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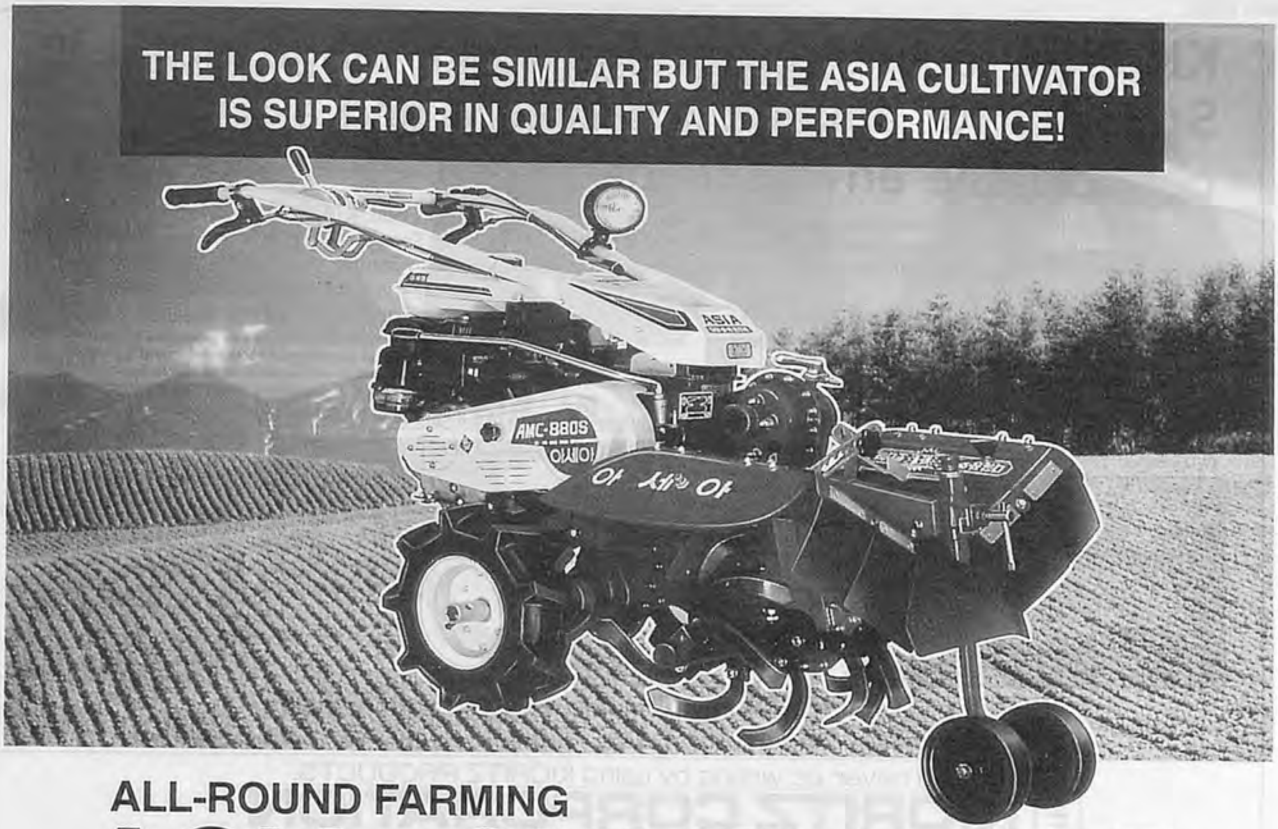

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EDITORIAL

A Rose by Any Name is Just as Sweet

Work is underway at the American Society of Agricultural Engineers (ASAE) to update or restructure its charter, including the language of its constitution and by-laws. Specifically, the move, among other considerations, is to drop the use of the term "agricultural engineering" in favor of the phrase "engineering in agriculture, food and biological systems" — a little bit a mixture of three basic disciplines into one. But, of course such a change is nobody else's choice and business but the ASAE's.

The AMA does not challenge that move but does point out the fallacy that the term "agricultural engineering" seems to have already outlived its usefulness insofar as the ASAE diction is concerned. The truth of the matter is that the term is very much alive and useful where English is the medium of communication.

Be that as it may, the 21st century and beyond would still give credence and meaning, and hence continue its use of two key-words: "agriculture and agricultural engineering". For how otherwise can anyone dissociate these key-words with man's effort to produce the food to feed the ever increasing population on a global basis? Technology must continue to be developed in agricultural engineering, particularly in agricultural mechanization, in order to fully harness the limited resources such as land, irrigation water and energy in the common endeavor to maximize agricultural productivity. Seen in this light, it is only proper to label every technology, old or new, that is concerned with agriculture as "agricultural engineering".

In consonance with the ASAE's move to restructure its chartter, another trend seems to be that of relegating to the background the terms "farmer" and "agriculture". This is because in the US and other democratic and developed countries, the urban population represents and overwhelming majority leaving only about an average of two percent of the total population representing the rural dwellers. The implication is that most social policies address only the welfare and problems of urban residents as urban votes elect the law makers and policy makers.

This truism also implies the need for technology transfer in agriculture and agricultural engineering from advanced countries to the developing and underdeveloped countries. But if the terms agriculture and agricultural engineering become history and forgotten, how then may an effective transfer of technology be realized?

It is equally true that many beautiful expressions such as sustainable agriculture, peaceful world order or international cooperation are being coined from time to time. Those terms are, however, hollow when not substantiated with deeds and actions, hence only tend to sow further confusion. Let there be less confusion and let the use of "agricultural engineering" and "agricultural mechanization technology" remain in their proper stations under the sun in order to remain as key-words.

Yoshisuke Kishida
Chief Editor

Tokyo, Japan
October, 1997

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Vol. 28, No. 4, Autumn 1997

Effect of Lime Application on the Transport of NO_3-N into Groundwater Quality and pH

by

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Abstract

Experiments were conducted in field lysimeters located at the Iowa State University Research Center near Ankeny, Iowa, U.S.A., in order to evaluate the effects of different lime application rates on groundwater quality and pH. Results from the two-year study period were very encouraging. The data reveal that lime application has a significant effect on the quality of subsurface water. The NO_3-N concentrations in groundwater decreased as the lime application rate increased.

The application of lime also affected the groundwater pH. The pH values increased as the lime application rate increased during the study years. Higher pH values were observed in lysimeters with 4 200 kg/ha lime application rate as compared to those observed at control, 1 400 and 2 800 kg/ha lime treatments. However, no significant differences in pH values were observed at the two sampling depths.

Introduction

Nitrogen fertilizers and pesticides are recognized as potential sources of groundwater contamination. Several studies have reported increased nitrate losses on account of high application rates and poor fertilizer use efficiency (Allison, 1966; Chichester and Smith, 1978; Tyler and Thomas, 1977). This has raised concern among large numbers of people, including Iowa farmers, about the impact of agricultural activities on groundwater quality. This is because the NO_3-N concentrations in groundwater have some times exceeded the acceptable limits of 10 mg per liter for drinking (Walters and Malzer 1990). Iowa farmers are currently investing about US$300 million in nitrogen fertilizer each year. Continuous use of nitrogen fertilizers at high rates is posing seriouis threat to Iowa's groundwater resources.

With about 1 million tons of nitrogen fertilizer applied annually in Iowa, about 15 to 30% is lost through leaching with drainage water (Kanwar et al. 1988) which is equivalent to about US$90 million in economic loss to the farmer. Also, this loss is equivalent to 75 000 000 to 150 000 000 gallons of diesel fuel costing between US$3 million and 6 million. The continuous use of nitrogen fertilizer also has significant effect on soil acidity. When the pH drops below 5.5, some cation concentrations become toxic to plants and reduce the availability of essential nutrients to plants, thereby affecting overall crop production. The effect of pH on the availability of nitrogen is indirect. The microorganisms that change ammonia to nitrate can not function in acidic soils. Also, some of the herbicides (atrazine) may leach at a faster rate into the groundwater system under low pH conditions. These problems could be corrected by adding lime to the soil (Kanwar, 1992). The addition of lime is suggested as a management alternative that may reduce N-leaching losses. Liming has been necessary to ensure proper soil structure.

It is principally used to neutralize soil acidity commonly measured by soil pH, some times used to supply Ca and Mg for plant growth and maximizing crop yields (Bertsch and Alley 1981). Furthermore, the effects of liming persist for many years which could alter the chemistry of streams and drainage waters (Bolton, 1977; Floate and Logan, 1981; Hornug et al. 1986). This study was designed particularly to obtain data on the effect of lime application on NO_3-N concentration and pH of subsurface drainage water. The overall goal of this study was to develop a close understanding of the use of agricultural lime to reduce the movement of agricultural chemicals (nitrate and pesticides) in the groundwater.

Materials and Methods

Experiments were conducted in field lysimeters located at the Iowa State University Research Center near Ankeny, Iowa, U.S.A. for the two growing seasons (May through October) during 1991 and 1992. The soils at this site are poorly drained and classified as Nicollet loam in the Clarion-Nicollet-Webster Soil Association. Some of the physical properties of these soils, as reported by Charkhabi (1990), are presented in **Table 1**.

Table 1. Particle Size Distribution, Gravel Percentage, and Soil Reaction of Nicollet Loam Soil

Horizon	Depth cm	Sand %	FI.Silt %	Co.Silt %	Clay %	Gravel %	pH
Ap	0-15	29.5	11.3	33.0	26.2	0.1	5.9
A1	15-25	28.7	13.1	32.1	26.1	0.4	6.1
A2	25-46	31.5	17.2	23.2	28.1	0.2	6.6
AB	46-56	34.4	10.8	27.4	27.4	1.1	7.0
Bw	56-76	38.6	9.2	24.9	27.3	2.2	7.1
BC	76-86	31.0	11.8	32.5	24.7	1.9	7.2
C1	86-102	40.1	10.8	26.8	22.3	3.0	7.7
C2	102-117	38.2	12.0	30.2	19.6	2.0	7.8
C3	117-135	39.2	11.8	29.1	19.9	2.2	8.0
C4	135-160	38.6	12.6	29.0	19.8	1.5	8.1

(Adopted from Charkhabi, 1990).

At the experimental site, 18 box-type lysimeters were constructed and installed in 1989. Five 6.2-mm thick plastic sheets were bolted together by using angle irons to construct a box-type lysimeter. Each lysimeter was 229-cm long, 90-cm wide, and 152-cm deep. A perforated plastic tile drain of 10-cm diameter and 220-cm long was placed at the bottom of each lysimeter. The plastic drain was then connected to a water sump located outside the lysimeter box. An adjustable float system was installed in the water sump to control water level.

After the construction of lysimeters, soil profile was excavated in 30 cm layers to a depth of 150 cm by a grave-digging machine. Each layer of soil was separated with a plastic sheet. After the excavation, the lysimeter box and the sump were placed in the pit, and each soil layer was repacked and compacted inside the lysimeter to match with the original distribution of soil profile and bulk density. Water sump was connected to the lysimeter through plastic tile drain. Two solute suction tubes were installed at the center of each lysimeter at 60- and 120-cm depths. These solute suction tubes were designed to collect groundwater samples from saturated and unsaturated zones. Observation wells were also installed to monitor the water-table position in the lysimeter.

All lysimeters were treated with nitrogen fertilizer at the rate of 175 kg-N/ha. They were also treated with phosphorous (P_2O_5) and potassium (K_2O) at the rates of 60 kg-P and 60 kg-K/ha, respectively. Fertilizers were broadcast within and outside each lysimeter. Herbicide atrazine was surface-applied at the rate of 2.2 kg/ha on the same day of fertilizer application. Following fertilizer and herbicide applications, corn variety Pioneer 3379 was planted with seed-to-seed distance of 20 cm and row-to-row distance of 75 cm. Thus, each lysimeter was planted with 12 seeds with a plant population of 66 500/ha. Corn was also planted in the area outside the lysimeters.

Lime was applied at the surface of each lysimeters. Twelve lysimeters were randomly selected and used for four different lime treatments (i.e., control, 1 400, 2 800, 4 200 kg/ha) in this study. Each treatment was replicated on three lysimeters. A water-table depth of 90 cm was maintained in each lysimeter 40 days after planting (DAP) to 120 DAP. Soil samples were collected at 15-, 30-, 60-, 90-, and 120-cm depths before planting and after harvesting for NO_3-N and pH analyses. Groundwater samples were collected bi-weekly at depths of 60 and 120 cm. These samples were analyzed for NO_3-N concentration and groundwater pH.

Results and Discussions

The average NO_3-N concentration in groundwater, and pH at 60- and 120-cm depths for 1991 are shown in **Table 2**. Data in this table show that at 60-cm depth, the NO_3-N concentrations were always higher in the lysimeters with control treatment. The NO_3-N concentrations in the beginning, and at the end of the season were low in the lysimeters with 4 200 kg/ha lime application rate as compared to control, 1 400, 2 800 kg/ha treatments. NO_3-N concentrations decreased with

Table 2. Average NO_3-N Concentrations (mg/ℓ) and pH as Function of Lime Application Rate at Ankeny Lysimeter Site During 1991

DAP	Lime rate kg/ha	Sampling depth 60 cm	120 cm	sump	Sampling depth 60 cm	120 cm	sump
51	Control	11.3	6.5	1.8	5.9	6.2	5.5
	1 400	4.0	3.8	1.3	6.6	7.1	7.5
	2 800	3.4	2.7	1.4	6.6	6.8	7.9
	4 200	2.6	2.2	1.4	6.3	7.0	7.6
65	Control	NS	NS	NS	6.8	6.8	7.0
	1 400	1.4	2.1	0.9	7.6	7.7	8.0
	2 800	0.9	0.9	0.5	8.0	7.6	8.1
	4 200	0.8	0.3	0.6	7.4	8.0	7.9
79	Control	2.5	1.5	0.6	6.0	6.8	6.2
	1 400	1.0	1.0	0.5	7.1	6.8	6.4
	2 800	0.4	0.9	0.4	7.0	7.2	6.3
	4 200	0.3	0.4	0.5	7.0	7.1	6.6
94	Control	1.3	1.1	0.3	6.2	6.0	6.1
	1 400	0.2	0.5	0.3	6.4	6.2	6.1
	2 800	0.1	0.4	0.2	6.6	6.3	6.2
	4 200	0.4	0.2	0.2	7.0	6.4	6.4
107	Control	4.4	1.8	0.9	7.7	7.7	7.6
	1 400	NS	1.3	0.7	NS	7.8	7.7
	2 800	NS	0.9	ND	NS	7.8	7.7
	4 200	0.3	ND	ND	7.8	7.9	7.8
115	Control	ND	0.1	1.8	7.8	7.8	7.5
	1 400	NS	0.1	0.6	NS	7.9	7.5
	2 800	NS	NS	0.5	7.8	7.9	7.5
	4 200	ND	ND	0.2	8.0	7.9	7.6

Note: NS — No sample available; ND — Not detected.

Table 3. Average NO_3-N Concentrations (mg/ℓ) and pH as Function of Lime Application Rate at Ankeny Lysimeter During 1992

DAP	Lime rate kg/ha	Sampling depth 60 cm	120 cm	Sampling depth 60 cm	120 cm
45	Control	25.9	42.6	6.0	6.3
	1 400	17.7	24.2	6.4	6.4
	2 800	18.1	30.5	6.3	6.5
	4 200	12.5	16.3	6.6	6.6
60	Control	10.6	3.7	6.4	6.4
	1 400	3.8	1.4	6.3	6.4
	2 800	1.7	3.2	6.5	6.5
	4 200	1.9	1.0	6.7	6.6
73	Control	2.3	0.7	6.8	6.6
	1 400	2.1	0.8	6.9	6.8
	2 800	1.3	0.8	7.4	7.5
	4 200	1.6	0.7	7.8	7.6
89	Control	1.6	0.6	7.3	7.0
	1 400	0.7	0.6	7.3	7.7
	2 800	0.7	0.4	7.7	7.6
	4 200	0.9	0.5	7.9	7.9
103	Control	1.7	0.5	7.2	6.9
	1 400	1.0	0.5	7.3	7.4
	2 800	0.5	0.4	7.6	7.6
	4 200	0.3	0.3	7.7	7.7
120	Control	0.4	0.3	6.5	6.8
	1 400	2.5	0.3	7.3	7.3
	2 800	1.0	0.3	7.6	7.6
	4 200	0.4	0.3	7.8	7.8

time during the growing season. At 120 cm depth, the NO_3-N concentrations in groundwater showed similar trends. The highest NO_3-N concentrations of 6.5, 3.8, 2.7, and 2.2 mg/ℓ were observed in the control, 1 400, 2 800, and 4 200 kg/ha treatment, respectively, on 51 days after planting (DAP).

The average NO_3-N concentrations at 60- and 120-cm depth for 1992 are shown in **Table 3** indicating that the NO_3-N concentrations were always higher in the lysimeters without lime application (control). At the 60-cm depth, the highest NO_3-N concentration of 25.9 mg/ℓ was observed under control treatment on 45 DAP, whereas, it was 12.5 mg/ℓ in the lysimeters treated with 4 200 kg/ha. The NO_3-N concentrations ranged between 0.4 to 25.9, 0.7 to 17.7, 0.5 to 18.1, and 0.4 to 12.5 mg/ℓ for the control, 1 400, 2 800, and 4 200 kg/ha, respectively. However, the lower NO_3-N concentrations in the beginning, and at the end of growing season were observed in the lysimeters with 4 200 kg/ha lime application rate. The NO_3-N concentrations decreased as the growing season progressed. At the 120 cm depth, the NO_3-N concentrations in groundwater showed similar trends. The highest NO_3-N concentrations were observed with the no-lime treatment during the initial periods of the growing season and the lowest NO_3-N concentrations were observed with the maximum application rate of 4 200 kg/ha. The highest NO_3-N concentrations of 42.6, 24.2, 30.5, and 16.3 mg/ℓ were observed for the control, 1 400, 2 800, and 4 200 kg/ha, respectively. However, towards the end of the growing season, differences in NO_3-N concentrations were almost negligible.

Groundwater pH for the samples taken at 60- and 120-cm depths and in the sump water are shown in **Table 2**. In most cases, higher pH values were observed in the lysimeters treated with 4 200 kg/ha lime application. The pH value decreased as the lime application rate decreased. At the 60-cm depth, the pH was high in the lysimeters treated with 2 800 and 4 200 kg/ha lime application. Similar trends were observed for the control treatment. However, the pH values of sump water samples ranged between 5.5 and 8.1.

Groundwater pH values for 1992 at the 60- and 120-cm sampling depths are shown in **Table 3**. Higher pH values were observed in the lysimeters with 4 200 kg/ha lime application rate as compared to those observed at control, 1 400, and 2 800 kg/ha treatments. The pH of water increased from 6.6 to 7.9 during the growing season of 1992 with lime application rate of 4 200 kg/ha. Almost similar trends were observed at 120-cm sampling depth, pH was high in the lysimeters with 4 200 kg/ha lime application as compared to those for the control, 1 400, and 2 800 kg/ha lime application. However, no significant differences in pH values were observed at the two sampling depths.

Conclusions

Experiments were conducted to evaluate the effects of different lime application rates on groundwater quality and soil pH. Results from the two year experiments with lime were very encouraging. It was observed that lime application has a significant effect on the quality of subsurface water. Results showed that increased amount of lime application has potential to reduce NO_3-N and to increase pH in the groundwater. The pH values increased as the lime application rate increased for the two years of study. High pH values were observed in the lysimeters with 4 200 kg/ha lime application rate as compared to those observed at other three-lime treatments. However, no significant differences in pH values were observed at the two sampling depths.

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Energy Requirements for Production of Major Crops in India

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Abstract

The share of agriculture in national energy consumption has been rising consistently over the last three decades. Presently, it accounts for nearly a quarter of the country's electric consumption and one-tenth of diesel consumption. Going by the increaased need for higher productivity and bringing additional area under high yielding varieties, it is inevitable that the share of agriculture in the national energy consumption would increase further. This paper deals with energy consumption in the productivity of some of the major crops in different states of India. It also highlights the future energy needs to achieve desired yield levels and production targets.

Introduction

Farming is one of the major occupations in most of the developing countries. It uses energy intensive technologies for maximizing the productivity. In India, the intensity of mechanization is still quite low. As such the agricultural energy consumption is not as high as in the developed countries. However, the energy use over the years has been rising steadily. Presently, agricultural and allied activities account for over a third of the country's gross domestic product. Indian agriculture has changed considerably since the introduction of high yielding crop varieties (HYV) and introduction of new crop production techniques with the advent of the Green Revolution beginning the mid-1960. Foodgrain production has increased from 51 million mt in 1950-51 to nearly 185 million mt in 1993-94. As a result, crop production has emerged as one of the major consumers of commercial energy in the form of diesel, electricity, fertilizers, agrochemicals, machines, etc. Conservation of energy and avoiding of wastage has also assumed great significance.

Energy Requirements in Crop Production

Energy is primarily used for agricultural operations such as land preparation, interculture, irrigation, harvesting, threshing and transportation. However, it is also used indirectly as fertilizers and pesticides, commercial sources, i.e., electricity and petroleum account for a major portion of energy for farm irrigation. The consumption of these sources is, however, on a limited in-land preparation, interculture and harvesting. Rather, these are extensively used in the production of fertilizers and other agricultural chemicals.

Fig. 1 shows the energy requirements for different farm operations and **Fig. 2** gives the sources of energy for the production of agricultural crops in the state of Punjab, which is agriculturally the most advanced state of the country. As evident, amongst different farm operations, irrigation consumed 51.1% of the total energy used. Harvesting and threshing consumed 19.4% and seedbed

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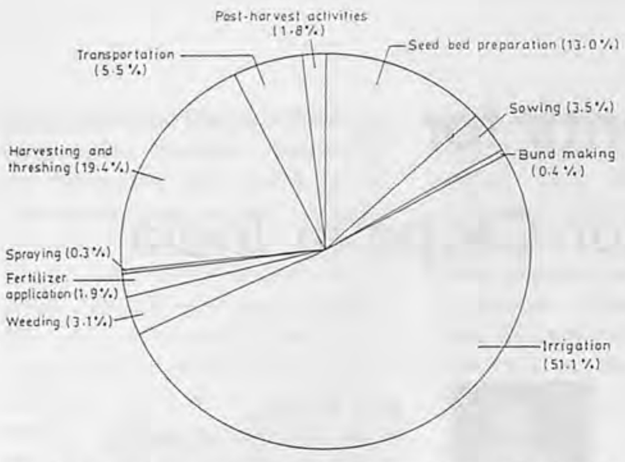

Fig. 1 Contribution of energy in different farm operations in Punjab agriculture.

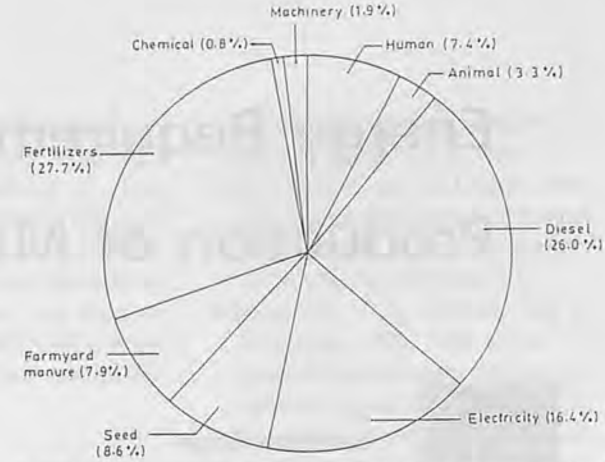

Fig. 2 Contribution of different sources of energy in Punjab agriculture.

preparation 13.0% of the total energy used for crop production operations. Thus, these three operations together consumed 83.5% as against 16.5% energy consumed by all other operations. Amongst different sources, chemicals and fertilizers accounted for the maximum energy input (28.5%). Diesel was the next higher energy consuming input (26%) followed by electricity (16.4%), seed (8.6%) and farmyard manure (7.9%). Thus, the three main commercial energy sources, namely, chemical fertilizers, diesel and electricity together accounted for 70.9% of the total energy input. The contribution of energy from animate sources was 10.7% and that from seed was 8.6%. The contribution of energy from agricultural machinery to the energy input matrix was only 1.9%.

Energy Requirements for Major Crops Grown in India

Energy required for cultivation of major crops in selected States of India are detailed in **Tables 1** through **6**.

Energy for Rice Crop

Energy requirements for the cultivation of rice crop in different States of the country varied widely. These were 7 777 MJ/ha for Madhya Pradesh to 103 104 MJ/ha for Tamil Nadu **(Table 1)**. The variation in energy requirements in different States could be attributed mainly to irrigation requirements and quantity of fertilizer applied. About 90% of the total energy required in rice cultivation in Tamil Nadu was through electricity used in irrigation. However, in the Punjab, rice cultivation required 32 892 MJ/ha of energy and nearly 50% of it was used for irrigation and about 30% through fertilizers and chemicals. Rice cultivation required 8 645 MJ/ha to 17 427 MJ/ha energy in West Bengal, 12 658 MJ/ha in Uttar Pradesh and 9 784 to 11 330 MJ/ha in Orissa.

Output-input energy ratio was highest (10.22-12.75) in Orissa and the lowest (2.15) in Tamil Nadu. It was 3.96 in Punjab, 7.26 in Madhya Pradesh, 7.12-8.66 in West Bengal and 5.0 in Uttar Pradesh. The energy required to produce one kg of rice was also the lowest in Orissa (1.79-2.70 MJ) and highest in Tamil Nadu (17.31 MJ) as evident from **Table 1**. Specific energy requirement was 5.77 MJ/kg in Punjab, 3.89 MJ/kg in Madhya Pradesh, 3.46-4.20 MJ/kg in West Bengal and 2.48 MJ/kg in Uttar Pradesh.

Energy for Maize Crop

Table 2 shows the energy requirements for the production of maize in Punjab, Madhya Pradesh, West Bengal, Tamil Nadu and Uttar Pradesh in the range of 2 322-13 110 MJ/ha — the lowest being for West Bengal and highest for Tamil Nadu. The highest energy requirements in Tamil Nadu could be attributed to heavy energy expenditure in irrigation. Total energy input varied from 5 773 to 15 185 MJ/ha: lowest in West Bengal and the highest in Punjab; 6 918 MJ/ha in Madhya Pradesh, 13 480 MJ/ha in Tamil Nadu and 12 783 MJ/ha in Uttar Pradesh. The energy-ratio was highest (17.02) in Madhya Pradesh due to low energy input and 10.89 in Uttar Pradesh due to high maize yields. Yield was highest in Uttar Pradesh (3 398 kg/ha) followed by Tamil Nadu (2 180 kg/ha), Madhya Pradesh (2 000 kg/ha), Punjab (1 532 kg/ha) and West Bengal (1 075 kg/ha). Specific energy requirements were lowest (3.46 MJ/kg) in Madhya Pradesh followed by 3.76 MJ/kg in Uttar Pradesh, 5.37 MJ/kg in West Bengal, 6.18 MJ/kg in Tamil Nadu and 9.91 MJ/kg in Punjab.

Energy for Wheat Crop

Table 3 shows the energy requirements for cultivation of the wheat crop: total energy input were 18 881 MJ/ha in Punjab, 8 496 MJ/ha in Madhya Pradesh, 14 000 MJ/ha in West Bengal and 17 486 MJ/ha in Uttar Pradesh. The variation in energy input was due to the variation in fertilizer

Table 1. Energy Requirements of Rice Production, Selected States

Operation/ Source	Punjab	Madhya Pradesh	West Bengal		Tamil Nadu	Uttar Pradesh	Orissa	
			Boro	Aman			Kharif	Rabi
Operation-wise energy, MJ/ha								
Tillage	1 584	800	1 443	1 769	3 237	1 708	1 061	846
Transplanting	421	226	1 220	559	483	767	307	458
Bund making	57	—	—	—	—	—	—	—
Irrigation	15 280	538	2 769	133	89 538	2 301	4 780	1 970
Weeding	15	596	368	178	311	487	490	412
Fertilizer application	64	188	70	107	56	67	—	—
Spraying	6	4	67	23	1 264	—	—	—
Harvesting & threshing	783	795	1 174	654	869	598	676	1 029
Transportation	249	137	—	—	—	63	—	—
Post-harvest activities	46	86	—	—	—	—	—	—
Paddy nursery	2 214	—	—	—	2 450	—	—	—
Total	20 719	3 370	7 111	3 423	98 208	5 991	7 314	4 715
Source-wise energy, MJ/ha								
Human	2 278	1 396	2 786	1 800	3 528	2 160	1 090	1 067
Animal	349	1 295	1 235	1 620	1 837	834	820	1 055
Diesel & electricity	19 164	946	3 089	—	89 575	3 096	2 770	2 775
Seeds	—	1 924	1 353	1 099	882	328	514	514
FYM	1 657	860	—	—	—	—	—	—
Fertilizers & chemical	9 066	1 280	8 671	4 047	5 795	6 240	4 326	5 644
Machinery	378	76	293	79	1 487	—	264	275
Total	32 892	7 777	17 427	8 645	103 104	12 658	9 784	11 330
Yield, kg/ha	5 696	2 000	4 150	2 500	6 015	5 098	3 630	6 335
Energy-ratio	3.96	7.26	7.12	8.66	2.15	5.00	10.22	12.75
Specific energy MJ/kg	5.77	3.89	4.20	3.46	17.31	2.48	2.70	1.79

Sources: 1. Research Digest (1988), Energy Requirements in Agricultural Sector (ERAS), Department of Farm Power & Machinery, Punjab Agricultural University, Ludhiana.
2. Research Digest (1985), Coordinating Cell of Energy Requirements in Agricultural Sector, Punjab Agricultural University, Ludhiana.
3. Research Digest (1989), Department of Agricultural Engineering, Indian Institute of Technology, Kharagpur.
4. Research Digest (1993), Department of Farm Machinery & Power, Jawaharlal Nehru Krishi Vishva Vidyalaya, Jabalpur.

Table 2. Energy Requirements of Maize Production, Selected States

Operation/ Source	Punjab	Madhya Pradesh	West Bengal	Tamil Nadu	Uttar Pradesh
Operation-wise energy, MJ/ha					
Tillage	1 444	1 102	276	1 600	1 578
Sowing	338	236	65	215	334
Bund making	51	—	—	—	—
Irrigation	1 765	—	1 795	8 257	1 769
Weeding	766	472	113	904	559
Fertilizer application	954	157	38	875	33
Spraying	—	26	8	—	—
Harvesting & threshing	1 128	525	27	1 259	232
Transportation	288	79	—	—	981
Post-harvest activities	357	26	—	—	—
Total	7 091	2 623	2 322	13 110	5 486
Source-wise energy, MJ/ha					
Human	1 534	1 160	262	2 976	720
Animal	1 043	1 192	239	1 750	—
Diesel & electricity	3 832	1 189	2 142	284	4 360
Seeds	304	294	440	370	294
FYM	4 974	548	—	—	—
Fertilizers & chemicals	3 210	2 418	2 690	8 100	7 200
Machinery	288	117	—	—	209
Total	15 185	6 918	5 773	13 480	12 783
Yield, kg/ha	1 532	2 000	1 075	2 180	3 398
Energy-ratio	5.74	17.02	4.83	8.72	10.89
Specific energy, MJ/kg	9.91	3.46	5.37	6.18	3.76

Sources: Above Cite.

input depending upon the availability and purching power of the farmers. The average wheat yield was 4 183 kg/ha in Punjab, 2 100 kg/ha in Madhya Pradesh, 2 450 kg/ha in West Bengal and 4 516 kg/ha in Uttar Pradesh (Terai region). Output-input energy-ratio was high (7.22) in Madhya Pradesh owing to low energy input and low (2.34) in West Bengal due to low yields. The energy-ratio was 5.78 in Punjab and 6.54 in Uttar Pradesh. Specific energy requirement was lowest in Uttar Pradesh (3.87 MJ/kg).

Energy for Groundnut, Sugarcane, Gram and Cotton

Energy requirements for the production of groundnut, sugarcane, gram and cotton are shown in **Tables 4** to **6**. Groundnut cultivation in Tamil Nadu was highest at 17 580 MJ/ha and also led to the highest yield (3 105 kg/ha) leading to high energy ratio of 6.00. In general, energy requirements were high in Tamil Nadu due to irrigation. Likewise, sugarcane cultivation required 128 969 MJ of energy per hectare in Tamil Nadu followed by Punjab, 73 799 MJ/ha and Madhya Pradesh, 58 827 MJ/ha. Yield level was also high in Tamil Nadu, 97 500 kg/ha; and low in M.P. 44 000 kg/ha highest 6.67 and specific energy requirements lowest at 1.13 MJ/kg in Punjab.

Gram cultivation in Madhya Pradesh gave high yield (1 100 kg/ha), high energy-ratio (8.60) and required less energy per unit of production (4.76 MJ/kg) as compared to Punjab. Cotton cultivation required the highest energy of 40 757 MJ/ha and gave higher yields (1 766 kg/ha) as compared to Punjab. Energy-ratio was the highest (8.35) and energy requirements per unit of production were lowest at 9.45 MJ/kg in Punjab. This could be attributed to the fact that the energy expenditure for irrigation was also highest in Tamil Nadu as compared to Punjab.

Table 3. Energy Requirements Wheat Production, Selected States

Operation/Source	Punjab	Madhya Pradesh	West Bengal	Uttar Pradesh
Operation-wise energy, MJ/ha				
Tillage	1454	738	1789	1589
Sowing	373	339	356	288
Bund making	41	—	—	—
Irrigation	3516	2191	5908	5198
Weeding	129	65	154	339
Fertilizer application	19	147	65	12
Spraying	20	14	—	—
Harvesting & threshing	3166	799	1059	3733
Transportation	250	116	—	1445
Post-harvest activities	264	40	—	—
Total	9232	4449	9331	12604
Source-wise energy, MJ/ha				
Human	923	986	1003	928
Animal	276	1174	1502	—
Diesel & electricity	7540	2530	7495	6888
Seeds	1411	1520	1621	1470
FYM	40	526	—	—
Fertilizers & chemicals	8279	1408	2035	7667
Machinery	412	352	344	533
Total	18881	8496	14000	17486
Yield, kg/ha	4183	2100	2450	4516
Energy-ratio	5.78	7.22	2.34	6.54
Specific energy, MJ/kg	4.51	4.05	5.71	3.87

Table 4. Energy Requirements of Groundnut Production, Selected States

Operation/Source	Punjab	Madhya Pradesh	Tamil Nadu
Operation-wise energy, MJ/ha			
Tillage	958	1101	1665
Sowing	175	321	710
Bund making	17	—	—
Irrigation	1354	—	12796
Weeding	822	252	1227
Fertilizer application	95	183	695
Spraying	—	23	—
Harvesting & threshing	1035	344	469
Transportation	331	46	—
Post-harvest activities	102	23	—
Total	4889	2293	17562
Source-wise energy, MJ/ha			
Human	901	905	2630
Animal	241	1056	2400
Diesel & electricity	2368	1330	12550
Seeds	1141	2080	—
FYM	1421	454	—
Fertilizers & chemicals	2903	949	—
Machinery	147	33	—
Total	9122	6807	17580
Yield, kg/ha	1688	900	3105
Energy-ratio	5.97	5.00	6.00
Specific energy, MJ/kg	5.40	7.63	5.66

Sources: 1. Research Digest (1988), Energy Requirements in Agricultural Sector (ERAS), Department of Farm Power & Machinery, Punjab Agricultural University, Ludhiana.
2. Research Digest (1985), Coordinating Cell of Energy Requirements in Agricultural Sector, Punjab Agricultural University, Ludhiana.
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4. Research Digest (1993), Department of Farm Machinery & Power, Jawaharlal Nehru Krishi Vishva Vidyalaya, Jabalpur.

Table 5. Energy Requirements of Sugarcane Production, Selected States

Operation/Source	Punjab	Uttar Pradesh	Tamil Nadu
Operation-wise energy, MJ/ha			
Tillage	3850	2767	1708
Sowing	500	951	289
Bund making	21	—	—
Irrigation	8347	2356	70400
Weeding	570	1195	3190
Fertilizer application	558	566	803
Spraying	18	7	—
Harvesting & threshing	3107	1915	2695
Transportation	2631	1570	—
Post-harvest activities	1535	—	—
Total	21137	11327	79085
Source-wise energy, MJ/ha			
Human	2965	3113	8617
Animal	1811	—	1950
Diesel & electricity	15038	6063	69202
Seeds	39642	39750	39750
FYM	1872	—	—
Fertilizers & chemicals	11150	9450	9450
Machinery	1321	451	—
Total	73799	58827	128969
Yield, kg/ha	65298	44000	97500
Energy-ratio	6.67	6.15	5.82
Specific energy, MJ/kg	1.13	1.34	1.32

Table 6. Energy Requirements of Cotton and Gram Production, Selected States

Operation/Source	Gram		Cotton	
	Punjab	Madhya Pradesh	Punjab	Tamil Nadu
Operation-wise energy, MJ/ha				
Tillage	1213	771	1366	2533
Sowing	226	304	335	309
Bund making	31	47	136	—
Irrigation	25	350	1849	26872
Weeding	209	—	1515	778
Fertilizer application	2	—	15	5584
Spraying	0	23	362	2677
Harvesting & threshing	725	607	545	1454
Transportation	80	187	287	—
Post-harvest activities	65	47	181	—
Total	2576	2336	6591	40207
Source-wise energy, MJ/ha				
Human	742	538	1257	5199
Animal	728	1130	156	680
Diesel & electricity	1137	1389	4201	28678
Seeds	652	1213	528	188
FYM	55	—	17	—
Fertilizers & chemicals	481	889	6555	5560
Machinery	69	78	297	452
Total	3864	5237	13011	40757
Yield, kg/ha	460	1100	1377	1766
Energy-ratio	3.05	8.60	8.35	2.13
Specific energy, MJ/kg	8.40	4.76	9.45	23.08

Sources: 1. Research Digest (1988), Energy Requirements in Agricultural Sector (ERAS), Department of Farm Power & Machinery, Punjab Agricultural University, Ludhiana.
2. Research Digest (1985), Coordinating Cell of Energy Requirements in Agricultural Sector, Punjab Agricultural University, Ludhiana.
3. Research Digest (1993), Department of Farm Machinery & Power, Jawaharlal Nehru Krishi Vishva Vidyalaya, Jabalpur.

Future Energy Demands for Efficient Crop Production

A study of the energetics of crop production in Punjab (**Fig. 3**) shows that inspite of the already high level of energy consumption as well as production, the energy requirements, especially for commercial energy, are bound to escalate. In 1965-66 through 1988-89, the production of foodgrains increased from 1.03 mt/ha to 3.15 mt/ha and that of all the crops (including oilseeds, cotton,

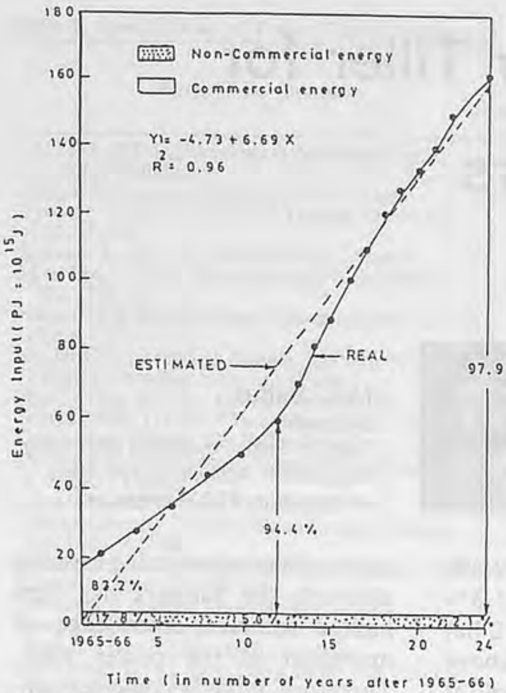

Fig. 3 Growth in energy consumption in Punjab agriculture.

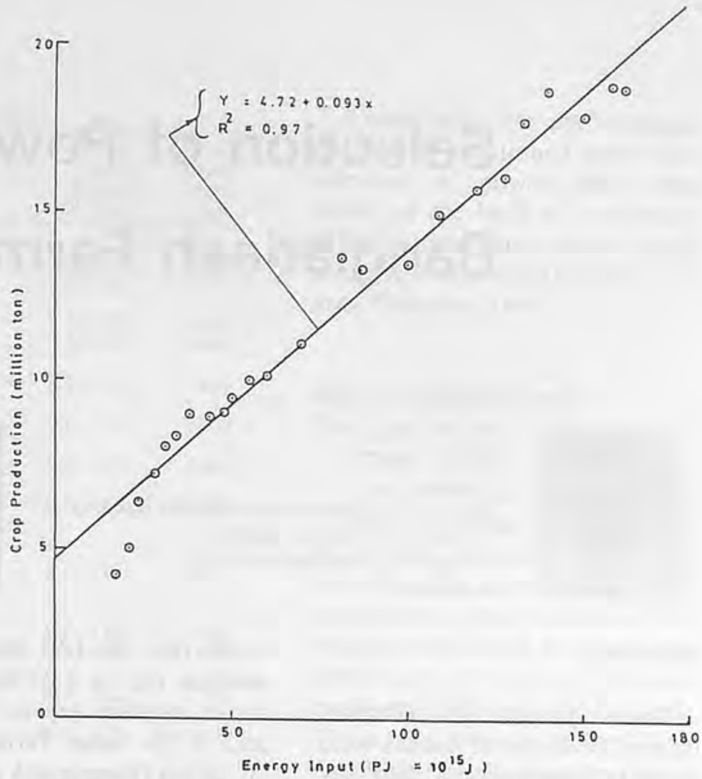

Fig. 4 Energy input and crop production inter-relationship, Punjab agriculture.

sugarcane and potato) from 1.05 mt/ha to 2.9 mt/ha. It could be seen from **Fig. 3** that the total foodgrain production increased by 440% with an annual increase of 18.3% and the total energy input incrased by 829% with an annual increase of 34.5%. Non-commercial energy in the form of human labour, draft animals and farmyard manure did not change materially. Its share decreased from 17.8% in 1965-66 to 2.1% in 1988-89. But the commercial energy input (direct and indirect in the form of diesel, electricity, chemicals, fertilizers, seeds and machinery) increased by 1006% with an annual increase of 41.9%. This shows that modern agriculture was highly energy intensive, particularly in respect of commercial energy inputs.

Fig. 4 shows that as the energy input increased the crop production also increased. There existed a linear relationship between crop production and energy input. The best-fit models are as follows:

$$Y = 4.72 + 0.093 X_1$$
$$R^2 = 0.97 \quad (1)$$
$$Y = 5.00 + 0.093 X_2$$
$$R^2 = 0.97 \quad (2)$$

where,

Y = Production of all crops, million mt

X_1 = Total energy input, PJ

X_2 = Commercial energy input, PJ

The projected energy requirements (total as well as from commercial sources) to achieve desired production levels are shown in **Table 7**. Energy required to produce 250 million mt of foodgrains in the country would be 2 637 PJ. Out of this, 2 634 PJ will be from commercial sources. It is also seen in **Table 7** that in order to achieve 25 times increased production, the energy requirement would be 46 times more. In order to produce 200 million mt of foodgrains, 9 696 million litres of diesel, 28 868 million-kWh of electricity, 9 695 million-kg of fertilizers and 140 million-litres of chemicals would be required. ■■

Table 7. Projected Energy Requirements of Desired Levels of Production, All India

Desired level of production (million mt)	Projected Energy Requirements, PJ		Commercial Energy Requirements in Original Units			
	Commercial	Total energy	Diesel million lit.	Electricity million kWh	Fertilizers million kg	Chemicals million lit.
20	161	164	757	2 294	757	10.9
30	269	272	1 256	3 739	1 256	18.1
40	376	379	1 750	5 210	1 750	25.3
50	484	487	2 249	6 695	2 248	32.5
60	591	594	2 743	8 166	2 742	39.6
70	699	702	3 241	9 650	3 241	46.8
80	806	809	3 735	11 121	3 735	53.9
90	914	917	4 234	12 606	4 233	61.1
100	1 021	1 024	4 728	14 077	4 727	68.3
150	1 559	1 562	7 212	21 472	7 211	104.1
200	2 097	2 100	9 696	28 868	9 695	140.0
250	2 634	2 637	12 176	36 250	12 174	175.8

Source: Energy in Production Agriculture by S. Singh and J.P. Mittal. Mittal Publication (1992).

Selection of Power Tiller for Bangladesh Farmers

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Abstract

Twelve power tillers (2-wheel tractor) of different brands were tested to determine the field performance under various field conditions in recent years. Test results were analyzed to select the power tillers for farming in Bangladesh. The paper deals with the effective field capacity and rate of fuel consumption and those were considered as the criteria for the selection of power tillers. The test results confirmed that the Dong Feng-12 (Farmers Friend Brand) power tiller was the most economical to operate for farming under Bangladesh condition because of its high effective field capacity (0.15 ha/h) and minimum fuel consumption (12.14 ℓ/ha).

Introduction

Bangladesh has 6.32 million ha of cultivable land for rice cultivation which is about 69.22% of the total cultivable land. Of the 6.5 million farm holdings 43.6% are small (up to 1.01 ha), 39.4% medium (up to 3.02 ha), 15.3% above medium (up to 10.12 ha) and 1.7% large farms (above 10.13 ha) (*Bangladesh Bureau of Statistics, 1987*). Statistics show that a pair of bullocks can cultivate about 1.52 ha from their available power which is equal to 0.374 kW. The minimum draft power required for land preparation was 0.373 kW/ha. Accordingly, 0.127 kW/ha and a total of 1 733.5 MW draft power shortage prevails in Bangladesh considering 150% cropping intensity. Presently, 17 million draft animals are available in the country and they supply 68% of the total draft power needed for tillage operation. It is evident that agriculture in Bangladesh needs a further 32% of draft power to boost agricultural production (*Jabber, 1985*).

The Bangladesh government has given emphasis for farm mechanization and for this purpose, exempted taxes on import of agricultural machinery. Because of the shortage of draft power and facilities given by the government, the farmers are becoming interested to use power tillers extensively. Both the government and non-government organizations are importing power tillers mainly from China, Japan and South Korea as shown in **Table 1**. The use of power tillers is increasing rapidly, although the farmers has very limited technical knowledge of operation of the power tiller. Therefore, it has become very important to select appropriate size and type of power tiller suitable for Bangladesh conditions, especially because of smaller plots and smaller farm sizes.

The power tillers used in Bangladesh are of the 3.75 to 12 kW size which are mostly used by medium and large farmers for the preparation of both dry and wet land. An attempt was made to develop a guideline for selecting power tiller based on experimental field performance data.

The main objective of the study was to determine the effective field capacity and specific fuel consumption of different power tillers and to compare their field performance in the selection of suitable power tillers for Bangladesh condition.

Materials and Methods

The following conditions and criteria were used in the test. The evaluation of power tillers is shown in **Table 1**.

Type of soil:

Clay loam and sandy loam

Soil moisture content:

Acknowledgment: The authors acknowledge the co-operation received from the Department of Farm Power and Machinery, Bangladesh Agricultural University for providing necessary information and thankful to different Power Tiller Companies and Agencies/vendors, for their co-operation during testing of power tillers.

Table 1. Specification of Power Tillers Available in Bangladesh

Power Tiller Brand	Nominal Powre Rating kW (hp)	Rated Engine Speed rpm
BMTF-1 (PT-3), Bangladesh Machine Tools Factory, Bangladesh	3.75 (5)	2400
Chakal-1, Yanmar Diesel Co. Ltd., Japan	3.75 (5)	2400
Yanmar: YZC(XES 105C), Yanmar Diesel Co. Ltd., Japan	7.50 (10)	2400
Kubota: K-120, M/S Kubota Ltd., Japan	7.50 (10)	2400
Mitsubishi-CT83, Mitsubishi Agric. Machinery Co. Tokyo	8.25 (11)	2400
Nanya-12A, Small Tractor Manufactory Co. Ltd., China	9.0 (12)	2000
Model EM-12 (EMEI Brand), Sichuan Tractor Factory Tianyang Sichuan, China	9.0 (12)	2000
Dong Feng: DF-12L (Dong Feng Brand) Changzhau Tractor Plant. Changzhau, China	9.0 (12)	2000
Dong Feng: Model 12 (Taihu Brand) Wuxy Country Tractor Manufactory, Jiangsu Co. Ltd., China	9.0 (12)	2000
Dong Feng-12 (Chang Tuo Brand) Wuxy Country Tractor Manufactory, Jiangsu Co. Ltd., China	9.0 (12)	2000
Sifang Megn-12, Yongkong Tractor Factory China	9.0 (12)	2000
Hunan-12 (Nan Yue Brand) Hengyang Tractor Manufactory, China	9.0 (12)	2200
Dong Feng-12 (Farmers Friend Brand) Fujian Tractor Manufactory, China	9.0 (12)	2000
Dae Dong: DT85, Dae Dong Industrial Co. Ltd., South Korea	8.25 (11)	2200

BMTF: Bangladesh Machine Tools Factory, Dhaka.
Source: Power Tiller Agencies/vendors of Bangladesh and Department of Farm Power and Machinery, Bangladesh Agricultural University.

25-50%
Soil strength (hardness):
0.23-3.27 MPa
Soil density:
1 100-2 000 kg/m^3
Field length for test:
30.0 m
Implements used for tests:
Moldboard plow and rotavator
Working speed of power tiller operation:
1.27-3.0 km/h
Average width of cultivation:
60.0 cm
Average depth of plowing:
9.0 cm
Depth of water for puddling operation:
6-15 cm
Number of replication done:
3 for each operation.

Rate of Fuel Consumption

The rate of fuel consumption was determined by filling the fuel tank to its full capacity before the test started and measuring the quantity of fuel consumed during the test by using a graduated measuring flask.

Fuel consumption, ℓ/h,

$$F = Q/t \quad (1)$$

where,
Q = Quantity of fuel consumption during the test, ℓ
t = Duration of test, h.

Field Capacity

The effective field capacity was determined by measuring the area tilled and keeping the record of time for tillage operation.

$$EFC = A/t \quad (2)$$

where,
EFC = Effective field capacity, ha/h.
A = Area tilled, ha.
t = Duration of tillage operation, h.

Rate of fuel consumption per unit area is given by,

$$F_1 = F/EFC \quad (3)$$

Considering the performance parameters mentioned above the selection of power tillers was made on the basis of maximum effective field capacity and minimum fuel consumption per unit area (*Saleque, 1989*).

Result Analysis and Discussion

The nominal power rating of power tillers used in Bangladesh was within the range of 3.75-9.0 kW (**Table 2**). During the survey it was noticed that the power tiller vendors were asked to change the power unit on the power tiller according to their need and demand. The market prices of power tillers (**Table 3**) indicate that the power tillers manufactured by the Chinese company are comparatively cheaper than others. As a result, the farmers preferred to purchase Chinese-made power tillers mainly due to initial investment cost without considering the other factors such as effective field capacity, specific fuel consumption, etc.

The power tillers in Bangladesh are mainly Japanese, Chinese and Korean makes. The economy of power tiller utilization in tillage operation depends upon the field performance such as maximum effective field capacity and minimum specific fuel consumption (*Corneli, and Roberto, 1986*). According to the test criteria, Dong Feng-12 (Taihu Brand) and EM-12 (EMEI Brand) occupied the second and third positions, respectively. It was noted that the power rating of all Chinese made power tillers were 9.0 kW but Korean made power tillers were 8.25 kW. All the power tillers are operated by diesel engines. The specific fuel consumption of the tested power tillers ranged from 1.68 ℓ/h (14.0 ℓ/ha) to 2.49 ℓ/ha (20.79 ℓ/ha) with a mean of 1.94 ℓ/h (17.90

Table 2. Field Performance of Power Tillers

Power Tiller Brand	Nominal Rated Power (kW)	Effective Field Capacity (ha/h)	Fuel Consumption ℓ/ha	Fuel Consumption ℓ/h
BMTF-1 (PT-3)	3.750	0.140	6.230	0.870
Chakal-1	3.750	0.140	6.250	0.880
Kubota: K-120	7.500	0.150	14.460	2.160
Yanmar: YZC (XES 105C)	7.500	0.120	9.750	1.170
Dae Feng: DT85	8.250	0.120	20.790	2.490
Mitsubishi: CT83	8.250	0.100	17.070	1.710
Dong Feng-12 (Farmers' friend brand)	9.000	0.150	12.140	1.820
Dong Feng-12 (Taihu brand)	9.000	0.120	14.000	1.680
Dong Feng-12L (Dong feng brand)	9.000	0.100	17.960	1.800
Hunan-12 (Nan yue brand)	9.000	0.090	24.080	2.170
Power Tiller: EM-12	9.000	0.110	17.540	1.920
Sifang Megn-12	9.000	0.090	18.850	1.700
Mean	7.750	0.119	14.927	1.698
Standard deviation	1.954	0.022	5.566	0.502

Table 3. Market Price of Power Tillers Available in Bangladesh

Power Tiller Brand	Market Price	
BMTF-1 (PT-3) (Not available in the market)	Tk. 75000	US$2279
Japanese power tiller (all brands)	Tk. 80000-125000	US$2430-3740
Chinese power tiller (all brands)	Tk. 40000- 50000	US$1215-1520
Korea power tiller	Tk. 50000- 65000	US$1520-1975

BMTF: Bangladesh Machine Tools Factory, Dhaka.
Source: Personal contact with the agencies/vendors of power tillers in Bangladesh.

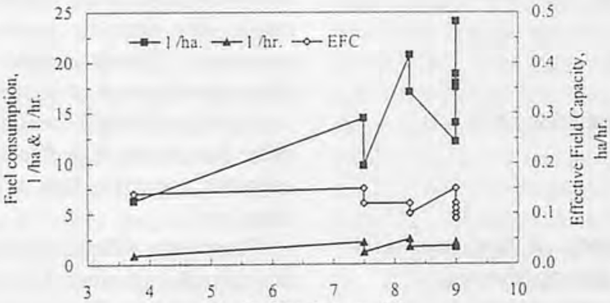

Fig. 1 Comparative results of effective field capacity and fuel consumption with nominal rated power of power tiller.

ℓ/ha). It was found that the effective field capacity of the tested Chinese and Korean made power tillers ranged from 0.09 ha/h to 0.15 ha/h with a mean of 0.11 ha/h (**Fig. 1**).

Conclusion

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

The analysis of the field performance indicated that the Dong Feng 12 (Farmers' friend brand) was the best among the tested power tillers (**Table 2**) hence recommended for the farmers of Bangladesh.

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Development and Field Evaluation of Manually-operated, Six-row Paddy Transplanter


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In order to solve the problem of rice transplanting, emphasis was laid on conducting adaptive trials/ demonstrations of manually-operated paddy transplanter on farmer's fields. Accordingly, 30 machines of the manually-operated type, 6-row paddy transplanter which uses mat-type seedlings, were fabricated at the Punjab Agricultural University Ludhiana. The machines were evaluated on an area of 30 ha at farmers' fields and 6 ha were transplanted at the Research Farms of the University in 1994. The trials were conducted at 19 different locations in two districts of Punjab. It was observed that two persons could easily transplant about 0.4 ha area per day, including uprooting and transporting of the nursery. Hill and tiller population as well as grain yield were higher as compared to the manually-transplanted fields at almost all locations. The number of hills transplanted by the machine varied from 25.2 to $28.8/m^2$. The averrage hill mortality after 15 days of transplanting was 12.1%. The average grain yield was about 250 kg/ha higher than the manually-transplanted fields. Transplanting of paddy by machine saved about 45% cost and 60% labour as compared to manual transplanting. Consequently, it has been decided to introduce about 200 machines in the State during the 1995 paddy transplanting season by providing 50% subsidy in the cost by the State Government.

Introduction

A comparative research was conducted on different types of paddy transplanters at P.A.U. Ludhiana in an effort to solve the problem of seedling transplanting. These were tractor-operated (4); self-propelled walk-behind (3); engine-operated (2); and five-row manually-operated machine (1). The riding type engine operated and manually-operated machines gave highly encouraging performance under proper field conditions. The engine-operated machine did not become popular due to high initial investment of about Rs. 40 000. Soil flow was also a problem, especially in heavy soil due to heavy weight of the machine. In comparison, the manual paddy transplanters are light weight and cost effective. Keeping the above factors in view, a 6-row manually-operated (IRRI-type) machine was developed which was an improved version of the 5-row machine developed earlier. It was decided to conduct field trials at selected locations in two districts with a total target area of about 40 ha. The major focus was on farmer's fields rather than research farms. For large-scale demonstrations, 30 machines were fabricated by means of jigs and fixtures.

Materials and Methods

Brief Description of the Machine

The machine **(Fig. 1)** is comprised of two wooden floats, a main frame assembly that supports the seedling tray, mat pusher, tray movement mechanism,

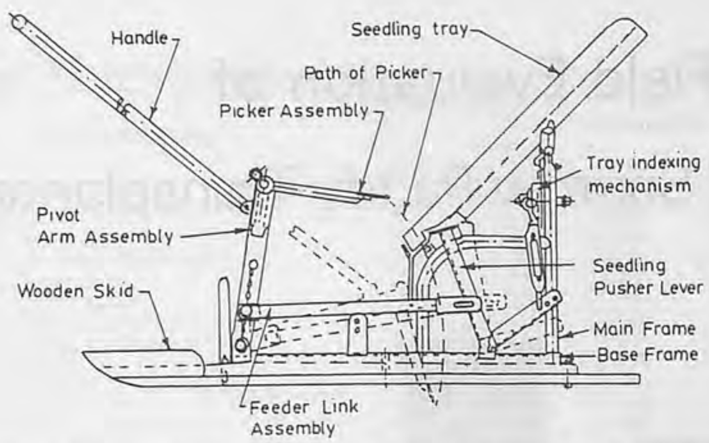

Fig. 1 Side view of sketch of the 6-row manually-operated paddy transplanter.

picker bar assembly and handle. The row-to-row spacing was kept at 20 cm whereas the plant to plant spacing could be varied according to requirement. This machine, being manually-operated was pulled through the field by the operator. As the operating handle is pushed down, seedlings from the mats are picked up and transplanted in the puddled field at a preset depth of about 2-4 cm. The handle is then pulled back towards the operator to retract the pickers and pull the machine forward for the next planting. The cycle is repeated to transplant another six hills. Each time the handle was pushed downwards, the seedling tray moved laterally to ensure that seedlings were in position to be picked up by the pickers during the next cycle. Planting depth and the number of seedlings per hill could be varied by adjustments on the transplanter.

Specifications

Type of machine:
Manually-operated paddy transplanter
Nursery used: Mat type
Power requirement: One person
Operating width, cm: 120
Number of rows: 6
Row to row spacing, cm: 20
Plant to plant spacing:
Adjustable
Planting depth, cm: 2-4
Provision for changing number of plants per hill:
By adjusting the tray holding plant-form w.r.t. fingers
Type of fingers:
Fixed opening type
Opening of the fingers, mm: 5-6
Size of the seedling mat on the transplanter, cm: 40 × 20 × 2
Material of construction for important components:
1. Frame: M.S. Pipe
2. Seedling tray, tray holder platform and pusher: G.I. Sheet
3. Float: Wood
Weight of the machine without nursery mats, kg: 20
Approximate cost of the machine, Rs.: 2 000

Nursery Raising Method

The mat-type nursery for seedlings used in the machine are raised as follows:

1. Select the nursery location in such a way that the transport of the seedlings to the field where transplanting is to be done is minimum. Nursery field should have a good soil. About 100 sq.m. area is sufficient for sowing nursery for one ha.
2. Prepare the field by harrowing and levelling at proper moisture content. A small quantity (4-5 kg/m^2) of farm yard manure should be added in the field before harrowing.
3. Spread 50-60 gauge polythene sheet of 100 cm width over a prepared level ground.
4. Place one or more wooden/steel frames each having 14 compartments of 40 × 20 × 2 cm size over the polythene sheet. About 900 g of polythene sheet spread to a length of about 50 m in sufficient for preparing seedlings for one ha.
5. Fill soil in the frames uniformly up to the top surface. The soil is lifted from both sides of the frames by making shallow furrows/channels.
6. Spread about 700 g of pre-germinated seed evenly in each frame. About 25 kg seed is sufficient to grow 500 mats required for transplanting one ha.
7. Cover the seeds with a thin layer (2-4 mm) of soil and sprinkle water by hand sprayer for proper setting of the soil.
8. Remove the frames and put these at the next place.
9. Repeat the above procedure for sowing the necessary number of seedling mats. Two persons can sow seedlings for 1.25-1.50 ha in a day.
10. After sowing, irrigate the field by slow flodding so that the seeds are not washed away. Care must be taken to keep the seedling mats always wet.
11. Spray or broadcast on the nursery, after about 10 days of sowing, with 300 g urea/200 mats after irrigating the nursery.
12. The seedling mats become ready at 25-30 days of age.
13. The seedling mats are uprooted by giving a cut along the boundaries of the mat. One person can uproot the seedlings for 2-2.5 ha in a day. The uprooted mats are transported to the field either by tractor trailor or other means of tansport.

Fig. 2 Grown up mat-type seedlings being uprooted.

Fig. 3 Six-row manually-operated paddy transplanter in stationary position.

Fig. 4 Six-row manually-operated paddy transplanter in operation.

Evaluation Procedure

For carrying out large-scale field trials/demonstrations, the seedlings were raised on the farmers' fields according to the method described above. To transplant more than 40 ha the seedlings were sown at 22 locations at farmers field and 3 locations at university farms. Grown seedlings being uprooted are shown in **Fig. 2**.

Evaluation trials of the machine (**Fig. 3**) were conducted at 19 of the 22 locations where the seedlings were grown and raised successfully. In addition, field trials were also conducted on the seed and research farms of the university. Also, two demonstrations were carried out at village Bhora and village Langroa where the State Minister of Agriculture was the chief guest. For these two demonstrations, the seedlings were transported from the university. At most locations, transplanting was done when the seedlings were 30 to 40 days old. In the beginning, the machines were operated by the trained operators and help was sought from the farmers for subsequent operation. At each location, sufficient machines were made available. During operation, no major break-downs were observed among the machines except minor adjustments. In all 35 ha were transplanted by the machines at different locations. After the evaluation cum-demonstration trials each location was visited to record the data regarding hills planted per square meter, plants per hill, plant mortality and grain yields etc. The responses of the farmers were also recorded regarding different aspects of the paddy transplanting by machine including its effect on grain yield. Nursery and machine performance results are given below. A machine in operation is shown in **Fig. 4**.

Number of nursery sowing locations, including university farms: 25;

Area for which nursery was sown, ha: 51.4 (This includes area of about 8 ha for training purposes.);

Number of locations where nursery was fully damaged: 2;

Number of locations where nursery was partially damaged (about 30%): 3;

Reasons for complete nursery failure: Lack of irrigation for more than 3 days;

Reasons for partial damage of nursery: Higher dose of urea, birds problem, stray animals and improper levelling of nursery beds;

Seed rate used for nursery sowing: 25-30 kg/ha;

Number of frames used at each location for nursery sowing: 4-6;

Labour required for nursery sowing: 7.5-12.5 man-h/ha;

Labour required for nursery uprooting: 2.7-8.7 (avg. 5.4) man-h/ha;

Labour required for transplanting: 19.6-31.59 (Avg. 25.0) man-h/ha;

Labour required for nursery transport: 6.9-24.0 (14.0) man-h/ha;

Average total time for nursery uprooting, transport and transplanting: 44.4 man-h/ha;

Average machine capacity with trained operators: 0.4 (with the help of 2 persons) ha/day;

Hill mortality: 6.82-19.6 (Avg. 12.0)%;

Average plant population after 15 days of transplanting (hills/m^2): 22 as compared to 18.4 in case of manual transplanting;

Average tillers/hill: 18.9 as compared to 15.4 in case of manual transplanting;

Average grain yield, kg/ha: 7 000 as compared to 6 707.5 in case of manual transplanting;

Financial saving in machine transplanting over manual transplanting: 45%;

Labour saving in machine transplanting over manual transplanting 60%.

Results and Discussion

The transplanter could transplant rice seedlings up to 0.4 ha per day with the help of 2 persons. However, labour requirement for seedling transport could be considerably reduced by proper management. Also, transplanting time could be reduced by proper training the operators and by gaining experience. The overall savings in transplanting by machine would be higher if one could employ 5 persons to operate 3 machines along with seedling uprooting and transport. It was also observed that the operators could operate the machine continuously for the whole day without any problem. However, for sandy field conditions, the draft requirement was high. The transplanting was operated after one day of puddling in heavy soils. No problem of soil

Table 1. Mortality of Hills after Transplanting Paddy Using Manual Transplanter

Experiment Number	Average hills/m² At transplanting time	Average hills/m² After 15 days	Hill mortality (percent)
1	25.8	23.3	9.7
2	25.2	21.5	14.7
3	27.1	21.8	19.6
4	27.4	25.5	6.9
5	30.8	27.7	10.1
Average	27.3	24.0	12.1

Table 2. Distribution of Plants per Hill

Tillers/ Hill	At Time of Transplanting		After 15 Days (Post Mortality)	
	Percentage of such hills	Cumulative percentage	Percentage of such hills	Cumulative percentage
1	29.2	29.2	40.06	40.06
2	19.8	49.0	22.16	62.22
3	14.2	63.2	14.66	76.88
4	10.1	73.3	10.98	87.86
5	9.0	82.3	6.00	93.86
6	7.3	89.6	3.34	97.20
7	3.7	93.3	1.86	99.06
8	3.0	96.3	0.94	100.00
9	1.2	97.5	0	100.00
10	2.5	100.0	0	100.00

flow was observed.

The machine transplanted 25.2 to 30.8 hills/m^2 (average 27.3). However, after 15 days, the fields had 17.5 to 25.3 hills/m^2 with an average of 22 hills/m^2 compared to 18.4 (range 14.4 to 20.2) in the traditional manual method. Thus hill population transplanted by the machine was about 20% higher than the traditional manual method. There were some missing hills at the time of transplanting due to various factors. Also, during the first 15 days of plant growth, there were some plant/hill mortality due to seedling condition, field and machine factors which are controllable. The most critical machine factor contributing to the hill mortality was accidental cutting of the seedlings by the transplanting fingers of the machines. It was observed that hill mortality ranged from 6.82% to 19.6% with an average of 12% (**Table 1**). The research trials after the transplanting season indicated that if straight nursery trays are replaced with curved nursery trays, the plant mortality is reduced considerably. The plant cutting was also observed when the nursery mats were not of proper width (200 mm). The number of plants/hill in a machine transplanted fields were observed to vary from 1 to 8. At the time of transplanting 63% of the hills had up to 3 tillers each whereas 90% of the hills had up to 6 tillers each (**Table 2**). The variations in the number of plants/hill were due to seedling density variations in the nursery and due to buckling of the mats at the bottom.

The number of tillers per hill in the machine transplanted crop were found to vary from 15.2 to 25.5 with an average of 18.9 tillers as compared to manual method of transplanting in which it varied from 9.7 to 21 with an average of 15.4 tillers. Thus the number of tillers per plant were about 20.3% higher in the machine transplanted crop as compared to the manually transplanted crop. The grain yield in the machine transplanted crop varied from 6 040 kg to 8 450 kg/ha (average 7 000 kg/ha) as compared to 5 725-7 587 kg/ha (average 6 707 kg/ha) in the traditional manual method. Thus, on an average, higher grain yield (about 3.41%) was obtained in the machine transplanted crop as compared to the manual method of transplanting. This data is confirmed by the yield in the responses of the farmers which have been independently recorded by the State Directorate of Agriculture as well as the team constituted by the University. The crop stand was also observed by the university experts and many farmers at village Hiyatpura during the field day which was organized when the crop was mature. The overall response of the farmers towards the adoption of this machine was highly positive. Financial and labour savings with machine transplanting was about 45% and 60%, respectively, as compared to manual transplanting.

Conclusions

It has been decided to introduce about 500 machines in the Punjab state during 1995 paddy transplanting season at 50% subsidy in cost.

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Development of Power Tiller-operated Groundnut Planter Cum-fertilizer Drill

by

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Abstract

Orissa State is a prominent place in groundnut production in India. The farmers of Orissa derive very marginal benefit from this cash crop as they follow indigenous production methods. The local practice followed in sowing groundnut is to drop seeds manually behind the plough which is labour intensive and expensive. To attain optimum plant conditions for higher productivity, a power tiller-operated groundnut planter cum-fertilizer drill was developed and tested. The actual field capacity of the machine was 0.160 ha/h with a field efficiency of 80.94%. A net savings of Rs 237.47 can be achieved per ha by using the planter cum-fertilizer drill over the manual dropping of seed behind the plough.

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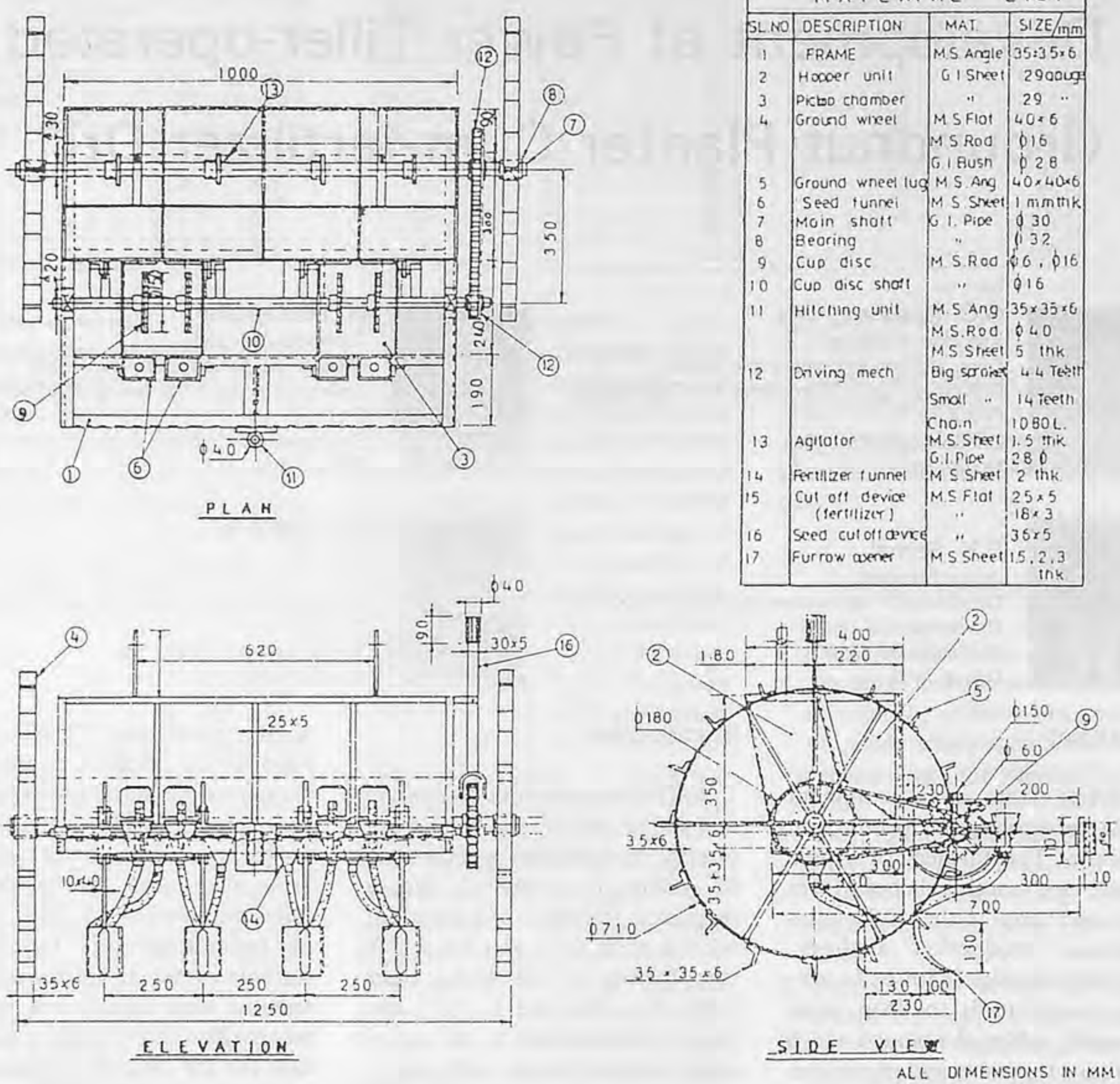
Introduction

In Orissa groundnut is grown in an area of 396 000 ha of land out of total cropped area of more than 88 million ha (1990-91). Orissa produced 558 000 t of groundnut with a yield of 1.41 t/ha which was highest in all India basis (1990-91). But due to very low level of mechanization, the use of more manual labour with higher wage rate, the net benefit derived from this cash crop is marginal. To enhance productivity, the establishment of an optimum crop stand is a critical factor. The local practice of sowing groundnut is to drop seeds manually behind the plough. In this method the optimum crop stand with desired spacing is seldom achieved. This is also a labour intensive, time consuming and expensive method. In the process of mechanization, the main hurdle is the small and scattered land holding pattern and socio-economic condition of the average farmer. Power units like tractors and their implements are not suitable for small and scattered land holdings. These are also beyond the reach of a common farmer as the initial investment is very high. So an intermediate power source like power tiller has been introduced and is gaining popularity among the farmers. It has become necessary to develop suitable matching implements to enhance the annual use of the power tiller and to make it acceptable for the farmers of the state.

Considering the above aspects a power tiller-operated groundnut planter cum-fertilizer drill was developed and its field performance, was compared with the local practice followed, i.e., manually dropping the seeds behind the plough.

Materials and Methods

The details of the developed power tiller-operated groundnut planter is shown in **Fig. 1**. The main parts of the planter are 1) Hopper units for seed and fertilizer; 2) Pick up chamber; 3) Ground wheels for power transmission; 4) Furrow openers; and



MATERIAL LIST			
SL.NO	DESCRIPTION	MAT.	SIZE/mm
1	FRAME	M.S. Angle	35×35×6
2	Hopper unit	G.I. Sheet	29 gauge
3	Pickup chamber	"	29 "
4	Ground wheel	M.S. Flat	40×6
		M.S. Rod	ϕ16
		G.I. Bush	ϕ28
5	Ground wheel lug	M.S. Ang	40×40×6
6	Seed funnel	M.S. Sheet	1 mm thk
7	Main shaft	G.I. Pipe	ϕ30
8	Bearing	"	ϕ32
9	Cup disc	M.S. Rod	ϕ6, ϕ16
10	Cup disc shaft	"	ϕ16
11	Hitching unit	M.S. Ang	35×35×6
		M.S. Rod	ϕ40
		M.S. Sheet	5 thk
12	Driving mech	Big sprocket	44 Teeth
		Small "	14 Teeth
		Chain	1080 L.
13	Agitator	M.S. Sheet	1.5 thk
		G.I. Pipe	28 ϕ
14	Fertilizer funnel	M.S. Sheet	2 thk
15	Cut off device (fertilizer)	M.S. Flat	25×5
		"	18×3
16	Seed cut off device	"	36×5
17	Furrow opener	M.S. Sheet	1.5, 2, 3 thk

Fig. 1 O.U.A.T. power tiller-operated groundnut planter cum-fertilizer drill.

5) Hitch. The hopper units consist of two chambers: one for seeds and the other for fertilizer. The capacity of the seed chamber is 0.066 m^3 where 23 kg of groundnut seed can be accommodated and that of the fertilizer hopper is 0.052 m^3. For seeds, there is a main hopper and a subsidiary pick up chamber. There are four discs in the pick up chamber and in each disc eight cups are provided. The diameter and depth of each cup was standardized to 13 mm dia and 12 mm depth so as to accomodate a single seed in each cup. Power is transmitted from the ground wheel to pick up the chamber shaft by means of chain and sprocket system. The number of teeth in the driving shaft main sprocket is 44 whereas the number of teeth in the sprocket of the pick up chamber shaft is 14, so as to maintain plant to plant distance of 10 cm. The fertilizer box is directly mounted over the main shaft. Fertilizer fall by gravity through circular holes of 1 cm dia. at the bottom of the fertilizer hopper. The rate of fertilizer fall is controlled by the adjustment of hole size. Vane type agitators are provided on the main shaft to

Fig. 2 Power tiller-operated groundnut planter cum-fertilizer drill in operation.

Fig. 3 Groundnut crop as line sown by power tiller-operated groundnut planter cum-fertilizer drill.

Fig. 4 Sowing of groundnut by local method i.e., manual dropping of seed behind the plough.

Fig. 5 Groundnut crop as sown by manual dropping of seed behind the plough.

facilitate easy flow of fertilizer. Four shovel type furrow openers are provided which can be adjusted to sow the seed and drop fertilizer at depth of 5 cm and 7.5 cm for Kharif and Ravi seasons, respectively.

Performance Evaluation

The performance of the seeder was evaluated for AK-12-24 groundnut variety of seed and fertilizer mixture of S.S.P. and M.O.P. in the laboratory and are shown in **Tables 1** and **2**. From the laboratory calibration, the maximum percentage variation of the seeds among the rows was 4.02% only. It was also observed that only a single seed was accomodated in each of the cups and the deviation between actual and desired seed rate is marginal. No mechanical damage was found while calibrating the planter. The average percentage variation of fertilizer (S.S.P. 120 kg/ha and M.O.P. 35 kg/ha) between the rows was 8.55. The deviation between the actual and the desired fertilizer rate was 3.64%.

The power tiller-operated groundnut planter cum-fertilizer drill was tested in an area of 0.75 ha during Ravi season in 1994. The parameters i.e., effective field capacity, field efficiency, depth of placement, seed rate, row spacing, plant spacing, plant density and yield were recorded. The local practice followed by the farmers was observed from the village of Dhauli in the district of Khurda.

Table 1. Laboratory Calibration of the Power Tiller-operated Groundnut Planter Cum-fertilizer Drill for Groundnut Variety AK 12-24

Rate setting	No. of obser-vations	Weight of seeds from furrow openers after 25 revolutions of groundwheel (g)					Total seed fall from all furrow openers (kg/ha)	Stan-dard devia-tion (g)	Percen-tage varia-tion be-tween openers
		No.1	No.2	No.3	No.4	Avg.			
120 kg/ha	1	168.75	175.00	177.00	167.60	172.10	121.15	4.61	2.68
	2	176.10	164.75	168.20	171.75	170.20	119.82	4.86	2.85
	3	177.25	165.00	170.45	180.60	173.32	122.02	6.97	4.02
	4	176.00	163.00	171.00	167.50	169.37	119.24	5.50	3.24
	5	163.50	176.50	171.50	177.25	172.19	121.22	6.32	3.67
Average		172.32	168.85	171.63	172.94	171.44	120.69	5.652	2.89

Table 2. Laboratory Calibration of the Power Tiller-operated Groundnut Planter Cum-fertilizer Drill for Fertilizer Distribution (SSP 120 kg/ha and MOP 35 kg/ha)

Rate setting	No. of obser-vations	Weight of seeds from furrow openers after 25 revolutions of groundwheel (g)					Total fertilizer fall from all openers (kg/ha)	Stan-dard devia-tion (g)	Percen-tage varia-tion be-tween rows
		No.1	No.2	No.3	No.4	Avg.			
155 kg/ha	1	215.00	194.50	223.50	219.50	213.125	150.04	12.892	6.04
	2	217.00	185.00	186.90	224.00	203.225	143.07	20.166	9.92
	3	201.75	239.00	219.20	189.70	212.412	149.53	21.467	10.10
	4	201.50	235.50	200.00	225.00	215.500	151.71	17.573	8.15
	5	221.60	219.80	190.40	234.10	216.475	152.38	18.510	8.55
Average		211.37	214.76	204.00	218.46	212.147	149.35	06.13	8.55

Results and Discussion

The theoretical field capacity, actual field capacity field efficiency and labour requirement under these two methods are shown in **Table 3**. The actual field capacity of the planter was 0.160 ha/h with field efficiency of 80.94% whereas the actual field capacity by manual dropping of the seeds behind the plough was only 0.053 ha/h with field efficiency of 70.81%.

The labour requirement by the planter was only 12.07 man-hour/ha whereas the labour requirement for manual dropping of the seed behind the plough was 75.47 man-hour/ha 37.74 bullock-hour/ha.

Plant conditions such as depth of planting, planting uniformity, plant spacing and plant density are shown also in **Table 3**. A depth of planting of 7.53 cm was achieved by the planter against a depth of 4.26 cm in behind the plough method during Ravi season. It was also observed that in Ravi season, if the depth of planting of groundnut exceeded 8 cm, there was delayed germination. When the depth of planting was less than 5 cm, germination percentage becomes low due to non-availability of sufficient moisture. Hence, the optimum depth of placement was attained by the planter. The seeds and fertilizer were placed side by

Table 3. Comparison of Power Tiller-operated Groundnut Planter Cum-fertilizer Drill with Manual Dropping of Seed behind the Plough

Parameters	Manual dropping of seeds behind plough (T1)	Power tiller-operated groundnut planter cum-fertilizer drill (T2)
Type of soil	sandy loam	sandy loam
Mean clod diameter (mm)	4.2	4.2
Variety of seed	AK 12-24	AK 12-24
Actual field capacity (ha/h)	0.053	0.160
Field efficiency	70.81	80.94
Average row to row distance (cm)	27.8	25.00
Average plant to plant distance (cm)	13.34	11.54
Average depth of placement (cm)	4.26	7.53
Seeding uniformity (%)	67.10	81.48
Average plant density (nos/m^2)	28.19	33.27
Average yield (Q/ha)	12.70	14.88
Time requirement (man-hour/ha)	75.47	12.07
(Bullock hour/ha)	37.74	—
Cost of operation/ha (Rs)	531.06	293.59

side at an average horizontal distance of 2.1 cm. The average plant-to-plant distance of 11.54 cm was observed as against 13.34 cm by behind the plough method. The plant density of 33.27/m^2 with 81.48% uniformity was achieved by the planter against a plant density of 28.19/m^2 with 67.10% uniformity in behind the plough method.

The cost of planting and yield in both methods are shown in **Table 3**. The cost of operation of a pair of bullock using the indigenous plough was Rs. 9.47/h. The costs of operation of the power tiller with rotavator and groundnut planter cum-fertilizer drill were Rs. 38.30/h and Rs. 43.85/h, respectively. An average yield of 14.88 quintals/ha was obtained with planting cost of Rs. 293.59/ha in the case of the planter whereas an average yield of 12.07 quintals/ha with planting cost of Rs. 531.06/ha was obtained in the local method of dropping the seeds behind the plough. The higher yield obtained by using the planter was due to high planting uniformity, optimum depth of placement and better utilization of fertilizer by the plants.

The estimated cost of the power tiller-operated planter cum-fertilizer drill was Rs. 5 000.00. To place the seeds behind the plough 75.47 man-hour/ha and 37.74 bullock-hour/ha were needed. A net savings of Rs. 237.47/ha was obtained by using this planter over the local method of dropping the seeds behind the plough.

Conclusions

On the basis of the results obtained from the laboratory calibration and field evaluation of the power tiller-operated planter cum-fertilizer drill the following conclusions are drawn:

1. From the laboratory calibration the percentage variation in seeds among the rows was well within the permissible range of 5%. No mechanical damage of seeds was observed during the test. The variations of fertilizer rate between the rows was 7.56% which is slightly higher.
2. The effective field capacity of the planter was 0.160 ha/h with field efficiency of 80.94% which was much higher than that of the local practice.
3. A depth of planting of 7.54 cm and plant density of 33.27/m^2 with uniformity of 81.48% were obtained by the planter which were close to optimum conditions.
4. The cost of the planter was only Rs 5 000.00. A net savings of Rs 237.47/ha can be achieved by using this planter cum-fertilizer drill over manual dropping the seed behind the plough. Therefore, the power tiller-operated groundnut planter cum-fertilizer drill will benefit the farmers in mechanizing the groundnut cultivation.

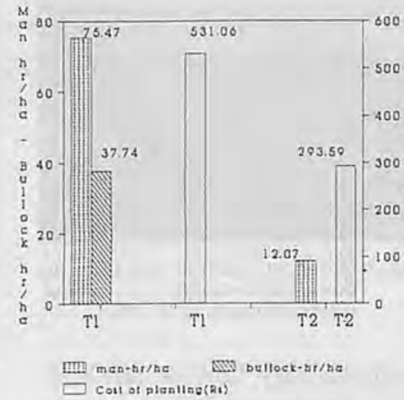


Fig. 6 Comparative time and cost requirements in different methods of groundnut planting.

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Getting the Best Out of Ram Pump

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Abstract

Automatic hydraulic ram pumps are inexpensive, low in maintenance cost, and environmentally friendly devices using a renewable energy resource to pump water for domestic or agricultural use. Since being superseded by pumps using electrical or fossil fuel energy nearly a century ago, they are now coming back into favour for use in the developing world.

This paper describes a simple, yet rational approach to the design of ram pumps operating under zero recoil conditions. Data for two Australian-made ram pumps have been obtained empirically and the design process is illustrated with many examples. The procedure predicts drive pipe length, supply head, impulse valve mass and stroke, beat frequency, quantity, delivered and source capacity for both pumps when working optimally.

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Introduction

The automatic hydraulic ram pump has been in existence for over 200 years. Invented in 1776 by Joseph-Michel Montgolfier (one of the two brothers who constructed the first hot air balloon in 1783) it is a device for pumping water powered solely by the potential energy of the supply. Its construction is simple having only two moving parts and it is cheap and pollution-free. Since the supply is usually from a convenient stream having sufficient fall, the ram pump costs nothing to run and needs maintenance only every few years or so.

Hydraulic ram pumps were used during the 19th and early 20th centuries for the supply of water to farms and country estates. With the introduction of piped water and electrical supplies to rural areas they became obsolete. Recently, however, enthusiasm for cheap, low maintenance, environmentally friendly devices using a renewable energy resource has revived interest in their use for water supply in developing countries.

A ram pump system consists of: a) source of supply; b) drive pipe; c) pump with impulse and delivery valves; d) air chamber; and e) delivery pipe as shown in **Fig. 1**. The function of the air chamber is to store water at the delivery head between strokes and to absorb the shock of pumping. The air chamber must always be charged with air and this is often achieved by the inclusion of a small "snifter" valve placed just under the deliv-

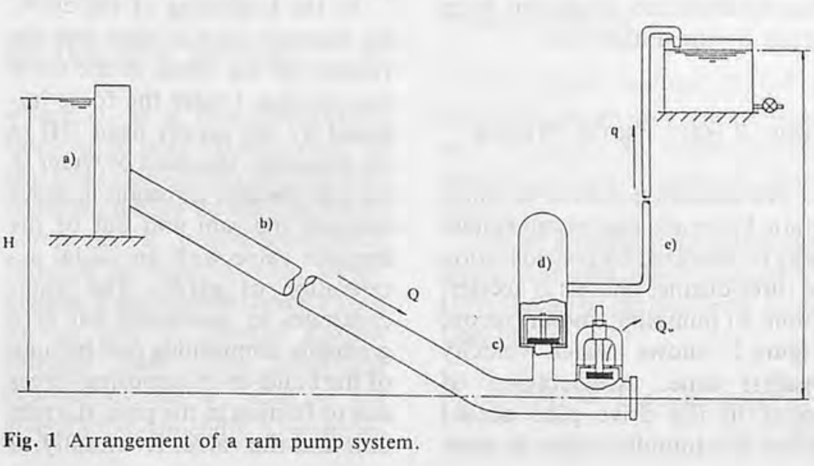

Fig. 1 Arrangement of a ram pump system.

ery valve. The Platypus ram, one of the two pumps whose behaviour is investigated here, does not need a snifter valve since it employs an air chamber with a pressurised compartment separated from the water by a rubber diaphragm; the other ram tested, a Wilcox, is fitted with a crude snifter valve. There is some doubt about the need for a snifter valve at all since air ingested with each stroke of the impulse valve is automatically drawn into the air chamber whenever the delivery valve opens.

The complex behaviour of ram pumps is now fairly well understood and a number of analytical approaches are available (1,2,3). Until recently (4), the only design procedures employed were unsatisfactory rules-of-thumb based upon the experience of ram pump manufacturers and installers. This paper presents a simplified approach to the optimum design of ram pumps by specifying the desired delivery head to be at a point of zero recoil.

The pulse theory of O'Brien and Gosline (1) was the first rational explanation of ram behaviour. Tacke (2) carried out a large number of tests on commercial rams and employed a modified version of the O'Brien and Gosline theory to explain their performance. A semi-graphical analysis based on the work of O'Brien and Gosline and Tacke has been given by the author (3).

How a Ram Pump Works

The operating cycle of an automatic hydraulic ram pump system may be idealized by consideration of three distinct phases: i) acceleration; ii) pumping; and iii) recoil. **Figure 2** shows water velocity against time. Acceleration of water in the drive pipe occurs when the impulse valve is open and the delivery valve is closed, pumping takes place after the impulse valve shuts and the delivery valve opens. Recoil, or the reversal of flow in the drive pipe, usually occurs at the end of the pumping stage after closure of the delivery valve. The suction resulting from the recoil causes the impulse valve to open and the cycle is ready to begin again. At certain values of delivery head, however, recoil does not take place and it is then that the pump is operating optimally since recoil represents a loss of energy in the system. Our concern here is to design ram pumps to work under conditions of zero recoil. To do this, we first have to identify the critical delivery heads at which this effect occurs.

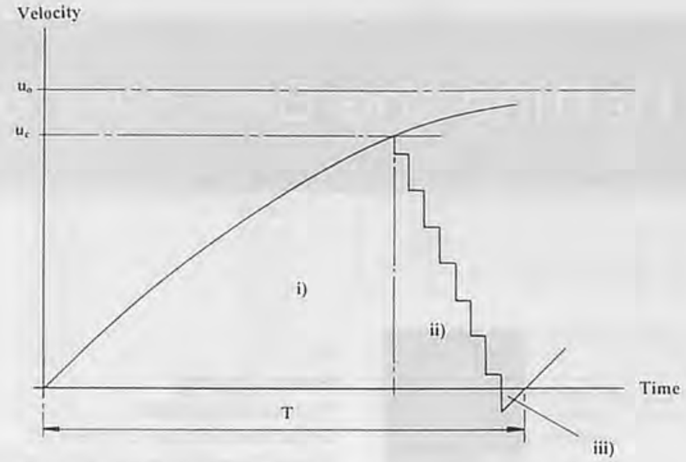

Fig. 2 Drive pipe velocity-time diagram.

The Acceleration Phase

At the beginning of the cycle, the impulse valve is open and the velocity of the water in the drive pipe is zero. Under the force imposed by the supply head (H) in the reservoir, the mass of water in the pipe (length, L) begins to move towards the ram and out of the impulse valve with an initial acceleration of gH/L. The water continues to accelerate but at a gradually diminishing rate because of the build-up of opposing forces due to friction in the pipe, the ram unit and the valve. Eventually, if the impulse valve is prevented from closing, the flow becomes steady at a velocity u_o. If the impulse valve is allowed to operate normally, the flow of water through the valve generates hydrodynamic forces causing the valve to close abruptly at a certain critical velocity u_c which must be less than u_o otherwise the valve will never close and the ram will not work. The steady state velocity is given by:

$$u_o = \sqrt{(2gH/k)} \quad (1)$$

where

$k = m + f(L/D)$

m is a valve loss coefficient, f is the drive pipe friction factor, and D is the diameter of the drive pipe.

The velocity (u_c required to close the impulse valve is a characteristic of a particular ram and depends upon the valve geometry, stroke and weight (or spring stiffness, if the valve is spring controlled). The minimum reservoir head under dynamic conditions required to close the impulse valve is H_{min} (= $H_s + H_{fc}$), where H_s is the head necessary to close the impulse valve under static conditions and H_{fc} is the friction head loss in the drive pipe. In practice, H needs to be greater than about 1.5 H_{min} for the ram to operate effectively. The critical velocity is given (4) by:

$$u_c = \sqrt{(2gH_s/m)} \quad (2)$$

and the velocity ratio (a) by,

$$a = u_c/u_o = \sqrt{(kH_s)/(mH)} \quad (3)$$

For the satisfactory operation of a ram pump, it is recommended that the velocity ratio should not exceed 0.8.

The Pumping Phase

On closure of the impulse valve, which occurs when the velocity in the drive pipe reaches u_c, the water adjacent to the valve is brought to an abrupt halt, causing water hammer shock waves to travel up and down the drive pipe at the speed of sound, c. As long as the magnitude of the pressure wave at the ram end of the drive pipe exceeds the delivery head h, the delivery valve will open and a pulse of water will be injected into the air chamber and thence to the delivery tank. At each pulse there is a corresponding reduction in the drive pipe velocity of approximately gh/c. This process continues until the velocity of the water flowing in the drive pipe is exhausted. The maximum head (h_m) generated by a ram pump is obtained if the water is brought to rest in one step, in other words if $u_c = gh_m/c$, hence $h_m = cu_c/g$.

The Recoil Phase

If the drive pipe velocity is not reduced exactly to zero, the water will recoil, or start moving backup the drive pipe towards the supply tank. This effect is clearly undesirable because energy must be expended to reverse the flow before the next cycle can begin. It has been shown (3) that zero recoil occurs at delivery heads of $h_N = h_m/2N$, where N (= 1, 2, 3,...) is the number of pressure pulses occuring in the drive pipe. For optimum design therefore, $h_m = 2Nh_N$, or $u_c = 2Ngh_N/c$.

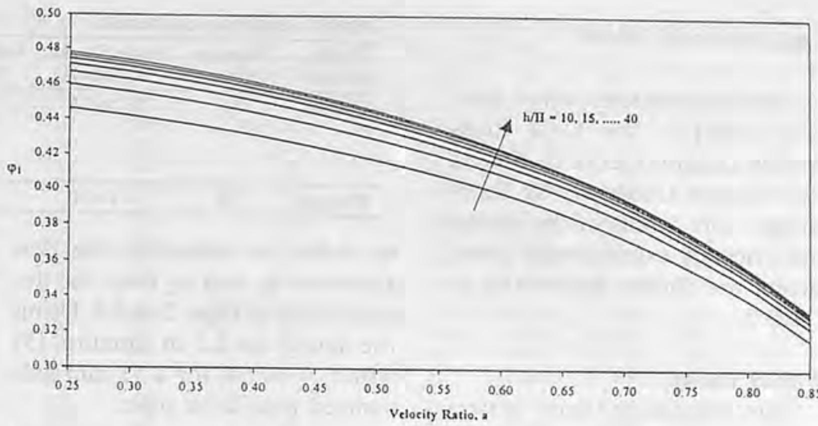

Fig. 3 Function φ_1 for h/H from 10 to 40.

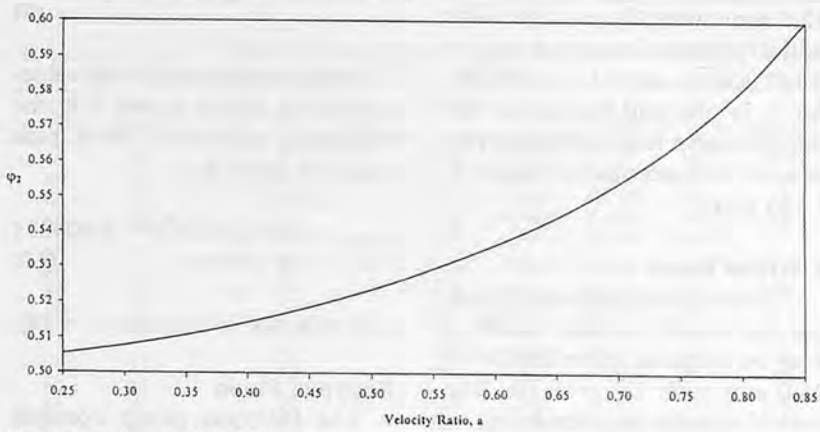

Fig. 4 Function φ_2 for H/h = 0.

Theoretical Relationships

It can be shown (3) that at zero recoil, the following non-dimensional relationships apply to a ram pump;

$$(q/D^2u_c) = C_d(\pi/4)(H/h)\varphi_1 \quad (4)$$

$$(Q/D^2u_c) = (\pi/4)\varphi_2 \quad (5)$$

$$\text{and } (nu_c/g) = 2(H/L)\varphi_1 \quad (6)$$

where φ_1 is a non-dimensional function of both velocity ratio (a) and head ratio (h/H) and for conservative design φ_2 may be considered as a non-dimensional function of velocity ratio alone. **Figures 3** and **4** show design charts for φ_1 and φ_2 plotted against velocity ratio. The analytical expressions for φ_1 and φ_2 are given in the Appendix. Q is the total quantity of water used by the pump (m^3/s), n is the beat frequency (Hz), C_d is the delivery valve discharge coefficient, g is the acceleration due to gravity (9.81 m/s^2), q is the quantity delivered (m^3/s) and h is the delivery head (m).

Power Output

The power output (P) of a hydraulic pump may be expressed as $P = \rho gqh$ (W), where ρ is the density of the working fluid (kg/m^3).

For an automatic hydraulic ram pump, the unit power output P_u (W/m) may be derived from equation (4) as:

$$P_u = P/H = C_d(\pi\rho g\varphi_1/4)D^2u_c \quad (7)$$

Experimental Work

Two low-cost ram pumps have been tested in the Civil Engineering Laboratories of the Papua New Guinea University of Technology. The details of the pumps and relevant experimental parameters are shown below and in **Table 1**.

Wilcox Pump

The maximum unit power output occurred for $N = 1$ at an impulse valve stroke of 12.5 mm with $C_d = 0.60$. The critical velocity is given by $u_c = 0.147\ s_v\sqrt{M_v}$ and $H_s = 0.40M_v$ for s_v in mm and M_v in kg. The impulse valve loss coefficient (m) at $s_v = 12.5$ mm was 2.5 and $c = 1\ 100$ m/s.

Platypus Pump

The maximum unit power output was found to occur for $N = 2$ at an impulse valve stroke of 26.0 mm with $C_d = 0.70$. The critical velocity is given by $u_c = 0.050s_v\sqrt{M_v}$ and $H_s = 0.12M_v$ for s_v in mm and M_v in kg. The impulse valve loss coefficient (m) at $s_v = 26.0$ mm was 1.36 and $c = 1\ 020$ m/s.

Table 1. Experimental Details

Pump Name	Diameter D (mm)	Valve Stroke s_v (mm)	Valve mass M_v (kg)	Drive pipe length L (m)	Supply head H (m)
Wilcox	51	6 to 16	0.83	11.8	2.76
				15.1	2.76
				18.3	2.76
				15.1	3.25
Platypus	76	14 to 30	2.50	13.6	3.44

Design Procedures

Wilcox Pump

To get the best out of a Wilcox pump, it should be operated at delivery heads of between 60 and 100 m. Using the data given in 5.1 above and setting $u_c = 2NGh_N/c$ with $N = 1$ and $h_N = h_1 = h$ (the design delivery head, which includes the friction head loss in the delivery pipe) the required valve mass is obtained as:

$$M_v = 90h^2 \times 10^{-6}\ \text{kg} \qquad (8)$$

To obtain q, Q and n from equations (4), (5) and (6), we first have to calculate the velocity ratio in order to determine the two functions φ_1 and φ_2 from the design charts in **Figs. 3** and **4**. Using the data from 5.1 in equation (3) with $f = 0.030$ for a 51 mm galvanized iron drive pipe:

$$a = 0.006h\sqrt{[\{1 + (L/4.25)\}/H]} \qquad (9)$$

From equation (9), if the velocity ratio is not to exceed 0.8, the maximum permitted drive pipe length is given by:

$$L_{max} = \{(75.5H/h^2) - 0.00425\} \times 10^3\text{m} \qquad (10)$$

L should not be less than 5 m (4).

Platypus Pump

The Platypus pump operates best at delivery heads between about 30 m and 60 m. Using the data given in 5.2 and setting $u_c = 2Ngh_N/c$ with $N = 2$ and $h_N = h_2 = h$ (the design delivery head), equations corresponding to (8), (9) and (10) with $f = 0.025$ for a 76 mm galvanized iron drive pipe are:

$$M_v = 876h^2 \times 10^{-6}\ \text{kg} \qquad (11)$$

$$a = 0.01h\sqrt{[\{1 + (L/4.13)\}/H]} \qquad (12)$$

and

$$L_{max} = \{(25.1H/h^2) - 0.00413\} \times 10^3\ \text{m} \qquad (13)$$

Design Examples

In order to use equations (10) and (13) we need a value for H and to use equations (9) and (12) we need a value for L as well. Both H and L may be dictated by the topography of the site, but in the design examples which follow, some freedom in the choice of these two parameters will be assumed.

Example 1: Design a Wilcox ram for maximum power output at a delivery head of 100 m.

Solution:

From equation (8), $M_v = 0.9$ kg, thus $u_c = 1.74$ m/s. Since the weight of the impulse valve as supplied is 0.83 kg, an additional mass of 0.07 kg is required which may be clamped between the lock-nuts.

Supposing the supply head available is $H = 5$ m, L_{max} is obtained from equation (10) as 33.5 m. It is advantageous to choose L close to L_{max} in order to keep the beat frequency as low as possible and hence prolong the life of the pump. As a first trial, we will take L as 30 m.

From equation (9), $a = 0.76$ thus $\varphi_1 = 0.37$ for $h/H = 20$ and $\varphi_2 = 0.57$ from **Figs. 2** and **3**. From equation (4) we obtain the discharge as 39×10^{-6} m^3/s or about 2.35 ℓ/min.

An upper bound value for the source capacity Q is obtained from equation (5) as 2.02×10^{-3} m^3/s or about 121 ℓ/min.

Finally, the beat frequency is obtained from equation (6) as 0.69 Hz, or about 41 beats/min, which is satisfactory.

Several other design solutions for $h = 100$ m are shown in **Table 2**, for comparison. **Table 3** gives solutions for $h = 60$ m. Notice that M_v is less than the mass of the impulse valve as supplied. In order to lighten the valve, the massive cast iron annulus on

Table 2. Design of the Wilcox Ram for h = 100 m: u_c = 1.74 m/s and M_v = 0.9 kg

H (m)	L (m)	L_{max} (m)	L/H	a	q (ℓ/min)	Q (ℓ/min)	n (min^{-1})
4	25	26	6.2	0.787	1.84	123	39
	22		5.5	0.746	1.93	120	46
	20		5.0	0.717	1.98	119	52
	18		4.5	0.686	2.03	118	59
5	32	34	6.4	0.784	2.30	122	38
	30		6.0	0.762	2.35	121	41
	28		5.6	0.739	2.40	120	45
	25		5.0	0.704	2.48	118	52
6	40	41	6.7	0.790	2.71	123	36
	36		6.0	0.754	2.82	121	41
	32		5.3	0.715	2.92	119	48
	28		4.7	0.675	3.02	117	57
7	45	49	6.4	0.772	3.21	122	38
	40		5.7	0.732	3.34	119	44
	35		5.0	0.689	3.46	117	52
	32		4.6	0.662	3.52	116	58

Table 3. Design of the Wilcox Ram for h = 60 m: u_c = 1.05 m/s and M_v = 0.32 kg

H (m)	L (m)	L_{max} (m)	L/H	a	q (ℓ/min)	Q (ℓ/min)	n (min^{-1})
4	50	80	12.5	0.643	2.04	69	36
	45		11.2	0.613	2.08	69	41
	40		10.0	0.581	2.12	68	47
	35		8.7	0.547	2.16	68	54
5	60	101	12.0	0.626	2.55	69	37
	55		11.0	0.601	2.59	68	41
	50		10.0	0.575	2.62	68	46
	45		9.0	0.548	2.66	68	52
	40		8.0	0.519	2.69	67	59
6	80	122	13.3	0.654	2.97	69	33
	70		11.7	0.614	3.04	69	38
	60		10.0	0.571	3.11	68	45
	50		8.3	0.525	3.18	67	56
7	100	143	14.3	0.674	3.37	70	30
	90		12.9	0.641	3.45	69	34
	80		11.4	0.606	3.52	68	39
	70		10.0	0.569	3.58	68	45
	60		8.6	0.529	3.65	67	53

Table 4. Design of the Platypus Ram for h = 60 m: u_c = 2.31 m/s and M_v = 3.15 kg

H (m)	L (m)	L_{max} (m)	L/H	a	q (ℓ/min)	Q (ℓ/min)	n (min^{-1})
4	22	24	5.5	0.755	10.72	355	34
	20		5.0	0.725	11.01	350	38
	18		4.5	0.694	11.29	346	44
	15		3.8	0.646	11.69	340	54
5	30	31	6.0	0.771	13.01	357	30
	25		5.0	0.713	13.74	348	38
	20		4.0	0.649	14.40	340	50
	18		3.6	0.621	14.64	338	56
6	35	38	5.8	0.754	15.70	354	31
	30		5.0	0.704	16.40	346	38
	25		4.2	0.651	17.03	340	47
	22		3.7	0.616	17.39	337	55
7	40	45	5.7	0.741	18.32	351	32
	35		5.0	0.698	18.98	345	38
	30		4.3	0.652	19.60	340	45
	25		3.6	0.602	20.18	335	56

Table 5. Design of the Platypus Ram for h = 30 m: u_c = 1.15 m/s and M_v = 0.79 kg

H (m)	L (m)	L_{max} (m)	L/H	a	q (ℓ/min)	Q (ℓ/min)	n (min^{-1})
4	50	107	12.5	0.543	11.71	165	33
	45		11.3	0.517	11.84	164	37
	40		10.0	0.490	11.96	163	42
	35		8.8	0.462	12.08	163	48
	30		7.5	0.431	12.20	162	57
5	60	135	12.0	0.529	14.34	165	33
	55		11.0	0.508	14.46	164	37
	50		10.0	0.486	14.58	163	41
	45		9.0	0.463	14.70	163	45
	40		8.0	0.439	14.81	162	51
	35		7.0	0.413	14.92	161	59
6	65	163	10.8	0.501	16.95	163	36
	60		10.0	0.483	17.06	163	40
	55		9.2	0.463	17.17	162	43
	50		8.3	0.443	17.28	162	48
	45		7.5	0.422	17.39	161	54
7	80	191	11.4	0.512	19.21	164	33
	70		10.0	0.480	19.42	163	39
	60		8.6	0.447	19.63	162	45
	50		7.1	0.411	19.83	161	55

the valve shaft should be removed and replaced with a thinner aluminum alloy disc of adequate strength.

Example 2: Design a Platypus ram for maximum power output at a delivery head of 60 m.

Solution:

From equation (11), M_v = 3.15 kg, thus u_c = 2.31 m/s.

Supposing the supply head available is H = 4 m, L_{max} is obtained from equation (13) as 23.7 m. As a first trial, we will take L as 22 m.

From equation (12), a = 0.75 thus φ_1 = 0.36 for h/H = 15 and φ_2 = 0.56 from **Figs. 3** and **4**. From equation (4) we obtain the discharge as 178×10^{-6} m^3/s or about 10.7 ℓ/min.

An upper bound value for the source capacity Q is obtained from equation (5) as 5.9×10^{-3} m^3/s or about 355 ℓ/min.

Finally, the beat frequency is obtained from equation (6) as 0.56 Hz, or abut 34 beats/min, which is acceptable.

Several other design solutions for h = 60 m are shown in **Table 4** for comparison. **Table 5** gives solutions for h = 30 m.

Summary and Conclusions

Design equations for the optimum operation of two ram pumps of Australian manufacture at zero recoil have been presented and examples of their use have been given. The design process predicts all pump system parameters, including impulse valve stroke and weight and beat frequency.

Tables 2 and **3** show combinations of H and L for delivery heads of 100 m and 60 m for the Wilcox ram. **Tables 4** and **5** show corresponding combinations of H and L for delivery heads of 60 m and 30 m for the Platypus ram. These combinations have been selected to give operating frequencies in the range 30 to 60 beats/min. This range ensures that drive pipe length will not be excessive and that pump life (which is inversely proportional to the frequency) will be maximized. It will be observed that L/H increases as the delivery head decreases in order to contain the frequency within the preferred range.

For a given supply head (H), decrease in drive pipe length (L) is accompanied by an increase in beat frequency (n), an increase in quantity delivered (q) and a decrease in the total quantity (Q) required to operate the pump.

For a given drive pipe length, decrease in supply head is accompanied by a decrease in beat frequency, a decrease in quantity delivered and a small increase in the total quantity. It should be noted that these parameters become more sensitive to changes in drive pipe length as the delivery head increases.

Preferred drive pipe length and the L/H ratio are inversely proportional to the magnitude of the delivery head whilst quantity delivered is only marginally improved as the delivery head decreases. On the basis of drive pipe cost, it might, therefore, be argued that it is more economical to operate the pump at a higher delivery head than specified. However, valve mass increases with delivery head resulting in greater impact forces on the valve assembly which will have the effect of shortening pump life.

Comparison of **Tables 3** and **4** shows clearly that the use of multiple pumps in parallel, which is sometimes advocated in place of one pump of larger size, is not an economic solution. For h = 60 m and H = 5 m, one Platypus pump with L = 30 m provides the same quantity delivered as five Wilcox pumps each with a drive pipe of 40 m if the beat frequency is kept within the preferred range.

Ram pumps have not been well served in the past by irrational and unreliable design methods. It is hoped that the procedures presented here, which are based upon sound scientific principles, will help restore the reputation of this unique device. The design process can be applied to any pump for which the necessary empirical data has been obtained.

Disclaimer

The Civil Engineering Department of the Papua New Guinea University of Technology has no commercial interest in either the Wilcox or the Platypus ram pump.

Notation

- a - velocity ratio (u_c/u_o)(-)
- c - velocity of sound (ms^{-1})
- C_d - discharge coefficient (-)
- D - drive pipe diameter (m)
- f - friction factor (-)
- g - acceleration due to gravity (9.81 ms^{-2})
- h - delivery head (m)
- h_m - maximum delivery head (m)
- h_N - delivery head at zero recoil (m)
- H - supply head (m)
- H_{min} - minimum dynamic head required to close the impulse valve (m)
- H_{fc} - friction head loss in the drive pipe (m)
- H_s - static head to close impulse valve (m)
- k - system loss coefficient (-)
- L - length of drive pipe (m)
- L_{max} - maximum drive pipe length (m)
- m - valve loss coefficient (-)
- M_v - mass of valve disc (kg)
- n - beat frequency (Hz, min^{-1})
- N - number of pressure pulses in the drive pipe (-)
- P - power output (W)
- P_u - unit power output (Wm^{-1})
- q - quantity delivered (m^3s^{-1}, ℓ min^{-1})
- Q - capacity of source (m^3s^{-1}, ℓ min^{-1})
- Q_w - quantity wasted (m^3s^{-1}, ℓ min^{-1})
- s_v - valve stroke (mm)
- T - period of cycle(s)
- u_c - velocity to close impulse valve (ms^{-1})
- u_o - steady state velocity (ms^{-1})
- α, β - functions of the velocity ratio (-)
- $\varphi_{1,2}$ - functions of velocity ratio and head ratio (-)
- ρ - density of working fluid (1 000 kgm^{-3} for water)

Appendix

The analytical expressions for the non-dimensional functions φ_1 and φ_2 in Section 3 may be obtained (3) as:

$$\varphi_1 = \{\alpha + (2H/h)\}^{-1}$$

and $$\varphi_2 = \{2\beta + (C_dH/h)\}\varphi_1$$

where $\alpha = \ln\{(1+a)/1-a)\}/a$ and $\beta = \ln\{\mathrm{Cosh}(a\alpha/2)\}/a^2$
For h >> H, an upper bound for φ_2 is obtained as $2\beta/\alpha$ which is the value plotted in **Fig. 4**.

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Deep Well Man-powered Pumps for Agriculture

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Abstract

Small-scale irrigation and safe drinking water demand man-powered pumps in Bangladesh. For this purpose the UNICEF Tara Pump was introduced in the country in 1986. To date about one hundred thousand units have been fielded. Delivery of the pump and the corresponding operators' conditions are reported in this paper. Delivery of the pump is much less when operated by minors and reaches a maximum for people of ages between 30 and 45 years. The operators become tired during an operating cycle for one minute. Operators' reactions on the performance of the pump demands further improvement.

Introduction

Agricultural development is one of the prime means for improving the GDP of Bangladesh. This sector is being taken care by both government and non-governmental organizations. Irrigation is an important criterion in Bangladesh for improving agriculture. Small-scale irrigation is getting its popularity in rural areas. Its use is now wide spread due to its low cost and ease of operation. This kind of irrigation is performed by low-cost, man-powered pumps. In addition, they are used for safe drinking water in rural and urban areas. A series of models of man-powered pumps are available in Bangladesh. Manufacturers are in competition to establish the superiority of their own manufactured man-powered pumps. Recently its use has become more challenging. This is due to the desire to save fuel by using sweat energy. The common models of man-powered pumps fielded in Bangladehs are: UNICEF No. 6 pump, rower pump, treadle pump, tara pump and bangla pump.

The leading pumps are those used for water head less than 6 m. The other types are used for water head more than 6 m. In some regions of Bangladesh water level falls seasonally down to 30 m. So the latter two types are being fielded in these regions. Tara pump is fielded by UNICEF. About one hundred thousand of this kind of pump have already been fielded. The other type is new and it is still on trial run. Performance study of these pumps are essential for standardization. In addition, it demands testing in terms of examining the material, components and maintenance/repair. Some performance characteristics of the Tara pump are presented in this paper. This type of pump is claimed to be lifting water from a deep source of up to a head of about 50 m.

Features of Tara Pump

The Tara pump is a deep well pump. It is operated by manual force. The piston is immersed in the water. A schematic view of Tara pump is shown in **Fig. 1** with all components labelled. The raising main of the well is fixed in a concrete platform. It is fitted with a PVC cylinder that contains the piston. Manual force is applied on the piston through a handle at the top of the pump. A motion in the

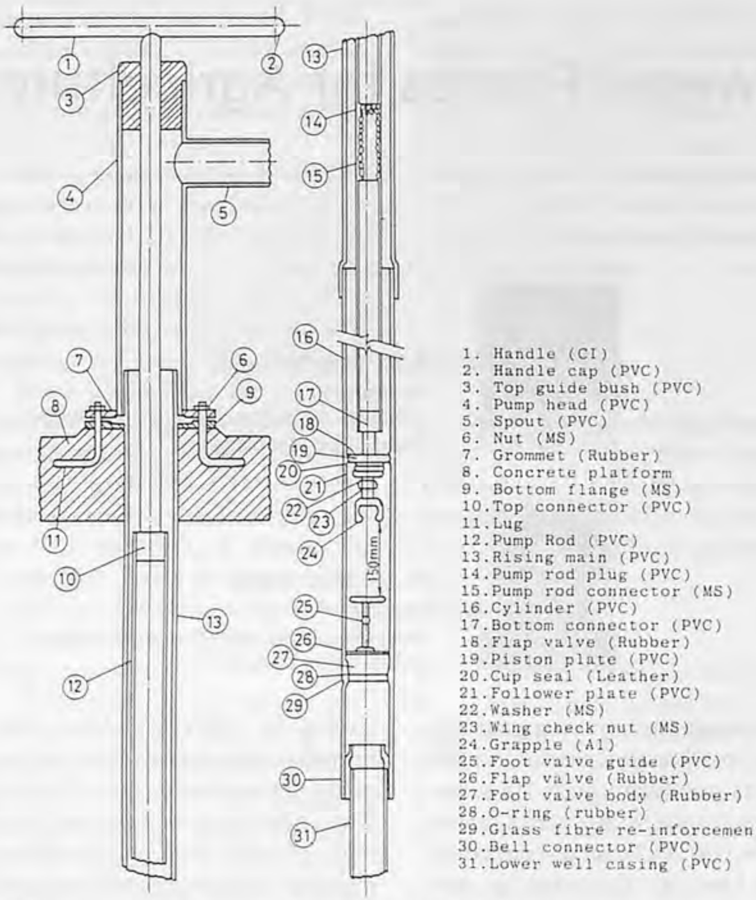

Fig. 1 Schematic diagram of Tara pump showing all parts.

form of reciprocating style (upward and downward) is transmitted to the piston which is immersed in the water. When the piston is forced to move downward, the flap valve opens and water flows upward through the annular space. This causes water to come out through the spout at the pump head. On the other hand, when the piston is pulled upward, the flap valve remains closed and makes water flow upward.

Manual force that pushes the piston down is much greater than the force required to pull it up. This is due to upward bouyant force acting on the piston assembly.

Experiments

A Tara pump was installed on a flat bed to lift ground water. Its operation was made easy and normal to an operator according to installation procedure. Then the delivery and the corresponding head were measured. Delivery was measured by direct collection of water. The operator could work on the pump in one turn for about a minute. Water delivery was collected in a tank during this operating period. The collected water was then measured directly.

The Tara pump draws water from a deep layer of ground water. For this case, it is not easy to measure the head. Conventional method of dropping a weight attached to a wire is not applicable here. Available electric method is expensive and unreliable. So a low cost electronic circuit was built. When a sensor touches the water surface, the electronic signal is passed on. This signal produces sound and emits light sensing water level in the well. The circuit diagram of the device is shown in **Fig. 2**. This device is cheap, reliable, durable and easy to operate. The head and discharge were measured and plotted to show the performance of the pump.

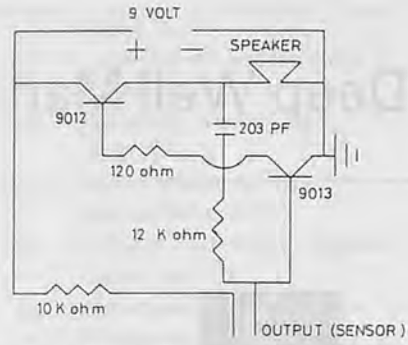

Fig. 2 Circuit diagram of head measuring device.

Results and Discussion

Pump delivery and operators' data were measured at a head of 20 m. The head is naturally available in a season. This head varies seasonaly. Similar data are also gathered in other seasons of different heads. It is a high head pump. Water lifting is tiresome for this pump. The operator can not operate more than a minute in one turn. Then he needs rest for operating a second turn. The pump discharge and comfortable time of operation of different ages of operators is shown in **Fig. 3**. At the beginning of a turn the discharge rate is high. It is reduced gradually with time. This might reach constant values after some time for each case. But the operation is limited to less than a minute only during a turn. This may be reduced more with an increase in pump head. An average discharge for the head of 20 m is about 5.5×10^{-4} cumec.

The tiredness level of the operators is indicated by heart beat

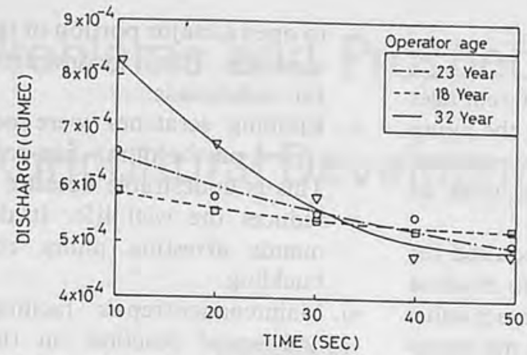

Fig. 3 Pump delivery by operators at different operating cycle time.

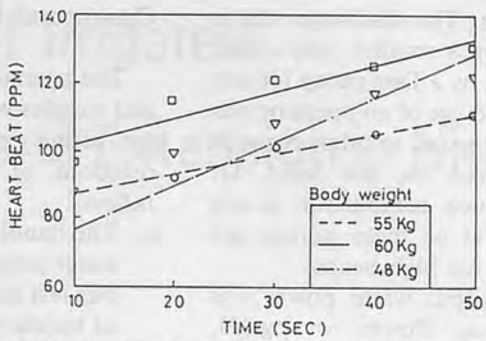

Fig. 4 Operators' heart beat change for different operating cycle time.

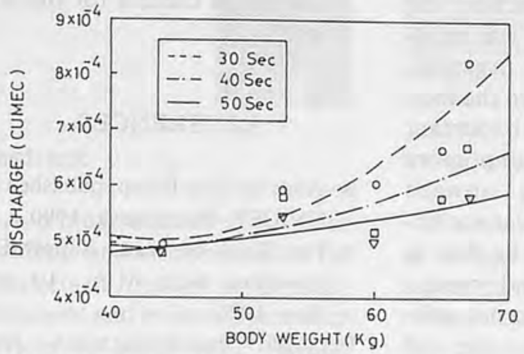

Fig. 5 Delivery by operators of different body weights.

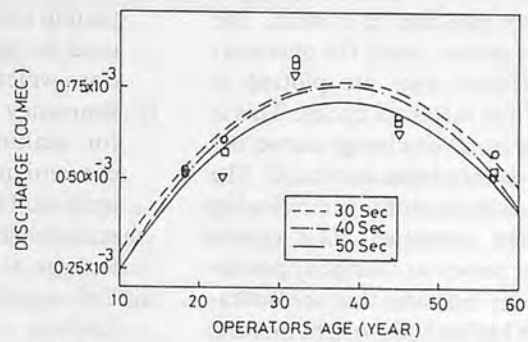

Fig. 6 Delivery by operators of different ages.

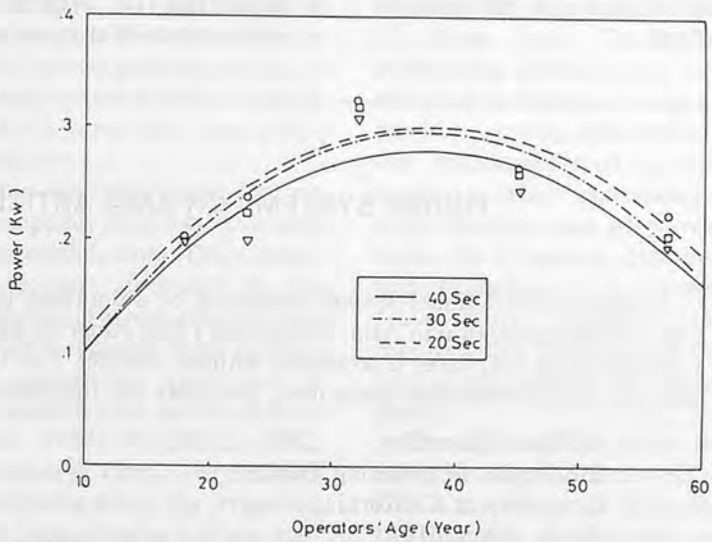

Fig. 7 Output power by operators of different ages.

change after a turn of operation. The heart beat increases sharply with time as shown in **Fig. 4**. The heart beat change for persons of different weights are shown in **Fig. 4**. It increases linearly with operation time. The heart beat reaches more than 100 ppm even after 30 seconds. The operator becomes very tired in operating the machine for 60 seconds. During a turn an operator pumps less than 30 ℓ/m of water. However, the heart beat is an indication of energy spent for water pumping. The operators' body weights have a sharp influence on discharge. The pumps are operated for 50 secs, 40 secs, and 30 secs cycles by an operator of definite weight. The operator of higher body weights can pump more water as shown in **Fig. 5**. It was observed that the operators' delivery is greater if the pump is operated at shorter cycle time. It means that the average delivery for 30 secs cycle is more than that for 50 secs cycle. This is due to a fall of the operators' efficiency caused by exhaustion. This will fall more due to an increase of pump head in the dry seasons.

The operators' age plays an important role on discharge volume. The delivery by a minor is lesser than that of a young boy as shown in **Fig. 6**. The operators of ages between 30 and 45 years can deliver maximum water. The minors and old operators deliver less water. It is very tiresome for minors. The discharge results for different ages of operators are shown in **Fig. 6**. The pump was operated for a fixed cycle time by different operators. It is interesting to note that the discharge varies parabolically with operators' ages. The discharge rate is higher for a smaller time cycle. Discharge by a Tara pump for any weight and age of an operator was small compared to other types of pumps used for low head. Of course, such comparison is not meaningful as these pumps are designed for high heads.

The output water power was defined as, Power = ρgQH, where ρ is density of water, g is acceleration due to gravity, Q is delivery rate and H is head. The output power curves for operators of different ages are plotted in **Fig.** 7 for different cycles. This is similar to a discharge curve because the head was not varied. The input was varied by employing different operators. This causes output power to change appreciably. This indicates that the operators of higher body weight impacts on the pumping efficiency. Hence, the optimum design efficiency is undefined.

Operators' Reaction

The operators of different ages and weights worked on the pump for lifting water. The common reactions of operators were as follows:

i. The handle force required for water pumping is too much at this test head. The exact value of handle force was not measured in this experiment. But for this kind of direct action, the puump handle force was measured by some other organizations which supported the fact.
ii. Bouyancy force is important for making the pump more convenient during upward motion. This force was not observed. This might be due to leakage at valves and joints.
iii. Delivery of water was not satisfactory for any age of operators.
iv. Repairing of broken and replacement of any part needs to open a major portion of the assembly. This is inconvenient for technicians.
v. Rubbing scratches were observed on the pump line rod. This is undesirable because it reduces the well life. It demands arresting pump rod buckling.
vi. Maintenance/repair facilities and social reaction on this pump is still unknown. These are useful criteria for the end users.

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Problems and Prospects of Irrigated Agricultural Development and Extension in Nigeria

by
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Abstract

A critical examination of the problems and an appraisal of the prospects of irrigated projects development and irrigation extension services to small scale farmers which dominate the farming system was carried out in Ogun State, Nigeria. The study revealed problems perceived by farmers to be really important among those listed by the responsible agency as non-completion and failure to construct irrigation projects according to design, the very little emphasis placed on irrigation in favour of other competing needs (supply of drinking water, fish pond projects and hydro-electric power generation) for water, and the limited contacts maintained by extension agents with farmers in the project enclaves within the state. Finally, the study proposes an effective irrigated agricultural extension service programme for improving the farmers' productivity in Nigeria.

Acknowledgement: The author is grateful to the management of OORBDA for granting permission to my research assistant to collect data for the study within its project sites. Gratitude is similarly extended to may research assistant, Mr. A.A. Adedoyin, for his thoroughness in the data collection effort for the study.

Introduction

Farmers in the humid tropics, as in Ogun State of Nigeria, can assure themselves of high and more dependable crop yields through the provision of efficient irrigation system and adequate water supply. In humid tropics, irrigation provides soil moisture during the best growing period of crops and makes double cropping possible in areas with long growing seasons.

Crops are more dependent on water supplies for growth than any other growth factors. Thus, irrigation becomes necessary in the humid tropics when available soil moisture is reduced to the point at which significant reduction in plant growth rate occurs (Christiansen, 1953; NAERLS, 1982; and Legoupil, 1991). The methods of conveying water for irrigation can be categorized as surface, subsoil and overhead.

Of the 98 million ha of land in Nigeria, 53 million ha are cultivable. Already some 9 million ha of the cultivable land have been identified as irrigable (Fatokun and Ogunlana, 1991). These authors claimed that if 25% of the irrigable land in Nigeria were irrigated and cropped twice in a year to grow maize and rice, at least 2 million mt of maize and 5 million mt of rice would be produced annually. This, they claimed was capable of wiping out the food deficit, leaving a lot for export within a very short time.

Following the devastating draught of the early 1970s, Nigeria intesified efforts in water resources development. A total of 11 River Basin Development Authorities (RBDAs) are now in existence in Nigeria. These agencies have, among other functions, the responsibilityof providing water to urban consumers and rural dwellers and of providing water for irrigation. Despite the huge investment in irrigation infrastructure, Ibrahim (1991) reported that Nigeria was yet to have a comprehensive irrigation policy.

The Ogun-Oshun River Basin Development Authority (OORBDA) is one of the 11 River Basin Development Authorities established in Nigeria. It has headquarters, and some of its key project sites, located within Ogun State but also covers Lagos, Oyo and Oshun States. The authority performs a number of functions, part of which is the development of both surface and underground water resources for multi-purpose use, including of irrigation services in some farmer-based irrigation project sites (OORBDA, 1990).

The farmer-based irrigation project of the authority is an agricultural production unit in which a group of farmers are settled as irrigated farm plot owners who pay partly for the capital expenses but fully for the recurrent inputs supplied to them and their plots. The farmers own the proceeds from the irrigated farm plots.

Despite the establishment of OORBDA in 1975, Ibrahim (1991) still observed greater demand for food and other farm products than is currently available in the market during the dry season.

This observation suggests that the agency has been unable to adequately enhance farmers' productivity, especially through all-year-round farming. This study, therefore, becomes pertinent in examining the problems and appraise the prospects of irrigation projects development and irrigation extension services in Ogun State

Specifically, the objectives of the study were as follows:

i. To identify the problems limiting irrigation systems development, particularly the irrigation extension services in Ogun State.
ii. To determine the priority of OORBDA with regards to the use of its dams in Ogun State.
iii. To determine the extent and purpose of contact between OORBDA's irrigation extension projects and farmers at the projects sites.
iv. To highlight the prospects of irrigation system development and irrigation extension services in Ogun State.

Methodology

The Ogun-Oshun River Basin Development Authority had only four functional irrigation project sites at the time of this study (conducted between January and April, 1992). The schemes were Oke-Odan, Oyan River, Lekan Are (at the agency's headquarters) and lower Ogun (Mokoloki) irrigation projects. The Oyan River Dam irrigation project is the first major dam of OORBDA. It is a multipurpose dam designed to supply 525 and 175 million litres of raw water per day to urban centre of Lagos and Abeokuta, respectively. It was also designed to provide water for the irrigation of 12 500 ha of farmland and to generate nine megawatts of hydroelectric power. But in reality, only a 10-ha pilot irrigation scheme was set up at the site at the time of the study.

The Lekan Are Irrigation Scheme, located at the OORBDA's headquarters at Abeokuta has 28 ha of farmland under sprinkler irrigation for training and demonstration purposes. There were no farmers involved in the project. On the other hand, the Lower Ogun (Mokoloki) Irrigation Project has 344 ha of land under cultivation with 72 participating farmers. The Oke-Odan Irrigation Project has a 400-ha sprinkler irrigation scheme being put to use by the participating farmers.

Data could only be collected from three sites (Oyan, Mokoloki and Oke Odan) since there were no farmers at the Lekan Are project sites. Specifically, data were collected on problems limiting irrigation systems development and the provision of irrigation extension services, priority of OORBDA on the use of water in its dams, the extent and purpose of contact between OORBDA's irrigation extension projects and farmers at the projects sites, and the prospects of irrigation systems development and irrigation extension services in Ogun State. Both the purposive and random sampling techniques were adopted in the selection of 30 irrigation farmers and 30 rainfed farmers from among the participants at the three project sites. Interview schedule was the instrument used to obtain information from farmers because of their low level of literacy while a questionnaire was administered to obtain informaiton from project officials.

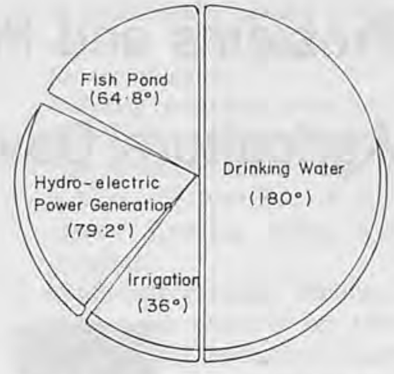

Fig. 1 Pie-chart of dam water allocation by OORBDA.

The appropriateness and relevance of the research instruments were ensured by subjecting them to validation exercises and reliability tests.

Irrigation development and agricultural extension experts examined the drafts of the research instruments to give them face validity. Also, they were subjected to the test - retest reliability evaluation to confirm the consistency of the instruments.

Data analysis was carried out through relative frequency or percentage analysis and chi-square (X^2) tests. For example, problems indicated by 50% and above of the respondents were classified as "Important" while those indicated by less than 50% were classified as "Not Important". With regards to dam water allocation by OORBDA, the order of the degrees on the pie chart is taken as the order of priority (**Fig. 1**). Also with regards to the chi-square (X^2) test, the null hypothesis is rejected when the calculated value is greater than the table value and vice versa at specified level of significance (Ogunfiditimi, 1986).

Results and Discussion

Problems Limiting Development of Irrigation Projects and Irrigation Extension Services

The problems identified through review of official documents to be confronting OORBDA on its irrigation projects and in the provision of irrigation extension services in Ogun State, which were also supported by the findings of Alarms (1984), Mahmood (1991) Ibrahim (1991), and Yahaya (1992) are listed in **Table 1**. While the OORBDA project officials perceived all the items as serious problems, the project (irrigation and rainfed) farmers perceived them differently, as also shown in **Table 1**.

For example, 83% of the farmers perceived both inadequate/poor development of irrigation infrastructure and exhorbitant cost of irrigation equipment as important factors confronting OORBDA. Also, 80% of the farmers perceived excessive priority placed on supply of drinking water and non-availability of extension agents at project sites as important factors. Other problems perceived as important by the farmers are: commercialization of OORBDA (75%), land tenure problems (67%), shortage of farm labour (67%), lack of needed infrastructure (58%), failure to construct irrigation systems according to design and mismanagement of funds (58%), and inadequate funding (50%). The farmers did not perceive inconsistency in policy, inaccessibility of irrigable lands, irregular electricity supply, lack of appropriate technology, and lack of interest by farmers as serious problems.

Table 1. Problems Identified to be Militating Against Irrigation Projects and Irrigation Extension Services by Farmers in Ogun State

Problems	Response		
	Frequency	Percentage	Decision
Inadequate/poor development of irrigation infrastructure	50	83.3	I
Changes in policy	15	25.0	NI
Inadequate funding	30	50.0	I
Exhorbitant cot of irrigation gadgets	50	83.3	I
Land Tenure problems	40	66.7	I
Failure to construct irrigation systems according to design and or mismanagement of funds	35	58.3	I
Inaccessibility of irrigable land	12	20.0	NI
Irregular electricity power supply	08	13.3	NI
Lack of interest by farmers	20	33.3	NI
Lack of appropriate technology	09	15.0	NI
Lack of needed infrastructure	35	58.3	I
Commercialization of OORBDA	45	75.0	I
Non-availability of inadequate availability of extension agents at project sites	48	80.0	I
Shortage of labour	40	66.7	I
Excessive priority placed on supply of drinking water	48	80.0	I

I = Imporatnt and NI = not important.

Table 2. Chi-Square Analysis on Extent of OORBDA's Contact with Farmers

Farmers	Monthly	Forthnightly	Weekly	Irregular Intervals	No Contact	Total
Irrigation	02(05)	16(10.5)	12(11)	0(02.5)	0(01)	30
Rainfed	08(02.5)	05(10.5)	10(11)	05(02.5)	02(01)	30
Total	10	21	22	05	02	60

X^2 calculated = 16.54; X^2 table = 09.49 at 0.05 level of significance.
X^2 calculated > X^2 table.

Dam Water Allocation by OORBDA

Responses from project officials of OORBDA and information gathered through review of official documents revealed that the agency concentrates more on supply of drinking water as 50% of water in storage was distributed for that purpose Hydro-electric power generation was given 22%, fish pond, 18% while irrigation was provided with only 10% of the total supply.

Extension Contact Activities of OORBDA

The extension contact activities of OORBDA include field demonstration, training programmes on irrigation farming, education, supply of relevant inputs such as fertilizer, seeds, chemicals, tractorization, irrigation water supply; and provision of storage facilities. An hypothesis was tested that "no significant difference existed in the extent of extension contact by OORBDA with irrigation farmers and rainfed farmers within the project areas". The result of the test shows that a significant difference existed in favour of irrigation farmers as shown in **Table 2**. Although it should be expected that OORBDA officials will maintain greater contact with irrigation farmers than rainfed farmers at the project sites but this test was still necessary to ascertain the situation. This is because the project is expected to be promoting irrigated agricultural ventures for the purpose of enhancing farm productivity and production of crops all year round.

However, accute shortage of extension workers, very small coverage areas with few farmers involved, and the little emphasis placed on irrigation projects in favour of supply of drinking water were indicated to have continued to limit the impact of the project with respect to the enhancement of agricultural productivity.

Prospects of Irrigation Systems Development and Irrigation Extension Service in Ogun

Ogun State is endowed with rivers and streams as sources of providing water for crop irrigation, especially during the dry season. The land is naturally and potentially fertile. The perennial streams can be impounded by constructing dams or can be pumped directly into the farm sites.

The factors limiting the prospects of irrigation development and irrigation extension services have been identified in the present study.

Decision: The null hypothesis is rejected and the alternative is accepted. Such factors are as follows:

i. Non-completion, abandonment or outright cancellation of OORBDA projects (dam construction);
ii. Faulty management practices and lax fiscal discipline;
iii. Unwillingness of communities to release land for the project;
iv. Insufficiency of available irrigation equipment;
v. Unsuitable topographical nature of some of the project sites; and
vi. Roads disrepair impeding transportation of irrigation equipment and/or farm products.

Well concerted efforts should be made to eliminate these constraints.

Information collected in the course of this study further reveals that farmers were usually engaged in other occupations during the dry season thereby abandoning farming until the next rainy season due to lack of irrigation services. Obviously, farmers need irrigation services to supplement the inadequate rainfall during the fluctuating periods and during the dry season. This will also encourage the opening up more agricultural lands to boost food production.

The study also reveals that most of the farmers interviewed were above 50 years of age and that women participation in farming was low. There is thus the need to encourage the more active group of people (youths) to take to farming as a way to achieve improved livelihood. More women should also be encouraged to go into irrigation farming whereby they can be planting vegetables on small or large irrigated plots.

The development of irrigation in Ogun State should be supported with appropriate marketing arrangements for the farm products, agro-service facilities for ease of land preparation and supply of inputs. In particular, the services of Village Extension Agents (VEAs) from Ogun State Agricultural Development Programme (OGADEP), State Ministry of Agriculture and Natural Resources, and from the universities within the state should be expanded.

The Farm Settlement and the farming programme of the Directorate of Employment could be specifically supported with irrigation services. On the other hand, small earth dams to impound work from perennial rivers or streams could be constructed close to the farms.

OORBDA should establish more irrigation pilot farms in order to educate farmers on the proper use of irrigation water. Regular extension services should also continue to be provided to farmers through group meetings, field training and demonstration, media programmes and individual contact methods.

Finally, the Directorate of Food, Roads and Rural Infrastructure (DFRRI) should render adequate support services in the area by providing farm-to-market roads to various irrigation project sites.

Conclusion

Irrigation could be a source of prosperity to the nation if provided and properly managed. Irrigation development towards the attainment of self-sufficiency in food production calls for new technologies, sound and consistent policies, an effective and functional irrigation extension system, inter-agency cooperation and contributions both at national and international levels.

Implications

In most developing countries, the role of extension services is not fully appreciated while its importance is underestimated and culminating in underfunding (FAO, 1986). Irrigation areas may suffer, especially if extension is introduced at too late a stage in the project implementation sequence. Agricultural productivity can be increased only if farmers understand the technology being transfered to them on irrigation agriculture. Farmers, training programmes should, therefore, be linked to innovations meant for improving their lot.

Recommendations

Based on the findings of this study, the following recommendations are proposed:

i. The RBDAs should be properly oriented, equipped, staffed and strengthened to perform irrigation extension services.
ii. The cost of irrigation water needs to be subsidized as irrigation technology is relatively new and farmers need to be attracted into the system first with

very minimal cost before gradually increasing it.

iii. The government should adequately fund irrigation agriculture. All abandoned projects should be completed and existing ones given face-lift as strategy for ensuring self-sufficiency in food production.

iv. The emphasis must be placed on irrigation extension services to improve farmers' knowledge on farming and thereby enhance their productivity.

v. The projects should always be constructed according to design and that project funds should not be squardered.

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Pedal-operated Drybean Thresher for Small-scale Farmers

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Abstract

A pedal-powered dry bean thresher for small-scale farmers was designed and tested at the Department of Agricultural Engineering, Sokoine University of Agriculture. This thresher was specially designed for use in small-scale family farms accessed from narrow foot paths. The thresher was built using parts and manufacturing methods that are readily available locally in Tanzania. The threshing mechanism consisted of a rubberized wooden cylinder and a concave.

The thresher was tested for its threshing capacity, threshing effectiveness and seed damage on two improved bean varieties, Tmo 241 and Tmo 216. Results obtained gave a threshing capacity of 26.4 kg/h and 27.6 kg/h for Tmo 241 and Tmo 216, respectively. Threshing effectiveness was 93.4 and 93.1 for Tmo 241 and 216, respectively, and seed damage was 1.5% for Tmo 241 and 1.4% for Tmo 216 at 14% mc.

The cost of production of the thresher was estimated at about US$75 which is within the purchasing ability of most small-scale farmers in Tanzania.

Introduction

In Tanzania, beans (*Phaseolus vulgaris, L*) are grown largely on small-scale farms around farmers' homesteads. Due to the small size of the plots, most of the field and processing operations are done manually, normally by women and children. Bean threshing is one of the most tedious operations in bean processing, consuming a lot of energy and time.

The recent success of research on improved high yielding and disease resistant bean varieties have lead to a tremendous increase in yields in most parts of Tanzania. The increased yields have put more demand on the time and energy resources of the bean farmers, especially during threshing. This made it seem prudent to develop a simple and cheap mechanical means of threshing beans to keep up with this anticipated harvest demands. This challenge was originally addressed by the Department of Agricultural Engineering, Sokoine University of Agriculture. So far the Department has developed one hand-operated bean thresher which proved very popular with bean farmers around the University.

However, despite the fact that the thresher demonstrated a great potential for success, some problems have emerged during field operation. One of the problems was that the feed rate had to be slow to avoid plugging the thresher and the work was strenuous such that it was not possible to operate the machine continuously for a long period of time. Because of these hindrances and in order to facilitate the threshing operation, it was necessary to design a new dry bean thresher for small-scale farmers.

Objectives

Three objectives were identified for the design of this new bean thresher.

i) To develop a thresher that thresh beans from vines in a continuous process with minimal loss and efficient power utilization;
ii) To utilize locally available low cost materials in a design that has a combination of compactness, easy to operate and maintain; high reliability, robustness and one which can be afforded by the small-scale bean farmers in Tanzania; and
iii) To test the thresher and document its threshing capacity and efficiency

Beside these objectives, some design criteria needed to be addressed. It was necessary to design the machine to be conveniently transported on narrow foot paths from the homestead to the farm or from one farm to another. Also, it should be small in size such that it could be stored inside at night to prevent theft. Meeting these and the above objectives should produce a successful design that would meet the needs of most small-scale bean farmers in Tanzania and other developing countries.

Materials and Methods

Thresher Design and Construction

The problems with the previous prototype threshers were plugging and high power consumption. The thresher woud plug and stop when large quantities of pods or vines were fed into the machine. This requires the feeding rate to be very slow and a lot of time was wasted to unplug the thresher. The machine also had high power consumption: It was difficult for one person to operate it continuously for more than 5 minutes. The large power requirements and plugging problem made it necessary to redesign the thresher for more efficient threshing.

In order to solve the problem of thresher plugging it was decided that the momentum and the roughness of the threshing cylinder should be increased so that vines and pods would be pulled through the thresher rather than plugging it. Momentum was increased by enlarging the threshing cylinder diameter from 30 cm to 38 cm; and increasing its speed from 300 rpm to 350 rpm. The combined increase in mass and speed of the threshing cylinder brought about a large increase in momentum. Cylinder roughness was increased by increasing the number of rubber strips on the cylinder surface from six to twelve. In order to reduce the power rquirement, the separating fan on the original design was removed and the hand pedal was replaced by a foot pedal.

The thresher was designed to use a cylinder and concave as its threshing mechanism (**Fig. 1**). The cylinder was constructed from a hard-wood log lathed into a 38 cm cylinder and mounted on 18 mm mild steel shaft. The concave was made from 16 gauge mild steel sheet. Both the cylinder and the concave were covered with used rubber auto tyre belting. Twelve rubber strips, also from used car tyre, were attached to the cylinder surface to aid pulling pods and vine through the thresher thus reducing the occurrence of plugging. The spacing between the threshing surfaces was set so that pods would roll between them to accomplish a gradual shelling action rather than sudden shearing force.

The main body of the thresher was constructed of parts that would likely be found locally in most parts of Tanzania. The frame was built from a 3.5 cm angle iron that was welded together. The gears and chains for power transmission and the foot pedal were all adopted from used bicycle parts. All of the bearing for the shafts were made of oiled hardwoods. Sheet metal was used as guards of the moving parts and could be reverted or screwed in place.

The thresher was operated by one person who pedalled and one person who fed materials into the thresher. The operator needed to maintain a pedal speed of 60-70 rpm to produce a cylinder speed of 300-350 rpm. A coster brake was placed between the operator's pedal mechanism and threshing cylinder in order to stop the machine or to allow the operator to regain his or her footing should slip.

The thresher was designed so as to be easily transported through narrow paths connecting the family's farm plots. It was mounted on two bicycle wheels and the cross-piece below the seat which serves as both a stabilizer when the thresher is in use and as a handle to push or pull the thresher from one plot to another or from farm to home for storage. The thresher was also designed with the safety of the operator's in mind. In order to reduce the chance of injury from gears and chains, guards could be easily attached over exposed gears and chains and other moving parts. (No guards are shown in **Fig. 1** which is only for the purpose of illustration).

Fig. 1 The dry bean pedal thresher.

Capacity Tests

A number of threshing tests were carried out on the thresher to determine its threshing capacity and threshing effectiveness. Each test lasted for 5 min during which one person operated the thresher while another fed material (bean vines) into the thresher. The operator had to maintain a pedal speed of around 60 rpm which produced a threshing cylinder speed of about 300 rpm. Vines were fed into the thresher at a rate which would not exceed the strength and endurance of the operator. The tests were replicated three times. For each run, threshed material was collected on the collection area and separated into three categories: threshed beans in the collection area; unthreshed beans in the collection area; and damaged beans in the collection area.

Due to the different varieties of beans grown in Tanzania, it was necessary to design a thresher that would accommodate these variations. Thus two common bean varieties were used in the determination of performance of the thresher. A large bean; Tmo 241 and a small bean Tmo 216, were used (the former is approximately 1.3 by 0.8 by 0.5 in size while the latter is about 0.9 by 0.6 by 0.3 cm). The moisture content of the beans throughout the test period was 14% (wb).

Results and Discussion

Two series of threshing tests were performed on the bean thresher. The first series utilized Tmo 216 and the second, Tmo 241. Each test was performed in a timed five-minute test period. The results from these tests are summarized in **Table 1**. The results showed a threshing effectiveness of 93.1% and 93.4% for Tmo 216 and Tmo 241, respectively. The threshing capacity was 27.6 kg/h and 26.4 kg/h for Tmo 216 and Tmo 241, respectively. Seed damage was 1.4% for Tmo 216 and 1.5% for Tmo 241.

Tmo 241 was easily threshed than Tmo 216, though this difference was not statistically significant. The threshing capacity was higher in Tmo 216 than in Tmo 241. This difference could be attributed to the difference in pod fill and seed size. Seed damage, although very low for both varieties, was higher for variety Tmo 241 than for Tmo 216 due to the bigger size of Tmo 241 seeds.

The output of the thresher was greatly increased over that of the earlier prototype. An average threshing capacity of 27.6 kg/h for Tmo 216 and 26.4 kg/h for Tmo 241 indicates a human productivity of 13.8 kg/h and 13.2 kg/h for the two varieties, respectively, an increase of almost two times over the previous prototype in which threshing capacity was 7.5 kg/h for both varieties. Also, the problem of thresher plugging was completely solved.

Table 1. Thresher's Performance Results

Item	Tmo 216	Tmo 241
Threshed material (kg)	12.84	11.86
Threshed beans (kg)	2.3	2.0
Unthreshed beans (kg)	0.17	0.14
Total kg	2.47	2.14
Time taken (mm)	5	5
Threshing capacity (kg/h)	27.6	26.4
Threshing effectiveness (%)	93.1	93.4
% Damage	1.4	1.5

Conclusions

The following conclusions can be drawn from the study:

1. The designed thresher is efficient in use of power and productive in capacity. It is operated by two people, one person who pedals and another feeds the vines. The power required to operate the thresher does not exceed the capacity of human being for substantial period of time.
2. The threshing capacity of the thresher indicates a substantial improvement over the previous prototypes and an acceptable output. The average output of 27.6 kg/h allows farmers to expand their farms and use improved high yielding bean varieties without any problem.
3. The machine was simple in design, safe and easy to maintain. The materials are available locally and can easily be manufactured by local artisans or farmers themselves. The thresher is stable and transportable by one person and is easily navigated on narrow paths from farmers' house to the field. The thresher is small and can be stored indoors. The thresher is sturdy in construction given the rough conditions existing on the farms. The total cost of production of the thresher is estimated at the equivalence of US$75.00 hence affordable by most of the bean farmers of Tanzania.

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■■

Utilization of Engine-waste Heat for Paddy Drying and Validation of Stationary-bed Model in Variable Low Temperature Drying

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Abstract

A small engine-powered flatbed rough rice dryer was constructed in order to check the accuracy of the partial differential equation model for deep-bed drying of grain in variable low temperature drying. The validity of the model was checked with experimental data for different depths of rough rice beds dried by engine-waste heated dryer. The model, in general, tended to under-predict the mean moisture content of the grain bed in low temperature drying. The model also under-predicted the temperature in the top layers and the largest difference in observed and predicted temperature was found in this layer. However, a reasonable agreement has been observed between the measured and predicted values. The waste heat was sufficient to increase the drying air temperature from 7 to 12°C at an air flow rate 8.8 to 5.7 m^3/min, while the average ambient temperature and relative humidity were 24°C and 70%. About 195 kg of rough rice was dried in one batch in 14 h using engine-waste heat.

Introduction

Rough rice is ordinarily harvested at moisture contents above safe storage levels, with a normal range from 17 to 25% (w.b.). Sometimes it goes even higher when rice is harvested in wet weather. Unfortunately, the latter case seems to happen quite frequently in Bangladesh and in other rice producing non-industrialized countries. The excess moisture, therefore, must be immediately removed by some drying process, mainly to improve the storability of the grain. Proper drying of freshly harvested paddy is necessary to maintain grain quality and minimize spoilage losses. In tropical areas, humid weather makes the stored rice more susceptible to organisms and mold, especially when the grain moisture exceeds a high level. Many experiments showed that when initial rice moisture content after harvesting is 24% and above, drying must start within 24 hours; with 21 to 23% within 48 hours; and with 18 to 20.9% within three days. In order to avoid the danger of deterioration, the drying operation should be carried out as soon as possible. Drying may be achieved by either the sun or a mechanical drying method.

Rough rice drying in non-industrialized countries like Bangladesh is commonly achieved by spreading it on beaten earth or mats directly exposed to solar radiation. Using the sun drying method, there is no guarantee on the final quality of dried rice. This method is slow and susceptible to rainfall, birds, insects, dust and other contamination. Spoilage may also result from occasional rains. Accurate scheduling of farm operations and efficient use of land, labor, machinery, and other resources can not be coordinated well with the sun drying method due to weather uncertainty. Most of the farmers in Bangladesh and in other non-industrialized countries operate on a small scale and can not afford sophisticated mechanically powered drying systems. An intermediate solution, that takes the advantage of the availability of small engine used for small-scale irrigation and rice milling purposes, is the engine-wasted heat grain dryer. Recent work by Basunia et al. (1996) on the simulation of engine-waste heated rough rice dryer has proven that engine-waste heat is a potential source of energy for low temperature grain drying in the rural areas of non-industrialized countries. The partial differential equation model of deep-drying of grain, basically developed for high temperature drying, has not yet been validated for variable low temperature deep-bed drying of rough rice such as by engine-waste heat. In this paper, the simulation study (Basunia et al. 1996), on the basis of the measured available engine-waste for drying using stationary-bed grain drying model, is extended to practical work.

The specific objectives of this study were: (i) to utilize the engine-waste heat for rough rice drying; and (ii) to validate the stationary-bed grain drying model for variable low temperature drying of rough rice.

Materials and Methods

A prototype of the engine-powered flat bed rough rice dryer was constructed as described by Basunia et al. (1996) and shown in **Fig. 1**. Temperature, relative humidity and flow rate of the drying air were monitored while drying each of 10-, 20-, 30- and 40-cm deep grain beds according to the procedure described by Basunia et al. (1996). In order to test the validity of the drying model in low temperature drying, comparisons were made by drying 10-, 20-, 30- and 40-cm deep rough rice bulks with a constant dryer base area of 0.81 m^2.

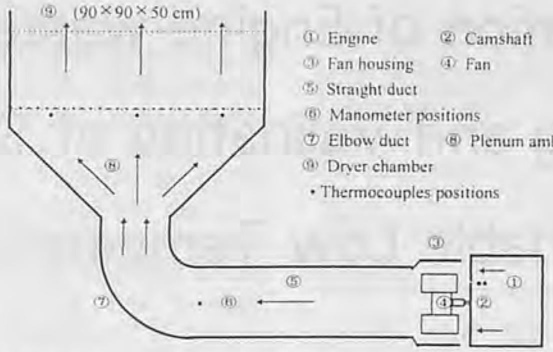

Fig. 1 Schematic diagram of the drying apparatus used in the experiment.

To monitor the drying air temperatures while drying different depths of grain beds, three copper constantan thermocouple probes were connected at the entrance of the dryer base (**Fig. 1**). Temperatures measured by three thermocouples were averaged and recorded as the drying air temperature. Nine thermocouples were connected within the grain bed, three at each of top, middle and bottom layers of the grain bed while drying 20-, 30- and 40-cm deep grain beds. Temperatures were recorded at the bottom and top layers only while drying a 10-cm deep grain bed. At each layer thermocouples were placed at three locations: the center, near the wall, and between the center and the wall of the dryer. At each location, the temperature was recorded individually to find the temperature gradient in the horizontal direction of the dryer and then an average was made at each layer. Thus the temperature recorded at the bottom, middle and top layers during the drying period were the mean of three replications, respectively. Two thermocouples were placed just over the grain bed to record the dry-bulb and wet-bulb temperatures of the air leaving the grain bed while drying different depths of grain beds. Two more were also used to record the ambient dry-bulb and wet-bulb temperatures. Thermocouple probes were connected through an interface of an AD converter (Green kit 77A model) then to personal computer for data collection. The temperature readings from the thermocouple probes were recorded every five minutes. The air flow rate was measured indirectly by connecting manometers at the end of the straight duct. The relative humidity was calculated from the measured dry-bulb and wet-bulb temperatures.

For the determination of moisture content of the grain bed during the drying periods, grain samples were collected from the top, middle and bottom layers at hourly intervals while drying 20-, 30- and 40-cm deeps grain bed. Moisture contents were determined at the top and bottom layers only, at the same interval, while drying a 10-cm deep grain bed. Grain samples were collected from the middle and bottom layers by manual probe. Grain samples from the surface layer were collected directly by hand. At each layer grains were collected from three locations: the center, near the wall, and between the wall and the center of the dryer. At each location moisture content was determined individually in order to determine the moisture gradient in the horizontal direction and then the average was made at each layer. So the moisture content at each layer at an interval of one hour was the mean of three replications. The moisture content measured at the top, middle and bottom layers were averaged which represented the mean moisture content of the entire grain bed during the drying periods. Thus, the mean moisture content during the drying period was the mean of nine replications. The moisture content was checked by a single grain moisture meter before drying terminated. The engine was stopped when the average moisture content of the grain bed was approximately 15% (w.b). Finally, the moisture content was confirmed by the oven drying method, according to the standard procedure of the Japanese Society of Agricultural Machinery (JSAM). After the drying was terminated, the grain was left in the dryer undisturbed for about 10 h. The average moisture content of the entire grain bed was also measured 10 h after the air supply was stopped while drying each depth of grain bed.

Medium grain (Japonica type) rough rice was used for the experimental studies. It was grown in southwest area of Japan and harvested in October 1995. It was harvested at an average moisture content of 24.7% w.b. and was stored at a low temperature at this moisture level in a refrigerator for the subsequent drying tests. The tests were done in the research laboratories of the Biomechanical Systems Department at the University of Ehime, Matsuyama, Japan.

Results and Discussion

Comparison of the Measured and Simulated Values

The detail of the stationary-bed grain drying model and their numerical solution in finite difference method have been described by Basunia et al. (1996) and others. The main (basic) input data for the simulation model is shown in **Table 1**, which are slightly different than the simulated values as indicated by Basunia et al. (1996) because of the different ambient conditions and air flow rates during practical drying. So the simulation was repeated for the values as found practically **(Table 1)** to validate the model in variable low-temperature drying. Standard tabulated values were used in the model regarding the drying air, the medium grain rough rice and the water properties. Drying air temperatures and their relative humidities changed in the model every hour as observed practically throughout the drying period while drying each depth of grain bed.

Deep-bed drying of rough rice was simulated using the Page type (Page, 1949) empirical equation developed by Agrawal and Singh (1984). The equilibrium moisture content (EMC) of rough rice was calculated using the Chung and Pfost (1967) equation developed by Zuritz et al. (1979). With Δz = 1 cm and Δt = 1 min, the total time for computation and printing results for a 1 hour interval was approximately 15 min in a microcomputer for the total drying period 14 h, which is very low.

The principal measured and simulated results are shown in **Figs. 2** and **3** which plot the moisture content (% w.b.) against drying time. Almost no moisture or temperature gradient was observed in the horizontal direction of the dryer. This indicated that heat and mass transfer were mainly in the vertical direction which satisfied one of the assumptions made for the derivation of the model.

As the speed of the engine was kept constant at 3 000 rpm, the air flow rate, drying air temperature and relative humidity were varied depending upon the depth of grain bed and ambient temperature **(Table 1)**.

Figures 2(a), (b), (c) and **(d)** show, respectively, a comparison of the measured and simulated moisture content at different layers of 10-, 20-, 30- and 40-cm deep beds of rough rice bulk. Good agreement has been observed between the measured and simulated moisture contents at given layers of a 10-cm deep grain bed **(Fig. 2a)**. Simulated and measured moisture contents at given layers of higher deep of grain beds do not agree well with the exception of the middle layers **(Figs. 2b-d)**.

Figures 3(a), (b), (c) and **(d)** show, respectively, a comparison of the predicted and simulated mean moisture contents with drying periods for 10-, 20-, 30- and 40-cm deep grain beds. Good agreement between the measured and predicted mean moisture content of the entire grain bed was found in smaller depths of grain beds compared to larger depths

Table 1. Air Flow Characteristics for Different Depths of Grain Beds at Engine Speed of 3 000 rpm

Depth of grain bed (cm)	Air flow rate (m^3/min)	Static pressure (Pa)	Drying air		Ambient air	
			Temperature	r.h.*	Temperature	r.h.*
10	8.8	50	29.2	44.3	22.3	81.8
20	7.7	98	32.3	31.6	24.1	67.2
30	6.9	120	33.8	25.0	24.3	68.2
40	5.7	138	36.4	24.6	24.7	64.1

*r.h. = relative humidity

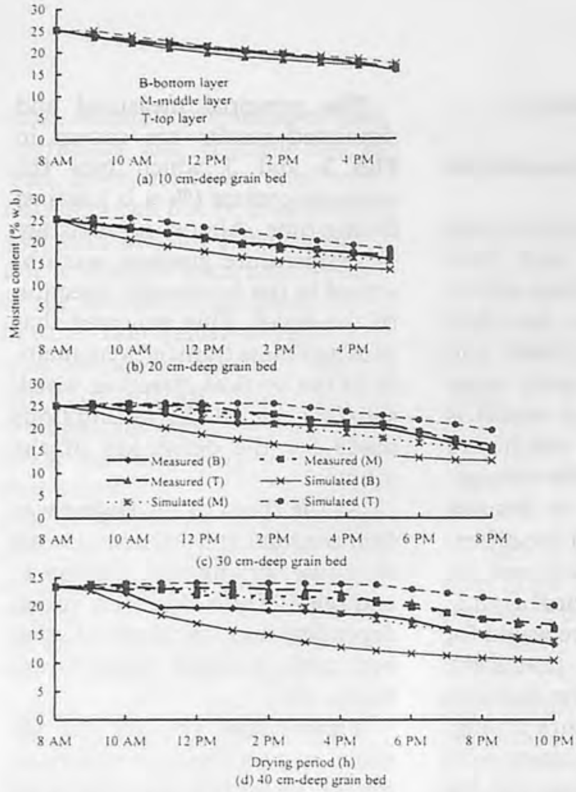

Fig. 2 Comparison of measured and simulated moisture content at given layers of different depths of grain beds and under different drying conditions.

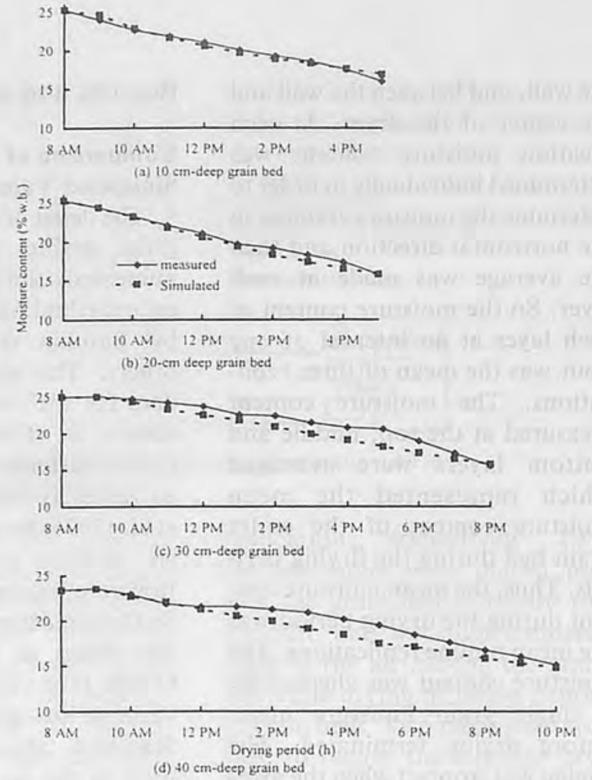

Fig. 3 Comparison of measured and simulated mean moisture contents (% w.b.) for four different depths of grain beds and under different drying conditions.

(Figs. 3a and 3d). In most of the cases, the simulation tended to consistently predict faster drying. The difference in moisture values was larger in the higher depths of grain bed (Figs. 2c and 2d). The simulation showed that the moisture gradient between the top and bottom layers of a 40-cm deep grain bed was about 9.4% (w.b.) (Fig. 2d). But in practical drying it was only 3.4%. Though, in general, the model predicted the mean moisture content of the grain bed with reasonable accuracy, but it over-predicted at the top layer and under-predicted at the bottom layer (Figs. 2a-d). The difference in moisture values was larger in the bottom layers than in the top layers. The maximum difference between the measured and simulated moisture contents was 4.5% (w.b.) in the bottom layer of a 40-cm deep grain bed. The fact that the single layer equations predicted a faster drying rate in the bottom layer than observed suggests that a slow drying rate

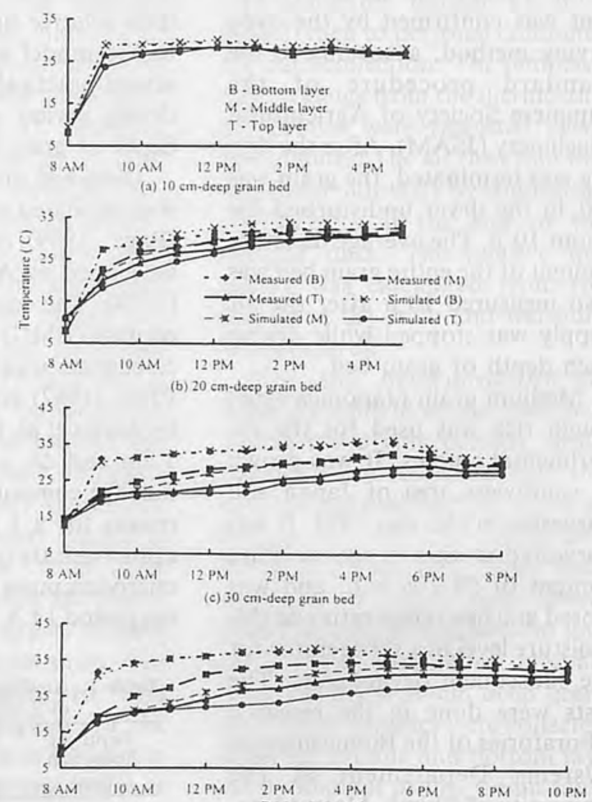

Fig. 4 Comparison of measured and predicted temperatures at given layers for four different depths of grain beds and under different drying conditions.

should be theoretically expected in the top layer due to the lower or reduced drying potential of the air as it reached the top layer. This did happen, and the simulation model over-predicted in the top layer. However, the difference between the predicted and actual moisture value was much smaller. An explanation for this trend could be the way that the condensation of water from the saturated air in the upper layer was calculated in the simulation program. When the drying air attained an infeasible state (relative humidity > 100%) at the early stage of drying, it was necessary to simulate the condensation of water from the air into the grain to bring the relative humidity between 99 and 100%. In the drying test, the relative humidity of the drying air in the upper layer did not exceed 100% at all while the depth of grain bed was within 30 cm. The relative humidity was slightly over 100% for the first half hour of drying only while the depth of the grain bed was 40 cm, but it was more than 90% for a long time. Therefore, limitation of 100% relative humidity of the drying air in the simulation model did not cause any discrepancy in the simulated results. The measured moisture content of the top layer of grain bed, however, was lower than in the simulation. This discrepancy indicated an insufficient precision of the moisture equilibrium isotherm equation in the deep bed drying model at relative humidity above 90%. The over-drying in the bottom layer of rough rice was possibly due to the lack of accuracy of the thin-layer rough rice drying equation in low temperature drying which was basically developed for high temperature drying (+60°C) (Sharp, 1982). These might have caused under-prediction of moisture in the bottom layer and the over-prediction in the top layer.

Simulated air temperatures are compared with observed temperatures at given layers and for given depths of grain bed in **Fig. 4**. In all the cases of drying, a reasonably good agreement was observed between the measured and predicted temperatures at the bottom and middle layers of the grain bed, respectively, **(Figs. 4a-d)**. Simulated temperatures were lower than the observed values at the top layers and the largest difference was generally, in the top layers. The under-prediction of temperatures in the top layers appears to agree with the general over-prediction of moisture in the top layers. Since less moisture was removed from the top layers, less water was evaporated leaving more energy available as sensible heat, thus the measured temperature was higher than the simulated temperature. There was no significant difference between the simulated air and grain temperatures.

Dryer Performance

The main experimental results are summarized in **Table 2**. It was observed that within the range of 5.7 to 8.8 m^3/min of air flow, engine-waste heat was sufficient to increase the drying air temperature 12 to 7°C, while the average temperature and relative humidities of the ambient air were 24°C and 70%. The moisture content of all rice was approximately 24.7% (w.b.) at the beginning of drying and was dried to an overall average of approximately 15.5% moisture content (w.b.). The average bulk density of rough rice was approximately 605 kg/m^3, according to the volume occupied by the grains in the dryer. The initial weight of the moist grains in 10-, 20-, 30 and 40-cm deep grain beds in the dryer are shown in **Table 2**.

The results show that the drying times required to bring the average approximate moisture content of 15.5% (w.b.) from the initial 24.7% moisture content (w.b.) were 9, 9, 12 and 14 h in drying 10-, 20-, 30- and 40-cm deep grain beds, respectively **(Fig. 3)**. The durations required in drying 10- and 20-cm deep grain beds were similar because of the comparatively high ambient air relative humidity while drying the 10-cm deep grain bed. Another reason is that, as the depth of grain bed was reduced, drying air quickly moved through the grain bed without proper utilization due to its high velocity. The moisture gradient was negligible in the horizontal direction at the end of drying. The moisture gradients between the top and bottom layers were 0.4, 1.6, 2.2 and 3.4% (w.b.) of 10-, 20-, 30- and 40-cm deep grain beds, respectively, at the end of drying. These results show that the moisture gradient between the top and bottom layers is a problem in a deeper grain bed. The moisture gradient increased as the depth of grain bed was increased. The measured moisture gradient was considerably high in the 40-cm deep grain bed. This indicates that, if 4% moisture gradient is considered acceptable then 40- to 50-cm deep of grain bed seems to be optimum in order to avoid over-drying in the bottom layer and under-drying in the top layer. The average moisture content of the entire grain bed determined immediately after stopping the engine was

Table 2. Effect of Depth of Grain Bed on Moisture Gradient to Dry to 15.5% m.c. (w.b.) from Average Initial Moisture Content 24.7% w.b.

Depth of grain bed (cm)	Initial weight of grain (kg)	Moisture content (% w.b.) after drying: Top layer	Moisture content (% w.b.) after drying: Bottom layer	Moisture gradient % w.b.
10	48.5	15.5	15.9	0.4
20	96.0	14.8	16.4	1.6
30	141.8	14.3	16.5	2.2
40	193.2	13.5	16.9	3.4

1.5 to 2% more than the moisture content determined after 10 h, while drying each depth of grain bed. This indicates that it is better to under-dry the grain by 1.5 to 2% m.c (w.b) than the safe moisture level for storage and leave the grain in the dryer undisturbed for a few hours to avoid over-drying.

Conclusions

The partial differential equation model of grain drying can predict the temperature and mean moisture content changes with position and time with reasonable accuracy. Although an exact prediction of grain dryer performance may be impossible, comparative performance studies of different dryer designs can be made with confidence. In the deep bed simulation, the mean moisture content was under-predicted by the thin-layer empirical equation in low temperature drying. The model over predicted the moisture content at top layers and under-predicted at bottom layers. The largest difference between the observed and predicted moisture contents were at in the bottom layers. This study reveals that a more accurate measurement of low temperature thin-layer drying and equilibrium moisture content of rough rice over 90% relative humidity are very important to the stationary deep-bed drying simulation model to predict the deep-bed drying well.

The engine-wasted heat grain dryer can be used in the rural areas of non-industrialized countries like Bangladesh.

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The World Food Prize

The World Food Prize Foundation requests nominations for the 1998 World Food Prize, which recognizes outstanding individual achievement in improving the quality, quantity, or availability of food in the world. The Prize emphasizes the importance of a nutritious and sustainable food supply for all people and recognizes that improving the world's food supply for the long term depends on nurturing the quality of land, water, forests, and other natural recources.

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Design, Development and Testing of a Low-cost Vegetable Seed Extracting Machine

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Abstract

A vegetable seed extracting machine was designed and developed. The cost of fabrication of the machine was US$62.50. The machine consists of a fixed cylindrical casing with a sieve and rotating shaft with cutting, crushing and conveying blades. Water was sprinkled during seed extraction. The test results of this machine using a 0.5 hp electric motor showed that the capacity was 210.96 kg/h for tomato at 370 rpm with an average seed extraction efficiency of 84.7%. The germination percentage of the seed was 82.8% without any visible damaged seeds. The cost of seed extraction was US$0.18/qtl. (1 US$ = Rs. 32.00)

Introduction

Vegetables are universally recognized as an important food and are rich sources of certain essential vitamins, minerals, proteins and dietary fibres which also provide additional calories. India is the second largest producer of vegetables next to the Peoples' Rep. of China with an estimated production of about 48.5 million mt from an area of over 4.5 million ha. India produces the largest variety of vegetables. However, the daily per capita consumption of vegetables in India is only 135 g which is much less than the requirement of about 285 g for a balanced diet.

Increased production and improved handling of vegetables have great potential to enhance the nutrition of rural and urban poor as well as the increase their income and provide greater employment opportunities. Economic trends suggest that vegetable will increasingly contribute to improved diets in developing countries, particularly in India. The non-availability of quality seeds, due to its inadequate production, is the most important constraint. The cost of quality seeds is too high because of limited production and availability.

Seed extraction from matured vegetables is carried out mostly by manual methods. Manual techniques include crushing of the fruits with packer or wooden mallet, trampling under feet and squeezing with hands followed by scooping the seeds with hand. In the case of some vegetables, after crushing they are kept in water for fermentation for 24 to 48 hours. Then the seeds are separated cleaned and dried. Manual seed extraction is unhygenic and highly time- and labour-consuming as it often leads to physical injuries to the hands and feet of the workers. Non-availability of trained and experienced labour for manual seed extraction during peak harvesting season is another serious constraint. In addition, manual seed extraction practices are slow. Mechanical extraction of seed has not gained popularity in the country, in general, and in Orissa, in particular, because the seed extraction machines are mostly imported ones which are costly and, therefore, beyond the means of small farmers. Therefore, it was decided to develop a small vegetable seed extracting machine.

Literature Review

Nicholos (1971) developed a mechanical seed extracting machine which comprises of a rotary shaft with beaters which rotates inside a horizontal fixed drum. Seed separating screen, holding frame, seed and pulp outlet and a water pipe attachment are the major components of the machine. The capacity of the machine was 2 000 kg/h for tomato, with 0.5 hp electric motor. It was operated by two persons. Kalra et al. (1983) developed a manually-operated tomato seed extractor which has a rotary hollow metalic cylinder with corrugations and a helix fixed on its surface, a stationary expanded metal concave, a feed hopper and a holding frame. This machine had a capacity of 60 kg/h for tomato. Verma, Singh, Kalkat (1992) developed an axial flow vegetable seed extracting machine to extract the seeds from common Indian vegetables. The machine comprises of a frame, a cylindrical casing, a feeding chute, axially mounted cutting, crushing, sweeping and conveying blades, water sprinkling system, and seed and pulp outlet. The capacity of the machine was 1 930 kg/h, 500 kg/h and 460 kg/h for tomato, brinjal and chilli, respectively, using a 2 kW electric motor. This machine was operated by 3 persons.

Materials and Methods

The various factors considered for design and selection of materials for the vegetable seed extracting machine are;

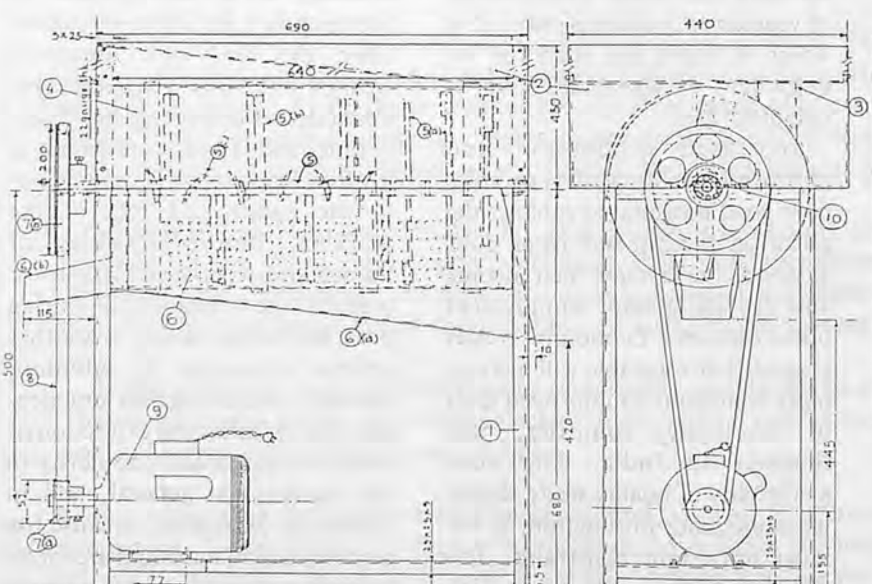
1. Suitability of the machine for wet seed extraction.
2. Axial flow of material inside the machine.
3. The spare parts should be locally available and its operation and maintenance should be easy for semi-skilled worker.
4. Power requirement of the machine should be within the capacity of 1 hp prime mover and the total cost of the machine should be low.

The machine comprises of a frame, hopper, cyclindrical casing with sieve, rotor shaft with cutting, crushing and conveying elements, tray for collecting seeds along with juice, pulp outlet and seed outlet.

Frame - The frame is made of M.S. angle of 25 × 25 × 3 mm size with height of 66 cm and 32 cm width. The motor base and cylindrical casings are attached to this frame. It is designed for minimum vibration in operation.

Hopper - The hopper is 78 cm in length 38 cm in width and 43 cm in height and made of G.I. sheet metal and has an inlet opening of 12 × 10 cm. The hopper base has an angle of 15° to horizontal. The feeding material enters the cutting chamber through the inlet opening on the inclined G.I. Sheet.

Cylindrical casing - The cylindrical casing is of 32 cm dia and 64 cm length consisting of two halves. The upper half is a G.I. cover with inlet for vegetable



MATERIAL LIST

P.No.	DESCRIPTION	MAT.	SIZE/mm	NOS
1	FRAME	M.S. ANGLE	25X25X3	-
2	HOPPER	M.S. FLAT G.I. SHEET	25×3 22 gauge	-
3	INCLINED PLATE WITH CHUTE	G.I. SHEET	22 gauge	
4	SEED EXTRACTING DRUM	G.I. SHEET	22 gauge	
5	ROTOR SHAFT	M.S. ROD	22 ϕ	1
5(a)	CUTTING BLADE	M.S. FLAT	25×3	6
5(b)	CRUSHING BLADE	M.S. ANGLE	25×25×3	6
5(c)	CONVEYING RAKE	M.S. FLAT	25×3	6
6	SIEVE	G.I. SHEET	22 gauge	1
6(a)	SEED TRAY	G.I. SHEET	22 gauge	1
6(b)	PULP OUTLET	G.I. SHEET	22 gauge	1
7	PULLEYS			
7(a)	MOTOR PULLEY	C.I	52	1
7(b)	ROTOR PULLEY	C.I	200	1
8.	V-BELT	—	B-59	1
9.	MOTOR	—	1 HP	1
10	BEARING FOR ROTOR	BALL-BEARING	ϕ 40	2

Fig. 1 Design details of vegetable seed extracting machine.

Fig. 2 Front view (Chopper is removed).

Fig. 3 Left hand side view (without hopper).

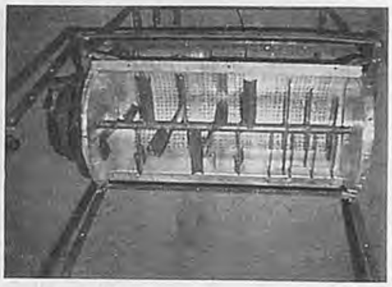


Fig. 4 Rotor shaft (When hopper and upper half of cylindrical casing is not attached).

and for sprinkling of water and the lower half is a G.I. sieve with 5 mm dia holes at a spacing of 7.5 mm c/c. The two halves are reinforced with M.S. flats and angles and are attached to the frame.

Rotor shaft - The rotor shaft is 22 mm dia M.S. rod of length 75 cm. The effective length remaining inside the cylindrical casing is 68 cm on which three sets of blades for cutting, crushing and conveying the vegetables are attached. Three cutting blade holders of length 8, 10.5 and 12.5 cm are arranged in a row 5.6 cm apart. Two such rows are provided on the rotor shaft 180° apart with provision for attaching replacable cutting blades. Four counter blades of 12.5 cm length each are welded to the cylindrical casing for effective cutting. The cutting blade holders and counter blades are made of 25 × 5 mm M.S. flat. The crushing blades are made of 25 × 25 × 3 mm M.S. angle of length 12.5 cm each. Six such blades were welded directly on the rotor shaft spirally 90° apart. The conveying rake with holders are made of 25 × 5 mm M.S. flat of 12.5 cm length with a curved M.S. sheet of 7 × 6 cm size welded at its tip helped in pushing the crushed vegetables axially towards the pulp outlet. There are 6 of conveying rake holders welded spirally 90° apart. Curved M.S. sheet of 7 cm × 6 cm size were also attached to the tips of the cutting blades for feeding the cut materials to the crushing zone.

Seed and pulp outlet - A curved G.I. tray is provided for collection of juice with seeds. A pulp outlet is provided at the other end with an inclined chute for collection of crushed pulp with seeds if any.

It is decided to use a 0.5 hp electric motor for testing which is attached to a motor base made of M.S. angle. A pulley of 5 cm dia size is used with the motor and attached by a v-belt to a 20 cm dia. pulley on the rotor shaft for providing an rpm of 370. A plastic bucket with a pipe is provided to sprinkle water flowing by gravity through small nozzles into the cylindrical casing.

For calculation of various parameters the following formulae have been used.

Percentage of seed loss (%)

$$= \frac{S_2}{S_1 + S_2} \times 100$$

Percentage of damaged seed (%)

$$= \frac{S_d}{S_1 + S_2} \times 100$$

Seed extracting efficiency (%)

$$= \frac{S_1}{S_1 + S_2} \times 100$$

Where,

S_1 = Weight of seeds collected (under the sieve) from the seed outlet, kg.

S_2 = Weight of seed passing through the pulp outlet, kg.

S_d = Weight of damaged seed, kg.

Test Results

The results of the tests conducted with the designed and developed vegetable seed extracting machine are shown in **Table 1**.

Economics of Use

The hourly cost of operation of the machine was calculated taking the cost of machine (P) as Rs. 2 000.00, its useful life (L) 2 000 hours in 8 years and salvage vaue (S) as 5% of P as follows:

Fixed costs

1. Depriciation, (P − S)/L = Rs. 0.95/h
2. Interest @18% of (P + S)/2 = Rs. 0.756/h
3. Cost of shelter @1.5% of (P+S)/2 = Rs. 0.063/h

Variable costs

1. Repair and maintenance @15% of P = Rs. 1.20/h

Table 1. Test Data per Capacity, Extraction Efficiency*

RPM Rotor shaft	Total quantity of tomato seed (kg)	Time taken for seed extraction (min, sec)	Capacity (kg/h)	Seed output (g) (after drying)	Seed loss (g)	Seed extraction efficiency (%)
370	5	1'22"	219.51	14.25	2.934	82.92
370	5	1'27"	206.89	14.775	2.850	83.82
370	5	1'29"	202.24	15.320	2.816	84.47
370	5	1'23"	216.86	13.385	1.970	87.28
370	5	1'26"	209.30	15.890	2.798	85.04
Average	5	1'25"	210.96	14.724	2.637	84.70

*No damaged seeds were visible in all five cases.
Feeding of each sample was done twice successively in each case.

2. Labour cost (two workers with hourly wage of US$0.78 each of 8 hours work) = Rs. 1.56/h

Total hourly cost = Rs. 4.53/h

Taking over head charges 20% the cost of operation of the machine = Rs. 11.07/h

The hourly cost of operation of the motor is calculated by taking the cost of motor (P) as Rs. 4 500.00, its useful life (L) 15 000 hours on 15 years and salvage value (S) as 10% of P.

Fixed costs

1. Depreciation, (P − S)/L = Rs. 0.27/h
2. Interest @18% of (P + S)/2 = Rs. 0.445/h

Variable costs

1. Repair and maintenance @5% of P = Rs. 0.22/h
2. Power cost (Power consumption has been calculated as 0.37 kW/h, taking the cost of power as 0.95/kWh = Rs. 0.35/h

Total cost of motor operation = Rs. 1.28/h

Taking over head charges 20%, total cost of operation of motor = Rs. 1.53/h

So the cost of seeds extraction/h = Rs. 12.60/h

Taking the capacity of the machine as 210.96 kg/h

The unit of cost of seed extraction for tomato = Rs. 5.90/qtl. = US$0.18/qtl

Summary and Conclusion

1. The cost of the developed power-operated vegetable seed extracting machine was US$ 62.5 (without motor).
2. The capacity of the developed vegetable seed extracting machine was 210.96 kg/h for tomato (BT-1) at a rpm of 370. This capacity was measured by using a sieve with 3/16 inch (4.76 m) dia holes.
3. The average seed output was 2.944 g/kg.
4. The average seed loss was 0.527 g/kg.
5. The average seed extraction efficiency was 84.70% with no visible seed damage.
6. The germination percentage was 82.8%.
7. The cost of seed extraction by this machine was US$ 0.18/qtl.

Table 2. Effect of Mechanical Seed Extraction on Germination

No. of Seeds Tested	No. of Germinated Seeds	Percent of Seed Germination
100	86	86
100	83	83
100	81	81
100	85	85
100	79	79
Average	82.8	82.8

Table 3. Seed Output Capacity for Manual Tomato Seed Extraction*

	Total weight of sample (g)	Weight of dried seeds (g)
	1 000	3.245
	1 000	3.320
	1 000	2.975
	1 000	3.184
	1 000	2.988
Average	1 000	3.142

*Seed loss in all cases was negligible.

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■■

Design and Development of Feeding Unit to Power Groundnut Stripper for Operators' Safety

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Abstract

A feeding unit was designed and developed as an attachment to a mechanical groundnut stripper. The width of the conveyor belt was 250 mm with a peripheral speed of 4.2 m/min. The design rotational frequency of the driving roller was 15 rev/min. Top and bottom metal plate belt supports were provided so that the groundnut plants were held firmly in between the belts when the moving belts carried them.

Introduction

Groundnut or peanut, *Arachis hypogaea L.* is a major oilseed crop in India. India ranks first in the world in terms of both groundnut area and production which were 7.7 million ha and 6.6 mt, respectively, (Babu and Reddy, 1989). The total groundnut production in the country increased from 5.12 mt in 1985-86 to 8.62 mt in 1992-93 (Anon., 1994). Manpower availability in the farm decreased from 82.7% in 1951 to 79.3% in 1981 due to migration of farm hands from rural to urban areas (Anon., 1982). The educated youth generally shun away from farm work due its tedious nature and also due to better employment opportunities throughout the year in urban areas. Hence, labour-saving groundnut strippers are handy when farm labor is scarce.

One of the reasons for the non-popularity of power-operated groundnut strippers is their lack of safety arrangement to the operator's hands during operation. Hence, an appropriate feeding mechanism to ensure safety of the operators' hands is a necessary attachment to the groundnut stripper. For this purpose, a belt-type mechanical feeding attachment for the power-operated groundnut stripper was designed and developed.

Review of Literature

Thangavelu and Swaminathan (1985) studied the performance of plain beater, star, delta, eye, loop, nail and screw type of stripping drums. The rotor speed was varied from 2.83 to 4.65 m/s. The output and percentage damage were determined at different moisture contents of the crop ranging from 15 to 40%. The study shows that the screw type stripping drum was better than the other types.

Thangavelu et al., (1986) optimized the spacing of stripping pegs along with the periphery of stripping drum as 160 to 200 mm and spacing of pegs along the axis of the drum as 20 mm for efficient stripping. The force required to strip a single pod varied from 45 to 50 g which is 10 times that required for wheat or rye grain.

Verma et al., (1990) developed mechanisms for removing the shucks from the mature pecan nuts. Two high friction belts were used for shucking the nuts by means of different relative speeds in the same direction.

Gol and Nanda (1991) developed and tested a power-operated double drum groundnut pod stripper with vertical spikes. The study shows the following: a) the peripheral speed of 615 m/min for the stripping cylinder was optimum for maximum stripping capacity of the groundnut pods; b) the capacity of the stripper was 72 kg/ha at 24.49% moisture content (w.b.).

Mathew and Shukla (1991) incorporated a feeding unit to the mechanical sugarcane cleaner and evaluated the performance of the machine. A maximum cleaning efficiency of 87.4% was obtained

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for the double cane feed rate which decreased with an increasing feeding unit speed. Cane stalk and cane eye damage increased with an increase in feed rate and feeding unit.

Datta (1991) surveyed the thresher accidents in Punjab and found that about 73% of the accidents were due to human factors like lack of skill and entanglement of garments and clothes. About 13% of the accidents were due to machine factors like improper feeding system and use of inferior material of construction. In order to minimize the accidents, he suggested to modify the feeding system in the threshers.

Materials and Methods

The components of the feeding unit were designed and developed. The performance of the machine was evaluated after attaching the feeding unit.

Design of Belt Width and Length

The width of conveyor belt was 250 mm considering the average length of vines minus the leafy portion of groundnut plants.

The length of the conveyor belt (open flat belt) for the lower belt assembly was determined by using the following formula:

$$L = \frac{\pi}{2}(D_1 + D_2) + \frac{(D_1 - D_2)^2}{4C} + 2C$$

where

C = distance between the center of the two rollers

D_1 = diameter of driving roller

D_2 = diameter of driven roller

The length of the straight selections in the upper conveyor belt (**Fig. 1**) was calculated by the following formula:

$$L_{ij} = [C_{ij}^2 \pm \{\frac{PD_i \pm PD_j}{2}\}^2]^{1/2}$$

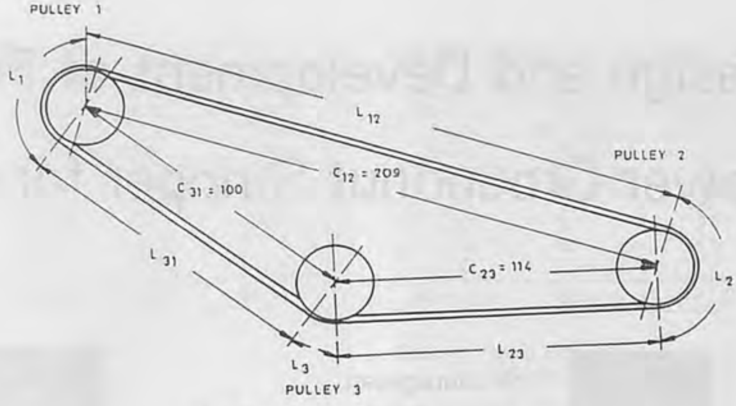

Fig. 1 Upper conveyor belt assembly.

where i and j are the two sheaves. The −ive sign is used for open sections and +ive sign for closed sections.

The arc of contact was calculated by the expression:

$$\phi_j = \pi - \tau \pm \phi_{ij} \pm \phi_{jk}$$

where

$$\phi_{ij} = \frac{PD_j \pm PD_i}{2C_{ij}} \text{ and}$$

τ_j = angle between center to section lines of each roller. The belt length of each curved section was calculated by the relation:

$$L_j = \frac{\phi_j PD_j}{2}$$

The total length of the upper belt = length of straight sections + length of curved sections.

The length of the lower and upper conveyor belts were determined to be 4.50 m and 4.51 m, respectively.

Design of Roller Shaft

Diameter of driving pulley, D_1 = 90 mm

Diameter of driven pulley, D_2 = 90 mm

Power transmitted by the belt = 0.5 hp at 15 rev/min

Torque transmitted by the driven

$$\text{pulley, } T = \frac{0.5 \times 4\,500}{2\pi \times 15} = 23.88 \text{ kgm}$$

If T_1 and T_2 are tensions of the tight and slack sides of the belt, respectively,

$$(T_1 - T_2) \times \frac{D_2}{2} = T$$

$$T_1 - T_2 = 530.78 \text{ kg} \quad (1)$$

Coefficient of friction for fabric belt on wooden roller, μ = 0.23

Angle of lap

$$= 180 - \frac{D_2 - D_1}{C} \times 60$$

$$= 180°$$

$$= 3.14 \text{ rad}$$

By Euler's formula

$$\frac{T_1}{T_2} = e^{0.23 \times 3.14}$$

$$\frac{T_1}{T_2} = 2.06 \quad (2)$$

By solving the equation (1) and (2),

T_2 = 500 kg

T_1 = 1 032 kg

T_1 was taken as uniformly distributed load acting on a span of 300 mm ie., the length of roller shaft (**Fig. 2**).

Uniformly distributed load, w = 3.44 kg/mm

Maximum bending moment, M =

$$\frac{wl^2}{8} = 38.6 \text{ kg/m}$$

Moment of inertia, $I = \frac{\pi}{64}d^4$

Permissible bending stress, f = 1 650 kg_f/cm^2

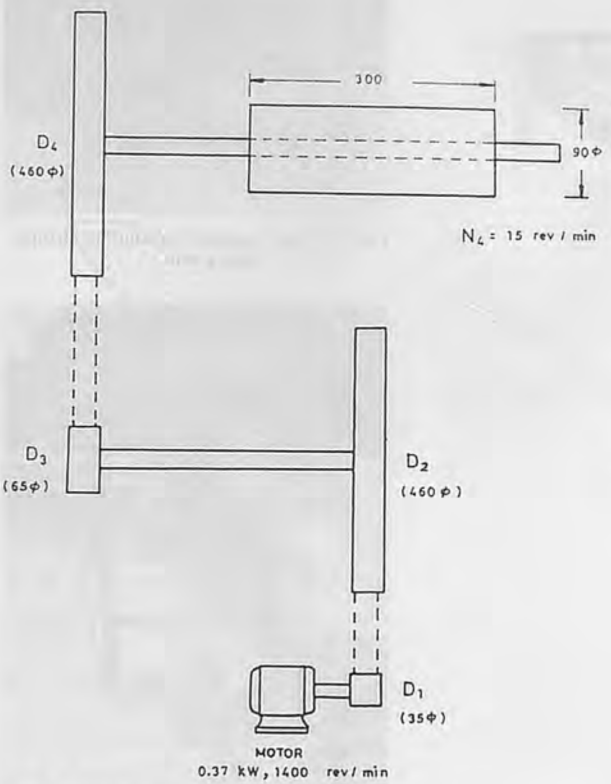

Fig. 2 Speed transmission system.

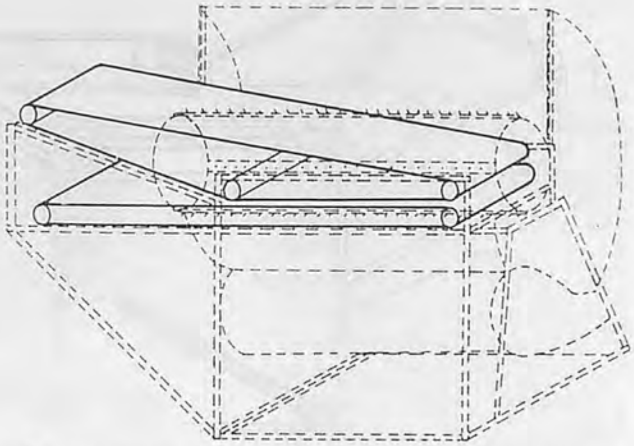

Fig. 3 Schematic diagram of belt-type mechanical groundnut stripper.

Maximum fibre distance, y = d/2

Using flexural formula, $\frac{M}{I} = \frac{f}{y}$

Therefore shaft diameter, d = 28.7 mm

Hence 30 mm diameter mild steel (MS) shaft was used for mounting the wooden rollers.

Design of Rollers

Design width of the conveyor belt was 250 mm. The width of the rollers was 300 mm allowing 25 mm clearance on either side. The length of travel of groundnut crop in the stripper which is the total length of stripping drum was 1 440 mm. Generally, four labourers feed the harvested groundnut plants to the unit. The total time of contact between plants and stripping drum was 20 seconds (**Fig. 3**).

Design feeding belt speed

$$= \frac{1\,400 \text{ mm}}{20 \text{ s}}$$

$$= 4.2 \text{ m/min}$$

Taking the diameter of driving roller of the lower conveyer belt assembly as 90 mm.

$$\pi DN = 4.2$$

$$N = \frac{4.2}{0.09XII} = 15 \text{ rev/min}$$

Design rotational frequency of driving roller = 15 rev/min.

In order to obtain the design rotational frequency of the driving roller of 15 rev/min, a two-stage speed reduction was adopted with the use of V-belts and pulleys. A 0.37 kW, 1 400 rev/min AC single phase motor was used as power source for the feeding unit assembly.

Development Details

The components of the feeding unit assembly (**Fig. 4**) viz., wooden rollers, feeding chute, outlet chute, idler rollers and top and bottom metal plate supports were fabricated and mounted on a suitable framework made of 25 × 25 × 5 mm MS L - angle sections, which was fitted to the stripper (**Fig. 5**). The feeding chute was fixed to the upper part of the lower belt at 20 degree horizontal inclination (**Fig. 6**). When the plants are stacked in the feeding chute in an orderly manner so that the root portion touches the stripping rotor (**Fig. 7**), the plants slide down the feeding chute and conveyed by the belt.

The outlet chute was fixed at the outlet end of the feeding unit at 40 degree horizontal inclination (**Fig. 8**). The plummer block of the idler rollers were provided with adjustable bolt and nut arrangements so that by tightening the nuts, the belt tension can be adjusted. To grip the groundnut crop against pulling force exerted by the stripping drum on the pods, metal plate supports were provided on both sides of the inner belts so that the plant goes along the length of the belt without sliding.

Performance Evaluation of the Machine

A test was conducted to evaluate the performance of the stripper after attaching the feeding unit assembly. The stripping rotor, blower and feeding unit were operated separately by 0.75 kW,

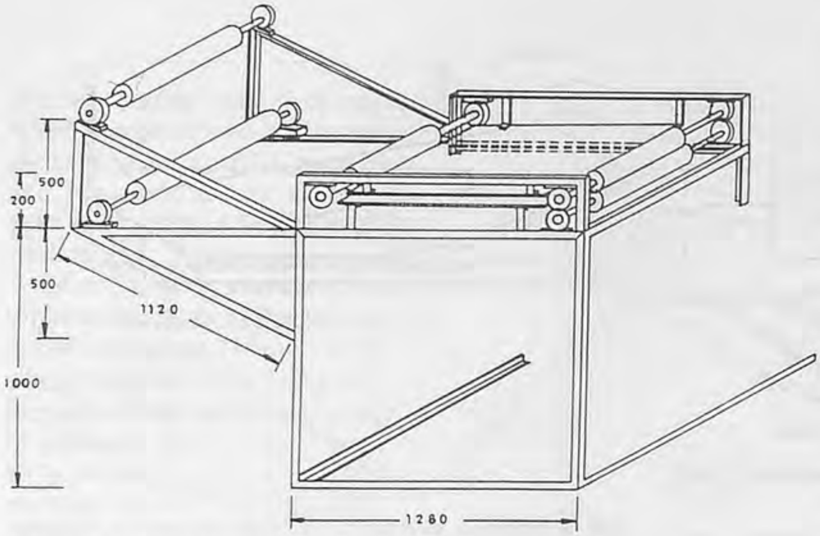

Fig. 4 Feeding unit assembly.

Fig. 5 Power-operated groundnut stripper with feeding unit.

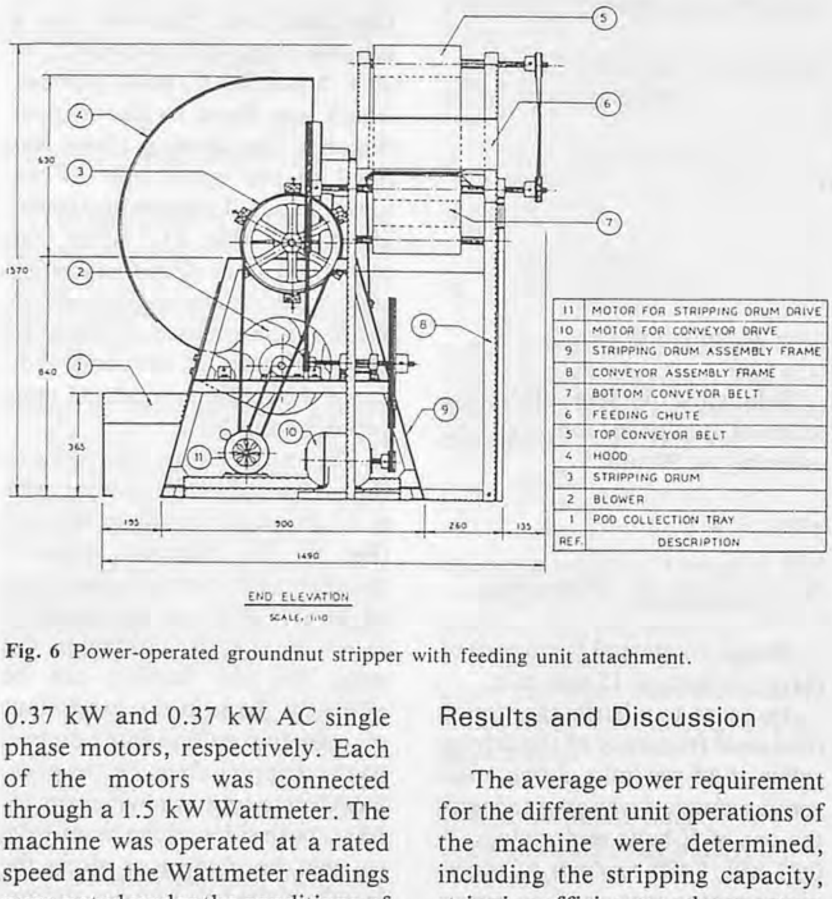

Fig. 6 Power-operated groundnut stripper with feeding unit attachment.

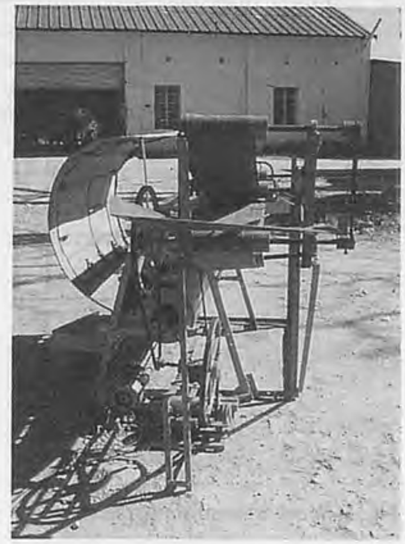

Fig. 7 View from inlet side.

Fig. 8 View from outlet side.

0.37 kW and 0.37 kW AC single phase motors, respectively. Each of the motors was connected through a 1.5 kW Wattmeter. The machine was operated at a rated speed and the Wattmeter readings were noted under the conditions of no load and load. The independent variables studied were feeding belt speeds of 2.83, 4.24, 5.65, 7.07 and 8.48 m/min and feed rates of 0.5, 1.0 and 1.5 kg/min. The dependent variables measured were stripping capacity, stripping efficiency and percentage damage to the pods.

Results and Discussion

The average power requirement for the different unit operations of the machine were determined, including the stripping capacity, stripping efficiency and percentage damage to the pods. The cost of the machine was calculated.

Power Requirement and Performance of the Machine

Power consumption of the unit operations of the machine viz., stripping cylinder, blower and feeding unit were measured under the conditions of no load and load. The maximum power consumption of the stripping cylinder, blower and feeding unit were 340, 630 and 250 W, respectively. The total power consumption of the groundnut stripper with the feeding unit assembly was 1 220 W

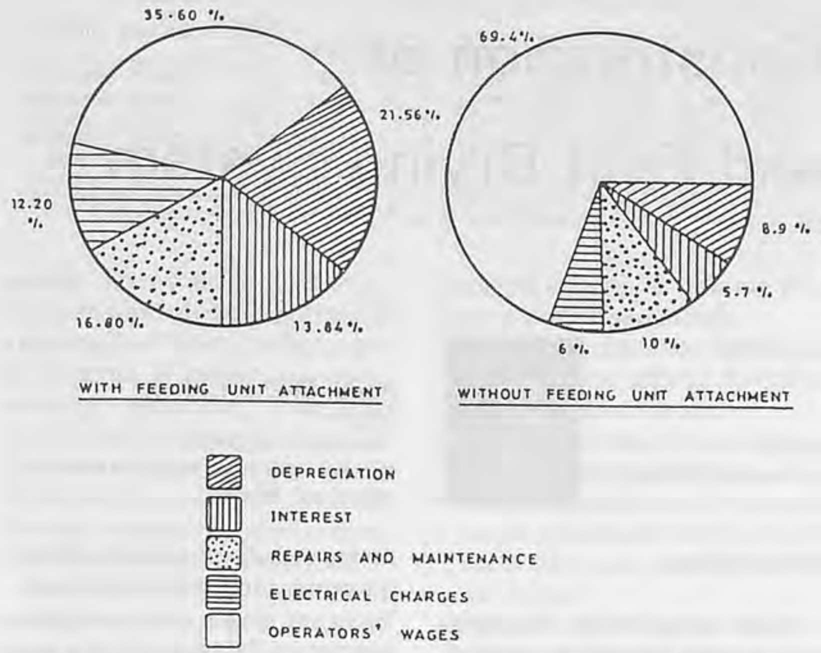

Fig. 9 Comparison of component costs of power-operated groundnut strippers.

(1.65 hp) whereas that under no-load was 995 W. The vines after stripping by the machine had negligible damage. The stripping efficiency was 80%. The capacity of the machine was 40 kg/ha with 6% damage to the pods.

The Economics of the Machine

The purchase price of the power-operated groundnut stripper with minus the feeding unit assembly was US$533. The feeding unit assembly was US$292. The component costs viz., depreciation, interest, repairs and maintenance, electrical charges and operators' wages of the groundnut stripper with the feeding unit were 8.9 to 21.6%; 5.7 to 13.4%; 10.0 to 16.8%; 6.0 to 12.2%; and 69.4 to 35.6%, respectively (**Fig. 9**).

Due to the increase in the initial cost of the machine with feeding unit attachment, all the fixed costs components have increased. Due to the higher power requirement of the prime-mover, the electrical charges were also high. By having the feeding unit attachment, the operators' charges could be reduced by about 50%.

Conclusions and Suggestions

A conveyor belt type feeding unit was designed, developed and attached to the power-operated hold-on type groundnut stripper having stripping drum fitted with screws. The damage to the stripped vines was almost negligible while using the stripper. The groundnut vines fetch a market value of US$81/ha and the valuable vines could be saved from damage by using the machine.

The fabric belt provided in the feeding unit assembly can be replaced by rubber belt or canvass belt, in particular grooved belts along with grooved rollers so as to reduce the expansion and slipping of belts during operation.

Larger diameter rollers can be used to increase the gripping of belt on rollers.

The upper and lower belts may be driven at different linear speeds so that the groundnut plants will have rolling action during stripping, thereby the stripping capacity and stripping efficiency can be increased.

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Design and Construction of Solar Grain and Fruit Drying System

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Islamabad, Pakistan

Abstract

In order to reduce the risk of spoilage of farm and horticultural crops during both drying process and in storage, a solar drying system was designed and constructed at the Farm Machinery Institute (FMI), National Agricultural Research Centre, Islamabad. In order to meet the system heat demand, eight flat plate solar collectors were designed and constructed. Each flat plate solar collector has a gross area of 2.0 m^2, effective area of 1.86 m^2, and an average heat generation capacity of 18.6 MJ/day (at 50% efficiency), if installed at Islamabad. A bin of one ton capacity was developed for grain/seed (maize, sunflower, soybean) drying system. Whereas a dehydrator of 250 kg capacity was constructed for fruit/vegetable (apricot, grapes, persimmon, onion, chillies etc.) drying system.

An economic analysis reveals that FMI solar drying system is very economical for drying grain/seed of hybrid varieties of different crops and for dehydration of fruit/vegetables. Therefore, it has a promising potential among seed, fruit, and vegetable growers.

Introduction

Solar energy is fast becoming an important alternative source of energy. It is preferred to other sources of energy because it is abundant, inexhaustible and non-polluting. It can be tapped at relatively low-cost and has non-associated environmental dangers. Therefore, the use and application of solar energy for agricultural application cannot be overemphasized. Pakistan is situated between latitude 23°30′ and 36°45′ North and longitude 61° and 75° East. For Pakistan, the average yearly daily insolation on horizontal surface is about 17 MJ/m^2. Thus a great potential exists for meeting some of crop drying requirement by solar energy in the country.

The fruit/vegetables which need to be dried for storage are apricot, grapes, dates, persimmon, tomato, onion, chilies, okra, etc. Due to the absence of good drying facilities, the prices of these commodities fluctuate many fold during the year. Secondly, in order to optimize crop yield, low cost seed of hybrid varieties of maize, sunflower, and soybean is an important pre-requisite. For proper storage of seed, there is need to dry it up to moisture level of 12% for most seeds using low temperature drying techniques, because drying with direct sun light effects the germination ability of the seed. So far sun drying is the prevailing practice in Pakistan. During sun drying these products are neither protected against dust and rain nor against rodents, birds and insects. Poor quality due to contamination with partly pathogenic microorganisms and high losses caused by uneven or incomplete drying are the characteristics of natural sun drying. To overcome these problems a solar grain and fruit drying system was designed and developed at the FMI, Islamabad.

This paper concentrates on the design and construction work done at FMI in connection with development of solar grain and fruit drying system. It also presents an economic comparison of FMI solar drying system and conventional green house type solar dryer.

Literature Review

The use of solar technology has often been suggested for the dried fruits industry both to reduce energy costs and economically speed up drying which would be beneficial to final quality (Lambert et al, 1980; Szulmayer, 1973). El-shitry et al (1991) dried grapes, okara, tomatoes, and onions using solar

Table 1. Monthly Average Daily Solar Radiation on Horizontal Surface at Various Stations in Pakistan

Station	Latitude	Elevation (m)	Radiation, MJ/m^2												
			Annual	Jan.	Feb.	Mar.	Apr.	May.	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Islamabad	33.36	511.0	16.69	10.66	13.08	15.50	20.54	23.38	23.50	21.13	20.06	19.01	15.92	11.53	9.23
Peshawar	34.01	318.0	17.80	11.15	14.70	18.43	22.14	26.39	26.32	23.20	21.23	19.40	16.75	13.83	10.73
Lahore	31.34	208.5	16.63	9.76	15.02	17.63	20.26	22.17	22.16	20.46	19.33	18.98	14.71	11.37	9.94
Multan	30.12	122.0	17.33	11.23	14.17	16.63	20.95	22.19	21.56	20.78	20.10	19.29	15.65	12.31	9.98
Quetta	30.12	1680.0	19.30	10.91	13.53	15.46	21.86	24.04	25.43	23.83	23.06	21.48	17.68	14.45	11.21
Karachi	24.0	11.0	17.73	14.37	16.92	18.63	21.85	22.01	21.41	16.70	15.99	19.03	17.34	14.15	12.86

Source: Geophysical Centre, Pakistan Meteorological Department, Government of Pakistan, Quetta.

energy. They concluded that drying time was reduced significantly resulting in a higher product quality in terms of colour and reconstitution properties. They also believe that as compared to oil or gas heated dryers, solar drying facilities are economical for small holders, especially under favourable meteorological conditions.

Muller et al (1987) used solar energy for drying mint, sage and hops. They obtained high quality crude drugs in terms of colour and content of active ingredients. Shove (1977) reported that solar energy was considered as a useful source of energy for drying variety of crops, including corn, soybeans and peanuts. Morrison and Shove (1975) conducted drying experiments at Illinois, U.S.A. using bare plate collectors on the side wall of a corn drying bin and concluded that such collectors may be economically feasible, when relatively inexpensive material are used for the construction of the collectors.

Mulbauer et al (1993) stated that in developing countries, the use of solar energy technologies in agriculture are most economically viable compared to industrialized countries. The introduction of solar drying system seems to the most promising alternative in reducing post harvest losses and could have significant contribution to warrant continuous food supply.

Design and Construction of the System

The solar drying system was designed keeping in view the following design parameters:

- The system should be flexible so that it can be utilized for various agricultural crops.
- It should be ideally suitable for low temperature drying.
- It should be durable, simple and can be manufactured using local materials and manufacturing technology.
- Its grain/seed drying capacity should be about one ton per three days' period. However, its fruit/vegetable drying capacity should be 250 kg/three days period.

It was decided to incorporate flat plate solar collectors in solar drying system because these are ideally suitable for low temperature drying and use diffused radiation to produce heat even on cloudy days. To design the required collectors area, the following steps were taken:

1. Monthly average daily solar radiation data on horizontal surface for various cities in Pakistan were obtained from the Geophysical Centre, Quetta (**Table 1**).

2. Available solar energy at tilted surface of flat plate solar collectors installed at Islamabad and facing south were predicted using computer program developed by the principal author during his Ph.D. program at Iowa State University of Science and Technology, Ames, Iowa, USA (based on methodology given by Duffie and Beckman, 1980). Monthhyly average daily total radiation on tilted surface for Islamabad is presented in **Table 2**. It is revealed that, on an average, 10 MJ/m^2/day energy is available at 50% collector(s) efficiency. From April to September maximum solar radiation are available at 30 degree tilt angle. However, October to March maximum solar radiation are available at 45 degree tilt angle.

Table 2. Monthly Average Daily Total Radiation (MADTR) on Tilted Surface at Islamabad, Pakistan

Month of year	Tilt Angle (degree)	MADTR (MJ/m^2)	System Output at 50% Efficiency
January	45	17.36	8.68
February	45	17.92	8.96
March	45	17.65	8.82
April	30	21.19	10.59
May	30	22.30	11.15
June	30	21.66	10.83
July	30	19.79	9.90
August	30	19.96	9.98
September	30	21.02	10.51
October	45	20.93	10.46
November	45	18.09	9.04
December	45	15.77	7.88
		Total:	116.8
		Average	10.0 MJ/m^2/day

Note: Islamabad is situated at 33.3 North latitude and 511 m above sea level.

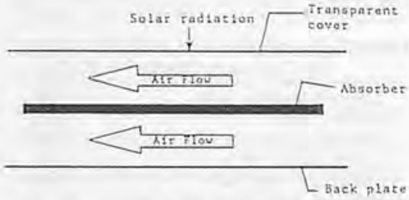

Fig. 1 A configuration of covered suspended plate solar collector.

3. To generate heat for drying, a suspended plate version of flat solar collector was designed and developed initially. The configuration of covered suspended plate air-type flat plate collector is presented in **Fig. 1**. It has absorber, transparent cover, and back plate. The absorber is between a transparent cover and a back plate, and air is passed on both sides of the absorber. Convection

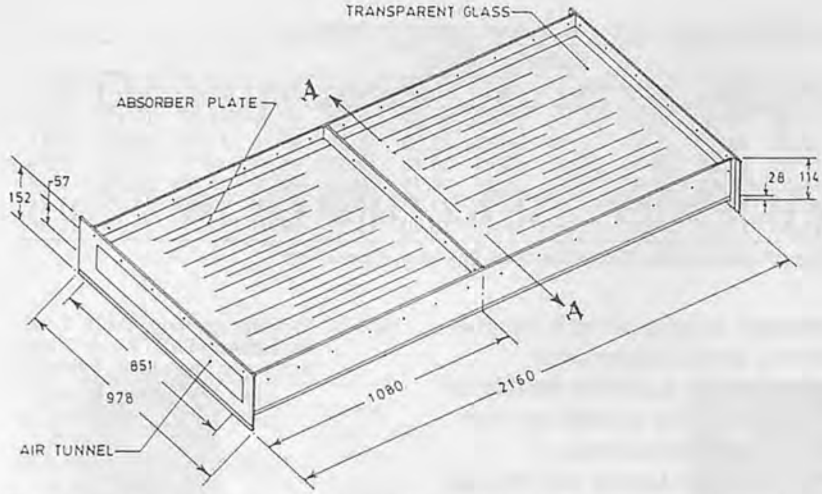

Fig. 2 An isometric view of a flat plate solar collector (All dimensions are in mm).

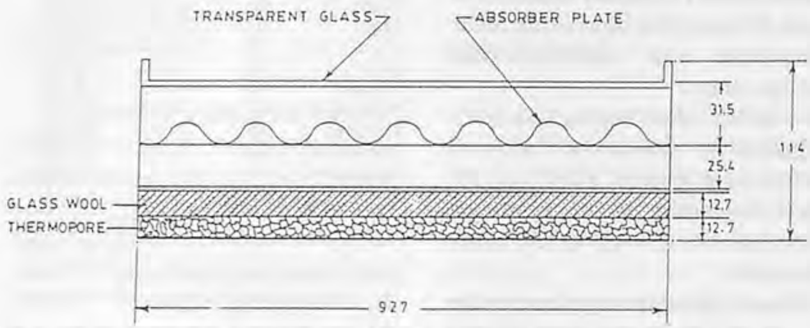

Fig. 3 A cross section of a flate plate solar collector (All dimensions are in mm).

Table 3. Specifications of a Flat Plate Solar Collector Developed at FMI

1. Overall length, mm	2 160
2. Width, mm	925
3. Height, mm	120
4. Gross area, m^2	2.0
5. Effective area, m^2	1.86
6. Weight, kg	82.5
7. Cross sectional area of air-tunnel, m^2	0.048
8. Effective to gross area ratio	0.92
9. An average heat generation capacity at Islamabad (MJ/day), at 50% efficiency	18.6
10. Price (Rs.)	5 000

heat loss due to wind blowing across the surface of the collector is reduced by the glass cover. It acts as a barrier between the wind and absorber plate. An isometric view and cross section of a designed flat plate solar collector is presented in **Figs. 2** and **3**, respectively. However, its specifications are presented in **Table 3**. It has a gross area of 2.0 m^2, effective area of 1.86 m^2, and effective to gross area ratio is 0.92. An average heat generation capacity is 18.6 MJ/day at 50% efficiency, if installed at Islamabad.

4. To dry one ton of maize seed from 24% moisture content (MC) to 13% M.C., 126 kg of water is needed to be removed. To remove this amount of moisture 378 MJ are required. To meet this energy requirement of the system, 13 m^2 effective collector area is required (design calculations are presented in **Table 4**). Eight flat plate solar collectors with each an effective area of 1.86 m^2, and a bin of one ton capacity was constructed for grain/seed drying system.

5. To dry 250 kg of fruit/vegetables from 70% M.C. to 20% M.C., 156 kg water is needed to be removed. To remove this amount of moisture 468 MJ are required. To meet this heat demand, 16 m^2 effective collector area is required (design calculations are presented in **Table 5**). However, glass was used on the top of the dehydrator at 25-degree tilt angle to receive solar energy from an additional 2.25 m^2 area. The dried fruit/vegetables output of the system amounted to about one t/month. However, fresh pealed fruit/vegetable intake of the system is 2.5 t/month.

To construct this system, dura-

Table 4. Design Calculations for Solar Grain Drying System

1. Energy required to remove water from one ton of grain to bring it down from 24% to 13% M.C.	
- Total water in the produce	= 1 000 kg × 0.24 = 240 kg
- Dry matter at 0.0% M.C.	= 1 000 − 240 = 750 kg
- Final weight of produce at 13% M.C.	$= 760 \times \frac{100}{100-13} = 874$ kg
- Thus the water to be removed	= 1 000 − 874 = 126 kg
- Total energy required	$= 3000 \frac{KJ}{Kg\ of\ H20} \times 126\ kg = 378$ MJ
2. Design collector area for 3 days drying period	$= 378\ MJ \times \frac{m^2\ day}{10\ MJ} \times \frac{1}{3\ days}$
	$= 12.6 \simeq 13\ m^2$
3. Monthly dried grain output at 13% M.C.	$= \frac{874\ kg}{3\ days} \times 30 = 8740$ kg
	= 8.75 t
4. Monthly grain intake at 24 M.C.	$= \frac{1000\ kg}{3\ days} \times 30 = 10000\ kg = 10$ t

Table 5. Design Calculations for Solar Fruit and Vegetable Drying System

1. Energy required to remove water from 250 kg of fruit/vegetable to bring it down from 70% to 20% M.C.	
- Total water in the produce	= 250 kg × 0.70 = 175 kg
- Dry matter at 0.0% M.C.	= 250 − 175 = 75 kg
- Final weight of produce at 20% M.C.	$= 75 \times \frac{100}{100-20} = 94$ kg
- Thus the water to be removed	= 250 − 94 = 156 kg
- Total energy required	$= 3000 \frac{KJ}{Kg\ of\ H20} \times 156\ kg = 468$ MJ
2. Design collector area for 3 days drying period	$= 378\ MJ \times \frac{m^2\ day}{10\ MJ} \times \frac{1}{3\ days}$
	$= 15.6 \simeq 16\ m^2$
3. Monthly dried fruit/vegetable output at 20% M.C.	$= \frac{94\ kg}{3\ days} \times 30\ days = 940$ kg
4. Monthly fruit/vegetable intake at 70% M.C.	$= \frac{250\ kg}{3\ days} \times 30 = 2500$ kg

Table 6. Cost Break Down of FMI Developed a Flat Plate Solar Collector

Materials Specification	Price in 1994 (Rs.)
1. G.I. Sheet for box, 1.2mm, size 1.22 m × 2.44 m	850
2. M.S. Sheet, 0.7mm, size 2.21 m × 1.06 m	400
3. Transparent glass sheet, 5mm, size 1.06 × 0.91m, No.2	300
4. Tin sheet, 0.31mm thick, size 2.21mm × 1.19m	450
5. Thermopore, (1m × 1m × 1.27cm), 2.5m²	80
6. Glass wool with aluminum foil (2.54cm thick), 2.5m²	325
7. Aluminum angle (2.54cm × 2.54cm × 3.17mm), 7m	140
8. Aluminum "T" (2.54cm × 3.17mm), 1m	20
9. Angle iron (2.54cm × 2.54cm × 3.17mm), 2.54m	40
10. "T" iron (2.54cm × 3.17mm), 4m	80
11. Flat bar (2.54cm × 3.17mm), 11m	150
12. Silicon sealant, 110mℓ	60
13. Screws and pop rivets	60
Cost of materials	3 000
Manufacturing cost and manufacturer profit	2 000
Total cost of a collector	5 000

ble, cheap and easily available materials were used in order to keep the price low enough. The specification, quantity required, and cost of material used for constructing a single unit of flat plate solar collector is presented in **Table 6**.

A brief description of material used is presented below:

- Five-mm thick glass used for cover material, because of its excellent transmittance and weathering resistance;
- The corrugated steel sheet was used as absorber. It was painted black. However, in the future, absorbers will be coated with a selective surface material for better efficiency;
- To avoid heat loss from side and back plate, glass wool with aluminum foil was used as insulation material; and
- Galvanized sheet was used as back plate for better durability and to resist bad weather conditions.

A grain bin of one-ton capacity with perforated bottom and a drying chamber or dehydrator for fruit/vegetable was also constructed using locally available materials. A steel frame was constructed to mount eight solar collectors in series. To join these collectors with the grain bin or dehydrator, a special duct was designed. This duct is connected to solar collectors on two sides (four on each side), and a fan to the third side. The fan takes the hot air from the collectors and pressurizes it beneath a perforated bin and dehydrator. The estimated cost of grain and fruit drying systems is Rs.60 000. The solar grain and fruit drying systems are shown in **Figs. 4** and **5**, respectively.

Fig. 4 Solar grain drying system.

Fig. 5 Solar fruit/vegetable drying system.

Economics of FMI Solar Drying System

An economic comparison of solar fruit drying system was made with green-house type solar dryers developed and commercialized by Malakand Fruit and Vegetable Development Project, Mingora, Swat. The following assumptions were made in order to make economic comparison of the two systems.

- It was assumed that both the systems will be in operation only for 3 months period in a year. Therefore, dried fruit/vegetable output capacity for the period of three months was used for making economic comparison of both the systems; and
- Labour cost for cutting, peeling, and other drying operations were assumed equal for both systems. This assumption was not included in the analysis.

The data about purchasing/installation cost, dried fruit/vegetable capacity of greenhouse type solar dryer (6 m × 3 m) were obtained from a progressive farmer (Mr. Sar Buland Khan) of Matta, Swat.

It will be shown in **Table 7** that the cost of drying fruit/vegetable using FMI solar drying system is Rs.3/kg. Whereas the cost of drying is three times more with greenhouse type dryer. In addition, the capacity of FMI solar drying system is about seven times greater than the green-house type solar dryer. It can be concluded that the FMI solar fruit drying system is more economical than the greenhouse type solar dryer. Its dried fruit/vegetable output capacity is

Table 7. Economic Comparison of FMI Solar Fruit Drying System with Conventional Green House Type Solar Dryer

Item	FMI Solar Fruit Drying System (6m × 3m)	Green-house Type Solar Dryer
Purchasing cost (Rs.)	60 000	30 000
Useful life (years)	20	20
Salvage value (10%)	6 000	3 000
Fixed cost (Rs/year)		
Depreciation	2 700	1 350
Interest (14%) on average investment	4 620	2 310
Total fixed cost (Rs./year)	7 320	3 660
Variable cost (Rs./year)		
Electricity	300	—
Repair & maintenance cost (Rs./year)	1 000	500
Total cost (Rs./year)	8 620	4 160
Dried fruit/vegetable output capacity (kg)	3 000	450
cost (Rs./kg)	2.87	9.20

much higher than the present system. This will make possible the dehydration of large quantity of fruit/vegetable during harvest season.

The cost analysis of solar grain/seed drying system shows that the cost of drying is Rs.210 /t (if 35 t grain/seed dried per annum) — economical for seed growers indeed.

Conclusions

1. A solar grain and fruit drying system was designed at the National Agricultural Research Centre, Islamabad. Flat plate solar collectors were designed and constructed to meet the heat demand of the system. However, there is need to test and evaluate this system for drying grain/seed, fruit, and vegetables in various parts of Pakistan.
2. The FMI solar grain and fruit drying system can be constructed using locally available material and manufacturing technology.
3. The cost of drying fruit/vegetable using the FMI system is three times less than the cost of drying with conventional greenhouse type solar dryer. Whereas its dried fruit/vegetables output capacity is much higher (7 times) than the conventional system. A higher dried fruit/vegetable capacity of this system as compared to conventional system will make possible for growers to dehydrate greater quantity of their products. Consequently, greater quantities of fruit/vegetables can be processed and preserved during harvest season.
4. It is also good technology for drying seeds of hybrid varieties because sun drying improves the germination ability of the seed.

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Effect of Mechanization on Sunflower Production

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Abstract

Three improved implements, namely; Jyoti multicrop planter for planting; multipurpose hoe for interculturing; and pedal-operated sunflower thresher for threshing were introduced in the production programme of the sunflower crop. Their performance, effect on production and productivity and their economics were studied in comparison with the prevalent local practices. All other input costs were kept constant. The field trials were conducted during 1992, 1993 and 1994 on farmers' fields at 8 locations over an area of 7.07 ha. The study shows that the improved implements reduced the cost of production by an average of Rs. 328.34/ha. Besides saving the cost, time and labour these implements reduced the drudgery of operation. The productivity parameters related to yield were also influenced positively. This was evidenced by an increase in the yield to the extent of Rs. 900/ha. The margin of profit of the farmers in the production of sunflower crop was thus increased by a total of Rs. 1 228.34/ha because of the inclusion of these improved implements.

Acknowledgement: The project was undertaken at the Agricultural Engineering Research Centre (MPKV) Pune under the All-India Coordinated Research project on Farm Implements and Machinery financed by the Indian Council of Agricultural Research, New Delhi.

Introduction

Sunflower is one of the important oil seed crops of India that ranks next to groundnut in oil content (groundnut 50% and sunflower 46%). It is grown over 12 to 19 lakh ha, the major states being Karnataka, Punjab, Tamilnadu Andhra Pradesh and Maharashtra with an estimated output at 9-10 lakh t. During 1991-92 nearly 5 lakh ha area was under sunflower crop in the state which yielded 4.04 lakh t of seed (Jadhav and Chaudhari, 1991 and 1992). The crop can be grown throughout the year, i.e., in Kharif, Rabi and summer seasons on all types of soils and under scanty rainfall conditions or even on megre irrigation facilities (Salunkhe et al, 1982). At present all the operations except the primary tillage, in the cultivation of sunflower crop are done with traditional tools and implements which are very much inefficient, labour intensive and cumbersome to operate (Jadhav and Deshapande, 1988). Their use results in an increased cost of operation, loss of time and reduced margin of profit for the farmers. They also create scarcity of labour during the peak periods of farm operations. The operation of threshing of sunflower with conventional methods (beating with sticks, rubbing earheads against stones, bricks or any rough surface, treading under bullocks' feet etc.) is very much arduous and inefficient. Such a situation discourages the farmers from growing sunflower crop. Under the rising crisis of edible oils and when the nation needs more oil to meet the demands of its people, it becomes imperative to work out ways and means of increasing sunflower oil seed production. By increasing per ha yield or/and the area planted to oil seed crops the target could be achieved. And if the margin of profit in the production of sunflower crop could be increased by mechanizing the operations using suitable improved implements, the farmers woud pay purposeful attention to this crop.

The paper presents a study in which three proven improved implements designed and developed by the department of FMP, MPKV, Rahuri were introduced in the production programme of the sunflower crop. The effects of this new technology on production and productivity are quantified in comparison with the local methods and the local implements so that the available package of new implements could be recommended to the sunflower growing farmers.

Materials and Methods

At present in the cultivation of sunflower crop farmers do have suitable improved implements for seed bed. Seeding, interculturing and threshing are then the major cost contributing operations for which farmers as yet have not adopted improved implements. Available improved implements, briefly described in the following paragraphs were, therefore, included in the production programme of the sunflower crop. Their field performances in comparison with the local implements were evaluated and the effects on production and productivity were quantified.

Jyoti Multicrop Planter

A bullock drawn improved multicrop planter (named after the great social reformer "Mahatma *Jyoti*ba Phule") was used for planting the sunflower crop. Besides sunflower, this multicrop planter is suitable for planting groundnut, safflower, soybean, jowar, maize, wheat gram and tur (simply by changing the seed rotors of the metering device). It can also drill granular fertilizer simultaneously. The planter has three furrow openers each provided with a separate seed box of 4.5 kg capacity. The spacing between the furrow openers can be varied from 22.5 to 45 cm. For sunflower planting rotors specially designed for sunflower seeds (dia = 95 mm, number of cells = 5) and for the recommended plant spacing (10 cm) were mounted on the rotor shaft of the metering device. The spacing between the furrow openers was adjusted to give a 45-cm row spacing.

Under the local method a common traditional manual metering type single bowl, bullock-drawn drill with 3 furrow openers spaced at 45 cm was used.

Multipurpose Hoe

A bullock-drawn improved multipurpose hoe suitable for operating in row seeded crops was used for interculturing operation. The width of the head piece of this hoe is adjustable to any row spacing between 30 and 60 cm. The number of tines on this head piece can also be varied between 3 and 6 depending upon the row spacing and also the crop growth, e.g., a sunflower crop of poor growth on light soil may need 4 sweeps and, therefore, 4 tines on the head piece whereas the same crop on heavy soil having vigorous growth may allow working of only 3 sweeps in the space between the rows for interculturing and would need only 3 tines on the head piece. This hoe does the mulching and weeding with the sweeps fitted on the tines during the first interculturing at the plant age of 15 to 20 days. During the second interculturing at 30 to 35 days crop age when the roots usualy attend a depth of 8 to 10 cm the hoe can do tilling of the soil between the rows to the desired depth. This is done with the shovels fitted on the tines for aerating the root zone. At 45 to 50 days age, the crop needs interculturing in which the soil between the rows is tilled and the loosened soil is put to the base of the crop rows to provide additional support to the plants (earthing up). This could be done with the multipurpose hoe by shovels on the tines of the head piece and an additional earthing-up equipment attached behind the head piece. A bullock pair can pull 2 to 4 hoes on a single yoke without any draft problems.

Under local method a 22.5 cm single blade (fixed) hoe was used. This conventional hoe cannot

Fig. 1 Jyoti multicrop planter.

Fig. 2 Multipurpose hoe.

Fig. 3 Phule sunflower thresher.

achieve all the objectives of the interculturing operation. But in the absence of a suitable improved hoe, the farmers at present have to use only this local hoe for all the three interculturings.

Phule Sunflower Thresher

This thresher is pedal-operated, hold-on type sunflower thresher consisting of a horizontally mounted spoked threshing wheel of 66 cm dia, a four-holed (each hole 25 cm dia) top cover, a grain mixture collector, a seed conveying passage with a fan, a chain sprocket pedal assembly and a seat for the driver. Four labourers, including driver are needed to work on this thresher. The sunflower heads are inserted through the holes of the top cover and are held on the rotating threshing wheel till all the seeds on the head are detached. One of the labourers while feeding the heads to thresher also operates the thresher by pedalling it. Because this is a hold-on-type of thresher, the threshing efficiency obtained is very high. The threshing on this thresher can be done in the crop moisture range of 12 to 20%. However, threshing at higher moisture content is recommended because in that case, only the grains are detached from the earheads and the grains received at the outlet are completely free of any debris. At lower moisture contents the papery scales covering the seeds in the receptacles are also detached along with the seed. They can be blown away with an airblast provided by the fan. Threshing of the sunflower heads below 12% moisture content, however, results in the breakage of some of the earheads lowering down the cleaning efficiency.

Sunflower threshing by prevalent conventional methods is a costly, tedious and tiresome job. The method common in this region is beating the earheads with wooden sticks to detach the grains from the sunflower heads. The method involves an average cost of threshing of Rs. 540/ha and this value was used for comparison with the cost of threshing by pedal-operated Phule sunflower thresher.

Results and Discussions

In order to study the effects of the improved implements on sunflower production and the productivity, the field trials were conducted during 1992, 1993 and 1994 at 8 different locations over an area of 7.07 ha. Data ade-

Table 1. Summary of Field Performance of Planting Implements for Sunflower (Jyoti multicrop planter vs local seed drill)

Item	Average of 4 trials (1992)	Average of 2 trials (1993)	Average of 2 trials (1994)	Overall average	
	JMP	JMP	JMP	JMP	LSD
Planting depth, (cm)	5.9	5.75	5.9	5.83	5.0
Width covered, (cm)	135	135	135	135	135
Operational speed, (km/h)	2.62	2.36	2.5	2.49	2.59
Plant spacing, (cm)	9.32	8.51	9.20	9.01	5.5
Seed rate, (kg/ha)	8.46	7.25	7.75	7.65	12.42
Number of plants/m^2	18.63	17.82	28.65	28.40	54.54
Effective FC, (ha/day)	2.03	2.18	2.13	2.11	1.75
Theoretical FC, (ha/day)	2.81	2.93	2.83	2.86	2.79
Field Effi., (%)	72.24	74.40	75.27	73.97	62.72
Draft, (kgf)	72.50	72.75	75.25	73.50	54.75
Power required,					
(machine h/ha)	3.95	3.67	3.77	3.80	4.58
(man h/ha)	3.95	3.67	3.77	3.80	4.58
(bullock h/ha)	7.90	7.34	7.54	7.6	9.17
Cost of operation, (Rs/ha)	54.75	74.46	76.49	68.57	68.47

JMP = Jyoti Multicrop Planter, LSD = Local Seed Drill, FC = Field Capacity
Effi. = Efficiency.
Soil type: medium black. Crop variety: modern-ss56.
Moisture content: 17-22% (wb). Row spacing: 45 cm.

Table 2. Summary of Field Performance of Interculturing Implements of Sunflower (Jyoti multicrop planter vs Local hoe)

Item	Average of 4 trials (1992)	Average of 2 trials (1993)	Average of 2 trials (1994)	Overall average	
	MH	MH	MH	MH	LH
Tilling depth, (cm)	7.5	7.0	7.25	7.25	2.93
Earthing height, (cm)	5.48	5.85	6.25	5.86	3.0
Weeding Effi., (%)	74.23	66.75	76.19	72.39	67.02
Draft required, (kgf)	37.50	36.90	36.57	37.05	26.50
Field capacity, (ha/day)	2.7	2.22	3.49	2.80	1.99
Plant damage, (%)	3.17	3.91	4.52	3.87	9.64
Power requirement,					
(man h/ha)	11.14	10.85	6.87	9.62	12.03
(machine h/ha)	11.14	10.85	6.87	9.62	12.03
(bullock h/ha)	7.42	7.53	4.58	6.41	8.06
Cost of operation, (Rs/ha)	184.37	172.19	109.02	155.16	189.87

MH = Multipurpose Hoe, LH = Local Hoe, Effi. = Efficiency.
Crop age: 30-37 days, Soil: Medium black, Hoes/Bullock pair: 3,
Crop height: 25-30 cm, Moisture content: 15-18 (percent, wb), Row spacing: 45 cm,
Crop variety: Morden ss-56.

Table 3. Results of Performance Evaluation Trials of Pedal-operated Sunflower Thresher

Item	Average of 4 trials 1992	Average of 2 trials 1993	Average of 2 trials 1994	Overall Average
Crop factor				
1. Crop variety	MSFH-18	Morden	Morden	
2. Location	AC, Pune	TSF, Charoli	TSF, Charoli	
3. Harvesting date	12.2.90	10.1.92	17.10.92	
4. Threshing date	14.2.92	14.1.92	17.10.92	
5. Av. dia of flower	15 to 28	15 to 23	18 to 25	
6. Grain straw ratio	0.3	0.395	0.32	
7. Grain M/C, (%)	11.2	14.3	10.45	
Operational data				
1. Labourers on job	4	4	4	4
2. Threshing wheel speed, (rpm)	156	156	156	156
3. Feed rate, (kg/h)	193.89	115.25	95	134.71
4. Duration of test, (min)	41	53.36	120	—
Test results				
1. Broken grain, (%)	NIL	NIL	NIL	NIL
2. Blown grain, (%)	0.02	2.79	1.2	1.34
3. Clean efficiency, (%)	97	97.42	96.5	96.94
4. Thresh. efficiency, (%)	100	100	100	100
5. Output capacity, (kg/h)	46.87	44.12	42.5	44.5
6. Cost of operation, (Rs/ha)				
PST:	227.40	250.90	260.50	246.30
LM:	...	...	...	540.00

PST = Phule Sunflower Thresher, M/C = Moisture Content, LM = Local Method.

Table 4. Effect of Improved Implements on Economics of Sunflower Production

Operation	Cost of production (Rs/ha)				
	1992 IM	1993 IM	1994 IM	Average IM	Average LM
Planting	54.75	74.46	76.49	68.57	68.47
Weeding	184.37	172.19	109.02	155.16	189.87
Threshing	227.40	250.90	260.50	246.27	540.00
Total	466.52	497.55	446.01	470.00	798.34
Average production, Rs/ha				9900	9000

Average savings in cost of production, Rs/ha = 798.34 − 470.00 = 328.34
Average increase in production, ... Rs/ha = 9900 − 9000 = 900
Increase in net income, ... Rs/ha ... ... = 1228.34

IM = Improved Method of production, i.e., use of improved implements in sunflower production.
LM = Local Method of production, i.e., use of local implements in sunflower production.

quate to estimate the parameters related to the performance of the machines and the crop yields were collected. It was analyzed and the summary results are given in **Tables 1** through 4.

The results of the planting of sunflower crop are summarized in **Table 1**. It will be shown that the Jyoti Multicrop Planter gave a uniform seed distribution and a proper placement of seed. The values of the depth of seed placement, row spacing and plant spacing are much closer to the recommended values. For morden variety of sunflower, the recommended seed rate was 10 kg/ha (for traditional type of drills). The Jyoti multicrop planter planted seed at an average rate of 7.65 kg/ha whereas local seed-drill drilled was 12.42 kg seed/ha. Thus, there was a saving of 4.77 kg of seed/ha, i.e., a saving of about Rs. 72/ha. The field eificiency of the Jyoti multicrop planter was 73.97% as against 62.72% for the local seed-drill. This was mainly because the automatic continuous metering of the seed by the Jyoti multicrop planter saved lot of its operational time compared to the hand metering of the traditional drill. However, there is not much difference in the cost of operation of the two machines. The values are Rs. 68.57 and Rs. 68.47/ha for the planter and the drill, respectively. The Jyoti multicrop planter could show no saving in cost of operation because the initial price of the planter was Rs. 4 000, much higher than the initial price of the local drill which was Rs. 1 350 only.

From **Table 2**, the tilling depth, earthing height and weeding efficiency indicate that the interculturing operation was made more thorough, effective and uniform by using the bullock-drawn multipurpose hoe (MH) as compared to the operation with the local hoe (LH). The average field capacity of the multipurpose hoe was 2.80 ha/day as against 1.99 ha/day for the local hoe. Frequent cleaning of the blade of the local hoe consumed a lot of its operational time and reduced its field capacity. A pair of the multipurpose hoes, on an average, involved a cost of operation of Rs. 155.16/ha whereas the local hoe-pair needed Rs. 189.87/ha.

Table 3 shows the better performance of the pedal-operated sunflower thresher in comparison with the local hand-beating method of threshing. The machine gave 100% threshing efficiency and 96.94% cleaning efficiency with an output capacity of 44.5 kg/h. Further, the broken grains and the blown grains percentages were also negligible, i.e., 1.34%. As far as the cost of operation is concerned the machine required Rs. 246.27/ha for threshing of sunflower heads as against Rs. 540/ha with local method of threshing. This is because the output rate of manual threshing is less and the wage rate demanded for the operation is high.

The inclusion of the three improved implements in the package of the implements needed for sunflower production programme reduced the cost of operation by Rs. 328.34/ha (**Table 4**). Because of the proper seed placement and distribution, the timeliness and effectiveness of operation achieved with the improved implements the average production increased by Rs. 900/ha. Thus there is an increase in the net income from the sunflower crop by Rs. 1 228.34/ha. By including the cost of the seed saved, i.e., Rs. 72/ha, the margin of net income is raised to Rs. 1 300.34 ha.

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ABSTRACTS

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

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Pumping Energy in a Tomato Processing Plant: Ghuman, B.S., Associate Professor; and Y. Singh, Senior Research Engineer, respectively, Dept. of Processing and Agric. Structures, Punjab Agric. University, Ludhiana-141004, India.

The effect of operating variables-temperature and shear rate on the viscosity, friction factor, pressure drop, pumping energy and cost of pumping were determined for tomato concentrate samples in a large tomato processing plant. Shear stress-shear strain was measured on a rotational viscometer. The Power-law constants, apparent viscosity, effective shear rate, pressure drop were determined at various pumping stations covering the entire processing line and in temperature range of 30-90°C. Effective shear rate values were affected by the material flow rate and the pipe diameter. Viscosity and friction factor were found to depend upon the temperature and shear rate. For an existing pumping system the temperature was the single most significant parameter affecting pumping energy and cost of pumping.

537

Development and Field Evaluation of a Manually-drawn Mustard Drill: Pattnaik, J.B., P.G. Student; R.C. Dash, Lecturer; D.K. Das, Professor and Head; S.C. Pradhan, Associate Proffessor, A.I.C.R.P. on Power Tiller, respectively, Dept. of F.M.P., C.A.E.T., O.U.A.T., Bhubaneswar, Orissa, India

Sowing of small seeds like mustard in line is very much desirable to save seed, to reduce cost of sowing and weeding. Thus, a two-row manually drawn mustard drill was developed and evaluated in the field. It required only 4 kg of seeds to sow one ha of land at desired depth and row specification. Seed distribution efficiency and field efficiency of the developed mustard drill were recorded at 84.28 and 67 percent, respectively. One ha of land can be sown by this drill only in 13 hours with a net saving of Rs. 232.00/ha in comparison with the traditional method of sowing behind the plough.

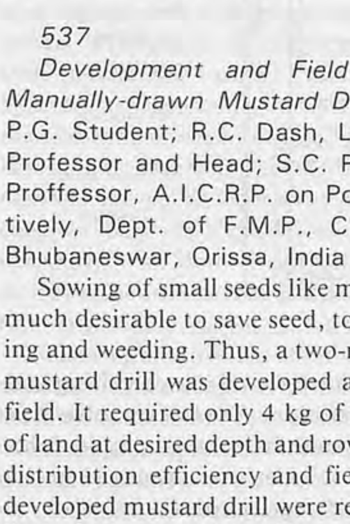

Fig. 1 Seed drill for small seed.

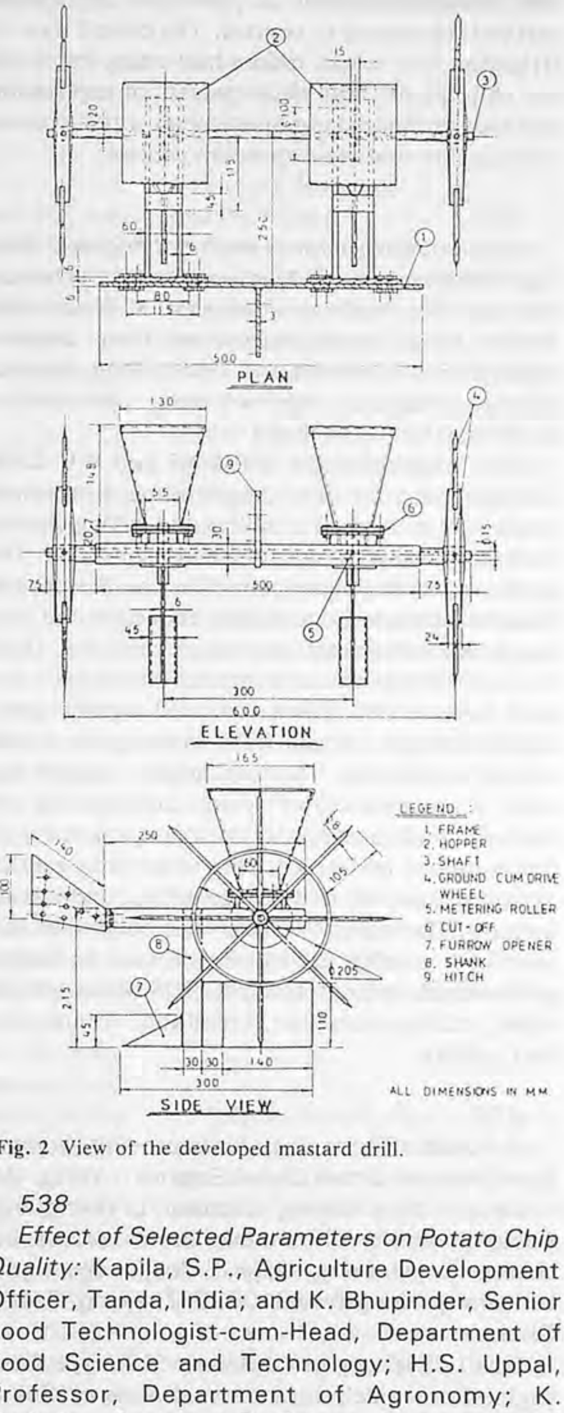

Fig. 2 View of the developed mastard drill.

538

Effect of Selected Parameters on Potato Chip Quality: Kapila, S.P., Agriculture Development Officer, Tanda, India; and K. Bhupinder, Senior Food Technologist-cum-Head, Department of Food Science and Technology; H.S. Uppal, Professor, Department of Agronomy; K. Harinder, Assistant Professor, Department of Food Science and Technololgy, respectively, Punjab Agricultural University, Ludhiana-141 004, India

A study on selected parameters as cut off date of irrigation before harvesting and methods of potassium application on potato chip quality was carried out. Nitrogen, phosphorus and potassium

uptake was higher in two-week cut off irrigation before harvesting and at all potassium application methods compared to control. The cut off date of irrigation four weeks before harvesting improved the chip quality and yield. potassium application methods produced large-sized tubers with increased chip quality and yield over the control.

540

Effect of Environment on Functional and Baking Performance of Medium Protein Wheats: Harinder, K., Assistant Professor; K. Bhupinder, Senior Food Technologist-cum-Head, Department of Food Science and Technology, respectively, Punjab Agricultural University, Ludhiana-141 004, India

Two wheat cultivars (PBW 65 and WL 2265) recommended for rainfed agriculture in northern India were evaluated for milling and baking characteristics at two locations for two seasons each. The environment had significant effect on the physiochemical characteristics, milling extraction and baking performance (loaf volume) of cultivars. There was no effect of the environment on mixing tolerance index value which indicated equally good machinability of dough from wheat grown under rainfed conditions. The loaf quality (crumb and crust characteristics) of wheat cultivars did not change at both locations for two seasons hence satisfied consumer preference. Thus wheat from rainfed agriculture can be used for the milling and baking industry. The variety WL 2265 was found to be best suited for rainfed agriculture because of higher grain weight, hectolitre weight, SDS sedimentation value, milling extraction, bread loaf volume and loaf quality.

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A Suitable Technology for Improving Working Conditions of Small Diesel Engines: Yong, He, Professor; Ying Xiafang, Lecturer; Li Zhengfang, Postgraduate; and Xi Wenbin, Professor, respectively, Engineering Dept., Zhejianag Agric. University, Hangzhou 310029, Zhejiang, P.R. of China.

Small diesel engines, specially S195 type diesel engines, are widely used in rural areas of China. According to the result of investigation and inspection of 21000 tractors, we found that the working conditions of the engines are generally bad. The average specific fuel consumption increased by 25.6% while the average power decreased by 18.2% compared with the rated specific fuel consumption and rated power, respectively. A new suitable technology — optimal adjustment and inspecting technology is recommended for improving the working conditions of small diesel engines. With this new suitable technology, the average specific fuel consumption decreased by 11.21 ~ 29.47 g/kWh and the average power increased also by 0.18 ~ 0.97, respectively, after the engines were inspected and optimally adjusted. The technology is one of the major popular projects of the State Commission on Science and Technology of China. It was estimated that over 939.8 thousand tractors in use have been inspected and optimally adjusted; 97.7 thousand t of fuel have been saved; and 959 thousand kW of power have been regained during 1991 to 1994.

557

Groundnut Stripper for Small-Scale Farmers: Lazaro, E.L.; D.F. Mselela, respectively, Dept. of Agricultural Engineering, Sokoine University of Agriculture, P.O. Box 3003, Morogoro, Tanzania.

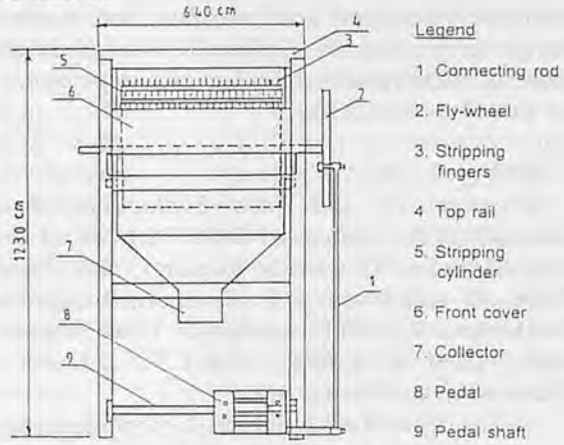

Fig. Main assembly of the pod stripper.

Groundnut stripping by hand is a very tiring and time consuming operation. To try to solve this problem for small-scale farmers, a simple foot-operated groundnut stripper was developed at the Sokoine University of Agriculture.

The machine was tested for its stripping capacity and effectiveness on a number of local groundnut varieties. The stripping capacity was 13 kg/man hour while the stripping effectiveness was 92% and no pod damage was observed.

The machine was found to be very useful in time-saving and simplifying the pod stripping operation. The performance test results obtained were very encouraging when compared to hand-stripping which was around 2.1 kg/man h. The production cost of the machine was estimated at about US$60 which is a reasonable amount, hence within reach of most small-scale farmers in Tanzania. ■■

13th International Congress on Agricultural Engineering

February 2-6, 1998
Rabat, Morocco

During its 1990 General assembly, CIGR selected Morocco to host the 13th International Congress of Agricultural Engineering. This Congress is held in a period where developing agriculture is seeking a harmonious integration to the era of exchange globalization. In this context, agricultural engineering is called upon to efficiently contribute in making this agriculture sustainable and capable of responding to a double concern: economical and social.

The Moroccan National Committee of CIGR (ANAFID) takes a great pleasure in reextending his most cordial invitation to all the persons interested in the various fields of agricultural engineering to attend the 13th International Congress. The latter will be held from February 2 to 6th 1998 and will be followed by post congress tours which provide an opportunity to visit Morocco and to have an idea on its achievements in agricultural engineering.

Following the diffusion of the first announce of this congress, ANAFID has already received pre-registartion from participants from 50 countries from around the world.

The Moroccan National Committee will spare no effort to ensure a full success and a most enjoyable stay to all congress participants in a country known for its legendary hospitality and welcoming nature.

Congress Topics

Section 1: Land and Water Use — Integrated land and water management in arid and semi-arid areas.
Section 2: Structures, Equipment and Environment.
Section 3: Mechanization
Section 4: Electricity and Other Energies.
Section 5: Management and Ergonomic.
Section 6: Processing

Scientific Secretariat

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5th ISTVS Asia-Pacific Regional Conference

October 20-22, 1998
Seoul National University, Seoul, Korea

The 5th ISTVS Asia-Pacific Regional Conference will be held on October 20-22, 1998 at the Convention Center of the Seoul National University in Seoul, Korea. The conference will continue building on the successful the ISTVS Asia-Pacific regional conferences held in Beijing, China in 1986, Bangkok, Thailand in 1988, Changchun, China in 1992 and Okinawa, Japan in 1995.

The 5th ISTVS APRC will bring together researchers, engineers, and other professionals in terrain vehicle systems to exchange information, discuss opportunities and address challenges for the future researches. The technical session will feature the latest in academic and applied researches. The 5th ISTVS APRC is sponsored by the Seoul National University and the Korean Society for Agricultural Machinery.

Topics of the Conference

Papers, for either oral or poster presentations, are invited on the following:

- Traction
- Soil-Vehicle Interactions
- Performance Modeling
- Conservation of Terrain Environment
- Soil Properties
- Soil-Tool Interactions
- Vehicle Dynamics
- Test and Evaluation

Call for Papers

Authors wishing to present a paper are requested to submit an abstract to the Conference Chairman by November 30, 1997. The abstract should be about 200-300 words, single-spaced and must emphasize objectives and results. The authors will have 10-15 minutes to present highlights of their papers and will participate in a poster session.

For Information Contact:

Prof. Kyeong Uk Kim. Agricultural Engineering Department, College of Agriculture and Life Sciences, Seoul National University, 441-744 Suweon, Korea. Tel: (331) 290-2382, Fax: (331) 294-1815, E-mail: kukim@plaza.snu.ac.kr

The International Conference on Computers in Agriculture

October 28-30, 1998
Hyatt Orlando, Orlando, Florida, USA

This conference is the eighth in a series of conferences (and the seventh international conference) that is intended to provide an exchange of information on the applications and use of computers in all agricultural disciplines. Contributions from various countries will allow a broadened perspective for all attending.

Sponsored by:

ASAE — The Society for engineering in agricultural, food, and biological systems, Information and Electrical Technologies Division.

For conference content information contact:

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Hua-Nan '98 — South China International Exhibition on Agriculture

November 11-14, 1998
Guangzhou, P.R. of China

Improving agriculture production is a top priority of the Chinese government. The Ministry of Agriculture estimates that during the Ninth Five Year Plan (1996-2000) 20% of the government budget will be spent on agricultural development. In order to reach this promising market CCPIT Guangdong and the Royal Dutch Jaarbeurs are organizing Hua-Nan '98, the first and only South China International Exhibition on Agriculture. The exhibition will take place at the China Foreign Trade Centre, venue of the well known China Export Commodities Fair in Guangzhou (Canton). The dates are November 11-14, 1998.

CCPIT Guangdong is the province's Chamber of Commerce. This non-governmental trade organization is made up of social dignitaries and business people. Since establishing an exhibition department in 1980, CCPIT Guangdong has organized over 500 trade fairs and exhibitions. Royal Dutch Jaarbeurs is one of Europe's most experienced exhibition organizers. Jaarbeurs has organized several international exhibitions in related industries in Asia, Europe and South America.

Feed and Food Pavilion

Since the start of preparations last month, CCPIT Guangdong and Royal Dutch Jaarbeurs already have reached an agreement with Victam International on the organization of a Feed and Food Industries Conference and the incorporation of a special Feed and Food Pavilion at Hua-Nan '98. In addition to this conference, other international seminars will be organized as well, covering recent agricultural developments, issues and trends. Together with the exhibition, visitors and exhibitors get a comprehensive view of everything happening in this market.

Categories

Agricultural points of interest in South China are horticulture, aquaculture, vegetables, poultry and pigs. This is reflected by the exhibitor profile of Hua-Nan '98 which includes food processing and packaging equipment, agricultural production, horticultural productoin, intensive animal production, fishery and fish farming and food products. The product categories are poultry, pigs, dairy, horticulture, fruit, cereals, fish farming, food packaging and processing.

Hua-Nan '98 has the support of the Chinese Ministry of Agriculture, the Guangdong provincial government and the Agricultural Commission of Guangdong province.

For information on participation please contact Mr. Ivo de Lange, phone +31 30 295 5088 or fax: +31 30 295 5709, e-mail: huanan.china@jaarbeursutrecht.nl.

International Agricultural Engineering Conference 1998

December 7-10, 1998
Bangkok, Thailand

The last conference in 1996 was held in India and now, it has been decided to have the next conference in 1998 back at AIT.

The proposed 1998 conference aims at providing a friendly and relaxed atmosphere to encourage the interchange of ideas between peers, and provide opportunities for researchers, managers and planners to learn from each other.

The conference will be organized by the Asian Institute of Technology, Bangkok, Thailand and will be held on the AIT campus which is 17 km north of Bangkok international airport.

Topics

- Power and Machinery
- Food and Process Engineering
- Soil and Water
- Energy in Agriculture
- Agricultural Systems
- Structures and Environment
- Electronics in Agriculture
- Agricultural Waste Management
- Agro-industry
- Agricultural Engineering Education
- Ergonomics
- Terramechanics
- New Materials
- Emerging Technologies

Call for Papers

The emphasis of the conference is on all aspects of research, design and development work in the various disciplines of Agricultural Engineering. The purpose of the conference is to stimulate discussions on various aspects of research in agricultural engineering and related fields.

Abstracts in English not exceeding 500 words should be submitted before 31st January 1998. Each abstract will be reviewed and the decision of the Editorial Board will be conveyed to each author by 31st March 1998. The final papers must be submitted by 31st July 1998. The instruction for writing the paper will be forwarded along with the acceptance letter. Only those papers of authors who pay the registration fee or attend the conference, will be published in the conference proceedings. Therefore, pre-registration is encouraged.

Deadlines

Return of Information Form
31st Dec. 1997

Receipt of Abstracts

31st Jan. 1998
Notification of Acceptance
31st March 1998
Receipt of Full Papers
31st July 1998
Pre-registration 31st Aug. 1998

For further information contact: Prof. V.M. Salokhe
Agricultural and Food Engineering Program, Asian Institute of Technology, P.O. Box 4, Klong Luang, Pathumthani 12120, Thailand. Tel. 524-5479, 524-5450, Fax. (66-2) 524-6200, 516-2126, E-mail: salokhe@ait.ac.th

Giuseppi Pellizzi Receives ASAE Kishida International Award

Giuseppi Pellizzi, AMA Co-editor, is the recipient of the 1997 Kishida International Award in recognition of outstanding contributions as an engineer, visionary, organizer, and leader. He has advanced the profession of agricultural engineering around the world and is widely acclaimed for his unique combination of academic, scientific and interpersonal skills.

Pellizzi is professor of agricultural machinery and mechanization, University of Milano, Italy. His leadership role in the International Commission of Agricultural Engineering (CIGR), President 1992-94, was instrumental in initiating the change of CIGR from a European focused organization to a global agricultural engineering network. Under Pellizzi's guidance, the Institute of Agricultural Engineering of the University of Milan, Italy, hosted the XII Congress of CIGR in 1994 which was attended by over 700 agricultural engineers from 54 countries. He is founder and President of the renowned "Club of Bologna", which has served as a forum since 1989 for developing strategies to promote mechanization and to encourage appropriate technology transfer to developing countries.

His academic accomplishments include service on several academic boards, societies and committees and authorship of over 200 scientific and technical papers and 6 published books related to agricultural mechanization and efficient energy utilization.

A 27 year member of ASAE, Pellizzi is also a member of the French Academy of Agriculture, Russian Academy of Agricultural Sciences, and the Italian Academy of Agriculture.

Annual Assembly of UNACOMA

Bologna, June, 13th, 1997

The annual assembly of Unacoma, Italy's association grouping the makers of machinery for agriculture, gardening, public green spaces and earth moving, promises to be of particular importance this year. For one thing, the association's president, Alfredo Celli, is ending his second mandate, which offers a chance to review the agricultural mechanization picture in the 1990s, from crisis in 1990 to the great recovery which enables good marks to be assigned for both productivity and the quality of the machines produced as the end of the decade approaches.

Trends in the 1990s

At the start of the decade, agricultural mechanization came to a standstill because of the general crisis in farming in Italy and the most industrial nations, and also thanks to European policies of setting aside agricultural land, discouraging animal husbandry and surplus crops, and laying down production ceilings.

In 1991, when bankruptcy loomed, Italy's Federconsorzi, an extensive network of agrarian consortiums, was placed in the hands of a special administrator. At a critical moment, a system that represented a reference point for farmers and suppliers as a channel for the distribution of agrarian products of all kinds and as a source of agrarian credit disappeared after 99 years. Credit and employment suffered, and so did the commercial interests involved. Buying by farmers and sub-contractors became rudderless.

In 1991, Celli was elected as Unacoma's president, at a time when the agricultural machine industry was in one of its most critical moments, and the crisis continued in 1992. Production fell by 10.07% in 1991 and by 3.57% in 1992. Even though domestic demand fell by 9.22% in 1993, production rose by 2.02% thanks to a strong surge in exports, in part due to the lira's devaluation.

The sector went on recovering in subsequent years, in part because farmers had a run of good years, in part because the manufacturers got their marketing act together. In 1995, domestic sales rose by 10.09%, foreign sales by 12.63%, and production rose by 10.08%. The picture painted by Celli at the Unacoma annual meeting for 1996 is a rosy one with further increases in production and record-breaking export figures registered.

Agricultural and Gardening Machinery

In 1996, agricultural machinery production, including tractors, agricultural operating machines, gardening machines, incomplete tractors and tractor parts totalled 863 400 t, an increase of 7.7% over 1995, a new record added to the record figure for 1995. In terms of retail prices, the value was 10 898 billion lire, up 10.36% on 1995's total of 9 874.5 billion lire. The domestic market bought 412 538 t (+4.14% on 1995) of which 332 800 t were produced domestically (+3.36% on 1995) and 79 738 t came from abroad (+7.55%).

For domestically made tractors, domestic sales dropped slightly by 1.94% on 1995, but this was offset by a growth in exports of 13.76%. In total, 75 206 tractors were produced, weighing 217 850 t for a value of 3 270.6 billion lire, with an increase of 8.67% of units produced, 2.14% in weight and 4.96% in value.

Incomplete tractors and tractor parts also produced a good result, due mostly to exports: 131 050 t (+35.48%) for a value of 1 983 billion lire (+25.13%). Other agricultural, including gardening machiens totalled 514 400 t (+4.66%) for a value of 5 644.3 billion lire (+9.1%), thanks above all to a 5.27% rise in exports and a smaller increase in domestic sales.

The Italian trade account for the sector is solidly in the black, with the other EU countries accounting for 55%. Sales totalled 530 785 t (+10.34%) for a value of 5 613.9 billion lire (Cif and Fob values) and an increase of 12.52%, against imports of 79 738 t for a value of 943.1 billion lire. In terms of weight, the surplus of 451 047 t was an increase of 10.85% on 1995; in monetary terms, it was 4 670.8 billion lire, an increase of 14.41%.

Unacoma's Activities

There are hopes of maintaining the good results of 1996 in 1997. They are linked in part to the relaunching of Italian products abroad; these are tending to maintain the market shares they won thanks to devaluation in 1993-1995. This is partially due to a slightly more favourable economic moment for farming compared to the early 1990s, but above all to the capacity of Italian companies for investing in research and technological development, analysing new agricultural mechanization needs, and building highly innovative machines. As always, Unacoma's function has been to support the industry in terms of overall promotion, improvement in the quality of support services (especially as regards the EU's Machines Directive), quality, and information.

1992 saw the first EIMA in Campo event, putting machines through their spaces in the field. The aim was to permit a direct contact between the machine builders and agriculture in the Italian regions. This year, the fourteenth edition will be held at Eboli on July 6. In May, the first edition of Comamoter in Campo was added.

One task to which Unacoma has devoted constant attention is the improvement of the services offered by Eima, the international agricultural machinery exhibition organized with Bolognafiere. This has been improved year by year. In the last editions over 100 000 visitors have attended each year. As regards gardening machinery, apart from the traditional venue in Bologna, Eima and the Milan Fair have also signed an agreement to organize the Milan Garden Show, or Miga.

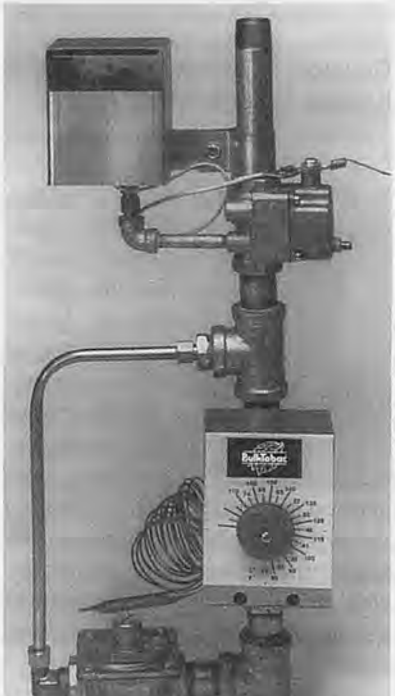
The provision of information on agricultural mechanization, new technology, and the policy and regulatory aspects of mechanization was ensured by creating Mondo Macchina — Machinery World. This was set up in 1992 with six issues a year. As of this year, it is a monthly.

Board of Directors Elected

The Annual Assembly of UNACOMA, convened in Bologna (Villa Cicogna, S. Lazzaro di Savena) on 13th June 1997, after having approved the Association's annual report presented by Chairman Alfredo Celli, who has completed his second term in office, proceeded in accordance with the Association's bylaws to elect the Chairman and Members of the Board of Directors for the next three years (1997-2000).

The new Chairman elected by the Meeting is Mr. Aproniano Tassinari, New Holland's area manager for the Italian market.

BulkTobac Tobacco Curing Systems



Available using lower cost propane, butane or natural gas, the BulkTobac® Conventional Tobacco Curing Systems are ideal for Virginia, Cigar and burley-type tobacco. They provide a simpler and more productive curing alternative to labor-intensive wood, coal or oil systems for cleaner, higher volume and more profitable curing without electricity.

(Continued on page 79)

Agriculture africaine et traction animale

(France)

Animal traction and African agriculture is a development workers guide for giving advice and training in the use of animal traciton in the inter-tropical areas of Africa. Its originality, compared with previous works which have concentrated on technical aspects, lies in its integration of the mechanization of animal traction into the production system. In an agricultural world in the process of being restructured, where project management tasks are being replaced with advice-giving activities, this work will help the farmers to make choices based on their needs in their production units.

The first part describes the different natural environments encountered in sub-Saharan Africa and analyzes the many factors — natural, human, economic, and organizational — involved in the development of animal traction, using concrete case studies. The second part considers the study of draught animals and their management. The third part explains how to get the most out of the animals in terms of usable energy for traction and describes harnessing devices. The fourth part considers technical aspects — crop management sequences, equipment, and maintenance — by presenting the possible choices corresponding to the working conditions, the strength of materials, and the practical constraints encountered by the farmers.

Contact:
CIRAD-SAR
BP5035
34032 Montellier Cedex 1
France

Institute for Agricultural Engineering in the Tropics and Subtropics, University of Hohenheim — Research and Development

(Germany)

The Institute for Agricultural Engineering in the Tropics and Subtropics was established in 1989 at the University of Hohenheim as part of the Center for Agriculture in the Tropics and Subtropics. It is composed of the Mechanization and Irrigation division and of the Postharvest Technology and Energy in Agriculture division.

The institute offers courses in Agricultural Engineering in the Tropics and Subtropics for students from agricultural sciences. It is also involved in organizing training courses for scientists from developing countries.

In the area of research, the institute has developed a research concept which combines measures to increase yields and promote sustainable and environmentally friendly cultivation. It develops applied technologies and provides expertise on conservation tillage, water and energy saving irrigation systems, drying of agricultural products and solar energy utilization in rural areas. The interdisciplinary research activities are conducted in close cooperation with other institutes of the Center for Agriculture in the Tropics and Subtropics and with national and international research institutions in developing countries. To promote the immediate adaptation of newly developed or optimized technologies, the industries are also involved during the conceptualization and implementation of the research projects.

As part of its information dissemination activities, the institute publishes every two years a progress report in German containing its activities in teaching, research and extension. To disseminate the information to English speaking countries in the Tropics and Subtropics, the institute publishes this English R&D report which contains brief descriptions of research projects and selected publications.

Published by: Prof. Dr. W. Mühlbauer, Institute for Agricultural Engineering in the Tropics and Subtropics, University of Hohenheim, Garbenstraße 9, 70599 Stuttgart, Germany.

Jahrbuch Agrartechnik — Yearbook Agricultural Engineering / Edition 1997

(Germany)

by Prof. Dr.-Ing. Dr.-Ing.E.h.H.J. Matthies and Dr. agr. F. Meier

In recent years, the "Yearbook of Agricultural Engineering", whose ninth edition is available now, met with the interest of an always increasing readership. It gives us great pleasure that the number of copies which can be sent abroad has further risen. Due to the renewed support of the Bundesministerium für Ernährung, Landwirtschaft und Forsten (BELF), agronomists in all countries of Eastern Europe could be provided with the Yearbook, where they find concentrated information about the current standards and the development in the agricultural engineering sector in Germany.

The bilingual text has proved useful. The Yearbook is not only employed as a source of information, but it also serves as an "encyclopedia" at the universities.

The basic structure has been retained. This year, the Yearbook is supplemented with a description of the activities of the "Kuratorium für Technik und Bauwesen in der Landwirtschaft" (KTBL) — Committee for Technology and Structures in Agriculture — and of the "Deutsche Landwirtschaftsgesellschaft" (DLG) — German Agricultural Society — in the sector of agricultural engineering.

As usual, the Yearbook also includes a very extensive bibliography. The listed national and international publications provide additional information which supplements the overview given in the individual chapters.

Main Contents

General Development; Agricultural tractors; Transportation and conveyance; Tillage; Tillage and sowing; Plant protection and plant cultivation; Application of mineral fertilizers; Irrigation and sprinkling; Hay harvesting; Grain harvesting; Root crop harvesting; Engineering in intensive cropping; Farm building; Cattle husbandry techniques; Techniques of pig husbandry; Energy engineering (Renewable energies); Agricultural engineering in the tropics and subtropics; Municipal engineering and landscape maintenance techniques; Inspection of plant protection equipment in Europe; Farm work science; Reports from the agricultural associations; and Bibliography.

Published by Landwirtschaftsverlag GmbH, Postfach 480249, 48079 Münster, Germany (Tel. 02501/801-118, Fax. 02501/801-204).

Club of Bologna Vol. 6 — Proceedings of the 6th Meeting of the Full Members

(Italy)

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50 Experts from 24 countries attended the meeting — held under the auspices of CIGR — discussing a general subject on "An appropriate agricultural mechanization in the various world regions". The subject was subdivided into three main topics:

1) Methodologies for the identification of the optimum mechanization levels;
2) Technological levels needed in the various agricultural areas; and
3) Role of high technologies to contribute to the machine design and operations.

Session 1. Methodologies for identification of optimum mechanization levels

Three key-note reports by E. Audsley (UK), P. Jannot (F) and G. Castelli and F. Mazzetto (I) were presented. Each summarizes the advances in modelling of mechanization management in the three countries.

Session 2. Technological levels needed in different agricultural areas

Four key-note reports by J.K. Schueller and B.A. Stout (USA) were presented covering the industrialized countries, south-asian, central and east-european and latin-american countries, respectively.

Session 3. Role of advanced technologies in machine design and operation

The key-note report by F. Sevila, J.M. Roger and B. Bonicelli (F) focussed mainly on mechatronics. This term is widely applied to machines operating with less direct human involvement.

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Tel (06) 44231370, Fax (06) 4402722

Vegetable Crops Agribusiness — Proceedings of a Workshop

(Taiwan)

Compiled by M.L. Chadha, Kamal U. Ahmad, S. Shanmugasundaram, and Abul Quasen

Bangladesh, with 120 million people, and still growing has an actual per capita vegetable consumption of 40 g/head per day. This is far below the daily requirement of 200 g/head per day. Over 1 million tons of vegetables produced from 152 000 ha land area is not enough to meet the required consumption.

Considering the country's limited arable areas for vegetables, production should be maximized through improved farming systems to achieve a tenfold increase in production in order to keep pace with increasing population in the country.

Enhanced vegetable production shall answer the country's nutrition deficiencies; promote more business; generate wider employment opportunities; and women empowerment. This could be attained if proper farm inputs such as good quality seeds, fertilizers, integrated pest management, irrigation, and post harvest facilities are put in place. Proper training, availability of credit facilities, and networking with other countries are essential to bolster the country's marketing setup. Vegetable-based agribusiness is a step to raise the level of managerial skills among the producers. This could also pave the way towards a balanced distribution of both fresh and processed vegetables in the country.

Promoting vegetable research that makes nutritious vegetables physically and economically available to the consumers and profitable to the producers in fact, builds the foundation for national development. This scenario has spurred AVRDC, BARC, and BARI to organize a workshop on vegetable crops agribusiness funded by the USAID held on 2-4 May 1995 at BARC, Farmgate, Dhaka, Bangladesh. The workshop convened researchers, extension workers, farmers, seed producers, businessmen, government and nongovernment organizations to examine different areas in vegetable production; identify and analyze problems; and formulate goals, solutions and action plans thereof to help vitalize and boost both production and consumption of vegetables and augment financial benefits.

AVRDC. 1996. Vegetable Crops Agribusiness: Proceedings of a workshop held at BARC, Farmgate, Dhaka, Bangladesh, 2-4 May 1995. Asian Vegetable Research and Development Center. P.O. Box 42, Shanhua, Tainan, Taiwan (ROC). Publication No. 97-457. 223 p.

The Sustainability of Rice Farming

(U.K.)

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by D.J. Greenland, Visiting Professor, Dept. of Soil Science, University of Reading, UK.

Rice has supported a greater number of people for a longer period of time than any other crop. Nearly half of the global population is dependent on rice as its major staple food. While Asia remains the main centre of production and consumption of rice, the importance of rice is increasing rapidly in Africa and Latin America, and exports of rice from the United States and Australia are of major importance to the world rice trade.

This book explores the factors which have contributed to the sustainability of rice production over the eight or nine thousand years for which rice has been produced. Sustainability is defined as the maintenance or improvement of production levels and protection of natural resources, within the context of economic viability and social acceptability. The author covers a wide range of issues, including soil fertility, plant breeding, pest management, irrigation, land degradation and social and economic factors. Greatest emphasis is placed on the special features of wetland rice production, and the importance of the nutrient balance. It is also shown that without the Green Revolution there would have been a period of mass starvation in Asia, a problem which continues to threaten and which will be unavoidable unless the successes of the Green Revolution can be sustained.

The book provides a unique review of the sustainability of the production of the world's most important crop, and should be of interest to students, research workers and policy makers in agriculture, soil science, and agricultural economics and food policies, as well as all interested in development in the third world.

Contents:

- The Importance of the Sustainability of Rice Farming
- The Origins and History of Rice Farming
- Rice Farming Today
- The Biophysical Basis of the Sustainability of Rice Farming
- Maintaining the Nutrient Requirements of Rice
- Maintaining Water Supplies for Rice
- Social and Economic Factors and the Sustainability of Rice Farming
- Concerns About the Sustainability of Rice Farming
- Increasing and Sustaining Rice Production

April 1997 / 288 pages / £49.95 (US$90.00).

Contact: CAB INTERNATIONAL, Wallingford, Oxon OX10 8DE, UK. Tel: +44(0)1491 832111 Fax: +44(0)1491 826090 E-mail: cabi@cabi.org

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(Continued from page 76)

NEWS

The BulkTobac Systems are an affordable way to cure more tobacco automatically in less time using less labor and curing it to higher quality standards than alternative systems. It also relates how easy it is to convert a farmer's current barn to the BulkTobac system.

If the automatic thermostatic control is the brains of the system, then the dual burner/stove station assembly is its heart. Why two burners? The first burner is a 1.46 kW (5 000 BTU) unit which functions both as a pilot light for the main burner and is used by itself in the leaf yellowing process. Begin your curing cycle using only the yellowing burner to achieve perfect leaf color, then switch on the main burners (11.72 kW/40 000 BTU) to set the color, dry the leaf, and completely dry the stem.

Each dual burner assembly is mounted under a 61 × 61 cm (24 × 24 in.) flame spreader assembly. These rugged, rust-resistant, all-steel assemblies provide excellent heat distribution, as well as providing a wind screen around the burners, protecting the flame from drafts. The entire system is completely protected by safety shutoff devices built into the thermostatic control unit. And since electricity is not required, the system continues to operate during power outages and voltage drops.

For free copies of the new BulkTobac Conventional Tobacco Curing System fliers, contact Gas-Fired Products, Inc., BulkTobac Division, P.O. Box 36485, Charlotte, North Carolina 28236, U.S.A. Telephone number is (704) 372-3485; Fax is (704) 332-5843. The Toll-Free number is the U.S. is 1-800-438-4936.

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BACK ISSUES

(Vol. 27 No. 1, Winter 1996 ~)

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INSTRUCTIONS TO AMA CONTRIBUTORS

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

Criteria for Article Selection

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

a. are written in the English language ;
b. are relevant to the promotion of agricultural mechanization, particularly for the developing countries ;
c. have not been previously published elsewhere, or, if previously published are supported by a copyright permission ;
d. deal with practical and adoptable innovations by small farmers with a minimum of complicated formulas, theories and schematic diagrams ;
e. have a 50 to 100-word abstract, preferably preceding the main body of the article ;
f. are printed, double-spaced, under 3,000 words (approximately equivalent to 6 pages of AMA-size paper) ; and those that
g. are supported by authentic sources, reference or bibliography.
h. written on floppy disc.

Rejected/Accepted Articles

a. As a rule, articles that are not chosen for AMA publication are not returned unless the writer(s) asks for their return and are covered with adequate postage stamps. At the earliest time possible, the writer(s) is advised whether the article is rejected or accepted.
b. When an article is accepted but requires revision/modification, the details will be indicated in the return reply from the AMA Chief Editor in which case such revision/modification must be completed and returned to AMA within three months from the date of receipt from the Editorial Staff.
c. "The AMA does not pay for articles published. However, the writers are given collectively 5 free copies (one copy air-mailed and 4 copies sent by surface/sea mail) of the AMA issue wherein their articles are published. In addition, a single writer is given 25 off-prints of the article and plural writers are given 35 off-prints (also sent by surface/sea mail)"
d. Complimentary copies: Following the publishing, three successive issue are sent to the author(s).

Procedure

a. Articles for publication (original and one-copy) must be sent to AMA through the Co-operating Editor in the country where the article originates. (Please refer to the names and addresses of Co-operating Editors in any issue of the AMA). However, in the absence of any Co-operating Editor, the article may be sent directly to the AMA Chief Editor in Tokyo.
b. Contributors of articles for the AMA for the first time are required to attach a passport-size ID photograph (black and white print preferred) to the article. The same applies to those who have contributed articles three years earlier. In either case, ID photographs taken within the last 6 months are preferred.
c. The article must bear the writer(s) name, title/designation, office/organization, nationality and complete mailing address.

Format/Style Guidance

a. Article must be sent on 3.5 inch floppy disk with MS DOS format (e.g. Word Perfect, Word for DOS, Word for Windows.....) along with one printed copy.
b. The data for graphs and the black & white photographs must be enclosed with the article.
c. Whether the article is a technical or popular contribution, lecture, research result, thesis or special report, the format must contain the following features :
   i) a brief and appropriate title ;
   ii) the writer(s) name, designation/title, office/organization ; and mailing address ;
   iii) an abstract following ii) above ;
   iv) body proper (text/discussion) ;
   v) conclusion/recommendation ; and a
   vi) bibliography
d. The printed copy must be numbered (Arabic numeral) successively at the top center whereas the disc copy pages should not be number. Tables, graphs and diagrams must likewise be numbered. Table numbers must precede table titles, e.g., "Table 1. Rate of Seeding per Hectare". Such table number and title must be typed at the top center of the table. On the other hand, graphs, diagrams, maps and photographs are considered figures in which case the captions must be indicated below the figure and preceded by number, e.g., "Figure 1. View of the Farm Buildings".
e. The data for the graph must also be included.
f. Tables and figures must be preceded by texts or discussions. Inclusion of such tables and figures not otherwise referred to in the text/discussion must be avoided.
g. Tables must be typed clearly without vertical lines or partitions. Horizontal lines must be drawn only to contain the sub-title heads of columns and at the bottom of the table.
h. Express measurements in the metric system and crop yields in metric tons per hectare (t/ha) and smaller units in kilogram or gram (kg/plot or g/row).
i. Indicate by footnotes or legends any abbreviations or symbols used in tables or figures.
j. Convert national currencies in US dollars and use the later consistently.
k. Round off numbers, if possible, to one or two decimal units, e.g., 45.5 kg/ha instead of 45.4762 kg/ha.
l. When numbers must start a sentence, such numbers must be written in words, e.g., Forty-five workers..., or Five tractors..." instead of 45 workers..., or, 5 tractors.

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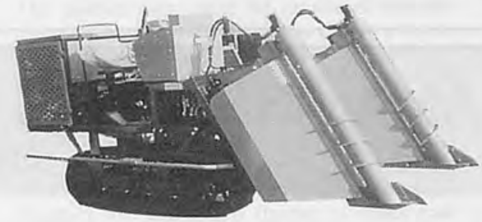

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