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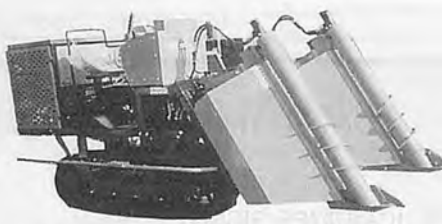

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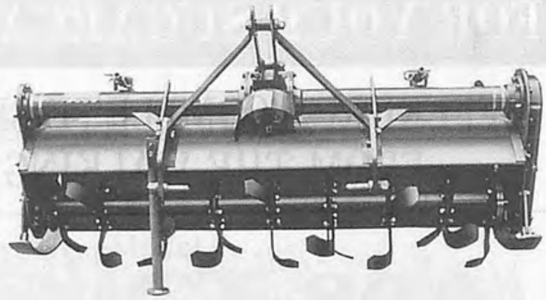

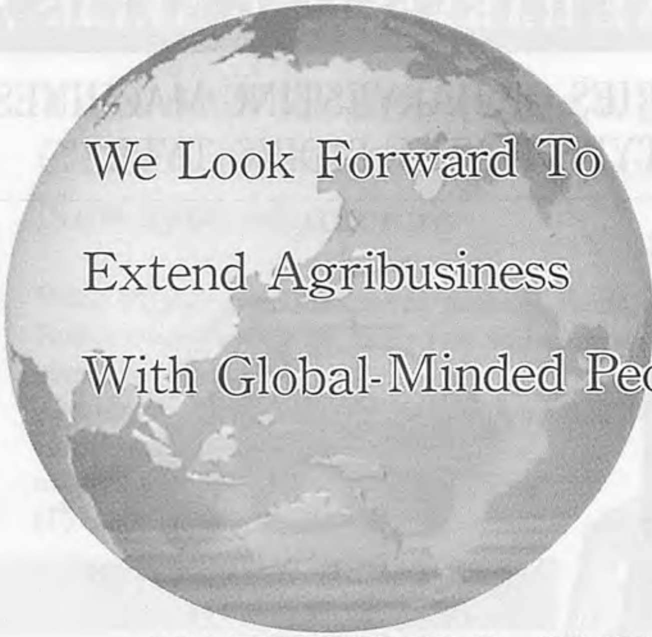

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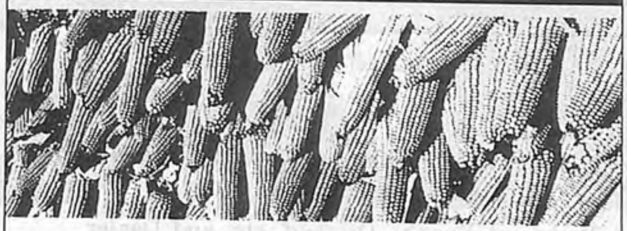

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AMA ABSTRACTS AND INDEX, 1971–1980

— A Key to Wealth of Information —

As the AMA enters its 13th year of publication this year, the Editorial Staff deems it appropriate to commemorate the event by publishing "Abstracts and Index 1971-80" in May, 1983 for only ¥2,000 a copy, including sea mail postage.

During the decade 1971-1980, more than a thousand articles were received by AMA from readers and co-editors. Over 600 of these contributions were published from which the abstracts and index in various aspects of agriculture and agricultural mechanization in developed and developing countries were arranged for use as a handy reference by students, government officials, ressearchers and academicians interested in agriculture and agricultural mechanization. For example, at a glance, the abstract and index tell about the content of the article, author and AMA issue number. The publication form is A3 size (18.5 cm x 21 cm) 82 pages.

A limited number of copies are still available for which reason they will be sold on a first-come, first-served basis. In order that interested readers get their copies of the publication, it will be very useful for them (and convenient for the AMA Staff) to fill up the order from inserted in this issue and mail it to —

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This is the 106th isssue since its maiden isser inthe Spring of 1971

EDITORIAL

Good-bye, 1900's Welcome 2000 !

As we bid the 1900s good-bye and almost simultaneously welcome the new millennium 2000, the AMA staff greets everyone, especially AMA readers, contributing editors and advertisers a VERY HAPPY NEW YEAR ! Aren't we all glad and thankful that the arrival of Y2K turned out to be Y2OK instead-against the horrendous glitches that some doomsayers' imagined. Well, all's well that ends well.

Looking back awhile to the 20th century gone by, we note, among other happenings, that two world wars and a few regional wars were fought; many changes in the face of the world came about; world leaders came and went; and the human population exploded. The increase in population, by some estimates, put it at 100 million people annually - a rather outstanding happening of the past millennium. To be sure, human population of that magnitude puts a great deal of pressure on Mother Earth that creates a threat to dwindling resources such as fossil fuel, water and farmlands.

These developments suggest that mankind has to survive on limited resources, food in particular, in the next few centuries unless ways are found to accelerate the best use of these resources via technological breakthroughs in yields of staple crops, livestock and fisheries and food processing.

At the expense of being repetitive, I have since been harping, via the editorial of AMA issues, that farm mechanization is the "way to go", hence the turn-key that will steer agricultural development in developing countries of the world. Since the 1990s, the term " precise agriculture" began to draw world-wide attention from policy makers, academicians, engineers and scientists that farm mechanization before long will be more automatic, more electronic, more high-speed and a more precise technology.

This editorial is not necessarily pessimistic but rather suggestive that from a historical viewpoint, advancement in new mechanization and rationalization of agriculture in developing countries will spur agricultural productivity into greater heights. Need I reiterate the need for agricultural engineers, scientists and policy makers to pool resources and expertise to rally behind a common endeavor to increase food availability? Toward this end, AMA will continue to provide all that it can in bridging communication gaps in the process.

Yoshisuke Kishida
Chief Editor

Tokyo, Japan
January 2000

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AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

Vol.31, No.1, Winter 2000

Effects of Traffic-induced Tillage Methods on Soil Properties and Development of Grain Crops in Southwestern Nigeria

by

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Abstract

A tillage experiment was conducted over three rainy seasons in a bi-modal rainfall area during 1989-90 with the objective of evaluating the effects of traffic-induced, no-tillage and discing on soil physical properties and crop growth of maize, cowpea and soybean. The values of soil dry bulk density, penetrometer resistance, saturated hydraulic conductivity and moisture content were higher under no-tillage than under discing. The percentage emergence and root growth were higher in no-tillage than in discing. No-tillage resulted in increasing grain yields over a successive period of cultivation whereas discing gave declining yields with time.

Introduction

Soil compaction refers to the compression of unsaturated soil, during which the density of the soil body increases and there is a simultaneous reduction in fractional air volume. In other words, the effect of compaction on a soil body is a change in its structure.

Adverse soil compaction effects on plant growth in tropical Africa have been reported (Macartney et.al., 1971; Ojeniyi, 1989). Some studies on mechanical land clearing show that compaction severely inhibits crop root growth (Hulugalle and Lal, 1986). Consequently, the increased mechanical stress on the root system may reduce plant water and nutrient uptake.

The effects of compaction on nutrient uptake by roots have received much less attention than effects on plant growth itself. Whereas compaction might be expected to increase the movement of ions to roots by diffusion (Kemper et.al., 1971), restricted growth of roots generally results in smaller amounts of nutrients being absorbed from compacted than from uncompacted soil (Boone and Veen, 1982). Scanty available information on the effects of compaction on nutrient contents by crops in tropical Africa show some increase in nutrient contents by paddy rice (Ogunremi et.al., 1986), and possible decrease in nutrient contents of maize (Babalola and Lal, 1977). The consequences of compaction are particularly important when considering that increased mechanization is inevitable in tropical Africa to meet the high demand for food and cash crop production. There is, therefore, a need for further research on the effects of traffic-induced compaction on root growth and plant nutrient uptake of tropical crops.

The literature available from tropical regions shows that crop yields are markedly reduced by excessive soil compaction (Grewal et.al. 1984; Yao-Kouame and Yoro, 1991). Most available information concerning the effects of mechanized tillage systems on alterations in soil properties and crop yield for tropical Africa is, however, fragmented and sketchy. It is important to establish a cause-effect relationship between alterations in soil properties and subsequent crop growth on one hand, and motorized tillage and other farm operations, on the other.

The objective of this study was to evaluate the effects of traffic-induced tillage methods on changes

Acknowledgement: Financial support from the International Institute of Tropical Agriculture (IITA), Ibadan-Nigeria, is gratefully acknowledged.

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in soil physical properties and subsequent crop growth of maize, cowpea and soybean.

Materials and Methods

A tillage experiment was conducted in three consecutive growing seasons during 1989-90 at the International Institute of Tropical Agriculture (IITA) near Ibadan, Nigeria. The predominant soil series at the experimental site is Egbeba, whose distinct features are coarse-textured surface horizons and the predominance of angular and subangular quartz gravel in subsoil horizons. The soil is derived from fine-grained biotite gneiss and schist parent material and is classified as an Alfisol (Oxic Paleustalf) according to Soil Taxonomy (Soil Survey Staff, 1975). There are two growing seasons in this ecological zone; the first from April to July, and the second season from late August to mid-November. The total annual rainfall varied from 908 mm in 1989 to 921 mm in 1990. The weather during the three growing seasons is shown in **Table 1**. Rainfall in the second season in 1989 was much below moisture demand. In 1990, however, the rainfall exceeded open pan evaporation during May-July in the first season, and during September in the second season.

Prior to the initiation of the experiment, the site was disc-ploughed and cropped to maize for 4 years and subsequently put under vegetation fallow for 2 years. Beginning in September, 1989, treatments were laid out in a randomized block design with three replications. Discing (D) and no-tillage (NT) were tillage treatments. Discing was done by a tractor-drawn disc plough to 20 cm depth followed by harrowing. No-till plots were sprayed with paraquat (1-1' dimethly-4,4'-bipyridylium ion) at the rate of 2.5 l/ha using a manually operated knapsack sprayer one week before planting. A traffic treatment of 2 passes of a 2-Mg roller (60 cm in diameter and 180 cm long) pulled by a 33.6 kW tractor, was then performed on each of the disced and no-till plots. The roller was used as a compacting tool for its easy manoeuvrability and suitability for uniform compaction of coarse-textured soils on small-sized plots. The roller simulated field traffic in the range of 1.5-2.5 Mg. The contact area between the roller and the soil was 0.1729 m^2. Thus the average contact pressure exerted by the roller on the soil was 113 kPa per pass, well within the typical range of 100-300 kPa observed on wheel-tracked soils under cereal crop production (Voorhees et.al., 1985). Each plot was divided into three equal portions, each of which was planted to either maize (cv. 'TZPB'), cowpea (cv. 'IT82E-9') or soybean (cv. 'TGx 306-036C'). Randomization was used to allocate a crop to a portion of a particular plot. The size of the plot was 240 m^2. There was neither cultivation on trafficked plots before planting nor additional traffic after planting. Tractor wheel tracks (as a result of pulling the roller) were not considered when sampling.

The crops were planted manually using dibblers at spacings of 25 × 75 cm for maize and cowpea and 5 × 75 cm for soybean. Soybean seeds received no Rhizobia inoculation before planting because the variety used nodulated freely with Rhizobia indigenous in the experimental soil. Fertilizer applied uniformly at planting consisted of 120 kg/ha N (40 kg at planting time and

Table 1. Growing season rainfall, open pan evaporation, and air temperature at IITA

Second season, 1989	August	September	October	November	Total
Rainfall (mm)	76.0	66.8	103.5	10.4	256.7
Departure[1]	-34.0	-115.2	-62.0	-22.6	-238.8
Mean air temp.(℃)	24.0	25.5	25.7	27.0	-
Open pan evap. (mm)	89	97	125	136	447
First season, 1990	April	May	June	July	Total
Rainfall (mm)	80.8	236.2	160.8	108.4	586.2
Departure[1]	-59.2	86.2	-20.0	-37.6	-30.6
Mean air temp. (℃)	29.0	27.5	25.9	24.7	-
Open pan evap. (mm)	170	155	119	86	530
Second season, 1990	August	September	October	November	Total
Rainfall (mm)	36.1	139.2	38.3	28.6	242.2
Departure[1]	-85.9	-42.0	-133.7	-3.4	-265.0
Mean air temp. (℃)	24.0	25.4	26.9	27.8	-
Open pan evap. (mm)	75	94	129	145	443

[1] *Departure from a 30-year average.*

Table 2. Effects of traffic-induced tillage on dry bulk density (g/cm3) of soil

Tillage	Soil depth (cm)			
	0 -5	5 -10	10 -15	15 -20
15 September 1989				
No tillage	1.45	1.51	1.53	1.55
Discing	1.46	1.47	1.42	1.49
11 April 1990				
No tillage	1.47	1.47	1.48	1.48
Discing	1.41	1.42	1.42	1.46
11 September 1990				
No tillage	1.65	1.62	1.59	1.63
Discing	1.67	1.63	1.60	1.63

Table3. Average values of penetrometer resistance (kPa) of the soil surface immediately after traffic-induced tillage

Tillage	15 September 1989	11 April 1990	11 September 1990
No tillage	268	313[a]	294
Discing	239	245[b]	272
	NS		NS

Letters a-b denote significance at the 5% level using Duncan's new multiple range test. NS = Not Significant.

80 kg 4 weeks later) as urea for maize, 26 kg/ha P as single superphosphate and 30 kg/ha K as muriate of potash for maize, cowpea and soybean. Cowpea and soybean received no N. The first season crops were planted in mid-April; the second season crops in mid-September.

The soil bulk density was measured immediately after the application of traffic treatments by the core method (Klute, 1986) down to a depth of 20 cm in 5 cm increments. Penetrometer resistance was measured with a pocket penetrometer on the soil surface. Saturated hydraulic conductivity was determined on undisturbed cores using a constant-head permeameter (Klute, 1986), the samples being soaked for 24 h prior to making measurements. Soil moisture was measured gravimetrically in the 0 - 10 cm layer immediately after the application of traffic treatments.

Seedling emergence was determined in each experimental unit until no additional germination occurred. During the first season of 1990, root samples were taken by the core method at two-week intervals in 7-cm increments down to 21 cm from areas where shoots had been removed for measurements of growth. These samples were saturated overnight and then washed with a gentle spray of water over a 2-mm sieve. Washed roots were picked up by forceps, rewashed and then dried at 60°C. Ear leaf samples of maize at flowering and upper canopy leaf samples for cowpea and soybean at anthesis, were collected each season. The leaf samples were oven-dried and ground to pass a 425 _m screen. Total N was determined colorimetrically using a Technicon Auto-Analyser. P, K, Ca, Mg, Zn and Mn were determined by emission or atomic absorption spectrophotometry after wet digestion. Grain yield was recorded at 10% (w/w) moisture content at maturity.

Results and Discussion

Soil Physical Properties

Changes in dry soil bulk density resulting from trafficked tillage treatments are shown in **Table 2**. Although not significantly different ($P \leq 0.05$), the dry bulk density of no-till soil was generally higher than that of trafficked disced soil during September 1989 and April 1990. In September 1990, however, the dry bulk density of disced soil was higher than in no-till soil throughout the depth of measurement. There was an increasing trend in soil bulk density values of no-till, top soil (0 - 10 cm depth) from September 1989 to September 1990. This was attributed to cumulative compaction effects from two previous seasons. The high dry bulk density of disced soil (compared to no-till soil) in September 1990 was, nevertheless, caused by high rainfall received during that month which made the soil more susceptible to traffic. Consequently, the dry bulk density of disced soil had similar values to those of no-till soil throughout the depth of measurement in September 1990.

The penetrometer resistance on the soil surface was higher in no-till than in disced plots at all periods of measurement, and the increase was statistically significant ($P \leq 0.05$) in April 1990 (**Table 3**). The penetrometer resistance of disced plots increased steadily from 239 kPa in September 1989 to 272 kPa in September 1990. This was partly attributed to cumulative compaction effects and partly due to continuous cropping in subsequent seasons.

The saturated hydraulic conductivity of trafficked no-till and disced plots is shown in **Table 4**. Although not statistically significant ($P \leq 0.05$), the saturated hydraulic conductivity values of no-till plots were generally higher than those of disced plots at all periods and depths of measurement. There are two reasons for this phenomenon. The continuity of channels created by earthworms and related biological activity, and macropores created by decaying root systems of previous crops were important factors in enhancing water transmission through the profile of no-till soil during intensive storms (Lal, 1989).

A significant difference in soil moisture content between the two tillage treatments occurred in April 1990 (**Table 5**). In April 1990, the soil moisture content in no-till plots was higher than in disced plots. Similar results were reported by Baryeh (1986) in Cameroon. The crop residues and other dead plant material on the surface of no-till soil improved water infiltration into the profile thus increasing soil-water storage in the root zone.

Table 4. Effects of traffic-induced tillage on saturated hydraulic conductivity (cm/h) of soil

Tillage	Soil depth (cm) 0 -5	5 -10	10 -15	15 -20
15 September 1989				
No tillage	78.5	76.2	88.7	92.7
Discing	67.1	73.7	77.6	87.4
11 April 1990				
No tillage	94.5	97.9	112.7	117.6
Discing	76.0	85.4	97.4	109.5
11 September 1990				
No tillage	70.8	95.8	105.8	104.3
Discing	64.8	81.1	107.5	117.4

Table 5. Soil moisture content (% w/w) at 0-10 cm depth immediately after traffic-induced tillage

Tillage	15 September 1989	11 April 1990	11 September 1990
No tillage	7.7	3.9^a	8.9
Discing	8.2	1.5^b	9.3
	NS		NS

Letters a-b denote significance at the 5% level using Duncan's new multiple range test. NS = Not Significant.

Crop Emergence

The percentage emergence of maize, cowpea and soybean was generally higher in no-tillage than in discing (**Table 6**). Higher emergence percentage on no-till plots could be attributed to less compaction on these than on disced plots due to the presence of crop residues. Crop residues also provided favourable temperatures and soil moisture to the emerging seeds.

Root Growth

The root growth of maize, cowpea and soybean as affected by traffic-induced no-tillage and discing methods of seedbed preparation is shown in **Figures 1, 2** and **3**, respectively. Root density of maize, cowpea and soybean was significantly higher in no-till plots than in disced plots at 0-7 cm soil depth.

At 8 weeks after planting (WAP) for example, root density was 1.73 and 1.44 mg/cm^3 in maize (**Fig. 1**); 0.37 and 0.28 mg/cm^3 in cowpea (**Fig. 2**); and at 0.93 and 0.72 mg/

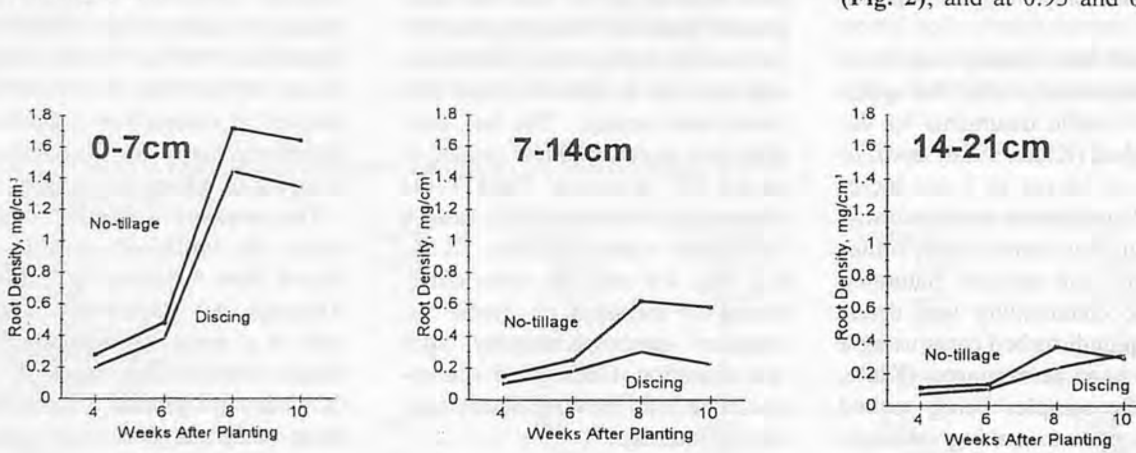

Fig. 1 Influence of Traffic-induced Tillage on Root Growth of Maize (first season, 1990).

Table 6. Effect of Traffic-induced tillage on percentage emergence of grain crops

Treatment	Maize Sept 1989	Apr 1990	Sept 1990	Cowpea Sept 1989	Apr 1990	Sept 1990	soybean Sept 1989	Apr 1990	Sept 1990
No tillage	75.2^b	88.5^a	84.1^a	71.2^a	87.4^a	91.2^a	68.3^b	83.0^a	78.3^a
Discing	83.0^a	67.3^b	79.5^b	58.0^b	83.7^b	84.1^b	77.4^a	72.7^b	67.0^b

Letters a-b denote significance at the 5% level using Duncan's new multiple range test. Means with the same letter are not significantly different.

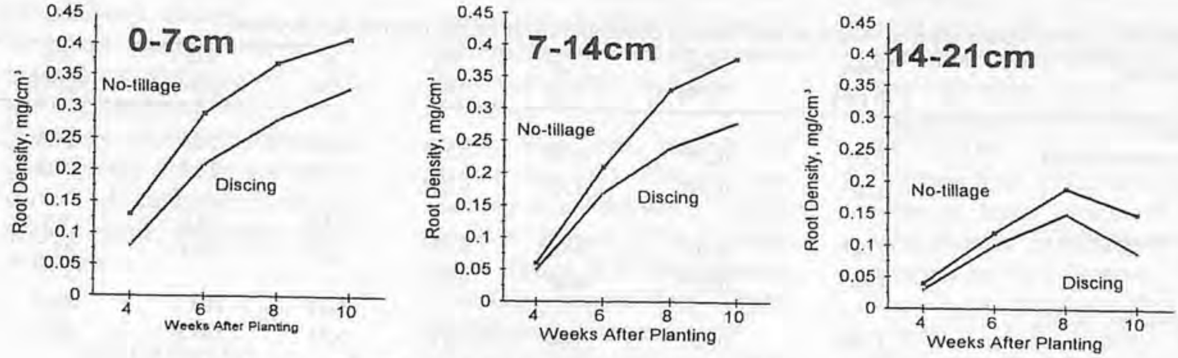

Fig. 2 Influence of Traffic-induced Tillage on Root Growth of Cowpea (first season, 1990).

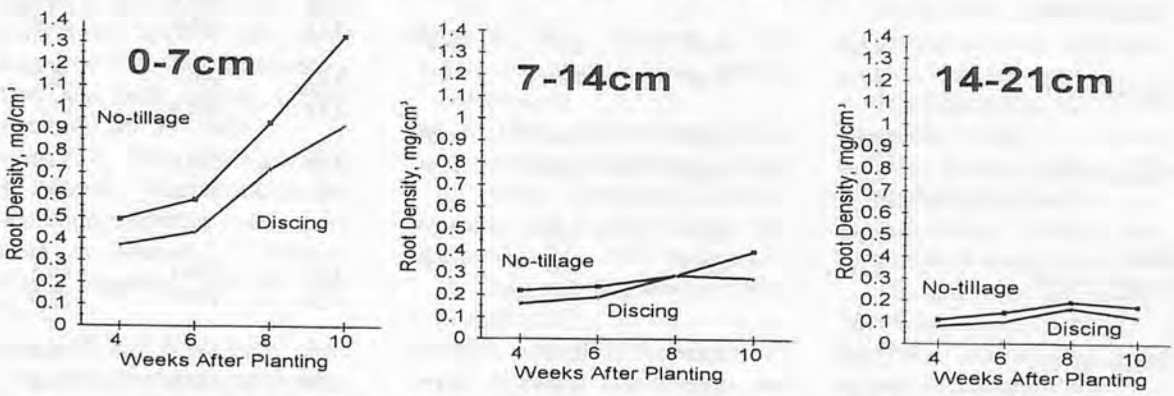

Fig. 3 Influence of Traffic-induced Tillage on Root Growth of Soybean(first season, 1990).

cm^3 in soybean **(Fig. 3)** under no-tillage and discing, respectively, at the 0-7 cm depth. Root density of maize and soybean declined more sharply with an increase in soil depth. Root density decline with an increase in depth was very gradual in cowpea due to its ability to penetrate soil layers of high strength and bulk density (Townend et.al., 1996). Higher root density in no-till than in disced plots could be attributed to less compaction on no-till soil than on disced plots due to the presence of crop residues on the no-till soil surface. It could also be attributed to the stability and continuity of channels created by earthworms and decaying roots of previous crops in the untilled soil that favours deep root system development into the gravelly subsoil horizons (Lal, 1989) which are otherwise difficult for roots of these seasonal crops to penetrate.

Leaf Nutrient Concentration

The results of leaf nutrient analyses for maize, cowpea and soybean are shown in **Table 7**. No-tillage resulted in significant lower leaf nutrient concentration of N in maize, cowpea and soybean compared with discing. Leaf nutrient concentration of Ca was also significantly lowered in maize and soybean, and also Mg in soybean, compared with discing. Although not significant, the leaf nutrient concentration of P for the three crops was higher under no-tillage than under discing. The effects of traffic-induced tillage on the leaf nutrient concentration, as reported above, could possibly be explained in the following way: The reduced leaf nutrient concentration of N, Ca and Mg under no-tillage as compared with discing, were a result of: (i) the surface application of a low rate of superphosphate containing P, Ca and S which may have restricted the uptake of the elements; (ii) the antagonistic effect of increased concentrations of K (from fertilizer) at the soil surface on Ca and Mg uptake; and (iii) greater nitrogen immobilization by crop residues.

Grain Yields

There were no significant differences in grain yield between no-tillage and discing except for soybean **(Table 8)**. The yield of soybean was significantly higher under discing than under no-tillage during the second season of 1989 and the first season of 1990. Looking at yield trends during the three consecutive cropping seasons, however, the yields of maize, cowpea and soybean under discing declined continuously from one season to the next. The yields of these crops under no-tillage, on the other hand, declined during the second season of 1989, but increased in the first

Table 7. Effects of traffic-induced tillage on leaf nutrient concentration of maize, cowpea and soybean

Treatment	Total N (%)	Total P (%)	Ca (%)	Mg (%)	K (%)	Mn (ppm)	Zn (ppm)
Maize							
2nd season '89 NT	1.83^{a}	0.28^{a}	0.26^{a}	0.16^{a}	3.80	76.4	24.0
D	2.03^{a}	0.24^{a}	0.32^{a}	0.20^{a}	3.78	72.7	28.3
1st season '90 NT	2.24^{b}	0.30^{a}	0.46^{b}	0.15^{a}	3.53	97.6	8.2
D	3.04^{a}	0.23^{b}	0.60^{a}	0.20^{a}	3.59	99.4	25.7
2nd season '90 NT	2.44^{a}	0.35^{a}	0.64^{a}	0.31^{a}	5.43	193.7	48.6
D	2.65^{a}	0.29^{b}	0.50^{a}	0.28^{a}	5.01	168.8	40.9
Cowpea							
2nd Season '90 NT	4.56^{a}	0.38^{a}	2.63^{a}	0.40^{a}	3.78	509.6	45.2
D	4.37^{a}	0.38^{a}	2.84^{a}	0.45^{a}	3.73	469.6	55.8
1st season '90 NT	4.89^{a}	0.39^{a}	2.68^{a}	0.40^{a}	3.47	650.1	18.7
D	4.87^{a}	0.35^{a}	2.84^{a}	0.43^{a}	3.41	452.9	21.1
2nd season '90 NT	3.29^{b}	0.24^{a}	1.83^{a}	0.42^{a}	4.25	548.6	33.0
D	3.70^{a}	0.22^{a}	2.03^{a}	0.45^{a}	4.32	371.1	34.2
Soybean							
2nd season '89 NT	3.80^{b}	0.27^{a}	2.72^{a}	0.33^{a}	3.23	218.1	60.5
D	4.38^{a}	0.27^{a}	2.53^{a}	0.37^{a}	3.30	177.7	57.5
1st season '90 NT	2.52^{a}	0.28^{a}	1.01^{b}	0.40^{b}	2.78	187.1	18.7
D	2.91^{a}	0.25^{a}	1.11^{a}	0.46^{a}	2.79	156.8	26.6
2nd season '90 NT	3.22^{a}	0.20^{a}	1.14^{a}	0.45^{a}	2.74	195.5	36.1
D	3.38^{a}	0.19^{a}	1.02^{a}	0.42^{a}	2.72	200.4	43.3
					NS	NS	NS

Letters a-b denote significance at the 5% level using Duncan's new multiple range test. NS = Not Significant.

Table 8. Effects of traffic-induced tillage on grain yields of maize, cowpea and soybean

Treatment	MEAN VALUES								
	Maize			Cowpea			Soybean		
	Sept 1989	April 1990	Sept 1990	Sept 1989	April 1990	Sept 1990	Sept 1989	April 1990	Sept 1990
No tillage	4.2	3.1	3.3	1.1	0.8	0.9	0.7^{b}	0.9^{b}	1.4
Discing	4.9	4.1	2.8	1.0	0.9	0.8	1.5^{a}	1.1^{a}	1.0
	NS	NS	NS	NS	NS	NS			NS

Letters a-b denote significance at the 5% level using Duncan's new multiple range test. NS = Not Significant

season 1990 and peaked during the second season of 1990. The decline in crop yields was attributed to the substantial degradation of physical soil properties more on disced plots than on no-till plots as a result of continuous cropping (Baryeh, 1986; Yao-Kouame and Yoro, 1991). The increasing crop yield trends on no-till plots were, however, attributed to the stability and continuity of channels created by earthworms and related biological activity, and macro-pores created by decaying root systems of previous crops which favoured deep root system development **(Figs 1 - 3)**.

Conclusions

The following conclusions are drawn from the study:

1. The values of soil dry bulk density, penetrometer resistance, saturated hydraulic conductivity and moisture content were higher under no-tillage than under discing.
2. The percentage emergence and

root growth were higher in no-tillage than in discing.

3. No-tillage resulted in lower leaf nutrient concentration of N, Ca and Mg, compared with discing.
4. No-tillage resulted in increasing grain yields over a successive period of cultivation whereas discing gave declining yields with time.

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APPENDIX 1. Influence of traffic-induced tillage on root growth (mg/cm3) of maize, cowpea and soybean during the first season of 1990 (for Figures 1,2 and 3, respectively)

Week after planting (WAP)	4			6			8			10		
Soil Depth (cm)	0-7	7-14	14-21	0-7	7-14	14-21	0-7	7-14	14-21	0-7	7-14	14-21
Maize												
No-tillage	0.28	0.22	0.11	0.48	0.25	0.13	1.72	0.88	0.36	1.64	0.64	0.29
Discing	0.20	0.15	0.07	0.38	0.25	0.10	1.44	0.62	0.23	1.34	0.58	0.31
LSD (5%)	0.06	0.10	0.03	0.07	0.18	0.18	0.26	0.30	0.16	0.22	0.22	0.37
Cowpea												
No-tillage	0.13	0.06	0.04	0.29	0.21	0.12	0.37	0.33	0.19	0.41	0.38	0.15
Discing	0.08	0.05	0.03	0.21	0.17	0.10	0.28	0.24	0.15	0.33	0.28	0.09
LSD (5%)	0.02	0.01	0.01	0.02	0.05	0.03	0.02	0.15	0.02	0.01	0.11	0.04
Soybean												
No-tillage	0.49	0.22	0.11	0.58	0.24	0.14	0.93	0.29	0.19	1.33	0.40	0.17
Discing	0.37	0.16	0.08	0.43	0.19	0.10	0.72	0.20	0.16	0.92	0.28	0.12
LSD (5%)	0.05	0.06	0.04	0.13	0.03	0.02	0.12	0.30	0.13	0.19	0.14	0.05

LSD(5%) = Least Significant Difference at 5% level.

Development and Evaluation of Axial Flow Pump Attached to a Power Tiller

by

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Abstract

Many developing countries extensively use centrifugal pumps for lifting water even at low heads (1 to 3 meters) because of their widespread availability. At low heads, the efficiency of the centrifugal pump can drop by as much as 50 per cent of its maximum efficiency. In contrast, axial flow pumps are efficient and have high capacity at low heads. There are extensive areas like pumping irrigation water from canals, draining rain water to save the crop in low lands where low lift pumps are highly suitable. The axial flow pump developed attached to a power tiller consists of a specially designed axial flow impeller which is secured to a pump shaft and encased inside a 190 mm diameter mild steel discharge tube. A flexible shaft connects the power tiller engine and the pump shaft. The pump was evaluated for its performance. A maximum discharge of 4250 lit/min at 0.25 m head and a minimum of 2400 lit/min at 3.0 head was possible. The comparative performance of the pump with a 100 mm centrifugal pump showed that the capacity of the axial flow pump is 2 to 3 times higher than that of the centrifugal pump for lifts between 1.0 and 3.0 m. The cost analysis reveals a low efficiency of the centrifugal pump at low lifts.

Introduction

The general constraint attributed to the possession of power tiller is its low utilisation. Though several agricultural operations like tillage, sowing, inter-cultivation, irrigation, harvesting etc. can be accomplished by using power tillers, no concrete efforts have been made to develop various matching equipment to this multipurpose power source to make it versatile. Realising the importance of draining rain water at a fast rate in order to save the crop in low lands and considering the need for pumping water from the canals, the need for development and evaluation of low lift, high volume pump operated by a power tiller has been felt. The water so pumped can be transported through appropriate sub-canal system to the farthest part of the land area.

Review of Literature

Many developing countries extensively use centrifugal pumps for lifting water even at low heads (1 to 3 meters) because of their widespread availability. At low heads, the efficiency of the centrifugal pump can drop by as much as 50 per cent of its maximum efficiency. In contrast, axial-flow or propeller pumps are more efficient and have high capacity at low heads. This type of pump is in fact very popular in Thailand, because there are extensive areas where low lift pumps are suitable and the technology is basically the same as that of outboard motors for boats, which are widely manufactured and used in Thailand. The Thailand axial-flow pump is essentially a boat propeller and shaft encased in a long tube and coupled with an engine. The propeller is made to turn in a direction such that water is sucked in from the propeller and driven out to the other end.

In 1979, the IRRI Agricultural

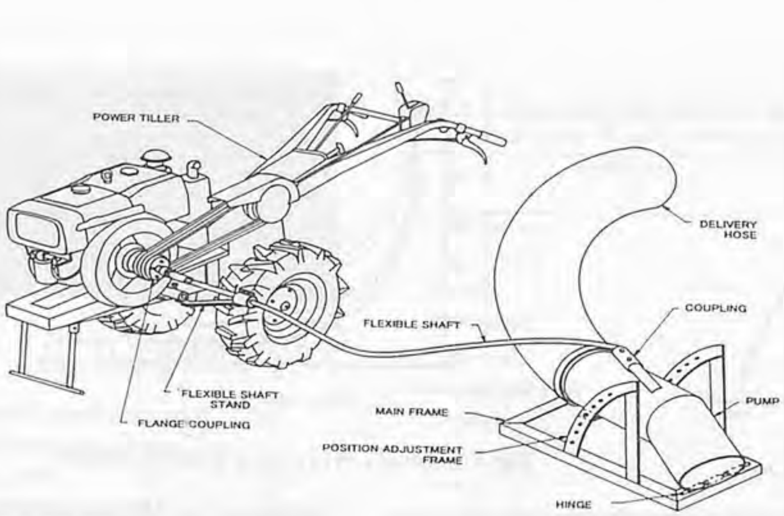

Fig. 1 Sketch of Axial Flow Pump.

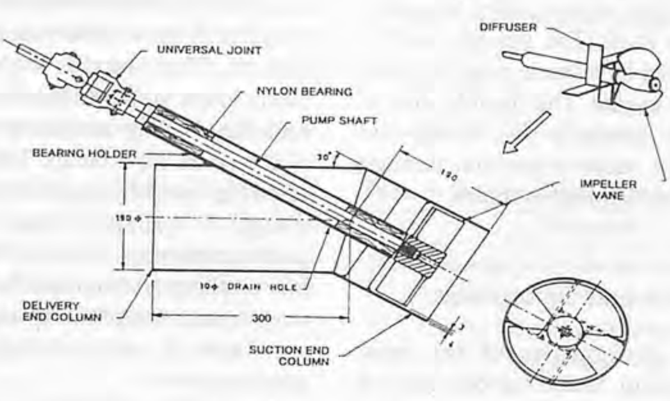

Fig. 2 Universal Jointed Propeller Shaft for Axiel Flow Pump.

Engineering Department initiated a project to improve the efficiency of the Thailand axial-flow pump and to simplify the design in a manner that would reduce the cost and enable the fabrication by workshops in rural areas. The specification of the pump are total lift, 4m; maximum speed of operation, 3000 rpm; power transmission, direct coupling (or) belt drive; diameter of discharge tube, 15 cm; and pump output 3000 lit/min. IRRI (1979) also developed a 25-cm axial-flow pump to make full use of the power of 8 to 10 HP diesel engines and to double the capacity of the smaller 15-cm pump. The pump is basically a scaled-up model of the 15-cm size pump and closely followed its critical design features. The pump has a capacity of 5300 lpm at a lift of 2.8 m when operating at 1450 rpm. Chinnan Chetty (1983) designed and developed an axial flow pump driven by the PTO shaft of the tractor. The salient features of the pump include a discharge rate of 11.6 m^3/min at total head of 4.3 m, the operational speed of 1000 rpm and efficiency of 50.4 percent.

Materials and Methods

The design consists of a specially designed axial flow impeller which is secured to a pump shaft and encased inside a 19-cm diameter mild steel discharge tube **(Fig.1)**. The pump is supported by a stand with an adjustable frame and hinged at the discharge end and inlet end, respectively. A flexible shaft connects the power tiller engine pulley and the pump shaft. The 30 degree cut along the tube axis is provided to avoid vortex formation and to reduce losses.

Behind the axial flow impeller is a set of diffusion vanes which serve to straighten the spiral flow from the impeller for improved efficiency. The average pitch of the impeller is 20 degree for maximum efficiency. The stand is used for securing proper alignment of flexible shaft as well as to support the pump during the operation.

Important Design Features and Components of The Pump

(a) Axial flow impeller

The impeller was designed for high efficiency and easy fabrication by small shops. It has two mild steel sheet-metal vanes which are bent into shape and welded to a threaded hub with the help of a fabrication jig **(Fig.2)**. The impeller has an average pitch of 20 degree for optimum efficiency and must be set in the pump tube at a radial clearance of at least 3 mm for optimum efficiency and capacity.

(b) Diffusion vanes

The diffusion vanes located behind the axial flow impeller is a set of 4 mild steel sheet-metal vanes designed to straighten the rotational flow of water from the impeller and there by reduce friction and turbulence losses. The vanes have an average pitch of 90 degrees which is dynamically balanced with the 20-

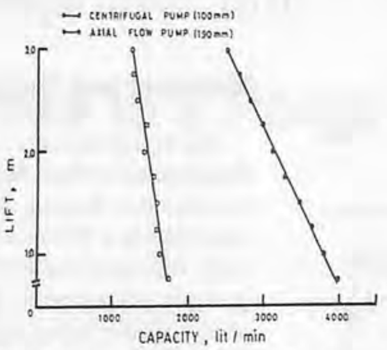

Fig. 3 Capacity Performance Curves.

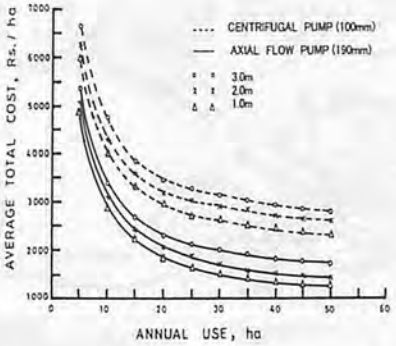

Fig. 4 Effect of Lift in Cost of Water per Hectare.

Table 1. Evaluation report of axial flow pump attachment to power tiller

Head (m)	Discharge (lpm)
0.25	4250
0.50	4125
0.75	3920
1.00	3775
1.25	3622
1.50	3400
1.75	3275
2.00	3125
2.25	2925
2.50	2725
2.75	2600
3.00	2400

degree pitch of the axial flow impeller. For design economy, the primary wooden bearing is integrated to the hub of the diffusion vane assembly. Thus it serves also as a bearing holder **(Fig.2)**. Similar to the impeller, the diffusion vanes can be fabricated by simple bending and welding technique with the help of a fabrication jig.

(c) Nylon bearings

The impeller shaft runs in a long nylon bearing housed in mild steel tube which is welded to the pump assembly at an inclination of 30 degrees. A coupling is provided between the impeller shaft and the flexible drive.

(d) Discharge tube

The pump discharge tube is fabricated from 18 gauge mild steel sheet by simple rolling and welding techniques, thereby avoiding the weight and expense associated with commercially available pipes or tubes. A flexible canvas hose fitted at the discharge end carries the water to the discharge place.

(e) Engine coupling system

The pump can be coupled to the power tiller engine pulley through a flexible shaft. The flexible shaft is supported by a frame near the power tiller engine. The flexible shaft is aligned perfectly by fixing the pump in desired position through hinge and adjustable frame.

Results and Discussion

The performance of the axial flow pump under various size of heads was evaluated. The result is shown in **Table 1** and represented in **Fig.3**. A maximum discharge of 4250 lit/min at 0.25 m head and a minimum of 2400 lit/min at 3.0 m head was observed. Above the designed head of 3.0 m, the performance of the pump resulted in considerable reduction in discharge and higher torque on flexible shaft.

The comparative performance of the axial flow pump and 100 mm centrifugal pump, both operated by power tillers are shown in **Fig.3**. It is observed that the capacity of the axial flow pump is 2 to 3 times higher than that of the centrifugal pump for lifts between 1.0 and 3.0 m.

The cost calculations of the power tiller operating a 190-mm axial flow pump and 100 mm centrifugal pump are shown in **Table 2** indicating a similar capital outlay for both the pumps. The annual fixed costs for the centrifugal pump are high due to a high initial cost. Both pumps show a similar variable costs per hour. On per hectare basis, however, their respective variable costs at each lift showed substantial differences. The reason is the significantly lower volume capacity of the centrifugal pump compared to that of the axial flow pump. This indicates the low efficiency of the centrifugal pump and its inappropriateness at lower lifts. A low discharge rate means the pump must operate longer hours per hectare **(Table. 3)** and incur high operating expenses.

Fig. 4 shows the total average cost per hectare for the axial flow pump that is low at three different lifts compared to the centrifugal pump at similar lifts. As annual utilization increases, and total average costs per hectare decreases due to spreading out of the fixed costs.

Specification of the unit:

Power, hp	8-10
Weight, kg	35
Width, mm	620
Diameter of the discharge tube,mm	190
Average pitch of the impeller, degree	20
Total lift, m	3.0
Maximum operation speed, rpm	1500

Fig. 5 Power Tiller Operated Axial Flow Pump in Action.

Flexible shaft size, mm	15
Maximum discharge rate, lpm	4500
Cost of the unit, Rs	3000

Conclusion

The salient features of the power tiller operated axial flow pump are:
Simple in design and construction;
Easy to operate and transport;
Highly suitable for lifting water from open water sources such as canals and rivers;
Increases the versatility of the power tiller;
Capacity is 2 to 3 times higher than that of centrifugal pumps for lifts between 1.0 and 3.0 metres; and
High efficiency at lower lifts when compared to centrifugal pumps.

Table 2. Comparative cost analysis of power tiller operated 190 mm axial flow pump and 100 mm centrifugal pump

Particulars	Axial flow pump (Rs.)	Centrifugal pump (Rs.)
Capital outlay		
Capital cost		
Pump	3,000.00	4,800.00
Power tiller	70,000.00	70,000.00
Total cost	73,000.00	74,800.00
Fixed cost per year		
Depreciation		
Power tiller	6,650.00	6,650.00
Pump	480.00	304.00
Interest on average capital investment, 14%	5,110.00	5,236.00
Insurance, 2% of average capital	730.00	748.00
Repair and maintenance, 10% of capital	7,300.00	7,480.00
Total fixed cost per year	20,270.00	20,418.00
Variable cost per hour		
Diesel and oil	11.00	11.00
Labour	5.00	5.00
Total variable cost per hour	16.00	16.00
Total variable cost per hectare at		
1.0 m lift	847.70	1,910.45
2.0 m lift	1,032.25	2,206.90
3.0 m lift	1,319.60	2,560.00

Table 3. Command area capacity of axial flow pump and centrifugal pump

Particulars	Axial flow pump	Centrifugal pump
Pump capacity at 3 different lifts, m^3/hr		
1.0 m static head	226.50	115.50
2.0 m static head	187.50	88.50
3.0 m static head	145.50	75.00
Average water requirement per ha - season = 12,000 m^3		
Pumping hours required per hectare - season		
1.0 m static head	53.92	103.90
2.0 m static head	64.00	135.60
3.0 m static head	82.47	160.00

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Development and Evaluation of Power Tiller-Operated Ladder

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Abstract

Fruit crops play an important role in agriculture. The conventional methods of fruit harvesting are crude, laborious and time consuming. Power tillers are visualised as potential source of power for orchards due to their compact size and manoeuvrability in between trees.

With a view to simplifying the fruit harvesting operation and to enhance the versatility of power tillers, a power tiller operated ladder was developed. The unit consists of two telescopic box type sections, one sliding inside the other. It is mounted on the power tiller trailer. The power from the power tiller is transmitted to the ladder through a worm gear box, universal joint and tumbler gear mechanism for lifting and lowering the telescopic section. The stability of the unit is 21.8°. The unit is evaluated for its performance in plucking fruits from orchard trees. The performance is compared with the manual system and the tractor mounted hoist system. The maximum height of reach is 8.0 m.

Introduction

The Power tiller is a multipurpose hand tractor designed primarily for rotary tilling and other operations on small farms. While in operation, an operator walks behind to maneuver it. It is also known as a garden tractor, hand tractor, walking tractor or a two-wheel tractor. Non-availability of matching equipment for different farm operations limits the versatility of the power tillers. Implements initially offered with the power tillers included rotavator attachment, trailer and in some cases a plough and ridger. The initial introduction of power tillers was without a complete range of matching equipment.

Power tillers are visualised as potential source of power for orchards due to their compact size and maneuverability in between trees. With the development of matching implements like tall tree sprayer, tall tree duster, and auger digger their application in orchard has immense potential. Fruit harvesting is a labourious process which is time consuming too. While harvesting the fruits one has to practically climb up individual trees. Usually in India the farmers practice conventional harvesting system only with such attendant problems as; (i) the fruit damage; (ii) the quality of fruit is reduced; (iii) time consumption is great; (iv) involves greater labour, especially in orchards. In order to eliminate the above problems and to increase the versatility of power tillers, a power tiller operated telescopic ladder was developed.

Review of Literature

Ray and Smith (1963) reported an aid to harvest the fruits, which is a three wheeled vehicle, the essential part of which is a moving chassis supporting a boom and hoist. The vehicle travels straight down each row guided by a pair of discs fitted ahead of the front wheel. Preliminary tests have shown that the quantity of fruits which can be picked by the machine with single operator can substantially exceed that picked in the same time by the

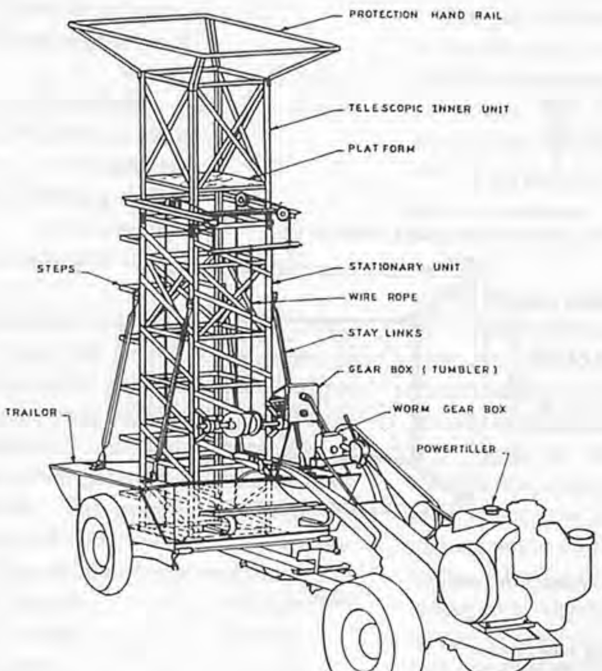

Fig. 1 Power Tiller Operated Ladder.

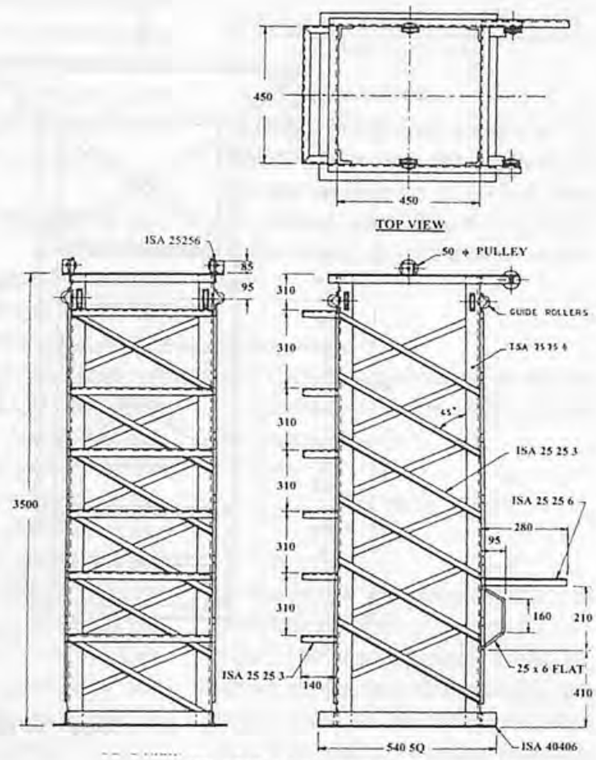

Fig. 2 Stationary Unit.

conventional ladder, bag and yield box method. Except while adjusting his position the operator has both hands free for picking. He snips the fruit off the tree and drops it in to a funnel between his legs, from where the fruit will move automatically to a bin on the platform.

McBirnery (1967) made a height- adjustable picking platform machine-adoption of a self-propelled machine with adjustable height platform for picking. A lift attachment was added for lifting the cabin a few inches off the ground and carrying it along. A bucket with quick emptying bottom was mounted on the framework of the picker platform to reduce the frequency of emptying. Such adoptions increased the effective use of the machine.

`Pictiatio-Chen *et al.* (1982) developed and tested an experimental system for harvesting oranges. Flexible curved fingers of predetermined curvature and stiffness were used as plucking criteria. The experiment consisted of a picking unit supported by a positioning mechanism on a self-propelled carrier which was powered by two independent hydraulic circuits: one for powering all the four ground wheels and, the second, for the attendant functions and accessories. A fork lift mask provided up and down movement of the picking unit. The picking tines were moved into and out of the tree with a track and carriage assembly.

Summer and Hedden (1982) developed a tractor-mounted limb shaker to reduce investment cost of a mechanical harvesting system for citrus. The shaker boom operated best over the tractor hood in high canopy trees, but was at a disadvantage when clamping low limbs. Sahu *et al.* (1985) developed a fruit harvesting device suitable for hilly regions. They reported that many kinds of local methods are used for harvesting fruits by shaking of tree or tree branches by hand or direct hitting of fruits with a stick. However, the fruits get damaged as they directly hit the ground, making almost fifty per cent of the fruits unmarketable. Moreover, a huge quantity of fruits are lost as they roll down the hill slopes.

Rajkumar et al. (1986) developed a tractor-mounted hoist for fruit harvesting. The unit consisted of a four-bar linkage mechanism for lifting and lowering a rectangular platform. It was mounted on the three point linkage connections of the tractor. The operating range was 7 m high. Tajuddin and Karunanithi (1986) while reporting the development of low-cost and easy to use improved devices for plucking fruits like sapota, guava and mango claim that while using conventional fruit plucking devices one has to physically pull the fruit. This often damages the fruit which then deteriorates in quality. The improved fruit plucking devices are

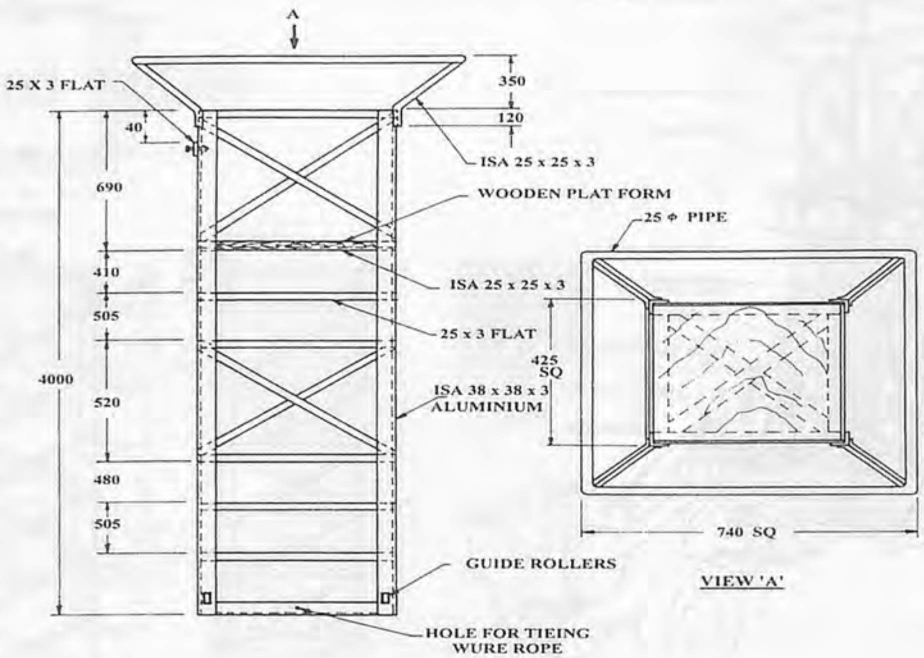

Fig. 3 Sketch of Telescopic Inner Unit.

designed to detach the fruit form the tree with a slight pull. This is achieved by means of a sharp knife fixed to these devices which avoids even the slightest bruising on the fruit rind.

Materials and Methods

Description of the Unit

The unit is a tower type structure fabricated in two box sections: one sliding inside the other with the help of side railings **(Fig.1)**. The ladder is mounted on the power tiller trailer with a set of wire-rope pulleys and a worm gear arrangement for lifting and lowering the extending (inner) section to any required height. A platform with hand rail projection is provided on the top of the extending section for the man to stand and work safely. The height when fully extended is 8 m. It is light in weight but sturdy, rustproof and mainly designed for convenient plucking of the fruits from orchard trees and other allied works.

Important Design Features of the Unit

Stationery Unit- This is a 450 × 450 × 3500 mm box type structure made of 35 × 35 × 6 mm mild steel 'L' angles. It is reinforced with braces made of 25 × 25 × 3 mm mild steel 'L' angles on all the sides **(Fig.2)**. Eight 38 mm dia guide rollers are fixed at the top portion of the unit. Four 50 mm dia mild steel pulleys are provided at the top of the unit for the 10 mm wire rope to pass through. Steps provided on the rear side of the unit for climbing up and down on the operator. The unit is fixed to a base of 540 mm mild steel 'L' angle square frame which inturn is mounted rigidly on the trailor body of the power tiller. A gear box with a reduction ratio of 1:22 and a wire rope drum are fixed in the front portion of the unit with necessary supports .

Telescopic Inner Unit- This is of similar construction of 425 × 425 × 4000 mm size but made of aluminium 'L' angle for light weight **(Fig.3)**. It is provided with a wooden platform at the top for a person to stand on. Hand protection rails are provided all around for the safety of the worker. Eight 50 mm dia guide rollers are fixed at the bottom of the unit. Two wire ropes clamped to the bottom side section of the unit pass through the clearance space between the stationary and telescopic sections. Two wire ropes pass through the four pulleys fixed on the top of the stationary unit and clamped to a 'L' angle, which inturn connected to a rope drum **(Fig.3)**. The worm gear box can be operated by the power tiller operator with the handle.

Worm Gear Box- The power from the power tiller clutch pulley is transmitted through a 'V' belt transmission to the gear box mounted on the power tiller handle with necessary supports. The specifications of the gear box follows :

i. Gear box type:Worm gear box
ii.Type of worm:Involute helicoidal

iii.Profile angle : 20°
iv.Number of start : 3
v.Working radius of worm : 82 mm
vi.Axial module : 3.15 mm
vii.Number of teeth on worm gear : 20
viii.Working radius of worm gear : 110 mm
ix.Reduction ratio : 1.6

Universal Joints

From the gear box the power is transmitted to the tumbler gear mechanism fitted at the base of the stationary unit through a pair of universal joints with transmission shafts. The specifications of the joint follows :

i. Type of joint: Single ended hook type
ii.Diameter : 40 mm
iii.Length : 160 mm
iv.Speed : 250 rpm

A telescopic arrangement with 25 mm m.s. square bar is provided to accommodate the change in length during the movement of power tiller handle.

Tumbler Gear Mechanism

The drive from the gear box is transmitted through a pair of universal joints and telescopic transmission shaft to the tumbler gear mechanism fixed with the stationary member of the ladder unit. This mechanism has been provided for lifting and lowering the telescopic inner section of the ladder unit by means of a gear shift lever with locking arrangement. The specifications of the tumbler gear mechanism follows:

a) Input gear dia - 60mm
Module - 2.5
Number of teeth - 29
Pitch circle dia - 35 mm
b) Output gear dia - 77 mm
Module - 2.5
Number of teeth - 22
Pitch circle dia - 49 mm
c) Idle gears dia - 60 mm
Number of teeth - 22
Module - 2.5
Pitch circle dia - 49 mm

The power from the power tiller is transmitted to the ladder unit through the worm gear box, universal joints and the tumbler gear mechanism. During the trials the rate of lift was 1.1 to 2.0 m/min.

Determination of Stability of the Ladder

The trailor - ladder combination was checked for stability by taking moments due to self-weight of the trailor acting through the centre of gravity of the trailor and due to the self-weight of the ladder acting through the centre of gravity of the ladder and the self-weight of the man standing on the platform of the ladder. The centre of gravity of the ladder was determined by simple balancing method which was 2.5 m from the base of the fixed bottom section. The centre gravity of the man was assumed to be acting at his centre of the total height.

The ladder was fixed on the centre of the trailor base. The height of the trailor base from the ground level was 30 cm. The man was standing on a platform at a height of 7.2 m (max) from the ground level. So his weight i.e., 60 kg, was acting at a height of 7.2 m on the ladder with respect to the ground level. The weight of the ladder was acting at the centre of gravity which was of 2.8 m from the ground level. The trailor weight of 300 kg was acting at a distance of 30 cm from the ground level.

In order to find the overall centre of gravity, the moment about the ground level was taken.

The overall centre of gravity
= (weight of the trailor × its distance from the ground level)
+ (weight of man × his distance from the ground level)
+ (weight of ladder × its distance from the ground level)
÷ (weight of trailor + weight of man + weight of ladder)

∴ Overall centre of gravity

$$= \frac{(300 \times 0.3) \times (115 \times 2.8) + (60 \times 7.2)}{(300 + 115 + 60)}$$

=1.75 m

Hence, the overall weight of the ladder, trailor and the operator is acting at a distance of 1.75 m from the ground level. The tilting angle of the ladder is calculated as follows :

Tilting angle =
$\tan^{-1}$(half the wheel base of the trailor) /(distance of the overall Cg from the ground level)

$$= \tan^{-1} \frac{0.70}{1.75}$$

$$= 21.8°$$

The trailor - ladder assembly was stable up to a tilting angle of 21.8°. This 21.8° was a critical point, because above this tilting angle, the ladder will not be stable. In practice, this trailor - ladder assembly will not be tilted to that extent. Hence, this assembly is safe against tilting. During transportation, the ladder can be kept in an inclined position by means of support derived from the rear portion of trailer. This facilitates easy movement through farm roads.

Evaluation of the Ladder

The ladder unit was evaluated for its performance in plucking fruits from orchard trees in comparison with manual plucking and plucking with tractor mounted hoist. The performance results are furnished in **Table 1** and the comparison of cost of fruit plucking operation is shown in **Fig.4**.

It is inferred that plucking operation with the power tiller ladder is faster by three times when compared with the manual plucking of fruits. Even though the cost plucking of fruits/kg is higher in using the ladder, the damage caused to the fruits is much more than in the case of manual plucking. When compared to the tractor-mounted hoist the cost of plucking fruits is less in the case of power tiller-operated ladder.

The ladder was also used for plucking coconut (dwarf varieties) and for pruning of trees. It was also used for maintenance workshops / buildings either interior or exterior and for telegraphic post lines with satisfactory performance.

The specifications of the unit follows :

Type	:	Box type telescopic ladder
Overall dimensions (L × B × H), mm	:	70 × 70 × 4000
Weight, kg	:	115
Worm gear reduction ratio	:	1:22
Maximum reach, m	:	8.0
Rate of lift, m/min	:	1.1 to 2.0
Cost of unit, Rs.	:	12000

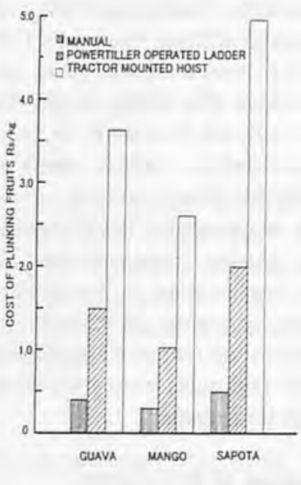

Fig. 4 Comparison of Cost of Fruit Plucking Operation.

Fig. 5 Power Tiller-operated Ladder in Action.

Conclusion

The salient features of the power tiller operated ladder are :

* Well suited for plucking fruits in orchard trees;
* Can also be used for picking coconut from dwarf varieties;
* Ideal for tree lopping, tree pruning and spraying on tree canopy;
* Used for maintenance of building and telegraphic post lines;
* Versatility of the power tiller is increased;
* Safe and stable in operation;
* Easy transportation and
* Cost saving and quick in operation.

Table 1. Performance of ladder attachment to power tiller

Type of fruit crop	Average fruit bearing height (m)	Spacing (m)	Manual method	Power tiller ladder	Tractor mounted hoist
Quantity harvested (kg/hr)					
Guava	3.20	3 x 3	13	42	46
Mango	6.10	7 x 7	16	57	62
Sapota	6.50	5 x 5	10	31	34
Quantity damaged (kg)					
Guava	3.20	3 x 3	1.75	0.50	0.60
Mango	6.10	7 x 7	2.00	1.20	1.30
Sapota	6.50	5 x 5	1.10	0.60	0.65
Cost of plucking fruits (Rs/kg)					
Guava	3.20	3 x 3	0.38	1.48	3.62
Mango	6.10	7 x 7	0.31	1.09	2.70
Sapota	6.50	5 x 5	0.50	2.00	4.91

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Down-Time and Availability of Vertical Conveyor Reaper

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Abstract

The study was conducted on down time and availability through field interviews using samples size of 51 machines spreading over 37 villages in Hisar and Sirsa districts of Haryana (India). The mean to down time (MTDT), average annual down time, down time ratio and annual availability was 7.97 hours, 15.94 hours, 0.25 and 0.75, respectively.

Introduction

Harvesting is an important activity in crop production. Today's intensive agriculture leaves only a very limited time between harvesting of one crop and sowing of the next one. Crops are susceptible to shattering if harvesting is delayed.

In order to circumvent the labour scarcity in the harvesting season of paddy and wheat, the intermediate technology between sickle and combine-harvesters in the form of Vertical Conveyor Reaper commonly called VCR was developed by the International Rice Research Institute (IRRI), Philipines for harvesting of paddy and wheat.

Farm equipment failures during the busy harvest season cause delays which result in yield reduction and inefficient labour utilization. Many times these breakdowns are minor and can be repaired in a very short time if spare parts are available. Unfortunately more time is often wasted in procuring parts than in making actual repairs. If an estimate of failure frequency can be made before hand, sufficient spare parts can be stocked to minimize down time although inventory costs must be balanced against the savings resulting from the operation.

Materials and Methods

Data on use and down-time of the tractor drawn Vertical Conveyer Reaper was collected through field survey in Hisar and Sirsa districts of Haryana.

Since the number of machines available in these two selected districts was not very large, an effort was made to study all the farm machineries in the area of study. Only a limited number of machines operateing in the selected districts might have escaped in this study. The study was started from a particular village known to have some farm machineries operating there. All the machine owners were interviewed in the study. The study was extended to other areas of two districts in obtaining information about the machine-owing villages from the farmers. Thus a total of 51 machine-owners spreading over 37 village were studied. The distribution of the machineries studied is given in **Table 1**. The number of machines purchased by the farmers' during diffrent years is given in **Table 2**.

Down-Time

This is the period of time during which an item or machine is not fit to perform its intended function satisfactorily under given conditions. It is the sum of active-down-time, logistic-time and adminstrative-time. Active-down-time is the actual time spent in repairing the machine. Logistic-time is the number of down-time hours consumed in awaiting parts or components needed to effect a repair replacements. Administrative-time includes all down-time which is not specifically allocated to either active or logistic time. It is the probability that the machine is operating satisfactorily at any point in time while in regular use.

Mean Annual Down-Time

The mean-annual-down-time of machines was found on the basis of machine age by simple arithmetic mean of annual down-time of all the machines during each year of age. This was done in order to determine weather the age of the machine had any effect on down-time and determined by simple arith-

Table 1. Village-wise distribution of vertical conveyor reaper

District	Block	Village	Number of machines
Hisar	Hisar-I	Dabda	1
		Dev Muklan	1
		Kaimri	1
		Mirka	1
		Kharar Alipur	2
		Shahpur	3
	Fatehabad	Dhani Nanaksar	1
		Daryapur	2
		Nakhatia	1
		Hazranva Kala	1
		Bigher	2
		Ahlisadar	3
		Jhalnia	1
		Gorkhpur	2
		Mahmmadpur Rohi	1
		Haripura	1
		Shahidawali	1
	Adampur	Kali Ravan	1
		Siswal	1
	Bhuna	Jandlikalan	1
	Hansi-I	Pehni Amirpur	1
	Hansi-II	Jamavari	2
		Shekhpura	1
	Tohana	Baliawali	1
		Samen	1
	Ratia	Hansga	1
Sirsa	Sirsa	Paniwari	1
		Maujukhera	2
		Patli Daber	1
	Chopta	Jodhnka	4
		Ding	1
	Baragudha	Phaggu	1
		Malri	2
	Odhan	Rohanwali	1
		Kalanwali	1
		Paniwala Mota	1
	Rania	Bani	1

Table 2. Year-wise population of vertical conveyor reapers (VCR)

Year	No. of Machines	No. Machines Cumulative
1987	2	2
1988	1	3
1989	3	6
1990	10	16
1991	9	25
1992	6	31
1993	7	38
1994	9	47
1995	4	51

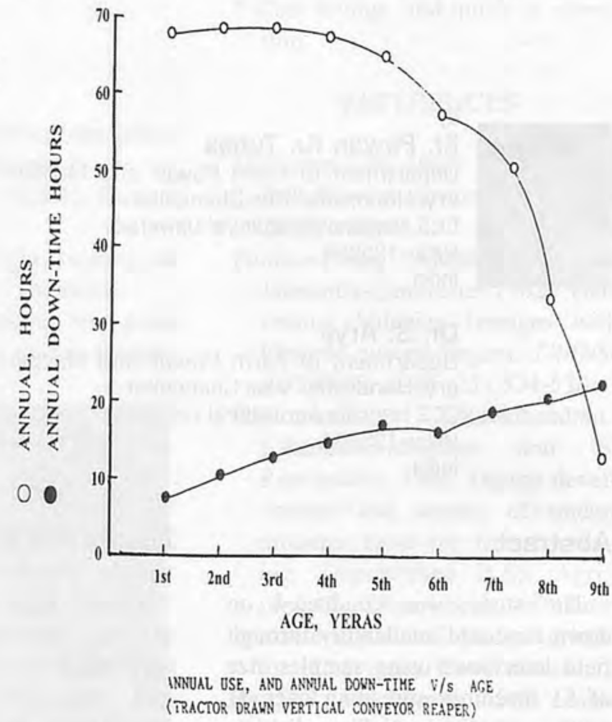

Fig. 1 Annual, down-time .

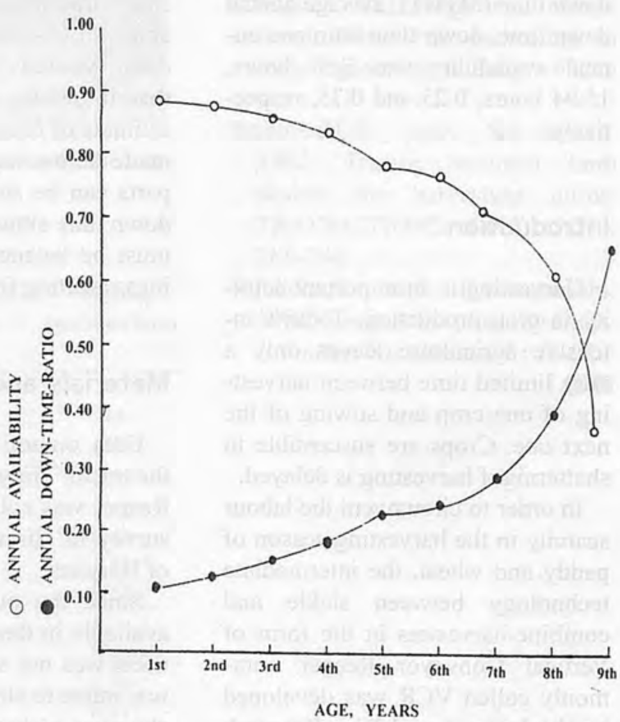

Fig. 2 Annual avalability down-time ratio.

Table 3. Age-wise mean annual down-time of vertical conveyor reaper

Age, Yr.	Down-Time Mean Annual	S.D.	C.V.
1st	8.14	8.07	0.99
2nd	10.04	6.88	0.68
3rd	11.90	8.35	0.70
4th	14.28	8.94	0.62
5th	18.07	9.58	0.53
6th	17.50	9.06	0.51
7th	19.27	18.27	0.94
8th	20.52	16.50	0.80
9th	22.48	20.35	0.90
Overall Mean	15.79	4.67	0.29

Table 6. Age-wise annual use

Age	Annual use (hr/machine)		
	Mean use	S.D.	C.V.
1st	68.57	45.38	0.66
2nd	69.14	39.43	0.57
3rd	68.54	32.60	0.47
4th	66.40	33.18	0.50
5th	64.35	26.06	0.40
6th	58.50	55.83	0.95
7th	50.75	46.68	0.91
8th	32.20	20.56	0.63
9th	12.55	10.00	0.80
Mean	54.55	18.67	0.34

Table 4. Age-wise down-time ratio (dtr) of vertical conveyor reaper

Age, Yr.	Down-Time-Ratio
1st	0.106
2nd	0.126
3rd	0.147
4th	0.176
5th	0.219
6th	0.230
7th	0.275
8th	0.389
9th	0.641
Mean	0.256

Table 5. age-wise availability of vertical conveyor reaper

Age, Yr.	Availability
1st	0.890
2nd	0.878
3rd	0.852
4th	0.828
5th	0.780
6th	0.769
7th	0.240
8th	0.610
9th	0.358
Mean	0.740

metic mean.

Mean to Down-Time (MTDT)

The MIDT it was calculated by dividing the sum of all down-times for all failures by the number of failures.

Down-Time Ratio (DTR)

The down-time ratio, defined as the ratio of the down-time to the sum of use time and down-time . It was determined for each year of age by dividing the annual down-time by the sum of annual use and annual down-time for that year by using the equation.

$$DTR = \frac{\text{Annual down-time}}{\text{Annual down-time} + \text{Annual use time}}$$

Availability

This is the probability that the machine is operating satisfactorily at any point in time when used under stated operating conditions which was calculated for each year of age by using the equation.

Availability =

(Average annual use) over (Average annual use (hrs) + Average annual down-time (hrs))

Results and Discussion

Age-wise Annual Down-Time

Table 3 shows that the down-time of the machine increased from 8.14 hrs in the first year to 22.48 hrs in the ninth year. As the age of the machine increases its down-time also increases due to the increase in number of failures caused by wearing of components. The overall mean annual down-time was 15.79 hrs. **Fig. 1** shows the trends of increase or decrease in annual use and down-time with age of the machineries.

Mean to Down-Time

The mean-to-down-time of the machine was 7.97 hrs, meaning thereby, that a failure took an average of 7.97 hrs to rectify.

Down-Time Ratio (DTR)

Table 4 shows that as the age of the machine increased the down-time ratio also increased from 0.11 in the first year to 0.64 in the ninth year. The overall mean annual down-time ratio was 0.25.

Availability

Table 5 shows that as the age of the machine increased, the availability of the machine decreased from 0.89 in the first year to 0.36 in the ninth year. The overall mean availability was 0.74 **Fig. 2** shows the trends of increase or decrease in annual down-time ratio and availability with age.

Summary and Conclusions

The study was conducted in order to determine the down-time availability patterns on 51 vertical conveyor reapers. Following conclusions were drawn from the study :

1. The mean-to-down-time of the machine was 7.97 hrs.
2. The average annual down-time, down-time-ratio and availability of the vertical conveyor reaper was 15.79 hr., 0.25 and 0.74, respectively.
3. The down-time and down-time-ratio of the vertical-conveyor reaper increased with age, while the use and availability of the machine decreased. ■■

Handling and Storage of Grain in Cameroon

by
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Abstract

A survey was carried out to determine and analyze the technologies used in post-harvest handling and storage of grain by farmers. Two hundred farmers were surveyed and several visits were made to research farms and trial and demonstration stations.

Traditional technologies exist in the handling and storage of grain. Improved technologies are being introduced but these are not being adopted by farmers either because the technologies are expensive or farmers are reluctant to introduce change.

Losses start immediately after harvest where contaminating agents and injuries are introduced along the many temporary handling stages before conditioning. Maize is still dried in the banda, a practice dating back from times when house roofs were made from thatch. The current roof design of the kitchen/living house, with corrugated sheets as roofing material is not conducive to the rapid drying of maize. A design which permits more air exchange with the outside would aid in the rapid removal of moisture from the drying grain.

The maize crib is the predominant storage structure for grain in the middle plateau region of the country. This structure can store maize successfully for up to 8 months but it is inappropriate for environments with varying relative humidities.

Introduction

Cameroon has three major climatic zones, the semi-arid zone in the North, the middle plateau with a modified guinea savanna climate and the humid forest in the South. The vegetational zones largely reflect the type of grains grown. In the humid rain forest, the major grains are maize and rice; the middle plateau area grows mainly maize with some upland rice and the semi-arid North grows millet, sorghum and rice.

About 90% of the production effort in grain production is undertaken by small- and medium-sized farmers whose skills in post-harvest handling and storage are very marginal. Efficient handling and storage play a prominent part in minimizing waste and loss of food grains. Improved storage structures prevent stored products from spoiling and allow storage for longer periods with minimum loss of quality and quantity. This also permits the availability of grain during off seasons and improves food security.

Methodology

Data for this study were collected through a survey using questionnaires and personal interviews with farmers and through interviews with agencies involved with post harvest work. Extension workers and students were used in the survey. The questionnaire designed for the study was simple and short to provide information on: type of structure, capacity, material used for construction, duration of storage, approximate age of structure and possible cost of construction and maintainance. Farmers were also asked about their willingness to adopt new technologies.

Results and Discussions

Many of the farmers interviewed produce cereals as thier main crop of which 69% in the middle plateau belt produce maize as the principal crop. Farmers growing other cereals (rice, millet, etc.) do so to sell to marketing organizations. These farmers harvest the crop, partially dry it and then sell it to the cooperative organization where further processing and storage are carried out.

Harvesting is done by hand using simple hand tools such as the paddy knife and sickle. Small grains are threshed, sun-dried and winnowed manually before storage. Maize may be stored in husks or dehusked, the practice varies and depends on the customs in the region.

Techniques for handling and storing grain in the semi-arid region are similar to those practiced in Nigeria and other african countries with a similar climate (Igbeka and Olumeko; 1996, Birewar, 1990 and Adesusyi, 1993). The rhumbu or woven baskets are the standard structures with little or no protection against pests.

Grain handling and storage practices in the plateau region are those that are inherently peculiar to Cameroon. Maize in the plateau belt is harvested around August/September. Rainfall during this period is very intense. The maize is harvested by hand, put into baskets and then carried to a temporary holding place on the farm from where it is later transported to final drying and/or storage area. The method of transportation depends on the local traditions and customs. In many regions the maize is carried in special baskets woven for the purpose. In the Bui highlands, these baskets are placed on both ends of a bamboo and transported slung across the shoulder. In other areas such as Kom, the baskets are carried on the head (Berinyuy, 1992). In either case, transporting harvested maize from the farm is a social activity involving many family members and friends.

Vehicle transport is playing an increasingly important role in the handling of maize from the farm to the house, especially in areas where the farms are far. In this case the maize is transported first by head by the harvesters to the edge of a motorable track where this does not reach the farm. The maize is again placed at a holding place for a few days until transportation is available. The husked cobs are placed inside the vehicle (usually a light truck) and transported to the drying/storage area. Sometimes the maize is again discharged onto the ground before being placed into the drying/storing facility. At the temporary holding sites the maize is exposed to the weather and predators. Although it is always covered with old stalks and leaves, this is not enough to keep off predators and moisture. These temporary holding places are often a source of a lot of damage and infestation.

Traditional Technologies

These are technologies that have been practiced over the years by the indigenous farmers and are inherently local to the region. This is to distinguish from those technologies that were introduced into the region or are adaptations of technologies developed elsewhere. Many of the traditional structures are well adapted to their environment and storage losses are low (typically about 5% of grain weight over the storage period) although such factors as the storage of high yielding varieties (HYVs) with poor storability has tended to increase this value.

Drying- Maize carried from the farm (harvested at about 22% to 24% moisture content wet basis) can be dried in one of three ways: placed directly into the ceiling of the house, dehusked, tied into bundles and hung outside from eaves of house, or hung above the fire place in the kitchen/living house. In the arid regions of the north the maize may be tied into bundles and hung from a tree. The maize in the ceiling is dried by radiant heat from the cooking fire. Drying maize in the ceiling has been described by many researchers as *Banda Drying* (Awondo, 1991). In many cultures in the region, these two types are practiced and serve different ends. The one hung from beams dries faster and is for immediate consumption while that placed on the ceiling is reserved for later use and for storage. Maize hung from the beam may also be darkened by smoke. Although the darkened maize may appear unattractive to the eye, its nutritive value has not decreased. The smoke may actually protect it from infestation (Asanga, 1994).

The drying rate for the maize dried in the ceiling is slow and is affected by other parameters like condensation and the degree of ventilation through the roof. The condensation creates very favourable conditions for the growth of mold and also favours germination.

In some areas (the Bui highlands), farmers dry the maize on platforms (*wuh - nchum*, sometimes called the Donga-mantung platform), on the farms. This drying structure is a platform made from posts and bamboos with a thatched gable roof over it. The size is typically 3m wide by 5m long by 2.5m above the ground but varies and depends on the farmer. Some farmers may have many of these structures on one farm. The roof above this platform has the gable ends open. Although this provides adequate aeration of the maize, it is also a source of additional moisture and pests as no rodent guards are used.

The maize is dried by ambient air and it may stay on the field from harvest up to November when it is then transferred to storage. During field drying the farmer turns the maize over periodically. Many farmers are increasingly storing

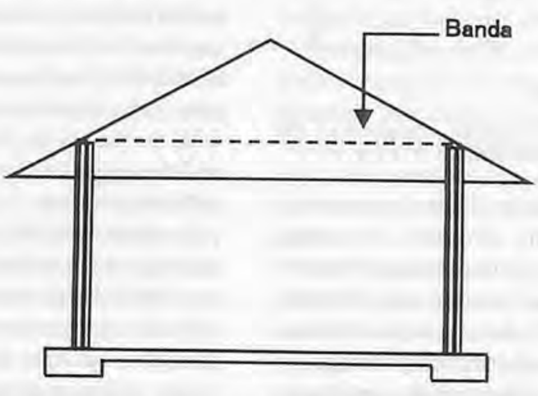

Fig. 1 A Traditional Kitchen/Living House Showing the Banda.

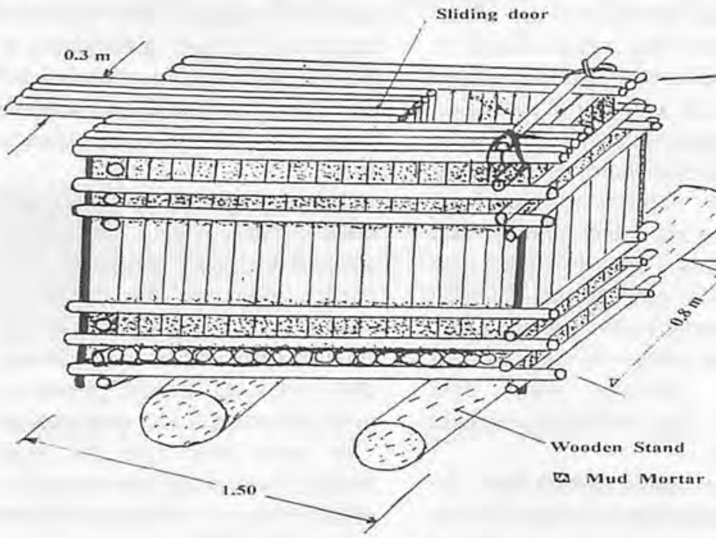

Fig. 2 Sketch of a Bamboo Crib for Storing Cob Maize.

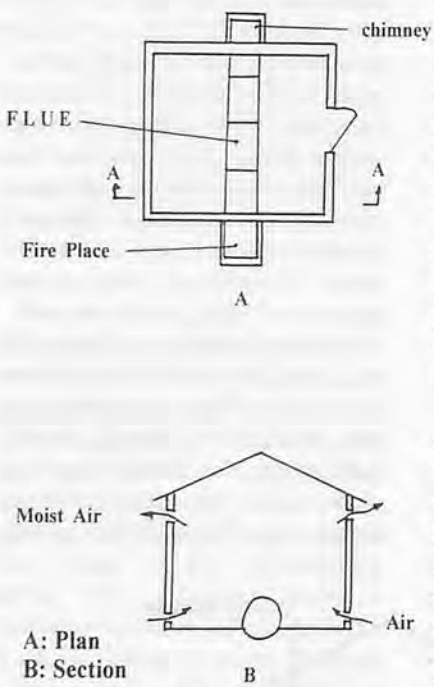

Fig. 3 A Schematic Diagram of the Martin Hot Air Dryer.

their maize in these structures as some of the structures are being made from more permanent materials. Stealing is often the determining factor in the use of this method of drying and temporary storage.

Storage- Many of the small producers use the banda described above as a store. Due to its small quantities, by the time the grain is traditionally moved into store, the remaining quantity does not warrant the extra effort. The bamboo crib is the main storage structure in the middle plateau area of the country. The crib is made of raffia bamboos and is rectangular in shape. It has a loading and off-loading hole provided at the top. Sizes depend on individual farmers but vary from 1 to 7 m^3.

Slight variations exist in the design and construction of the crib. In the Western province the bamboos are placed horizontally **(Fig 1)** and held in place by woven strings made from raffia fibers. The crib is sealed with dry plantain leaves tied together and forced into the edges of the crib. In the northwest province, the structure is constructed with the bamboos placed vertically and the edges of the box are sealed with mud mortar.

In either case, the crib is mounted on logs or on a platform 20 to 30 cm above the ground and placed in a shade either at the side of a house or some distance away from the house under a specially prepared structure. Thorny grass may be attached to the bottom to serve as rodent guards. Farmers are increasingly (55% of those sampled) using the chemical actellic powder to protect the grain against weevils. The powder is dusted onto the box and onto the corn. Some of the powder is lost through the gaps between the bamboos during the dusting of the box because of the nature of the floor. The traditional practice, however, is to use plant materials (Eucalyptus and cypress leaves were the most popular) to protect against weevils, the principal cause of storage losses in this area. Rodents were also identified as the next most important pest of stored grain (Berinyuy, 1992).

Maize is stored from November and many farmers indicated that storage life of one year was normal. The average cost of construction of the bamboo crib is 6,000 cfa. Prices as low as 2000 cfa reported in the Bui highlands while prices as high as 10,000 cfa also reported in some areas in the western Province. The crib has a useful life of 5 to 8 years but this life may be shortened if it is contaminated by moisture or attacked by termites. Maize stored in these cribs beyond the dry season begins to acquire moisture as the relative humidity increases.

Solar Dryers- Solar drying is to be distinguished from sun drying which may be understood as the exposing of a commodity in the sun without the aid of any structure to enhance the insolation. Solar energy is abundant in the region and a number of studies have been carried out on the use of solar energy for maize drying. In spite of its alluring characteristics, solar energy has not broken ground as a viable technology for cereal drying. Several reasons may be responsible for this. Solar drying systems generally require high capital outlay. In addition, the low drying rates for natural convection systems tend to discourage their use. In addition, the harvesting season is characterized by

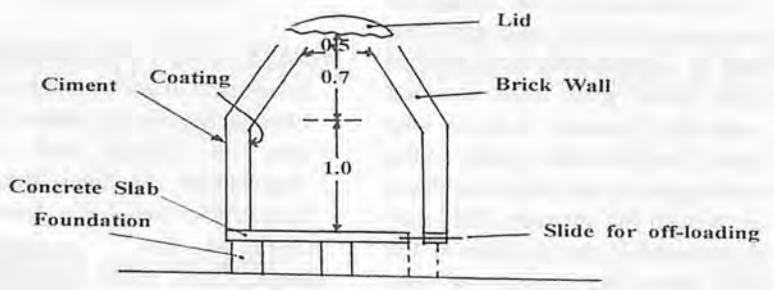

Fig. 4 Ferro- ciment Slio or Rhombus.

heavy clouds, intermittent heavy down pours, etc. which may render the solar dryer inoperative.

Improved Technologies

Many organizations in the agriculture sector are working on improved technologies for the drying and storage of grain. These include the "Mission de Dèvèloppement de la Province de Nord Ouest" (MIDENO) and Promotion of Adapted Farming System Based on Animal Traction, (PAFSAT) in the Northwest Province; "Institut de Recherche Agronomic (IRA) and the National Cereal Research and Extension (NCRE) programme for the Northwest and Western Provinces. These and other technologies are briefly described as follows.

The PAFSAT Cowshed - This is a multipurpose building used for housing livestock and storage of equipment. The ceiling is used for drying and storing cereals and legumes. Some 6.5% of the farmers interviewed indicated that they use animal traction for land preparation and thus cultivate more than 1 ha each. The PAFSAT cowshed is a standard feature of this form of agriculture which was recently introduced into the Northwest-Province.

The Martin Hot Air Dryer-This batch dryer, also known as the *Samoan Dryer* (**Fig. 2**) which has been used for years in the cocoa producing areas is being popularized in the Northwest Province by MIDENO. The drier is a rectangular house of sun-dried brick walls and thatch or corrugated metal roofing. The grain is held on shelves (four on three walls) within the house and heat applied through a flue made from empty 200 litres oil drums. The source of energy is firewood.

A 50 m^3 hot air dryer with corrugated metal roofing will cost around 100,000 cfa and can dry 12 bags* of unshelled maize from 24% to 14% moisture content (wet basis) in seven days. It requires about 25 m^3 of good quality wood** to dry seven tons unshelled maize, i.e., about 1.8 kg of wood per kg of dried grain. The dryer also serves as a store for the dried grain when there is no further need for drying.

The efficiency of drying could be improved if the maize is shelled and if a properly designed chimney is installed to evacuate saturated air. Improvements on heating can be obtained by looping the flue round the house and by providing some minimal insulation.

The FAO Crib- This crib is being popularized in Cameroon for the drying/storing of cob maize. Its advantages such as ease of construction and adaptability to the quantity of grain harvested, and shortcomings such as exposure to moisture and flying pests, have been described elsewhere (Bodholdt, 1985). Although this technology is simple and can be adapted to local materials, the rate of acceptance is very low. Larger and modern versions capable of holding up to two hundred tones of unshelled maize are used by cooperatives.

Ferro-cement silo or The Rhombus- This is made of concrete with wire netting to reinforce the structure (**Fig. 3**). This is used for storage of shelled corn for a period of up to two years. Because of the cost and complexity of construction of this silo, it has remained only at the teaching and demonstration centres. The maize is loaded into the silo and the silo sealed. Unloading is through a discharge chute at the bottom of the silo. It can keep grain dried to 12 to 13% moisture content for up to 2 years.

Recommendations

The stages in the handling of maize after harvest are many and lead to grain damage and infestation. These holding places or temporary storage in the field need to be reduced to limit the exposure of the maize to moisture and pests.

Transporting fresh grain in light trucks leads to a lot of mechanical damage. The cracks could later be sources of infestation during storage. Adequate padding using dry leaves should be provided to reduce shocks.

The Dunga Mantung platform is an efficient low cost drying structure. It is similar to the FAO crib in operation. Its efficiency can be improved by placing wire mesh across the gable ends to prevent rodents

*One bag of unshelled corn weights about 90 kg.

**Value caluculated using hardwood as described in the Handbook of Mechanical Engineers.

and birds from entering. Rodent guards could also be constructed on the frames.

The quality of dry maize is often poor and varies from one farmer to another. This makes potential commercial buyers like breweries import maize, thus depriving the farmers of much needed income. It is important to improve post harvest hygiene so as to guarantee the quality of the grain.

Traditional drying is carried out in the *Banda* of the kitchen/living house. This practice dates back from early days when all houses had thatch roofs. The design and construction of these roofs provided adequate aeration of the *Banda* which facilitated the removal of moisture from the drying grain. Modern roof design and construction does not have the same facility. The roofs are always sealed and this does not permit easy exchange of air with the outside.

Rapid drying is still a major problem. Although many systems have been introduced, farmers have not adopted them. One of the reasons is the assumption that corn dried rapidly does not produce *fufu* of the same elastic consistency as that from slowly dried corn. There is need for education to overcome this myth. The nutritional value of the grain does not change because of drying in a dryer.

Much of the maize remains stored on the farm or villages and damage and losses caused by insects are high. These losses may have been increased by the introduction of new hybrid varieties (Awondo, 1991). Losses may be reduced through improvement grains on standards of hygiene and use of insecticides. Although many farmers are dusting their with actellic powder (54.8%), this is often not readily available and the cost is relatively high on the part of to the farmer. The lack of knowledge by small farmers of the possible advantages of using pesticides for stored products protection is also a constraint to pesticide use.

The bamboo crib for storage of cob maize is widely used and when used in combination with insecticides holds grain with minimal losses for 8 months or more. One factor that affects the quality of the stored grain is the flow of ambient air through the structure. This may be impeded if the structure is too thick (along the direction of wind flow). Studies carried out in Malawi (Golop et al., 1983) indicate that moisture loss during the period of dry weather took place rapidly at the periphery of the store, but at the centre the rate was much slower and related to the diameter of the store. Subsequent gain in moisture after the onset of the rains will follow the same pattern increasing rapidly at the periphery. The principal shortcoming of the crib is the fact that it cannot hold maize in a high humidity environment without the maize gaining moisture. It is important to provide a moisture barrier for the grain if the grain will be stored beyond the dry season. The crib also needs to be placed on a platform and rodent guards should be installed.

Conclusion

Many post-harvest technologies have been introduced in the country. Some of these are simple and effective. The acceptance rate has been very low although the innovations are technically relevant and will lead to an improvement in food security and the farmer's income.

The traditional systems for handling and storing grain are effective for short term storage and for small quantities. Research should be conducted to see how these can be adapted to large scale and long term storage. The farmers will likely accept these as the modifications will not introduce any new concepts into the traditional system of handling and storing.

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A Comparative Study of Maize Storage Structures in Tropical Rain Forest Zone, Nigeria

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Abstract

The on-farm maize storage structure used by some farmers in Southwestern Nigeria were studied. Results show that of the cribs, barns and silos being used by these farmers, 70% of them make use of cribs. Even though silo was reported to store maize better than the crib and barn, farmers are still not eager to accept the method because they believe it is not cost effective to construct one.

The cost of construction of these structures depend highly on the availability of the materials used. With about 85% of the farmers interviewed (being mainly rural farmers), there is a need to develop a more efficient post-harvest technology that can easily be adopted by the farmers in the study area.

Introduction

In Nigeria, as in many other developing countries in Africa, there are many problems facing expansive productivity of the agriculture sector, of which storage of farm products still constitutes one of the major problems to be solved. Maize (*Zea mays* L.) is one of the most important cereals grown for human and livestock consumption in Nigeria. In the past, the cultivation was mainly in the southern part of the country, millet and sorghum being the predominant cereal in the North (Opadokun, et al. 1979). However, because of the demand for maize, it is now grown practically throughout the country.

According to the FAO (1991) estimate, national maize production was on 1.9 million tonnes with an estimate of 1.2t/ha and ranks the third most important cereal crop after sorghum and millet. Maize forms a major component of poultry and piggery feeds. It is also part of the concentrate ration of dairy, beef, cattle, sheep and goats. In all these, maize is a source of energy and forms 55-75% of such rations (Wudiri and Fatoba, 1991). This predominant sector is estimated to consume about 60% of the total national maize production.

Despite the importance of maize in the country, little is known about the effectiveness of the various types of storage structures used by farmers, particularly in Southwestern Nigeria. Thousands of tonnes of the crop are lost annually due to inefficient or inadequate storage structures. Food loss in Nigeria has been estimated at 35% of total annual production (FAO, 1975). Efficient storage plays a predominant role in minimizing waste and loss of food grains. Increased productivity cannot be translated into a proportionate increase in the level of real income if storage is inefficient. The storage system thus has a direct relationship to the economy of an agro-based nation such as Nigeria. The types of storage generally used in the tropics are extremely varied, from the vast silos of large-scale importers to the small quantities handled by individual farmers in traditional storage structures (Girish et al., 1990). Differences in technical management depending on ownership, extension and accessible technology add further variety.

On-farm storage is typically small-scale bulk storage, with the structural material and design being influenced by availability of materials, the form of grain and the requirement for in-store drying. Each type of store also has an associated pattern of management and use. Cooperative and private traders normally store and handle grain in bags. In large-scale storage, there is a choice between bag or bulk handling (Muller, 1983). This choice is a complex one, and the factors to be considered are not only those of economics and engineering (Acasio and Maxon, 1991) but also management, logistics and social issues.

One of the major problems of maize storage under humid tropical condition is microbiological deterioration. This is more so with Nigeria where the bulk of annual production is grown in the Southwestern zone with the main harvest coming up in the wet months of the year (Broadent and Oyeniran, 1978). The high moisture content recorded in maize at this time of harvest (22-25%) is much higher than the safe moisture level of 12% and this is the major cause of microbiological deterioration. Haines (1991) listed the major causes of loss in storage systems. The common causes of loss in a typical postharvest grain system fall into three categories: unavoidable (e.g., weather), human-induced (e.g., contamination, spillage, theft) and pest-induced (e.g., insect, mites, rodents).

This research was conducted to determine the choice of the main storage structures used by farmers in Southwestern Nigeria. Since improvements in the postharvest subsector have a high potential for increasing agricultural production and economic efficiency through job creation and increasing farm income, it is attracting much attention (Dien, 1995). In addition, upgrading of postharvest technology will help remove the bottlenecks appearing in the preharvest stage and will stimulate production.

Materials and Methods

Description of Site

Data for this study were collected over a three-month period (April to July 1995) from four local governments in Ogun State, Southwestern Nigeria. Ogun State lies within latitudes 6°N and 8°N and longitude 2°30'E and 5oE. It is situated within the humid tropical climate and covers about 16,400 sq km (approximately 1.9% of the area of Nigeria). To the west of Ogun State is the Republic of Benin (Dahomy), Lagos State to the South, Ondo State to the East and Oyo State to the north.

The rainfall distribution is bimodal with peaks in June and September. The dry season extends from November to March. The annual rainfall ranges from 1250mm to 1500mm. The average minimum and maximum air temperatures are 20°C and 32°C, respectively. Relative humidity varies from 62% to 96% coinciding with the dry and wet seasons, respectively. The mean daily sunshine hours range between 3.80 and 6.90. The value decreases as cloudiness increases, particularly during the months of June to September where the range is 3.48 – 4.98. The estimated population is over 2.3 million as of 1991 with an annual rate of growth of about 3.4%.

Sampling Technique

Four prominent local governments in Ogun State (Ijebu-Ode, Ijebu-North, Ijebu-East and Odogbolu) were used as the population sample for the study. Samples of respondents were drawn from local governments, agricultural development project (ADP), farm settlement Ago-Iwoye and private farms to allow valid and reliable generalization of responses in the findings.

All the population sampled were made up of farmers or farming enterprise making use of cribs, barns and silos on the farm, as well as those involved indirectly by hiring this available storage structures to farmers either on small or large scale at affordable prices.

The primary data collected were that of a fixed point which does not change within the research period. This includes size of household types, number, ages, values of tools and requirement, sources and amount of loans. Others are input and output data such as hours of family and non-family labour input, tasks undertaken, wages paid, cost and quantities of crops harvested, quantity consumed at home, quantity sold or given as gift or reserved as planting materials and prices and cost of construction and maintenance of storage structure, etc. The questionnaire technique was used to obtain the data used.

Secondary data was derived from agriculturally related agencies – local government and ADP. The questionnaire also deals with finding out information on finance, regulatory environment long-term objectives, solution to some peculiar problems encountered, obstacles to expansion and history of the enterprise.

The questionnaire involved reading and explaining the questions fully to some of the farmers sampled. The reason is the illiteracy level of majority of the farmers. The only information that was fully completed in the questionnaire were analyzed. A total of 120 questionnaires were sent out and 100 were returned with complete information.

Types of Storage Structures

The types of storage structures that were studied are as follows:

Ventilated Crib- The most common type of this structure consists of a raised (1.22m above ground level) platform of 1.22m breadth and variable length (**Figure 1a**). The platform carries the maize grain cobs. The platform is provided with a roof structure which consists of vertical poles at the sides of the platform. The roof material can be made of grass thatch if the structure is constructed entirely of farm material or iron sheet if it is made of wood. The sides of the roof structure from the platform height are protected by slated bamboo. Rodent guards are provided on the pillars to ward off the entry of rodents into the crib.

Barn- This is known as *rhumbu*. They are traditional silos made of mud mixed with grass (to strengthen the structure). The rhumbu is elevated with the aid of stones to guard against attack of rodents, and completely sealed with a thatch

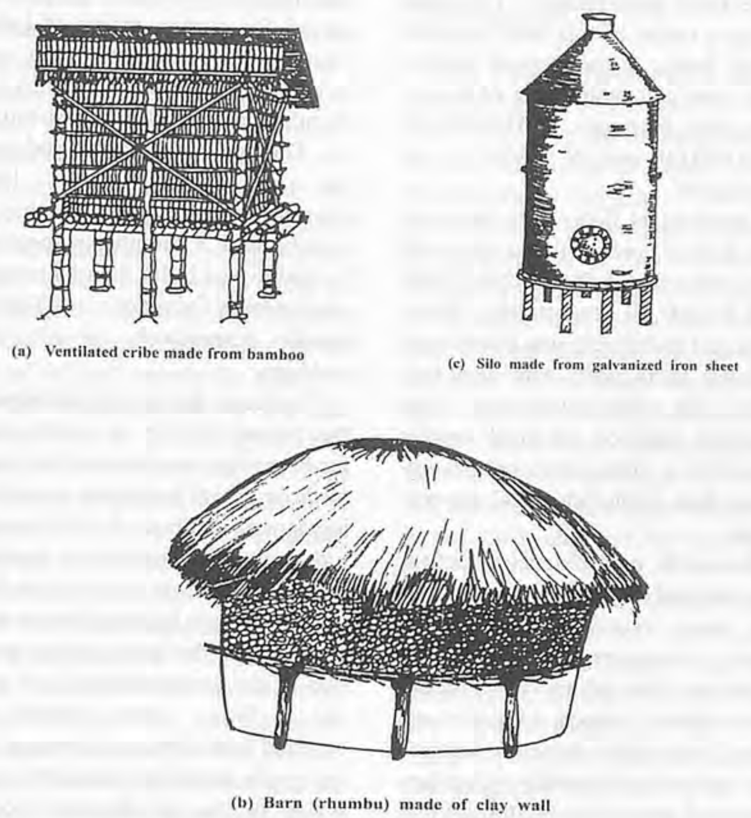

Fig. 1 Different storage structures used by farmers.

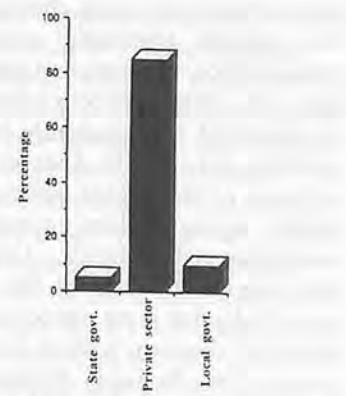

Fig. 2 Distribution of respondents according to farm tenure.

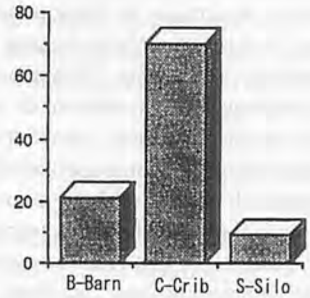

Fig. 3 Distribution of respondents according to level of usage of Crib, Soil and Barn.

roof placed over it to protect it against rain **(Figure 1b)**.

Silo- Silo is a bulk storage structures **(Figure 1c)** fabricated from metal, aluminium or concrete. Installed or reinforced concrete platforms are used. These are usually cylindrical in shape, but a few rectangular ones of concrete types are known.

Results and Discussion

Figure 2 shows the distribution of the respondents according to farm ownership. The private farmers were the majority constituting about 85% of the total farmers interviewed. Agricultural practices are mainly in the hands of rural farmers using hand tools for farming operations to produce maize and other crops. The local governments and State governments farms accounted for about 10% and 5%, respectively, of the farmers interviewed.

It can, therefore, be seen that in order to overcome problems relating to agricultural production and help farmers in this area realize their full potential, the government has to pay much attention to the postharvest activities of drying, processing and quality control of maize. It should be considered one of the priority targets in the economic development policy to focus on rural development program.

Figure 3 shows the distribution of respondents according to the level of usage of crib, barn and silo. The figure shows that 70% of the farmers use cribs for maize storage. Udoh et al (1994) also observed a similar trend in a research of storage of maize in Nigeria from five agro-ecological zones. This observation may be due to the fact that crib is cheaper to construct than silo and most farmers do not easily have access to the usage despite the fact that silo stores for a longer period than cribs. Farmers using barns and silo were 21% and 9%, respectively. Using silos were mainly those from local and State government farms. Even though barns are also cheaper to construct, many farmers complained about their inability to store maize effectively as cribs without deterioration.

One of the advantages advanced for the use of crib for storing maize is that it is cheap to maintain. It does not only require replacement of few materials but most of these materials are also available locally. It could be seen that most farmers in Nigeria have not abandoned the age-old traditional systems based on hoe, machete, and matchbox. The absence or poor adoption of improved and apparently high-yielding technologies deserves the attention of sociologists, anthropologists, policy makers, extension specialists and engineers. One of the principal reasons for the low rate of adoption is the top-down approach of research, without participation of the farmer in prioritizing critical issues, defining research methods, and in validating and adopting the technology by fine tuning it to local conditions. Researchers often perceive a research problem according to their assessment of the farmer's constraint to enhancing production. They design methodology for on-station or on-farm experimentation, develop a hypothesis, collect and analyze data and publish results without interaction with farmers. It is not surprising, therefore, that the so-called 'improved technology' is often rejected by the farmers in sub-saharan Africa (Lal, 1993).

Figure 4 shows the average cost of construction of the storage structures in each of the four local governments. It is found that the average cost of construction of crib, silo and barn is highest in Ijebu-Ode local government. This may be as a result of this local government being a commercial centre. The cost of construction of a silo, crib and barn are *₦110,000.00, ₦15,000.00 and ₦ 8,000.00, respectively.

However, at Ijebu East, the average cost of constructing a silo, crib and barn are ₦98,000.00, ₦9,020.00 and ₦5,000.00, respectively. Materials cost in this area was found to be cheaper, particularly with local materials for construction work. For example, bamboo are much readily available in Ijebu-East local government than Ijebu-Ode local government.

Research and extension activities focused on improving technology have received considerable fewer resources in developing countries than preharvest, production-oriented aspects of grain and other food supply systems. Despite the apparent universality of the fundamental principles of stored-grain management, their widespread applications though desirable, may not always be cost effective for those involved in storing grain or be considered sufficiently important to warrant substantial government support in many developing countries (Jayas et al. 1995).

Figure 5 shows the period of storage for the different storage structures in each local government. The figure reveals that the average period for storing maize at Ijebu-Ode local government using silo, crib and barn are 13 months, 11 months and 7 months, respectively. The corresponding period storage at Ijebu-North local government are 11 months, 9 months and 5 months, respectively. Ijebu-East is 10, 8 and 4 months while that of Odogbolu is 9, 8 and 3 months, respectively, for silo, crib and barn.

The factor that mainly influenced the period had to do with some farmers who have access to usage of dryer which help their maize being stored at about 12-13% moisture content. One major problem that these farmers have is the lack of proper grain hygiene which aims to minimize the insect pest population at the commencement of storage. Grain stores should be emptied and physically cleaned using grain handling machinery followed by use of shovels, broom, etc, supplemented as appropriate by the use of air-blower and vacuum (Bengston, 1995). Besides, most farmers in this area do not have access to good quality seeds that are resistant to insect attack.

In many tropical countries, too often, pest control is based only on fumigating with phosphine under poor air-tightness conditions which

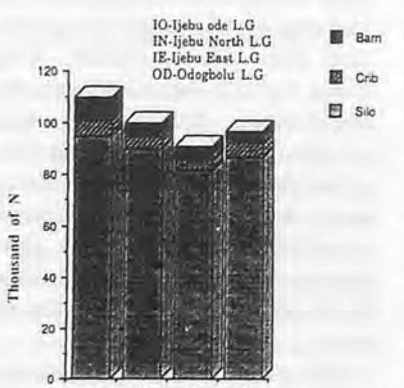

Fig. 4 Average cost of construction of storage structure in each of the four local governments.

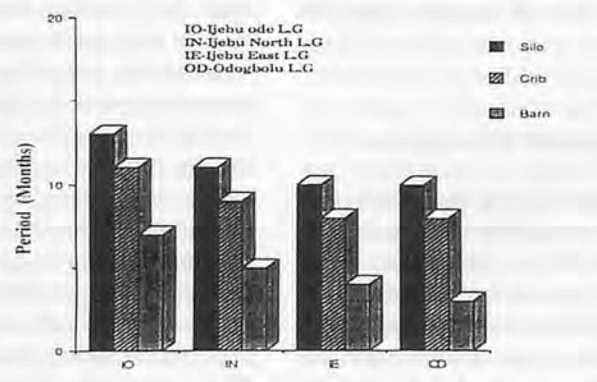

Fig. 5 Period of storage for differsnts storage structures in each local goverments.

*₦85= 1 US$

may lead to resistant development in insects. For the small-scale farmer in developing countries, the use of inert locally produced, biological control might be alternatives to chemical insecticides (Jayas et al., 1995).

Spraying of the cobs with ash and pepper, smoking the storage structure and use of leaves of local plant were the common methods reported by Udoh et al. (1994) to combat storage problems. In the use of ash and pepper, the pepper is ground very finely and the ash mixed with it then sprayed/sprinkled over the maize cobs. This type of storage treatment is believed by farmers to be very effective against rats and other rodents. The leaves of certain local plants, e.g., bitter leaf (*Vernonia amygdalina* Delile) are usually placed in alternate layers of the corn with a final covering layer over the cobs. The leaves are changed periodically when they are dried. The farmers believe that the leaves contain compounds which are harmful to insects and rats.

Table 1 shows the relative storage proportionality of the farmers. Most of the farmers cultivate less than 5 hectares of land planted to maize. The higher quantities of stored maize come from the farms of local and State governments and individuals that have access to tractor and equipment hiring units. The farm sizes also determine the type of storage structures that are used by these farmers.

Conclusions

This study focuses on the comparative study of the use of crib, barns and silos as on-farm maize storage structures in Ogun State, Southwestern Nigeria. Results show that the larger percentage of the problems is the lack of reliable storage system. Much of the maize are sold green or eaten because of lack of dryer and other post-harvest facilities. Even though the silo has been reported as being the most effective structure for storing maize, farmers are still not eager to accept the method because they believe it is not cost effective to construct one.

About 85% of the farmers interviewed operate at low-level scale production. This suggest that any enhancement of their income from farming activities must focus on cheap but reliable storage structure. The usage of barns and cribs are still preferred to silos because of the cost. Other farmers were also found to use some other means such as raised platform in the farm, over the fire-place, on the ceiling, in a clay pot, in basket, and on a bare floor. However, the effectiveness of these are very low. The following recommendations should improve on the current storage practices being carried out in this area:

(1)Farmers should be enlightened on the condition for safe storage for maize such as practising grain hygiene and drying to safe moisture level before storage.

(2)Since traditional storage structures vary with climatic regions, ethnic background and sociologically-obtainable materials, an indepth study of these parameters in this zone is very crucial for effective storage systems.

(3)One of the dilema facing the maize farmers in this area is how to store high-moisture grain from the main crop that is harvested in a period when sun drying is not possible. It is very necessary for the government to establish post-harvest processing centres that will provide artificial dryer so as to reduce the hazard of mould development and insect attacks of stored products.

Table 1. Relative storage proportionality of farmer

Size of farm (ha)	Average yield (ton)	Store (ton)	Amount consumed (ton)	Amount sold (ton)
1-5	6	2	1.5	2.5
6-10	9.5	3.5	2	4.0
11-15	10	4	3	13
16-20	25	7	5	12
21-25	27	8.5	7	13
26-30	35	10	8	17
31-35	45	12	8.5	25.5
36-40	60	14	15	31

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NEW TECHNOLOGY IN GRAIN POSTHARVESTING

by Ritsuya Yamashita
Professor emeritus of Kyoto University

This book contains the last lecture of professor Ritsuya Yamashita at his retirement by the age limit, which were summarized from his enormous researches for a long time, and supplementary recent new technologies of post harvesting. Therefore, topics in this book are extended to all techniques of postharvest processing and a lot of new findings and techniques are described from fundamental studies for their actual applications.

Details are explained especially on property of rice, low cost drying system of rice from the taste point of view, husking, whitening and polishing techniques and dynamic storage. This book is consisted of 9 chapters and 4 appendixes: Chapter 1 Introduction, Chapter 2 Harvesting, Chapter 3 Drying, Chapter 4 Husking, Chapter 5 Whitening and polishing, Chapter 6 Separation and rice mixing, Chapter 7 Storage, Chapter 8 Quality adjusting by moisture control, packing and distribution, Chapter 9 Conclusion (future technique), Appendix-1 Evaluation of rice taste by taste meter, Appendix-2 Numeric color expression by color difference meter, Appendix-3 Example of calculation of drying speed with temperature control and Appendix-4 Equations for respiratory type gas distribution to possible and necessary future techniques from quality, taste and low cost production of rice point of view.

The author is convinced that this book is surely useful as a guide for technicians, administrators and researchers concerning to the postharvest.

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Optimal Energy Requirements for Groundnut Cultivation in Orisa, India

by

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Abstract

The experiment was conducted for groundnut crop with three farming systems, viz. bullock, power tiller and tractor and two levels of energy inputs. The farming systems with high energy intensity showed higher yields over low energy intensity.The modified mechanization levels have significant effect on yield, human energy, indirect energy, total energy and cost of total energy requirements. The power tiller farming system with high energy intensity proved to be superior to tractor and bullock farming system with higher energy intensity. The average total energy requirement and average cost of farm operations for the highest yield of 14.34 q/ha of groundnut were 4041.31 mJ/ha and Rs675.93/ha. On yield basis these were 281.82 mJ/q and Rs186.60/q, respectively. The optimum machine set use cost for different holding sizes for groundnut cultivation were also determined through a developed programme.

Introduction

Agricultural production process consists of a number of operations and their timely operation. The use of farm machinery, therefore, not only increases the quantum of energy inputs to the production process but also helps in timely operation. This is possible by the introduction of inanimate sources of energy and improved agricultural implements.

In Orissa out of 72.1 lakh ha of cultivable area, groundnut is grown on 39.7 lakh ha with 52.10 lakh tons of annual production. Human and animal power are the primary sources of energy for traditional farming of groundnut. It is felt that energy inputs in agriculture have a composite constitution integrating the human and animal labour with mechanical power. These components of direct energy combined with indirect energy make up the total energy inputs for crop production.

Panesar et al(1987) developed energy co-efficients for both animate and inanimate energy sources taking in many assumptions considerations. They followed the process analysis approach and standard energy norms for different materials. Singh, V.V.(1980) in carrying out field experiments on energy requirements and power losses, used the method of estimating human, animal,mechanical and electrical energy by multiplying the power exerting capacities into time of operation in the case of animate sources and by multiplying the actual fuel and electricity consumption into the observed time for inanimate sources. He also reported that the effect of increased energy input and human energy on yield of paddy,wheat and mung crop. Maru et al(1984) reported a comparision of power tiller farming with bullock farming for wet and dry seed bed preparation.

Energy requirement depends upon the sources of power used, type of crop, tillage system combinations, farm size and agroclimatic conditions. Therefore, it is necessary to study the energy inputs and cost of each element of farm operations to asses the most efficient production system. The present research work was conducted in order to generate adequate information on the pattern of energy utilization and economics of the energy inputs for groundnut cultivation.

Materials and Methods

The field experiment was conducted at the central farm of the Orissa University of Agriculture and Technology, Bhubaneswar at the East and Southeastern coastal plain agroclimatic zone of the state situated between 18:46' and 20:95' m/day.

The experiment was designed in RBD(factorial) with four replications and conducted with six levels of modified mechanization. Details of the treatments and the schedule of operations are presented in **Tables 1** through **3**. The layout plan of the experiment is shown in **Fig. 1**.

During the crop production process, observations were recorded for time utilized by human, bullock, machine and power units per unit area and fuel and electricity consumed per unit time on per unit area for a particular farm operation. Large numbers of observations were made to get the realistic average values. The average values of speed of operation and with the coverage of the implements were also recorded through sufficient large numbers of observations. For the calculation of energy inputs, the observed time, fuel and electricity consumption were multiplied with energy coefficients. All the above categories of energy were put under direct energy. The indirect energy input due to use of machinery in the field was computed with the help of formula putting the observed values of hours of use of the machine. The seed, manure, chemical fertilizer and pesticides as part of indirect energy were kept constant in the study as these are essentially required equally irrespective of energy treatments.

Table 1. Details of operations carried out under various energy treatments in bullock farming system

Sl. No.	Operation Particulars	Details of energy treatment: E_1I_1 (Bullocks with improved implements and with low energy inputs)	E_1I_2 (Bullocks with improved implements and with higher energy inputs)
1.	Seedbed prepareation	Ploughing with MB plough X 2 Disc harrowing X 2 Planking X 2 Manuring X 1	Ploughing with MB plough X 3 Disc harrowing X 2 Planking X 2 Manuring X 1
2.	Seed decortication	By hand operated decortiator X 1	By hand operated decortiator X 1
3.	Planting	Manually drawn groundnut planter X 1	Manually drawn groundnut planter X 1
4.	Fertilizing	Manually X 1	Manually X 1
5.	Interculture	Manually by wheel hoe X 1	Manually by wheel hoe X 1
6.	Irrigation	By 5 HP diesel pumpset X 1	By 5 HP diesel pumpset X 1
7.	Plant protection	Spraying by Knapsack sprayer X 1	Spraying by Knapsack sprayer X 1
8.	Harvesting	Manually uprooting X 1	Manually uprooting X 1
9.	Threshing	By pedal operating thresher X 1	By pedal operating thresher X 1
10.	Transport		
	Manure	By bullock cart X 3	By bullock cart X 3
	Seed	By bullock cart X 1	By bullock cart X 1
	Fertilizer	By bullock cart X 1	By bullock cart X 1
	Crop	By bullock cart X 3	By bullock cart X 3

Table 2. Details of operations carried out under various energy treatments in power tiller farming system

Sl. No.	Operation Particulars	Details of energy treatment: E_2I_1 (Power tiller with low energy inputs)	E_2I_2 (Power tiller with higher energy inputs)
1.	Seedbed prepareation	Rota tilling X 2 Manuring X 1	Rota tilling X 3 Manuring X 1
2.	Seed decortication	By hand operated decortiator X 1	By hand operated decortiator X 1
3.	Planting	Manually drawn groundnut planter X 1	Manually drawn groundnut planter X 1
4.	Fertilizing	Manually X 2	Manually X 2
5.	Interculture	Manually by wheel hoe X 1	Manually by wheel hoe X 1
6.	Irrigation	By 5 HP diesel pumpset X 1	By 5 HP diesel pumpset X 1
7.	Plant protection	By Knapsack sprayer X 1	By Knapsack sprayer X 1
8.	Harvesting	Manually uprooting X 1	Manually uprooting X 1
9.	Threshing	By Power operating thresher X 1	By Power operating thresher X 1
10.	Transport		By power tiller trailer
	Manure	By powertiller trolly X 3	By powertiller trolly X 3
	Seed	By powertiller trolly X 1	By powertiller trolly X 1
	Fertilizer	By powertiller trolly X 1	By powertiller trolly X 1
	Crop	By powertiller trolly X 3	By powertiller trolly X 3

North Latitude and between 83:48' and 87:3' East Longitude. The average rainfall in this zone is 1340 mm. About 74 per cent of the annual rainfall is received during the months of June through September.

The physical characteristics of the soil of the experimental site were: sandy loam, bulk density 1.55 gm/cc, field capacity of 15 percent, permanent wilting point at 6 percent and hydraulic conductivity at 0.25

The following relations were adopted in order to estimate the total energy requirements from individual sources to perform various farm operations:

$$TE = DE + IDE$$

Where,

TE = total energy requirements for farm operations, mJ/ha

DE = direct energy requirements, mJ/ha

IDE = indirect energy requirements, mJ/ha

The direct energy input was calculated with the help of the following relationship:

$DE = 1.96\ HLH + 8.07\ BPH +$

Table 3. Details of operations carried out under various energy treatments in tractor farming system

Sl. No.	Operation Particulars	Details of energy treatment	
		E_3I_1 (35 HP tractor with low energy inputs)	E_3I_2 (35 HP tractor with higher energy inputs)
1.	Seedbed prepareation	Cultivating X 2 Disc harrowing X 1 Manuring X 1 Planking X 1	Cultivating X 2 Disc harrowing X 1 Manuring X 1 Planking X 1
2.	Seed decortication	By hand operated decortiator X 1	By hand operated decortiator X 1
3.	Planting	Manually drawn groundnut planter X 1	Manually drawn groundnut planter X 1
4.	Fertilizing	Manually X 2	Manually X 2
5.	Interculture	Manually by wheel hoe X 1	Manually by wheel hoe X 1
6.	Irrigation	By 5 HP diesel pumpset X 1	By 5 HP diesel pumpset X 1
7.	Plant protection	By Knapsack sprayer X 1	By Knapsack sprayer X 1
8.	Harvesting	Manually uprooting X 1	Manually uprooting X 1
9.	Threshing	By Power operating thresher X 1	By Power operating thresher X 1
10.	Transport		
	Manure	By tractor trolly X 2	By tractor trolly X 2
	Seed	By tractor trolly X 1	By tractor trolly X 1
	Fertilizer	By tractor trolly X 2	By tractor trolly X 2
	Crop	By tractor trolly X 3	By tractor trolly X 3

56.31 F C + 11.93 E C

Where,

HLH = human labour hours used, hr/ha

BPH = bullock pair hours used, hr/ha

F C = fuel consumption, lt/ha

EC = electricity consumption, kwh-ha

The indirect energy input due to the use of machinery in the field was computed with the help of the following relationship:

$$IDE = \frac{C \times WM \times MOH}{WL \times AU}$$

Where,

C = energy coefficient, mJ/kg of machine

WM = weight of the machine, kg

WL = wear out life of the machine, hr

AU = annual use, hr

The total energy requirements

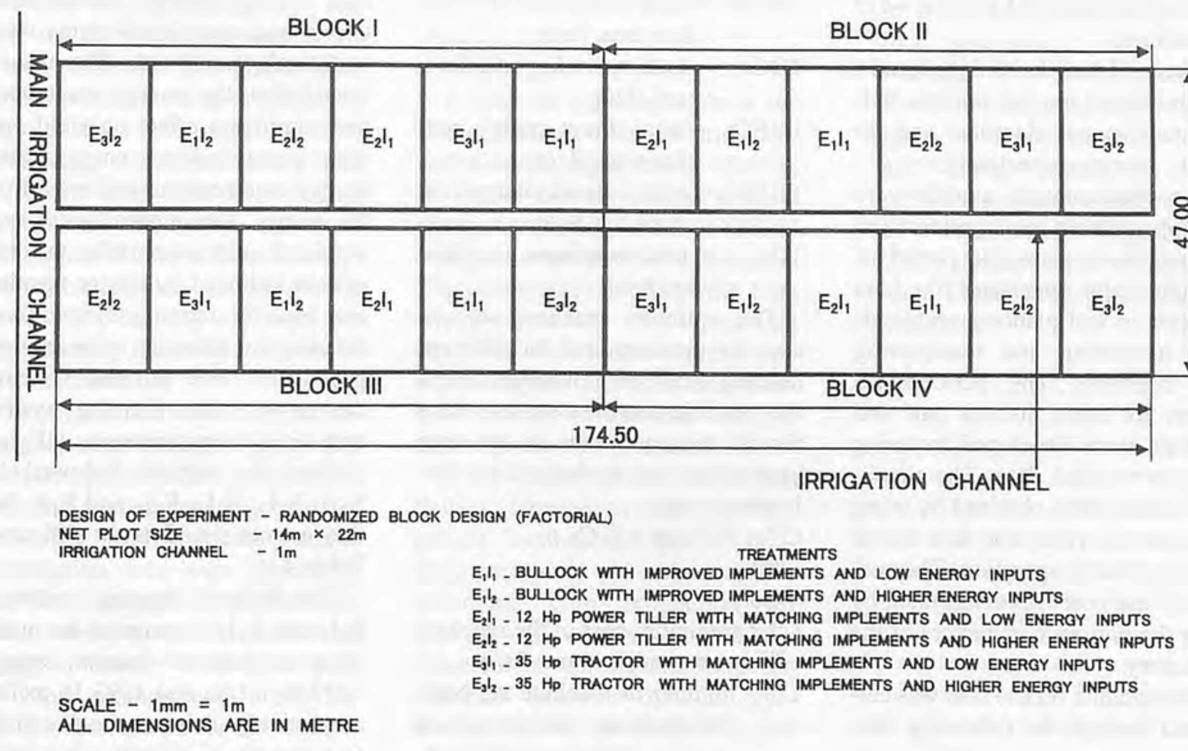

Fig 1. Layout Plan of Experiment.

Table 4. Average energy required for various farm operations in different energy treatments

Source of energy	E_1I_1	E_1I_2	E_2I_1	E_2I_2	E_3I_1	E_3I_2
Human (mj/ha)	1193.16	1229.88	855.44	874.48	820.57	824.29
Bullock (mj/ha)	735.25	866.06	0.00	0.00	0.00	0.00
Mechanical (mj/ha)	1015.26	1040.04	2827.87	2816.05	3131.39	3517.67
Electrical (mj/ha)	0.00	0.00	155.74	157.17	157.17	156.72
Indirect (mj/ha)	243.19	251.66	161.11	193.61	267.13	300.21
Total (mj/ha)	3186.96	3387.64	4000.16	4041.31	4375.10	4798.89
Average yield (mj/ha)	11.78	12.40	13.63	14.34	12.85	13.31
Total (yield basis) (mj/ha)	279.53	273.19	293.48	281.82	340.47	360.54

Table 5. Average cost required for various farm operations (power source-wise) in different energy treatments

Source of energy	E_1I_1	E_1I_2	E_2I_1	E_2I_2	E_3I_1	E_3I_2
Seedbed preparation	646.86	780.55	558.75	767.16	747.29	947.44
Decortication	17.15	16.93	17.26	17.07	17.00	16.93
Planting	105.32	102.25	98.96	99.76	96.25	97.28
Fertilizing	78.37	79.53	78.43	80.25	80.68	80.62
Interculture	134.05	125.06	117.47	114.90	114.01	109.68
Irrigation	328.86	336.83	328.76	326.84	312.02	303.84
Plant protection	56.33	56.25	55.77	54.34	64.18	51.94
Harvesting	664.84	673.84	681.90	697.06	681.71	687.09
Threshing	484.83	490.49	201.28	203.12	201.62	202.55
Transporting	342.24	346.80	316.86	315.43	436.08	442.69
Total (Rs/ha)	2858.85	3008.53	2455.44	2675.93	2750.84	2940.06
Total (yield basic) (Rs/q)	242.68	242.62	180.15	186.60	214.07	220.89

for a particular farm operation were expressed as:

$$TE = HE + BE + ME + EE + IDE(machine)$$

Where, H E, B E, M E, E E,and I D E(machine) are the human, bullock, mechanical, electrical and indirect energy, respectively.

The mathematical models were developed taking into consideration the maximum allowable period of the four major operations like land preparation and planting, interculture, harvesting and transporting and threshing. The performance factors for man, bullock pair and machine were developed by using the experimental data. The timeliness factors were obtained by using the observed yield loss data due to delay in timely operation. The machinery use cost was determined by using the various cost factors of the machinery.

The machine set use cost was calculated through the following relationship:

$$MSUCs = TFCns + TOCs + TIDECs + TCs$$

Where,

MSUCs = machine set use cost for s set, Rs/q
TFCns = total fixed cost for s set & n area, Rs/q
TOCs = total operating cost for s set, Rs/q
TDECs = total direct energy cost for s set, Rs/q
TIDECs = total indirect energy cost for s set, Rs/q
TCs = total timeliness cost for s set, Rs/q

The optimum machine set use cost for the crop and for different holding sizes were obtained out of the possible machine set use costs for all the operations in the crop production system through the following model:

$$C^{m}_{min} = I^{min} (MSUCs)$$

Where,

C^{m}_{min} = minimum cost of the machine set combinations, Rs/q
I = number of machine set combinations in the production system in the range of 1 to 4

Results and Discussions

The observed data for yield, human energy, indirect energy, total energy and cost of total energy were statistically analysed. The results reveal that the energy treatments had significant effect on yield, human energy,indirect energy, total energy requirements and cost of total energy. The highest yield was obtained under power tiller farming system followed by tractor farming and bullock farming system.Considering the intensity of energy inputs to all three farming systems, the power tiller farming system with high energy intensity (E_2I_2) yielded the highest followed by E_2I_1, E_3I_2, E_3I_1, E_1I_2 and E_1I_1, but they are not significantly different (**Table 4**).

The bullock farming system (E_1I_2 and E_1I_1) consumed the maximum amount of human energy, 1229.88 mJ/ha and 1193.16 mJ/ha, respectively. This may be due to the fact that the machinery used under power tiller and tractor farming systems reduced the human energy requirements. Similarly, greater human energy was required in power tiller farming than tractor farming due to the fact that during transportation greater human energy was required in power tiller than tractor.

The indirect energy component was highest for the in tractor farming system followed by bullock farming and power tiller farming system. But considering the total energy requirements for all the six treatments, it was observed that tractor farming system E_3I_1 and E_3I_2 consumed large quantities of total energy as compared to power tiller farming E_2I_2 and E_2I_1, because of the fact that tractor farming demanded greater number of operations for good seed bed preparation than power tiller.

The average cost requirements on various farm operations are presented in **Table 5**. It was observed that cost of total energy was highest in the case of bullock farming with high energy intensity, E_1I_2 followed by E_3I_2, E_1I_1, E_3I_1, E_2I_2 and E_2I_1 and the treatments were significantly different. The power tiller farming showed the lowest total energy cost as compared to other treatments, the reason being that the power tiller used its matching implements efficiently and consumed less human efforts. Though the total energy cost is greater for power tiller farming with high energy intensity the yield is highest in this treatment.

The production system of groundnut crop was analysed by system analysis approach.The performance time and performance capacities of individual power unit and machine combination sets were developed and the machine set performance time were evaluated under human energy constraint. With the help of developed mathematical model the feasible machine power unit combinations for different holding sizes were identified. The machine set use cost which is the sum of the cost of machine use, direct energy cost, indirect energy cost, and timeliness cost for each of the four major operations of groundnut production system were obtained by using the developed programme. The various feasible sets were assigned for each operation according to farm sizes. The machine set use cost for different farm sizes were calculated from the feasible sets.

The results of the analysis show that bullock farming system with improved implements and practices was considered optimum for holding sizes below 6 ha whereas 12hp power tiller with matching implements and practices for holding sizes 6 to 10 ha was the optimum. A 35hp tractor with matching implements was observed to be optimum for holding sizes of 10 ha and above. The total machine set use cost per unit yield for various machine set combinations decreased with their use on increased size of holding.

Conclusion

It may be concluded from the above discussion that the mechanization levels significantly effected the yield, human energy, indirect energy total energy and cost of total energy for groundnut cultivation. The power tiller farming with high energy intensity i.e., rototilling thrice was found to be superior giving the highest yield,less total energy consumption and less cost per unit of groundnut produced.

It may also be concluded that bullock farming system with improved implements showed optimum machine set use cost for groundnut crop production for holding sizes below 6 ha. A 12 hp power tiller with its matching implements form the optimum system for holding sizes 6 to 10 ha and a 35 hp tractor with matching implements and machines was optimum machine set for farm size above 10 ha as it showed the minimum machine set use cost.

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Utkal Model Bio-gas Plant:An Innovative Approach Using Ferro-cement Technology

by

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Abstract

An Utkal model fixed dome bio-gas plant, using ferro-cement technology was found to be superior than the existing models of bio-gas plants like K.V.I.C. Janata, and Deenabandhu in terms of easiness, time and cost of construction. Cost of construction of Utkal model bio-gas were 59. 16, 53.29 and 26.41%lower than the K.V.I.C., Janata and Deenabandhu model bio-gas plant, respectively.

Introduction

The role of energy has become an essential component for sustenance of all life forms with the growing sophistication and rapid industrial acceleration. The world is now in hard grip of the energy crisis. Efforts are being made for minimizing the specific energy consumption for unit production and make the best use of the avail-able energy sources. Bio-gas is one such steps for making scientific use of the organic waste.Besides providing fuel and high quality bio-fertilizers, it would help keeping the environment clean, providing light, motive power and bringing about a qualitative change in the life style of the rural population, especially that of women.Among the con-ventional models of bio-gas plants like K.V.I.C., Janata and Deen-abandhu, the later model is very popular in Orissa. Deen-abandhu model is accepted for popularization by the national project on bio-gas development. First class chimney bricks are used in the Deenabandhu model bio-gas plant which is not only costly but also not available in most of the areas of Orissa. The present Utkal model bio-gas plant is a modified design of the popular Deenabandhu model bio-gas plant resulting in the reduction of cost of construction by 20-25%. The technology adopted in constructing this plant has been modified to suit the Indian rural condition by eradicating the brick-work and some practical hindrances faced while constructing the Deenabandhu model bio-gas plant.

The Technology

The technology adopted in the construction of the Utkal model bio-gas plant is ferro-cement technology. Ferro-cement is a kind of composite material where the filler materials are usually brittle in nature called matrix which is reinforced with fibers dispressed throughout the composite resulting in better structural performance than the individual ones. A rich Portland cement mortar is used without any coarse aggregates and thickness rarely exceeds 25 mm. Ferro-cement has a greater percentage of reinforcement compared with R.C.C., comprising closely spaced small diameter wire mesh distributed uniformly throughout the cross section. Its tensile strength tow eight ratio is higher than R.C.C. and its cracking behavior is superior due to uniform distribution and high surface area to volume ratio of its reinforcement.

Composition

The essential ingredients of mortar are Portland cement, sand, water and, in some cases, an admixture. Locally available Portland cement is suitable but it should be fresh, uniform consistency and without lumps of foreign matters. Clean and inert sand free from organic matters should be used. Particle size should not exceed2 mm. Water free from organic matters, oil chlorides, acid and other impurities should be used. Small quantity of admixture like super plasticizer can be used for water reduction. Mix proportions for sand-cement ratio and water-cement ratio should be 1:2.5 and 0.35:0.50,respectively. G.I. wire of 4 mm É" is used for framework at a spacing varying from 75 to 300 mm. A mildsteel rod of 6 mm É" is used forjoining the panels.

Site Selection

The site for the bio-gas plant, specially the Utkal model plant installation, has been selected basing upon the following criteria.

i) It should be nearest to the kitchen so as to minimize expenses on plumbing;
ii) It should be at least 10 m away from drinking water sources to prevent contamination;
iii) It should be preferably on an elevated area to avoid submerging during rainy season;
iv) The area should be free from shade and there should be no trees nearby whose roots may cause damage to the digester in the long run;
v) The plant should be away from foundation of permanent structures;
vi) Water should be available near the plant; and
vii) The outlet of the Utkal model bio-gas plant should face south direction so that indirect heating of the digester can be made during winter season to facilitate adequate bacteria growth for more gas production.

Procedure of Construction

The Utkal model bio-gas plant can be constructed by three types of moulds, namely; instant mould, fixed type mould and portable mould. Instant mould is used for the construction of isolated plants where transportation of bulky material is difficult. It is prepared out of locally available stuttering materials like wooden planks, bamboo and mud. Fixed type mould is used when the digester segments are to be constructed at a central place and need installation at another site of construction. The fixed type mould is prepared using scrap and bulky materials like stone, broken bricks, sand, etc. Portable moulds are prepared using mild steel flats and sheets in segments to facilitate easy transportation and removal through outlet of the plant. This mould is expensive initially but convenient and cost effective for plants constructed in clusters.

Layout and Pit Digging

The Utkal model bio-gas plant is shown in **Fig. 1** and the dimensions are given in **Table 1**. The layout of the bio-gas plant at the selected site is drawn as per the dimensions of the required plant shown in **Fig. 2** to 5.First, straight cylindrical digging followed by rectangular outlet chamber digging is completed. The discharge hole of the outlet upper tank is kept 75 to 100 mm above the ground level for easy discharge of the digested slurry. Four heaps of bricks/earth is placed around the cylindrically dug surface. The center of curvature of the curved base

Table 1. Dimensions of Utkal Model Bio-gas Plant (Capacity 2 cum,H.R.T.-40 days)

Component symbol	Dimension mm,
A	600
B	650
C	470
D	2550
E	1000
F	720
G	50
H	400
I	645
J	510
K	300
L	600
M	25
N	1000
O	1050
P	1700
Q	1650
R_1	1275
R_2	2015
S	20
T	30
U	600
V	600
W	1000
X	600
Y	600
Z	150

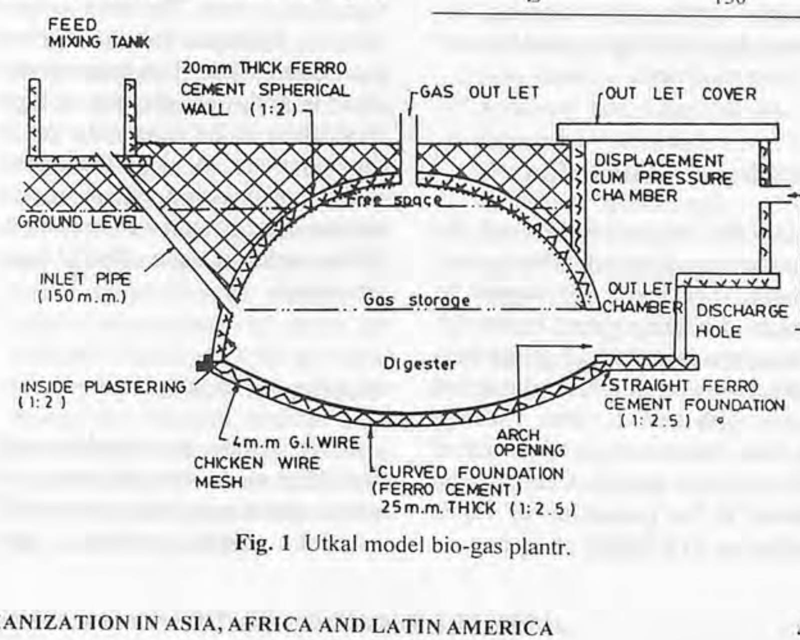

Fig. 1 Utkal model bio-gas plantr.

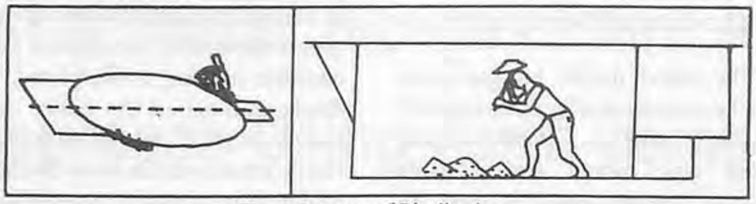

Fig. 2 Layout of Pit digging.

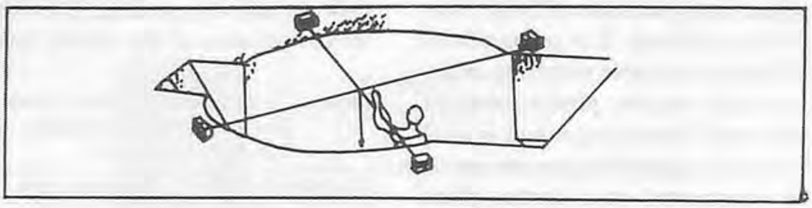

Fig. 3 Fixation of centre of curvature.

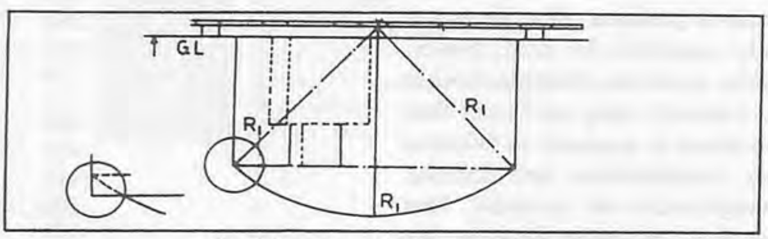

Fig. 4 Curvature digging procedure.

is marked by fixing two strings on the four heaps crossing each other as shown in **Fig. 3**. Another string of length equal to the radius of curvature R2 is tied at the centre of the curvature. The base is dug in the shape of a spherical segment by matching it with the free end of the string of length equal to the radius of curvature plus 25 mm. The surface is hardened by ramming followed by spreading of sand layer of 25 mm thickness.

Casting of Foundation

On the curved surface of the foundation 4 mm G.I. wires are arranged. The joints are tagged by means of binding wire. On the G.I. wires, two layers of 22 gauge hexagonal wire mesh is spread and tied firmly with the G.I. wires. Then the skeletal framework is taken out of the curvature surface. Cement-sand mortar in the proportion of 1:3 is spread up to a height of 12 mm on the curvature surface of the foundation and the skeletal framework is placed immediately on it. Pure cement water solution is sprinkled over it followed by spreading of cement-sand mortar in the proportion of 1:2.5 with recommended dose of waterproof compound. The mixture is carefully and evenly spread without allowing any void in the foundation work. The some procedure is followed for the bottom foundation work. The same procedure is followed for the bottom foundation of the rectangular pit of the outlet tank. A plane foundation of 50 mm thickness is constructed surrounding the curved foundation. Water curing is done after 12 hour of casting.

Casting of Dome

After casting the foundation of the Utkal model bio-gas plant, the dome can be cast by instant mould, portable mould or fixed type

Fig. 6 Constraction of Utkal model bio-gas plant.

mould. In the case of portable mould the mild steel mould segment are arranged on the foundation edge. The surface of the mould is cleaned and 4 mm diameter G.I. wire rings are surrounded at 200 to 250 mm intervals and also from top to the base of the mould at 150 to 200 mm intervals (**Fig. 6**). The junctions are tied with binding wires. Hexagonal 22 gauge wire mesh is spread over it in two layers and fastened thoroughly by means of binding wires. The surface is smoothened and skeletal frame is prepared, leaving space for outlet arch opening and inlet pipe fitting. Then the skeletal frame is taken out and burnt lubricating oil or cowdung water mixture is spread over the mould to facilitate removal of the mould after casting. Then the skeletal frame is placed on the mould surface. The dome pipe is fixed and tied up at top position of the upper hemisphere vertically. Cement-sand mortar is prepared in the ratio of 1:2.5. Admixture is added to this mortar in order to increase the strength and reduce permeability. The mixture thus prepared is applied over the skeletal framework. Care should betaken to fill up all the void spaces. Water curing should be done after24 hours of

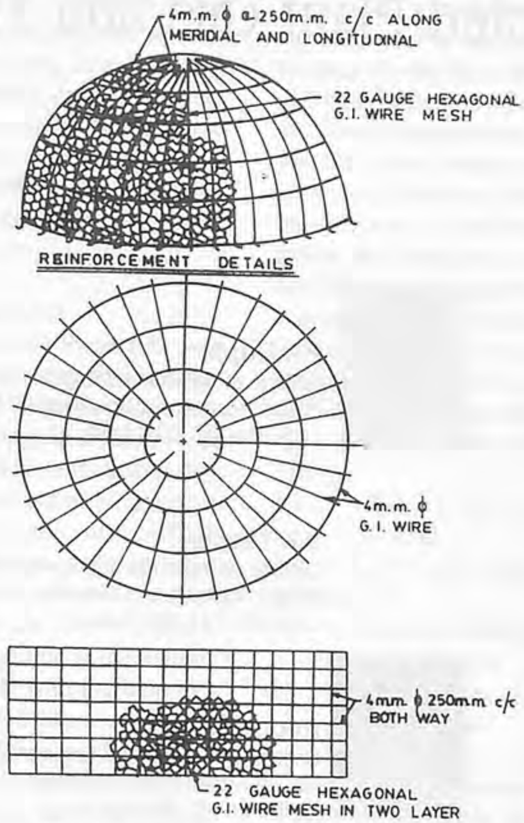

Fig. 6 Arrangement of reinforcement on the dome.

casting. The mould materials are taken out of the digester after 5 days through the arch opening. The inner surface of the digester is cleaned properly by means of brush and pure cement water solution is applied thinly followed by inside plastering by cement-sand mortar in the ratio of 1:2. The outlet bottom tank, displacement chamber, inlet pipe and mixing tanks are constructed and fitted with the digester.

Temperature Control during Winter Season

Raising the height of the outlet wall adjacent to the digester and keeping a double layer transparent polyethylene sheet over it as outlet cover the temperature inside the digester can be increased during winter season resulting in enhancement of gas production. For this arrangement, the outlet should face south direction and the height of the wall adjacent to the digester is so arranged that the angle becomes 15degrees more than the latitude of the area.

Comparison of Cost of Construction

The cost of construction of different models 2 cum capacity bio-gas plants is given in **Table 2**. The cost of construction of K.V.I.C. model bio-gas plant is Rs. 9550 which is highest among the different models of bio-gas plants followed by Janata, Deenabandhu and Utkal model bio-gas plants. The cost of construction of newly developed Utkal model bio-gas plant is only Rs. 3 900 which is lowest among the different popular models. Deenabandhu model bio-gas plant which is very popular in Orissa costs 35.89% higher than the Utkal model bio-gas plant.

Table 2. Cost of Construction of Different Models of Bio-gas Plants

Tlpe of plant	Capacity (cum)	Cost of Construction(Rs.)
Utkal model	2	3900
Deenabandhu model	2	5300
Janata model	2	8350
KVIC model	2	9550

Conclusion

The Utkal model bio-gas plant using ferro-cement technology is struc-turally sound and economical than all other types of existing bio-gas plants. It can be constructed without the use of a single brick. It is suitable for all types of soil condition and can be constructed in less time using portable moulds. Due to temperature control gas production occurs at a faster rate in the winter season in comparison with other bio-gas plants. As the cost of construction of Utkal model bio-gas plant is much less than the other models, it is suitable for low income farmers of the state.

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Characteristics of Selected Plant Oils and Their Methyl Esters

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Abstract

Among the biomass-based fuels, plant oil esters hold a good promise as an alternate fuel for compression ignition (CI) engines, especially during periods of diesel shortage. Under an ICAR adhoc project, esters of four plant oils, viz. linseed, jatropha, sunflower and rice bran were studied. The methyl esters were prepared using an inexpensive, relatively simple and less time-consuming process developed earlier in this Department. Important characteristics of the plant oils and their esters were determined and are discussed in this paper. It was observed that methyl esters exhibited lower values of viscosity, flash point, and density as compared to their un-esterified plant oils in all cases. However, no significant variation was noticed in the gross heat values of these oils.

Introduction

The use of plant oils as fuels for CI engines dates back to 1900 when Rudolf Diesel displayed an engine fueled on groundnut oil (Borgett et al. 1994). With the discovery of petroleum and its low cost products, the non-conventional fuels faded away. The recent fear of shortage of petroleum has aroused back the interest in renewable fuels (Borgett et al. 1994 and Aggarwal et al., 1991). Plant oils score over other renewable fuels due to their good self-ignition characteristics. However, the oils require modifications to overcome problems faced during the course of long duration engine operation, mainly due to their high viscosity.

Various methods for reducing the plant oil viscosity have been reported in literature (Niehaus et al. 1985 and Soni, 1987). Techno-economically, trans-esterification is considered one of the most promising methods. Esterification procedure suggested by Freedman et.al. (1984) and Peterson et al. (1991) has been simplified by Gupta (1994) resulting in an inexpensive and less time- consuming farm level esterification method. In order to use the plant oils and their esters as CI engine fuels, it is necessary to first determine their characteristics and study their suitability for the purpose. Gupta et al. (1994) and Peterson et al. (1990) have reported soybean, cereals, rapeseed, sunflower, peanut, safflower, corn, coconut and many other oilseeds as potential feed stocks for bio- diesel. This paper deals with the measurement of important characteristics of three plant oils and their esters.

Materials and Methods

Three crude plant, oils; namely linseed, jatropha and sunflower were used in this study. Linseed and jatropha oils were selected being non-edible oils. Sunflower oil was included as it was emerging as a promising oilseed crop in Punjab. Linseed and sunflower oils were procured from local oil expellers. Jatropha seeds were obtained from Rajasthan and the oil was extracted locally.

Esterification of Oil

Esterification of these oils was done by using the simplified method of Gupta (1994). For each test, 100 g of oil (heated to 60°C) was reacted with alkaline methanol (homogeneous mixture of 16 g methanol and 1 gm of NaOH). Oil-alkaline methanol mixture was stirred for 5-10 minutes and allowed to settle for 2 hrs. Glycerol, being heavier, settled at the bottom. It was removed with the help of a separating funnel. The ester collected was given three washings with water to remove excess alkali, if any. The washed ester was heated to evaporate the traces of remaining moisture.

Fuel Characteristics

Details of methods used for identifying different characteristics of the oils/esters are given below:

Kinematic viscosity — Redwood Viscometer No.1 (Toshniwal make) was used for measuring the kinematic viscosity of oil samples. This apparatus was based on the principle of measuring the time of gravity flow (in seconds) of a fixed volume (50 ml) of fluid through a specified hole made in an agate piece (as per IP 70/62 issued by Institute of Petroleum, London). The apparatus could be used for the flow times between 30 and 2000 seconds.

The oil was placed in a cup fitted with agate jet at the bottom up to a specified level indicated in the cup. The cup was surrounded by water jacket having an immersion heater. The water could be heated to any temperature with the help of a voltage regulator to regulate the rate of heating. A metallic ball was provided to open and close the agate jet. Two thermometers: one each for the water jacket and oil cup, were also provided. A standard 50 ml volumetric glass flask was kept below the agate jet to collect the flowing oil/ester. Each test was replicated three times. The experiment was performed at 38°C. Kinematic viscosity in centistokes (cS) was calculated from the time units by the following formula (Guthrie, 1960):

$Vk = 0.26\,t - 179/t$, when $34 < t < 100$ and

$Vk = 0.24\,t - 50/t$, when $t > 100$

Where,

Vk = kinematic viscosity in centistokes, cS

t = time for flow of 50 ml sample, seconds

Density — The density of oils and esters was measured by the use of capillary stoppered relative density bottles of 50 ml capacity (of Borosil make). The relative density bottle was first completely dried and weighed. It was then filled with the sample material and capillary stopper was placed gently on the neck of the bottle, taking care that no air bubble was left inside the bottle. The bottle was then cleaned from outside with the help of filter paper and placed in an oven maintained at 21oC. After a few minutes, when the temperature of the density bottle rose to 21oC, the bottle was brought out and again cleaned from outside. It was again kept in oven to regain the temperature. It was taken out and weighed. The density was calculated as under :

Where,

d = density of sample, g/ml

M2 = Mass of relative density bot-

$$d = \frac{M2 - M1}{50}$$

tle plus sample, g.

M1 = Mass of empty relative density bottle, g.

Gross heating value — A bomb calorimeter, model 1252 of Parr make, USA was used in order to measure the gross heating values of samples. A weighed sample contained in gelatin capsule was burnt in oxygen in the bomb calorimeter. The total weight of the sample and capsule was fed to the controller and the results, including the gross heating value came on a print out. Knowing the weight and heat value of capsules, which was measured before hand, the heat value of the sample was calculated. The weight of sample varied between 0.4 to 0.8 g.

Flash point — The flash point of the sample was measured using the Pensky-Martens flash point (closed) apparatus of Toshniwal make. The sample was placed in the test cup up to the specified level. It was heated at a slow and constant rate with continual stirring. A small test flame was directed on to the cup at regular intervals. The flash point was taken as the lowest temperature at which the application of the test flame caused the vapor above the sample to ignite momentarily.

Cloud and pour point — A set up was prepared to achieve low temperatures below the freezing point of water. A plastic container was properly insulated on sides and bottom using glass wool. In the cover, holes were provided to insert test tubes containing the sample. Each tube was fitted with a thermometer coaxially. Ice and calcium chloride mixture was placed in the plastic container. The tube containing sample (up to a height of 5 cm from bottom of tube) was placed in the plastic container. At every 1°C fall in temperature, the tubes were taken out, observed for cloud/pour point condition and replaced back. The taking out and putting back of tube should not take more than three seconds.

Results and Discussion

The characteristics of the studied plant oils and their esters are shown in **Table 1**. The viscosity values of all the samples in the specified range of 30-50 cS as proposed for plant oils **(Table2)**. Thus, plant oils were many times more viscous than diesel as reported by Auld et.al. (1982) and Peterson (1986). Among the plant oils studied, jatropha was the most viscous followed by sunflower oil and linseed oils.

Plant oil esters were less viscous than plant oils. The reduction in viscosity was mainly due to the removal of glycerol part of triglycerides during esterification. Therefore, plant oil esters were more suitable than plant oils for use in CI engines. The viscosities of the three esters did not differ much with values ranging from 8.2 to 9.8 cS. Pryde (1982) had reported that viscosities upto 8-10 cS may be acceptable in some diesel engines. However, the suggested range of viscosity for plant oil esters was 3-6 cS **(Table 2)**. Mittlebach (1994) has also studied the parameters defining the quality of bio-diesel with respect to rapeseed oil methyl ester. He suggested the required viscosity of 6.5-8.0 mm^2/s.

Table 1 shows the pour point value of -2°C for jatropha oil ester,-4°C for linseed oil ester and -6°C for sunflower oil ester. All values are comparable to suggested specifications of - 5°C **(Table 2)**. Compared to esters, the corresponding plant oils had much lower pour points. Similar results were reported by Ryan et.al. (1984), Volkswegan (1981). Further, the pour point value of all the three esters prepared was comparable to that of diesel (- 4.83°C). Thus, just like diesel, the esters were not supposed to create problem in engine operation at low ambient temperatures.

The gross heat value of plant oils is quite close to that of diesel (45.676). On an average, the gross heat values of all the samples were 13% less than that of diesel **(Table 1)**. Moreover,the gross heat value of the six samples did not vary much from each other. Lower heat content will result in high fuel consumption requirements as compared to diesel fuel with maintain the same power output.

The density of esters and plant oils did not differ much from that of diesel (0.849 g/ml). The density of linseed oil ester, sunflower oil ester and jatropha oil ester was higher than that of diesel by 6%, 5% and 5%, respectively **(Table 1)**. High density would help the esters in increasing the mass flow rate of the fuel at higher loads. This could compensate for low heat value of esters. Among the esters, linseed oil ester exhibited the highest density. Therefore, it was expected to produce more power as compared to other esters. However, all the esters had lower density compared to their corresponding plant oils. Similar results had been reported by Volkswegan (1981) and Chancellor and Raubach (1981).

It could be inferred from **Table 1** that flash point values of all the es-

Table 1. Characteristics of Selected Plant Oil and Their Esters

Sample	Dessity (g/ml)	Cloud point (°C)	Pour point (°C)	Viscositu (cS)	Gross heat Value (MJ/kg)	Flash point (°C)
Linseed oil	0.94	-2	-15	37.85	39.46	221
Linseed ester	0.90	+3	- 5	9.75	39.52	160
Sunflower oil	0.93	-4	-18	44.86	39.88	232
Sunflower ester	0.89	+6	- 6	9.42	37.83	176
Jatropha oil	0.93	-4	-15	49.04	40.63	256
Jatropha ester	0.89	+5	- 2	8.16	40.97	170

Table 2. Suggested Standards for Vegetable Oil and Ester Fuels

Property	Oils	Esters	Diesel
Cloud point (max)	20°C	20°C	6°C above 1/10* percentile minimum ambient temperature
Pour points (max)	-5°C	-5°C	–
Flash point (min)	(300°C)	(300°C)	52°C
Viscosity cSt 100°F	30-50	3-6	1.9-4.1°C
Specific gravity, 15/15°C	0.91-0.93	0.8-0.9	–

* For example, the 10th percentile minimum temperature for Northern Illinois is 6°F for Nov. and 12°F for March, bracketing the winter period when there would be minimum. tractor activity in field.

ters were low as compared to their respe-ctive plant oils. However, compared to No. 2 diesel (52°C), the flash points of esters were much higher be due the to presence of long carbon chains. The higher flash points ensure safe transportation and handling of esters. Among the esters, linseed oil ester had the lowest flash point **(Table 1)**.

Conclusions

The three plant oil esters had characteristics close to that of diesel fuel. As such, it is recommended that these may be tried as fuel for CI engines. Reports regarding the use of sunflower oil methyl ester are available in the literature, Hassett & Hasan (1982) and Hawkins & Fuls (1982).

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A Simple Method for Quantitative Estimation of Oil to Ester Conversion


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Abstract

The feasibility of use of plant oil esters as fuel in CI engines is being studied under an ICAR adhoc project. A simple method has been developed and standardised to quantitatively estimate the percentage conversion of plant oil to its ester. In this method, the unconverted triglycerides are estimated using spectrophotometer. Esters of four plant oils viz. linseed, jatropha, sunflower and rice bran was studied. Oil to ester conversion was found to be 92, 91, 88, and 75 percent in the case of linseed, jatropha curcas, sunflower and ricebran oils, respectively. Storage studies were also conducted. It was observed that no significant deterioration in quality of linseed oil ester was observed during a storage period of six months. This was assessed by estimating the free fatty acid content in the samples.

Introduction

The availability of fossil fuels, especially petroleum oil has been under constant threat (Aggarwal et al. 1991 and Soni, 1987). It is found to affect every sector of the economy. As the modern food production system heavily depends on the diesel fuel, one has to do advanced planning to sustain agricultural production. The number of diesel-run tractors and pump sets in India exceeds 1.3 m and 4.8 m, respectively and that in Punjab 0.33 m and 0.2 m, respectively, (Verma et al. 1993 and Singh et al. 1997). World-wick researchers are on the lookout for alternate sources of energy. Agricultural research workers are more interested in biomass-based renewable fuels. Some of the biomass based fuels tried in IC engines include alcohol (Bandel, 1977 and Holmer, 1977), biogas (Dass et al. 1978 and Mehta et al. 1980), producer gas (Jain, 1987) and plant oils. Of these, plant oils have an edge over the others because of better self-ignition characteristics, high energy content, safe handling, easy processing, and good compatibility with the fuel injection system of existing CI engines (Gupta, 1994 and Gupta et al. 1994). Instead of plant oils, non-edible oils are being preferred for use as engine fuel even as edible oils are also being studied.

Investigations reveal that unmodified plant oils lead to many problems when used in CI engines, including injector coking and carbon deposits in various parts of the engines (Johanson et al. 1982, Shyam, 1984 and Ziejewski et al. 1982). The main reason is the high viscosity of the plant oils. High acid value and the presence of gum/wax are some other reasons. To overcome these problems, plant oils are modified either by cracking, blending, heating or esterification (Ziejewski, 1982 and Niehaus et al.

1985). Among these methods, esterification is considered to be the best alternative techno-economically. The cost of esterification can be fully off-set if glycerol, which is a by-product of this reaction, could be traded in the market after proper refining.

Quantitative estimation of oil to ester conversion is important in determining the suitability of the prepared ester as fuel for engines. Up to the present time, this conversion has been estimated semi-quantitatively using the TLC plates. Some other, cumbersome and time consuming methods are reported in the literature for this purpose. This paper describes a simple quantitative method for the estimation of oil to ester conversion using a spectrophotometer.

Materials and Methods

Esters of four crude plant oils, namely; linseed, jatropha curcas, rice bran and sunflower were prepared using a simple, inexpensive and time saving esterification method already developed in this Department (Gupta, 1994). Linseed and jatropha curcas oils were selected because these are non-edible oils. Sunflower oil was preferred as it was gaining popularity and was a promising seed crop in Punjab. Linseed and sunflower oils were procured from a local oil expelling mill, whereas jatropha curcas seeds were obtained from Rajasthan. Its oil was expelled from a local expeller (Kohlu). Ricebran oil, which is a by-product of rice milling, was procured from local rice mill.

Esterification of Oil

Esterification was done using the method reported by Gupta (1994), which is a modification of the method proposed by Freedman et al. (1984) and Peterson et al. (1991). For each test, 100 g of oil (heated to 60°C) was reacted with alkaline methanol (a homogeneous mixture prepared by dissolving 1 g of NaOH pellets in 16 g methanol). Stirred the oil-alkaline methanol mixture for 5-10 minutes and allowed to settle for 2 hrs. Glycerol separation was effected by using a separating funnel. The ester collected was given three washings with water to remove excess alkali, if any. The washed ester was heated to evaporate the traces of moisture.

Free Fatty Acid (FFA) Estimation

FFA estimation in the sample was done by the method as suggested by Mc.Killican (1966).

Results and Discussion

The present study is mainly concerned with the standardization of a quantitative chemical method for estimation of the amount of ester formed from the oil. Earlier, percent conversion was estimated semi-quantitatively using the TLC plates. From the TLC plates, one could only have an approximate idea of percent oil to ester conversion. For example, from the TLC plates shown in **Fig. 1**, it may be inferred that in the case of linseed, jatropha and sunflower oil, the percent conversion of oil to ester was close to 90 per cent or more. However, for the rice bran, the conversion seems to be less. Similar results were reported by Gupta (1994). Freedman and Pryde (1982) also used the silica coated TLC plates for semi- quantitative analysis. Thus, the TLC gave only an approximate idea of the percent conversion.

For estimating the exact precentage of conversion, the spectrophotometric method was developed and standardized. This method basically involved the estimation of glycerides present in the form of unconverted oil in the prepared ester. Total glycerides in the oil and unconverted glycerides in the ester were estimated. The glyceride estimation was done in terms of glycerol, which was obtained after saponification of the test sample.

Saponification was done by the method of Sastry and Kates, as reported by Work and Work (1972). Two ml sample of oil/ester was taken in a round-bottomed flask. Then 0.8 ml of 33% aqueous potassium hydroxide and 20 ml of 95%

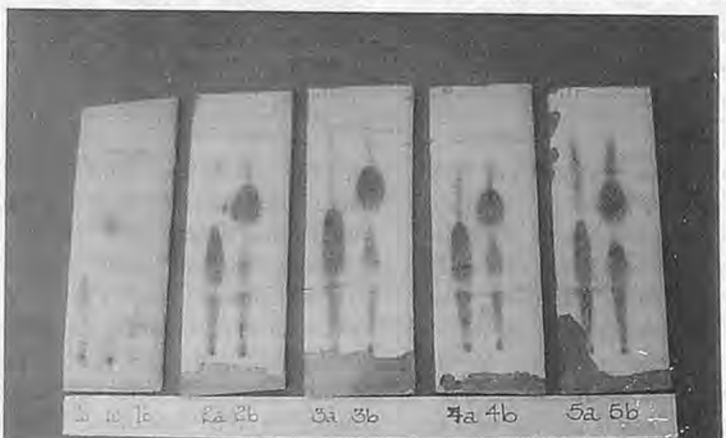

Fig.1 TCL of Plant Oils and their Esters.
Slide1. Standards, a; Tripalmitin, b; Methylstearate, c; Palmitic Acid
Slide 2. a; Linseed oil, b; Linseed oil ester
Slide 3. a; Jatropha curcas oil, b; Jatropha curcas oil ester
Slide 4. a; Sunflower oil, b; Sunflower oil ester
Slide 5. a; Ricebran oil, b; Ricebran oil ester

Table 1. Percent Oil to Ester Conversion (with LR Methanol) and Recovery for Selected Plant Oil Esters

Oil	Percent conversion	Percent recovery
Linseed	94	91
Sunflower	88	83
Jatropha	91	78
Ricebran	75	50

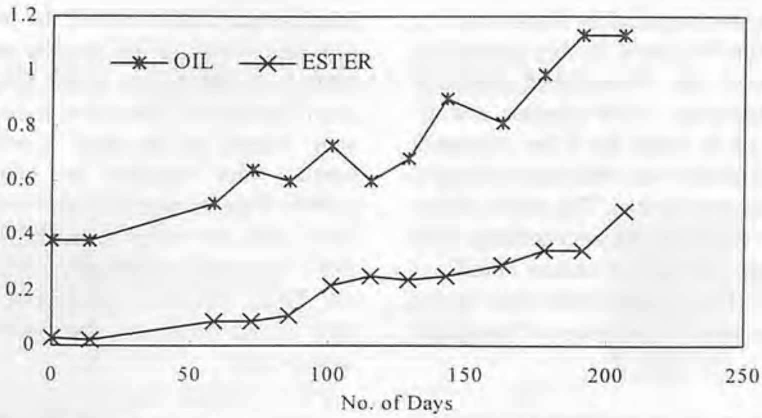

Fig. 2 Effect of strrage time on average. FFA (%) content of licseed oil and its methyl easter.

Table 2. Effect of Storage Time on Free Fatty Acid Content (% Oleic acid) of Linseed Oil and its Methyl Ester

Date of Observation	Linseed oil(%)		Esters(%)				
	I	II	I	II	III	IV	V
14/04/96	0.38	-	0.03	-	-	-	-
28/04/96	0.38	-	0.02	0.04	-	-	-
11/06/96	0.52	-	0.09	0.10	0.13	-	-
25/06/96	0.64	-	0.09	0.10	0.09	0.16	-
09/07/96	0.60	0.33	0.11	0.15	0.22	0.16	0.10
24/07/96	0.73	0.50	0.22	0.11	0.31	0.31	0.30
07/08/96	0.60	0.50	0.25	0.27	0.31	0.36	0.30
21/08/96	0.68	0.50	0.24	0.25	0.30	0.34	0.27
04/09/96	0.90	0.46	0.25	0.27	0.31	0.41	0.35
24/09/96	0.81	0.58	0.29	0.35	0.35	0.46	0.35
09/10/96	0.99	0.71	0.35	0.42	0.42	0.56	0.42
23/10/96	1.13	0.92	0.35	0.49	0.49	0.56	0.56
07/11/96	1.13	0.85	0.49	0.49	0.56	0.56	0.56

ethyl alcohol were added to it. This mixture was refluxed for 90 minutes on boiling water bath. Immediately after refluxing, 20 ml of 2N HCl was added. Thereafter, the mixture was cooled and 40 ml of petroleum ether (40×C - 60×C) was added. The solution was thoroughly mixed again and allowed to settle down for about 20 minutes. The upper layer of the petroleum ether containing FFA was discarded. The lower layer of the ethanol water containing the glycerol was evaporated to half the volume in order to remove the excess alcohol. After this, the volume of the solution containing glycerol was doubled with distilled water.

Glycerol in the above solution was estimated by the method of Renkonen as reported by Work and Work (1972). Glycerol estimation directly gave the total glyceride content in the solution. In this method, 0.5 ml of the sample was taken. Then 0.5 ml of distilled water and 0.1 ml of 10 N H_2SO_4 was added to it followed by addition of 0.5 ml of 0.1 M sodium periodate ($NaIO_4$). It was mixed thoroughly and left at R.T. for 5 minutes. Thereafter, 0.5 ml of 10% sodium bisulfite ($NaHSO_3$) was added to it followed by addition of 5 ml of chromotropic acid reagent (0.18%, 100 mg dissolved in 10 ml distilled water and mixed with 45 ml of 24 N H_2SO_4), which was the final coloring agent. The contents were mixed thoroughly and the tubes were placed in boiling water bath for approximately 2 hrs. The tubes were cooled and the absorbance of solution was recorded at 570 nm. Standard glycerol (0.02 micromole - 0.1 micromole)

and a blank containing distilled water was also run simultaneously. The final coloring agent, chromotropic acid had to be added with great care, as even a single drop of it could cause variations in the reading. Thus, the absolute reading of the sample could vary from time to time, but the percent conversion was always similar with S.D. of ± 3.

Mittlebach (1994) also reported a method for the estimation of total glycerides in terms of glycerol, in which glycerol was estimated enzymatically, but the present method was independent of the expensive thermolabile enzymes. Results were calculated in terms of micromoles of glycerol (glyceride) per ml. Total glyceride in oil and unconverted glyceride left in the ester were determined. Finally, the percentage of ester formed from oil was calculated by subtracting unconverted glyceride from the total glycerides.

The data presented in **Table 1** gives the quantitative percentage of oil converted to ester. In case of linseed oil, oil to ester conversion was 94% while for jatropha curcas and sunflower oils, it was 91% and 88%, respectively. Hawkins and Fuls (1982) suggested the esterification yield to be atleast 90%, if the esters were to be used as efficient fuels in CI engines. Hassett and Hasan (1982) prepared the Sunflower oil methyl esters with a yield of 87-90% and referred to it as fuel grade methyl ester.

In addition to percent conversion, considerable ester recovery was also achieved in all the three oils used in this study(**Table 1**). However, in the case of parboiled rice bran oil, the conversion was 75% and ester recovery was just 50%. This could be attributed to the presence of excess wax and gums in the crude rice bran oil. Studies are in progress to increase the percent conversion and percent recovery of rice bran oil ester.

A study regarding the effect of storage period on the quality of ester was also undertaken. The effect of storage period (six months) on the quality of linseed oil and its ester was studied. The quality of ester and oil had been assessed in terms of free fatty acids (FFA), because at elevated temperatures fatty acids react with many metals like zinc, lead, manganese, cobalt or tin (Pryde, 1982 and Romano, 1982) and the resulting fatty acid metal salts could increase engine wear. The data given in **Table 2** and **Fig. 2** show that in the case of linseed oil, the average FFA content increased from 0.36% to 1.13% in six months of storage period. Whereas in the case of linseed oil ester the increase in average FFA content was from 0.08% to 0.49%, which was below the BIS recommendations (Anonymous, 1974). Storage studies are still in progress and effect of storage period on the viscosity of oil and ester is also underway, since increased viscosity poses a major threat to long term engine running.

Conclusions

This method is very useful and can be successfully used in quantifying the percent oil to ester conversion. The final coloring agent, i.e., chromotropic acid, had to be added with great care, as even a single drop of it could cause variations in the reading. However, it affects only the absolute reading of a sample but the percent conversion value is not affected. The deterioration in quality of linseed oil ester occurs during a storage period of six months was not siginificant.

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Higher Education in Agricultural Mechanization in Jordan

by

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Abstract

The Jordan University of Science and Technology is the first school in the country that offers B.Sc. degree in agricultural engineering technology. The establishment of the agricultural engineering and mechanization program aims to produce specialized agricultural engineers who should be able to apply technology and engineering in agriculture to fill in a great need-now and in the future. This advent is important for agricultural development also for neighboring countries as well. The features of this higher education in agricultural education are discussed in this paper.

Introduction

Jordan is a developing country which depends primarily on agriculture as one of the main resources for the national income. On an average, 50% of the country's export comes from the agriculture sector. A high percentage of Jordan's total population works in agriculture. The majority of them are farmers by legacy and they practice farming using human labor and simple traditional agricultural tools and implements.

Increased food production has become an urgent need for the security of most countries in the region due to large increase in population. The shortage of water resources requires an efficient use of available water. The timeliness in the completion of various agricultural operations depends on the use of modern farm machinery which is essential in the development of the agricultural productivity using trained manpower in agricultural mechanization.

The government has since made efforts to encourage the use of agriculture engineering technology in Jordan such as the provision of a low rent rate in the use farm machineries such as seed drills and sprayers to farmers, on-farm demonstrations on the proper use of specific farm machineries, organizing and holding farm machinery shows, and tax-free importation of farm equipment. However, no great success in this regard has been achieved on account of most farmer's preference for the traditional farming practices such as manual sowing of seeds. Importation of expensive farm machineries not be suitable to work under local conditions and generally poor farm management on the part of farmers.

In order to overcome these problems and to enhance the usage of agricultural mechanization technology, a training program in agricultural mechanization at the university level is needed. The first B.Sc. degree program was introduced during the 1990-91 academic year at the Jordan University of Science and Technology (JUST) which aims to prepare and produce engineers capable of doing the required engineering operations to study, analyze, design, evaluate, supervise, and to maintain agricultural projects. The purpose of this paper is to describe the agricultural mechanization program in Jordan which is designed to combine theoretical knowledge with field work in order to produce specialists who can enhance the existing techno-logy for use by local farmers.

Agricultural Engineering Technology Program

The JUST is a governmental institution established in 1985. It is the only institution in Jordan and in neighboring countries which offers a bachelor's degree in agricultural engineering technology through the sixth department in the faculty of engineering. Currently, the program offers two major options of specia-lization: agricultural mechanization or power and machinery; and irrigation and drainage. All students in the program are required take common core courses during the first three years. By the fourth and the fifth years they specialize in one of the two options mentioned above. The first group of students in the agricultural mechanization option graduated at the end of the second semester of the academic year 1996-97. At the present time, of the 10 faculty members in the department of Agricultural Engineering, seven of whom did their Ph.D. degrees from leading universities in the United States and Canada through scholarships from JUST. Of these faculty members, four specialize technology in farm power and machinery, four in irrigation and drainage and two in environmental. There are present three scholars sponsored by JUST pursuing their Ph.D. degree in the United States: two of them specialize in farm power and machinery and the third in irrigation and drainage. Two other candidates for scholarships now work as teaching assistants in the department for two years before they leave for graduate studies in the United States. Two laboratory technicians are now assigned to the department for the power and machinery laboratories, including soil and irrigation water laboratories.

The Department Curriculum

The number of credit hours required for graduation from the department is 162. As shown in **Table 1**, these credit hours are distributed into three major categories; university requirements, 28 credit hours in languages, education and humanities; college requirements, in mathematics, physics and chemistry 24 credit hours; and departmental requirements, 110 credit hours in field crops, soils science and farm mechanization. The department has the following facilities; laboratories in farm power and machinery; agricultural tractors and machinery laboratory in the field; soil and irrigation water laboratories; irrigation and drainage laboratory; outdoor facility for irrigation and drainage practicum; a drawing room to accommodate 30 students; and a huge farm shed for agricultural machineries of the department. The Department's computer laboratory is equipped with 10 micro-computers and an experimental field for the faculty to conduct research. In addition, students in farm power and machinery option can use other necessary resources on the JUST campus such as the university micro-computer laboratory a modern, well-equipped workshop for teaching and research, fluid and hydraulic power laboratory at the civil engineering department, properties and strength of materials laboratory, internal combustion engine laboratory, and instrumentation laboratory at the mechanical engineering department, and the agricultural equipment at the university agriculture center.

During the first three years, students are given a solid and strong background in basic sciences (mathematics, physics, chemistry, and biology) as well as fundamentals of engineering **(Table 1)**. The summer semester of the fourth year is devoted entirely to industrial training, where students are sent to agricultural industries to apply some of what they have learned at school. This summer training is usually for 12 weeks after the students finish 120 credit hours.

Table 1. Categories of the Agricultural Mechanization Program

Category	Credit Hours
University Requirements (languages, education, humanities)	28
College Requirements (mathematics, physics, chemistry and their labs)	24
Departmental Requirements (some field crops, soil physics, and basic agricultural mechanization and technology courses)	110
Total	162

Graduates of the farm power and machinery program are expected to be responsible for the following: introduce new designs and concepts of agricultural machineries to perform certain and specific jobs; adjust and improve designs of existing machineries to maximize performance under local conditions; optimize the use of existing farm machineries and advice farmers in selecting appropriate farm equipment for specific operations; combine the use of land, labor, and capital to achieve the highest possible productivity; carry out comparison tests and evaluate the performance of different agricultural machineries and vehicles; match power units to the size and type of machines to enable all field operations to be carried out on time with minimum cost; and study problems that might arise as a result of the interactions between agricultural machineries with soil. Graduates of the irrigation and drainage option are expected to calculate the plant need for water which requires knowledge in evapotranspiration and the factors affecting it; how to preserve water in upper soils to be used by plants; how to construct dams and water structures for storage and conveyance of water to fields; design irrigation networks that ensure efficient distribution of water to plants with least water losses; reclamation of saline soils by designing and constructing proper drainage systems to reduce soil salinity; and how to manage water distribution for agricultural projects to avoid excessive use of water.

Problems with the Program

In Jordan and neighboring countries, agronomists are wrongly known among people as agricultural engineers who are in fact, agriculturists and experts in agriculture sciences and not in agricultural engineering technology. Agricultural science and agricultural engineering are two different disciplines in agriculture and they complement each other. The first batch of students suffered from this problem but with the aid of the faculty in the department the problem was subsequently corrected. Another problem the department facing is the lack of teaching assistants. The absence of a graduate program is the main reason for the shortage in teaching assistants. The faculty receives assistance from mechanical and civil engineering departments. The department is about to overcome this problem by offering permanent positions for teaching assistants to deserving graduates. The small number of applicants was a major problem in the department until recently. As mentioned earlier, this comes from a mixed understanding of agronomy and agricultural engineering but this problem seems to be vanishing knowing that the number of applicants has reached 74 students for the coming academic year.

Future Plans

Since this is the first university program farm mechanization in the country, it is not expected to be perfect. After the first graduates went into the job market, a study is now being conducted to find out their acceptability in various jobs. A modification of the program and study plan is under consideration in terms of meeting the real and changing needs of farmers.

As in all engineering branches, the graduates are not guaranteed jobs and this might affect the number of applicants to the department. Therefore, it is necessary to start attracting students from neighboring countries in the region which requires program adjustments to meet a regional need and not just the need in Jordan.

A graduate study program is one of the targets of the Department of Agricultural Engineering and Technology in the near future. Already there are some on-going research projects that study the mechanics of offering at last a master of science degree program.

The department plans on offering a food engineering technology within the coming three years. Waste management and green houses are among the topics which are expected to be added to the departmental curriculum soon.

Tbale 2. Undergraduate Curriculum in Agricultural Mechanization Program

First Semester		Second Semester	
Courses	Credit Hours		Credit Hours
First Year			
Arabic Language I	3	General Physics II	3
English Language I	3	General Physics Lab	1
General Physics I	3	General Chemistry II	3
Arabic Language Lab	1	General Chemistry Lab	1
General Chemistry I	3	Calculus II	3
English Language Lab	1	General Biology	3
Calculus I	3	General Biology Lab	1
		Introduction to Computer Science	3
Total	17		18
Second Year			
Statics	3	Dynamics	3
Engineering Drawing	3	Strength of Materials	3
Intermediate Analysis	3	Ordinary Differential Equations	3
Computer Programming	2	Engineering Workshop	3
Introduction to Agricultural Engineering & Technology	3	Field Crops	3
Military Science	3	Instrumentation	2
		Instrumentation Lab	1
Total	17		18
Third Year			
		Power & Hydraulic Machines	3
Fluid Mechanics	3	Fluid Mechanics and Hydraulic Machines Lab	1
Theory of Machines	3	Mechanical Drawing	2
Soil Physics	3	Engineering Economics	2
Soil Science Lab	1	Numerical Methods	3
Thermodynamics	3	Evapotranspiration	3
University Elective	3	Strength of Materials Lab	1
Total	16		15
Fourth Year			
Fundamentals of Electrical Engineering	3	Farm Electricity	3
Applied Math for Engineers	3	Machine Design II	2
Machine Design I	3	Exercises in Agricultural Machine Design	1
Mechanical Vibrations	3	Heat and Mass Transfer	3
Engineering Materials	2	Farm Machinery	2
University Elective	3	University Elective	3
Total	17		14
Fifth Year			
Stability and Traction of Off-Road Vehicles	3	Harvesting Machines	3
Tractor and Field Machinery Lab	1	Agricultural Machinery Management	3
Internal Combustion engine	3	Internal Combustion Engines Lab	1
Soil-Machine Relations	3	Graduation Project II	3
Graduation Project I	1	Technical Elective	3
University Elective	3		
Technical Elective	3		
Total	17		13

Research Areas of Interest

The current faculty in the department have the following research areas of interest in agricultural mechanization and irrigation and drainage: Agricultural Mechanization-The tentative list of research areas in agricultural mechanization are machine design, crop harvesting machines, tillage systems, pesticide application, waste management and composting, finite element modeling and analysis, soil compaction, environmental control, green houses, and computer simulation.

Irrigation and Drainage-On the other hand, research projects in irrigation and drainage are eyed on soil and water, crop water requirements, plant microclimate, energy balance and instrumentation, evapotranspiration, hydrological modeling, irrigation water and contaminant movement through heterogeneous soils.

Conclusions

There was a great need for a university level training program in agricultural mechanization because of the shortage of trained personnel to spur the agricultural engineering technology in Jordan. The graduates of the program described in this paper are expected to make a great contribution to the development and advancement of mechanization in the country.

Because of its uniqueness, the program is expected to have a bright future. As discussed in the paper, there are some minor problems that need to be solved before the program becomes, as expected, a solid and strong branch in the college of engineering at Just.

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Shidid, F. (1993). Workshop about manufacturing tractors and farm machinery. ■■

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Anthropometry of Indian Female Agricultural Workers and Implication on Tool Design

by

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Abstract

With a view to generating anthropometric data base for women agricultural workers in the southern region of India, an anthropometric survey was conducted. Different body dimensions of the subjects having direct implication on agricultural tool/implement design were collected from 137 female workers during this survey. The data are compared with that of the male workers of the region as well as the data of females from other ethnic groups. Application of this data on tool design is illustrated through an example.

Introduction

In India women constitute 50.2 percent (Sony and Varshney, 1984) of the agricultural work force. They use a variety of hand tools and implements to perform various tasks in crop production process and post harvest operations. Most of the tools are indigenously developed and their dimensions and shapes are left to the skill and imagination of the local artisans.

However, in recent years, efforts were made to standardise these implement and to improve their design, incorporating ergonomic principles, which are expected to enhance the work output and worker's efficiency, keeping in view her comfort and welfare. A thorough understanding on the various body dimensions of the expected users of these implements is a pre-requisite for the successful formulation of any such project. Although a few anthropometric surveys are conducted on Indian male agricultural workers (Gite and Yadav, 1989, Fernandez and Uppugonduri, 1992 and Yadav et.al, 1997), data on women subjects are yet to be generated. Several authors (Mustafa et.al, 1987, Schmidlke, 1988) have identified and emphasised the need for generating anthropometric data base for women as "using extrapolated male data to assess women in relation to their work would be prejudicial" (Writtle, 1984). Rogan, in her systematic review (Rogan, 1992), underlined the need for initiatives in this direction, specially in the case of the vast women labour force engaged in the agricultural sector in developing countries. This study is an effort to bridge this information gap.

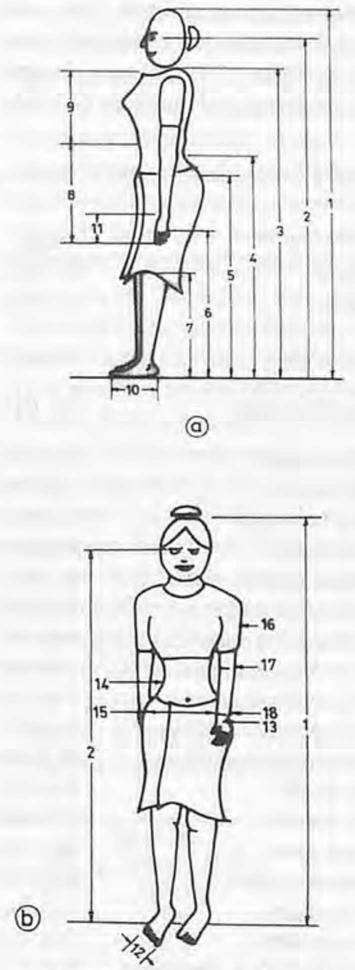

Fig.1 Body Dimensions of Women Wowkers.

Acknowledgement: The authors are thankful to all farm workers and authorities who participated in this work, for extending their patient and whole hearted cooperation, without which this study would not have been successful.

Table1. Body Dimensions Measured during the Survey

No	Measurement	No	Measurement
1	Weight	12	Cylindrical grip span
2	Stature	13	Circumference at wrist
3	Eye height	14	Circumference at elbow
4	Shoulder height	15	Circumference at biceps
5	Elbow height	16	Hip height
6	Hip height	17	Hip breadth
7	Knuckle height	18	Waist girth
8	Knee height	19	Buttocks to knee
9	Middle finger to elbow	20	Foot length
10	Elbow to shoulder	21	Foot breadth
11	Forward arm reach	22	Hand breadth at metacarpal
		23	Hand length

Fig.2 Posture While Operating Weeder

Methodology

Anthropometric data from 137 female agricultural workers were collected and analysed from the southern region of India. The subjects were selected randomly, from the northern (35 subjects), central (55 subjects) and southern (47 subjects) parts of the region to have full representation. For comparison, data were also collected from 45 male agricultural workers. The subjects were in the age group of 20 to 65 years (mean 42 years with standard deviation 9.7).

The subjects were briefed about the survey beforehand demonstrating the measurement procedure, in order to ensure their full co-operation. The equipment included an anthropometer, medical balance and an especially made hand grip diameter measuring device. Twenty-two different body dimensions **(Fig. 1)** having direct bearing on agricultural implement design were recorded during the study. Standard anthropometric procedures (Hertzberg et.al, 1954) were followed for the study.

Table 2. Anthropometric data of women agricultural workers in Kerala

Measurement	Range	mean	SD	SE	Percentile 5th	50th	95th
Weight	30.5-63.5	46.6	7.4	0.51	35.5	46.3	59.2
Stature	121.4-161.7	147.3	6.8	0.75	140.5	150.7	155.6
Eye height	114.2-149.9	140.4	5.6	0.65	132.3	139.6	145.4
Shoulder height	100.7-136.5	124.6	7.7	0.55	115.4	122.8	129.7
Elbow height	81.7-102.5	73.6	13.5	1.49	55.2	93.4	95.6
Hip height	71.0-89.8	51.6	5.5	0.06	77.2	50.4	56.6
Knuckle height	41.5-65.0	62.1	13.4	1.48	57.4	61.3	63.9
Knee height	34.0-50.1	45.6	3.1	0.34	41.5	46.0	49.2
Middle finger to elbow	35.2-44.7	37.3	1.6	0.21	36.5	39.1	43.7
Elbow to shoulder	24.0-34.3	30.5	2.7	0.29	27.2	29.4	31.1
Forward arm reach	60.0-70.1	65.5	3.1	0.34	60.2	64.3	70.2
Cylindrical grip span	12.0-20.5	16.5	1.5	1.17	14.0	16.8	19.0
Circumference at wrist	13.0-15.5	15.4	1.2	0.13	13.1	15.5	17.5
Circumference at elbow	17.5-27.5	23.4	1.6	0.21	20.4	23.5	26.5
Circumference at biceps	26.7-45.0	37.8	4.3	0.45	30.0	37.8	45.5
Hip height	71.0-57.5	51.6	5.4	0.59	77.2	50.4	56.6
Hip breadth	25.0-60.2	38.1	4.9	0.54	30.1	38.7	45.0
Waist girth	56.0-77.4	74.2	7.4	1.04	62.0	73.1	96.3
Buttocks to knee	40.2-51.0	46.5	5.3	0.78	41.7	46.6	51.5
Foot length	15.2-24.1	21.6	2.2	0.26	15.6	21.1	23.5
Foot breadth	7.2-10.9	10.1	1.1	0.41	7.5	9.5	10.6
Hand breadth at metacarpal	7.6-5.5	5.1	1.3	0.38	7.7	5.0	5.2
Hand length	14.4-19.5	17.3	2.1	0.93	15.2	17.1	18.7

Results and Discussion

The body dimensions **(Table 1)** of the subjects under study are shown in **Table 2** indicating the mean, standard deviation and standard error along with 5th, 50th and 95th percentile values **(Fig. 1)** . The relative high standard deviation, in general, shows the diversity in body dimensions of the subjects. The percentile values are logical in most of the design situations.

Table 3 shows the comparison between the data for male and female agricultural workers of the region. For obvious reasons, male body dimensions are higher than that of their female counterparts. However, there is no prominent differences between the two, as one would expect. For example, in the case of stature, male data is only 5.8 percent higher than that of the female data. Similarly, shoulder

Table 3. Comparison of Anthropometric Data of Male and Female Subjects in Kerala

Measurement	Male mean	Male SD	Female mean	Female SD
weight	49.3	8.4	46.6	7.3
stature	158.1	5.5	149.3	6.8
eye height	148.5	5.8	140.3	5.9
shoulder height	130.2	6.5	124.6	7.7
elbow height	106.7	4.2	93.9	13.5
hip height	98.3	3.9	81.6	5.4
knuckle height	70.8	3.8	62.1	13.4
knee height	48.8	2.0	45.9	3.1
mid finger to elbow	42.9	1.9	39.3	1.9
elbow to shoulder	27.7	2.3	30.5	2.7
forward arm reach	69.3	2.6	65.5	3.1
cyl. grip span	18.9	1.6	16.8	1.6
wrist circumference	15.1	0.9	15.4	1.2
elbow circumference	21.4	4.5	23.4	1.9
biceps circumference.	34.4	3.8	37.8	4.3
waist girth	75.8	10.0	74.2	9.4
hip breadth	45.9	5.6	38.1	4.9

height and knee height of Indian male subjects are higher only by 4.8 percent and 6.5 percent, respectively, than that of the female subjects. It should be noted that, for British population corresponding increments in stature, shoulder height and knee height are 8,8.8 and 9.1 percent. For Americans it is 7.7,8.7 and 8.9 percent and for German 6.7,10.9 and 7.9 percent respectively, (Pheasant, 1986).

Table 4(a). Comparison of Anthropometric Data of Different Ethnic Groups

Measurement	Indian 5th	Indian 50th	Indian 95th	British 5th	British 50th	British 95th
Stature	140.5	150.7	158.6	150.5	161.0	171.0
Eye height	132.3	139.6	145.4	140.5	150.5	161.0
Shoulder height	115.4	122.8	129.7	121.5	131.0	140.5
Elbow height	88.2	93.4	98.6	66.0	72.0	78.0
Knee height	41.5	46.0	49.2	45.5	50.0	54.0
Mid fing.to elbow	36.8	39.1	43.7	40.0	43.0	46.0
Elbow to shoulder	27.2	29.4	31.1	30.0	33.0	36.0
Forward arm reach	60.2	64.3	70.2	65.0	70.5	75.5
Hip height	77.2	80.4	86.6	74.0	81.0	88.5
Hip breadth	30.1	38.7	35	31.0	37.0	43.5
Buttocks to knee	41.7	46.6	51.8	52.0	57.0	62.0
Foot length	18.6	21.1	23.8	21.5	23.5	25.5
Foot breadth	7.8	9.8	10.6	8.0	9.0	10.0
Hand length	15.2	17.1	18.7	16.0	17.5	19.0
Hand breadth	7.7	8.0	8.2	7.0	7.5	8.5

Table 4(b).

Measurement	French 5th	French 50th	French 95th	German 5th	German 50th	German 95th
Stature	150.0	160.0	170.0	152.0	163.5	175.0
Shoulder height	121.0	130.5	140.0	124.0	132.0	140.0
Elbow height	92.5	100.0	107.5	92.5	100.0	107.5
Knee height	45.5	49.5	53.5	45.5	50.5	55.5
Buttocks knee length	52.0	56.5	61.0	52.5	58.0	63.5
Hip height	75.0	82.0	89.0	76.0	84.0	92.0

Table 4(c).

Measurement	Japanese 5th	Japanese 50th	Japanese 95th	American 5th	American 50th	American 95th	Egyptian 5th	Egyptian mean	Egyptian 95th
Stature	145.0	153.0	161.0	152.0	162.5	173.0	148.7	160.6	172.4
Shoulder height	107.5	114.5	121.5	122.5	132.5	142.5	120.7	130.6	140.4
Elbow height	89.5	95.5	101.5	94.5	102.0	109.5	88.3	95.5	102.6
Knee height	42.0	45.0	48.0	46.0	50.5	55.0	42.8	48.1	53.4
Hip height	89.5	95.5	101.5	76.0	83.5	91	--	--	--
Buttock knee length	48.5	53.0	57.5	52.5	57.5	62.5	49.9	56.5	63.0

Anthropometric data of females of different ethnic groups are compared in **Table 4**. It can be seen that Indian female workers are smaller than British, French, German, Egyptian and Turkish population. This implies that the devices and implements designed for these populations should be suitably modified before introducing them to the Indian farm workers.

Typical Design Implications

A given work situation demands a particular body posture for efficient operation and maximum work output. The field studies recounted by Corlet (1981) showed how poor working postures could lead to postural stress, fatigue and pain, which may in turn force the worker to stop work until the muscles recover. Typical examples of such work situations could be those of involved in paddy production system viz. transplanting, weeding and harvesting. In these operations the workers (usually female in most of the developing countries) have to bend over work surfaces for targets which are too low. It may be suggested that pain rather than capacity may often be the limiting factor in such task situations. In view of this the posture assumed in a task is solely depended on the size and dimensions of the device or the equipment being used for performing the task. As a result, a good equipment or machine design will have a great bearing on the anthropometry of the worker.

In paddy production system, women agricultural workers use different types and designs of devices, namely; weeders for weeding operation, spades for channel making, sickles for harvesting, and baskets for load carrying on head. Body dimensions of the expected operators and movements that their body members make without difficultly or strain, should be considered for the successful design of these implements and tools. Although a designer will have options to choose from 5th, 50th or 95th percentile values, judicious selection should be made depending on the specific work situation. An example of utilising the anthropometric data collected in the design of the handle of a weeder (most commonly used hand tool used by the women workers in the region) is illustrated below.

The recommended body posture while weeding with a manual weeder is shown in **Fig.2** . For maximum work efficiency, it is suggested that it should be in the range of 85-110 degrees (Grandien, 1988). Several studies have suggested a value of 50-60 degree for I (Sengupta et al, 1974, Pradhan et al, 1987 and Inns, 1985). Taking these into consideration and knowing the elbow height (x) and knuckle to elbow height (y) form the anthropometric data, from the geometry, one can easily figure out the optimum length of the handle Z as

$$Z = \frac{x + Y\cos\beta}{\sin\theta}$$

Taking β - as 100 degrees and I as 55 degrees, for the population under the study, the handle length should range from 110 to 120 centimetres, giving marginal clearance for the hand grip. Handle diameter of the tools should be selected in such a way to ensure that the operators longest finger does not touch her palm while gripping the handle. At the same time it should exceed the internal grip diameter (Parik, 1980). From the anthropometric data one could suggest a range of 3.5 to 4.5 centimetres for the handle diameter.

Conclusions

An anthropometric data base for the women agricultural workers in the southern region of India is generated which could be useful in the design of agricultural implements. Application of these data in tool design is illustrated with an example of the design of handle for manually operated weeder. Work is in progress regarding optimisation of the most appropriate body posture in various field operations. Energy cost of these activities is also being investigated. More information would be available in the subsequent paper which is under preparation.

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Farm Mechanization in Jiangsu Province, P.R.China

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Abstract

Development of farm mechanization in Jiangsu Province in recent years is discussed in this paper. Development speed of farm mechanization at present is the highest. Investment mode has utterly shifted from state investment to private investment on farm machines. Main problems in farm mechanization and suggestions for solving these problems are presented.

Introduction

Agriculture overview of Jiangsu

Jiangsu province is one of the developed regions in China. It is located in the southeastern part of China, a region that encircles the lower part of the Yangtze River. Its agricultural situation is shown in **Table1.**

Present situation and character of farm mechanization

Collective farming has shifted to private farming. This shift has greatly stimulated the development of farm mechanization . At present, farm mechanization level in Jiangsu is the highest in China. However, this level is still low compared with other countries and area. (**Table 2.**)

Three characteristics exist in the development of farm mechanization in Jiangsu.

The first is the shift in the investment mode. State and collective investments no longer play an important role. Instead, private investment on farm machines is the main source and the collective investment only plays a minor role. For instance, in 1996, 36 units of Yama combine were bought by Wujin county of Jiangsu, 34 units of which are purchased by private farmers. Another example is that, in Yiancheng district in Jiangsu , more than 64 million Yuan RMB was invested in 1995 on farm machinery, 95% of which was invested privately .

Table 1. Basic situations of agriculture in Jiangsu, 1994

Population (million)		Farm Area	Crop Yield	Average Grain Yield (kg per mu)		Average Income (Yuan RMB)	
		(1,000 ha)	(excluding beans)	Jiangs	Whole	Jiangs	Whole
sum	rural		(10,000 ton)	Province	country	Province	country
67.42	51.89	5742.90	3046.20	445.92	379.28	1851.53	1200.98

Table 2. Comparative farm mechanization in Jiangsu and other Asia Countries

	Tractor (1,000 units)	Truck (1,000 units)	Percent mechanized farming (%)			
			Planting	Transplanting	Harvesting	Threshing
Jiangs Province(1995)	773	30	83	29	rice 5.0 wheat 35	96
Taiwan (1986)	123.8	980	98	97	97	67
Korea (1985)	760.1	910	89	84	100	18
Japan (1986)	468.3	884	100	100	100	100

The second development is that farm machinery service has entered into the market. This system of service has already covered the farming sector such as husbandry, food processing, transportation and almost every part of the rural economy. No doubt, such services do largely improve the output and the profit of the farms and thus made the investment on farm machine profitable. In 1995, gross income of private and collective farm machine services in Jiangsu province reached 10000 million Yuan RMB. Net profit was 3000 million Yuan, among which more than 2000 million Yuan was earned by private farmers. In Wujing county, for instance, professional machinery service families not only provide farming service locally, but also cater to neighboring provinces in the harvest season to enlarge their business.

The third characteristic has to do with the economy and geographic location, including machinery type, service mode, and development level. Three regions in the province represent these characteristics: Taihu, Lixiahe, and Xuhuai regions. In the Taihu region(Suzhou, Wuxi and Changzhou districts), the rural economy is prosperous. Its town and village industries are largely developed, rural labor force has greatly shifted to secondary and industries. Farming in this region has experienced three steps: From collective farming before 1980s to private farming in the 1990s, then to the autonomous collective farming due to its special conditions since 1990. One distinction is that professional farmers have appeared in recent years. Some of them bought or rent farm land from surrounding families. Others purchase farm machines to provide farming services. The investment is mainly on larger-sized farm machines. For example, Wang Guorong, a private farmer, has purchased 2 units of Yama combine in the last two years. In the last year, the demand for Yama combine has surpassed its supply in this region.

The Lixiahe region (Nanjing, Zhenjiang and Yiangzhou districts) is surrounded by the Yangtze River, the Huai River and the East Sea.Irrigation and drainage are the main problems in farming. As rural economy in this region is middle level, investment on farm machines comes largely from collective. Farmers usually invest on transport and food processing machines. Diversified rural economy is one of the distinctions in this region.

In the Xuhuai region (Xuzhou, Huaiyin, Yiancheng and Lianyun districts), rural economy is relatively weak, farm mechanization is poorly developed. Though farmers purchase machines privately, small-sized farm machine poses the main part. Nearly 60% of mini-tractors of the whole province are used in this region. Farming objective in this region is to improve crop yield.

Problems in Farming Mechanization

1) Overall profit in farming in Jiangsu is not high. Macro-system of regulation and warranty are yet to be formed. In 1996, total power per hundred mu (6.66 ha) is 33.4 kW, tractor power was 11.2 kW, nearly equal to that of some developed countries in the world. But the level of farm mechanization is much lower compared with those developed countries. The reason is in that the replacement of discarded engines and the over all structure of farm machines are out of control. Statistics show that more than 40% of drainage machines and more than 30% of tractors have already entered into discarding age.

Another reason is that farm tractors are poorly supplemented. Supplemental the ratio for larger and medium sized tractors is 1:2.06, for small-sized tractors it is 1:1.68. Besides, the ratio of small-sized machines to maximum or medium sized machine is outrageous. Only 11% of power in ploughing is provided by medium and larger-sized machineries.

2) Mini-scale farm restricts farm mechanization. Family scale farming is not compatible with farm machine services. In many regions, the land is split into strips that the width is even less than that of the cutting platform of a combine. In Pizhou county of Xuzhou district , for instance, farm land for a family is usually 200-300 meters long and 2.5-5 meters wide. Such a farming condition only suits mini-tractors and mini-machines which greatly debase the efficiency.

3) Research, design and production of farm machines can not match the development of mechanization. Technical equipment of farm machine is poor. From research point of view, research equipment in many institutes are obsolete. Cash for research and exploitation to farm machine is meager. In addition to the lack of researchers, a gap appeared between farm machine supply and demand. The most urgent demand of farm machines in Jiangsu is the wheat and rice harvesters, 23-26 kW four-wheel-drive tractors and crop drying equipment. The machine in use in Jiangsu is mainly produced by other provinces or from abroad.

4) Education in farm mechanization is poorly provided. Qualified persons are short in the farming system. Though education system for farm mechanization is very powerful (with two universities having doctorate and masteral degrees in farm mechanization, a series of colleges and schools for farm mechanization), the educated men do not want to work in this area. They normally find jobs in other areas due to many reasons.

Conclusion and Recommendations

Suggestions on the improvement

of farm mechanization in Jiangsu are:

1) To set up a warrant system for farm mechanization-

a: To build well administered and diversified farm machine service systems .

b: Departments for farm mechanization at district and country level should be perfected for the system and to improve working and living conditions of farm machine researchers. In addition, cooperation with researchers of other departments is a good way for the research and exploitation in providing farm machinery.

2) To increase investment on farm machine development.

Various solutions for this can be applied. One is to stimulate private farmers investing on farm machine by providing them with low interest loan. Another is to allot certain amount of agriculture revenue for farm mechanization development.

3) To pass laws and regulations for the promotion and support for farm mechanization. Many countries in the world have effectively promoted farm mechanization through regulation, such a policy should also be adopted in Jiangsu. It is, at present, more important to carry out effectively the existing regulations and roles such as "Farm machinery management of Jiangsu", "Regulations for the farming product quality", and "Regulations of standard farming technology and implementation".

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Agricultural Management Bureau of Jiangsu Province: the developmental plan for farm mechanization in Jiangsu from 1996 to 2000

■■

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The Present State of Farm Machinery Industry

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Outlook of Agriculture

Trend of Agriculture

In 1996 agricultural total products was ¥6,655 billion, it occupied 1.3% of GNP. The imports agricultural products are on the increase. In 1997 the imports reached $37.0 billion (a decrease of 8.4% of the preceding year). The exports agricultural products are $1.6 billion (an increase of 4.6% of the preceding year). In Japan, feed cereals, soybean, wheat and so on depend on the imports from foreign countries. Self-sufficiency ratio of agricultural product for food by calorie base in 1997 is 41%, cereals is 28%.

Population mainly engaged in farming has been decreasing yet, in 1997 it was 3,150,000 persons. It was 4.8% of total working population. Farm house has decreased, in 1997 are 3,340,000 farm houses. And, commercial household was 77%. Arable land was 4,950,000 ha in 1997. Arable land per one farm family was about 1.5 ha very small.

In Japan, food life has varied since 1970's. While, rice, oranges, milk, eggs and so on have been overproduced. In such surroundings, the GATT settlement require Japan to have more competitive power. In Japanese agriculture, it is requested to reduce production cost, increase people destined to bear agricultural production, produce various products satisfying consumers' need, and to realize agriculture keeping the earth favorable.

Japanese government has started tariff on imported rice in 1999 April. In July, enacted the New Agricultural Stable Law, they decided steady food supplying by increasing domestic production. Also they decide enforce multi-functions of agriculture, sustainable development of agriculture and improvement of rural areas.

Trend of Farm Mechanization

Agricultural mechanization in Japan has remarkably progressed in the field of low land rice, chief crop, in a short period since 1955. Rice production at present almost planting and harvesting have been mechanized. In 1998 as to rice, working hours per 10 a decrease to 36.1 hours, they were 117.8 hours in 1970.

In recent years farm machinery for rice crop is developed to be larger-sized, higher-efficiency and more commonly used. In addition, farm machinery for field crops and live stock farming is being developed and improved, which had been lagged behind so far.

From 1993 Japanese government started the program developing the new high-tech machine to make farm working efficient and to reduce farm burden. By 1997 those developing have finished such as big size multipurpose combine and vegetable grafting robot so on 36 types. And we decided eleven types of unification for growing vegetables. Local governments have been developing the machine to vitalize special local products. Moreover, in 1998 new program developing 27 types machine have started.

In 1995 Ministry of Agriculture, Forestry and Fisheries made a committee which studied method to reduce cost of farm product materials like farm machines. Those farm product materials are major parts of farming cost. In 1996 concrete movement started in the field of production and distribution. Low cost machinery which reducing functions has been increasing.

Following are the numbers of popularization of farm machinery as of Feb.1,1995: riding tractor reached 2,309,000 units; walking tractor

Table 1. Major Farm Machinery on Farm — Unit: Thousand

Year	Walking type tractor	Riding type tractor	Rice trans-planter	Power sprayer		Power duster	Binder	Combine	Rice dryer
1990	2,185	2,142	1,983		1,871		1,298	1,215	1,282
1991	1,765	1,966	1,904	—		—	—	1,169	—
1992	1,786	2,003	1,881	—		—	—	1,158	—
1993	1,743	2,041	1,866	—		—	—	1,158	—
1994	1,669	2,060	1,835	—		—	—	1,149	—
1995	1,718	2,313	1,869		1,921		1,022	1,203	1,121

Source: "Statistical Yearbook of Ministry of Agriculture, Forestry & Fisheries" by the Ministry of Agriculture, Forestry & Fisheries and Other datas.

Table 2. Shipment Major Farm Machinery Unit: Number

Year	Walking type tractor	Riding type tractor	Rice trans-planter	Power sprayer	Power duster	Binder	Combine	Rice dryer
1990	205,944	95,691	89,139	183,820	107,227	37,117	65,247	51,954
1992	199,141	88,754	80,105	184,016	105,028	20,888	60,941	52,275
1994	172,471	88,501	82,210	162,422	98,266	22,589	60,741	57,070
1995	163,323	90,623	81,729	162,352	96,499	23,293	64,572	60,564
1996	173,894	93,660	73,204	165,467	99,342	18,476	60,198	59,546
1997	174,004	87,416	64,859	177,064	90,133	16,770	53,095	52,389
1998	173,397	71,840	52,337	159,215	59,946	11,757	41,282	38,842

Source: "Survey of Shipment Agricultural Machinery" by the Ministry of Agr., Forestry & Fisheries.

1,714,000; rice transplanter 1,865,000; head feed combine 1,202,000 (**Table 1**).

Shipments of major farm machinery in the domestic market in 1998 are as follows: riding tractor reached 72,000 units (those under 20PS were 24,000; those 20-30PS 32,000; 30-50PS 11,000; over 50PS were 5,000); walking tractor 173,000; rice transplanter 52,000; power reaper 12,000; combine 41,000 (standard types were 1,008); grain dryer 38,000; huller 27,000. A safety cabin and a safety frame for tractor which are devoted to guarding operator increased sharply. This shipment was 69,000 units (**Table 2**).

Recently more and more used farm machines are distributed. The rate of used farm machinery in 1996 in the total sales amount is as follows: riding tractors forms 37%; rice transplanter 29%; combine 34%.

Movement of Farm Machinery Industry

In Japan New agricultural Stable Law enacted July in 1999. Japanese agriculture is going to new era. New Law orients to environment friendly productions. This Law will influence a lot of fields of methods of agricultural production. Farm machinery industry must cope with this movement. Japanese farmer's attitude for farm machinery has changed. Gorgeous big size to simple small machinery. Especially, we find this tendency in rice planter. In 1999 , Maker sold small and light rice planter very well. Moreover farmers liked that low price.

A history of Japanese farm machinery was walking type to riding type. Farmers like riding type. This tendency will be stronger.

Sixty years old farmers were major power supporting agricultural production. In near feature, they will retire. After their retirement, who will support agriculture. But we find changes recently. We see their sons and daughters working in the field. It already has been beginning to hand their land to children.

We have finished a system of mechanization in the field of rice production. But we have a problem. That is weed grass cutting. Now farmers cuts by bush-cutter. This is very hard work. Farmers hope good cutting machines which help them.

Environment problem in agricultural production will be bigger and bigger. We know production damages environment. We use plastic films to cover field. Machines helping to take back plastic films are on the market. We need more agricultural machines which protect environment.

Trend of Farm Machinery Production

Farm machine production of 1998 amount to ¥492,0 billion (20.1% a decrease of over the preceding year). It was the first time under ¥500.0 billion from 1975.

Production of the major farm machinery is as follows: Riding tractor 144,774 units decreased by 9.8% under the preceding year. Seeing by h.p., those under 20PS amounts to 52,693 units, 20-30PS 48,109 units, over 30PS 43,972 units. Only over 30PS class increasing the preceding year.

The production of walking tractor amounted to 212,551 units, which showed an decrease of 5.6% over the preceding year. Under 5PS was 128,826 units, over 5PS was 83,725 units.

The production of combine, which is next to the riding tractor is 40,196 units (a decrease of 29.1% over the preceding year). Main type is its harvesting wide is about 1 meter head feed type.

Following are the production of other types of farm machinery : rice transplanter amounted to 53,122 units (a decrease of 16.2% over the preceding year), binder (walking type harvesting machine for rice and wheat, barley, etc.) 8,361 units (a decrease of 42.6%), thresher 5,102 units (a decrease of 43.6%), grain dryer 32,968 units (a decrease of 41.8%), huller 28,113 units (a decrease of 50.6%), bush cleaner 1,012,372 units (an increase of 6.8%), power pest-controller 251,398 units (a decrease of 13.5%) so on (**Table 3**).

Trend of Farm Machinery Market

In Japan distribution systems for farm machinery is roughly divided into two major channels: the traders concerned and Agricultural Cooperatives Association. As of June 1997, the retail shops were recorded to about 8,800, the employees amounted to 45,000 persons , and the annual sales amounted to ¥1,265.9 billion (**Table 4**).

According to the governmental survey by Ministry of Agriculture, Forestry and Fisheries, the total sales of farm machinery by Agricultural Cooperative Association reached ¥342.4 billion in 1997 (¥415.7 billion in 1996)(**Table 5**). In

Table 3. Yearly Production of Farm Machinery

Unit: Number, Million Yen

Year	Farm machinery total		Riding type tractor		Walking type tractor		Rice trans planter		Power sprayer		Power duster		Blower sprayer	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1990	—	585,561	115,939	198,557	269,027	38,248	91,141	52,462	220,528	12,339	149,789	5,575	9,565	9,514
1991	—	615,131	148,437	203,260	270,714	40,102	87,019	54,265	198,887	10,607	163,306	6,155	9,318	12,766
1992	—	575,986	145,948	195,189	245,675	35,917	80,540	50,760	181,475	7,826	162,040	6,548	9,923	14,884
1993	—	588,627	146,115	186,983	225,564	33,738	84,980	58,344	165,909	6,899	134,901	5,985	8,559	12,155
1994	—	606,279	156,039	198,278	212,539	30,921	85,837	66,726	141,556	6,569	123,268	5,670	6,260	8,261
1995	—	649,874	153,890	205,489	205,758	28,271	86,713	69,218	161,360	7,370	129,995	6,293	7,018	11,622
1996	—	637,209	152,956	201,357	214,702	31,400	70,614	57,581	154,260	6,752	126,594	6,121	8,280	12,843
1997	—	615,974	160,518	219,446	225,229	31,803	63,367	53,236	172,034	7,776	110,736	5,278	7,799	10,223
1998	—	491,973	144,774	194,954	212,551	29,669	53,122	46,218	156,890	7,256	86,535	4,086	7,900	9,150
(1999)		508,300	155,900	216,300	264,800	34,700	55,000	41,000	151,000	7,300	72,000	3,300	7,400	9,000

Year	Grain reaper		Brush cutter		Power thresher		Grain combine		Rice husker		Dryer		Grain polisher	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1990	42,502	11,110	1,601,652	25,798	22,634	9,118	68,993	138,396	60,006	18,332	59,269	39,990	58,500	4,871
1991	37,782	9,542	1,657,897	27,117	20,337	7,898	72,913	152,827	60,690	19,124	57,747	43,250	57,625	5,243
1992	30,511	7,753	1,890,427	28,994	12,656	4,838	65,673	143,335	50,208	15,292	51,821	38,236	45,182	4,274
1993	27,286	7,173	1,588,837	27,339	11,663	4,562	65,192	149,867	41,664	14,129	56,079	44,224	40,368	3,844
1994	21,033	5,379	1,554,478	28,726	11,422	4,439	61,242	148,537	42,115	14,680	62,044	49,846	53,514	5,493
1995	27,562	7,484	1,471,192	27,731	12,422	4,751	66,767	162,329	56,792	21,178	67,700	56,215	56,590	6,755
1996	21,541	6,364	1,220,005	24,291	11,593	4,568	63,371	168,391	60,021	22,639	64,969	53,483	44,451	6,096
1997	15,027	4,283	948,178	21,071	9,042	3,542	56,709	152,627	56,887	21,434	56,647	46,529	42,391	5,148
1998	8,631	2,336	1,012,372	22,236	5,102	1,988	40,196	103,435	28,113	10,705	32,968	26,543	39,729	3,588
(1999)	11,000	3,200	1,100,000	24,800	4,900	1,900	40,600	107,200	30,000	11,700	36,000	29,700	36,500	2,700

Source: "Survey of Status of Machinery, Production" by the Ministry of International Trade and Industry. Data by Japan Agr. Machinery Manufactures' Assn. and Land Internal Combustion Engine Manufacturer's Assn.

Note: Data for 1999 are forecast by Farm Machinery Industrial Research Corp.

Table 4. Farm Equipment Distributor and Sales Value

Unit:Million yen

Year	Number of retailers (1)	Employes	Annual sales value (2)	Inventory	Square meters of shop m^2	Annual sales value (2)/(1)
1979.6	9,257	48,548	1,007,298	159,772	898,854	108.8
1982.6	10,084	49,081	1,018,983	164,269	1,005,546	101.0
1985.6	9,142	43,921	946,507	144,837	985,453	103.5
1988.6	9,444	45,952	1,015,304	159,798	923,726	107.5
1991.6	9,480	45,705	1,158,924	170,104	984,700	122.2
1994.6	8,838	43,112	1,128,087	166,298	978,788	127.6
1997.6	8,820	45,090	1,265,902	170,350	901,851	143.5

Source: Ministry of International Trade and Industry.

Table 5. Handling of Farm Equipment by Agricultural Cooperative Association (1996 Business Year)

Unit: Million yen

Business year	Total number of coops. surveyed	Purchase in this term	Of which purchased through affiliated organs	Amount of supply and handling
1990	3,591	349,521	268,763	375,660
1992	3,204	354,728	268,393	388,031
1994	2,669	378,660	281,625	417,474
1995	2,457	374,952	283,193	413,664
1996	2,331	374,334	279,070	415,691
1997	2,112	310,008	229,205	342,423

Source: "Statistics on Agricultural Cooperatives—1995 business.

1996 numbers of Agricultural Cooperative was about 2,112. Amount of dealing machines per Cooperatives was about ¥160 million.

About half of traders are small firm which employees are under 5. In a long time, it is important problem to improve management structure.

Export and Import of Farm Machinery

Export

In 1998 the exports of farm machinery amounted to ¥143.8 billion, which showed an increase of 10.4% over the preceding year. The ratio of exports to the total production amounts to ¥492.0 billion ended 29.2%.

Seeing by the shipments, ¥75.3 billion for North America (an increase of 21.2%) , ¥23.0 billion for Asia (a decrease of 17.1%), ¥32.4 billion for Europe (an increase of 32.2%). For North America, ¥71.1 billion was U.S.A., tractor 64,283 units, ¥59.5 billion, which is a major part **(Table 6)**.

As for the types of farm machinery, tractor was chiefly exported : 107,284 units were exported in 1998 (the total production was 144,774 units). It amounts to ¥81.1 billion. Seeing by horse power, those under 30PS amounted to 75,770 units, those from 30 to 50PS 24,165 units, those over 50PS 7,349 units.

Major farm machinery, next to tractor, is bush cleaner. The total exports were 1,117,153 units, ¥26.4 billion. The exports of other farm machinery are as follows: walking tractor 55,115 units; power sprayer 52,060 units; lawn mower 40,768 units; grass mower 20,068 units; chain saw 166,995 units, etc.

Import

In 1998 the imports of farm machinery amounted to \27.5 billion, which means a decrease of 16.8% over the preceding year.

Followings are the major imported farm machinery: tractors 2,196 units (those more than 70PS were 1,470 units of all the tractors); chain saw 42,909 units, lawn mower

Table 6. Export of Farm Equipment 1997

Unit: FOB million yen

Year	Unit	Value	Ratio	Major destinations
1990		132,757		
1991		129,943		
1992		143,891		
1993		124,505		
1994		120,079		
1995		104,597		
1996		113,586		
1997		130,351		
1998		143,843	100.0	U.S.A., Taiwan, Korea, France
Power tiller	55,115	3,403	2.4	France, Spain, Germany
Wheel tractor	107,248	81,054	56.3	U.S.A.
Seeder, Planter	2,147	1,430	1.0	Taiwan
Power sprayer	52,060	1,936	1.3	Taiwan, Korea
Duster	16,575	492	0.3	Korea, Taiwan, Mexico
Lawn mower	40,768	4,496	3.1	U.S.A., France
Brush cutter	1,117,153	26,369	18.3	France, U.S.A., Korea
Mower	20,068	504	0.4	Korea, Malaysia, U.S.A., Taiwan
Combine	2,412	7,765	5.4	Taiwan, China
Chain saw	166,995	3,715	2.6	U.S.A., France, Italy
Other	—	12,679	8.9	

Source: "Ministry of Finance. Totaled by Japan Farm Machinery Manufacturer's Assn.

Table 7. Import of Farm Equipment 1997

Unit: CIF million yen

Year	Unit	Value	Ratio	Exporters
1990		33,205		
1991		26,598		
1992		25,778		
1993		25,578		
1994		27,779		
1995		27,015		
1996		33,542		
1997		33,069		
1998		27,513	100.0	U.K., U.S.A., Germany
Wheel tractor	2,196	9,372	34.1	U.K., France, Italy
Pest control machine	2,604,425	1,684	6.1	China, U.S.A., Israel
Lawn mower	37,963	1,919	7.0	U.S.A., Sweden, Germany
Mower	1,586	914	3.3	France, Netherlands, Denmark
Hay making machine	988	751	2.7	France, Germany
Bayler	814	1,511	5.5	U.S.A., France, Denmark
Combine	69	1,121	4.1	Belgium, Germany, Australia
Chain saw	42,909	1,312	4.8	Germany, Sweden, U.S.A.
Other	—	8,929	32.0	

Source: "Ministry of Finance. Totaled by Japan Farm Machinery Manufacturer's Assn.

37,963 units, mower 5,917 units, fertilizer distributor 1,804 units. Tractors 936 units were imported from U.K. and 554 units from Italy **(Table 7)**.

Trend of Research and Experiment

The surroundings of Japanese agriculture are very hard, because of claims for opening the market for agricultural products by U.R. settlement, consumer's various favor, the decrease of the new farmers, being called for the contribution to solve the environmental problems. That's why the structural and technical reforms in Japanese agriculture are requested urgently.

Researchers are chiefly made for high performance, automatic and popularized farm machinery in order to reduce burden of farm working. Electronics and mechatronics are positively adopted for their technology. In 1993, the law promoting agriculture mechanization was revised. "Urgent Development Program" which is promoting the machine has a weak demand, but has a strong needs, is going ahead. As a result, one of them like vegetables grafting machine is on market. And in 1998, new "Urgent Development Program" including 27 types study has started.

In 1998, in the field of farm machinery, there were movement as follows ;

Tractor has developed auto-running systems, and a study of multifunction tractors and implement for slope grass field.

In rice production, direct sowing methods are vigorous. A lot of kind method are studying. Studies have been developing, and which are high dense type and long-mat type rice-planters.

In vegetable production, many planters and harvesting machines has been developing. Seeding machine in row and harvesters by image-handling technology has been developing.

In fruits production, study of fruit-tree planters and machines working in slope, fertilizer distributor, pest control machine and carrier studies have been developing. Sensors for fruit ripe and inner damage of fruits are developing.

In stock rising, seed-cube press machine and distributing machine and system supporting design for animal house have been developing. Management of each livestock, slurry disposal technology for environmental problem have been developing.

In sustainable agriculture, small weeding robot for paddy field has been developing. Technology of precision spreading of chemicals and fertilizer by sensing-date has been developing. ■■

JAICAE -at a glance-

(The Japan Association of International Commission of Agricultural Engineering)

by
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Japan

About JAICAE

JAICAE, founded in 1984, is a federation of societies of agricultural engineers, each one representing the engineering and scientific societies concerned with its special area accredited by Science Council of Japan.

The purpose of the Federation is to promote the science and technology of agricultural engineering in the broadest sense in all agricultural and food systems, whether, for example, engineering, physical, biological, social or economic, in both theory and application including the development.

JAICAE is also closely related to CIGR(International Commission of Agricultural Engineering). As CIGR is global organization, JAICAE may be noted as the Japanese branch of it.

Therefore JAICAE-activities are not only for the participating societies in domestic events but also for everyone in international events sponsored by CIGR, in agricultural engineering research, development and education.

Eleven societies are involved in promoting and developing the area of agricultural engineering by organizing joint technical symposium and so on.

How JAICAE can be reached

Through your local society, to become active in international events by CIGR.

To get any required address or additional information, please contact the

JAICAE Secretariat
c/o JSIDRE, Shinbashi 5-34-4, Minato-ku, Tokyo, 105-0004, Japan
TEL: +81-(0)3-3436-3418
FAX: +81-(0)3-3435-8494

How JAICAE's technical symposium is organized

JAICAE organizes the joint technical symposium on the day for annual General Assembly of 11-participating societies. The technical symposium is performed by the Council-meeting which has a coordinating function and is responsible for planning technical meetings and promoting the respective sub-areas of agricultural engineering.

What is JAICAE, what are its aims

The primary objective of JAICAE is to serve all those concerned with the theory and application of agricultural engineering, where ever situated. To further this aim, it maintains working relationships with other organizations, national or international, especially with other non-governmental professional federations.

JAICAE provides a framework for collaboration between those working in agricultural engineering and promotes free exchange of ideas and experts within its professional fields.

JAICAE does not become involved in any kind of political activity, nor does it take a position in any such issue. JAICAE does not take part in any commercial activity with the explicit aim to acquire financial gain.

JAICAE pursues its purpose by organizing technical symposium, by coordinating agricultural engineering, recently as to JABEE and by any other means consistent with its constitution and which will enhance the interchange and circulation of information on agricultural engineering activities.

Especially, JAICAE is organizing "The XIV Memorial CIGR World Congress 2000 sponsored by Science Council of Japan as well as by CIGR". Information on the activities appears on the JAICAE homepage: http://bee2.en.a.u-tokyo.ac.jp/cigr2000/, and in the CIGR Newsletter.

JAICAE closely cooperates with such other organizations as SCJ(Science Council of Japan), JFAS(Japan Federation of Agricultural Societies) and JFES(Japan Federation of Engineering Societies).

History of JAICAE

In 1984, JAICAE was re-constructed by seven societies relating to agricultural engineering, namely Japanese Society of Irrigation, Drainage and Reclamation Engineering (JSIDRE), Japanese Society of Agricultural Machinery (JSAM), The Society of Agricultural Meteorology of Japan (SAMJ), Japan Association of Agricultural Electrification (JAAE), Japanese Society of Environment Control in Biology (JSECB), Japanese Society of Farm Work Research (JSFWR), Society of Agricultural Structures of Japan (SASJ). Prof. K. Shirai was elected as the first president of JAICAE.

In 1990, Association of Rural Planning (ARP) was accepted to join JAICAE.

In 1996, Japanese Society of Closed Environmental Life Support Systems (CELSS) and Japanese Society of High Technology in Agriculture (SHITA) were invited to join JAICAE for the preparation of CIGR World Congress 2000 in Japan.

In 1997, Japanese Society of Agricultural Informatics(JSAI) was also accepted to join JAICAE. Now(in 2000), JAICAE is the federation of eleven societies relating to agricultural engineering in Japan, its population becomes over 20,000 engineers.

JAICAE has seven Presidents since 1984.

Prof. Kiyotsune Shirai (JSIDRE) : 1984-1986
Prof. Seiji Sudo(JSIDRE) : 1986-1988
Prof. Nutsumu Kadoya(JSIDRE) : 1988-1990
Prof. Syoitiro Nakagawa(JSIDRE) : 1990-1992
Prof. Fumihiko SanoJSAM) : 1992-1994
Prof. Toshio Tabuchi(JSIDRE) : 1994-1997

The 7th President, Prof. Yasushi Hashimoto(SHITA & JSAI) was elected by the General Assembly in 1997 for the 1997-2000 term of office.

The JAICAE Secretariat has a permanent home. By invitation of the JSIDRE it has been situated in the office of JSIDRE:

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TWO-WHEEL TRACTOR ENGINEERING
for Asian Wet Land Farming

by Jun Sakai
Professor emeritus of Kyushu University , Co-operating Editors of AMA

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Introduction to the School of Biology-Oriented Science and Technology, Department of Intelligent Mechanics and Automation Laboratory, Kinki University

by
Minoru Yamazaki
Professor Department of Intelligent Mechanics
School of Biology-Oriented Science and Technology,
Kinki University
Former President of Japanese Society of Agricultural Machinery
Japan

Outline of Kinki University

Kinki University is one of the largest private universities in Japan consisting of 10 schools , 42 departments and many research institutes and facilities having the history of over seventy years. The university is well known for its blend of academic and practical excellance embracing future-oriented and progressive features. The main campus is located at Higashi Osaka city, but two Schools of Engineering are located in Hiroshoma and Fukuoka prefectures, School of Agriculture in Nara prefecture and our School of Biology-Oriented Science and Technology in Wakayama prefecture. The ten schools are as follows. School of Law, School of Commerce and Economics, School of Science and Engineering, School of Pharmacy, School of Literature, School of Agriculture, School of Medicine, School of Biology-Oriented Science and Technology, Hiroshima School of Engineering and Kyushu School of Engineering. School of Biology-Oriented Science and Technology The school was established in 1993 as a frontier research and education centre in Wakayama prefecture near Kansai International Airport and one hour drive from Osaka. It stands on a hill with a fine view of mountains and the famous river Kinokawa. Its distinctive feature is to create sustainable technologies by applying a bio-science. We are thinking scientifically the wonderfulness and strangeness of living things and applying their elaborate mechanisms to practical technologies. It consists of the following five departments ; Biotechnological Science, Electronic System and Information, Intelligent Mechanics, Genetic Engineering and Mechanical Engineering. As to the graduate school, we have the first-term doctoral program(master's degree) of Biotechnological Science, Electronic System and Information and Intelligent Mechanics, and the second-term doctoral program of Biotechnological Science and Electronic System and Information. As our school was founded just several years before, completion of the graduate school will be performed in the near future. The number of students enrolled in the school is 1800 in round numbers.

Fig. 1 Location of Kinki Univercity

Fig. 2(a) Picture of the Campus.

Fig. 2(b) Around the Campus.

Department of Intelligent Mechanics

The technologies of human beings have been developed via mechanical engineering. A new intelligent high precision mechanical engineering, or intelligent mechanics which combines the mechanisms of the past with control engineering, electronics and computer engineering has come into being. This is the field of " mechatronics " which combines mechanics and electronics. The department of Intelligent mechnics pursues mechtronics and also technologies which organically integrate biomimetics technologies which mimic the advanced functions of organisms. In order to achieve this, we give not only courses in conventional mechanical control engineering but also interdisciplinary lectures on micromechanics relating to medical engineering and tribology which focus on the structure of living body. The department has seven research laboratories ; control, information processing, robotics, precision measurement, automation, sesors and computer aided design. We advocate " education by practical and hands-on training " in addition to theory.

Automation Laboratory

There are two researchers in this laboratory. Professor Dr. M.Yamazaki from Kyoto University succeeded to Professor Dr. R. Yamashita who retired in March, 1999, and Instructor Dr. Itoh. The research subjects of this laboratory are related to automation of bioproduction system, plant growth control (Dr. Itoh). In addition to them, Professor Yamazaki is studying on full biomass fuels life assessment. We have only the first-term doctoral program and hope to have the second-term doctoral program in the near future. ■■

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E-mail:sinnorin@blue.ocn.ne.jp URL:http://www.shin-norin.co.jp

Main Production of Agricultural Machinery Manufactures in Japan

by
Shin-Norinsha Co., Ltd.
7,2-chome, Kanda Nishikicho, Chiyoda-ku, Tokyo, 101-0054 Japan

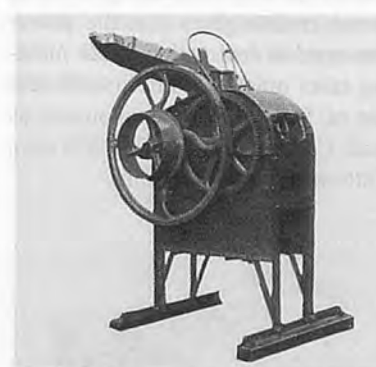
Introduced here are the main products of agricultural machinery manufactures in Japan with a number of photographs.

The products are developed and improved for both foreign and domestic markers. For further information please refer to the manufactures contained in the directory.

ARIMITSU Knapsack Power Duster Model SG-7030. Light-weight, compact design, but ensuring to produce bigger air volume due to high performance turbo-fan be driven by the powerful 60CC gasoline engine. Chemical tank can be quickly mounted or detached by menas of the lock or release lever. Size (L × W × H): 360Å~520Å~740mm, weight: 10.5kg, Max. output:3.7ps/7500rpm, Chemical tank capacity:28*l*, AIr volume: $140m^3$/min, Max. static pressure: 990 mm AQ.

BUNMEI Sugarcane Harvester Riding Type TK-5 Crop deviders equipped both sides raise fallen cane and give harvesting.

DAISHIN Portable Generator SGB4000HX. Brushless generator; Non-fuse breaker; Quiet operation; AC volage: (50Hz); (60Hz) Max.Output: (50Hz)3.6kVA (60Hz)4.5kVA.Engine: Air-cooled, 4-cycle,gasoline 5.2PS, 6.2HP;Dry weight 65kg.



CHIKUMA Corn Sheller Type3. Removes kernels from corn-cobs by a short time. Capacity: 750-1, 125kg/h, Power r'd: 1-2 PS, R.P.M.: 300-500, Size in mm: 1,015H × 575W × 1,010L, Weight: Net 90kg Gross 130kg, Shipping mess.: 18cft.

ISEKI TF325 Tractor. Mounted with powerful and economical 25PS water cooled diesel engine. The tractor offers wide range of travelling speeds from approximately 2 km/h to 22 km/h, which offers broad operating application and safe road travelling.

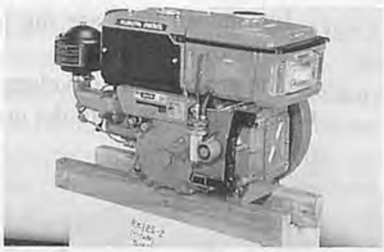
ISEKI SF300 Mower. The 28 hp diesel engine gives you the power you need to deal with all your mowing tasks quickly, while its efficient use of fuel makes it economical as well. Cutting width: 1524/1830 mm, Cutting height: 30-120mm.

ISEKI Multi-Purpose Tiller KV700D. Four-cycle/direct injection/6PS engine allows heavy-duty operation at low speeds with ample power in reserve. Light, Compact, Easy to use and high performance.

KIORITZ Battery-powered U.L.V.Sprayer(Shoulder type)ESD-5. A compact and lightweight battery-powered U.L.V. Sprayer providing easy portability combined with high performance. It is designed for use in environmental hygiene control such as malaria prevention, etc. in addition to general-purpose applications. Operates on six 1.5V batteries. A rechargeable battery pack can also be used.

KUBOTA Grand L Series Tractors. Built to handle a variety of agricultural applications, including field operations, heavy-duty front loader work. E-TVCS (Three Vortex Combustion System) Diesel Engine delivers more power and a high torque with cleaner emissions. In the GST (Glide Shift Transmission) models, the New GST features clutchless operation "shift-on-the-go" with faster response time and less power loss.

KUBOTA Combine Harvester SKY ROAD PRO 481. Easy to operate, micro-computerized 4-line combine harvester that cuts down on time as well as crops. Equipped with many helpful mechanisms and a reliable water-cooled diesel engine. Max. output: 48PS/ 27000 rpm.



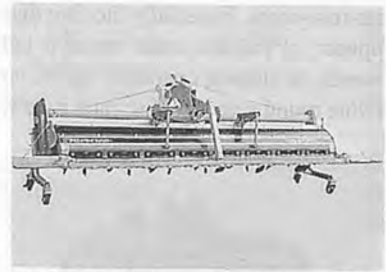
KUBOTA Diesel Engine RK 125. Based on Kubota's advanced engine technology, the horizontal, water-cooled and 4-cycle diesel engine can provide full-bore power with less fuel consumption, higher output, and quick and smooth starting. For power tillers, tractors, pumps, generators, welders and other farm and industrial used. Max. output: 12.5 HP/2400 rpm.

MAMETORA Vegetable Transplanter TP-4. This machine is available in both pot and soil block in seeding transplanting. Application: all vegetable nursery.

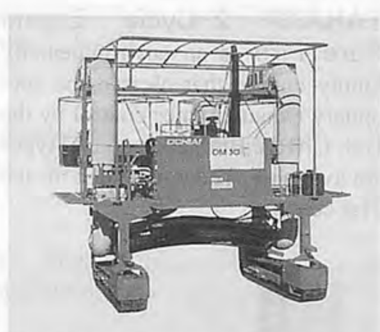
MAMETORA Power Cultivator SRV4F. Wide range use: cultivation to riding, Mounted with 7 PS engine.

MARUYAMA Portable Power Sprayers MSO55D. Engine: Air-cooled, 2-cycle, output 22.6cc, Pump: Suction capacity 5.1l/mm, max pressure 25 kg/cm^2, Weight: 8.5 kg.

MINORU 4-Row Onion Transplanter OP-41. Used for potted mature seeding. Seeding box can be directly put on the transplanter. Saving the labor and total cost. Measurement (mm): L-2720, W-1095, H-1150. Weight: 355kg(body only). Engine output(PS/rpm): 2.7/3,600;max. 3.5/4,000. Wheels: drum type × 2



NIPRO Drive Harrow HR-2408B-3S for paddy field. Working width: 244 cm; Required tractor horsepower: 24-40HP.

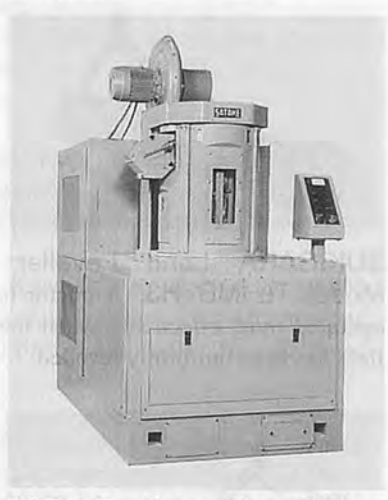


OCHIAI Riding Type Tea Picking Machine OM-30. Full working width cutter bar. Stepless speed control. Water-cooled Diesel engine 28.5PS

OREC Power Cultivator AR700. Wide range use: Cultivation to riding. Mounted with 7 PS ~ 7.5PS engine.

ROBIN Brush Cutter Model BF2100(AU). 2 cylinder engine (20cc) makes the lightest model in the wolrd and comfortable (low noise and vibration). Rotational speed of blade 4000-6000rpm.

SASAKI Fertilizer Spreader BF-300. The lever type action controls the amount of application with high accuracy. Application width: 10-12m. Hopper capacity: 300l. Required tractor horsepower: 20-50PS.



SATAKE New Rice Whiteness,Abrasive and Friction types, have higy recovery, uniform & gentle milling, less installation space and high capacity. Model:VRM8A(Abrasive type) & VMA8A (Friction type) Capacity: 8 to 10 mt/h brown rice.

SHIZUOKA's Single Kernel Moisture Tester CTR-800E for rough rice, brow rice, wheat and barley.

STAR Mini-Roll Baler MRB 0840. Automatic pick-up, rolling and ejection. One bale every 30 seconds, Handy bale size (50cm in diameter and 70cm long). Required tractor horsepower: 18-30 HP.

SUKIGARA Land Leveller-Model TL-MB/H3. A tractor is operated most effectively when the field has been uniformly levelled.

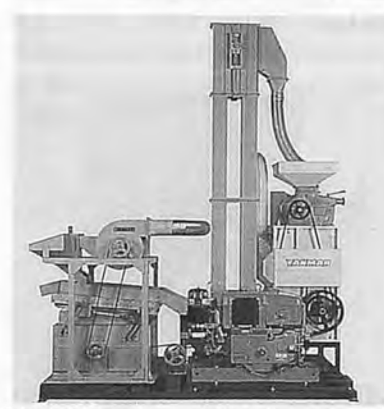
SUKIGARA Triple Row Ridger with Disc Opener is designed for use on tall weeds to be made remove inter-row-crops. Especially the fore disc opener of ridgers make remove tall weeds, so ridging operation easier, no twine round weeds to tines and ridges.

TANAKA 2-Cycle Engine Pure Fire is an environmentally kindly engine that cleared the secondary exhaust fumes control by the U.S. CARB. Both 26cc and 42 types are available. The engine just for the 21st century.

TIGER KAWASHIMA Rice Combi and Grader. Rice grading machine and automatic weighting and packing.

YAMAMOTO Rice WhitenerRicepal Series Model VP31T. High recovery rate. Immatured rice can be milled. No remaining rice in the machine. Easy-to-change milling screen. Durable construction. Milling system: vertical type single pass, Size (H × W × L): 850 × 330 × 450mm, Weight: 24kg, Power required: 0.3kW, Electric mains: single phase 100V (50/60Hz), Capacity: 30kg/h, Rpm:1440/1730, Hopper holding capacity: 15kg, Safety device: Circuit protection.

YANMAR Diesel Tractor F-ex Series. 5 models: 21ps, 28ps, 32ps, 37ps, 42ps. Compact, quiet and vibration-reduced diesel engines are mounted at the heart of these F-ex series tractors. Engine: vertical, 4-cycle, water-cooled. Transmission: gear shifting. F8 × R8 or F9 × R9 Drive system. 4-wheel drive.



YANMAR New Mill Mate YMS-650U. Cleaner/destoner + Huller & Polisher + Engine. Input cap: 800kg/h, Engine 23ps. This machine is a complete direct-through rice mill consisting of a hulling section, winnower and polishing section. ■■

DIRECTORY

Arimitsu	Arimitsu Industrial Co., Ltd.—3-7, Fukae-kita 1-chome, Higashinari-ku,Osaka, 537-0001. Tel. 06-6973-2010
Bunmei	Bunmei Noki Co., Ltd—11-4, 1-choe, Korimoto-cho, Kagoshima-city, 890-0065. Tel. 0992-54-5121
Chikuma	Chikumasuki Co., Ltd.—356 Koya, Yoshikawa, Matumoto-city, Nagano-pref., 399-0031. Tel. 0263-58-2055
Daishin	Daishin Industries, Ltd.—23-1, 3-chome Yoyatus-cho, Ogaki-city, 503-0858. Tel. 0584-75-7600
Iseki	Iseke & Co., Ltd.—3-14, Nishi-Nippori, 5-chome, Arakawa-ku, Tokyo 116-0013. Tel. 03-5604-7600
Kioritz	Kioritz Corporation—7-2, Suehirocho 1-chome, Oume-city, Tokyo, 198-0025. Tel. 0428-32-6118
Kubota	Kubota Corporation—2-47, Shikitsuhigashi 1-chome, Naniwa-ku, Osaka, 556-0012. Tel. 06-6648-2111
Mametora	Mametora Agric. Machinery Co., Ltd.—9-37, 2-chome, Nishi, Okegawa-city, Saitama-pref., 363-0017. Tel. 048-771-1181
Mayuyama	Maruyama Mfg. Co., Inc.—4-15, 3-chome., Uchi-kanda, Chiyoda-ku, Tokyo, 101-0047. Tel. 03-3252-2271
Minoru	Minoru Industrial Co., Ltd.—447, Shimoichi, Sanyo-cho, Akaiwa-gun, Okayama-pref., 709-0816. Tel. 08695-5-1122
Niplo	Matsuyama Plow Mfg. Co., Ltd.—5155, Shiokawa, Maruko-machi, Chiisagata-gun, Nagano-pref., 386-0401. Tel. 0268-42-7500
Ochiai	Ochiai-Shoji Co., Ltd.—58, Nishikata, Kikugawa-cho, Ogasa-gun, Shizuoka-pref., 439-0037. Tel. 0537-36-2161
OREC	Orec Co., Ltd.—548-22, Hiyoshi, Hirokawa-machi, Yame-gun, Fukuoka-pref., 834-0111. Tel. 0943-32-5002
Robin	Fuji Robin Industries Ltd.—35, Ohoka, Numazu-city, Shizuoka-pref., 410-0022. Tel. 0559-63-1111
Sasaki	Sasaki Corp. Ltd.—1-259, Satonosawa, Towada-city, Aomore-pref., 034-0000. Tel. 0176-22-31111
Satake	ISatake Corp.—7-2, Soto-kanda 4-chome, Chiyoda-ku, Tokyo,101-0021. Tel. 03-3253-3111
Shizuoka	Shizuoka Seiki Co., Ltd.—4-1, Yamana-cho, Fukuroi-city, Sizuoka-pref., 437-0042. Tel. 0538-42-3111
Star	Satr Farm Machinery Mfg. Co., Ltd.—1061-2, Kamiosatsu, Chitose-city, Hokkaido, 066-0077. Tel. 0123-26-1122
Sukigara	Sukigara Agiricultural Machinery Co., Ltd.—38, Sairinji, Yahagi-cho, Okazaki-city, Aichi-pref., 444-0943. Tel. 0564-31-2107
Tanaka	Tanaka Kyogyo Co., Ltd.—3-4-29, TsudanumaYatu, Narashino-city Chiba-pref., 273-0047 Tel. 047-438-4411
Tiger	Tiger Kawashima Co., Ltd.—4290, Fujioka, Fujioka-cho, Shimottsuga-gun, Tochigi-pref., 323-1104 Tel. 0282-62-3001
Yamamoto	Yamato Co., Ltd.—404, Oinomori, Tendo-city, Yamagata-pref., 994-0013. Tel. 0236-53-3411
Yanmar	Yanmar Agricultural Equipment Co., Ltd. —1-32, Chaya-machi, Kita-ku, Osaka-city, 530-0013. Tel. 06-6376-6336

■■

Rational Use of Renewable Energy Sources in Agriculture

April 9-15,2000
Budapest, Hungary

This Conference is organized by the Hungarian Electrotechnical Association, in cooperation with the 4th Section of CIGR and the Hungarian Society of Agricultural-Sciences, in the year of the 1000th' Anniversary of the foundation of the kingdom of Hungary, the 1OOth Anniversary of the Hungarian Electrotechnical Association and the 70th Anniversary of CIGR.

The First Announcement aroused great interest. Until now more, than130 experts announced their participation from 35 countries.

Scope:

The purpose of the Conference is to exchange experiences of the economical use of regenerative energy sources for production of heat and electricity in the agriculture, regarding the environmental effects. Energy saving technologies will also have a special position in the programme.

Topics of The Conference:

- Regenerative energy sources for developed countries, economic use.
- Regenerative energy sources for deveiopping countries, economic use.
- New role of the use of heat-pumps in the agriculture.
- Use of every form of biomass in the agriculture.
- Energy saving technologies in connection of the regenerative energy sources.

Location:

The Conference will be held in the House of Technics.

Budapest V., Kossuth Lajos ter 6-8. I. floor 135.

Study Tours:

One-day study tour will be organized to an agricultural farm with energy forest, to the town Tata with biomass heating and touristic scenerie, to the Camalduly-monastery, and to a vine-cellar. In case of enough applicants a two-day study tour will be organized after the Conference to the scenic town Sarospatak with renewable energy source-applications, with the famous castle and other touristic sceneries. Participation fee will be USD 120, board and lodging for the night 14/15 April included.

Programme for Accompanying Persons:

Special interesting programmes will be organized for accompanying persons. Participation fee is USD 140, in which the Welcome Party, the cultural programme and the one-day study tour are induced. We request you to remit the fees

- by bank transfer to the ABN AMRO Bank, account nr: 10200823-22212357-00000000 with indication RAE/CIGR 2000 Conference. Address of the Bank: 1054 Budapest, Arany J. u. 24.

or: - by international money order in favour of RAE/CIGR Conference sent to the Conference Secretariat of the Hungarian Electrotechnical Association, H-1055 Budapest, Kossuth L. ter 6-8.

Please, bring the copy of your remittance for the registration with you. In case of cancellation after 1"' March 2000 25% of the registration fee will be retained covering the organizing costs.

Preliminary Programme:

9. April, 15.00-18.00 Information and registration
10. April, 8.00-17.00 Registration
 9.00 Opening Session
 10.00-18.00 Working Sessions
 19.30 Welcome Party
11. April, 8.30-17.00 Working Sessions
 15.00-17.00 FAO Working Group Session Solar and other decentralized energy sources
 19.00 Cultural Programm
12. April, 8.30-15.00 Working Sessions
 15.30 Closing Meeting
13. April ,8.00-20.00 One-day Study Tour

14-15 April, 8.00- Two-days Study Tour

Correspondent Address:

Conference Secretariat of the Hungarian Electrotechnical Association(MEE) H-1372 Budapest, Pf. 451. Tel.: +36 1 353 0117, 36 1 312 0662, Fax: +36 1 353 4069, E-mail: asboth.mee@mtesz.hu

1999 World Food Prized Awarded to Britishi Veterinarian

John Ruan and John Ruan III awarded the 1999 World Food Prize to Dr. Waiter Plowright on Thursday, October 14, before a packed house at Hoyt Sherman Place in Des Moines, Iowa. Also participating in the award ceremony were Nobel Laureate Dr. Norman Borlaug and Elizabeth Dole, both members of the Council of Advisors to the World Food Prize. A closing tribute was offered by the British Consul General, Robert Culshaw.

☆ ★ ☆

NEWS

Miillennium International Conference Onrenevvable Energy

February 9-11,2000
Tamil Nadu, India

Need, Objectives & Scope:

Twentieth century has witnessed the emergence and wide acceptance of Solar, Wind, Biomass and other Renewable Energy Technologies (RETs) as reliable means to bridge the gap between the mounting global energy demand and the dwindling supply of finite conventional energy sources. The popular awakening regarding a cleaner environment at the global level further boosted the development of technologies for utilising the widely available and the almost inexhaustible renewable energy sources. The different sectors of energy consumption have adopted them with varying degree of success. In particular, the industrial sector has developed enough confidence in employing RETs for energy conservation, which is an important component of overall energy management. However, the real benefits of these RETs have remained in accessible to large sections of the global population because of the uncompromising economics of harnessing them for large scale application. Consequently, international efforts are now centred on maximising the efficiency and minimising the cost of RETs

Conference Topics:

1. Active Solar Thermal and Photovoltaic Technologies - status, upgradation and large scale commercialisation.
2. Wind Power Technology - recent trends, operational and maintenance issues.
3. Bio-mass - potential, ;utilisation technologies and techno-commercial aspects.
4. Integrated Renewable Energy Systems - perspectives and issues.
5. RET for Energy Conservation.
6. RET options for Food Processing Industries.
7. RET and Rural poverty alleviation.
8. Environmental aspects of RET.
9. Policies, financing and commercialisation of RET.
10. Case studies and success stories in RET.

Address

All correspondence related to registration,Exhibition, etc., should be addressed to:

Dr.C.Palaniappan, Organising Secretary, "Millennium Conference on Renewable Energy Technologies" Planters Energy Network,

171/2,M.K.University Road, Raj ambadi, Madurai- 625 021. INDIA.

Tel:0091-452-858607/ 856020.

Fax:0091 -452-858607/856020/ 742886.

E-mail :pen@vsnl.com

Pen @md3vsnl.net.in

A new leadership group was elected last July for administrate the SBEA

President: Dr. Irenilza de Alencar Nääs, UNICAMP,SP

Vice-president : Dr. Evandro C. Mantovani, EMBRAPA, MG

Executive Board Director: Dr. Luiz Carlos Pavani, UNESP, SP

Brazilian Society of Agricultural Engineering (SBEA) is an independent and a non-profit organization with the main objective to promote interaction among professionals working in the scientific and technological fields related to agricultural engineering, as well as, to transfer knowledge in the fields of engineering applied to agricultural problems. A scientific journal **"Revista Engenharia Agricola"** is edited by the Society to publish the research results in the following subjects: Agricultural Construction and Environment; Energy in Agriculture; Soil and Water Engineering; Machinery and Agricultural Mechanization; Post-Harvest Science and Technology; Surveying, Aerial-Photography and Remote Sensing; Teaching, Research and Extension and, Professional Politics. Today we are 800 affiliates, which are professors, researchers, and technicians from public and private organizations.

One of the main goals of this new presidency is to strengthen international cooperation among other Societies all over the world; among agricultural research institutes as well as to participate in discussion groups, in order to provide the affiliates with updated information in most fields related to agricultural engineering, and to act as a link for improving the relationship between organizations. For more information SBEA headquarter by e-mail : sbea.jab@netsite.com.br

Agro-Foodtech China, International Exhibtion For Agriculture, Animal Breeding, Food Processing & PackagIng

April 11-14, 2000
Beijing, China

The one event that all Chinese professionals in the Agri-Food industry attend - from animal breeders and individual farmers to State operated farms - from distant provinces to the major farming and breeding regions.

One destination gives you access

to the entire Chinese Agri-Food Industry

SIAL, the world's leading exhibitions for food products in Paris, Buenos Aires and Singapore organizes, the first SIAL China at the same time as Agro-Foodtech China, April 11-14, 2000 in Beijing.

This pairing will enable a perfect synergy, allowing exhibitors and visitors to optimize their participation in both exhibitions, arid create business links between international and Chinese exhibitors.

Market Update

Farming and breeding of livestock/Poultry continue to be inseparable industries in China's strategy and policy for development:

- Small family farms with livestock are rapidly growing. Fifty percent of China's food supply is produced by small farming households.
- Industrially bred swine and poultry are developing sectors. Their growth is closely tied to China's animal feed industry.
- Sheep and bovine farming are both witnessing rapid development. More and more, these operations are making the logical migration towards animal feed producing zones and leaving in their place additional land for grains and cereals for human consumption.

Exposium China

Eucimal, Beijing office Sulta 710, Union Place #20 Chooyangmenwai Dojie Beijing 100020 P.R. China
Tel:(+86-10)6587 2510/2511
Fax:(+86-10)6587 2512

Exposium France

1,Ave du Poic F-92593 Levallois- Perret Codex
Tel:+33(0)14768-5281
Fax:+33(0)147377233
E-mail:agro-foodtech@exposium.fr

6fh International Symposium On Fruit, Nut, And Vegetable Production Engineering

September 11-14,2001
Potsdam, Land Brandenburg, Federal Republic of Germany

THE SYMPOSIM

The sixth International Symposium on Fruit, Nut, and Vegetable Production Engineering will take place in the Federal Republic of Germany (Potsdam). Prior Symposiums were held in Israel (Bet Dagan) in 1983;France (Paris) in1988; Denmark, Sweden and Norway in 1991; Spain (Valencia-Zaragoza) in 1993, and U.S.A. (California) in 1997.

Potsdam, the capital of Land Brandenburg, is situated in the former GDR. It is about 40 km from Potsdam to the centre of Berlin. Potsdam is the Town of the Prussian King Frederic II and is included with it's landscape and palaces on UNESCO' S world cultural heritage list since1991.During the symposium guided tours to Potsdam and to Berlin will be arranged. Additionally a Post-Symposium Technical Tour is planned.

OBJECTIVES AND TOPICS

The objective of the Symposium of Fruit, Nut, and Vegetable Production Engineering is to bring together researchers involved in all aspects of engineering for the production of fruit, nut, and vegetable crops including post-harvest aspects. Presentations will be held in the following areas:

- Cultural systems
- Harvesting methods and systems
- Post harvest operations
- Human and environmental factors

SECOND ANNOUNCEMENT

Mid of 2000 Call for papers

LANGUAGE

The official language of the symposium will be English.

ADRESS

Institute of Agricultural Engineering Max-Eyth-Allee 100
D-14469 Potsdam Germany
Tel: 0049 331 5699 O
Fax: 0049 331 5699 849
e-mail: atb@atb-potsdam.de
Home page wifl be installed for the symposium:
http://www.atb-potsdam.de/kolloquien/index.html

Agricontrol 2000 International Conference on Modeling and Control in Agriculture, Horticulture and Post-Harvest Processing

July 10-12,2001
Wageningen, Netherlands

Scope

Production of food and other agriculturalproducts in the next millennium will rely more than ever on innovative new technologies and novel high-tech systems. Primary production and post-harvest processing will see a further penetration of modeling, advanced control and artificial intelligence techniques in order to meet demands of quality, scale, economy and ecology. The conference aims at creating an atmosphere for fruitful exchange of challenging ideas. Scientists and practitioners are invited to present the state-of-the-art of control and modelling applications in agriculture, horticulture and post-harvest processing. Contributions that stress generic concepts of wide applicability are particularly welcomed.

The following non-exclusive list gives ideas of the various themes for which contributions are solicited:

Application fields

- Greenhouse technology, e.g. climate control, hydroponics systems
- Control issues of precision farming, e.g. site specific operations, positioning, guidance
- Animal husbandry, e.g. climate control, identification tags
- Post-harvesting technology, e.g. drying system and control, storage systems

Information

http://www.aenf.wau.nl/conf2000

For further queries and all correspondence:

Congress Office
Wageningen Agricultural Univ., Costerweg 50, 6701 BH Wageningen, The Netherlands
Fax:+31-317-485309/484884
E-mail:
Joost.Meulenbroek@alg.vl.wau.nl

International Conference on Agricultural Machinery Engineering

November 13-16,2000
Seoul, Korea

The third International Conference on Agricultural Machinery Engineering(ICAME 2000) is being organized by the Korean Society for Agricultural Machinery, and sponsored by the Ministry of Agriculture and Forestry, Republic of Korea. ICAME 2000 will bring together engineers, researchers, managers, and other professionals in the fields of agricultural machinery and process engineering to exchange technological information for the 21st century.

Web Site & E-mail

http://ksam.snu.ac.kr/icame.htm
noh@snu.ac.kr
Fax:+82-331-294-1815 ■■

Finder System for Agricultural Engineering Publications Updated

A computerized index of technical articles appearing in 13 agricultural engineering periodicals, including Agricultural Mechaniaation in Asia, Africa and Latin Americal(since its beginning in 1971, has been updated through the end of 1998.

The index database comes with its own MS-DOS-based search engine, which is linked to an icon automatically placed on the Windows-95, -98 or -NT desktop Start panel upon index installation.

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

1. Connect Your Internet browser to the URL: http://asae.org, scroll down to "Publications" and click, then scroll down to "AE-INDEX" and click again to find.EXE. Next, click on AE-NDX99.EXE to download this file.
2. Connect your Internet browser to the URL: http://www.engr.ucdavis.edu/~bae/Outreach/aeindex.html to down load the (1.5 Mbyte) file, AE-NDX99.EXE.
3. Use File Transfer Protocol (FTP) from SWEETPEA.ENGR.UCDAVIS.EDU (or 128.120.65.61 for those wishing to use the IP address). Give as a User name: anonymous, and as a Password: guest. Before "getting" ae-ndx99.exe, first type: binary (enter).
4. Mail two (2) formatted (IBM Compatible) 1.44 Mbyte, 3 1/2-inch diskettes to:

W. J. Chancellor Biological and Agricultural Engineering Department University of California Davis, CA 95616-5294, USA

The file, AE-NDX99.EXE, (in two parts) will be transferred to the diskettes, and they will be returned to the sender by airmail.

The file, AE-NDX99.EXE, should be placed on a hard disk drive in a subdirectory (folder) by itself. Then, typing (or Running) AE-NDX99 (enter) followed by typing (or Running) HOW2LOAD (enter) will provide instructions for manual or automatic installation.

Those who have access to the Internet may search on-line an expanded agricultural engineering finder system index by TELNETing to SWEETPEA.ENGR.UCCTDAVIS.EDU (or 128.120.65.61), and when the prompt: "Username:" appears, type: SEARCH (enter), No password is required, and there is no charge.

W. J. Chancellor
wjchancellor@ucdavis.edu

BOOK REVIEW

Handbook of Functional Plant Ecology
(USA)

By Francisco I. Pugnaire, Fernando Valladares

A uniquely comprehensive treatment of its subject, the Handbook of Functional Plant Ecology offers the latest findings and research breakthroughs in plant ecology, as well as consideration of classic topics in environmental science and ecology. This wide-ranging compendium serves as an extremely accessible and useful resource for relative newcomers to the field as well as seasoned experts.

The Handbook of Functional Plant Ecology explores functional aspects of plant architecture...discusses plant ecophysiology... examines physiological responses and adaptation to environmental fluctuations and perturbations... compares interactions among co-occurring plants... illuminates factors affecting biodiversity... and more.

A superb general reference written by an international group of acclaimed scholars, and including over 2700 literature citations, the Handbook of Functional Plant Ecology is an excellent resource for plant ecologists, botanists, plant biologists and physiologists, foresters, and evolutionary biologist.

901 pages

Published by MARCEL DEKKER, Inc.

WWW: http://www.dekker.com

Controlled-Release Delivery Systems for Pesticides
(USA)

By Herbert B. Scher

This useful reference comprehensively covers the latest advances in pesticide delivery technologies — highlighting new means of reducing toxicity, increasing efficacy, lessening environmental impact, and facilitating new product development.

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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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Studies on Some Physical Properties of Grains: Dr. Yumnam Jekendra, Associate Professor, Dept., of Agric. Engg. College of Agriculture, Cenrtal Agricultural University, Iroisemba, Imphal-7950001, India

Experiments were conducted to determine bulk density, porosity, co-efficient of friction and angle of repose of paddy, wheat, maize, sorghum, blackgram and sunflower. The bulk density and porosity of grains decreased with the increase in moisture content and non-linear. Glass surface was found to have minimum co-efficient of friction followed by galvanized iron, aluminium and plywood sheets for all the grains studies. The maximum angles of repose were as follows: sorghum, followed by maize, paddy, blackgram, sunflower and wheat.

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Optimum Process Parameters for Polyurethane Rollers in Paddy Dehusking: K.P. Sudheer, Research Scholar, Indian Agricultural Research Institute, New Delhi, India, R. Viswanathan, Assistant Professor, Tamil Nadu Rice Research Institute, Abuthurai-612101, India

Polyurethane test pieces were made by mixing polyol and isocyanate at various proportions and curing durations. The shore A hardness, abrasion resistance, tensile strength and percent elongation at break were determined for the test pieces. The required levels of these properties suitable for use in paddy dehusking were obtained as 90° A, 0.13 cc per 40 m, 96MPa and 197.6 percent at polyol-isocyante proportion of 100:55 cured for 3 hours at 90 ± 2 ℃

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Performance of Polyurethane Rollers in Paddy Dehusking: K.P. Sudheer, Research Scholar, Indian Agriculural Research Institute, New Delhi, 110012, India, R. Viswanathan, Assistant Professor, Tamil Nadu Rice Research Institute, Abuthurai-612101, India

Thermoplastic polyurethane rollers of castable grade were obtained by mixing polyol and isocyanate at 100:55 proportion and cured at 90±2 ℃for 3 h duration. The rollers were evaluated in a laboratory model of Satake rubber roller/sheller of 300 to 500 kg/h capacity for the shelling performance at 10, 12, 14; and 16% moisture content of paddy; speed ratios of 0.21, 0.24, 0.28; and 0.32 and clearance ratios of 0.2, 0.3, 0.4 and 0.5 with raw and parboiled paddy of ADT 36 variety. The shelling performance of polyurethane rollers was similar to that of the rubber rollers. The result of analysis for the toxicity of cyanate and cyanide in the shelled rice was negative.

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Noise Distribution Pattern Around Power Tiller and Its Effect on The Operator : Dr.K.Kathirvel Assistant Professor, College of Agrl. Engg. TNAU, Coimbatore T.V.Job and R.Manian Professor, College of Agrl. Engg.TNAU, Coimbatore, India

An experiment was carried to study the noise level of different makes of power tillers at their rated rev/min by using an integrating sound-level meter. The noise level was measured for the power tiller up to a distance of 20 m from the centre in horizontal plane and up to a distance of 1.5 m in the vertical plane. The acoustic contour maps were drawn and the noise-distribution pattern of each power tiller was analysed. The maps of all the 3 power tillers showed uniform noise-level distribution in all the directions except near the silencer where the noise intensity was high. The influence of noise in limiting the exposure time of the operator for power tiller operation was also studied. The noise level produced by the power tiller was so high, i.e., 105-110 dB(A) at the operator zone restricting the exposure time to less than one hour. Empirical equations could be developed from the acoustic contour maps for predicting the noise level of the power tiller at any desired point.

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Development and Evaluation of Terracer Cum Leveller as an Attachment to Power Tiller: Dr.K.Kathirvel Assistant Professor, College of Agrl. Engg. TNAU, Coimbatore T.V.Job and R.Manian Professor, College of Agrl. Engg.TNAU, Coimbatore, India

Power tillers are visualized as potential source of power for small- and medium-sized farms. A number of matching equipment have been developed for

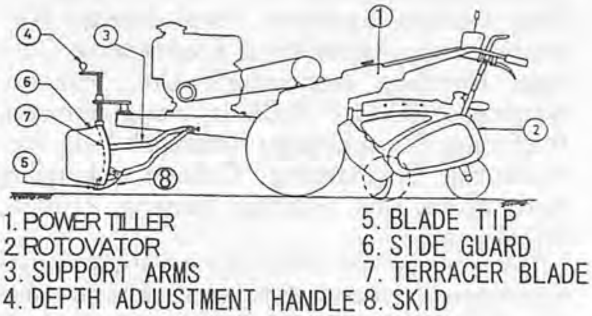

Fig.1 Terracer cum leveller attachment to powertiller.

Fig. 2 Terracer arm leveller as an attachment to power tiller.

performing various farm operations. In order to increase the utility of power tillers and to make them versatile, a terracer-cum-leveller as an attachment to power tiller was developed. The unit consists of a curved mild steel blade of 1.0 m width and 0.32 m height with a cutting edge and side guards. It is attached in front of the power tiller with a bracket and two side supporting arms.

The unit was field-evaluated for its performance for contour bunding and levelling operations and compared with manual and bulldozer blade operation. The costs of operation for forming bunds by manual, power tiller terracer and bulldozer were Rs.18.00, Rs.17.75 and Rs.12.80, respectively. Even though the cost of operation of powertiller terracer is similar to that of manual bunding, there is a distinct savings of time. This is an added advantage in labour scarcity areas, apart from increasing the versatility of the power tiller. For land levelling operation, the cost of operation amounted to only Rs 3.30 for moving 1 m^3 of soil to a distance of 1 m.

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Experimental Reserach on On-line Emulsification System on Diesel Engines: Ding Qishuo, Lecture, Rural Energy Research Lab, Agricultural Engineering College, Nangjing Agricultural Uni., Puzhen, Nanjing, 210032, P.R.China. Peng Songzhi, Professor,Rural Energy Research Lab, Agricultural Engineering College, Nangjing Agricultural Uni., Puzhen, Nanjing, 210032, P.R.China.

The emulsification ability of the fuel supply system of diesel engine was tested which shows that diesel can be satisfactorily emulsified on the engine's fuel supply system. Thus, a new kind of engine-dependent, on-line fuel emulsification system on diesel engines is feasible.

A certain amount of water can effectively improve the combustion conditions in IC-engine. Great efforts in the past have been made to apply this technology on diesel engine. At first, water injection technology into combustion chamber was tried but it faced many problems. Later, it was shown that use of emulsified fuel on diesel engine is an ideal method. Emulsified fuel was observed not only prevented rust on the engine but the saving efficiency was achieved and exhaustion reduced.

781

Development and Evaluation of Power-Operated Paddy Straw Baler: Dr. R. D. D. Prasad, Ph.D., Assistant Professor, Dept. of Animal Husbandry, Agricultural College, Bapatla-522 101, Andhra Pradesh. R. S. Reddy, M. Sc. (Agril. Engineering) Research Officer, Farm Implements and Machinery Scheme, Agricultural Research Institute, Rajendranagar, Hyderabad-500 030. Dr. M. R. Reddy, Ph.D., Professor and Head, Dept. of Feed and Fodder Technology, Veterinary College, Rajendranagar, Hyderabad-500 030. Dr. G. V. N. Reddy, Ph.D., Associate Professor, Dept. of Feed and Fodder Technology, Veterinary College, Rajendranagar, Hyderabad-500 030

A power operated paddy straw baler was designed, fabricated and developed at the Farm Implements and Machinery Scheme, Agricultural Research Institute of Acharya N. G. Ranga Agricultural University, Hyderabad. The baler was put to extensive use to evaluate its performance on density of paddy straw and urea-treated paddy straw. The baler had capacity of 10 bales per hour. The baler weighed 32.5 kg per bale. The average size of the bale was 65 x 82 x 78 cm. The density of the paddy straw increased from 30.8 kg/m^3 to 78.2 kg/m^3due to baling. The density of urea treated-paddy straw bales (4% urea; 50%

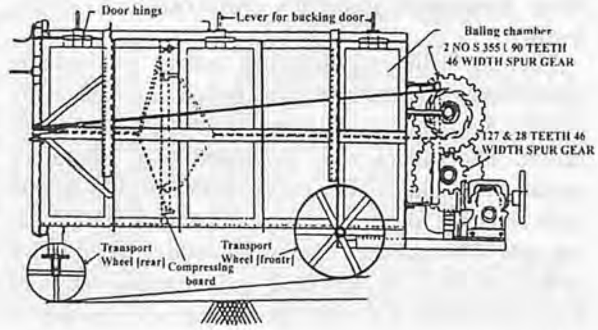

Fig. 1 Power operated straw baler (side view).

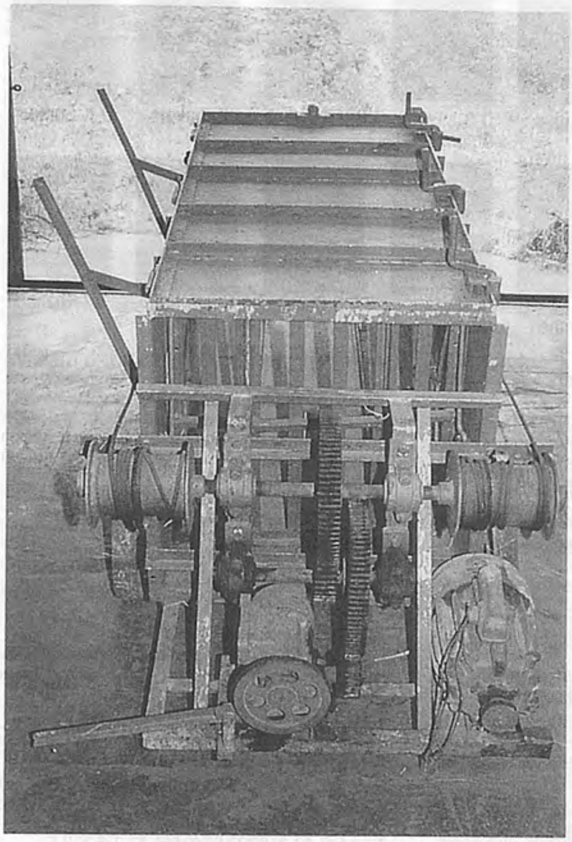

Fig. 2(a) Paddy straw baler-close view.

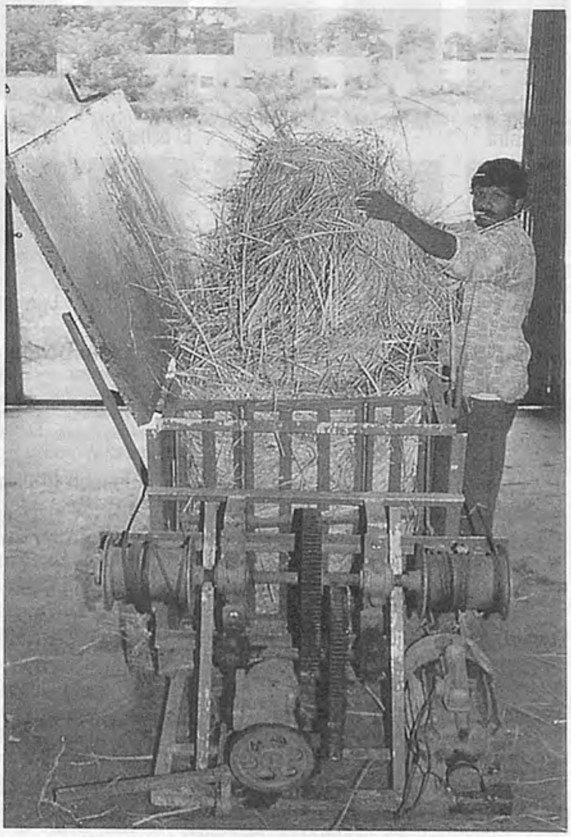

Fig. 2(b) Paddy straw baler-in operation.

moisture) immediately after treatment increased in density from 55.9 kg/m^3 to 141.9 kg/m^3. ■■

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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 :

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

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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 ;
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g. art: supported by authentic sources, reference or bibliography.
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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.
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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 offprints of the article and plural writers are given 35 offprints (also sent by surface/sea mail)"
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(Vol. 29 No. 2, Spring, 1998 ~)

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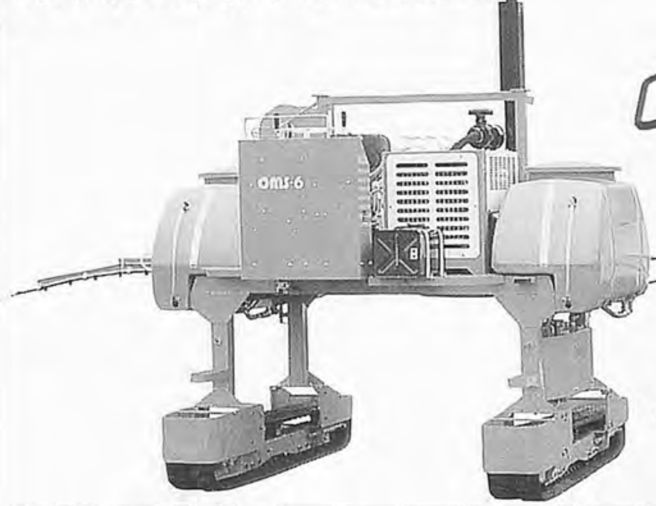

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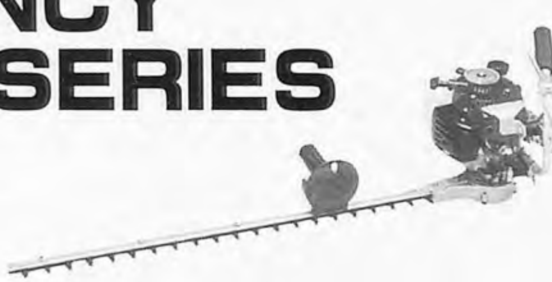

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