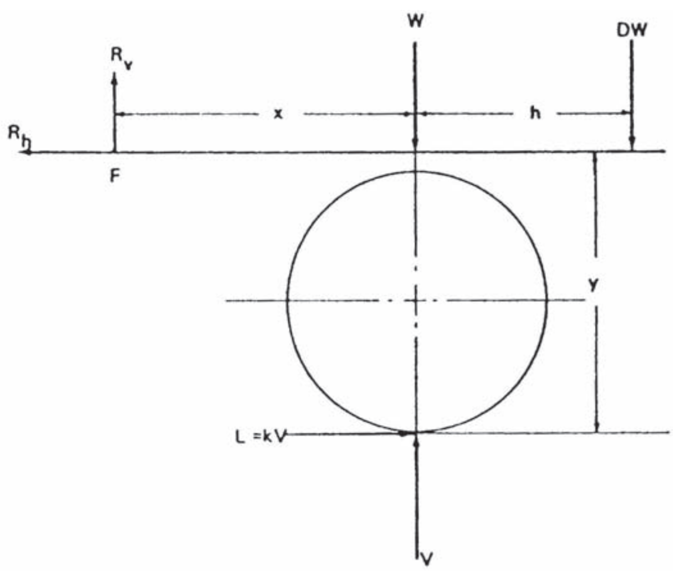

Fig.1 Vertical force relationship of a tool in vertical plane parallel to the dirsction on travel

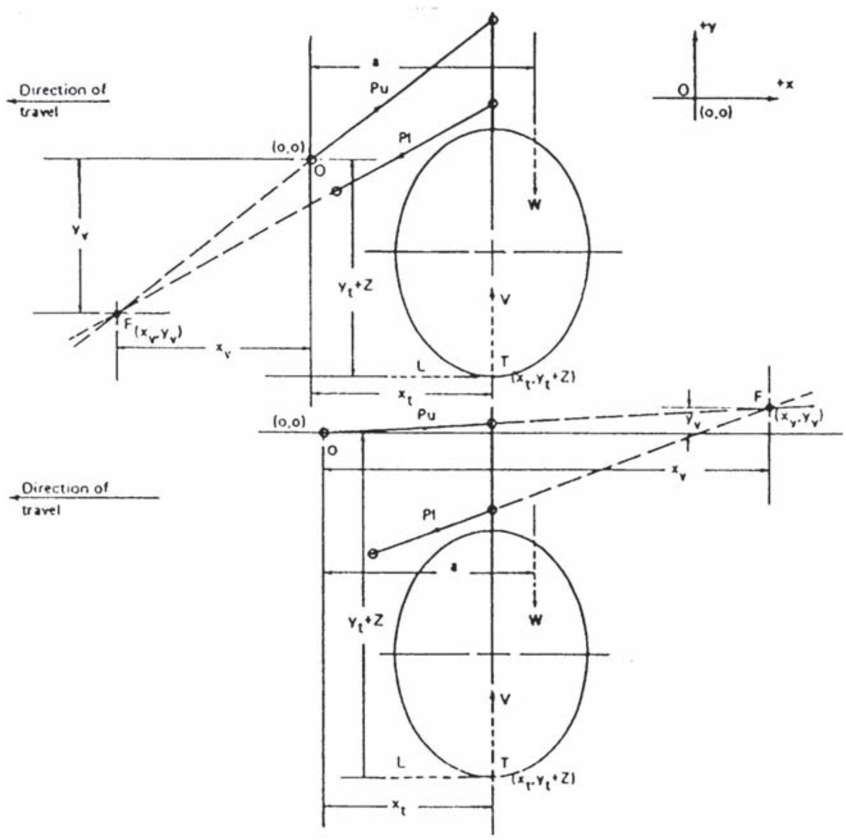

Fig.2 Vertical force relationship on a freely-rotating RCL and FCL types

dynamic weight transfer to the rear axle of the tractor for improving tractor performance. The principle of the vertical effects of mounted implements on the tractor was studied and analyzed by Clyde (1940). The importance of his analysis was mainly due to the recognition of the effect that the virtual hitch point was shown to play in penetration and traction. According to these principles, the resultant pull in the vertical plane parallel to the direction of travel is calculated to determine its effect on changes in vertical forces on tractor axles, and thus weight transfer onto the rear axle of the tractor. Adding these two factors together gives the actual loading on the drive wheels when the tractor is moving.

The objective of studying the soil resistance encountered by tillage tools was defined by Clyde (1937) as the collection of information for engineering design, such as mechanical strength and rigidity, for linkage analysis, for the best location of the pulling force and to investigate the effect of different shapes and angles of tools. The position and the direction of the pulling force can only be selected properly if the other forces, to which the pulling force is intimately related, are known. These other forces are the weight and the resultant soil force on the tool. Clyde (1954), divided the soil force reactions into two categories and recommended that a distinction between the two should be made. The force or resistance which a given tillage implement must overcome in cutting, breaking and moving the soil is denoted as the useful soil resistance force. The parasitic forces are the supporting forces including the resulting rolling resistance from the wheels. The magnitude of the parasitic forces can be controlled by the design of the tool or by the location of the pulling forces. Abo El Ees (1978) analyzed the performance of curved discs, used as furrow openers for direct drilling, mounted on three different free-linkage arrangements. These systems were; (a) a free-rotating single arm, (b) two free-rotating front converging arms (FCL) and (c) two free-rotating rear converging arms (RCL). For the first system (**Fig. 1**), he found that the depth of penetration was relatively shallow. And the final working depth depended largely upon the amount of dead weight acting over the disc. He explained this relation by the following mathematical expression,

$$NW = x.W + (h + x)DW / [x + K.y]$$

where, (W) is the weight of the implement, (x) is the horizontal distance from the center of (W) to the hitch point (F), (h) is the horizontal distance between the vertical lines through W and DW. (DW) is the dead weight and (y) is the height of the hitch point above the line of action of the draught.

The design analysis for the two linkages shown in **Fig.2** was achieved by replacing the actual hitch point on the freely rotating arms by a virtual hitch point (VHP). This allowed the height (y) of the hitch point to decrease to zero and even take negative values (**Fig.2**). This modification increased the amount of net penetration weight (NW), and consequently the working depth of the implement could be greater for a given weight on the frame. Abo El Ees (1978), achieved these results by replacing the single rotating arm by the two converging linkages. In real terms, there was a weight transfer between the tool and the main frame. If the virtual hitch point is low enough on the (FCL) the weight transfer will be from the main frame to the disc. This linkage design allowed for the weight needed for penetration to be taken from the machine frame instead of putting on additional ballast. During his experimental trials, Abo El Ees (1978) found some practical limitations in using the front converging linkage, with respect to the extent to which the vertical hitch point could be moved downwards to achieve sufficient depth with the least possible ballast. Therefore, he combined the two converging-link systems on his prototype in order to overcome these design limitations.

In the case of the rear convergence arrangement (RCL) the disc was pushed into the soil. The direction of the push force on the rear convergence pair of discs was inclined downward more steeply than the direction of pull on the front convergence discs. This was, in fact, equivalent to more weight transfer on the rear convergence disc than on the front convergence ones for a given relative height of the frame. He also derived, by analysis of the geometry of the links, the net weight (NW) for penetration of his system.

$$NW = W[a - x_v]/[(x_1 - x_v) + K\{(Y_1 + Z) + Y_v\}]$$

where, (W) is the total weight of the disc assembly including any ballast weights, (a) is the horizontal distance between the hinge point, O, of the upper link and the centre of gravity of the main frame, (x_v and Y_v) are the co-ordinates of the virtual hitch point with respect to the origin O, (x_t and Y_t+Z) are the co-ordinates of the resultant force point of action with respect to O, (Y_t) is the height of the point O above the soil surface and (Z) is the depth of penetration.

Lay-out of Gauge Wheels

Achievement of depth control with conservation tillage planters is a concern which has been addressed by use of wide gage wheels on both sides of the planter opener. This design is acceptable when planting widely spaced rows (Erbach *et al.,* 1983). Optimum seeding depth control is generally viewed as a desirable goal for all crop establishment systems. The consequences of the lack of seeding depth control were illustrated by Sunderman (1964) for nine wheat varieties; he showed that mean emergence dropped from 74% to 23% as depth changed from 7.6 to 12.6cm. The effect on crop emergence due to different depth control wheel lay-outs was evaluated by Morrison and Gerik (1985a). The lay-outs involved were; rear press wheel, front gauge wheel, rear press wheels and front gauge wheel connected by a rigid link and gauge wheels beside the furrow opener. From their results they found that the seed emergence Indices ($M=S_0^N E_n/N$) were similar for the front and rear depth control wheels, and that the linked front and rear wheel control produced (M) values intermediate between the highest emergences by side wheel control and the lowest emergence by either front or rear wheel control. Their results also show that for wheel positions between 36cm behind the furrow opener to 48cm ahead of the opener there was a variation in (M) of 17% for wheat, 36% for soyabean and 19% for sorghum. This showed that the best location of the depth control wheels, when the furrow spacing is not a restriction, is at the centre line of the furrow opener, in the case of double disc openers, or at the seed release point for tine openers.

External vertical forces (down pressures), are normally applied to a coulter-opener combination on row crop operation in residue-covered soil to enable soil penetration. Down pressure requirements for a given opener depend upon the physical properties of the particular residue and the soil encountered (Erbach *et al.,* 1983). Down pressure is required to improve seeding depth control, especially in conservation-tillage planting. Morrison and Gerik (1985b) have shown the effect of down-pressure magnitude on the standard deviation of depth produced by four different arrangements of depth control wheels. It can be apreciated that rear wheel and front wheel depth controls have a similar standard deviation of depth for the two crops (maize and sorghum) on which the system was evaluated at 712 and 934N down pressure. The arrangement of the linked wheels (front and rear) required less weight to stabilize the planting depth. They concluded that depth control wheel location, relative to the furrow opener, affected the mean depth of planting and depth variation. The best control was achieved by side wheels and linked wheels, with reduced control achieves by using the front wheels and the poorest control obtained by using the rear wheels.

For better depth control with the parallel linkage system it was suggested that tensile springs (acting with a constant pressure on one of the arms) rather than a compression spring be used. This provides a less variable weight transfer from the main frame to the planter as an effect of soil surface irregularities (Morrison, 1988a and 1988b).

Objective

One objective of this study was to develop a simple methodology for the prediction of planter frame behaviour as a function of one of the selected (RCL) linkage geometries and the soil surface irregularities; A related objective was to obtain an assessment of the effectiveness of weight transfer of two selected systems (RCL), and (PL), under laboratory conditions.

Methodology and Materials

To cover the first objective of the present work a Quattro Pro spread sheet was employed. Here the main purpose was to develop a simple programme which could determine, by the analysis of the linkage geometry for an (RCL), the effect of soil surface irregularities on the loci location of the (VHP) as well as the frame angle with respect to the horizontal. In order to do this the differ-

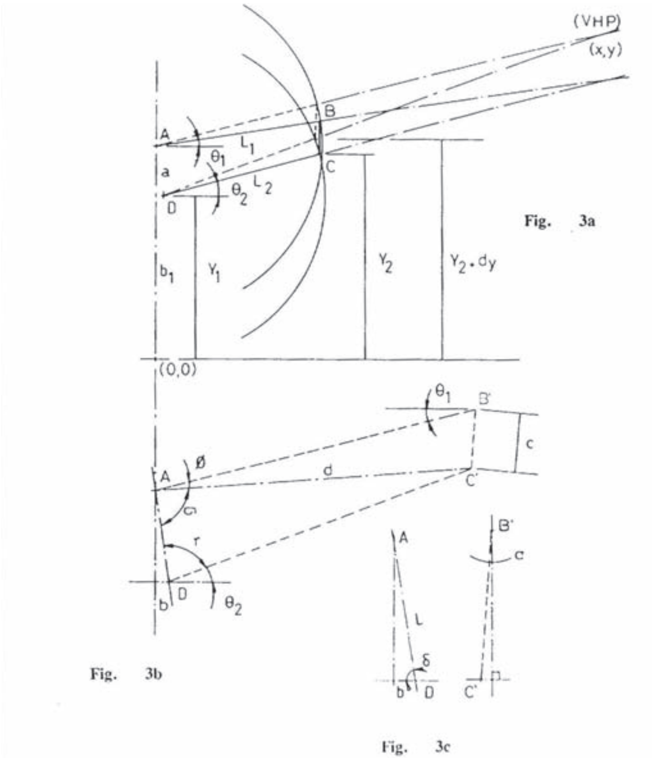

Fig.3 Location of the virtual hitch point (VHP) and planter frame slope (a) with two RCL

ent design parameters of the linkage were modified. These parameters are shown in (**Fig.3**), where, (L_1 and L_2) are the upper and lower link lengths, (a) is the vertical distance between centres of link rotation on the main frame, and (c) is the vertical distance between link centres on the planter unit.

The angles (Q_1 and Q_2) formed by the position of the upper and lower links, with respect to the horizontal on the vertical-longitudinal plane, are affected by the following heights with respect to the soil surface :
(Y_1) which is the height of the lower link on the main frame, and (Y_2) is the height of the lower link on the planter unit.

For the purpose of the analysis the height (Y_1), controlled by the hydraulics of the tractor on automatic position control, was kept constant, and the height (Y_2) of the planter frame was modified over a range of ±50mm with an increments (Dy_2) of 1mm. A series of different combinations of L_1, L_2, c, a, and Y_1-Y_2 were provided in order to determine the best geometry which gave the least frame angle sensitivity due to the soil irregularities as well as the minimum displacement of the (VHP) loci location.

To cover the second objective a test was carried out by using the facilities provided with the Universal soil test machine Campos (1993). The planter frame was attached to the carriage beam by means of the two different linkage arrangements (as shown in **Fig.4**), the (PL) and (RCL). The depth control (height of the planter frame, Y_2) was obtained by using two metal gauge wheels, of 10 by 30cm, located to the sides of the centre line of the furrow opener. The weight transfer was sensed by two ring transducers located on the carriage of the Universal soil test machine and the individual forces on the tine opener were measured by using a specially designed extended octagonal ring transducer. All the forces were recorded by a Micro-link data logger.

The soil conditioning procedure was thatused by Campos (1993) employed. The weight transfer on the (PL) was obtained by using two tensile springs with a spring rate K=3.6 N/mm and length span=130mm. The arrangement of the apparatus for evaluation purposes was: coulter-tine-linkage-gauge wheel. The coulter depth selected was 9.3cm which was equivalent to (diameter/depth=4.5) with a coulter diameter equal to 42cm. This was the one with best performance during coulter evaluation (Campos, 1993). The tine depths selected were 10 and 13cm.

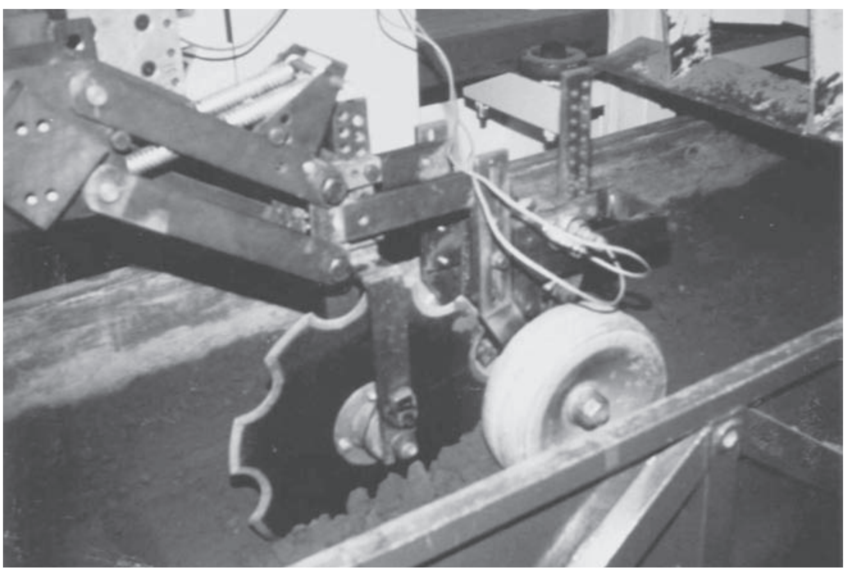

Fig.4 Designed apparatus for laboratory evaluation of disc counter-linkage-furrow opener arrangement

Frame Angle (a) and Loci of the Virtual Hitch Point (VHP).

The analysis of the linkage geometry was based on the instantaneous changes of (Q_1 and Q_2) produced by (Dy_2). These changes gave an infinite number of values of (a) inside certain limits. Where, a is the frame angle with respect to the vertical. That means there is only one position where (a=90º), (**Fig.3**) which represents a planter frame position that is parallel to the soil surface. For (a=90º), (Dy_2= 0) and the horizontal co-ordinates of point B and C (**Fig.3a**) are equal.

From the same figure:

$$B:\left[\sqrt{L_1^2-[Y_2+c-Y_1-a]^2};Y_2+c\right]$$
$$C:\left[\sqrt{L_2^2-[Y_2-Y_1]^2}+b;Y_2\right]$$
$$b=\sqrt{L_1^2-[(Y_2-Y_1)-(a-c)]^2}-\sqrt{L_2^2-(Y_2-Y_1)^2}$$

where, (b) is the horizontal distance, on the vertical plane, between link centres on the main frame. The slopes of each link are given by the next expressions:

$$m_2=\frac{Y_2-Y_1}{\sqrt{L_2^2-(Y_2-Y_1)^2}}$$
$$m_1=\frac{(Y_2-Y_1)-(a-c)}{\sqrt{L_1^2-[(Y_2-Y_1)-(a-c)]^2}}$$
$$Where..\theta_1=tan^{-1}m_1$$

where, (m_1 and m_2) are the slopes of the upper and lower links, with respect to the horizontal. The frame angle with respect to the vertical (a) is given by:

a = tan^{-1} *[(c/0)=¥] = 90°*

The (VHP) loci co-ordinate is given by the next expression:

$$X=\frac{b_1-b_2}{m_2-m_1}=\frac{a+bm_2}{m_2-m_1}$$
$$b_1=Y_1+a.;b_2=Y_1-bm_2$$

where, (b_1 and b_2) are the interception points of the upper and lower links with respect to the vertical axis and (X and Y) are the horizontal and vertical co-ordinates of (VHP).

When there is an increment (Dy_2), the value of (a¹90º) and the co-ordinates of the new position of points (B' and C') are given by:

$$B'=[L_1cos\theta_1;Y_1+a+L_1sin\theta_1]$$
$$C'=[b+L_2cos\theta_2...;Y_2+\Delta y_2]$$

and the slopes of the lower and upper links are given by the following set of equations:

$$m_2=\frac{(Y_2+\Delta y_2)-Y_1}{\sqrt{L_2^2-[Y_2+\Delta y_2-Y_1]^2}}$$
$$\theta_1=tan^{-1}m_1...Then..\theta_1=\phi+\sigma-\delta$$

where the angles (f, s and d) are shown on (**Fig. 3b** and **3c**) and given by the following expressions:

$$L=\sqrt{a+b}...Then..\delta=tan^{-1}\left(\frac{a}{b}\right)$$
$$\tau=180-(\delta+\theta 2)...Then...d=\sqrt{L_2^2+L_2\bullet L_2cos\tau}$$
$$\phi=cos^{-1}\left[\frac{d^2+L_2^1-c^2}{2d\bullet L_1}\right]...Then...\sigma=sin^{-1}\left[\frac{L2\bullet sin\tau}{d}\right]$$

therefore, the horizontal co-coordinates of (B' and C') are different (L_1 Cos Q_1 ¹ b+L_2 Cos Q_2) and consequently (a¹90º) and the planter frame angle(a) is given by:

$$\alpha=tan^{-1}\left[\frac{Y_1+a+L_1sin\phi_1-(Y_2+\Delta y_2)}{L_1\cos\phi_1-(b+L_2\cos\phi_2)}\right]$$

and the (VHP) loci co-ordinate location is given by the same expression.

Weight Transfer Prediction for (RCL).

Basic two-dimensional passive force calculations.

The passive soil reaction force on the tool soil interface is comprised of by two components, the frictional soil resistance P acting at an angle d to the interface and the tangential adhesive force on the tine A (Reece and Hettiaratchi, 1989) where,

$$A=[az\,cosec\alpha]w$$
$$P=\left\lfloor\gamma z^2(K\gamma-K_se^{-s})+czK_{ca}+qzK_q\right\rfloor w$$

Being the total soil resistance per unit width (R_t) and acting at an angle d_r with the normal with the interface, (Hettiaratchi and Reece, 1974).

$$Rt=\sqrt{P^2+A^2+2PA\,sin\delta}$$
$$\delta r=\delta+sin^{-1}\left[\frac{A\,cos\delta}{R}\right]$$

The K factors are provided by Hettiaratchi and Reece (1974), these charts allow agile computation of the forces (A and P) on plane machine elements developing two-dimensional soil failure. The method for determining factors K_{ca} and K_g for the intermediate boundary conditions are explained by Hettiaratchi and Reece (1974) They suggested that a geometric proportion could be used to find K factors between the perfectly smooth and rough blades as follows:

$$K_\delta=K_0\left[\frac{K_\phi}{K_0}\right]^{\frac{\delta}{\phi}}$$

where K_d is the desired K_{ca} or K_g factor for certain magnitude of d, and K_0 and K_f are the appropriate factors for the smooth and very rough blade cases, respectively.

Location of R_t line of action.

The approximately line of action of R_t below soil surface (Y_t) can be obtained by separating it into its gravitational frictional components P_g and its cohesive-adhesive-surchange component P_{cq} and assuming that P_g acts two-thirds the way along the interface from the surface and P_{cq} position is half-way from the same soil surface reference. (Reece and Hettiaratchi, 1989).

$$P_\gamma=\gamma z^2[K_\gamma-K_se^{-s}]$$
$$P_{cq}=[czK_{ca}+qzK_q]w$$
$$Y_t=zcos\delta sec\delta_r\left[\frac{4P_\gamma+3P_{cq}}{6R}\right]$$

Weight Transfer.

The weight transfer prediction was calculated by using the equation provided by Abo El Ees (1978) with a series of modifications due to the difference between the two experimental apparatus (**Fig.5**). The equation becomes,

$$NW = \frac{W(X - X_w)}{(X - X_{ct}) - K_3(Y + Y_{ct})} = V_{ct}$$

where the weight transfer from the main frame to the planter unit is given by,

$$WT = \left(\left| \frac{X - X_w}{(X - X_{ct}) - K_3(Y + Y_{ct})} \right| - 1 \right) W$$

where, (x_w) is the horizontal distance from (W) to the origin reference O, (X and Y) are the coordinates of (VHP) loci, (X_{ct} and Y_{ct}) are the coordinates of application of the resultant force of the system (R_{ct}) and (K_3) is the ratio between the draft force of the system (Fx_{ct}) and the total vertical force ($Fy_{ct}=V_{ct}$).

The (X,Y) coordinates of the (VHP) loci were determined by using the Quattro Pro programme and the value of (K_3) was obtained from the following expression:

$$K_3 = \frac{K_1 V_c + K_2 V_t}{V_c + V_t}$$

where, (K_1) is the ratio between the Horizontal (Fx_c) and vertical ($Fy_c=V_c$) forces on the disc coulter, (K_2) is the ratio between the Horizontal (Fx_t) and vertical ($Fy_t=V_t$) forces on the tine opener and (V_c and V_t) are the vertical soil reaction forces on the coulter and tine opener respectively.

The vertical distance (Y_{ct}) from the point of application of the resultant force to O is given by the expression,

$$Y_{ct} = \frac{Y_c(K_1 V_c) + Y_t(K_2 V_t)}{K_1 V_c + K_2 V_t}$$

where, (Y_c and Y_t) are the vertical coordinates of the point of application of the resultant forces on the disc coulter(R_c) and tine opener (R_t) to O.

The values of (f and C) used for the estimation of the point of application of R_t were the same as the ones described by Monjurul Alam (1989) and Nurul Hoque (1991) for the same soil texture (Ryton sand) and the N factors were obtained from the tables provided by Hettiaratchi and Reece (1974).

The horizontal distance (X_{ct}) from the point of application of resultant force (R_{ct}) to the origin reference (O) is given by the equation,

$$X_{ct} = \frac{V_c X_c + V_t X_t}{V_c + V_t}$$

where, (X_t) is the horizontal distance from the point of application of the tine resultant force (R_t) to O, and, is given by the expression

$$X_t = X_0 + \frac{r + 10}{sin\phi} - \frac{Y_t + r - d_c}{tan\alpha}$$

where, (X_0) is the horizontal distance from the coulter vertical axis to the point O, (a) is the tine rake angle and (r+10mm) perpendicular distance from the coulter centre axis to the tine opener.

The location of the point of application (Y_c,X_c) of the coulter resultant force (R_c) was obtained by using the same considerations as described by Nartov (1985) where R_c is acting from the middle point of the disc coulter arc section below the soil surface, and is given by,

$$Y_c = d_c - r\left[1 - \cos\frac{\theta}{2}\right]$$

$$Also...X_c = X_0 - r sin\left(\frac{\theta}{2}\right)$$

where, (d_c) is the coulter working depth, (r) is the coulter diameter and (Q) is the cos^{-1} ($r-d_c$)/r.

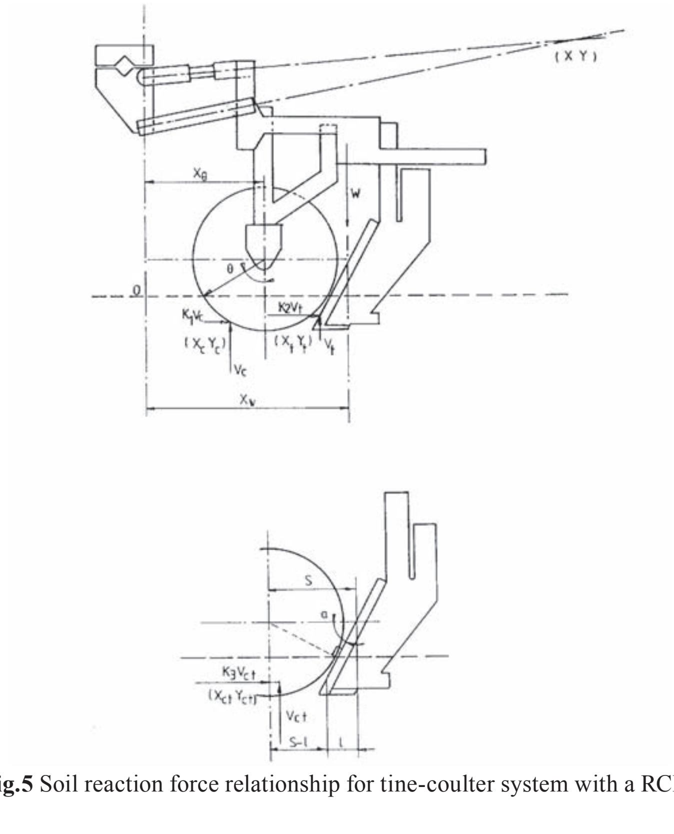

Fig.5 Soil reaction force relationship for tine-coulter system with a RCL

Results and Discussion

The values of K_3, K_2, and K_1 were obtained experimentally for this particular soil texture and soil conditions. The details are broadly explained by Campos (1993) in the sections relating to the Tine opener and Coulter. The values obtained were,

$K_3 = 0.124\ d_{ct}^{\ 0.827}$
$K_2 = 0.136\ d_t^{\ 1.136}$
$K_1 = 0.57\ d_c^{\ -0.22}$

where, (K_3) is the ratio of the Horizontal and vertical forces of the system for a constant coulter depth of 9.3cm.

For the purpose of the experimental work the dimensions for the

Fig.6 Measured forces on a RCL. Combining coulter and winged tine

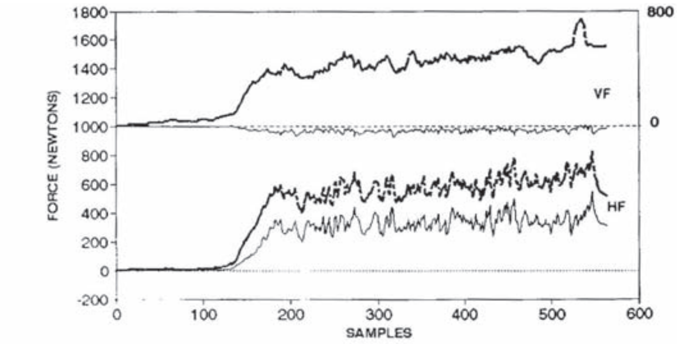

Fig.6a System coulter-tine with wings (CTW)

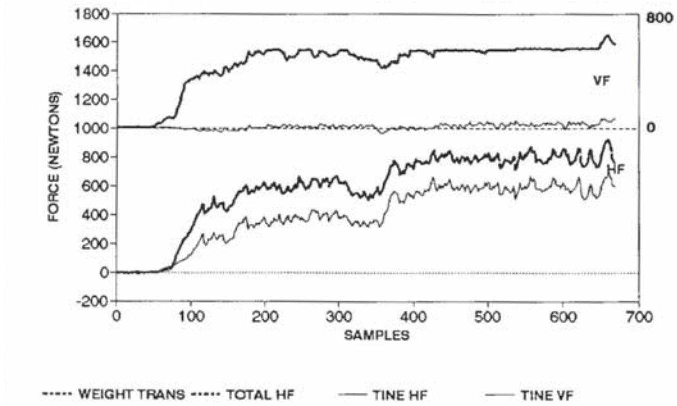

Fig.6b System coulter-tine without wings (CTN)

linkage geometry selected were: L_1=320; L_2=320; a=145 and c=100. With Y_1=500 and Y_2=600 this gave a (VHP) loci location of (X=996.3 and Y=813.6), all dimensions in mm. The weight of the planter unit was W=390N with an approximate value for x_w=470mm (**Fig.5**). The working depth for the disc coulter was (d_c= 93 mm) and the tine depth (d_t=130). The calculated net penetration weight was 665N which represented a weight transfer from the main frame to the planter unit of 275N.

In **Fig.6a** is shown the recorded experimental output of the weight transfer from the main frame with a sample mean value of 580N, which when compared with the calculated value gave an accuracy of theoretical prediction of 90%.

Another set of experimental tine-coulter combinations are described in **Fig.6**. Here the (NW) value is shown when the tine opener is used without wings (**Fig.6b**) for a similar tine working depth. From the figure it can be seen that there is an increment in the weight transfer ratio of approximately 70%. This shows that the system with wings could be used where more weight transfer is needed for a given working depth.

It is important to mention that the planter frame, with the depth control wheel to the side of the furrow opener, was tilted to the front as Abo El Ees (1978) explained. Because of this it was impossible in the initial of the work to locate the (VHP) loci at the desired height. The result of this was a very high weight transfer as shown in (**Fig. 6c**). This problem was alleviated by locating the vertical axis of the gauge wheels slightly forward of the calculated point of application of the coulter resultant force.

Conclusions

1.The programme used for predictions of the net weight available for penetration (NW) force predictions was accurate to within 90% of the experimental values.

2.The use of wings on the tine opener improved the effectiveness of weight transfer WT with the rear converging linkage (RCL) system.

3.It is necessary to incorporate into the rear converging (RCL) of the planter, a feature similar to that of a tractor three point linkage which is the making of the upper link adjustable, in length in order to level the planter frame in the field.

4.When the system was used with the parallel linkage it performed extremely well, without the planter frame being affected by the position of the gauge wheels and the magnitude of WT depended only on the stiffness of the tensile springs (**Fig. 4**).

5.for the same working depth of the tine-coulter system, in terms of the effectiveness of the use of the main planter frame weight, the rear converging system(RCL) arrangement required only 275 N to be transferred from the main frame, compared with 550 N with a requirement of the parallel linkage arrangement under actual laboratory conditions.

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Fablication and Performance Evaluation of Pre-Rasping Unit for Cassava Industries

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Abstract

A pre-rasping unit with a capacity of 1000kg/h was developed to separate and remove the stones embedded in cassava tubers. The unit consisted mainly of two components namely, a rotary type disintegrating unit and an oscillating tray type stone separator. Testing of the pre-rasping unit was carried out at three drum speeds: 750, 1000 and 1250 rpm, at three feed mixture ratios (liters of water: kg of cassava tubers): 0.5:1, 1:1, and 1.5:1, at three slopes of the oscillating tray: 12, 15 and 18 degrees and at three oscillating tray speeds: 600, 900 and 1200strokes/min. The pre-rasping unit recorded the best results under the following operating conditions; (a) water and tuber feed ratio, 1.5:1, (b) disintegrating drum speed, 1000rpm, (c) oscillating tray slope, 15 degrees and (d) oscillation tray speed, 600 strokes/min. The cost of the pre-rasping unit was $400 and its cost of operation was $0.30 or less per tonne of cassava processed.

Introduction

Tapioca or Cassava (*Manihot esculenta* Crantz) produced the highest tonnage of all the root crops of the world. The term cassava is usually used to denote the tubers whereas tapioca is used to denote the processed products of cassava. Cassava is grown over an area of 16.37 million ha globally with an annual production of 164.75 million tonnes of tubers. Nigeria is the country having the largest area under cassava, accounting for 16.5% of the world area and 18.5% of world production. In India, cassava is cultivated on an area of 0.24 million ha producing 6 million tonnes. Tamil Nadu is the leading state for the manufacture of tapioca starch and sago in India.

The prime importance of cassava is as a source of starch and its allied products. The production of starch and starch-based products from cassava in the small scale sector is done using indigenous technology and machinery which involves manual work in all operations, resulting in a poor quality product. In almost all sago industries, women laborers are used to peel the tubers. The increase in labor wages and the non-availability of laborers for peeling necessitates that mill owners adopt mechanical agitators for the partial removal of peel from the tubers.

As the tubers are not uniform in size and shape, sometimes small stones are retained in the curved bend portions of tubers, even though agitation and washing are done vigorously to remove the peel, before rasping. These small sized stones lodged in the curved portions of the tubers sometimes go into the rasping unit along with the tubers during starch production. A stone the size of a 5mm cube when lodged in a tuber is sufficient to damage the entire rasping drum surface within a few minutes. This problem requires immediate removal of the rasping drum and replacement of the perforated surface resulting in the stopping of all apparatus halting work for nearly 30-45 minutes. So, to overcome this problem, a pre-rasping unit was developed to separate stones from cassava tubers, and its performance was evaluated.

Review of Literature

Kerr (1950) stressed the need for processing cassava, as it contains a large quantity of starch, which can meet 50% of the per capita energy requirements of a hard working laborer. Grace (1977) made an economic study on the establishment of a modern cassava starch factory with a capacity of 24 tonnes of dry starch per day and estimated the capital requirements for establishment of such a sago factory.

Odigboh (1980) described the various unit operations to which cassava roots are commonly subjected in order to produce a food product, and he stressed the need for mechanizing each of the unit operations involved in cassava processing. Padmaja *et al*. (1990) reported that starch or sago factories are becoming obsolete due to the use of labor-intensive indigenous technologies, which often impart off-colors, bad smell and microbial contamination to the starch. There is an urgent need to modernize processing equipment for the production of high quality starch or sago.

Rangaswami (1993) stressed that the small-scale industries extracting starch and producing sago are adopting outdated technology, involving longer durations for extraction and unhygienic handling of the material, leading to poor quality of the end product. This crude method of manufacturing sago is being followed in all the 1000 cassava processing factories in Tamil Nadu.

Cao Van Hung *et al*. (1995) developed a cassava-grating machine with a capacity of 500-1000kg of fresh tubers per hour. The machine consisted of a cylinder made from solid hardwood. Nails or steel wire pieces having a projected radial length of 2-3mm were embedded on the surface of the cylinder. Fresh tubers were placed directly in the grating chamber. The cylinder diameter and the speed varied from 18-25cm and 3000-5000rpm, respectively. The slurry obtained after grating was well mixed with water after which it was filtered by a nylon cloth for starch separation.

Akinyemi *et al*. (1999) developed and tested a cassava-grating (rasper) machine. The machine which performed the grating operation consisted of a grating drum assembly rotating at high speed.

Materials and Methods

Description of the Unit

The pre-rasping unit for cassava tubers developed at Tamil Nadu Agricultural University, Coimbatore is shown in **Fig.1**. The pre-rasping unit consisted mainly of two components namely, (1) a rotary type disintegrator and (2) an oscillating tray type stone separator. The constructional details of the pre-rasping unit for cassava are given below.

Rotary Type Disintegrating Unit

The rotary type disintegrating unit for cassava tubers consisted of (1) a tray type feed hopper, (2) a disintegrating drum with pegs,

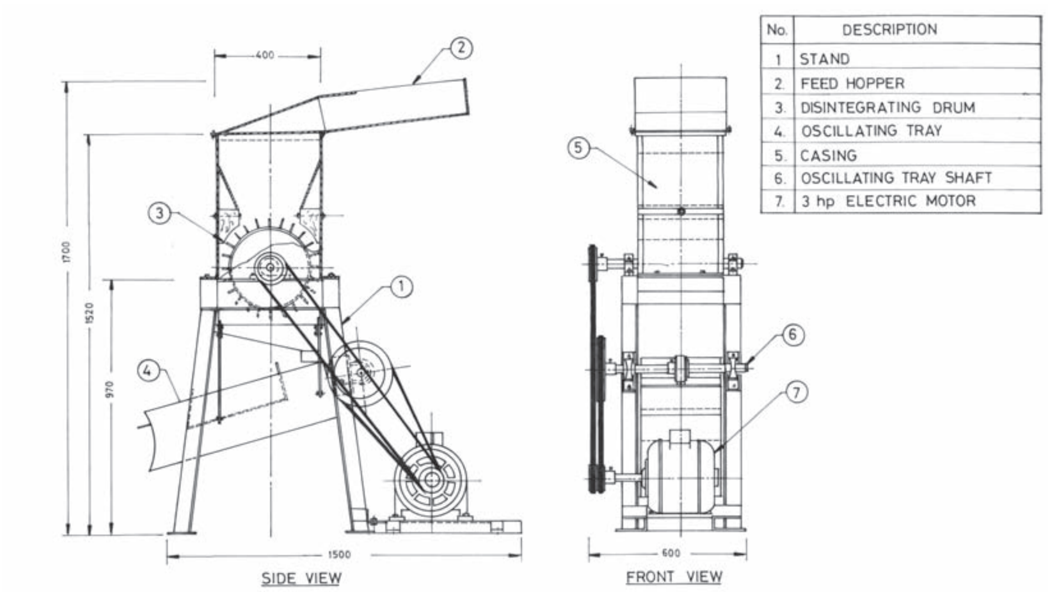

Fig.1 Pre Rasper Unit for Tapioca

(3) a rotor shaft, (4) a disintegrating chamber with wooden concave plates, (5) a motor and (6) a frame.

Tray type feed hopper: The tray type trapezoidal shaped feed hopper was provided at an angle of 30º to the horizontal, to feed the tubers into the disintegrating chamber. It was made up of 3mm thick mild steel sheet. The maximum length and breadth of the feed hopper was 550 and 370mm, respectively. The feed hopper was directly mounted on the disintegration chamber with suitable supports.

Disintegrating drum with pegs: A hollow drum of 330mm diameter and 300mm length was made with 5mm thick mild steel sheet. Two bushes of 45mm length having 35 and 70mm inner and outer diameters, respectively, were welded at the center portion of the two discs of 280mm diameter and 5mm thickness.

These discs were welded on both sides of the drum in such a way that the bushes projected outside and served as hubs for the drum. Based on the results of the preliminary experiments conducted on tubers embedded with stones, it was decided to place the pegs at an axial interval of 25mm. The pegs in peripherally adjacent rows were arranged in such a way that the first peg in the second row was placed laterally exactly between halfway the first two laterally adjacent pegs in the first row, i.e. the pegs in any row were offset at a distance of 12.5mm from those in the previous row so that the pegs in the alternate rows formed a circle. Based on the results of the preliminary experiments conducted with the tubers, pegs of 30mm length and 5mm diameter were selected and welded on the drum surface.

Rotor shaft: The rotor shaft of the disintegrating unit is an important component, which transmits the required power to the disintegrating drum to break the hard tubers into pieces. The rotor shaft of 33mm diameter was selected based on the typical size of rotor shaft used in the cassava starch processing industry. The rotor shaft fixed to the drum was mounted on ball bearings to obtain low-friction rotation. The length of the rotor shaft was extended on one side of the drum so as to attach a pulley by means of which power was transmitted to the drum. One B-section V-belt was used to transmit the power directly from the motor to the disintegrating drum.

Disintegrating chamber with wooden concave plates: The disintegrating chamber made of mild steel was a rectangular hollow box, having a cross sectional opening of 400 by 335mm and a height of 750mm. A U-shaped cut 35mm in width was made at the bottom of the chamber on two sides (opposite each other) to a height of 150mm so that the disintegrating chamber could be passed over the rotating shaft. The chamber was mounted on the main frame allowing clearance between the chamber walls and the disintegrating drum.

The disintegrating chamber not only served the purpose of enclosing the disintegrating drum, but also that, of holding the concave (made of teak wood). Due to the brakeage of tubers between the concave and pegs, the stones embedded on the tubers were released. The surface of the wooden concave plates was curved exactly to conform to the peripheral path of the outer surface of the disintegrating drum pegs so that proper disintegration of the tubers could be achieved. The wooden plates were provided on all four sides of the disintegrating chamber and provision was made to lower the concave to get the desired clearance between the disintegrating drum and wooden plates.

Motor: Based on laboratory experiments conducted with the tubers, a 3hp, 3-phase electric motor was selected as the prime mover to operate the unit. The motor was attached to the main frame in such a way that the power could be easily transmitted to both the disintegrating drum and the oscillating unit.

Frame: The frame was made of mild steel angle iron having a cross-section of 70×65×5mm. It had a trapezoidal shape. The size of frame was 450 by 350mm at the top, 800 by 350mm at the bottom and 870mm in height. The frame was brazed to provide rigidity to the unit and support to other parts of the machine which were also mounted on the frame.

Oscillating Tray Type Stone Separator

The oscillating tray type stone separator consisted of (1) a rectangular tray, (2) an eccentric mechanism, and (3) a tray suspension system.

Rectangular tray: A rectangular tray of 730mm length and 300mm breadth was made from 2mm thick mild steel sheet. This tray was of a special type having less depth at the inlet end and more depth at the outlet end. The outlet end of the tray was made in such a way that the bottom had a longer outward-projecting surface than was the case for the surface top. During oscillation of the tray, the stones, which were denser than the tubers, collected in the bottom of the tray and were retained at the bottom end of the tray.

The top of the oscillating tray was covered with another mild steel sheet in such a way that the feed received from the disintegrating unit was forced to go to the bottom of the oscillating tray for more than half of the tray length. Thereafter, the feed was allowed to move freely so that the separation based on density difference could take place with the help of the feed material (water and cassava) received from the disintegrating unit. Oscillations given to the tray assisted this free movement and subsequent separation. The sheet on top of the tray was fixed in such a way that during operation, even though the outlet was filled with discharge materials (broken tubers), there was no overflow at the inlet end. Suitable provi-

Parameters studied	Ranges adopted
1. Pre rasper feed mixture ratio [water (litre) : cassava tubers (kg)]	0.5:1, 1:1 and 1.5:1
2. Disintegrating drum speed (rpm)	750, 1000 and 1250
3. Oscillating tray strokes (number per minute)	600, 900 and 1200
4. Slope of the oscillating tray with respect to horizontal, degree	12, 15 and 18

Table 1 The performance of the unit was tested by varying the following operating parameters as detailed below.

$$\text{Efficiency of oscillating tray (per cent)} = \frac{\text{Number of stones retained in the oscillating tray}}{\text{Number of stones embedded on tubers and fed into the pre rasper unit}} \times 100$$

Table 2 The efficiency of oscillating tray was calculated by using the following formula.

sions had been made on the sides of the tray for attaching it to an eccentric drive mechanism and to the tray suspension system. Necessary provisions were incorporated in the suspension system so that the tray could be positioned at any desired slope.

Eccentric mechanism: An eccentric mechanism having a 20mm throw was fabricated and mounted on a shaft of 30mm diameter. The length of the eccentric shaft was 710mm. This eccentric shaft was mounted on two ball bearings and fitted with the help of bearing blocks. With the use of a suitable B-section, V-belt pulley power was transmitted from the prime mover to the shaft and to the oscillating tray.

Test Procedure

As it was very difficult to get the required number of tubers all having embedded stones for the study, the following procedure was adopted to test the performance of the unit. Different sizes of stones (weighing 2-14g) were fixed tightly into the tubers (one stone per tuber), and testing of the pre-rasping unit was carried out with these tubers as well as with good tubers (tubers without stones). During testing, the feed rate (1000kg/h) of tubers was kept constant. In each test, 50kg of tubers including 20 tubers having embedded stones were subjected to the pre-rasping operation. The performance of the unit in terms of percentage retention of stones was counted and calculated, both by checking the stones retained in the oscillating tray and also by checking stones coming out, if any, along with the disintegrated tubers and slurry. The experiment was repeated three times and the average values were recorded (**Table 1** and **2**).

The disintegrated tubers were divided into four size categories;, >30, 15-30, 7.5-15 and <7.5mm. The disintegrated tuber size of 7.5-15mm was considered as the most desirable when compared to the other sizes because, it was most effective in helping to retain the stones released in the tray as a result of the density difference.

Results and Discussion

The machine was tested with purchased cassava tubers, and fifty kilograms of cassava tubers were used during each test. The performance of the machine was evaluated by varying the parameters as mentioned above.

Performance Evaluation of the Disintegrating Drum

The effects of the speed of the disintegrating drum on disintegration of tubers at the speeds of, 750, 1000 and 1250rpm with different ratios of water to cassava tubers: 0.5:1, 1:1, 1.5:1 were determined and are presented in **Table 3**.

From **Table 3**, it can be seen that the percentage of 7.5-15mm size disintegrated tubers varied from 30.15 to 53.38% for different speeds of the disintegrating drum. The other sizes namely >30, 15-30 and <7.5mm were recorded at minimum levels of 4.15, 13.91 and 23.11% and at maximum levels of 12.00, 26.56 and 47.48%, respectively.

From the **Table 3**, it can be seen that in the cases of the 7.5 -15 and <7.5mm sizes the distribution patterns were similar at 750 and 1000rpm, and event 1250rpm these two size categories also comprised increased percentages of the total distribution as the cassava : water

Disintegrating drum speed, rpm	Feed	Disintegrated tubers, %			
	Water : Cassava	Size of disintegrated tuber, mm			
		>30	15-30	7.5-15	<7.5
750	0.5 : 1	12.00	26.56	38.33	23.11
	1.0 : 1	10.00	25.92	39.29	24.79
	1.5 : 1	8.88	23.32	41.17	26.63
1000	0.5 : 1	5.86	17.62	50.44	26.08
	1.0 : 1	4.74	16.16	51.65	27.21
	1.5 : 1	4.55	13.91	53.38	28.16
1250	0.5 : 1	5.25	18.57	30.15	46.03
	1.0 : 1	4.59	16.40	32.23	47.06
	1.5 : 1	4.15	14.97	33.40	47.48

Table 3 Effects of disintegrating drum speeds and feed mixture (water : cassava ratio) on disintegration of tubers

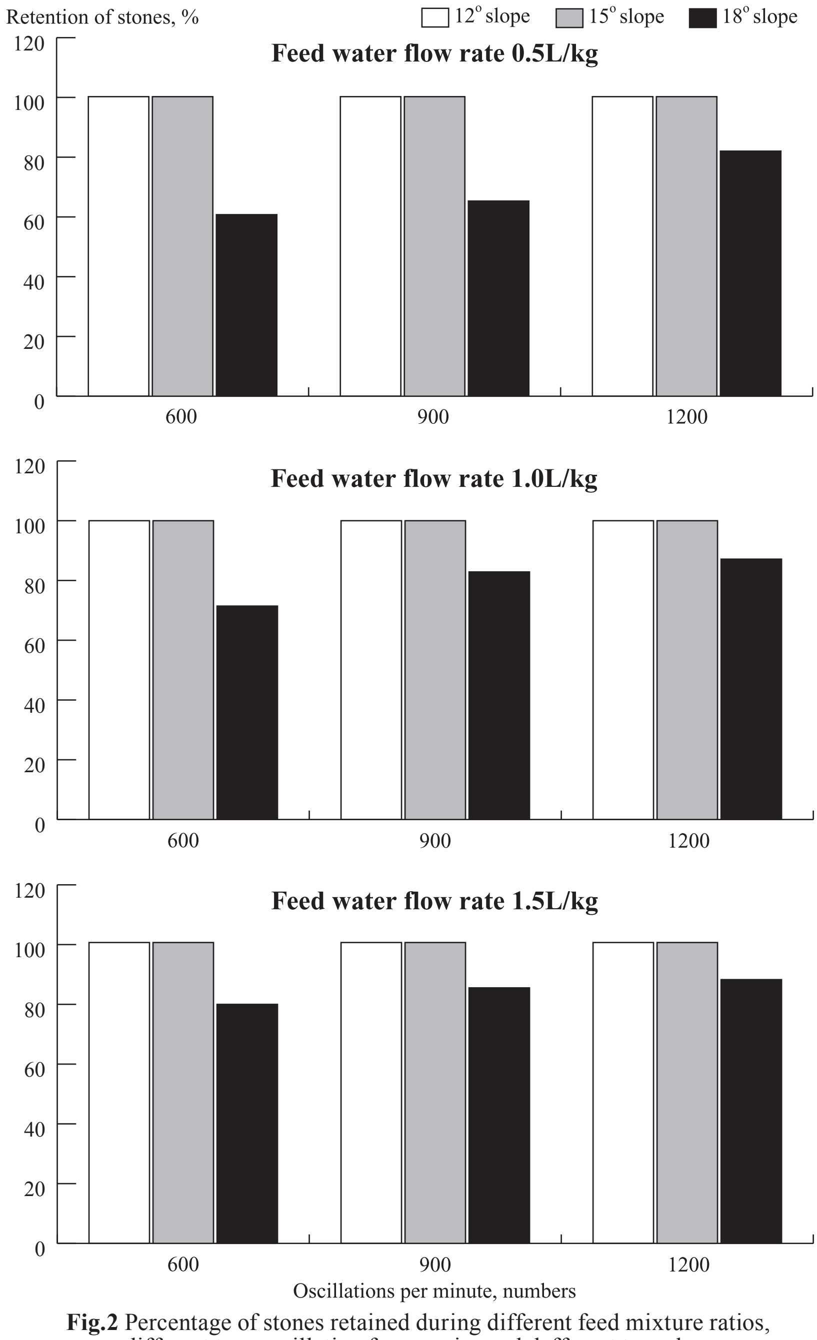

Fig.2 Percentage of stones retained during different feed mixture ratios, different tray oscillation frequencies and defferent tray slopes at 750rpm of the disintegrating drum

feed mixture ratio increased from 0.5 to 1.5:1. However, at 1250rpm, in the case of 7.5-15mm sized particles at different feed mixture ratios, the numerical values recorded were lower than the corresponding values at 750 and 1000rpm, but in the case of <7.5mm sized particles the values were higher than the corresponding values recorded at 750 and 1000rpm. This indicates that at higher speed due to higher impact force, even under wet conditions, the disintegration effect was greater i.e. the production of <7.5mm sized particles was greater when compared to the incidence of their production at lower speed. In general, as the disintegrating drum speed increased, and also as the feed mixture ratio (water : casssava), increased there was a reduction in larger sized particles (>30mm) and there was an increase in the production of smaller sized (<7.5mm) particles. The reason for this being that at higher speed, the impact force of the drum on the tubers was greater and hence, there was more disintegration.

From **Table 3**, it can be seen that the disintegrating drum speed of 1000rpm (i.e. 1036m/min) with 1.5 liters of water per kg of cassava tubers was the best combination of these two parameters, as it gave 53.38% of disintegrated tubers in the 7.5-15mm size range. Kailappan *et al*. (2001) reported using 1.5 litres of water per kg of brinjal fruit to separate the denser seed from the pulp. So, the 1.5 litres of water / kg cassava tubers used in this study appears to be compatible with the above findings. However, Kailappan et al. (2001) used 217.8m/min peripheral speed for separating 5mm sized seed from soft fruit, whereas in this study, a peripheral speed 1036m/min was used to release the stones of 10mm and larger from the tubers. i.e. a comparatively a higher impact force was needed to break the hard tubers into pieces and release the stones. Hence, the higher peripheral speed used in this study appears to have been justified.

Performance Evaluation of the Oscillating Tray

The performance evaluation of the oscillating tray type stone separator with regard to retention of stones at different feed mixture ratios, different oscillating tray slopes, different frequencies of oscillation per minute of the oscillating tray and at different speeds of the disintegrating drum were determined and are presented in **Figs. 2** to **4**.

Effect of feed mixture ratio (water: cassava) on performance of the oscillating tray: Upon analyzing the values recorded in **Figs.2** to **4**, it can be seen that the efficiency of the oscillating tray varied from 48.33 to 100% at different feed mixture ratios. The oscillating tray efficiency

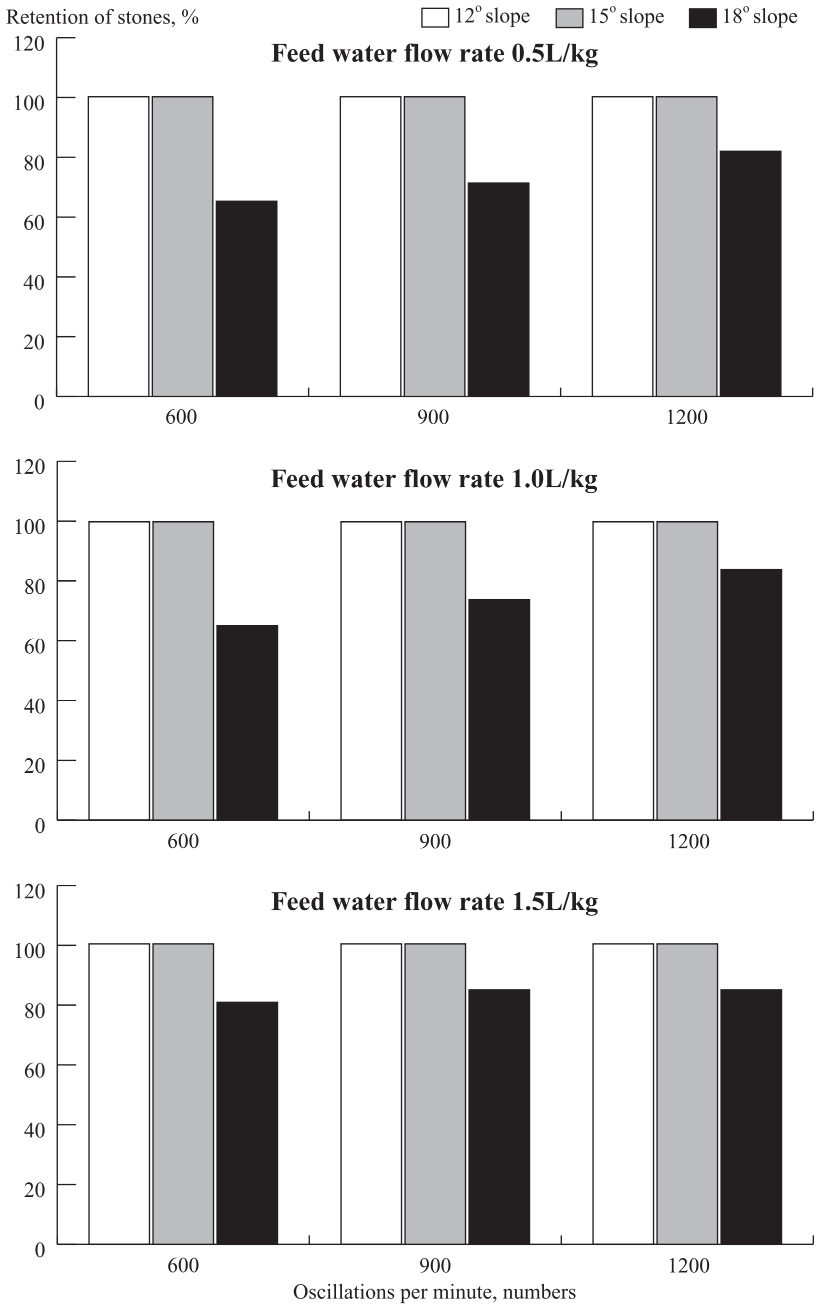

Fig.3 Percentage of stones retained during different feed mixture ratios, different tray oscillation frequencies and defferent tray slopes at 1000rpm of the disintegrating drum

was 100% at all the feed mixture ratios, at 12 and 15 degrees of oscillating tray slope and at all the disintegrating drum speeds studied. The efficiency levels at an 18 degree slope of the oscillating tray were generally lower than 100%. As the feed mixture ratio increased from 0.5:1 to 1.5:1, the efficiency of retention of stones by the oscillating tray having an 18-degree slope increased from 60 to 80, 65 to 85 and 81.7 to 88.3% at 600, 900 and 1200 oscillations per minute, respectively, when the speed of the distintegrating drum was 750rpm.

Effect of oscillating tray slope on the percentage of stones retained by the oscillating tray: From **Figs.2** to **4**, it can be seen that the percentage of stones retained by the oscillating tray was high i.e. 100% at 12 and 15 degrees slope of the oscillating tray at all feed mixture ratios and at all disintegrating drum speeds studied, when compared to efficiency levels obtained using an 18 degree slope of the oscillating tray. At the disintegrating drum speed of 750rpm, as the oscillating tray slope increased from 12 to 18 degrees, the percentage of stones retained by the oscillating tray decreased from 100 to 60, 100 to 70 and 100 to 80% at feed mixtures of 0.5:1, 1:1, 1.5:1 (water: cassava tubers), respectively, at 600 oscillations per minute of the tray. The corresponding values for 900 and 1200 oscillations per minute were 100 to 65, 100 to 81.67 and 100 to 85 and 100 to 81.7, 100 to 86.7 and 100 to 88.3%, respectively. This may have been due to the fact that at the higher slope i.e. 18º, the retention time of disintegrated tubers with stones in the tray was less than at lower slope levels, and hence, poor stone separation. The values recorded indicate that tray slopes of 12 and 15 degrees helped achieve 100% stone separation, and that any higher slope than this would not be suitable. Sahay and Singh (1999) reported the use of 4-12º slopes for the screen to get effective separation of grains, in an air screen cleaner. This result was compatible with our findings that 100% separation of stones could be obtained at 12 and 15 degree slopes of the oscillating tray. At 1000 and 1250rpm, the trend was the same. However, the values recorded (percentages of stones retained) at the 18 º slope at 1000rpm were higher than those at 1250rpm for all feed mixture ratios studied for the reasons set forth in the section on performance evaluation of the disintegrating drum.

Effect of the number of oscillations per minute of the oscillating tray on the percentage of stones retained: It can be seen from Figs. 2 to 4 that the percentage of stones retained by the oscillating tray was 100% at 600, 900 and 1200 oscillations per minute of the oscillat-

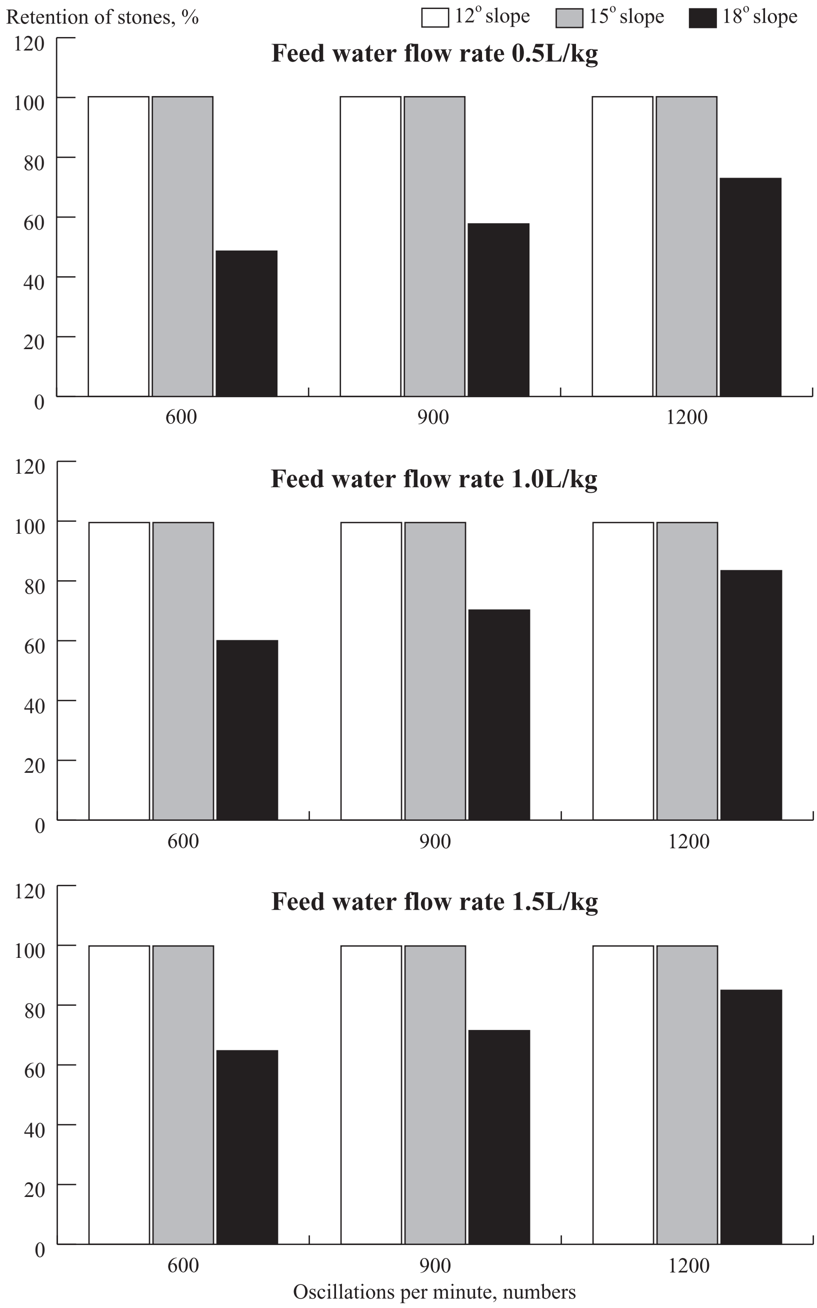

Fig.4 Percentage of stones retained during different feed mixture ratios, different tray oscillation frequencies and defferent tray slopes at 1250rpm of the disintegrating drum

ing tray, at oscillating tray slopes of 12 and 15 degrees and at all the feed mixture ratios, studied. But, at the 18-degree slope of the oscillating tray, an effect of the number of oscillations per minute of the oscillating tray on the percentage of stones retained could be noticed. The percentage of stones retained by the oscillating tray increased as the number of oscillations per minute of the oscillating tray increased from 600 to 1200 at an 18-degree slope of the oscillating tray, but the values recorded were always less than 100. This may have been due to the fact that at higher slopes, the retention time in the tray for the broken tubers with stones was less than was the case at slopes of 12 and 15 degrees, and hence, poor separation. From this it is clear that in order to achieve 100 percent retention of stones, a 12 or 15º slope of the oscillating tray was sufficient. However, during tests it was seen that at the 15º slope, material flow was free while at the 12º slope, stagnation of materials in the tray was observed. Hence, an oscillating tray with 15º slope and with 600 oscillations per minute could be considered as the best combination of operating conditions. This choice is also reinforced by earlier reports of 400 strokes per minute being recommended for grading small sized kernels by Sahay and Singh (1999).

Effect of disintegrating drum speed on the percentage of stones retained by the oscillating tray: **Figures 2** to **4** show that the percentage of stones retained by the oscillating tray was 100 at the following conditions : drum speeds of., 750, 1000 and 1250rpm, feed mixture ratios of 0.5 to 1.0, 1.5:1 and oscillating tray slopes of 12 and 15º. However, at the 18o slope, irrespective of the speed of the disintegrating drum, (750, 1000 or 1250rpm), an increase in feed mixture ratios, (0.5, 1.0 and 1.5:1) increased the percentage of stones retained by the oscillating tray. Nevertheless, at all combinations of operating conditions, all figures recorded for stone retention were less than 100% when the tray slope was 18 degrees. The above discussion indicates that for 100 percent retention of stones, it was sufficient if the disintegrating drum was operated at 750 rpm, the feed mixture ratio was 0.5:1 and the oscillating tray operated at 600 strokes per minute.

Overall performance evaluation of pre-rasping unit: Based on the above operating parameters recorded, for the best performance of the pre-rasper unit, the following operating conditions are recommended.

(i) Tuber feed rate: 1000kg/h
(ii) Water feed rate: 1500litres/h
(iii) Disintegrating drum speed: 1000rpm.

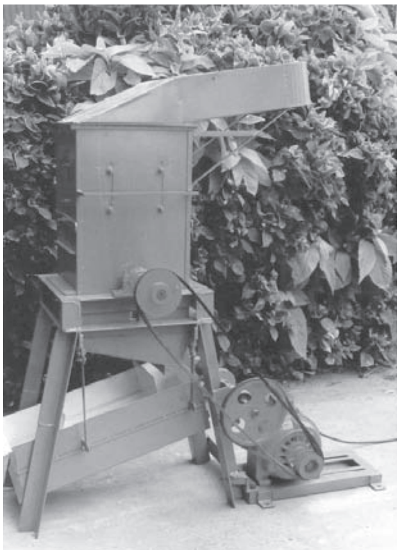

Fig.5 Photograph of the pre-rasper unit for cassava industry

(iv) Number of oscillations of the oscillating tray per minute: 600
(v)Slope of the oscillating tray: 15º

Cost Economics

The cost of operation of the newly developed pre-rasper unit was estimated. From the estimates made, it was found that the capacity of the pre-rasper unit for cassava was 1000kg/h. Assuming that the machine were to work for 1200 hours in a year, the cost of operation of the pre-rasper unit per tonne of cassava tubers was computed and found to be only $0.20 /tonne.

Conclusion

The pre-rasper unit is suitable for pre-rasping and for removal of any stones that may be present in the tubers. To get the best results, the unit should be operated at the following conditions.

Tuber feed rate: 1000kg/hour

Water feed rate: 1500litres per hour

Disintegrating drum speed: 1000 rpm

Frequency of the oscillating tray: 600 oscillations per minute

Slope of the oscillating tray: 15 degrees.

Cost of operation of the unit: $0.20 per tonne of tubers pre-rasped.

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Agricultural Tractor Ownership and Off-Season Utilisation in the Kgatleng District of Botswana

by

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Abstract

In recent years tractor power usage has increased among the smallholder farmers in Botswana due mainly to the influence of government loans, subsidies and grants on draft power financing. A study on tractor owners and tractors was conducted in the Kgatleng Agricultural District. Questionnaires asked owners about the tractor's usage, serviceability, operation and maintenance costs. It was found that 37% of the tractor owners were illiterate, 42% had primary education and 21% had secondary education. Forty two percent were over 60 years old and 41% were between 41 and 60 years. Mainly their owners and sons operated the tractors. The tractors, largely Massey-Ferguson make, were used mainly for ploughing. The average ploughing done by each tractor was 106.7ha/year, and they were parked most of the time during off-season. More than half the tractors were over 15 years old, and they were poorly serviced and maintained. Service records for tractors were non-existent and their current owners overhauled 68% of the tractors. Tractors experienced frequent problems with hydraulics, power loss, engine oil leakage, front wheel bearings and the electric system. Tractor owners were reluctant to use their tractors for non-ploughing activities. They used them sparingly during off-season in order not to risk damage. Regarding farming as a business, farmers could engage their tractors in all year activities, such as threshing, forage baling, operating mills, water pumping and transportation. These show potential for making ownership cost effective, but it is advisable to do a cost analysis of farm operations for farmers to realise profit.

Introduction

Botswana's agriculture has been dominated by animal draft power for many years. The introduction of animal draft power into smallholder farming systems dates back to a century ago (Baker, 1988). Animal draft power is well established and is the common form of power used by traditional farmers (Panin *et al*., 1995). The animals used include oxen, donkeys, horses and mules. They are used during most of the primary and secondary tillage operations. The animals are also a source of meat, milk, transportation and a trade resource. The animals are also prominent in a lot of social ceremonies.

However, in recent years, tractor power has emerged to rival the use of animals for draft. In the early 1970s only four percent of the total smallholder farming households used a tractor for ploughing and this figure rose dramatically to 17% and 39%, respectively, by 1980 and 1987 (Poulsen and Purcell, 1989). It is possible that in some parts of Botswana the figure could even be more than 80%.

The use of tractor draft power has increased among smallholder farmers in spite of the on-going debate on the sustainability and profitability of mechanising smallholder crop production systems (Litschaner and Kelly, 1981). Several factors though could be responsible for the increase: the primary reason could be the influence of government loans, subsidies and grants on draft power financing. Farmers were able to get financial assistance through schemes such as the Arable Land Development Program (ALDEP) and low-interest loans through National Development Bank (NDB). Periodic occurrence of droughts often led to such loans being either written-off or interest waived. High purchase prices for cattle offered by the Botswana Meat Commission (BMC), structural transformation in the Botswana economy, increased earnings through non-formal income such as remittances, and various other favourable agricultural mechanisation policies also made it easier for farmers to acquire tractors (Panin *et al*., 1995).

The Kgatleng agricultural district is one of the districts where the use of tractor draft power is predominant. During the 1998/99 cropping season, 183 tractors were registered with the Ministry of Agriculture for ploughing. Registration was done so that tractor owners could benefit through the Ministry's Accelerated Rain-fed Arable Program (ARAP) which paid out cash incentives to farmers (or hired services) for ploughing and tendering their own fields. The profitability of tractor use, therefore, was linked to the extent of utilisation during ploughing operations. But ploughing operations take place during the months of October to February that is only less than half of the whole year. Off-season use of tractors in the district has not been studied before and so the associated costs and profit can not be determined. In some parts of Botswana tractor usage has been found to be as low as 200 hours per year (Tapela and Nlisi, 1997), instead of the optimal 1000 hours per year (Lonnemark, 1967). Given the absence of previous studies on tractor use in the district and the low levels of tractor usage in other parts of the country, it was found necessary to carry out a study with the following objectives:

1. To determine the average hours of tractor usage per year in the Kgatleng agricultural district;
2. To identify activities other than ploughing and the proportions of tractor usage in the Kgatleng agricultural district; and
3. To determine the cost of owning and operating a tractor in the Kgatleng agricultural district

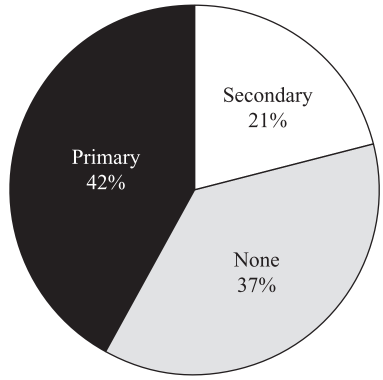

Fig.1 Education level of the farmers in the Kgatleng District

Method

A questionnaire was prepared to ask farmers who owned and operated tractors about the tractor's use, serviceability, and operation and maintenance costs. Other information asked was personal information that could help the researchers understand the ability of the farmer to effectively operate the tractor and keep records. A random (pathfinder) survey was carried out to administer the questionnaire to tractor farmers during the 1997-1998 ploughing season. In total, 19 farmers were interviewed, translating to about 10% of the total registered fleet of tractors for the agricultural district. The farmers interviewed were the owners who knew or had information on the performance of their tractors. During the interview, the researchers also made physical assessment of the tractors and noted their conditions. In cases where a farmer owned more than one tractor, each tractor was treated as a separate unit and information about its use was collected independently.

Results and Discussion

A total of 19 farmers were interviewed in the study, making 10% of the registered tractors in the district. The respondents in the study were the owners except in one case where the respondent was the owner's son. Therefore, each respondent had first-hand information about the use, operation and record keeping of the tractor. In all cases, the owners were married and were full-time farmers. In cases where wives were respondents, they demonstrated comparable knowledge about the

Fig.2 Operator description for tractor in the Kgatleng District

Tractor Model	Year of manufacture	Year of purchase	Engine Over-hauling?	Purpose of buying	Hacters per year	Other activities	Frequent problem	Location of service provider
MF 135	1970s	1993	No	Ploughing	25	None	Bearings	Local / Gaborone
MF 178	NA	1989	Yes	Ploughing	165	None	Air lock and punctures	Dealer in Gaborone
Ford 5000	1986	1994	Yes	Ploughing and hire	162	Kraal manure and water	Engine	Dealer in Pilane
MF 178	NA	1994	Yes	Ploughing	63	Water, animal,feed, threshing, livestock transoport	Engine	Self
MF 135	1976	1981	Yes	Ploughing	14	Firewood transport	Engine	Gaborone
Landini 6000	1971	1985	Yes	Ploughing	84	Water	Wrong parts	South Africa
MF / Landini engine	1971	1985	Yes	Ploughing	70	Firewood, water, funeral transport	Air lock, oil leaks	Dealer in Gaborone
MF 165	1977	1983	Yes	Ploughing	75	Transport produce	Poor operation	Gaborone
MF 240	1978	1979	NA	Ploughing	120	Firewood, diesel for water E/G	Hydraulics	South Africa
Landini / MF engine	1980	1991	Yes	Ploughing	30	Transport people	None	South Africa
Deere 1120	1972	1972	Yes	Ploughing	140	Firewood	Bearings	Local
MF 135	1974	1984	Yes	Ploughing and hire	160	None	Engine	Gaborone
MF 135	NA	NA	NA	Ploughing	160	Firewood	Starting and loss of power	Gaborone
MF 135	NA	1978	Yes	Ploughing, livestock transport	45	Sand, livestock transport	Bearings	Gaborone
MF 135	1974	1974	Yes	Ploughing	40	Water and sand	Engine and oil leaks	Dealer in Gaborone and Pilane
MF 285	1978	1982	Yes	Ploughing	175	Firewood, water, funeral transport	None	South Africa
MF 185	1972	1985	Yes	Ploughing, planting and hire	320	None	Tyres	Gaborone
MF 265	1980	1983	No	Ploughing	100	Farm duties	Lights	Dealer in Gaborone
MF 265	1983	1983	No	Ploughing	80	None	None	Local

Table 1 Information about tractor type, uses and service

tractor as their male counterparts.

The information was important to know since it reflected the ability of the farmer to comprehend operator's manuals and other written instructions as well as record keeping abilities. It was not surprising that 37% of them had no education at all. The majority of them have been educated only up to primary school level. This observation was made because equally 42% of them were an older generation with over 60 years of age, 41% were between 41 and 60 years old and the rest were younger. Lack of education may have been the reason why only 58% of the operators were licensed and the rest were not. Despite the education issue, the farmers showed reasonable knowledge about tractor operation systems and adjustments: knowledge possibly acquired through experience and interaction with peers.

The age distribution of farmers indicated a similar range observed by Baryeh (1982) among West African countries. Investigations on why young people tended to stay away from farming may be necessary to undertake. Their apparent disinterest in farming may lead to abandoned fields in the future or even result in the more expensive mechanised farming.

It was evident that in most cases the owner's sons were the primary operators of the tractors. They were the sole operators or at least worked alternately with their fathers or hired labour. The reasons for this arrangement may be that the sons are younger and so tended to be fit to withstand the demands of ploughing. They may also be more conversant and comfortable with modern technology than their fathers. Hired labour tended to be expensive and so to cut down on costs, it was better to use unpaid family labour. In fact, most of the families visited had over seven children and thus had a lot of labour reserve. Customarily, children especially sons, are expected to help with farming activities. The other operators used were a nephew, brother to the owner as well as a brother-in-law. This practice has a downside when the operators are not knowledgeable of the proper settings and adjustments.

Kgatleng district is within 50km from the capital city, Gaborone, where there is a Massey-Ferguson dealer. This fact accounted for the high number of the Massey-Ferguson tractors encountered during the survey (**Table 1**). Another Massey-Ferguson dealer was in Pilane, within the district. Farmers normally buy models that they are certain to easily find spare parts. Other tractor makes were available from neighbouring South Africa, requiring a long process with the customs department to import them.

The tractors were generally over 15 years old and were bought second hand. The conditions of the tractors varied widely. The authors could not establish how much of the damage on the tractors was acquired from the previous owner(s). The service records were not available. But it could be deduced that the tractors were bought in poor condition as 68% had to be overhauled by the current owner. Even with overhauling, some tractors experienced frequent problems with hydraulics, power loss, engine oil leakage, front wheel bearings and the electric system. The farmers could only mention these problems from memory and had no record of how frequent they occurred and the cost to fix them. That being the case, it was impossible to accurately perform any cost analysis for the tractors. Only theoretical values and experience from other districts and countries may offer a simple and easy way of gaining information on costs and how they are influenced by different factors (Lonnemark, 1967). The farmers relied on local mechanics, dealers and auto garages in Gaborone for repairs and servicing.

As previously stated, the tractors were pre-owned and 10.5% were bought between 1970-1975; 10.5% between 1976-1980; 42%, between 1981-1985; and 21% between 1991-1995. One farmer was not sure of the year of purchase. The period when most tractors were bought, that is between 1980 and 1995, coincided with the ARAP program became operational. Since ARAP paid cash incentives for ploughing, it was not surprising that most farmers said that their primary use of the tractors was for ploughing. The government paid farmers up to P120.00 (US$24.00)/ha for ploughing. They ploughed their own fields and thereafter hired out the tractors to other farmers. Despite the own ploughing and hiring-out arragement, the total hectarage done remained very low (**Table 1**). On average, the tractors ploughed only 106.7ha per year. Taking an average operation speed of 4km/hr and a plough width of 1.8m, this comes to 148 hrs per year. A number of factors could have resulted in the low hectarages, the main factor being the down-time of the tractors. It took some time for the tractors to get fixed once they were unserviceable. Correct parts were also expensive and not easily available. Sometimes the mechanics used were not qualified and not reliable. Also, the fields were relatively small, about 5ha each. This is why it took some to move about from field to field in order to plough a sizeable total area. Low rainfall and a short rainy season would also contribute to the low hectarage. It should be noted that the figures given were from the past season (1996-1997). Long-term averages could not be determined as farmers did not keep any written records.

Besides ploughing, planting and other on-field activities, tractor owners were generally reluctant to use them for anything else. Thus the tractor lay idle for most part of the off-season period. The reluctance stems from the fact that the farmers did not want to risk damaging the tractor and not having an operational machine at the beginning of the next season. Only occasionally did they use the tractors for transporting firewood, water, livestock and other farm produce, sand for building, and people during funerals (**Table 1**). In one case a farmer used his tractor for threshing sorghum. By using the tractor for stationary jobs such as threshing or water pumping the number of working hours per year can be increased and the average cost per hour reduced. Lonnemark (1967) notes that the cost is high up to 500 hours' annual use, but reduce very rapidly up to 1000 hours. It is important, therefore, to try to ensure that tractors are used for about 1000 hours annually.

Farming for most Botswana farmers is a lifestyle and not necessarily a business. As a result, the activities done were solely to sustain their lives. But if farming were to be taken as a business, then the farmers would appreciate the need to keep proper records and engage in income generating projects. From the listed activities above, it appears there was potential for engaging the tractor all year round and make ownership cost effective. A well maintained tractor that is hired-out will be able to bring income to help pay for the loan acquired to buy it. At present, the farmers use non-arable income or sold cattle to buy the tractors.

On the other hand, the authors

acknowledge that the tractor is just a power source and works attached to implements. Therefore, engaging the tractor in other activities takes more than just the decision to do so which requires procuring the necessary implements such as threshers, balers, trailers and hammer mills. But if farmers were motivated to get into agro-business, they could build upon what they already have and get more implements to vary their activities.

Pre-owned machines though relatively affordable pose a problem of assessing their useful life and worth. It is a challenge to try and do a cost analysis of a tractor that has been reduced to salvage value by the previous owner. Depreciation rate is difficult to determine. Lonnemark (1967) recommends that when the tractor is used for a short time per year, depreciation should be considered as a fixed cost and calculated from the amount to be written off which is the price of the machine, or the investment needed for its acquisition. We suggest that a thorough study be done into the cost analysis of pre-owned farm tractors. The available methods mostly deal with new machinery and where records are properly kept. As noted by Chen and Bateman (1988), there is no prevailing standard among the several alternatives. The lack of consistency lead to budget differences that may not be due to technology or productive capability. Other methods such as the one by Ward (1990) but complicated only understandable by scholars and researchers. This factor, together with the absence of written records by the farmers made it impossible for the authors to determine the cost of owning and operating a tractor in the Kgatleng agriculture district.

Conclusion

The study surveyed the use of tractors and their maintenance as well as the characteristics of tractor owners. The use of tractors by farmers in the Kgatleng district has grown over the years. Research aimed at optimal use of the tractors should also be stepped up. Presently, farmers have no means of knowing if it is cost effective to own and operate a tractor or not. Farm accounts are mixed up with other family activities such that it is impossible to know the contribution of each entity. They need to be trained to keep proper and simple records that can be used in tractor management decisions. If tractor ownership by individual farmers prove to be not cost effective, machinery circles by a group of farmers may be tried. However, since this would be a new venture, the farmers will need assistance from government agricultural extension workers.

It has also been found that tractors are old and not well maintained. They are not fully utilised especially during off-season. It could be profitable for farmers to use their tractors for off-season activities such as threshing, transportation, water pumping, and hay baling for a fee. Tractor owners were found to be mostly over 60 years old. Most of them had no education or had only primary education. Mainly the owners and sons operated the tractors.

It is imperative that the appropriate tractor is selected to suit particular farm size and operational requirements. But that option is not necessarily available for Kgatleng farmers. They often buy whatever tractor is available and affordable at the time. To address this problem, one way would be to establish a national farm machinery/equipment evaluation and testing centre that can help with documenting tractor condition at the time of purchase. The centre would evaluate and run tests on tractors at farmer's request and give it's report for farmers to make informed decisions

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Tillage Systems and Their Effect on Some Soil Properties, Crop Growth and Shoot Yield of Grain-Amaranth

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Abstract

Experiments were conducted in 1996 (May-July) and 1997 (January-April) to investigate the effects of tillage methods on soil hydraulic conductivity, resistance to penetration, percent aggregates, crop growth and shoot yield of Grain-amaranth.

Five tillage treatments comprised of No-tillage (NT), slashing (SH), ploughing (PHO), ploughing plus harrowing (PHA) and Ploughing plus harrowing plus bedding (PHB) were considered using a randomized complete block design with three replications.

The saturated hydraulic conductivity in the 0-10cm layer was significantly higher in the ploughed treatments than in the others (PHO=9.2×10^{-5}cms^{-1})>(PHA=9.1×10^{-5}cms^{-1})>(PHB=7.9×10^{-5}cms^{-1})>(NT=6.8×10^{-5}cms^{-1})>(SH=6.5×10^{-5}cms^{-1}). In the 10-20cm layer, the values were in the order: PHA (8.4×10^{-5}cms^{-1})>PHB (7.7×10^{-5}cms^{-1}). Resistance to penetration in the 0-10cm and 10-20cm layers was significantly higher ($P<0.05$) in the slashing (SH) treatment (18.83MPa) than in the others (PHA=10.69MPa, PHO=7.5MPa, PHB=3.5MPa). The soil with the slashing (SH) treatment was the most resistant to root penetration.

The geometric mean diameter, mean clod size and mean weight diameter of aggregates were similar for all the tillage treatments. However, the incidence of soil aggregates of approximately 2.00mm was highest for ploughing plus harrowing plus bedding (PH13) (2.170mm) and for the incidence of aggregates>4mm, slashing gave the highest mean value (2.89mm). Soil chemical properties were generally similar among all treatments except for the cases of calcium, magnesium and organic matter. The slashing (SH) treatment soil had the highest levels of Mg, the ploughing plus harrowing plus bedding (PHB) treatment soil had the highest levels of Ca, and the no-tillage (NT) treatment soil gave the highest mean value for organic matter (OM). Crop growth performed significantly more luxuriantly with the ploughing (PHO) treatment than with the others. Shoot yield of Grain-amaranth was significantly greater for the PHB treatment followed by that for the PHO treatment. However, when energy input, traffic induced soil compaction and the cost-benefit ratio factors were taken into consideration, the PHO treatment was found to be preferred as the optimum tillage method for Grain- amaranth production.

Introduction

Soil is generally conceived to exhibit high in-built resistance to degradation even under intensive traction operations. However, any abuse can accentuate total pore collapse beyond the plastic limit allowable for sustainable agricultural production. It is, therefore, acknowledged that the basic problems facing tropical soils is mismanagement without any plan for the conservation procedures that would be essential for sustainable food production. Consequently, soil degradation becomes prominently unresolved while exerting a profound and devasting influence on environmental pollution. This is a great threat to human survival (Babalola and Opara-Nadi, 1993).

The continent of Africa has only witnessed a marginal increase in food production of 2% a year (Lal and Stewart, 1992). Slater (1967) confirmed that the world population appreciated as follows: 1 billion in 1800 AD, 2.5 billion in 1950 with a predicted value of 4.7 billion in 1983, 6.2 billion at the end of 2000 AD and 11 billion by the end of the twenty first century. The consequence, of course, is that by the end of the year 2100 A.D; about 4.8 billion additional people may be required to be fed. Industrial development is on the increase daily which limits the available land left for food production. The report of the FAO (FAO, 1984) revealed that the carrying capacity of African soil has already been exceeded. About 38% of the total land is carrying more people than can be accommodated or fed with present inputs. Presently, only 3% of the world's arable land area is regarded as having a high capacity for intensive crop production (Buringh, 1989). Unfortunately, about 0.3% to 0.5% of these arable lands is lost to soil degradation annually, a product of uncontrolled tillage systems (Buringh, 1989). Soil conservation oriented tillage systems must be encouraged and properly implemented to preserve the remaining available land from further degradation, and to reclaim the depleted lands, otherwise not less than one- third of the world's arable land would be lost by the end of the year 2002 due to accumulated land misuse and cultivation (Afolayan, 1998). Tillage can be defined as any positive action where forces are reasonably applied with the aim of altering the soil conditions for agricultural purposes. Seed-bed preparation is a vital factor influencing the yield of crops in any ecosystem. The seed-bed is the place where seeds germinate, and the seed-bed is the medium from which the resulting plants, through their roots secure moisture and mineral nutrients. It is therefore essential that the seed-bed be able to facilitate an abundance of moisture, nutrients and aeration to allow full penetration of plant roots.

Tillage, though, could pose some problems to organic matter rejuvenation. Tillage is an unavoidable practice, however in the production of Grain-amaranth. Grain-amaranth differs from other crops in terms of seed size, crop duration to maturity and ability to attain full vegetative cover within a short period of time, all related to its having different rooting systems and root concentrations 15cm below the soil surface. It's response to nutrient recyling and decomposition dynamics could possibly point to Grain-amaranth as having potentials for effective maintenance of a sustainable soil profile when properly incorporated into the soil during tillage operations. The aim of the project reported in this paper was to address tillage issues involved in Grain-amaranth production.

Materials and Methods

The experiments were conducted at the National Horticultural Research Institute, (NIHORT), Ibadan, Oyo State, Nigeria at an altitude of 168m above mean sea level. Oyo State lies roughly between longitude 3° and 6° east and latitudes 6° and 8° north with an average annual rainfall of about 1300mm (NIHORT Met Garden record, 1996).

The following tillage treatments replicated four times were imposed.

1.No-tillage (NT). This treatment involved the use of herbicides (glyphosate) to kill the weeds at least four weeks before commencement of planting to allow for sufficient litter decomposition before planting. The soil was, however, smoothened with a hoe to create minimum soil tilth for the tiny seeds. Glyphosate was applied at the rate of 2.5 litre per hectare.

2.Slashing (SH). Here, tillage was limited to the use of traditional tools such as cutlasses and hoes to ensure minimum soil disturbance for effective seeding and seed-soil contact.

3.Ploughing (PHO). This technique involved the use of a disc plough while subsequent pulverization of the soil was accomplished with the aid of the normal traditional hoe common among local farmers.

4.Ploughing plus harrowing (PHA). Ploughing combined with harrowing was accomplished using a disc plough and a disc harrow. The device was adopted to enhance and provide a more effective improvement of soil tilth resulting in adequate and sufficient seed-soil contact.

5.Ploughing plus harrowing plus bedding (PHB). This is actually the conventional practice for Grain-amaranth production in Nigeria especially with mechanized farming. Tillage activities in this case incorporated the use of a disc plough (conventional), a disc harrow of the standard type and a disc bedder of a type improvised by NIHORT, purposely for making flat vegetable beds in order to promote adequate soil tilth. Beds, one metre width, were raised 10cm above soil surface. Drainage and sufficient aeration were guaranteed with this method.

The treatments were subjected to a randomized complete block design with three replications. Saturated hydraulic conductivity was measured based on the application of Darcy's law (eq.1) using the constant head permeameter method.

$$K_{sat} = \frac{QL}{At\Delta H}$$

where, Q=volume of water flowing through the soil column (cm^3); A=cross-sectional area of the sample (cm^2); t=time (s); L=length of the soil column (cm); DH=hydraulic head difference across the sample (cm).

Saturated soils contained in cores were placed on the funnel base. Water was allowed to percolate through the soil and drain into a reservoir on a tripod stand. Conical flasks containing water were clamped to a retort stand. Saturated hydraulic conductivity was, therefore, calculated using Darcy's equation using three replications. Cone penetration resistance values were measured using a Bush-Penetrometer (Anderson *et al*, 1980) with a cone having a 140 semi-angle and a standard cone base area. Readings were taking just immediately after land preparation and after the time of harvest. The data generated (the cone index) were calibrated on a kilogram scale. Four penetration readings at 10cm and 20cm depths were taken per plot in all the treatments.

Percentage distributions of aggregate diameter were determined by wet sieving following the method of Yoder (1936). Undisturbed core samples from the various tillage treatments were emptied into containers. The samples were made to pass through 10mm-size sieve out of which 50g was weighed from each sample. The 50g sample was emptied into a nest of 5 sieves clamped to a reservoir (cylindrical container) which was in turn lowered at a constant rate (30 strokes, of 12mm length per minute) (Kirchhoff and Basnet, 1989). The weight of soil retained on each sieve after oven drying was determined and recorded as a percentage of the total weight of the sample.

The cummulative percentage of soil mass passing each sieve was plotted against sieve size on a semi-log scale according to the method described by Watts and Dexter (1994). The medium clod size was read off as the aggregate size where the 50% mass line intercepted the plotted line (BSI, 1975).

Mean weight diameter (MWD) can be defined as:

$$NMD = \sum_{t=1} xiWi$$

was calculated using the numerical technique of Youker and Mc-Ginness (1956) where X_i=the mean diameter, W_1=weight of aggregates as a fraction of total weight, n=number of size fractions (Van Doren and Allmaras, 1978). The sieve size was also plotted against the cumulative percentage passing each sieve on log-log scale. The geometric mean diameter (GMD) is the size corresponding to 50% of the sample. The log of the standard deviation (∂r) is numerically equal to:

$$\delta r = \frac{size\,at\ 84.13\%}{size\,at\ 50.00\%} = \frac{size\,at\ 50.00\%}{size\,at\ 15.87\%}$$

(Gardner, 1956) where ∂r=log of the standard deviation.

Cutting of Grain-amaranth (five weeks after direct seeding) and at two-week intervals was done at 15cm above ground level and the harvested material weighed using a top-loading balance for the determination of shoot yield. Leaf area was measured with a 3100 model leaf area meter when the leaves attained optimum canopy. Plant height was measured from ground level to the tip of the terminal bud fortnightly using a metre rule. Stem girth was evaluated at ground level using a vernier caliper. Ten (10) plants were chosen out of a grid of 54cm by 4cm. Both root depth and root densities were determined with the aid of a metre rule and numerical counting, respectively. The number of leaves was counted manually. The selected plants were removed by digging about 15cm away, from the plant centre and about 20cm deep, ten weeks after planting. A standard shovel was used to lift the plants to ensure minimum damage to the root system. The data generated were analysed using a SAS software package as developed by Cary (1987).

Results and Discussion

The experimental seasons covered May to July, 1996 as the first cropping period and January to April, 1997 as the second cropping season. Both seasons witnessed different rainfall patterns.

The first season recorded a high total rainfall (499mm), a high relative humidity (85.4%), a low total evaporation (12.3mm), a low mean number of hours of sunshine (3.3h), a low mean net radiation and consequently a low mean soil temperature. The second season witnessed relatively non-extreme weather inputs. In spite of the fact that the second season lasted almost four months, the total rainfall was very low (309.2mm), the mean relative humidity decreased markedly (76.8%), total evaporation was high (21.5mm), with a high mean number daily sunshine hours(5.1h) and a relatively high mean net radiation and a relatively high mean soil temperature (28^{o}C). This set of climate conditions was typical of the bimodal rainfall pattern of the South Western part of Nigeria, thereby affecting the various weather inputs.

Table 1 Textural characteristics of the experimental soil under five tillage treatment

Code	Tillage	Sand (%)	Slit (%)	Clay (%)
NT	No-tillage	88.4	6.0	5.6
SH	Slashing	86.4	8.0	5.6
PHO	Ploughing	88.4	6.0	5.6
PHA	Ploughing plus harrowing	88.4	6.0	5.6
PHB	P loughingp lush arrowing plus bedding	88.4	6.0	5.6
	LSD (5%)	NS	NS	NS

Table 2 Effect of tillage methods on saturated hydraulic conductivity (cm/s) at 0-10 and 10-20cm

Code	Tillage	1st season		2nd season	
		0-10(cm)	10-20(cm)	0-10(cm)	10-20(cm)
NT	No-tillage	1.96×10^{-5}	1.6×10^{-5}	6.8×10^{-5}	6.8×10^{-5}
SH	Slashing	1.04×10^{-5}	1.2×10^{-5}	6.5×10^{-5}	7.3×10^{-5}
PHO	Ploughing	1.66×10^{-5}	1.1×10^{-5}	9.2×10^{-5}	7.6×10^{-5}
PHA	Ploughing plus harrowing	1.22×10^{-5}	1.2×10^{-5}	9.1×10^{-5}	8.4×10^{-5}
PHB	Ploughingp lush arrowing plus bedding	1.3×10^{-5}	1.1×10^{-5}	7.9×10^{-5}	7.7×10^{-5}
	LSD (5%)	NS	NS	2.5×10^{-5}	7.7×10^{-5}

Table 3 Effect of tillage methods on resistance to penetration (MPa)

Code	Tillage	1st season		2nd season	
		0-10(cm)	10-20(cm)	0-10(cm)	10-20(cm)
NT	No-tillage	14.3	16.2	14.3	16.2
SH	Slashing	18.3	18.7	18.8	18.7
PHO	Ploughing	7.3	13.8	7.3	13.8
PHA	Ploughing plus harrowing	9.1	15.6	9.1	15.6
PHB	Ploughingp lush arrowing plus bedding	4.3	4.0	4.3	3.9
	LSD (5%)	4.4	4.7	4.4	4.7

Table 4 Effect of tillage methods on percent aggregates (mm)

Code	Tillage	<0.125 (mm)	0.125-0.25(mm)	0.250-1.00(mm)	1.00-2.00(mm)	2.00-4.00(mm)
NT	No-tillage	13.4	14.6	10.7	1.7	2.69
SH	Slashing	13.3	19.0	5.3	1.1	0.23
PHO	Ploughing	13.6	17.0	5.3	1.2	0.08
PHA	Ploughing plus harrowing	16.2	17.5	5.0	1.1	0.33
PHB	Ploughingp lush arrowing plus bedding	12.5	21.2	5.4	2.2	0.37
	LSD (5%)	NS	NS	NS	0.7	0.72

Table 5 Effects of tillage methods on GMD, MWD, D50

Code	Tillage	GMD (mm)	MWD (mm)	D50 (mm)
NT	No-tillage	0.7	0.4	0.11
SH	Slashing	0.8	0.4	0.12
PHO	Ploughing	0.6	0.3	0.14
PHA	Ploughing plus harrowing	0.5	0.4	0.12
PHB	P loughingp lush arrowing plus bedding	0.6	16.0	4.8
	LSD (5%)	NS	NS	NS

GMD=Geometric Mean Diameter, NMD=Mean Weight Diameter, D50=Mean Aggregate Size

The textural characteristics of the experimental soil are presented in **Table 1**. Sand accounted for about 90% of the soil composition resulting in a highly porous soil profile.

Saturated hydraulic conductivity values were similar for all treatments during the first season at both soil depths. However, during the second season at the 0-10cm depth hydraulic conductivity of the soil in the field with the plowing treatment (PHO) was significantly higher ($P<0.05$) than that for the slashing (SH) treatment. The order of differences in hydraulic conductivity was: PHO>PHA>PHB>SH>NT, thereby, indicating the relevance of soil disturbance to soil water movement at the 0-10cm soil depth. The lowest saturated hydraulic conductivity was for the SH and NT treatments (**Table 2**). This could be attributed to the fact that soils planted to vegetables especially Grain-amaranth require some measure of soil pulverization to aid soil water movement for crop growth. At the 10-20cm depth, during the second season the soil with the plowing and harrowing treatment (PHA) was significantly less restrictive to water movement while that for the no-tillage treatment (NT) treatment was most impervious to water flow within the soil profile (**Table 2**). This, of course, was expected as water movement through undisturbed soils exhibit some ink-bottle constraints (Babalola, 1998). To penetration resistance values were observed to follow a logical order. The resistance of the untilled plots (NT and SH) to penetration was significantly greater than that for the tilled plots in both seasons and at both depths. Since the NT and SH treatments were not disturbed through tractor traffic passes, the underlaying soil profiles were possibly constituted by hard layer or plough pans which were not broken, thus, limiting the depth of penetration (**Table 3**). This finding was similar to that of Materchera and Mloza (1997).

Table 6 Effects of tillage methods on soil chemical properties

Code	Tillage	pH	Ca	Mg	K	Na	CEC	OM (%)
NT	No-tillage	6.7	3.7	0.95	0.3	5.1	1.4	2.1
SH	Slashing	6.6	4.1	1.1	0.3	5.0	1.6	1.9
PHO	Ploughing	5.6	3.2	0.6	0.3	5.7	1.4	1.4
PHA	Ploughing plus harrowing	6.6	4.0	0.8	0.3	5.9	1.7	1.6
PHB	P loughingp lush arrowing plus bedding	6.6	4.2	0.9	0.4	5.9	1.7	1.7
	LSD (5%)	NS	0.11	0.7	NS	NS	NS	0.4

CA, CEC=(Meg/100g)

Table 7 Effects of tillage methods on the growth performance and shoot yield of Grain Aramanth (1st season)

Code	Tillage	LAP (cm2)	NLP	SGP (cm)	PHP	NRP	RDP (cm)	Yield (t/ha)
NT	No-tillage	56.9	17.8	3.4	20.5	16.0	14.7	1.6
SH	Slashing	68.0	13.0	3.0	21.7	14.0	12.7	1.4
PHO	Ploughing	78.5	16.0	4.4	24.09	17.0	19.8	6.9
PHA	Ploughing plus harrowing	67.5	17.0	3.8	24.2	13.0	13.2	5.9
PHB	P loughingp lush arrowing plus bedding	99.9	23.0	4.6	22.0b	13.0	14.8	7.9
	LSD (5%)	15.2	NS	NS	NS	NS	NS	0.26

LAP=Leaf area per plant, NCP=No. of leaves per plant, RDP=Root depth per plant
SGP=Stem girth per plant, NRP=No. of roots per plant, PHP=Plant height per plant

Table 8 Effects of tillage methods on the growth performance and shoot yield of Grain Aramanth (2nd season)

Code	Tillage	LAP (cm2)	NLP	SGP (cm)	PHP	NRP	RDP (cm)	Yield (t/ha)
NT	No-tillage	69.8	16.8	3.7	12.0	21.0	33.9	1.20
SH	Slashing	59.5	14.0	2.4	14.0	23.0	33.8	0.98
PHO	Ploughing	67.7	18.3	4.2	16.2	27.0	37.9	1.61
PHA	Ploughing plus harrowing	98.9	15.0	4.0	14.0	34.0	35.8	1.31
PHB	P loughingp lush arrowing plus bedding	82.6	16.0	4.8	15.0	34.0	41.6	2.10
	LSD (5%)	23.8	NS	NS	NS	8.7	NS	1.16

LAP=Leaf area per plant, NCP=No. of leaves per plant, RDP=Root depth per plant
SGP=Stem girth per plant, NRP=No. of roots per plant, PHP=Plant height per plant

There were no significant differences in the mean percent of aggregates of a given size diameter among the tillage treatments in the 0.125mm, 0.250mm and 1.00mm sieve size ranges. However, in the 2mm and 4mm size ranges, the soils with the plowing, harrowing and bedding (PHB) and the no-tillage (NT) treatment were consistently high with regard to this parameter (**Table 4**). This sequence may not have been unconnected with the pulverized raised beds having loose soil grains as was typical with the PHB treatment, while this sequence with the NT treatment may have been due to multiple factors typical of untilled soils, but with larger size aggregates in lower layers, coupled with the effects of human traffic during the application of chemicals. The values of mean clod size were not significantly affected by the tillage treatments (**Table 5**). However, the mean aggregate size (D50) for the soil having the plowing, harrowing and bedding (PHB) treatment was highest. The mean value of the soil particle mean weight diameter was also similar. (**Table 5**). This arose as a result of tractor traffic thereby inducing some measure of compaction typical of tilled soils. Generally, it was observed that the type of tillage method used did not affect significantly the geometric mean diameter. This, of course, could be due to the fact that soil grains engaged by the plough, harrow and bedder discs suffered a minimum of shear during land preparation. However, the soil in the no-tillage (NT) plot suffered less shrinkage in particle size as compared to those with other treatment (**Table 5**). The lack of observed significant differences of the soil chemical properties during the experimental seasons and among the various tillage methods (**Table 6**) could be suggestive that the tractor traffic during the various tillage operations was not serious enough to cause damage to soil nutrient status. However, Ca, was highest in the PHB plots, Mg in the SH plots and OM in the NT plots, this last value being significantly higher than the OM levels in the plots for the PHA and PHO treatments. The initial concentrations of the elements were generally lower than the critical values (Bezdicek, 1978; Anne and Lal, 1995) as a result of the typical nature of tropical soils with antecedent low level of nutrients status (Ssali et al 1986; Norman et al 1983; Ker, 1995 and Iheanyichukwu, 1999).

Results in terms of crop growth parameters are presented in **Table 7** for the first season Table and **Table 8** for the second season. There were no significant differences ($P<0.05$) among the tillage treatments except for leaf area where the plowing, harrowing and bedding (PHB) treatment resulted in significantly more luxuriant leaf area followed in rank by the ploughing (PHO) treatment (first season). During the second season the highest leaf area was associated with the ploughing and harrowing (PHA) treatment, followed by the ploughing, harrowing and bedding (PHB) treatment. The results obtained may not be unconnected with the fact that intensive tillage techniques are not generally desirable for the production of Grain-amaranth. Shoot yield results in both seasons indicated that the ploughing, harrowing and bedding (PHB) treatment gave significantly higher yields than did the rest of the treatments, although yields with the PHB treatment were closely followed in magnitude by those with the PHO treatment (**Tables 7** and **8**). However, in view of the intensive financial involvement for ploughing, harrowing and bedding (PHB) coupled with its associated labour and energy requirements, the ploughing treatment (PHO) is concluded to be preferred, as it is as less capital-intensive and more advantageous with regard to soil chemical and physical properties.

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Effect of Concave Hole Size, Concave Clearance and Drum Speed on Rasp-Bar Drum Performance for Threshing Sunflower

by

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Abstract

A sunflower threshing unit was designed and fabricated to study the effect of machine and crop variables and to accumulate enough information for the best possible design of the thresher. A rasp-bar drum was used for the study. Three concave hole sizes, four concave clearances and four drum speeds were studied. Test results indicated that the concave hole size of 11x60mm gave the optimum sunflower threshing. The overall capacity values obtained with 29 and 35mm concave clearances were not significantly different from one another but, there was a significant difference at each drum speed. The threshing efficiency varied from 99.94 to 100%. The grain damage and grain loss figures were less than 1.5 and 1%, respectively, at drum speeds of 675 to 875rpm and 29 to 35mm concave clearances. The percentage of materials other than grain (MOG) separated through the concave at a 35mm concave clearance was lower than the percentages with other concave clearances. The lowest specific energy consumption was obtained with a 35mm concave clearance at all drum speeds. The best combination of drum speed, concave clearance and concave hole size to obtain high output capacity, high threshing efficiency, low grain damage, low grain losses and low specific energy consumption was a combination of 750 to 850rpm drum speed (10.9 to 12.4m/s), 35mm concave clearance and the concave and a hole size of 11x60 mm.

Introduction

Sunflower derives most of its economic value from the oil. The oil is considered to be of high quality and generally sells at a premium rate in world markets. The sunflower meal, obtained after the oil is extracted from the seed, is high in protein and used primarily in feed rations for livestock and poultry. In Thailand, the requirement of sunflower seed production for oil is around 100,000 tons per year (Aiamgrasin, 1996). Thai farmers produced 45,940 tons of sunflower seeds in 1997/98 (OAE, 1999). Sunflower seed production by farmers is not enough to satisfy requirements. During sunflower production, the most time and labour-consuming operation is the threshing of sunflower by beating the sunflower heads with a stick, rubbing earheads against a rough metal surface or power tiller treading (Sangpratum, 1996). The capacity figures for these threshing methods are very low, and impurities are very high. Farmers in some areas thresh sunflower with a rice or soybean thresher or a corn sheller. However, the results obtained indicated that these types of threshers are not efficient for threshing sunflower. Therefore, there was a need to develop a sunflower thresher for

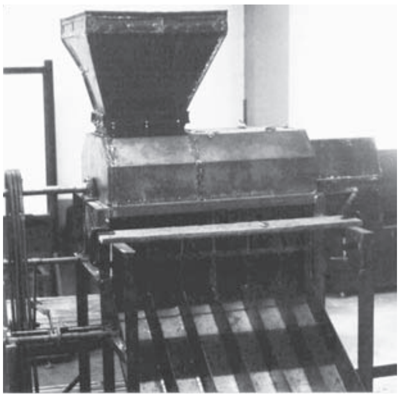

Fig.1 Sunflower threshing unit

use by Thai farmers. For the design and development of such a thresher knowledge of its working parameters is required. This research was undertaken to quantity the parameters of concave hole size, concave clearance, and threshing drum speed.

Literature Review

Vas and Harrison (1969) investigated the effect of mechanical threshing parameters on kernel damage and threshability of small grains. Cylinder speed and concave clearance were found to be the primary influencing parameters. Friesen (1971) reported that peripheral cylinder speeds of more than 910 m/min should not be used be as they could cause excessive broken seeds. Sharma & Devnani (1979) determined the effect of cylinder tip speed and concave clearance of a rasp bar thresher on threshing of sunflower. Threshing trials were carried out by varying the cylinder tip speed from 4.81 to 8.17m/s and concave clearance from 4 to 2mm. The germination percentage was directly proportional to the concave clearance and inversely proportional to the cylinder tip speed. Jadhav & Deshpande (1990) developed and evaluated a pedal-operated sunflower thresher. The human-powered, hold-on sunflower thresher consisted principally of threshing, cleaning and power transmission units. When fresh heads were threshed, the output capacity, threshing efficiency and cleaning efficiency were about 40kg(seed)/h, 100% and 96 to 98%, respectively. Rizvi et al. (1993) compared the performance of different threshing drums for sunflower threshing. The spike/peg tooth, rasp-bar and rubber strip cylinders with their respective concaves were used. The study showed that the peg tooth cylinder with a speed range of 400 to 500rpm and a concave clearance range from 2.54 to 3.00cm could be used for a sunflower threshing unit. Naravani & Panwar (1994) studied the effects of the impact mode of threshing on the threshability of a sunflower crop. The results showed that threshing efficiency increased as the impact energy increased at all seed moisture contents ranging from 5.76 to 13.56% (w.b.). The threshing efficiency of 71% with 9.7% (w.b.) seed moisture content at an energy level of 20.6N·m was observed. Bansal *et al.* (1994) evaluated different sunflower threshers. Most of the sunflower threshers used were based on axial flow designs. It was concluded that sunflower should be threshed at a cylinder speed of 6.5m/s with a feed rate of 1,500 to 2,000kg/h at a grain moisture content of 30% (w.b.). Bhutta *et al.* (1997) compared the performance of a locally-made sunflower thresher and combine harvester. The thresher was operated with a tractor power-take-off (P.T.O.). The power operated sunflower thresher had an output capacity of 447kg/h with a threshing efficiency of 97.3% and a breakage of 4.87%. The combine harvester threshing drum consisted of 8 rasp bars of 104cm length and 60cm diameter. The combine harvester had an output capacity of 1,000 kg/h with a threshing efficiency of 98.7% and breakage of 0.26%. Using basic principles adopted for cereal threshers, Anil et al. (1998) designed and developed a prototype threshing machine for sunflower seeds. Test results indicated that the optimal thresher performance was achieved at 9 to 13% moisture content, 180kg/h feed rate and 500rpm cylinder speed. Sudajan et al. (2001) determined some of the physical properties of both sunflower seeds and heads at various moisture levels for use in the design of a prototype sunflower thresher. Some of the varieties used in their tests included sunflower varieties such as: Hysun-33, Pioneer Jumbo and Cargill-3322 which are common in Thailand.

Materials and Methods

The sunflower threshing unit developed (**Fig.1**) operated on the principle of axial flow movement of the material. The threshing mechanism consisted of a rasp-bar drum, which rotated inside a two-section concave. The rasp-bar drum had given the best performance in previous studies. The length of the concave of the threshing unit was 96cm. The concave was divided into six equal sections by metal sheets underneath the concave. The threshing unit was operated by a tractor P.T.O.

For the first test concaves with three hole sizes, 7×60mm, 11×60mm and 15×62mm were designed (**Fig. 2**). The range of concave hole size was based on consideration of the results of tests of physical properties of sunflower seeds and heads, such as those of seed shape and seed dimensions (Sudajan *et al.*, 2001). The Hysun-33 variety was used. The average moisture content of grain and moisture content of the straw were 6.59 and 13.80% (w.b.), respectively, (ASAE, 1983). The average grain to straw ratio was 1.25. The drum speed of 850rpm and feed rate of 3,000kg(head)/h were used in this experiment. Also the concave clearance was kept at 35mm. A one-way ANOVA by SPSS for Windows (Version 7.5) was used for analyzing the data. Sunflower heads were fed to the threshing unit. Each test was replicated thrice.

For the second test, four levels

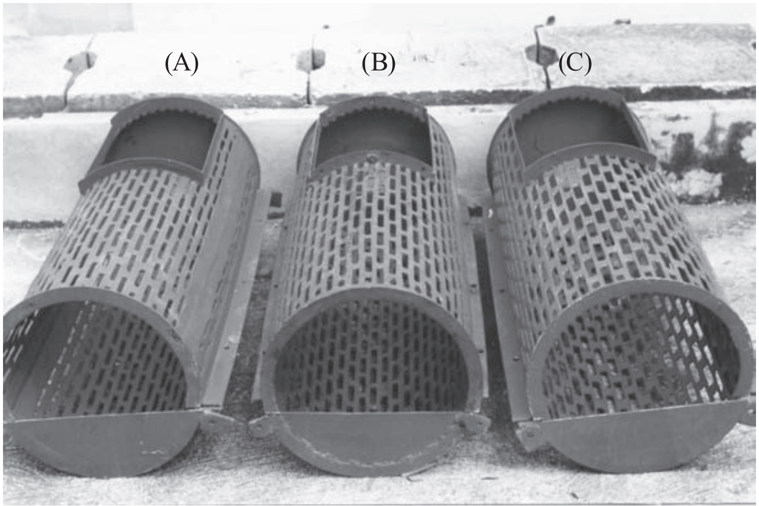

Fig.2 Three concaves with different hole sizes used for testing (A: 7x60mm, B: 11x60mm, C: 15x62mm)

of concave clearance: 17, 23, 29 and 35mm were used. The concave clearance between the threshing drum and concave was adjustable. Four levels of drum speed : 675, 775, 875 and 975rpm, equivalent to peripheral velocities of 9.8, 11.3, 12.8 and 14.2m/s, respectively, were used. These speeds were obtained by adjusting the engine throttle. The concave hole sizes from the first test were retained. Testing was done with the Hysun-33 variety. The average moisture content of grains and straw were 6.51% (w.b.) and 12.93% (w.b.), respectively. The average grain-straw ratio for the crop was 1.25. Threshing drum speed was measured using a proximity switch. A torque transducer was used to measure the torque. It was calibrated before being used. A strain amplifier was used to amplify the output signals. The power requirement was then calculated (Kepner *et al*.,1978; Hunt, 1995).

The performance indicators used for evaluation (RNAM Test code, 1995) were output capacity, threshing efficiency, grain damage, grain losses, separation of grain versus materials other than grain (MOG), power requirement and specific energy consumption. The performance of the experimental unit in sunflower threshing was analyzed at different drum speeds and concave clearances by using a replicated complete-block desigh (RCBD) 4x4 factorial experiment with three replications. A comparison between pairs of treatment means was made by determining the least significant difference (LSD) at 5% significance (Box *et al*., 1978; Gomez & Gomez, 1984).

Results and Discussion

Effect of Concave Hole Size on Performance of the Threshing Unit

The concave hole size significantly affected capacity, grain damage, grain losses, and the total grain-MOG separated by the concave, but did not affect the threshing efficiency. Comparisons among treatment means using the LSD are given in **Table 1**. The results indicated that the capacity, grain damage and grain losses with the 11x60mm and the 15x62mm concave hole sizes were not statistically different from one another. The threshing efficiency was almost the same at all the concave hole sizes. The percentages of total grain separated with the 11x60mm and the 15x62mm concave hole sizes were not significantly different from one another, but the values of total MOG separated were significantly different for all the concaves. For concaves with 11x60mm and 15x62mm concave holes, the average capacity, grain damage, grain losses and threshing efficiency ranged from 797 to 806kg/h, 1.38 to 1.48%, 0.52 to 0.97% and 99.98 to 99.99%, respectively. The minimum capacity of 730kg/h, maximum grain damage (2.57%) and maximum grain losses (10.36%) were found with the smallest concave hole size of 7x60mm.

Figure 3 shows the relationship between the length of concave and cumulative separable grain and MOG at a 3,000kg(head)/h feed rate and a 850rpm drum speed (12.4m/s peripheral speed). The percentage of total grain separated by the 11x60mm and 15x62mm concaves increased from 0 to 99.19% and 0 to 99.48%, respectively, as the length of concave increased from 0 to 96cm. As a result, the total grain separated through the 7x60mm concave increased linearly between 0 to 89.64% with increasing concave length. However, the percentage of grain losses at the straw outlet

Table 1 The comparison of treatment means at each concave hole sizes

Concave hole sizes	Capacity (kg/h)	Grain damage (%)	Threshing efficiency (%)	Grain ross (%)	Total grain separated by the concave (%)	Total MOG separated by the concave (%)
7x60mm	730b	2.57b	100.00a	10.36b	89.64b	42.09c
11x60mm	797a	1.48a	99.99a	0.97a	99.19a	46.39b
15x62mm	806a	1.38a	99.98a	0.52a	99.48a	53.08a
LSD0.05	66.96kg/h	0.816%	0.023%	2.915%	2.917%	2.520%

Remark: The mean value of performance indicators in each column which have the same letter shows non significant difference in LSD value at 5% level

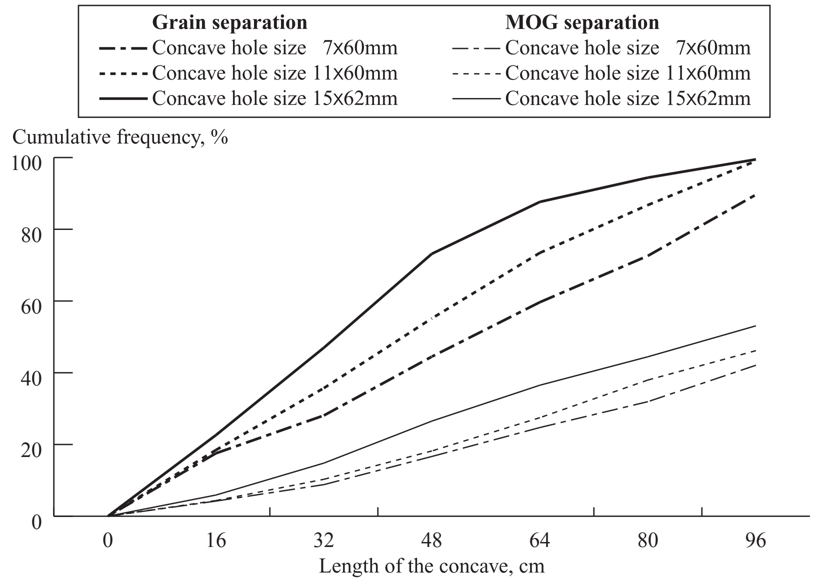

Fig.3 Relationship between the length of concave and cumulative separable grain and MOG with 3000kg(head)/h feed rate and 850rpm drum speed

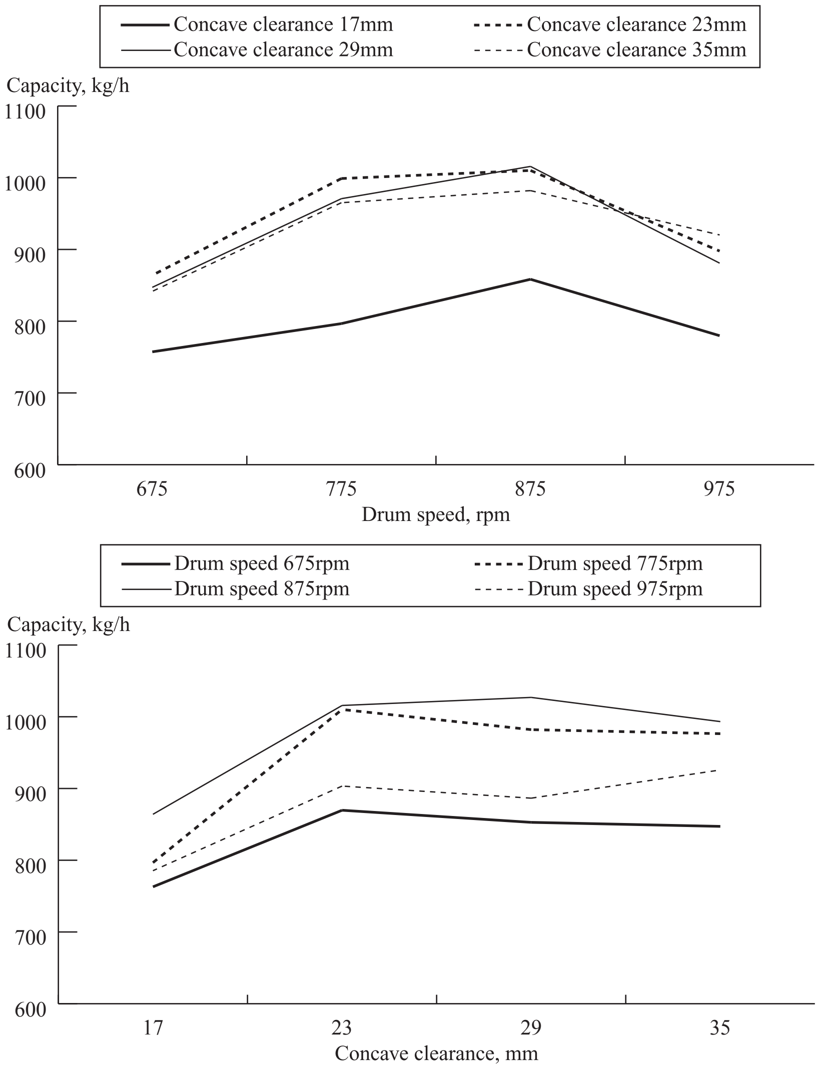

Fig.4 Effect of drum speed and concave clearance on capacity

with the 7x60mm concave was about 10.36%, higher than with the other concaves. The percent of MOG separated through the 15x62 mm concave was higher than that separated through other concaves. The percentages of total MOG separated at the straw outlet were about 46.92%, 53.69% and 57.91% for the 7x60mm, 11x60mm and 15x62mm concave hole sizes, respectively. The 15x62 mm concave allowed large quantities of MOG to pass through. This resulted in a large cleaning load and a reduction in the amount of sunflower seeds collected. This can be important with respect to the handling and separation of grain from the MOG in the cleaning system. Based on the results presented, a concave hole size of 11x60mm was considered as having given optimum performance and was, therefore, adopted for all studies in the development of the sunflower thresher.

Effect of Drum Speed and Concave Clearance on Capacity

The concave clearance and the drum speed significantly affected capacity at the 1% significance level. Comparisons among treatment means showed that the capacity levels with the 23, 29 and 35mm concave clearances were not statistically different from each other, but with the 17mm concave clearance the capacity was significantly lower than the capacity values obtained with the other three clearance levels. The effect of drum speed on the capacity values obtained with individual concave clearances is shown in **Fig.4**. The capacity with the 23, 29 and 35mm concave clearances increased rapidly with increase in the drum speed from 675 to 775rpm and increased slightly with a further increase in drum speed from 775 to 875rpm. In the case of the 17mm concave clearance, the capacity was lower than with the other concave clearances at the same drum speeds. The capacity levels at 23, 29 and

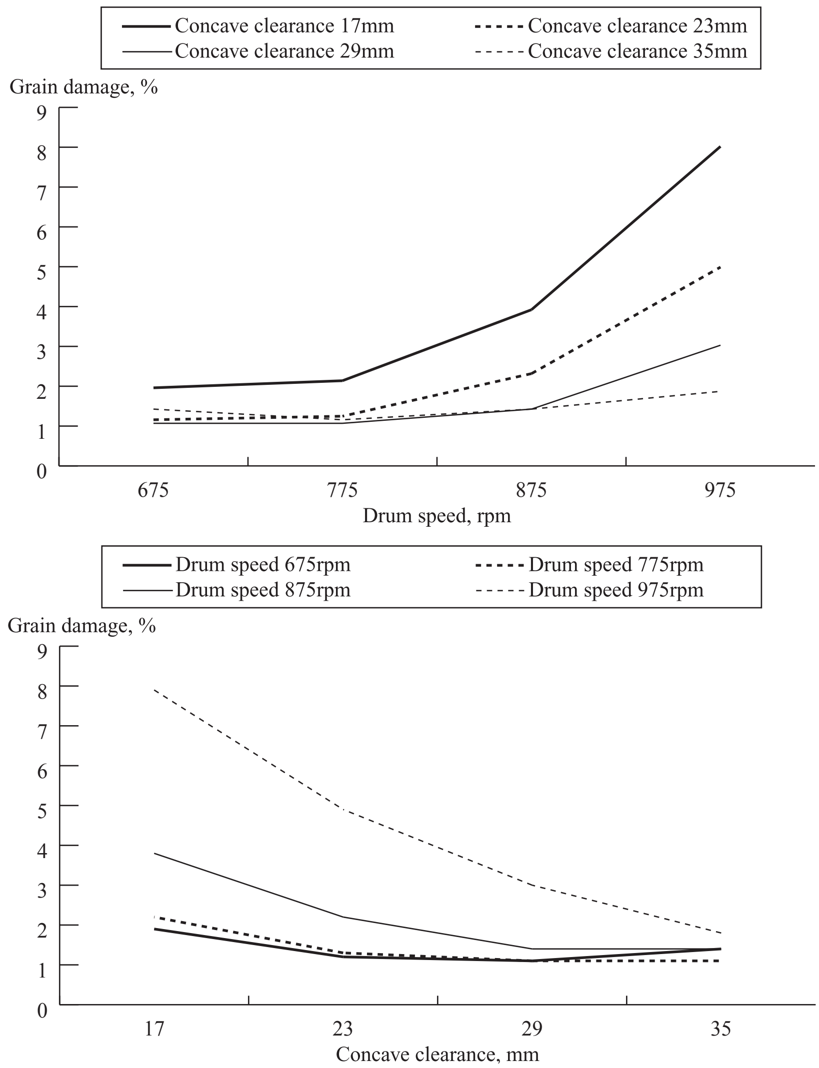

Fig.5 Effect of drum speed and concave clearance on grain damage

35mm concave clearance were between 865 to 1007, 848 to 1017 and 842 to 983kg/h, respectively when the drum speed was increased from 675 to 875rpm (9.8 to 12.8m/s).

The threshing capacity at all drum speeds increased rapidly as concave clearance was increased from 17 to 23mm, then it decreased slightly when the concave clearance was further increased from 23 to 35mm with drum speeds of 675, 775 and 875rpm except that this characteristic did not appear at a drum speed of 975rpm. This was because the resistance between the head and the drum decreased when the concave clearance increased. Thus, the force and frequency of impacts was also reduced. The rubbing effect would not take place when the clearance exceeded the height of the sunflower head.

Effect of Concave Clearance and Drum Speed on Threshing Efficiency

Changes in concave clearance and the interaction among concave clearance and drum speed levels did not affect the threshing efficiency, while drum speed changes showed a significant effect on threshing efficiency figures at the 5% level. The results indicated that the threshing efficiency levels with all concave clearances and with the three highest drum speeds were not significantly different. The threshing efficiency varied from 99.94 to 100% for all testing conditions.

Effect of Concave Clearance and Drum Speed on Grain Damage

The different levels of concave clearance, of drum speed and of the interactions among the various levels of concave clearance and drum speed were found to have a highly significant effect on grain damage. The percentage of grain damage for the four concave clearances at various drum speeds is shown in **Fig.5**. The percent grain damage increased with an increase in drum speed for all concave clearances, and it decreased with an increase of concave clearance for all drum speeds. This was due to an increase in the rubbing, impact energy and frequency of impacts to which the grains were subjected with increasing drum speed. The percentage of grain damage was in the range of 1.88 to 7.90%, 1.14 to 4.89%, 1.11 to 2.98% and 1.37 to 1.81% at concave clearances of 17, 23, 29 and 35mm, respectively, at all the drum speeds ranging from 675 to 975rpm. The grain damage was between 1.11 to 1.47% when the concave clearance increased from 29 to 35 mm within the range of drum speeds from 675 to 875rpm. In general, the magnitude of grain damage was higher for lower levels of concave clearance and for higher levels of drum speed.

Effect of Concave Clearance and Drum Speed on Grain Losses

Changes in concave clearance and the interaction among various levels of concave clearance and drum speed significantly affected grain losses at the 1% significance level. Comparisons among treatment means for grain losses showed that the grain losses at 775rpm drum speed were not affected significantly when the concave clearance was varied from 23 to 35mm. The grain losses at 675, 775 and 875rpm drum speed were not significantly affected when the concave clearance, was varied within the range from 29

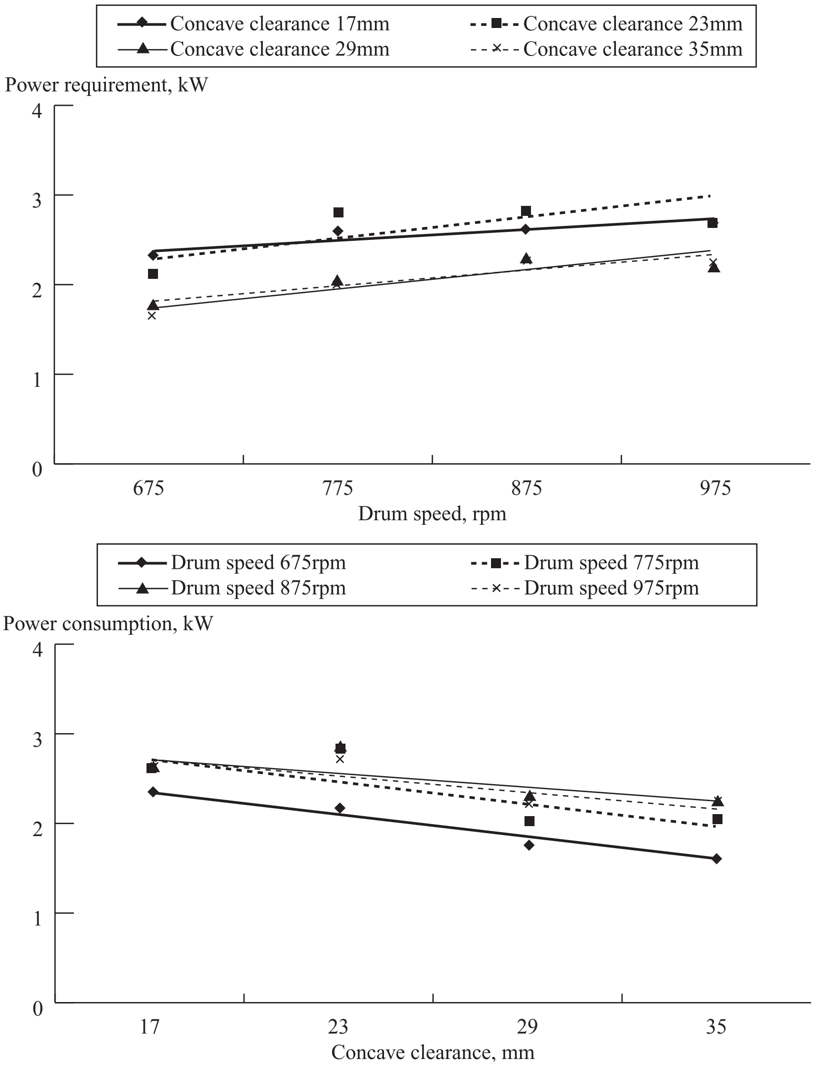

Fig.6 Effect of drum speed and concave clearance on power requirement

to 35mm. At 29mm concave clearance, the grain loss levels were not affected significantly by changes of drum speed from 675 to 875rpm. At 35mm concave clearance, the grain losses at the drum speed of 675rpm were not significantly different from those at drum speeds of 775 and 975rpm (11.3 to 12.8m/s). The percentage of grain losses was less than 1% when the drum speeds were in the range from 675 to 875rpm and concave clearance was varied within the range from 23 to 35mm.

Effect of Concave Clearance and Drum Speed on Power Requirement and Specific Energy Consumption

The results indicated that the main effects of variations of concave clearance and of drum speed significantly affected the power requirement and specific energy consumption values at the 1% level. The average power required at different concave clearances and drum speeds is shown in **Fig.6**. It was observed that the power requirement of the threshing unit increased as the speed of the threshing drum increased, but that the power required decreased with increases in concave clearance. The average levels of power required at 17, 23, 29 and 35 mm concave clearances ranged from 2.30 to 2.64kW, 2.12 to 2.81kW, 1.74 to 2.29kW and 1.61 to 2.24kW, respectively, when drum speeds increased over the full range from 675 to 975rpm.

The specific energy consumption at 29mm and 35 concave clearances were not statistically different from one another at any given drum speed. The specific energy consumption levels at drum speeds of 775rpm and 875rpm were also not significantly different from one another. It can be seen that the specific energy consumption increased with increases of drum speed and it decreased with increases of concave clearance (**Fig.7**). The specific energy consumption levels at 29mm and 35mm concave clearances between 1.92 to 2.41kW-h/ton and 2.37 to 2.83kW-h/ton, respectively, over the range of drum speeds tested. The lowest levels of power requirement and specific energy consumption were obtained with the 35mm concave clearance at all drum speeds.

Effect of Concave Clearance and Drum Speed on Grain and MOG Separation

Figure 8 shows the effect of drum speed and concave clearance on total MOG separation. The results indicated that by increasing the drum speed from 675 to 975rpm, the total MOG separated gradually increased at all concave clearances. The total MOG separated showed a maximum value when a concave clearance of 17mm was used, while the minimum value of total MOG separated was obtained at 35mm concave clearance at all drum speeds. As concave clearance increased from 17 to 35mm, the total MOG separated decreased. The maximum value of total MOG separated, as found for each level of concave clearance, was obtained at the 975 rpm drum speed.

Figure 9 shows the relationship between the length of concave and the percentages of cumulative separable grain and MOG separated at 3000kg(head)/h feed rate and 775rpm drum speed. The percentage of the total MOG separated with the 29mm concave clearance was slight-

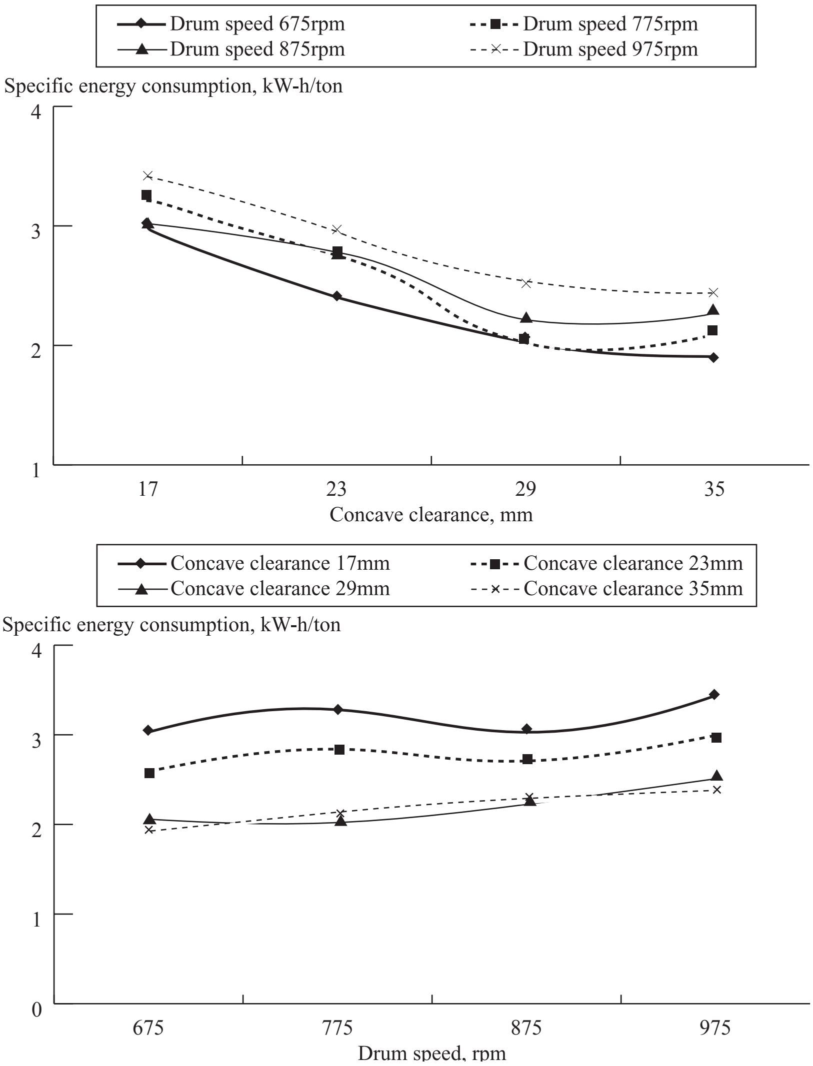

Fig.7 Effect of drum speed and concave clearance on specific energy consumption

ly higher than that with the 35mm concave clearance. The figure shows that the MOG separation at a 29mm concave clearance varied from 0 to 57.02% when concave length was increased, while the MOG separation at a 35mm clearance varied from 0 to 48.89% over the same range of concave lengths. From the above results, the design parameter levels providing the minimum total MOG separated and highest total grain separated were those obtained using the 35mm concave clearance, and thus, these parameter levels can be used in the development of a sunflower thresher.

Conclusions

The concave having a hole size of 11x60mm. Provided optimum performance in terms of high output capacity, high threshing efficiency, low grain damage, low grain losses and low MOG (materials other than grain) separated through the concave. The concave clearance and drum speed affected the output capacity. The capacity levels with 29 and 35mm concave clearances were not significantly different from one another, but there were significant differences at individual drum speeds. The capacity levels with the 29 and 35mm concave clearances ranged from 848 to 1017kg/h and 842 to 983kg/h when the drum speed was increased from 675 to 875rpm (9.8 to 12.8m/s), respectively. The threshing efficiency at all test conditions was more than 99%. The percentage of grain damage increased with an increase in drum speed and it decreased with an increase of concave clearance. The grain damage and grain loss values were less than 1.5 and 1%, respectively with drum speeds of 675 to 875rpm and concave clearances of 29 to 35mm. The lowest power requirements and specific energy consumption levels were obtained with the 35 mm concave clearance at all drum speeds.

The percentage of MOG separated through the concave with 35mm concave clearance was lower than that obtained while using the other levels of clearance. This means that the use of 35mm concave clearance could reduce the MOG load on the cleaning system. The best combination of drum speed, concave clearance and concave hole sizes in order to obtain at high output capacity, high threshing efficiency, low grain damage, low grain loss and low specific energy consumption was a combination of 750 to 850drum speed (10.9 to 12.4m/s), 35mm concave clearance and a concave hole size of 11x60mm. These specifications can be used for the development of a threshing unit for a sunflower thresher.

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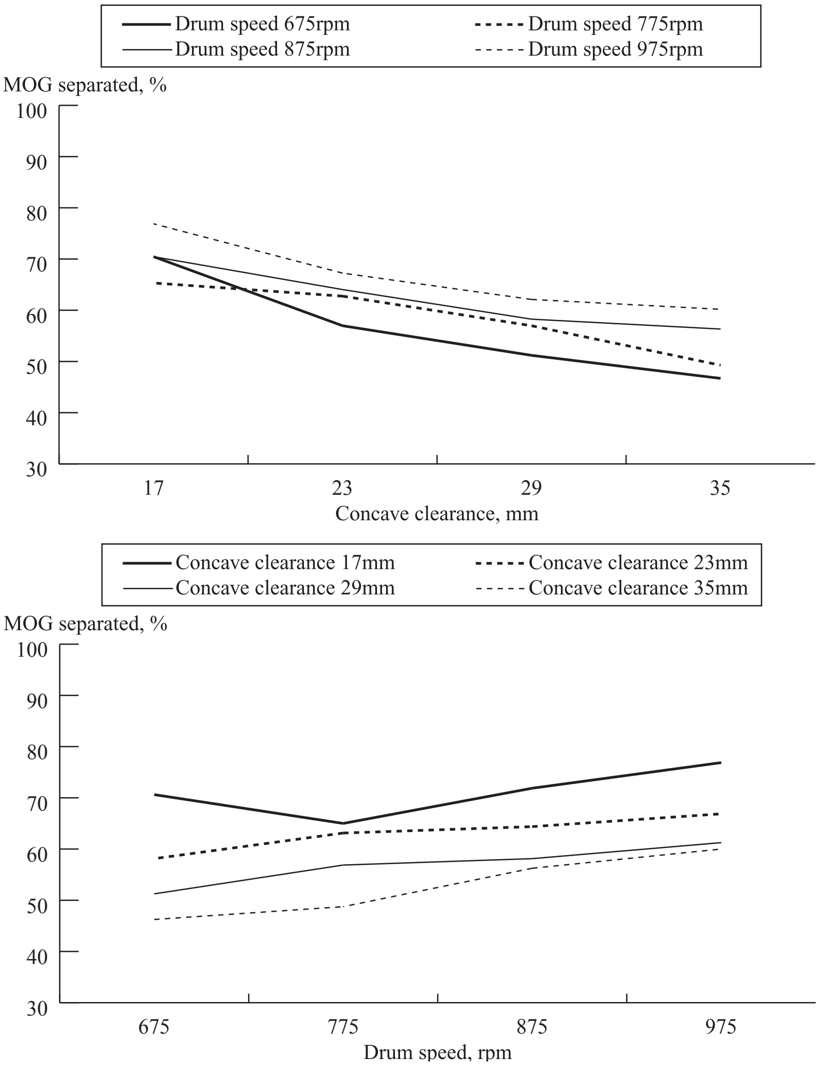

Fig.8 Effect of drum speed and concave clearance on MOG separation

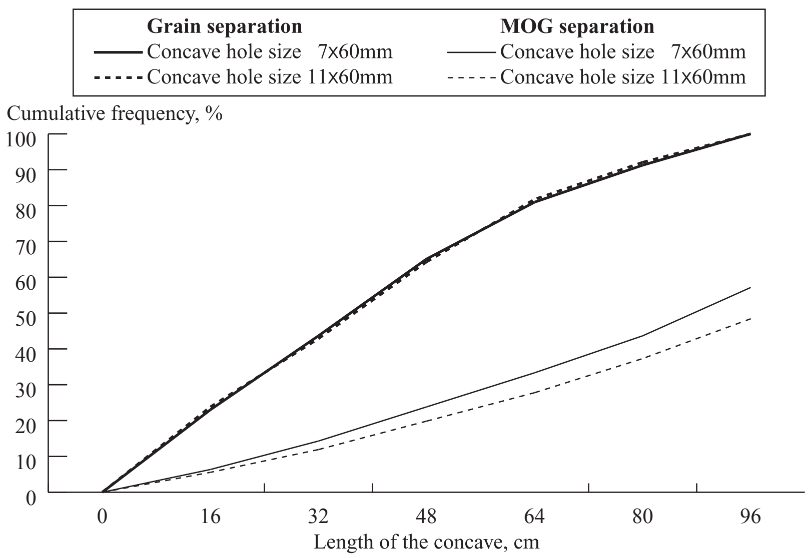

Fig.9 Relationship between the length of concave and cumulative separate grain and MOG with 3000kg(head)/h feed rate, 775rpm drum speed, 29 and 35mm concave clearance

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Performance Evaluation of Planters for Cotton Crop

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Performance Evaluation of Planters for Cotton Crop

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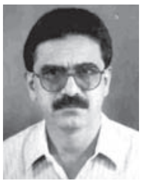

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Abstract

The seedbed and planting operations consume nearly 20% of the energy required from sowing to marketing and hence the choice of type of implement for seed bed preparation and sowing determines the economics of cotton cultivation. The available models of planters which can be used for cotton planting are tractor-drawn ridger seeder, tractor drawn pneumatic precision planter and tractor-cultivator mounted seeder. The above three implements were evaluated for their performance in cotton crop production. The standard deviation, coefficient of variation and deviation from the recommended depth were low in ridger seeder when compared to other seeders. Thus more uniform depth of seed placement was obtained with the ridger seeder. The planting operation with ridger seeder, pneumatic planter and cultivator seeder resulted in 44.00, 42.85 and 41.64% saving in cost, respectively, when compared to conventional method. Among the three implements, the savings in cost was high in the ridger seeder treatment. There was a savings of 96.4, 96.3 and 96.2% in time by the ridger seeder, pneumatic planter and cultivator seeder, respectively, when compared to manual sowing.

Introduction

Rational methods of tillage are directed at creating optimal conditions for plant growth and development at which the soil prepared for sowing has the necessary soil conditions for ensuring moisture conservation, good contact of seed with soil, uniform germination, good plant development and high yields. Efficient use of costly inputs by proper and timely operation can be achieved by appropriate adoption of machinery. In the dynamic and fast changing agricultural scenario in the country, particularly diversification in the cropping pattern and commercialization of agriculture more efficient and sophisticated equipment are required by the farmers. The demand for equipment in the country will continue to rise in the coming years. The present situation on migration of labour to various scholastic jobs and thrust more production to feed the increasing population make the cotton farming a tiresome one. This situation necessitates the introduction of machinery for cotton production.

Review of Literature

Singh *et al*. (1985) developed a two-row ridge planter for planting winter maize. The planter formed ridges and metered maize seeds on one side of the ridge. The machine was evaluated in the field over an area of 0.4ha. The average seed-to-seed distance was 0.198m, row-to-row spacing 0.60m and the average ridge height was 0.25m. The capacity of the planter was 0.10ha/hr at a forward speed of 2.5kmph. A tractor-drawn precision planter was designed and developed for the bio-scientists at CIAE, Bhopal. The machine has special provisions of changing the seed varieties and plot length to suit the specific requirements of the bio-scientist in their

Fig.1 Tractor drawn ridger seeder

Fig.2 Pneumatic precison planter

experiments. The machine is available in 2, 4 and 6 rows with plot length variations of 3-12m at an interval of 0.5 meter each (Yadav *et al*. 1987). Rodriguez and Soto (1989) developed a machinery that carried out four simultaneous operations, namely; soil loosening, soil leveling, drilling and fertilizer application. The field evaluation of the unit showed that at a forward speed of 4kmph a soil loosening efficiency of 82% was achieved and 214200 plants per ha was satisfactory. Savings of 57, 50 and 40% were attained for total operating cost, fuel and labour, respectively.

Materials and Methods

The available models of planters which can be used for cotton planting are:

Tractor-drawn ridger seeder (TNAU model)

Tractor-drawn pneumatic precision planter (CIAE model)

Tractor cultivator-mounted seeder (TNAU model)

These three implements were selected for the field performance evaluation. Their description and specification are shown below:

Description and specification of the cotton planters

a. Tractor-drawn ridger seeder (TNAU model)

The ridger seeder was designed and developed as a rear-mounted attachment to a four wheel tractor of 35 to 45hp range, commonly available among farmers. The developed unit consisted of a ridge-forming mechanism and a seeder (**Fig.1**) to form ridges and furrows and to seed on one side of the ridges in one pass. The ridges and furrows were formed by a three-bottom ridger. The planter consisted of cup feed-type seed metering mechanism, spiked ground wheel, chain and sprocket drive for transmitting power from ground wheel to the seed-metering shaft and seed placement devices. A dog clutch was provided to engage or disengage the power to the seed metering shaft. Markers were fitted on either side of the unit, so as to mark the next row over which the next pass of the implement has to start. The cost of the unit was Rs.17,500. Its salient features unit were formation of ridges and sowing of the seed simultaneously; an area of 3ha can be covered per day: The results were 24 and 90% savings in cost and time, respectively when compared with the conventional method. The specifications of the unit are shown in **Table 1**.

b. Tractor-drawn pneumatic precision planter (CIAE model)

The exact placement of single seed in the soil ensures savings in costly seeds, reduces the problem of thinning and crop yield was high as each plant got the desired quantity of sunlight, water and nutrients. The existing commercial planters do not meet the requirements of crops. A six-row tractor-drawn pneumatic precision planter was designed and developed at the CIAE, Bhopal, for precise planting of single seeds at predetermined seed/row spacing (**Fig.2**).

The machine worked on suction principles. Air was sucked through a rotating plate with various holes placed radially. Any seed coming in contact got stuck to the holes on the plate and fell immediately when suction was cut off at the lowest position near the ground. The fall of seed was synchronized with the predetermined seed spacing. Thus exact planting of single seed was obtained. Since the seed was lifted under suction, no mechanical seed damage occurred. However, the machine required high quality seeds for better performance. The cost of the implement was Rs.70,000. The specifications of the unit are shown in **Table 2**.

c. Tractor cultivator-mounted seeder (TNAU model)

This tractor-drawn implement was used for line sowing of crops such as cotton, groundnut, sorghum, maize and pulses. The tractor industry in India has grown and has now attained about 2.6 lakh tractors be-

Details	Value
Over all dimensions (LxBxH), mm	2400x1750x1100
Wight, kg	300
Number spacing, mm	3
Row spacing, mm	600-900 (Adjustable)
Plant spacing in rows, mm	150-300 (Adjustable)
Type of seeds used	Delined/coated cotton seeds
Nominal working width, mm	1350-1800 (Adjustable depending on variety of seeds)
Depth of planting, mm	30-50 (Adjustable)
Type of seed metering mechanism	Cup feed
Furrow opener and closer	No separate devices were provided. Mild steel tubes fixed on side of ridger bottom place the seed and soil turne by the ridger wings cover the seed

Table 1 Speciffication of tractor drawn ridger seeder

Details	Value
Over all dimensions (L×B×H), mm	2000x1520x2000
Wight, kg	300
Source of power	30-45hp tractor
Number of rows	2, 4 and 6 (Adjustable)
Type of seeds metering mechanism	Pneumatic suction principle
Plant spacing	Row spacing and seed to seed spacing adjustable as desired
Sprocket train	13 to get desired spacing of 30cm

Table 2 Speciffication of tractor drawn pneumatic precision planter

Details	Value
Over all dimensions (L×B×H), mm	2500x1030x1240
Wight, kg	410
Source of power	35-45hp tractor
Number of rows	3-5
Row spacing, mm	450-900 (Adjustable)
Plant spacing in rows, mm	150-300 (Adjustable)
Type of seeds used	Delined/coated cotton seeds
Nominal working width, mm	1800-2250
Depth of planting, mm	30-50 (Adjustable)
Type of seed metering mechanism	Cup feed
Furrow opener and closer	No cultivator shovels are used to open the furrows and a mild steel square bar is used to cover the seeds placed in the opened furrow

Table 3 Speciffication of tractor drawn cultivator mounted seeder

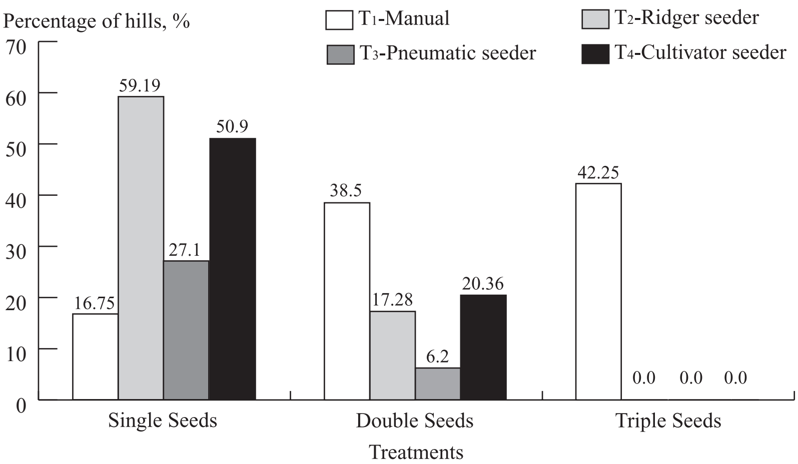

Fig.5 Percentage of hills with single, double and triple seeds

ing manufactured per annum. Even small-and medium-size farmers are hiring tractors for different agricultural operations. Any farmer who owns a tractor invariably has a the tractor-drawn cultivator. Seed boxes along with cup feed type seed metering mechanism are mounted on the cultivator frame and the seeds are dropped in furrows opened by the cultivator shovels (**Fig.3**). Detachable side wings are fixed to the existing shovel type furrow openers of the cultivator which helps in placing the seed at the required depth. The Power to operate the seed metering discs is taken from the ground wheel drive though a clutch. A square bar is provided at the back of the unit to close the furrows. The cost of the implement was Rs.10,000 without the cultivator. The salient features of the unit are: suitable for sowing cotton, groundnut, sorghum, Bengal gram, maize, soybean and pulse which result in 48 and 91% savings in cost and time, respectively; spacing can be adjusted according to the crop; and an area of 4 ha can be covered per day; The specifications of the unit are shown in **Table 3**.

Treatments Selected for The Investigation

All the selected three planters were evaluated for their performance in sowing cotton seed. The treatments selected for the investigation were:

T_1-Control (Tilling with cultivator twice + Ridge forming + manual sowing)

T_2-Tilling with cultivator twice + Ridger seeder

T_3-Tilling with cultivator twice + Sowing with pneumatic precision planter

T_4-Tilling with cultivator twice + Sowing with cultivator-mounted seeder

In the conventional method after the seedbed preparation, women labours were engaged for dibbling the seed on the sides of the ridges (**Fig. 4**). Each treatment was replicated thrice. For all the treatments, seedbed preparation was common. The operations were:

1. Ploughing once with tractor-drawn disk plough.

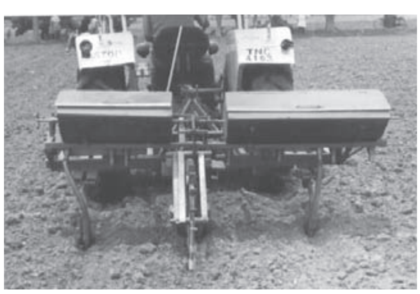

Fig.3 Cultivator mounted seeder

Fig.4 Conventional method

Date of test	14th August 2001
Test condition	
(a) Condition of seed	
Name of seed	Cotton
Variety	MCU 12
Shape of seed	Oblong
Weight of 1000 grains, gm	102.35
(b) Condition of field	
Location	Dept. of cotton, TNAU Campus
Length of field, m (each treatments)	45
Width of field, m	11.25
Area of field, m^2	506.25
Shape of field	Rectangular
Type of soil	Red soil
Texture	Sandy loam
Method of preparation of field (seed planters)	Ploughing once with disc and cultivator twice
For control	Ploughing once with disc, twice with cultivator and ridge forming by tractor drawn ridger
(c) Operational parameters of machine	
Row spacing, mm	750
Plant spacing, mm	300
Depth of seed placement, mm	20-30
(d) Speciffication of power source	
Make and model	Ford Escort
Rated power hp	45
Control plot	Mnual dibbling

Table 4 Field conditions under which performance test was conducted for all the tretments

Partculars	T_1 Manual	T_2 Ridger seeder	T_3 Pneumatic planter	T_4 Cultivators seeder
Actual operating time, min	20.73	7.25	7.85	8.5
Time lost for turning, min		2.63	2.67	2.77
Actual area covered, m^2	506.25	506.25	506.25	506.25
Effective working width, m	0.75	2.25	2.25	2.25
Operating speed, kph		2.92	2.61	2.36
Effective field capacity, ha/hr	250women hrs/ha	0.42	0.387	0.357
Theoretical field capacity, ha/hr		0.657	0.591	0.535
Field efficiency, %		64.0	65.5	66.7
Depth of seed placement, m	28.4	29.7	31.3	29.3
Distance between plants, m (average)	0.3192	0.3059	0.3054	0.3181
Number of plants per hill	2 to 3	1 or 2	1 or 2	1 or 2
Rate of missing hills, %	2.5	23.53	66.70	28.79
Seed rate, kg/ha	14.62	8.7	3.95	4.94
Row to row distance, m	0.75	0.75	0.75	0.75

Table 5 Results of field performance evaluation

2. Ploughing twice with tractor-drawn cultivator.
3. Formation of ridges and furrows by tractor-drawn ridger (for conventional method only).

A germination test was conducted to study the actual germination percentage of MCU 12 cotton seeds, which were used in the field evaluation of the unit. The mean value was 70%. The minimum germination percent for the cotton variety recommended was 65%. The field condition under which performance test was conducted for all the treatments is furnished in **Table 4**.

Results and Discussion

The data observed during the field trails and the results of the performance evaluation of the selected four treatments of investigation are shown in **Table 5**.

The field capacities of the ridger seeder, pneumatic planter and cultivator seeder were 0.42, 0.387 and 0.357 ha/hr and field efficiency were 64, 65.5 and 66.7%, respectively. An analysis of the plant spacing data of the selected four treatments is shown in **Table 6**.

The average spacing between plants sown using the manual dibble, ridger seeder, pneumatic planter and cultivator seeder were 0.319, 0.306, 0.306 and 0.318m respectively which are slightly higher than the recommended spacing of 0.3m in all the cases.

The coefficient of variation and standard deviation in control plot, ridger seeder, pneumatic planter and cultivator seeder were 0.072, 0.109, 0.42, 0.1 and 2.284, 3.334, 35.81, 3.09, respectively. It will be shown that the values of coefficient of variation and standard deviation were less for the ridger seeder when compared to other planters. The ridger seeder showed less deviation from the recommended spacing (3.38%) when compared to the others except the pneumatic planter (1.61%). But the percentage of missing hills was much higher for the pneumatic planter when compared with the others.

The missing hills for the ridger seeder, pneumatic planter and cultivator seeder were 23.53, 66.70 and 28.74%, respectively. But in the control plot the percentage of missing hills was 2.5%. This may be due to the sowing of 2 or more seeds at a time. The number of multiple hills was much higher (80.75%) when compared those of the seed planters.

Partculars	T_1 Manual	T_2 Ridger seeder	T_3 Pneumatic planter	T_4 Cultivators seeder
Number of seedling actions (in 5m length)	15.60	16.20	16.20	79
Average spacing, m	0.319	0.306	0.305	0.318
Deviation form recommended spacing (%)	6.412	3.38	1.10	6.89
Standard variation	2.284	3.334	35.81	3.09
Coefficient of variation	0.072	0.109	0.42	0.10
Number of missing hills	0.40	3.80	10.8	23
Number of hills with one plant	2.60	9.60	4.4	40
Number of hills with two plants	6.00	2.80	1	16
Number of hills with three or more plants	6.60	0	0	0
Missing hills (%)	2.50	23.53	66.7	28.74
Percentage of singles	16.75	59.19	27.1	50.90
Percentage of doubles	38.50	17.28	6.2	20.36
Percentage of triples or more	42.25	0	0	0

Table 6 Results of the analysis of plant spacing date

Sl. No.	T_1 Manual	T_2 Ridger seeder	T_3 Pneumatic planter	T_4 Cultivators seeder
1	2.5	2.9	3.1	2.8
2	3.0	2.8	3.3	2.9
3	2.6	3.1	3.0	2.9
4	3.1	2.9	3.4	3.1
5	2.9	2.8	2.9	2.8
6	2.6	2.8	3.3	2.7
7	2.5	3.0	2.9	3.0
8	3.1	3.0	3.2	3.1
9	3.2	3.2	3.0	2.9
10	2.9	3.2	3.2	3.1
Average	2.84	2.97	3.13	2.93
SD	0.2538	0.1487	0.1676	0.1345
CV	0.0894	0.0501	0.0536	0.0459
Percent deviation from recommended depth	5.30	1.00	4.30	2.33

Table 7 Depth of speed placement

Sl. No.	T_1 Manual	T_2 Ridger seeder	T_3 Pneumatic planter	T_4 Cultivators seeder
Total cost, Rs/ha	4,469	2,503	2,554	2,608
Saving in cost when compared to manual, %	-	44	42.85	41.64
Saving in time when compared to manual, %	-	96.4	96.3	96.2

Table 8 Abstract of appraisal of cost and time

In general, the germination percentage for cotton seeds varied from 65 to 80%. This means that percentage of missing hills using the planters was within the range of germination percentage. The percentage of hills using the single, double and triple plants in all the treatments are shown in **Fig.5**. It will be shown that for the ridger seeder and cultivator seeder, the numbers of single plants per hill were in the range of 50-60%, while in control plot it was only 16.75%. Thus it is evident that the seed planters planted the recommended number of seed in majority of the hills.

The varying depths of seed placements in the selected treatments are indicated in **Table 7**.

The average depths of placement of seed in control plot, ridger seeder, pneumatic planter and cultivator seeder were 2.84, 2.97, 3.13 and 2.93cm, respectively. From **Table 7** the standard deviation, coefficient of variation and deviation from the recommended depth were less for the ridger seeder when compared to the other seeders. Thus more uniform depth of seed placement was obtained with the ridger seeder. The abstract of cost of appraisal is shown in **Table 8**.

The planting operation using the ridger seeder, pneumatic planter and cultivator seeder resulted in 44.00, 42.85 and 41.64% saving in cost respectively when compared to the conventional method. Among the T_2, T_3 and T_4 the savings in cost was higher for the ridger seeder treatment. There was a savings of 96.4, 96.3 and 96.2% in time using the ridger seeder, pneumatic planter and cultivator seeder, respectively, when compared to the manual sowing.

Conclusion

1. The standard deviation, coefficient of variation and deviation from the recommended depth were less for the ridger seeder when compared to the other seeders. Thus more uniform depth of seed placement was obtained using the ridger seeder.
2. The planting operation using the ridger seeder, pneumatic planter and cultivator seeder resulted in 44.00, 42.85 and 41.64% savings in cost, respectively, when compared to the conventional method. Among the T_2, T_3 and T_4 the savings in cost was higher for the ridger seeder treatment.
3. There was a savings of 96.4, 96.3 and 96.2% in time using the ridger seeder, pneumatic planter and cul-

(continued on page60)

Special Distribution of the No-Till Opener Induce Seed Row Incorporated Crop Residue and Soil Loosening

by

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Abstract

The amount and position of crop residue incorporated in the seed row together with the seed zone soil loosening produced by the no-till furrow opener have been considered as the major two parameters characterizing no-till openers. Therefore, soil bin experiments were conducted to evaluate the performance of the two major no-till opener styles (disc and hoe openers) in relation to their induced soil loosening and incorporated crop residue. Experiments were conducted in the soil bin facility of the Institute for Agricultural Engineering in the Tropics and Subtropics, University of Hohenheim. The soil bin is filled with a sandy loam soil to a depth of 1.20m. Experiments were conducted under two soil moistures (7.5% and 9.8%), three levels of soil strength (low, medium and high) and three rates of crop residue cover (zero, 3t/ha and 8t/ha). A Multiple cone penetrometer and a soil plane were used to determine the opener induced soil loosening and incorporated residue, respectively. Both openers were adjusted to operate at a forward speed of 8km/h and a 50mm seeding depth. The major findings indicated that, the disc opener incorporated a significantly high amount of crop residue than the hoe opener. The percentage of crop residue incorporated by both openers was observed to increase with the increase in residue cover rate and decrease with the increase in both soil strength and soil moisture. Similarly, the hoe opener induced a significantly high soil loosening (65-79% in the upper soil layer, 50mm depth x 130mm width) compared to the disc opener (25-47%). The opener induced soil loosening was observed to decrease with the increase in both residue cover and soil moisture.

Introduction

Although maintaining a considerable amount of crop residue from the previous season on the soil surface (specified by many researchers to be at least 30% of the soil surface) is one of major characteristics identifying conservation tillage systems, high amount of crop residues left on the soil surface have been considered as the major problem limiting the widespread adoption of no-till systems as it makes the seeding operation relatively difficult, and may also reduce the efficiency of fertilizer application and interfere with the different weed and pest control operations. On the other hand incorporation of crop residue in the seed row increases soil macroporosity and hence soil aeration and soil temperature, decreases the degree of seed-soil contact, produces growth inhibiting substances and immobilizes nutrients. As reported by Wuest *et al.* (2000), the presence of soil between residue and seedling plants reduces and sometimes eliminates the effect of toxins produced by residue, indicating that soil microorganisms can detoxify phytotoxins. Unweathered crop residues can produce growth-inhibiting substances, stimulate pathogen growth, and immobilize nutrients; and the location of seed relative to residue may be an important factor in the early health of a crop. Also as quoted by Saviozzi *et al.* (1997), when plant residues, particularly cereal straw, with high C:N ratios have been incorporated into soil, N deficiency has often been reported. Similarly, the amount of seed zone soil loosening is of great importance in designing as well as selecting no-till drills because of its influence on many factors such as soil water infiltration, movement, storage, and evaporation; soil aeration; heat absorption and heat flux mechanisms; seed-soil contact and seed furrow closure. All these factors are greatly influencing seed germination and emergence, root growth and proliferation, and hence crop growth and production. Also according to Janelle et al. (1993), opener design should aim toward low soil disturbance to minimize loss of water from the furrow during post-seeding dry spells. Similarly, Haak (1997) stated that, less soil disturbance will usually mean improved soil moisture, better crop residue cover for erosion control, and reduced weed germination. However, openers that minimize soil disturbance will not kill existing weeds and may prevent you from applying all of your fertilizer requirement with the seed. As reported by Domitruck and Crabtree (1997), increasing soil disturbance increases fuel use and weed germination. For these reasons, seed row disturbance is best kept to a narrow band, immediately around the seed. Also Prior et al. (2000) reported that, increased losses of CO_2 and water vapor were directly related to increases in soil disturbance. The selection of the proper no-till drill that suit certain field conditions has been considered as a key factor in optimizing no-till practices, therefore the objective of this study is to evaluate the capability of different no-till openers in relation to their induced soil loosening and spatial distribution of seed row incorporated crop residue.

Materials and Methods

Soil bin experiments were conducted to evaluate the performance of both no-till disc and hoe openers in relation to their induced seed zone soil loosening and incorporated residue under different soil and residue conditions. The soil bin facility of the Institute for Agricultural Engineering in the Tropics and Subtropics, University of Hohenheim, Germany, is 46m long and 5m wide and is filled with a sandy loam soil to a depth of 1.2m. A single disc opener of John Deere Model 750-A and a hoe opener of Amazone Model Airstar Primera no-till drills were selected for these experiments.

Procedure

Determination of the Opener Induced Soil Loosening

Soil resistance to penetration was used for assessing soil strength and soil strength profiles were used to quantify the opener induced soil loosening. A multi-probe seed row compaction meter, consists of 11 steel probes of 150mm length and a diameter of 2mm spaced 13mm apart, according to Tessier et al. (1990) and Linke (1998a) was used to determine soil strength profiles. The degree of seed zone soil loosening was calculated by relating the values of soil resistance to penetration after treatments to that before treatments as illustrated by **Equation 1**:

$$\Psi = \left[1 - \frac{(PR)_a}{(PR)_b}\right] \bullet 100 \quad (1)$$

Where;

Ψ =Degree of seed zone soil loosening, %.

$(PR)_a$=Soil penetration resistance after treatments, MPa.

$(PR)_b$=Soil penetration resistance before treatments, MPa.

Determination Of Seed Row Incorporated Crop Residue

The spatial distribution of seed row incorporated crop residue was determined using the soil plane method according to Breitfuss (1954) and Linke (1998b), which has been modified at the Institute for Agricultural Engineering in the Tropics and Subtropics of Hohenheim University by adding a rotating cutting disc to cut horizontally through both soil and crop residues. The soil plane method is based on taking soil layers of 100mm width × 1000mm length × 10mm depth throughout the desired depth. The collected samples were first dried at 105°C to find out the sample total dry mass and then washed through a 2mm sieve to determine the amount of crop residue in each sample which was also dried at 105°C to determine its dry mass. The collected observations of the seed row incorporated crop residue were presented as a percentage of dry soil in the same sample as illustrated by **Equation 2**:

$$\Phi = \frac{m_r}{m_s} \bullet 100 \quad (2)$$

Where;

Φ =Percentage of seed row incorporated crop residue, %.

m_r=Dry mass of seed row incorporated crop residue, g.

m_s=Dry mass of residue free sample (i.e. mass of dry soil), g.

Execution of the experiments

The soil in the soil bin was reconditioned to represent two soil moistures (7.5 and 9.8%). At each soil moisture condition, three levels of soil strength were adjusted (low, medium and high), **Table 1**.

Wheat crop residue from the previous season with 74mm mean length and 11.7% water content was varied at 0, 3, and 8t/ha cover rates. Experiments for each opener under both soil moisture conditions

Soil condition	Soil Moisture	Soil strength level		
		Low	Medium	High
1	7.5%	0.54-0.64	0.78-0.86	0.86-0.88
2	9.8%	0.56-0.62	0.74-0.75	0.95-1.08

Table 1 Soil properties at time of experiments

Fig.1a Low soil moisture (7.5%)

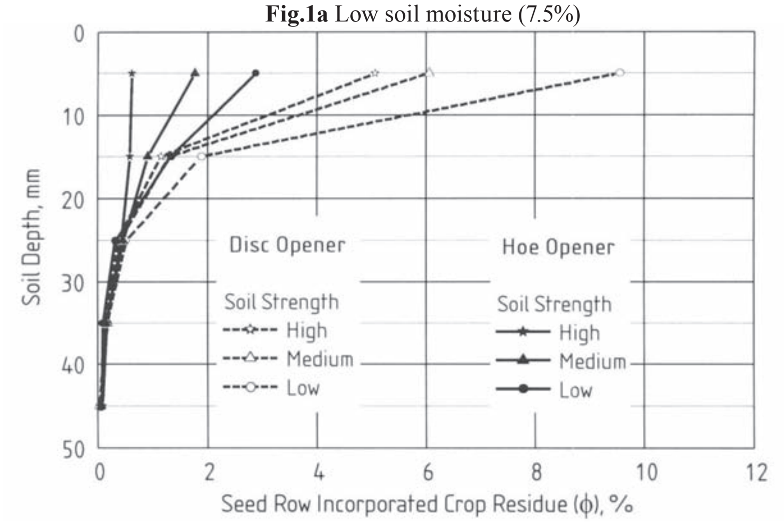

Fig.1b High soil moisture (9.8%)

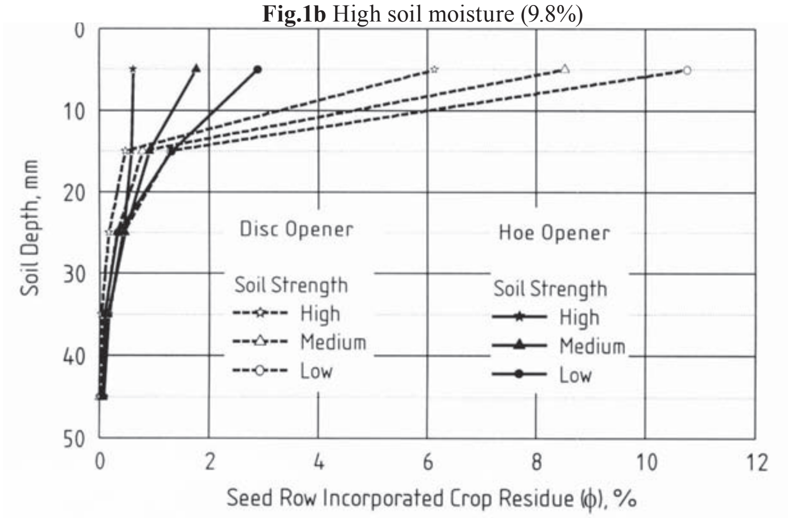

Fig.1 Spatial distribution of residue incorporated by both no-till opener, working at a forward speed of 8km/h and a sowing depth of 50mm, under two soil moisture and three levels of soil strength

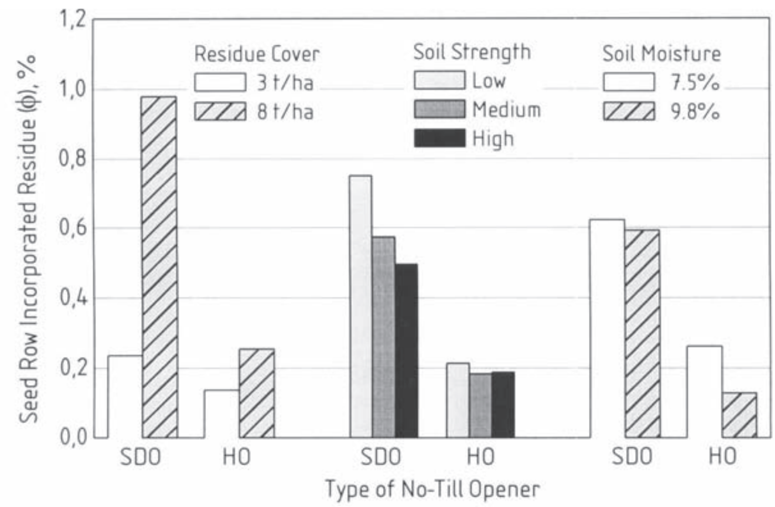

Fig.2 Crop residue incorporated in the top soil layer (0-50mm) by both opener as a function of residue cover, soil sorength and soil moisture (SDO ≡ Single disc opener & HO ≡ Hoe opener

were arranged in a 3x3 factorial experiments in a randomized complete block design. The two openers were adjusted to operate at a forward speed of 8km/h and 50mm working depth. Analysis of the results of these experiments was carried out using the Statistical Analysis System (SAS).

Results And Discussions

Spatial Distribution of Seed Row Incorporated Crop Residue

The spatial distribution of crop residue incorporated by both openers under two soil moisture conditions and three levels of soil strength is illustrated in **Fig.1**.

From **Fig.1** it is apparent that, the single disc opener incorporates the highest amount of crop residue than the hoe opener, specially in the top 30mm soil layer. These results are well corresponding with Linke and Koller (1994): tine openers incorporate significantly less straw than disc openers. Similar results were reported by Rump and Koller (1997), using disc type no-till drills, straw is not cut by the disc coulters but pushed to the bottom of the furrow. For further investigations, the total amount of the incorporated residue in the top soil layer (0-50mm) is evaluated as a function of crop residue cover, soil strength and soil moisture. The mean values are presented in **Fig.2**.

Fig.2 illustrates that, the amount of crop residue incorporated by both openers is increased with the increase in residue cover, with significant differences ($p \leq 0.05$) for the disc opener. In contrast, the amount of residue incorporated by both openers is decreased with the increase in soil strength. This could be attributed to the improvement in the cutting ability of the opener with the increase in soil strength. These results are in agreement with Cakir *et al*. (1999), adequate soil strength was found to be essential to cut dry

Fig.3a No-till single disc opener

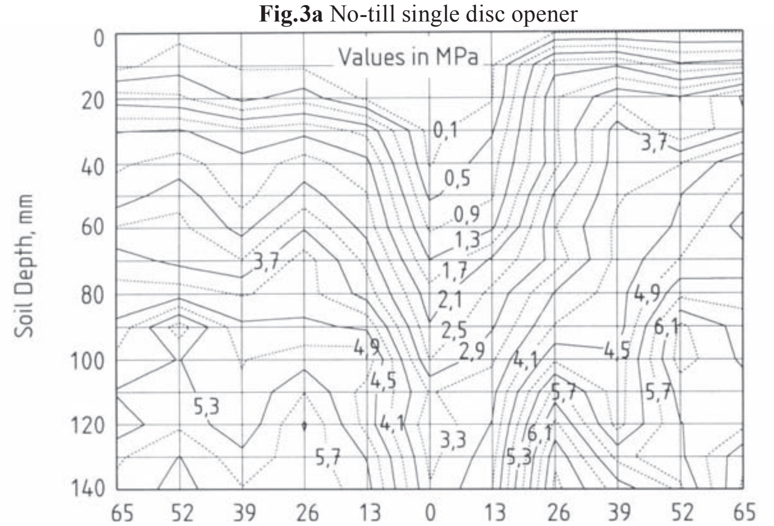

Fig.3b No-till single hoe opener

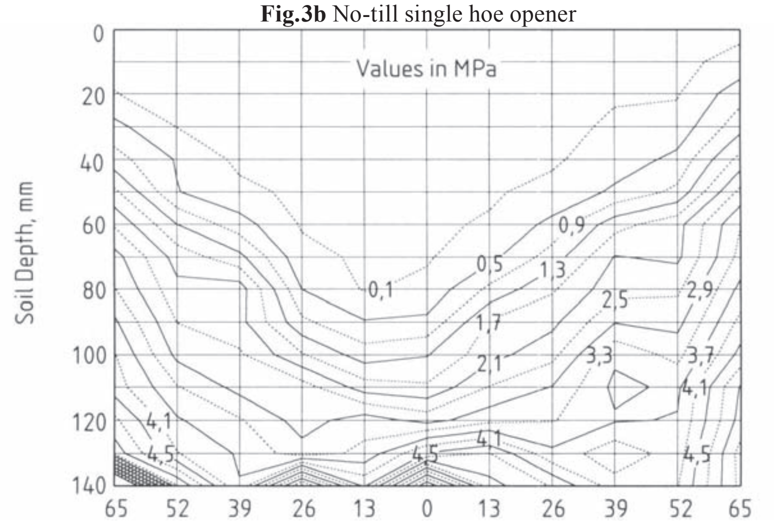

Fig.3 Example of soil strength profiles induced by both no-till openers working at a forward speed of 8km/h and a sowing depth of 50mm

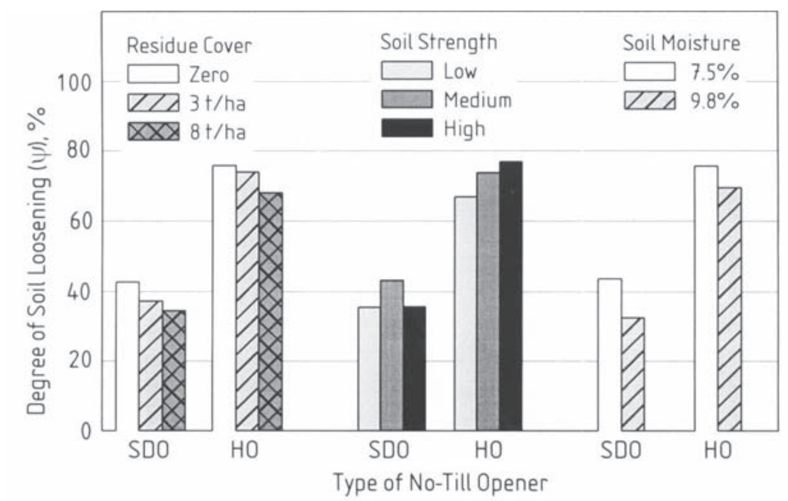

Fig.4 Mean values of the degree of soil loosening (%) produced by both no-till openers as a function of crop residue cover, soil strength and soil moisture (SDO ≡ Single disc opener & HO ≡ Hoe opener

or wet residue with both the flat and angled knives. Very soft soil did not give enough support to cut the residue. similarly, the amount of the incorporated residue was observed to decrease with the increase in soil moisture with significant differences ($p \leq 0.05$) for the disc opener.

Seed Zone Soil Loosening

The values of soil resistance to penetration were presented in a contour diagram to illustrate the no-till opener induced seed zone soil loosening both vertically and laterally, **Fig.3**.

As shown in **Fig.3**, the hoe opener loosened the seed zone soil much higher than the disc opener. That is due to the varying geometrical characteristics of both openers which greatly affect their efficiency in cutting and moving the soil. Similarly **Fig.3** illustrates that, the seed zone soil loosening induced by both openers is reduced with the increase in soil depth and when moving from the seed furrow center towards the sides. This is in agreement with Chi and Kushwaha (1990), the initial soil failure started around the bottom of the tool since the highest stress usually occurs in this region. As the load increased, the failure extended around the tool edge first then expanded towards the soil surface. For the ease of the comparisons, the degree of seed zone soil loosening was determined using Equation 1 was used as a unique index. The influence of soil moisture, soil strength and crop residue cover on the opener induced seed zone soil loosening (in the top 50mm soil layer) is illustrated in **Fig.4**.

Fig.4 shows that, the degree of soil loosening produced by both openers is decreasing with the increase in the amount of residue cover. That could be attributed to that: (a) the total energy needed to cut and move both residue and soil increases with the increase in the amount of residue cover on the soil surface which leads to less soil loosening, and (b) the existence of crop residue cover resist the process of soil throw and movement.

From **Fig.4**, the influence of the initial soil strength on the degree of soil loosening differ markedly between the two openers. For the disc opener, non-linear relation was observed. Theoretically, the disc opener induced soil loosening is supposed to decrease with the increase in soil strength. The fluctuation in the trend of the degree of soil loosening with the increase in soil strength could be attributed to the existence of crop residue on the soil surface. Crop residue cutting ability was observed to increase with the increase in soil strength, the result is an increase in soil penetration depth and hence more soil disturbance. The validity of this assumption is true when moving from low to medium soil strength. But at high soil strength, the total force needed will increase and further improvement in the residue cutting ability of a disc opener couldn't compensate the extra force needed to penetrate the more compacted soil, the result is reduced soil loosening. **Fig.4** also indicates that, the degree of seed zone soil loosening produced by both openers is decreased with the increase in soil moisture with significant differences ($p \leq 0.01$) only for the disc opener. This is in agreement with McKyes (1989), the degree of soil loosening by a tillage tool for two different soil conditions was increased with the decreasing soil moisture content.

Conclusions

From the results of this study, the following conclusions could be drawn:

The no-till single disc opener was observed to incorporate significantly high amount of crop residue in the seed row compared to the hoe opener.

The amount of crop residue incorporated by both openers was found to decrease with the increase in crop residue cover and decrease with the increase in both soil strength and soil moisture.

The hoe opener loosened the seed zone soil significantly higher than the disc opener.

The degree of seed zone soil loosening was observed to decrease with the increase in both crop residue cover and soil moisture for both openers.

The results of this study indicated that, the ability of the disc opener to cut through both crop residue and soil is significantly influenced by the rate of crop residue cover and soil strength. Improving the cutting ability of the disc opener could be achieved by increasing the disc sharpness, reducing the disc thickness and increasing the disc angle, increasing the down pressure applied on the disc opener and using residue management tools. The results of this study will greatly help in better understanding of the performance of no-till openers and hence in selecting the proper no-till drill.

Acknowledgements

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(Continued on Page 60)

Farm Mechanization in Lalgudi Taluk of Southern India

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Abstract

A study was conducted in Lalgudi taluk of southern India to assess the level of farm mechanization. About 540 farmers were interviewed using a structured questionnaire. The energy usage in various agricultural operations in the region was studied. The level of mechanization in the Lalgudi region is higher than the national average. Among the major crops grown, paddy cultivation is highly mechanized compared to sugarcane and cotton. Lack of suitable machinery and lack of training of farm machinery operators are the major problems that impede a complete mechanization system in this region.

Introduction

In the past three decades, agricultural output in India increased rapidly mainly through the introduction of high yielding varieties, increase in irrigated areas and increased use of fertilizers and pesticides. Along with the increase in food production, the use of from machinery in agriculture also increased. The wheat crop cultivation in the Punjab, Western Uttar Pradesh, and Haryana is almost completely mechanized. Mechanization of agriculture in this region has resulted in increased productivity and food production. The demand for labour in agriculture also increased due to mechanization (Pingali 1998). Many researchers have discussed the benefits of mechanization of agriculture in this region. A similar increase in the level of mechanization of the cultivation of paddy and other crops did not occur in the rest of India. Moreover, any reliable estimate of the mechanization itself is difficult to make for most parts of India because the basic data on the use of agricultural machinery for various crops is generally not available. Therefore a study was conducted in selected villages of Lalgudi taluk of southern India to make an assessment of the level of mechanization practised presently by the farmers and to determine the scope for further mechanization in that region. The area selected for this study lies in the Cauvery river side with assured irrigation water supply. The results obtained in this study pertain to Lalgudi taluk only but could be extended safely to other similar agro-climatic regions of Tamilnadu with few assumptions.

Obejctives

The specific objectives of this study were:

1.To collect information on the present level of farm mechanization in Lalgudi taluk;
2.To determine the scope for further mechanization of agriculture in Lalgudi taluk; and
3.To identify the problems of agricultural mechanization in Lalgudi taluk.

Methodology

The Lalgudi taluk lies in the Cauveri river basin and the farmlands in this region are mostly wet lands with assured irrigation either through canals or bore wells. The major crops grown in this region are paddy, sugarcane, and cotton. For this study 20 sample villages were selected randomly from the 117 villages of the Lalgudi taluk. These villages are located in 5 developmental blocks, namely; Anbil, Lalgudi, Peruvalappur, Pullambadi, and Valadi. At least 25 farmers were randomly chosen as sample farmers in each of the villages under study. In total, 540 sample farmers were interviewed using a structured

Farm size, ha	Farmers, %
Marginal (<1)	28
Small (1-2)	34
Medium (2-5)	23
Large (>5)	15

Table 1 Distribution of landholdings in Lalgudi taluk

questionnaire. Additional information on agricultural mechanization practised by the farmers were also gathered. The specific information asked in the questionnaires were: 1. Farm size; 2. Cultivation practices; 3. Use of tractors and implements; 4. Labour utilization and requirement; 5. Timeliness for agricultural operations; 6. Availability of repair facilities; 7. Availability of credit facilities; 8. Possibility of cooperative farming; and 9. Farmers' social conditions such as education, and knowledge of farm machines.

The assessment of mechanization was done on energy basis. Suitable energy equivalents for human, animal and tractor power were used to convert the man-hr, animal-hr, and tractor-hr into MJ of energy (Ojha and Michael 1998). For the important crops grown in Lalgudi taluk, the energy utilized in the various operations, namely; land preparation, sowing and planting, irrigation, crop protection, weeding, harvesting, and threshing were determined from the gathered information.

Results and Discussion

Present Scenario

In Lalgudi taluk, most of the farms are small and fragmented and there are no big commercial farms. The farm size distribution is given in **Table 1**. Of the farmers interviewed, 67% own their land, 11% were tenants and 22% were mixed operators who tilled their own land and land on lease. The major crops grown in this area are paddy, sugarcane, and cotton. Vegetables, banana, pulses, sorghum, cumbu, gingelly, tapioca, and groundnut are also cultivated to a limited extent (**Fig.1**). The crop rotations adopted in the blocks under study are given in **Table 2**.

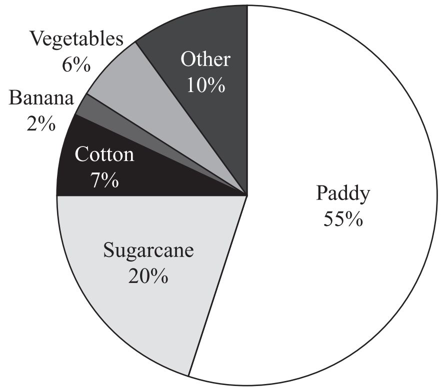

Fig.1 Crop grown in Lalgudi region (% area)

The energy utilization pattern for all the major crops in this region is given in **Fig.2**. This scenario closely reflects the actual energy utilization in small, medium, and large farms. The conditions pertaining to marginal farms may deviate from the average scenario presented here because smaller land size and subsistence level of farming do not favour the use of large machines.

The total energy requirement per ha for paddy ranged from 12449 MJ in Valadi to 17129 MJ in Anbil and that for sugarcane ranged from 3566 MJ in Anbil to 3977 MJ in Lalgudi. The total energy requirement for growing paddy was approximately 4 times greater than that for sugarcane. The energy used for land preparation in paddy cultivation was 51% in Anbil and Pullambadi blocks and 70% in Lalgudi and Valadi blocks. Next to land preparation, threshing required the most energy for paddy. About 32% of the total energy was used for threshing in Anbil and Pullambadi blocks and 10% of the total energy was used for threshing in Lalgudi and Valadi blocks. Irrigation was the second most energy intensive operation (31.7%) for sugarcane next to land preparation (38%). More than 95% of the total energy was drawn from mechanical sources for paddy cultivation whereas it was 55% for sugarcane cultivation. The energy requirement for cotton was 2339.01 MJ/ha, for chilli was 1820.98 MJ/ha, and for groundnut was 586.2 MJ/ha. While land preparation required the most energy for the above three crops (58.6%, 46.0%, and 66.6% respectively), irrigation was the second most energy intensive operation (21%) for cotton. Harvesting was the second most energy intensive operation for chilli (20.8%) and groundnut (29.3%).

For paddy, machine power was not employed for operations such as sowing, transplanting, and weeding. In sugarcane cultivation, machine power was not employed for operations such as sowing, planting, weeding, and harvesting. For cotton,

Block	No. of Villages	Crop rotations
Anbil	5	1. paddy-paddy-gingelly 2. paddy-paddy-black gram 3. sugarcane-gingelly
Lalgudi	4	1. paddy-paddy-gingelly 2. sugarcane-black gram 3. banana-black gram
Peruvalapur	4	1. paddy-cotton-sugarcane 2. paddy-chillie-black gram 3. groundnut-sorghum
Pullambadi	4	1. paddy-paddy-black gram 2. paddy-paddy-gingelly 3. paddy-groundnut
Valadi	4	1. paddy-paddy-gingelly 2. banana-black gram 3. sugarcane-black gram

Table 2 Crop rotations followed in Lalgudi taluk

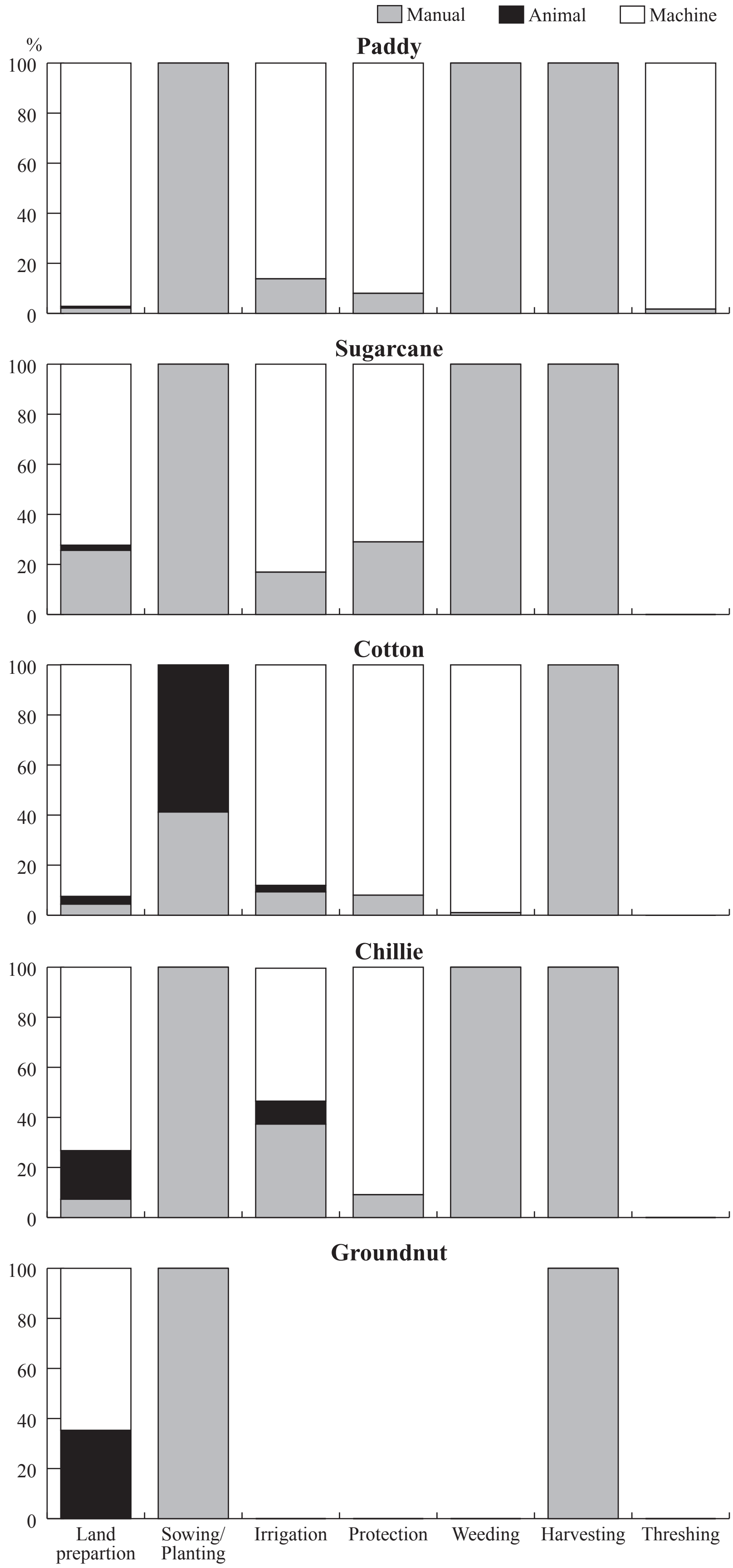

Fig.2 Sourcewise energy ultilization in major crops of the Lalgudi region

machine was not used for sowing, planting, weeding, harvesting, and threshing. In groundnut cultivation, machine power was used only for land preparation. All other operations were carried out manually. For the major crops, namely; paddy, sugarcane, and cotton, the energy supplied by machines constituted 92, 60, and 76% indicating that mechanization had already taken place to a considerable extent in Lalgudi region. For crops like chilli and groundnut the level of mechanization adopted is low.

Scope for Mechanization

Mechanization of agriculture is spreading fast in the Lalgudi region. Paddy is the economically important crop of this region. Mechanization of paddy cultivation has taken place to a greater extent compared to sugarcane, cotton, and other crops.

The power sources available for farming in the Lalgudi taluk is given in **Table 3**.

The bullock power available per ha of land sown was 0.13kW and the mechanical power availability was 4kW/ha. The mechanical power available was considerably higher than the national average of 0.74kW/ha (Singh, G. 1996). Growing labour scarcity and increasing wages of agricultural workers are the major causes for the rapid progress of mechanization in Lalgudi. Pingali (1998) observed that rural urban migration, increases in labour productivity, and escalating wage rates in the non farm sector put pressure on rural wage rates in Asian countries.

Although among the crops grown, paddy cultivation is highly mechanized, transplanting seedlings is yet to be done by machines. No transplanting machinery could be seen in the farms of Lalgudi. This could be due to non-availability of a machine of satisfactory performance. The imported transplanters from Japan, and South Korea were not entirely successful when tried in south Asia. This may be due to differences in

Characteristics	Anbil	Lalgudi	Peruva-llapur	Pullambadi	Valadi
Village	4	4	4	4	4
Area sown (ha)	199.4	92.4	108.4	97.0	94.4
Bullock pairs	12	7	18	21	9
Tractors	37	18	12	23	7
Pumpsets	102	97	82	131	58

Table 3 Sources of farm power in Lalgudi region

soil, climate and cultivation practices. A series of transplanters from China, South Korea, and locally developed prototypes were tested in Pakistan and none of them was accepted by the farmers due to operational problems, complexities, and initial high investment (Mufti and Khan 1995).

In sugarcane cultivation, planting, weeding, and harvesting need to be mechanized. No harvesting machinery for sugarcane is found in the farms of Lalgudi. Nearly 60% of the man power used in sugarcane cultivation was for doing these operations. Similarly, the operations of planting, weeding, and harvesting of cotton need mechanization.

Problems of Mechanization in Lalgudi

Although the level of mechanization and the availability of power/ha were higher in Lalgudi compared to the national average, complete mechanization of agricultural operations has not been achieved. The bottlenecks for near complete mechanization are: from size, farm machineries, knowledge of farmer, service centers and purchasing power.

Farm Size

Nearly 28% of the farmers interviewed possessed land holdings less than 1 ha each. These farmers carry out farming mainly using manual and animal labour. Most of the small farmers farming 1-2ha preferred hiring machines from neighbouring medium and large farmers. Although only 26% of the farmers owned tractors (medium and large farmers together constituted 38% of the total number farmers), 82% of the farmers used tractors for at least land preparation. This indicates that the awareness level of the farmers on using machines is high and the general trend is toward higher mechanization.

Farm Machineries

Land preparation was done by machines for all the major crops by most of the farmers (82%). Diesel engine or motor driven pumps were used for irrigation by most of the farmers interviewed. Besides land preparation and irrigation, the remaining agricultural operations for all the crops cultivated were done mostly manually. In paddy cultivation, threshers were used by 42% of the farmers. Suitable number of threshers were not available at the peak season of harvesting to enable all the potential users to go for hiring the threshers. Harvesters and combines were not seen in the farms of Lalgudi taluk. Non-availability of harvesters and combines is the major reason for the farmers not to mechanize the harvesting of paddy. Successful introduction of rice combines in the adjoining Perambalur district showed that poor supply of labour and increased efficiency of machines over manual operation were the factors responsible for Perambalur farmers to adopt combine harvesters (Anonymous 2000a). Similarly machines for transplanting paddy and planting sugarcane were not available. The farmers cultivating sugarcane in this taluk were in need of harvesting machinery. Farm implement dealers of the state have organized field demonstrations of imported machinery for harvesting sugarcane in this region. However, they received poor response from the farmers because of the clogging of the conveying mechanism due to twines in the field was a major constraint in using the harvesters. No machinery was available for cotton cultivation with the exception in land preparation. About 29% of the farmers complained about the non-availability of tractors in time for land preparation.

Knowledge of Farmers

Nearly 81% of the farmers were educated to at least the elementary level. However, only 8% of the farmers finished high secondary schooling. Most of the farmers (88%) were unable to answer the questions related to the farm machines. Training programs like the "TRYSEM" (Training Programme for Rural Youths for Self-Employment) organized by the state government to train the uneducated rural youths in using and repairing farm machinery were valuable. Similar training programmes in Taiwan in the early years of mechanization were reported to be very successful in disseminating farm mechanization technology to farmers and extension workers (Tien 1978).

Service Centers

The work shop facilities avail-

Place of workshop	Services available
Anbil	Tyre works, simple fabrications repair of implements, and motor widing
Pullambadi	Tyre works, simple fabrications repair of implements, and motor widing
Lalgudi	Tractor servicing, and repair supply of spare parts, tyre works, fabrication works, motor winding
Valadi	No workshop facility
Peruvalappur	No workshop facility

Table 4 Workshop facilities

Block	Source	Usage of loan
Anbil	Co-operative society, Primary co-operative bank	Fertilizer, Paddy, Sugar-cane, Tractor
Lalgudi	State bank of India, Agricultural co-operative bank, Co-operative society	Tractor, Seeds, Fertilizer, Splayer
Peruvalappur	Co-operative society, Indian overseas bank, State bank of India, Agricultural co-operative bank	Cotton seed, Fertilizer
Pullampadi	Agricultural co-operative bank, State bank of India	Tractor, Fertilizer, Splayer
Valadi	Co-operative society, Money lenders	Paddy

Table 5 Sources of finance for farmers of Lalgudi

able in the Lalgudi area are given in **Table 4**. A uthorized dealers and workshops for farm machines were located in Trichy city which is 30km away from the region under study. The workshop facilities currently available presently were not adequate for complete mechanization. However almost all farmers complained about the lack of good workshops and qualified technicians to undertake repairs and servicing of farm machines. About 27% of the farmers complained about the lack of spare parts for farm machines and tools. The quality of services provided to the farmers was expected to improve in the near future because more tractor and farm machinery companies were trying to start their sales and servicing operations in Trichy district to exploit the opportunities offered by the economic liberalization policy of the government, (Anonymous 2000b).

Purchasing Power

The purchasing power of all the farmers of Lalgudi were not high enough to own tractors and other implements. For example, only 26% of the farmers owned tractors and 9% owned threshers. However financial support in the form of loans were forwarded to the eligible farmers by various financial institutions located in the area (**Table 5**). There were various finance schemes devised and operated by these institutions which helped the farmers to buy agricultural machinery and implements. Short term and long term loans were also available to the farmers to buy other inputs for crop cultivation.

Conclusions

The following conclusions can be drawn from this study:

1.The farmers of Lagudi taluk adopted a high level of mechanization. The use of mechanical power was highest for paddy and lowest for cotton among the crops grown.

2.Planting and harvesting operations of all the major crops, namely, paddy, sugarcane, and cotton need to be mechanized.

3.Non-availability of suitable machinery for planting and harvesting was the major bottleneck in the progress of farm mechanization. As the education level of farmers is low, training programmes to improve their technical skills were necessary for successful farm mechanization. Government needs to play a major role in this issue.

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Comparative Evaluation of Field Performance of a Tractor Drawn Straw Reaper and a Flail Harvesting of Wheat Straw

by

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Abstract

Field investigations were carried out, to study and evaluate the comparative field performance of a straw reaper made in India and of a flail harvester made in Germany in the harvesting of wheat straw, at the SAG Bidaj Farm (India).

It was observed that the field efficiency, height of cut and straw loss had significantly different levels for the straw reaper relative to those for the flail harvester while speed, field capacity and fuel consumption per hectare were not significantly different between machines

Introduction

Harvesting of crops is one of the most labour consuming field operations. Acute labour shortages are felt during the harvesting season. Today's intensive agriculture leaves only a very limited time between the harvesting of one crop and the sowing of the next one. In order to circumvent labour scarcity in the harvesting season of paddy and wheat, farmers' started employing combine harvesters, which could quickly and efficiently harvest, thresh and make the crop ready for sale. The majority of farmers' have not favored the use of combine harvesters because their use was accompanied by loss of the straw and chaff, which materials have a ready market as animal feed. The one type of intermediate technology between the sickle and the combine harvester is available in the form of the vertical conveyor reaper. This was developed to harvest the crop by cutting the crop at height of 10-15cm above the ground and conveying the harvested material to the right side of the machine. Farmers' would then employ a thresher to separate the harvested crop into grain and chaff components. But farmers were still subject to some constraints in the use of the vertical conveyor reaper and the thresher because of an increased number of breakdowns with the vertical conveyor reaper, increased number of accidents during operation of the thresher and a generally higher labour requirement as compared with combine harvester use.

The tractor-drawn straw reaper has been developed for harvesting and collection of chaff and straw after use of the combine harvester. The flail harvester has been developed for harvesting, chopping and conveyance of green fodder crops. The straw reaper has a number of problems or flaws such as the number of breakdowns of the cutter bar, collection of lower quantity of straw or chaff etc. So while keeping these problems the present study was undertaken on the comparative evaluation of the field performance of a straw reaper and of a flail harvester

Fig.1 Tractor drawn straw-reaper

Fig.2 Tractor drawn flail-harvester

in the harvesting of wheat straw after the use of combine harvester.

Materials and Methods

The study was carried out on the evaluation of the field performance of a straw reaper and of a flail harvester at the SAG, Bidaj Farm (India). A HMT 5911 tractor was used to operate both the machines. **Fig.1** and **2** show the front view of the straw reaper and the flail harvester. The following observations were made regarding performance evaluations of these two implements:

Data Collection

Speed of operation (m/min): Speed was recorded by noting down the distance traversed by the machine during harvesting in one minute. The observation was replicated three times for each machine.

Effective field capacity (sq.m/hr): Field capacity was recorded by noting down the area, sq.m, harvested by the machine in one hour. The observation was replicated three times for each machine. The field capacity was subsequently calculated in ha/hr.

Fuel consumption (l/ha): Fuel consumed by the tractors in one hour of operation was recorded. This was replicated three times for each machines.

Height of cut (cm): Height of cut was measured from three randomly selected spots in the field serviced by each of the machines using a measuring tape.

Straw and chaff Yield (kg/ha): After harvesting and collecting the straw and chaff these materials were weighed on a balance and this procedure was replicated three times. The yield was then calculated in kg/ha. Subsequently the straw losses were determined in the case of the straw reaper and also in the case of the flail harvester, based on comparison with the chaff and straw obtained by use of a thresher.

Data Analysis

Equations 1 to 4 were used to calculate various parameters of field performance. The data so obtained, along with the data on speed, height of cut, fuel consumption, etc was used for an analysis of variance with a completely randomized design pattern, with the straw reaper and flail harvester as treatments and with six replications, each as block. The significance of various parameters was tested at the five percent level of significance. The various formulae and equations used were as follows:

(a)

$$\textit{Theoretical field capacity (ha/hr)} = \frac{W \times S}{10} \qquad \text{.............................(1)}$$

Where, W=width of cut (m), S= speed of operation (km/h)

(b)

$$\textit{Field efficiency} = \frac{\textit{Effective field capacity}}{\textit{Theoretical field capacity}} \qquad \text{.............................(2)}$$

(c) Straw loss, percent

(1) In case the of straw reaper:

$[(Sg\text{-}Sr)/Sg] \times 100$........................(3)

Where, Sr=straw yield by use of straw reaper (kg/ha), Sg=straw yield by use of thresher (kg/ha)

(2) In the case of flail harvester:

$[(Sf\text{-}Sg)/Sg] \times 100$.........................(4)

Where, Sf=Straw yield by use of flail harvester (kg/ha)

Results and Discussions

Table 1 shows the mean values of various parameters of comparative field performance of the tractor-drawn straw reaper (cutter bar width=2300mm) and the tractor-drawn flail harvester (working width=1650mm). The results presented in **Table 1** are discussed as follows:

Forward Speed: The average speed of tractor for operation of the straw reaper and the flail harvester was observed as 2.68 and 3.00km/h, respectively. This difference was non-significant at the 5 percent level.

Height of cut: The average height of cut for the straw reaper and the flail harvester were observed to be 9.7cm and 6.0cm, respectively. The height of cut was found to be greater in the case of the straw reaper due

Performance parameters		Mean value of parameters		Significance of difference between means
		Straw repaper (cutter bar width = 2300mm)	Flail Harvester (working width = 1650mm)	
Speed of operation	km/h	2.68	3.00	NS (0.39)
Height of cut	cm	9.52	6.00	S (4.07)
Field capacity	ha/hr	0.45	0.41	NS (0.04)
Field efficiency	%	73.77	83.67	S (9.82)
Fuel consumption	l/hr	6.6	5.25	S (1.32)
	l/ha	14.66	12.80	NS (1.86)
Straw loss	%	28	19	S (8.95)

Table 1 Comparative field performance of a straw reaper and of a flail harvester

to efforts on the part of the operator to avoid frequent break down of the cutter bar as caused by obstructions or uneven field surfaces etc. The greater height of cut resulted in loss of straw and chaff, whereas in the case of the flail harvester, the height of cut was closer to the ground level and the instances of breakdown of the movable flail type blades were fewer. The difference between the heights of cut for the straw reaper as opposed to those for the flail harvester was found to be significant at the 5 percent level.

Field capacity: The field capacity of the straw reaper and of the flail harvester was found to be 0.45ha/h and 0.41ha/h, respectively, which constituted a non- significant difference at the 5 percent level.

Field efficiency: The field efficiency of the straw reaper and of the flail harvester was observed to be 73.77 and 83.67%, respectively, which constitutes a significant difference at the 5 percent level. The field efficiency was found to be lower in the case of the straw reaper as compared to that of the flail harvester due to a greater turning radius required at the corners of fields, and thus more precautions being required during turning of straw reaper to avoid damage to the cutter bar, as a sizeable number of breakdowns of the cutter bar were observed during turning at the corners of fields.

Fuel consumption: The average fuel consumption of the tractor when operating the straw reaper & the flail harvester was observed to be 6.6 l/h (14.66 l/ha) and 5.25 l/hr (12.80 l/ha), respectively which represented a non-significant difference at 5 per cent level between the cases for these two machines.

Straw Losses: The straw losses were observed to be 28% and 19% for the straw reaper and flail harvester, respectively, while the average straw yield of 4500kg/ha was obtained with the use of the thresher. The straw losses were found to be greater in the case of the straw reaper because of a greater height of cut and an inefficient pick-up mechanism. However, the quality, in terms of the particle size, distribution of the chaff and straw was found to be better in case of the straw reaper than that in case of the flail harvester.

Summary and Conclusion

Studies were conducted at the SAG, Bidaj Farm (India) to evaluate the comparative field performance of a tractor-drawn straw reaper and of a tractor-drawn flail harvester. The following conclusions were drawn from the study:

1. The field efficiency of the flail harvester (83.67%) was greater than that of the straw reaper (73.77%).
2. The straw and chaff losses were greater in the case of the straw reaper (28%) than in that of the flail harvester (19%).
3. The average height of cut was greater for the straw reaper (9.52cm) than for the flail harvester (6.00cm).
4. The average speed of operation, field capacity and fuel consumption per hectare were not significantly different for one machine than the other.
5. The quality of straw was better in the case of the straw reaper while the quantity of straw collection was greater in case the of the flail harvester.
6. The straw reaper was found to be unsuitable for the harvest of green fodder and lodged crops, while the flail harvester was made especially for green fodder and lodged crops.

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Study on the Development of Agricultural Machines for Small-Scale Farmers (Part 1, Applied Technology for Morocco and Africa)

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Abstract

The process of the development of agricultural machines in African nations differs from the process undergone in advanced countries. Agricultural machines in many African nations have been evolving from traditional technology and technique. It can be said that there is a special development method in Africa, where modern technology has been adopted while integrating the best use of traditional technology. The self-sufficient cereal production of African nations, including the Sub-Saharan region, relies chiefly on small-scale farmers. A small-scale farmer who is supporting the self-sufficiency of those countries is very valuable and holds an important position. Therefore, it is necessary for these farmers to obtain a high income, and for farm management to be stabilized through the introduction of an agricultural machine development system and its continued improvement. The aim of this article is to put forward the results of a survey and of practical experiments carried out in the rain-fed agricultural area of Morocco. The article also describes the development of agricultural machinery. Such developments will improve the depth and draft uniformity of operation of the animal drawn plow as well as the performance of threshing machines and manual sowing machines in Morocco, and African countries.

Introduction

After African nations achieved independence in the 1950's and 1960's, large-scale agricultural machines were rapidly introduced from Europe. However, farm machinery especially adapted to the African context has not yet been developed, as mechanization might not be economical. Furthermore, no acceptable request has yet been put forward for farm machinery appropriate to small-scale, self-sufficient crop production in Africa. The African farmer worries about the payment of contract fees, such as those necessary for large-scale tractors and combines. At present, African nations are setting up developmental strategies. There are many countries which project the accomplishment of a development goal by 2020 (Mohammad, 1999) and (Jenane, 1998). A stable supply of farm products is especially important to advance their developmental strategies. Therefore, the improvement and advance of agro-technology in African nations is to be expected. In Morocco, after independence in 1956, a large number of large-scale agricultural machines from Europe were introduced into state farms in the 1960's as shown in **Fig.1**. However, large-scale agricultural mechanization as a national enterprise did not last long and gradually declined. Moreover, these agricultural machines are not considered useful and economical by the small-scale farmer. Even now, the development of farm machin-

Fig.1 Tractors introduced in the 1960's

ery is not progressing. At present, mechanized farming is only seen in the case of the tractor and the wheat harvest combines operating via contract farming. According to the presumption of the FAO, (Alexandratos, 1995) a typical rain-fed field in the northern part of Africa and Morocco presents a wide potential for cultivated zones in this hilly terrain. It can be said that 24% of the cultivated area consists of rain-fed fields. Sub-Saharan countries are said to be able to mobilize 40 to 45% of the cultivated area as potential rain-fed fields, but these fields have low-fertility soil and a tendency to have a high proportion of sandy and stony soil. Therefore, there are a lot of areas where farm machinery from advanced countries cannot be used. Farm machinery does not contribute to cereal production in African nations, including North Africa. Forty years after independence, traditional agricultural practices are still used including animal plowing and threshing by animal treading as seen in **Figs. 2** and **3**.

At present, animal traction and human power farming are still used in developing countries. The percentages of farm operations conducted by manual, animal traction and mechanical power in Asia, Africa and Latin-America are shown in **Table 1**. Among these three areas, Africa still has a high percentage of manual operation (35%). The present economic conditions, of African nations is giving rise to increasing levels of animal traction farming and, thus there is, development potential for this type of technology. North Africa, including Morocco, has a traditionally high percentage of animal traction farming as is shown in **Table 2**. The other African countries such as Senegal, Gambia and Mali etc. are increasing the use of animal traction due to development measures being carried out in these countries, and also there is development potential for animal traction countries such as Sudan, Somalia, Uganda, Burundi and Zambia etc,. However, in Gabon, Congo and Zaire etc. animal traction farming is limited and being introduced only gradually due to decrease in the incidence of tsetse flies (FAO. 1990).

This research has been carried out for the practical study of small-scale farmers in the rain-fed agricultural areas of Morocco. The development of agricultural machinery is important to small-scale farmers. It is necessary that this development, however, be based on the conditions of traditional agriculture. The factors promoting agricultural machine development for the small-scale farmer, and the realities and situation of a small-scale farmer in that area are considered, including the climate, the soil condition and the characteristic plant cultivation methods, etc. in the rain-fed farm area in Africa. Data were considered based on the investigation of actual conditions of farmers in Morocco.

Region	Required (hp/ha)	Rate (%) per ha		
		Manual	Animal	Mechanical
Asia	0.22	26	51	23
Africa	0.10	35	7	5
Latin-America	0.25	9	20	71

Table 1 Farm operation conditions of manual, animal traction and mechanical power in Asia, Africa and Latin-America

Definition of a Small-Scale Farmer

Farms in Africa especially in Sub-Saharan nations are defined as small-scale by social features, the cultivation system, and the cereals produced in the following countries:

Ghana

Farms of less than 2ha involve 85% of the total farming population. This includes the 60% of all farmers who are occupying less than 1.2ha which is only sufficient for mere subsistence cultivation. Farmers who work 2ha or more make up 15% of all farmers (Tsujinoto, 2000). Therefore, according to the cultivation-area scale, small-scale farmers are producing most of the cereals. These cereals are grown in the rainy season, and a so-called mixed cropping (inter cropping) farming system is widely used in the traditional rain-fed fields.

Nigeria

As in Ghana, land ownership is

Fig.2 Traditional animal plowing

Fig.3 Threshing by treading with a horse or mule

centrally controlled. In the case of village ownership, the chief of the village has jurisdiction over the land and has the authority to divide up the land for the farmer who wants to lease for one or several years. At the end of the lease period, the land returns to being under the chief's management, and someone else leases the land again, with these sorts of changes taking place continually. Because of this continual exchange, once the period of cultivation, has been completed, there is no incentive for continuous soil improvement, leading to soil depletion.

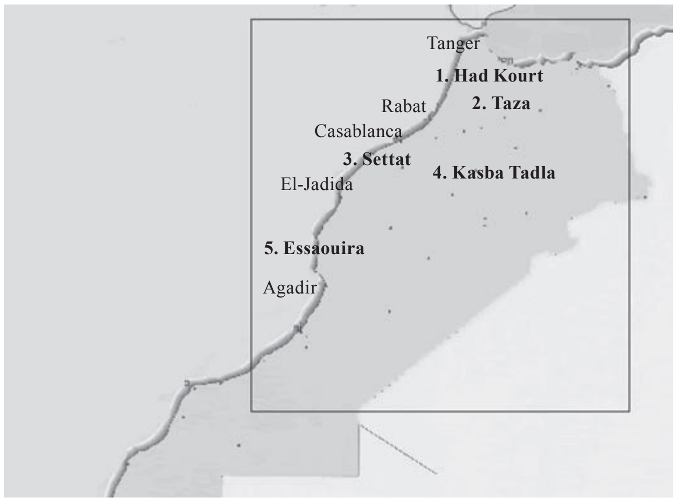

Fig.4 Location of the five survey areas on a map of Morocco

Morocco

Morocco is different from Sub-Saharan Africa in that it has a wide upland area. A small-scale farmer is defined in the following paragraph. This definition is based on the result of a survey of farmers executed in 2001-2002 in Morocco (Tsujimoto, 2002). More than 55.3% of farmers are engaged in farming land of 3ha or less. Improving their farming mechanization systems is very important to the stability of self-sufficient crop production in Morocco. A small-scale farmer is forced to be self-sufficient, and cereal, which is the staple food, is the main cultivated crop. In recent years in the survey area, the number of medium-scale farmers having about 10ha has gradually increased with the spread of contract-operated tractors and combines. However, even in these medium-and small-scale farms, the sloping cultivation area occupies a sizable proportion of the hill terrain area. Although plowing is done with tractors, harvesting and processing work are still done by manual labor. Therefore, it is obvious that development research into appropriate machinery is essential to ameliorate the high labor cost, and to improve the quality of work, etc.

Outline of Farmers Status in the Agricultural Mechanization Survey Area

Five typical rain-fed farm areas in Morocco were selected to be the agricultural mechanization survey areas in this research, which research was carried out at the Technical Center (CT) in the Provincial Directorate of Agriculture (DPA) of the Ministry of Agriculture and Rural Development (MARD). The areas chosen were he Had Kourt and Taza areas, located in the northern part of Morocco, the Settat area located in the northwest part, the Tadla area in the central interior, and the Essaouira area in the southwest (**Fig.4**).

A total of 94 farmers were investigated in the entire survey area. The average family structure consisted of 6.86 people. Those more than 60 years old, tended to be the heads of families and totaled 39 people (41%), while the 20-30-year-old age group totaled only 17 people, or 18%. The illiteracy rate found was extremely high, 70 to 80% overall, and increases with the age of the individuals surveyed.

The Mixed Cultivation and Yield of Small-Scale Farmers

Most farmers were doing not only mono-cultivation but also so-called mixed cultivation management, which was done by growing beans, maize, sunflower, alfalfa and vegeta-

Degree of importance	Name of country
(1)Still traditionally high percentage but decreasing tendency as compare to previous conditions	Morocco, Algeria, Tunisia, Libya, Egypt, Ethiopia
(2)Many used during colonial days but now being introduced again	Kenya, Zimbabwe, Namibia, South-Africa
(3)Animal traction use is increasing due to development measures	Senegal, Gambia, Mali, Burkina Faso, Coto D'Ivoire, Madagascar, Swaziland, Ghana, Nigeria, Niger, Chad, Cameroon, Tanzania, Botsuwana, Malawi
(4)There is development potential gradually increasing use	Sudan, Somalia, Uganda, Burundi, Zambia, Mozambique, Lesotho, Liberia, C.A.R, Togo, Benin, Mauritania, Guinea-Bissau, Guinea, Sierra Leone
(5)Severe limiting factors but introduction now taking place	Gabon, Congo, Equatorial Guinea, Zaire, Angola, Rwanda

Table 2 Importance of draught animals in Africa

bles in addition to cereal cultivation. The cultivation calendar of farming operations for these crops goes on throughout the year with many operations overlapping with regard to the time period in which they are conducted. This type of operation could not be accomplished by family labor alone. Therefore, animal power and agricultural employees were also used. Most farmers grew beans, one of the staple crops of Morocco, for self-consumption and to sell. Moreover, like cereal cultivation, the raising of livestock such as sheep, cows, and goats, was also important to farm production. Because of this domestic livestock production, the cultivation of pasture was an active undertaking. The cultivation of alfalfa was seen in various places, such as small-scale irrigated fields in the oasis area. Alfalfa was grown with beans and was sold at a high price. In the survey area, these crops were grown in mixed cultivation, which reflects, the farmers' aims with regard to the diffusion of risk, taking into consideration possible irregularities in the annual rainfall. For the farmer to secure self-sustenance, mixed cropping cultivation is an important element of the farming strategy in Africa and in Sub-Saharan nations, as well. The annual rainfall affects the farm production in the rain fed farm area. When the weather conditions of different rain-fed zones in Morocco are categorized, the survey area can be divided into three parts: the Had kourt and Taza areas, with rainfall of more than 400mm, the Settat and Tadla areas, with between 300-400mm, and the Essaouira area, with less than 300mm a year. The average cereal yield in the survey area was 1.93ton/ha. The yield was greatly affected by the annual rainfall. Recently in 1995/96, the national average yield was high 1.76ton/ha. The national average yield was very low in 1996/97, 0.87ton/ha.

Small-Scale Farming Methods

Plowing as the primary tillage operation and disk plowing by leased tractors can be observed in small- and medium-scale farms in the northern interior area of Morocco. However, the small-scale farmer does a lot of animal plowing, especially in the hilly terrain area and mountainous districts where it is difficult to plow with a tractor. The farmers in the plains area use tractors and disk harrows with plowing, leveling and seed covering work done concurrently. Also in this case, after the manual sowing by hand throwing, generally, tractor disk harrowing is used to accomplish leveling and covering of the seed with soil. Accuracy of work poses a problem. Because of high-speed, work becomes rough, and a lot of farmers complain about the quality of the work. In the case of animal-drawn operations of the traditional small-scale farmer, after seeding, an animal plow is used to effect seed covering. Therefore, the plowing depth is very shallow, about 8-10cm.

In general, though large-scale farmers use seeding machines with a large-scale tractor, this practice is hardly widespread. Fertilization is also important work. Though chemical fertilizers are used, compost fertilizer is widely used by the small-scale farmer in Morocco. The average rate of application of compost fertilizer is 3-5ton per ha. The application method is manual and with the use of animal trailers.

As for irrigation, the small-scale, vegetable-cultivation farmer mainly uses a small pump. The government is also encouraging the installation of small-scale irrigation with small pumps, and thus, a subsidy of 30% is attached to each purchase of a group pump. Spraying work is hardly seen in cereal cultivation, although small-scale farmers use a simple back-pack type sprayer for pest and disease control. Quite a lot of herbicide application is observed. Hours spent on field maintenance, including weeding, constitute the majority of the total labor hours. Shortening family labor hours in this area is also important. Though the cereal harvest is done more and more through contract work on small and medium-scale farmers, the result for small-scale farmers has been increased expense and decreased quality of work. Moreover, because the large-scale combine is difficult for the farmer in hilly terrain area to use, harvesting work is done manually.

The threshing work is done by treading with donkeys, mules or horses. Afterward, the winnowing is done naturally by the wind. Straw is an important crop for farmers in Morocco, and after the straw is threshed, it is preserved as livestock feed. At the same time, straw is often bought and sold as a farm product, and this is one of the farmer's sources of income. After being threshed, the straw is cut to approx. 5cm lengths and is trampled by the animals. It is evident that farmers prefers softened straw.

Development and improvement of threshers should take this fact into consideration. Although about 3,000 large-scale threshers made in Turkey have been introduced, it is still necessary to improve the design of the threshing drum in order to provide an outlet for the straw. Also important is the improvement of techniques for cutting the straw into lengths of the proper size. After threshing, and during natural cleaning by the wind in the field, a lot of foreign matter and dust may mix with the straw, so that the development of a simple winnower is also needed.

Machine Work in Agricultural Cooperatives and by Contractors

Cooperative use of farm machinery has been investigated in the five survey areas. Average numbers of agriculture machines in use in cooperatives are quite low in total. But, animal drawn plows and harrows are also common in agricultural cooperatives, and this type of equipment is important. Consequently, with their low income, small-scale farmers are not able to hire a worker throughout the year. Given the situation of most farmers in Morocco, this research into systems of farming mechanization, proposes considering both animal power and manual machines, and is based on the survey of the circumstances of small-scale farmers.

Manual Labor and Mechanization

In the case of Morocco, there are many difficult aspects of mechanization, such as the limited availability of tractors and combines, and a cultivation pattern that is related to geographical features such as the hilly terrain zone, the mountainous zone as well as to the size and dispersion of fields and stony fields. Therefore, it is necessary to emphasize the many hours that have to be spent for land preparation and harvesting work. As for the relation between farming work and mechanization, many elements are intertwined.

Primary consideration is to be given to the traditional small-scale farmer. This type of farming relies on family labor and on animal power The main cultivated crops of these farmers are wheat, barley and fava-beans (broad bean), and these farmers also raise domestic animals. The result of the survey study on the working hours for wheat and barley cultivation was that 188 hours per ha were required for manual operations and 80 hours of animal use per ha were required. In the cultivation of beans, manual operations of 252 hours per ha were needed, and 128 hours per hectare with animals were required. For maize, animal use was 92 hours per ha, and manual work was 212 hours per ha.

The second type farmer is one using a combination of animal power and machinery. In recent years, although this of combination of power sources has been introduced on small-scale farms, it is not widespread because of the shortage of tractors and combines. Contract work is done mainly on small-scale farms, because this type of farming still uses traditional animal power and manual operations in the main farming areas, including the plains area and the hilly terrain areas. Maintenance work is done manually and with animals. In wheat and barley cultivation, manual operation is 66 hours, animal use for transport work is 4 hours, and tractor operation is 12 hours, all on a per-hectare basis In the cultivation of beans, there is not much difference between machinery-using farms and traditional small-scale farms. Tractors are needed for 7 hours of work, animal power for 44 hours, and 237 hours are manual for each hectare. The effect of using tractors in maize cultivation is a minimal 10 hours. Animal use is 44 hours, and 196 hours is manual work per hectare.

Large-scale farmers makes up the third type. In wheat and barley cultivation, manual work per hectare is 34 hours, and tractor work is 18 hours. However, on a large-scale farm, a lot of animals are also kept for transportation work etc. For maize and bean cultivation, the use of animals shortens the total working hours. As seen from **Tables 1** and **2**, the items of importance to farmers which require reform are in the areas of land preparation and harvesting. Therefore, it can be said that for agricultural machine development and the improvement of small-scale farming, it is important to develop appropriate, equipment taking into consideration the local economy.

Proposal for an Agricultural Machine Development System for Small-Scale Farmers

According to the results of the survey, a farming system for the small-scale farmer in the cereal cultivation area should be able to reduce of the total 188 working hours per hectare by 70 hours. The needs for agricultural development and improvement of machinery and systems for the five survey areas are explained as follows:

Taza Area

According to the farmers, the repair cost of the machinery and the labor cost for harvest and for processing after the harvest is high. Also problematic is the inadequacy of the repair yard because of the lack of machine tools, and the lack of material such as steel. In addition, the lack of harvest machines has also been pointed out. Most importantly, the machine cannot harvest at the appropriate time. In the agricultural cooperative, machines should be operated properly. Appropriate guidance concerning the effective use of the subsidies is necessary. A low quality of work is pointed out by 20% of farmers who use contract work. Threshing work efficiency is very low because treading by tractors, mules, donkeys, and horses, etc is used for the threshing work in the hilly terrain area in this survey zone. The small-scale farmer needs an appropriate machine to cut in half the working hours for zone threshing and winnowing.

Had Kourt area

In this place, a lot of plows, ridgers, and trailers are used with animal power, especially in hilly areas. Farmers point out that this inhibits effective farming, because their croplands and small fields have been distributed across disparate areas. A traditional method of cultivation, harrowing and soil covering by disk harrows is done at the same time as the seeding operation. A plowing and seeding work system, which combines the animal plow with the broadcast-sowing machine, should be established. The result will make it possible to achieve high farming accuracy, good seedbed preparation work, and the reduction of work hours. Therefore, improvement of an appropriate animal plow and of a small seeding machine (broadcast-sowing) for a populated hilly zone by small-scale farmers needs to be developed.

Settat Area

There are many farmers whose poor quality of farming operations are linked to the use of hired contract machine work. The hired contractors do not have appropriate machines; moreover, new machinery purchase is expensive and difficult. According to the survey results, the average wheat yield is low, 700-790kg per ha. Operations are not done at the appropriate time. Animal plowing quality must be improved and timely operation of a proper farming system should be established in order to create an appropriate system of plowing and seeding to increase yield per hectare.

Tadla Area

There are no skilled operators. Therefore, the quality of the farming work is very low. It is necessary to have a qualified operator for farm machines such as a tractor etc. The farmland is divided into small fields and scattered. Therefore, large-scale agricultural machinery cannot be used effectively. In this case, the development of a suitable machine for these areas is very important. Appropriate farm machines, implements for cereal crops, threshing machines and grain cleaning machines should also be developed for use in this region. An improved farming system for small-scale farmers can be established by increasing threshing performance. Threshers made in Turkey have already been introduced. In addition to threshing, this machine will also have to be capable of proper straw processing.

Essaouira Area

There are many small-scale farmers in this typical southern area. Even medium-scale farmers find it financially difficult to buy and keep machines. Additionally, there is a lack of manpower. In recent years, the lack of rainfall has made field conditions poor. The field shapes are of irregular size. The farmland is small and scattered. The yield of cereal (wheat) is low, 700-800kg per ha as was seen in the survey results. Instead of primary tillage, crop seed covering is done at the same time as the land is worked by animal plows. Therefore, more effective plowing, seeding and harvesting work needs to be carried out.

Conclusions

It is important to study the development and improvements with regard to the depth and draft uniformity as well as the effectiveness of the animal-drawn plow, which has existed in Morocco for centuries. Concerning the seeding rate, the manual-broadcasting type of seeding machine can distribute the proper amount of seed per hectare. Manually operated broadcasting machines, which can apply both fertilizes and seed can be considered. Moreover, it is preferable that the development of the seeding machine for animal power be continued, in order that its use may spread to the small-and medium-scale farmers to help mechanize. The Turkish thresher has been introduced the harvest, but it is necessary to improve the threshing drum and the straw outlet of this machine. As for processing machines, a winnower for wheat and straw separation and cleaning must be developed.

In the future, it is important to continue proper prototype development and improvement, as part of the agricultural machine development system for small-scale farmers. The above-mentioned machinery development system will encourage interest in agriculture on the part of the young inheritors of the agricultural sector and will encourage them to stay on the land.

Lastly, it can be said that the above-mentioned proposals would be the major factors contributing to the first steps of the mechanization of the small-scale farming systems, the goal of which is, further agricultural development in Morocco as well as in other African countries.

Acknowledgement

The author would like to express this special thanks to President of Societe Hassouni Company, Mr. Madani Hassouni who provided photographs of the tractors introduced in the 1960's, as well as valuable information about the situation of agricultural mechanization in Morocco.

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ABSTRACTS

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

129

Effect of Threshing Timing on Grain Losses of Bread Wheat (cv. Mehran): L. A. Jamali, Faculty of Agricultural Engineering, S. K. Agha, G. H. Jamro, Faculty of Crop Production, Sindh Agriculture University, Tandojam 70060, N. A. Jamali, Agriculture Development Institute, Khanpur, Usta Mohammad, Balochistan, Pakistan.

Post harvest (threshing) grain losses of bread wheat (C.V Mehran-89) as affected by threshing timings were studied at Malir farm, Sindh Agriculture University Tandojam, Pakistan during 1998. The meteorological characteristics were slightly different during observing dates. The date demonstrated that grain losses of bread wheat as well as early threshing. Minimum grain losses were recorded during middle of the day and by comparing the types of losses, the maximum were un-threshed followed by un-broking grain losses.

171

Optimal Energy Requirements for Paddy Cultivation for Different Holding Sizes: S. K. Dash, Associate Professor, D. K. Das, Professor and head, Department of Farm Machinery and Power College of Agricultural Engineering and Technology Orissa University of Agriculture and Technology, Bhubaneswar, Orissa, India.

The experiment was conducted for paddy crop with three farming systems viz. bullock, power tiller and tractor and two levels of energy inputs. The farming systems with higher energy intensity showed higher yield over low energy intensity. The modified mechanization levels of all three farming systems have significant effect on yield, human energy, indirect energy, total energy and cost of total energy requirements. The power tiller farming system with higher energy intensity was proved to be superior to tractor and bullock farming systems with higher energy intensity. The average total energy requirement and average cost of farm operations for highest yield of 32.64q/ha of paddy were 6832.11mj/ha and Rs. 4640.94/ha. On yield basis these are 209.31mj/q and Rs. 142.18/q. respectively. The optimum machine set use cost for different holding sizes for paddy cultivation were also determined through developed programme.

187

Human Labour in Turkish Agriculture: Dogan Erdogan, Prof. Dr., Ali Ihsan Acar, Assoc. Prof. Dr., Dept. of Agricultural Machinery Agricultural Faculty Ankara University, Ankara, Turkey.

The main objective of this research is to determine required human labour data in growing major agricultural products. The data registered regularly before by the 31 Agricultural Research Institutes within Ministry of Agriculture of Turkey has been used in this study. According to the evaluations the data of human labour for all products except cereals and leguminous has been determined higher than the data of the literature. From the perspective of operations, the operations of plant husbandry, harvesting and post harvesting require more human labour.

188

An Analysis of Energy Consumption in a Mechanised Farm in Oyo State, Nigeria: S. O. Jekayinfa, Lecturer, Department of Mechanical Engineering, Ladoke Akintola University of Technology P.M.B 4000, Ogbomoso, Oyo State, Nigeria.

A study was conducted to determine and analyze the pattern of energy utilization in all sections of a typical mechanized farm in Oyo State, Nigeria. In this study, a three-year data (1997-1999) collected on energy performance of the farm was presented and analyzed indicating the yearly and total consumption of electricity and fuel. An average energy consumption per year of the 3 audit years was 1032.16GJ with fuel and electricity making up 58% and 42% respectively. The average value of the Normalised Performance Indicator (NPI) was 0.17GJ/m^2, 0.28GJ/m^2, 0.83GJ/m^2, 0.0087GJ/m^2, 0.015GJ/m^{2}and 0.082GJ/m^2, for feedmill, hatchery, mechanical workshop, piggery, poultry and administrative section respectively. These NPI values indicate a good energy consumption and management for all the six sections of the farm studied.

190

Variation of Friction and Normal Force in Roll Husker: D. Shitanda, Ph. D. Student, United Graduate School, S. Koide, Associate Professor, Department of Bio-resource Engineering, Iwate University, 3-18-27 Ueda Morioka, Japan.

Variation of friction normal force in an experimental rubber roll husker was analyzed using short (Akitakomachi) and long (Delta and L201) grain rice. Friction and normal force were found ton be higher for horizontal grain feed than for vertical grain feed. For the three varieties of rice, Akitakomachi had the highest friction force whereas Delta had the highest normal force. Coefficient of friction was constant above the optimal roll clearance of the three varieties of rice and was higher for vertical grain feed and short grain rice. It averaged 0.34 for Akitakomachi and 0.24 for Delta and L201.

234

Ergonomic Evaluation of Manually Operated Paddy Transplanter: Dr. K. Kathirvel, Professor, Er. K. P. Vidhu, PG

Student, Dr. R. Manian, Professor, Er. T. Senthilkuamr, Research Scholar, Department of Farm Machinery, College of Agricultural Engineering Tamil Nadu Agricultural University, Coimbatore-641 003, India.

Ergonomical evaluation of paddy transplanter can provide a rational basis for recommendation of method and improvement in equipment design for more output and operator's comfort and safety. Three subject were selected for the study based on the age and screened for normal health through medical investigations. The parameters used for the ergonomical evaluation of paddy transplanter include heart rate and oxygen consumption, energy cost of operation for all the selected implements, acceptable work load, endurance time, work rest cycle, discomfort ratings and force measurement. Based on the analysis the following inferences are drawn. The mean value of heart rate for operating the transplanter was 136.03bpm. The corresponding values of oxygen consumption were 1.171 lit min^{-1}. The energy expenditure for the operation of transplanter was computed as 24.45kJ min^{-1} or 5.82kcal min^{-1}. The operation of paddy transplanter was graded as "heavy". The energy cost of operation in terms of VO2 max was 63.64%. These values were much higher than that of the AWL limit of 35% indicating that the transplanter could not be operated continuously for 8 hours. The work rest cycle for achieving functional effectiveness of the paddy transplanter is 30 minutes of work followed by 14 min rest with two operators. The over all discomfort rate (ODR) was 14.37 necessitating an adjustable handle to accommodate the anthropometric suitability of the subjects and handle grip provision to avoid skin irritation and scale formation in palm. The force required for pushing the handle to pick the seedling and planting, force in pulling the fork back from the soil to the next planting position and the force in pulling the implement in the forward direction was 102, 94 and 129N respectively.

247

Power Tillers for Mechanising the Hilly Region of Jammu Division (J and K): Sushil Sharma, Assistant Professor, S. N. Pandita, Associate Professor and Division Head, Division of Agricultural Engineering, FOA Chatha, Jammu-180003, Sher[1]-e-Kashmir University of Agriculture Sciences of Technology-Jammu, India.

The Jammu division of Jammu and Kashmir, India State comprises of six districts, namely; Jammu, Kathua, Udhampur, Rajouri, Doda and Poonch with a total geographical area of 1.794m ha. Nearly 0.652m ha is under forest, 0.381m ha is cultivable, 0.226m ha non-agricultural use, 0.229m ha barren and undulated areas and other uses. Nearly 0.236m ha of the total cultivable area have characteristics of typical hill agriculture. The level of mechanization in the region as a whole is low, in general, more so in the hill agriculture where topography, terrace size and shape of field limit the use of tractors and other farm equipment. Thus most of farm operations in this hilly region are performed by hand tools, animal-driven small implements. In view of these conditions, the effectiveness and quality of operations can not be assured. In an endeavor to mechanize this hilly region, the adoption of power tillers can be promising. However, there is lack of awareness about the utility of power tillers among the farmers. It is, therefore, important to assess the suitability of the adoption of power tillers in the region.

261

Some Physical and Mechanical Properties of Nigerian Rice: M. A. Owan, Post Graduate Student, A. P. Onwualu, Senior Lecturer and Head, Agricultural Engineering Department, Faculty of Engineering University of Nigeria, Nsukka, Nigeria.

Physical and mechanical properties relevant to the design and development of machines for threshing and harvesting of rice in Nigeria were studied. The physical properties determined were grain length, width and thickness, plant height, tiller diameter, solid density, bulk density, porosity and thousand grain mass. The mechanical properties were maximum panicle stripping force, maximum tensile failure force, ultimate tensile strength and toughness. These were determined for different varieties of local rice (Faro15, Faro14, Faro8, Farox317, ITA326 and R8).

The mean thickness, width and length of paddy ranged from 1.92(0.05) to 2.17(0.10)mm; 2.46(0.18) to 3.15(0.01)mm and 8.74(0.59) to 9.38(0.05)mm respectively. Mean plant height, mean tiller diameter and mean tillers density per square meter values obtained ranged from 74.7(114 to 138.8(20.19cm; 3.6(0.60 to 5.3(0.62mm and 106.8(22.08 to 209.5 (20.16 per square meter respectively. Mean solid density, bulk density, porosity and thousand-grains-mass of paddy values ranged from 1.12(0.06) to 1.18(0.05)g/cm^3; 0.558 to 0.580g/cm^3; 48.9(2.99) to 51.7(1.99)%; and 30.57(2.27 to 33.90(0.85g respectively. Variety had significant influence on the bulk density of paddy. The values obtained for maximum panicle stripping force, maximum failure force, ultimate tensile strength and toughness ranged from 3.38N to 18.75(4.97)N, 68.75 to 193. 75(39.47)N, 5.03x10^{-2} to 10.84x10^{-2}(1.68x10^{-2})Nmm^2 and 154.69 to 1114.06(282.15) Nmm respectively. Maximum failure force was directly proportional to the rice stem diameter with correlation coefficient of R=0.71. The ultimate tensile strength and toughness were not significantly affected by the rice stem diameter. The properties determined have been useful in the design of a threshing machine for local rice varieties.

293

Assessing the Extent of and Constraints to Adoption of Intermediate Agricultural Processing Technologies

for Cereal Crops in a Traditional Farming Community of South Africa: V. I. O. Ndirika, Senior Research Fellow/Senior lecture, Department of Agricultural Engineering, Institute for Agricultural Research, Ahmadu Bello University, Zaria, Nigeria. A. J. Buys, Professor and Director, Institute for Technological Innovation, Faculty of Engineering University of Pretoria, South Africa.

An assessment of the extent of and constraints to adoption of intermediate agricultural processing technologies for cereal crops in Vergelegen rural community of South Africa was conducted. The assessment was based on the proportion of the farming households in the community using intermediate agricultural processing technologies, such as maize sheller, sorghum thresher, milling machine, grain dryer and storage system. From the results, it was revealed that the level of awareness and adoption of the existing intermediate agricultural technologies for cereal processing by farmers in the community are low for most of the technologies, except for the milling machines. It was found that the low level of awareness of the existing intermediate agricultural processing technologies is a constraint to adoption but not the only major constraint to adoption of such technologies. Other common constraints to adoption of intermediate agricultural processing technologies, experienced by the majority of the farmers are high cost of usage, inaccessibility, unaffordability and risks in usage of intermediate agricultural processing technologies.

294

Performance Evaluation of Local Rice Parboiling Techniques in North Eastern Nigeria: S. M. Dauda, Research Engineer, National Cereal Research Institute, Badeggi, PMB 8, Bida, Niger State, A. U. Dzivama, Lecturer, Agric. Engineering Dept. University of Maiduru; Borno State, S. M. Misari, Director/Chief Executive, Institute for Agricultural Research Ahmadu Bello University, Zaria, Nigeria.

The performance of local rice parboiling techniques in north eastern Nigeria were evaluated through a survey by personal interview, standard questionnaire and compared with an improved parboiler. The results revealed that the local rice parboiling techniques are generally not effective compared with the improved methods. Some of the factors preventing the efficient performance of local rice parboiling methods in this region are: lack of knowledge on the improved method of parboiling, lack of capital to acquire improved parboilers and the small holder's nature of rice parboilers which makes it impossible to own and operate an efficient rice parboiling enterprise. The quality of locally parboiled rice showed that, moisture content is 10.47%, which is below the requirement of 13%, colour and smell are not appreciable and also there are many broken kernels of 29.5% as compared with the milled rice using the improved method which had 12.6% broken kernels. Recommendations for proper and efficient parboiling methods to upgrade the milled rice qualities among others made.

373

Design and Construction of a Cassava Lifter: S. O. Nkakini, D. S. Zibokere, A. H. Igoni, A. J. Akor, Department of Agricultural Engineering, Rivers State University of Science & Technology, P.M.B. 5080, Port Harcourt, Nigeria.

The economic viability of the cassava processing industry has often been dampened by the tedium and ineffectiveness associated with the existing methods of cassava harvesting. A simple mechanical device for harvesting of cassava tubers has been designed and fabricated in the Department of Agricultural Engineering of the Rivers State University of Science & Technology, Port Harcourt, Nigeria and it is presented here. The cassava lifter, which is operated in a near-standing position of the operator, is devoid of drudgery and tedium inherent in the manual traditional methods of cassava harvesting. Field evaluation of the cassava lifter indicated average performance efficiency of 64.7%, which translates to a significant time and energy saving (p=0.05) over the manual traditional methods.

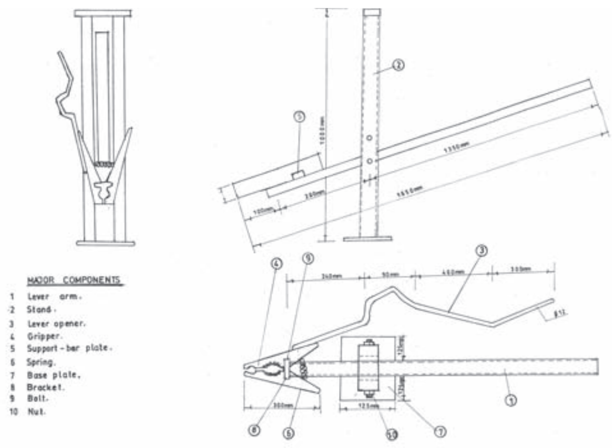

Fig.1 Cassava lifter

395

Determination of Terminal Velocity for Chick Pea: S. S. Mohtasebi, Assistant Professor, M. Behroozi-Lar, Professor, Department of Agricultural Machinery, Tehran University, H. Rabbani, Assistant Professor, Razi University, Kermanshah, Iran.

Terminal velocity is an important characteristics parameter in the pneumatic conveying systems and machinery design such as strippers. Eight groups of Chick Pea with different Geometric Mean Diameters (GMD) of 5.9mm, 6.45mm, 6.86mm, 7.39mm, 7.69mm, 8.13mm, 8.58mm and 8.91mm were classified to determine the terminal velocity at three moisture content of 7% (dry), 42% and 52% in a wind tunnel. A factorial with completely randomized design was used with two treatments that is;

physical size at eight levels and moisture content at three levels with eight replicates each. Four readings were recorded in every replicate. Specific mass (SpM) for the samples were also determined. Effect of both GMD and moisture content on the terminal velocity was obtained by regression analysis. The results showed an increasing terminal velocity with increase in GMD and moisture content. A relationship with correlation coefficient of 0.951 was established for the Terminal Velocity as a function of size and moisture content.

416

Performance of Improved Wood Stove Suited to Rural Masses: Mehta Manju, Assistant Professor Department of FRM, Sangwan V., Professor Department of FRM, College of Home Science CSS, Harayana Agricultural University Hisar, Sharma D.N, Professor Department of FPM, College of Agricultural Engineering & Technology CCS Harayana Agricultural University Hisar, India.

The existing traditional mud woodstove was constructed and considered as the control woodstove. Nine models of improved woodstove were developed and each was tested in the laboratory by conducting a series of experiments. The performance evaluation was done in terms of thermal efficiency, power output & specific fuel consumption. Least specific fuel consumption and the highest power output were recorded for model M_9 (Priyagni stove) i.e. 0.96kg/kw-hr and 1.69kw-hr respectively followed by M_{10} (1.32kg/kw-hr and 1.31kw-hr), and M_1 (1.56kg/kw-hr and 1.21kw-hr) respectively. The highest specific fuel consumption (2.16kg/kw-hr) and least power output (0.91kw-hr) were observed for traditional woodstove (M0). The highest thermal efficiency was observed in M_3 (18.41%), followed by M_5 (18.38%), M_2 (17.87%) & M_4 (16.83%) respectively. All the improved models exhibited better performance in terms of fuel saving, higher output and higher thermal efficiency. Model M_8 (double walled woodstove with vacuum, grates and flame concentration plate) could be an appropriate alternative to M_0 (traditional woodstove used in rural kitchens) as model M_8 (double walled woodstove with vacuum, grate and flame concentration plate) had shown the same performance, as that of existing improved two-pot woodstove (Nada & Sahyog woodstove).

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NEWS

CIGR News
Letter from the President

As my term as CIGR President begins, my first thoughts go to the members of our Agricultural Engineering Societies or Associations, National or Regional, and. in particular, to those members who carry responsibilities in the governing boards of these societies. It is because of them that CIGR exists after 75 years; it is for them that our activities will be developed; it is through them that CIGR will continue. I hope to serve our society in achieving our common goals in a participative manner, responding to both the ever-changing scientific and technical developments of our profession and to the social and cultural challenges posed by rural and agricultural development in our countries and regions.

I remember here all those that have devoted time and work to CIGR in these 75 years. I have had the chance to know many of the Past Presidents and I am glad that many of them continue to be present among us, and contributing valuably to CIGR. I will do my best to give continuity to their efforts, so to honour them through my work. Together with the other governing and working bodies, I will be engaged in making CIGR always more valuable for our members, for our profession and for our countries, thus providing for a world where agricultural engineering definitely contributes to food security, to the conservation of natural resources, to the preservation of the environment, to the welfare of the rural people, to peace and understanding.

The task of President is to be fulfilled by sharing responsibilities, advice and successes with the Past and the Incoming President, Axel Munack and Irenilza Naas, as well as by collaborating with the General Secretary, Peter Schulze Lammers. I will do my best to make the Presidium an effective cooperative governing body.

The work of CIGR is mainly performed through the seven Technical Sections and, therefore, due to the efforts of the respective Boards, particularly the devoted work of their chairpersons. New rules for the operation of the Sections have been recently approved, aiming at improving the effectiveness of their work and their cooperation with other working bodies of CIGR, including the E-Journal and the General Secretariat. The Presidium and myself in particular offer the best cooperation to the Section Boards and the respective chairpersons for implementing these new rules, particularly hoping that an open and effective dialogue will ensue. It is expected that each Section will find its own and free way to further develop its activities aiming at accomplishing its respective goals and those of CIGR. At the same time, all member societies are invited to collaborate with the Technical Sections by proposing new Board members, activities to be developed or sponsored, or themes to be considered.

The members of CIGR are the National and Regional Societies or Associations that group and represent National Societies. Therefore, it is my duty to be aware of the aims and expectations of our members and contribute to strengthening them. To do so, particular attention will be paid to the relationships with the Regional Societies and Corporate Members, aiming at supporting their own activities, strengthening their member societies and creating new National Societies in their regions. I hope that a good dialogue can be developed. The first step in this direction is to hold the next annual meetings of the Presidium, Executive Board and Technical Board in St. Petersburg as a way of supporting the implementation of the Euro-Asian Association of Agricultural Engineering and to improve the ties with the Russian Federation Association. Another step is to develop ties with several Arab colleagues that may result in an Arab society. An Arab version of the CIGR Newsletter has already been created by Past President Bartali through the Moroccan Association, the ties with the Egyptian society are being renewed, and the seeds for new societies in Tunisia. Lebanon and Syria are on the ground. The external and internal visibility of CIGR is mainly achieved through the World Congresses and Conferences, the scientific and technical meetings organized or sponsored by the Technical Sections, the CIGR E-Journal, the website, and the Newsletter. Let us remember in this context the very successful Beijing Conference that was held last October. It was a splendid event! The collaboration of all Member Societies is definitely necessary not only to make such activities more successful but also to better serve our members. In this perspective, I invite everybody to contribute to the Newsletter with news about their own societies and scientific and technical meetings, as well as with their opinions and suggestions.

The website is aimed to serve the Member Societies. If they have their own websites, links with the CIGR website should be developed: if such facilities are not available, timely information to the General Secretariat should be produced in such a way that the CIGR website will be their own web contact. Many activities are already announced on the website and in the Newsletter, but many more could be included if Member Societies made full use of these facilities. Thus, I strongly invite the National and Regional Societies to contribute and use the website to publicize their activities and to establish links with their members and other societies of CIGR.

Due to the efforts of many people, particularly Past President Bill Stout, the E-Journal keeps improving, and solid steps are being pursued to have it recognized by the ISI. But contributions by many others - authors, reviewers and editorial members - are also necessary. If authors are essential for the E-Journal to have papers, reviewers and editorial members are definitely required because they guarantee the quality of the Journal. Volunteer reviewers are needed!

The next Congress will be held in Bonn, Germany, from 3 to 7 September 2006. For further information, look up http://www.2006cigr.org/. The German organizers, EurAgEng, FAO and the Technical Sections of CIGR are co-operating to guarantee the success of our Congress. However, the collaboration of other member societies, particularly of non-European ones, is desirable to make the event a true World Congress. I am fully confident that such success will be achieved, and I am pleased to offer my contribution following the wishes of the organizers.

This letter will appear in the Newsletter early 2005. It is therefore my pleasure to wish you all the best for this year.

Prof. Luis Santos Pereira
CIGR President 2005/06

CIGR Elections 2004 Composition of the CIGR Boards 2005/2006

Presidium

President: Prof. Luis Santos Pereira, Incoming President: Prof. Irenilza de Alencar Naas, Past president: Prof. Axel Munack

Executive Board

Prof. Wayne Coats (ASAE), Prof. Vilas M. Salokhe (AAAE), Prof. Daniele de Wrachien (EurAgEng), Prof. Irenilza de Alencar Naas (ALIA), Dr. Nuhu Hatibu (SEASAE), Prof. Yohei Sato (Japan), Prof. Gao Yuanen (China), Philippe Marchal (France), Prof. Lal Kushwaha (Canada), Prof. El Houssine Bartali, Co-opted: Prof. Pierre Abeels, Prof. Jan Daelemans, Prof. Bill Stout, Yoshisuke Kishida

Auditing: P. Abeels (BE), Y. Seo (JP), F. Bakker-Arkema (US)

Report on CLIA 2004

The Latin America and Caribbean Association of Agricultural Engineering (ALIA) was founded in November 1994, during the International Congress of Agricultural Engineering, in Chillan, Chile. This federation was organized in order to unite all associations in Latin America and the Caribbean for the promotion of agricultural engineering.

The VI Latin American and Caribbean Congress of Agricultural Engineering was organized by the Costa Rican Association of Agricultural Engineering (ACIA), presided over by Eng. Roger Garcia with the support of the Agricultural College of the Humid Tropic (EARTH)/International University of Costa Rica, the University of Costa Rica through the Agricultural Engineering College, and the Agricultural Engineering College of the Technological Institute of Costa Rica (TEC). The Organizing Committee was formed by Ing. Roger Garcia, president, and Eng. Edgar M. Navarro, Eng. Alfonso B. Gamez, Dr. Omar Ulloa and Eng. Warner Rodriguez.

The technical sessions dealt with: *Agricultural mechanization*, covering the aspects of design, construction and test of machinery, maintenance and repair, production technology, administration, ergonomics, security and occupational health; *Soil and water* including drainage and irrigation engineering, soil and water conservation; *Post harvesting engineering* covering the aspects of technology and processes, equipments and process design, and selection and classification of packaging. In the field of Construction, the major subjects were structural design for agricultural constructions, controlled environment for both animal and crop production, use of residual waters, and alternative sources of energy for rural areas. The *engineering aspects of biological systems* included the following items: physical properties of biological materials, use of residue in animal and crop production, forest product processing; and aquaculture. The area of *Information technology* covered precision farming, input dosage and application; and *Research and Teaching* covered the topics of curricular arrangements and occupation profile for agricultural engineering for both undergraduate and graduate courses.

The congress was attended by around 200 delegates from several countries, among them Mexico, Chile, Nicaragua, Cuba, Colombia, Panama, Spain, USA, Germany and Brazil.

During the Congress CLIA2004 the 10th anniversary of ALIA's foundation was celebrated, and in the General Assembly this fact was emphasized, distinguished this congress from previous congresses held in Brazil, Argentina, Mexico and Cuba. The new president Dr. Omar Ulloa was elected during the General Assembly, as well as the new Board of Directors with representatives from several countries. Also during the General Assembly the future Congresses were programmed for the next years as follows: 2006 in Chille, 2008 in Nicaragua, and 2010 in Brazil.

Prof. Irenilaza De Alencar Nääs
CIGR Incoming President 2005/6

Club of Bologna Presidency and Management Committee Conclusion and Recommendations

I. Presidency and Management Committee

After the 14th Meeting of the Full Members of the Club of Bologna in 2003, Prof. Giuseppe Pellizzi resigned as President of the Club.

Before the 15th Meeting of the Full Members in 2004, the Management Committee (MC):

- confirmed the two new MC members designated in 2003: Prof. EI Houssine Bartali, replacing Prof. Ali M. EI Hossary; Mr. Yoshisuke Kishida, replacing Prof. Osarmu Kitani;
- elected four new MC members: Mr. Jacques Dehollain, Secretary General of CEMA (European Agricultural Machinery Manufacturers); Prof. Ettore Gasparetto, University of Milan (Italy); Prof. Luis Marquez, universidad Politecnica of Madrid (Spain); CIGR President (2003/04) Prof. Axel Munack, FAL (Federal Agricultural Research Centre, Germany).
- unanimously accepted the updated Club of Bologna internal Rules.

After the15th Meeting of the Full Members, the Management Committee unanimously endorsed the new President of the Club, appointed by UNACOMA, Prof. Ettore Gasparetto. Both the Full Members' Meeting and the Management Committee expressed their gratitude to Prof. Giuseppe Pellizzi for his long activity as President of the Club of Bologna.

II. Conclusions and Recommendations

36 experts from 16 countries took part in the 15th club of Bologna meeting, held on 12 and 13 November 2004 within the XXXV EIMA Show, under the aegis of CIGR and with the sponsorship of UNACOMA. There were three topics under discussion, of which the first was **"China Agricultural Machinery and Mechanization"** with contributions by a guest, Prof. Yuan Jiaping, "Actual State of China's Agricultural Machinery Industry and Prospects for International Cooperation" and by a Club member, Prof. Li Shuiun "Agricultural Mechanization Promotion in China-Current Situation and Future". The second topic was **"Cost Benefits of the Platform Principles for the Tractors and other Agricultural Machinery"**, with a keynote paper by Dr. Giuseppe Gavioli representing the CNH tractor and equipment manufacturer. The third topic was **"EU (European Union) Enlargement and its Influence on Agriculture and Mechanization"**, with a keynote report

by Prof. Andrea Segre of the University of Bologna.

1. China Agricultural Machinery and Mechanization. The first paper, presented by Prof. Yuan Jiaping, former Vice-President of the CAAMS (Chinese Academy of Agricultural Mechanization Sciences), pointed to the present state of Chinese agricultural machinery industry and to the prospects for international cooperation, focusing on the industrial side of the problem. After a period of self-development in the field of agricultural machinery, China began to cooperate with foreign manufacturers and now foreign-funded machinery ventures are an important part of China's agricultural machinery industry. As a result of both autonomous development and collaboration with outside manufacturers, the output of tractors and agricultural machinery increased, putting China's agricultural machinery industry among the top world entities, at least in produced units. Anyway the highest percentage of agricultural machinery is produced in private units, followed by state-owned manufacturers, while the foreign funded enterprises represent a small percentage (5-6%). Following economic liberalization, both imports and exports increased repeatedly in the last years. Up to almost 20 projects introducing foreign manufacturing technologies for farm machinery have been signed or are at present under study.

The second paper was presented by Prof. Li Shujun, Vice-President of CAAMS. Prof. Li presented a study on the current situation and the future of the agricultural mechanization promotion in China. With 8% of the world's farmland, China's agricultural is able to sustain 23% of the world's population. The total output of national agricultural products reached the first place in the world and the ancient long-term shortage of food changed into a basic balance and into a surplus in good harvest years. Of course this positive change has been the consequence -among other factors- of agricultural mechanization development.

Nevertheless, agricultural machinery utilization in China is still in its elementary stage with a great market and development potential; there is a big difference between a more developed East China and a West with less favorable conditions. Anyway, the agricultural machinery industry in China is developing fast, with the output and sales value increasing by 20% per year in the last period.

Having noted that the successful modernization and mechanization of Chinese agriculture is the most important issue in the 21th century for all the world, because of its big population and surface; **having recognized** that Chinese Government policy and laws strongly influenced the trend to agricultural mechanization, such that agricultural mechanization in China may be regarded more as a consequence of the rural development than as a catalyst to it; **having noted** that both the Chinese policy of granting more privately owned equipment and the new law for the promotion of agricultural mechanization will lead to an increase in larger scale equipment; **having recognized** that China offers a big market with large potential for foreign investors and that the political climate for private investment by farmers seems to be very favorable in the moment; **the members of the Club of Bologna recommend** that an increased promotion of international cooperation is essential to further improve the already favorable conditions of Chinese agricultural mechanization; **underline** that education will be even more important than food, energy and environment and **recommend** that the Club of Bologna should play a role to promote a more advanced education through world organizations and regional networks as well; **acknowledge** that China is following a process of privatization like in new EU countries and that a great deal of today's small farmers will be in the future part-time farmers or merge into bigger farms; **recommend** that drying, processing and storing of agricultural products be considered as an important factor or improvement of Chinese agriculture and economy, as up to now these processes have been partly left behind.

2. Cost Benefits of the Platform Principles for the Tractor and other Agricultural Machinery. Dr. Giuseppe Gavioli pointed to the world's steady or decreasing volumes of demand for agricultural tractors and machinery and to the necessity to increase the number of models, machine power capacity and automation. At the same time there is a strong dernand for less pollution, for more safety and for services. To reduce or keep the cost constant it is necessary to balance the higher product differentiation with an advanced component standardization. In addition the following measures are pointed out: develop/expand product fami1ies; develop global products; globalize the supplier base; carefully plan product development. Among agricultural machines the tractor is the most important one, both in agriculture and in the agricultural machinery industry. Consequently, special interest shall be applied to tractor development, which must consider not only off-road working but also public traffic regulations.

Having recognized that tractor and implement manufacturers seem to follow different development strategies and that there is a scarce relation between the updating of these fundamental branches of agricultural machinery: **the members or the Club of Bologna underline** that there should be for the future a better exchange of information between tractor and implement manufacturers in order to improve both the multi-functionality of the tractors and a better adaptability/fitting of equipment; **recommend** that new studies are needed to develop new tractor concepts for providing different sources of power and on-cab controls of the equipment, with the consideration of both the off-road working and of the circulation-on public roads; **confirm** that education at all levels is a fundamental factor for favoring the improvement of agricultural machinery understanding and utilization; **having noted** that the platform principle is very useful to reduce the cost of produced machinery and that, at the same time, it is necessary to develop better systems to fit each farmer requirements and an increased need for specialized machines in case of big farms or contractor operation; **reassert** that an efficient service is necessary for the machinery performance improvement in all the sectors of production, stocking and distribution systems; **recommend** that machinery producers should combine standardization and common platforms with innovations and advanced technologies from research institutes; **recognize** that the image and perception of agricultural machinery should be changed from "biological production" to "biological systems", including humans, animals and plants, to attract young people; **recommend** the establishment of incentives to promote innovations within the platform production lines and the cooperation between industry and research; recommend that the machine manufacturers should more strictly contact the farmers and other interested sectors, in such a manner to remain competitive.

3. EU Enlargement and its Influence on Agriculture and Mechanization. The presentation by Prof. Andrea Segre carried examined the conditions of economy, agriculture and agricultural machinery utilization and manufacturing in 10 of the 12 countries that have Just entered or will enter European Union over the next years, not taking into account Cyprus and Malta because of the relatively small importance of agriculture in their economic context.

Generally speaking, fragmentation of farm structure is common in these ten countries, with an exception for Czech Republic, Slovakia and Hungary. The level of farm mechanization is usually low. Access to new agricultural machinery is limited since farms generally do not own sufficient capital for machinery renewal and a high percentage of manpower is still employed in agriculture. Although Western European and other developed countries' products have already appeared, the machinery market is still dominated by local production and by imports from Eastern Europe. This trend is, however, likely to change due to the necessity to improve the structures for national agricultural mechanization and to meet EU environmental requirements regarding engine emissions, ergonomics and safety. The accession of these countries will significantly influence the agricultural machinery market due, on one hand, to the higher importance of the agricultural sector and, on the other hand, to the current generally obsolete and inefficient machinery stock available.

Having recognized the fragmentation of farm structure in most of the new members of EU: **having noted** that an easier access to the EU markets after enlargement is seen as an opportunity and that, at the same time, the possibility of increased competition in domestic markets is a threat; **having noted** that demand for agricultural machinery will develop in conformity to the application of the EU rural development policy; **the members of the Club of Bologna underline** that the purchase of agricultural machinery is expected to become increasingly dependent on real productive necessity since financial resources will be different; **recognize** that mechanization will be in a position to develop, provided that the machines respond to the requirements imposed by the new approach and provided that incentives are given to process rationalization, manpower qualification and environmental compatibility; **recognize** that machinery has to change, due to increased labor cost and to allow the use of renewable energies; **recommend** that the European Union supports the agricultural mechanization in the new member countries; **recommend** that a special consideration is given to the mechanization of the small farmers, to solve social problems and that part-time farming is considered as an important point; **recommend** that economic and technological conditions in the extended European Union are considered to promote a financing credit structure; **recommend** that the existing agricultural machinery manufacturers are considered for a different production in the different economic systems, changing their line into spare parts and/or other industrial items.

Professor Ettore Gasparetto
President Club of Bologna

XXXI CIOSTA - CIGR V Congress "Increasing Work Efficiency in Agriculture, Horticulture and Forestry" 19-21 September

This congress, sponsored by CIGR, CIOSTA, EurAgEng and VDI-MEG, will be held from **19 to 21 September 2005** at the **University of Hohenheim, Germany**. The congress language will be English. The scientific programme will include plenary sessions, parallel oral sessions and poster sessions on the following topics:

- Methods and modelling
- Process engineering and controlling
- Calculation and planning
- Farm management
- Ergonomics and work place design
- Work safety, prevention and risk analysis

On the basis of the submitted abstract, the scientific committee will decide whether the contribution is accepted as oral presentation or poster. Oral presentations will be limited to 20 minutes each, plus 10 minutes of discussion. The oral presentations will be supplemented by an exhibition of posters. Both will be published in the proceedings of the congress. Abstracts (2 pages 1400 words max. including graphs and figures) assigned to one of the above topics must state in a comprehensible way the scope, methods and results of the proposed presentation as well as the title of the presentation, the authors' names and full work addresses including e-mail, an indication whether oral or poster presentation is preferred. Please mail abstracts to ciosta@uni-hohenheim.de

Dates and deadlines:

Notification of acceptance: mid-March, 2005, Submission of camera-ready manuscripts: July 1, 2005.

The congress fee will be around 320 Euro (provisional estimate), privileges are intended. A technical tour will be organized on demand.

For further information please look up http://wtv.unihohenheim.de/ciosta-cigr and contact the co-ordinator: Dr. Monika Krause E-mail: ciosta@uni-hohenheim.de Tel.+49 711 459 3231 (Tuesdays only), Fax: +49 711 459 4307

2nd CIGR Section VI International Symposium "The Future of Food Engineering" 26-28 April 2006

CIGR Section VI deals with the food engineering principles in minimally processed food achieved under process control. It is intended to follow the trends and promote sustainability in food production. Its missions are:

- to bring together all those that are working in food processing,
- to stimulate research and education in food engineering,
- to promote participation in CIGR activities,
- to determine the areas that should be investigated and implemented into food production by using friendly, non destructive technology,
- to advance in knowledge for the assurance of safety of all food products for human consumption.

In order to better fulfill its missions. CIGR Section VI is organizing the 2nd International Symposium on physical properties of food, raw materials and semi products as well as bioproducts processing and food safety in **Warsaw, Poland** from **26 to 28 April 2006**. This symposium will include a series of presentations and discussions in plenary, scientific and poster sessions, and informal gatherings to highlight the most recent developments in food processing technologies as well as sustainability in food production. The full proceedings of the Symposium will be published on CD-ROM and provided to all participants at the registration desk during the Symposium.

The Symposium is jointly organized by Lublin Agricultural University and Warsaw Agricultural University.

The topics to be covered include:

- Properties of raw materials influencing process and final product quality
- Quantified methods for food quality evaluating and standardization
- Postharvest preprocessing & on-farm analysis technology
- Small-scale and regional food processing
- Gastrotechnology and catering
- Theory of unit operations and processes
- Mechanical and thermal processing

Emerging technologies

- Modelling of food texture and composition
- Extrusion and expanded products technologies
- Sensors in precision processing
- Tracking and traceability in controlling of food safety
- Energy saving in food chain
- Education and training for new challenges in food processing and quality management

You are invited to submit a paper to the Symposium on the Future of Food Engineering. Please not the following dates:

Deadline for abstract submission: 15 September 2005, Notification of abstract acceptance: 30 September 2005, Deadline for full paper submission: 31 December 2005, Technical programme on website: 30 December 2005.

For further information, please consult the Symposium web page at http://www.cigr.pl or contact the Conference Secretaries: Dr Agnieszka WERZBICKA, Dr Andrzej

POLTORAK and Dr Wojciech GOLIS, Warsaw Agricultural University, at ul. Nowoursynowska 159c, 02-776 Warsaw, Poland. E-mail: cigr2006@cigr.pl or info@cigr.pl

World Congress Bonn 2006 "Agricultural Engineering for A Better World" 3-7 September 2006

CIGR, EurAgEng, VDI-MEG and FAO are delighted to invite you to their joint World Congress, which will be held from **3 to 7 September 2006** at **Bonn, Germany**. The World Congress will combine the "XVI CIGR World Congress" with "AgEng2006" and the "64th VDI-MEG International Conference Agricultural Engineering". As part of the congress, FAO will hold a workshop on "Agricultural Engineering Contributions to solve Future Agricultural Problems" covering two half days. Moreover, a preconference on "Automation Technology for Offroad Equipment" will be held immediately before the World Congress.

The following topics and sub-topics will be discussed:

I. Land & Water Use and Environment

II. Power and Machinery

- Tractors
- Tillage & seeding
- Fertilising & plant protection
- Harvesting
- Automation technology

III. Information Systems and Precision Farming

IV. Livestock Technology

- Structures
- Environment
- Precision livestock farming

V. Processing & Post Harvest Technology and Logistics

VI. Energy and Non-Food Production Technology

VII. Systems Engineering and Management

- Emerging industrial products
- Marketing
- Service systems
- Traceability
- Work safety and ergonomics
- Farm management, calculation and planning

VIII. Fruit & Vegetable Cultivation Systems

- Protected cultivation
- Greenhouses
- Equipment for tree crops

IX. Global Issues

- Meeting needs of global markets for equipment
- Technologiesto enable agri-food exports

Dates and deadlines:

Submission of abstracts: 1 February 2006, Notification of acceptance: 15 March 2006, List of Papers made available: 15 April 2006, Submission of full paper: 1 June 2006.

For additional information please look up http://www.2006cigr.org/ or contact: VDI-MEG, Graf-Recke-Strasee 84, 40239 Dusseldolf, Germany. Phone:+49 211 6214266, Fax:+49 211 6214177, E-mail: info@2006cigr.org

International Agricultural Engineering Conference 6-9 December 2005

Under the auspices of AAAE, this conference on the theme "Agricultural Engineering-Technologies and Future Trends" will be held at the Asian Institute of Technology in **Bangkok, Thailand**, from **6 to 9 December 2005.**

Topics:

- Power and machinery
- Food engineering and biotechnology
- Soil and water engineering
- Energy in agriculture
- Agricultural systems
- Structures and environment
- Electronics in agriculture
- Agro-industry
- Agricultural engineering education
- Agricultural waste management
- Ergonomics
- Terramechanics
- New materials and emerging technologies

Important dates;

Deadline for submission of abstracts: 1 march 2005, Notice of acceptance: 31 March 2005, Full paper due: 1 August 2005, Early registration with payment due: 12 October 2005.

For more information, please contact: The Secretariat, Attn.: Dr. Emmanuel C. Canillas, International Agricultural Engineering Conference, ASE SERD Asian Institute of Technology, P.O.Box 4 Klong Luang, Pathumthani 12120, Thailand. Tel:+66 2 524 5494, Fax:+66 2 524 6200, E-mail: aaee@ait.ac.th, emann@ait.ac.th

CIACH 2005: The Agricultural Engineering Specialization in a Globalized World 10-12 May 2006

Co-sponsored by CIGR and organized by the Agricultural Engineering School of the University of Conception and the National Agricultural Research Institute, the 5th International Congress of Agricultural Engineering will be held from **10 to 12 May 2006**, at the University of Conception, **Chillán** Campus, **Chile**. The main topics to be covered in oral or poster presentations are:

- Computer aids and automation in a culture
- Agricultural mechanization
- Energy in agriculture
- Water resources in agriculture
- Food engineering
- Post-harvesting processing
- Civil work for agricultural and environment
- Biological system engineering
- Teaching on agricultural engineering

Important dates:

Abstract: 31 March 2005, Notification of acceptance: 30 April 2005, Extended papers: 31 July 2005.

The conference fees are US $ 140/160 (before/after July 30, 2005) and US $ 50 for students. Further information: "V Congreso Internacional de Ingenierría Agrícola", Av. Vicente Méndez 595, Casilla 537, Chillán, Chile. Tel:+56 42 208709, Fax:+56 42 275303, E-mail: ciach@udec.cl, http://www.udec.cl/ciach

7th Fruit, Nut, and Vegetable Production Engineering Symposium "Frutic 05" 12-16 September 2005

This symposium will take place from **12 to 16 September 2005** in **Montpellier**, **France**. Under the title "Information and technology for sustainable fruit and vegetable production" the programme comprises the following topics concerning fruit (including wine grape), nut, vegetables and fresh cut perishables:

- Precision agriculture, including acquisition of satellite and airborne georeferenced data
- Technological assistance to fruit and vegetable production: new tools enabling a more effective and environmental-friendly plant management, variety improvement in relation to automation of agricultural practices
- Sensors for collecting information either in field or for post-harvest applications
- Information processing and decision support systems both for agricultural and post-harvest management
- Post-harvest technology: relationship between technology and quality
- Data management: information systems. Databank creation and sharing, e-trading.

The official language is English. Simultaneous translation will not be provided. In a "young researcher" forum PhD students will be given an opportunity to present their studies.

Important dates:

Submission of full papers: 15 February 2005, Submission of corrected papers: 1 May 2005.

For further information look up http://www.ffutic05.org/ or contact: Michele EGEA, Phone:+33 467 046 386, Fax:+33 467 046 306, E-mail: FruticO5@montpellier.cemagref.fr

8th Workshop on Spray Application Techniques In Fruit Growing 29 June - 1 July 2005

The 8th Workshop on Spray Application Techniques in Fruit Growing will be held in Barcelona, Spain from 29 June 29 to 1 July 2005.

Topics:

- Novel spray application technology
- Performance of fruit crop sprayers
- Testing and adjustment of fruit crop sprayers
- Filling and cleaning of sprayers
- Nozzles, adjuvants. atomisation and spray quality
- Precision fruit crop spraying
- Decision support systems in plant protection
- Spray drift
- Spray optimization in plantation crops
- Risk assessment and management in fruit growing
- Dose rates determination in fruit crops
- Methodology of research on spray application
- Other related topics

Registration fees are Euro 200/220 before/after May 15, 2005. Substract Euro 120 to calculate student fees.

Dates and deadlines:

Decision of the Scientific Committee: 1 April 2005, Workshop early registration: 15 May 2005, Submission of full papers: 29 June 2005.

For further information, please contact the workshop secretary: Cristina Escobar Gonzalez, Universitat Politecnica de Catalunya, Escola Superior d'Agricultura de Barcelona, Departament d'Enginyeria Agroalimentaria i Tecnologia, C/Urgell, 187. 08036 Barcelona, SPAIN, Tel:+34 93413 7548, Fax:+34 93413 7501, E-mail: sprayfruit.2005@upc.es, http://www.insad.pl/sprayfruit2005.htm

III World Congress on Conservation Agriculture 3-7 October 2005

This congress, organized by the African Conservation Tillage Network (ACT), the Ministry of Agriculture of the Republic of Kenya, and the Kenya Conservation Tillage Initiative (KCTI) in association with the New Partnership for Africa's Development (NEPAD), will take place in **Nairobi, Kenya**, from **3 to 7 October 2005.**

Focusing on the main theme "Linking Production, Livelihoods and Conservation", it will deal with the following subthemes:

- CA in building communities resilience and ability to provide for own livelihood and development needs
- CA in mitigating/alleviating effects of social ills such as HIV-Aids, urbanization and declining interest in farming, especially among the young.
- Socio-economic, cultural, agroecological and technical factors in sustainable adoption of CA
- Soil life, biodiversity and agriculture
- Policies and infrastructure support in enhancing CA adoption
- CA contributing to global environmental quality concerns (carbon sequestration, green-house effect, etc.)
- Empowering farmers and farmer groups/associations in development and adoption of CA
- Effective research and dissemination strategies for CA adoption
- Stakeholder partnership and collaboration, including across sectors and disciplines
- Information-knowledge management

Important dates and deadlines:

Notification of acceptance: 5 February 2005, Submission of full papers: 30 June 2005.

Accepted papers and case studies will be published for wider distribution and some udl also be selected for oral presentation during the Congress. The official languages of the congress will be English and French (with simultenous translation). Please register online or download the congress registration form from the Congress website. For further information, please contact: IIIWCCA Secretariat, No. 9, Balmoral Road, Borrowdale, Harare, Zimbabwe.

E-mail: actnetwork@africaonline.co.zw, http://www.act.org.zw/Congress/index.html, Tel:+263 4 882107, Fax:+263 4 885596

14th European Biomass Conference and Exhibition 17-21 October 2005

Subtitled "Biomass for Energy. Industry and Climate Protection", this event is scheduled to take place from **17 to 21 October 2005** in **Paris, France.** It will be an excellent forum for the presentation of the latest innovative global strategies, technologies, projects and efficient practice rules for energy and environment. There will also be ample opportunity for information exchange and for discussions among scientists, policy makers, practitioners of the use of biomass for energy, industry and climate protection. The exhibition integrated into the Conference will provide an excellent opportunity for making business in the emerging biomass sector.

The five-day programme for this Conference will comprise plenary lectures describing the state-of-the-art in biomass technology; oral and visual presentations of research, development, demonstration and commercial projects; workshops on specific Biomass issues; an exhibition of biomass products, utilization and conversion technologies; and a social programme.

The following topics will be discussed:

- Biomass Resources
- Research and Development of Bioenergy Conversion Technology Systems:
- Demonstration and market implementation of bioenergy in the heat and electricity sector
- Demonstration and market implementation of bioenergy in the transportation sector
- Application of biomass for energy, and industrial products
- Economics and benefits deriving from biomass process technologies, integration and simultaneous production
- International biofuels trade, strategy, policy and climate protection issues
- International Co-operation for accelerating the large-scale worldwide deployment of bioenergy. Biomass in the Developing World

Dates and deadlines:

Abstract submission: 7 April 2005, Notification of acceptance: 31 May 2005.

Papers presented at the conference will be published in the Proceedings. For abstract submission instructions please look up http://www.conference-biomass.com /sysconf/abstract_intro.html, and submit your abstract online at: http://www.conference-biomass.com/abstracts. For futher information, look up http://www.comference-biomass.com/, For enquiries concerning abstract submission, please contact: ETA - Florence Attn.: Eng. Silvia Vivarelli, Tel:+39 055 500 2 173, E-mail: biomass.conf@eta.orence.it

Annual Scientific Conference and General Meeting of TSAE 21-23 November 2005

The 2005 Annual Scientific Conference and General Meeting of the Tanzania Society of Agricultural Engineers (TSAE) will be held at the former TANESCO Training Centre, **Morogoro, Tanzania** from **21 to 23 November 2005**. The TSAE 2005 Annual General Meeting (AGM) will be held at the end of the Scientific Conference on 23 November 2005. The main theme will be "Agricultural Mechanization and Industrialization in Developing Countries: Addressing the Problems of the Poor".

Members of TSAE, Institution of Engineers Tanzania (IET), and the general public within and outside Tanzania are invited to submit papers on any of the following sub-themes:

- Agricultural mechanization
- Industrialization
- Information and communications technologies (ICTs)
- Energy saving technologies
- Post harvest technologies
- Employment creation, entrepreneurship, income generation
- Education and training
- Environmental issues
- Water supply and sanitation
- Gender issues
- Role of the private sector
- HIV/AIDS.

Deadlines:

Abstracts: 30 April 2005, Full papers: 15 August 2005.

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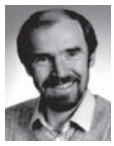
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(Vol.34, No.1, Winter, 2003-)

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