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AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

VOL.17, NO.3, SUMMER 1986

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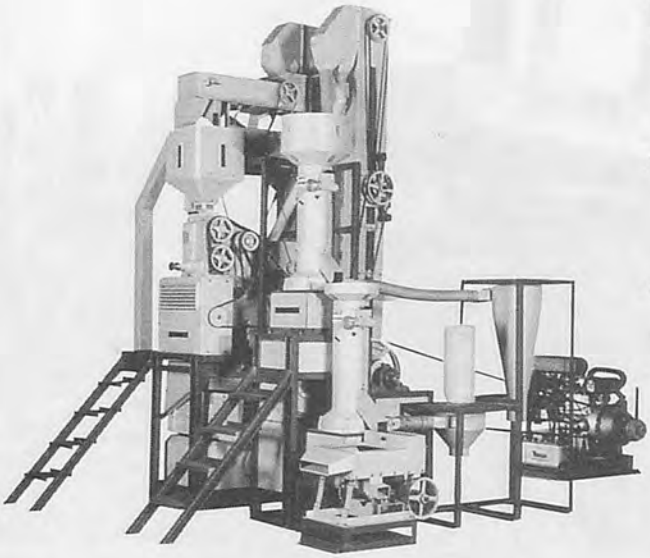

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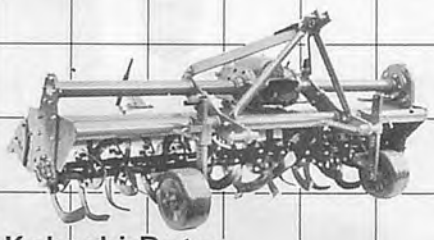

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EDITORIAL

Some Hard Realities

"It's a small world!" – somebody is apt to utter in surprise when he unexpectedly bumps into an old acquaintance in some unlikely place or occasion. "The world is getting smaller" – people are likely to chuckle when friends tell them that one can now jet the same day after breakfast in Tokyo, have lunch in Chicago and attend a business dinner meeting in London. "It's fantastic!" – one is likely to say when he receives a parcel from across the world in a matter of hours through some special courier service.

All this – and more – point out to some hard realities that indeed, modern transport and communication facilities these days have hastened a hundred-fold the spread of information through various efficient mass media. Satellites, of course, play very important roles in this regard.

However, the realities do not end but rather begin from there. For example, the gap between the "haves" and the "have nots" seem to widen in the face of a narrowing gap in time and space. In plain and simple economics, the benefits of modernity seem to be enjoyed much more by the well-to-do and much less by the poor.

Seen in a more graphic example, excess food production in not a few economically advanced countries are ironically used for feeding livestock whereas people in many food-deficit area in underdeveloped or developing countries are starving and dying. In this respect, the gap between food-surplus and food-deficit countries is even wider and rather unchecked. And it is in this connection that the speed and efficiency with which modern communication and transport facilities have not been very effective in alleviating the lives of the "have nots."

The AMA maintains its stance and stand on the issue, i.e., the management will continue to strive to contribute in bridging the gap in the communication flow from research results and technical papers that AMA regularly publishes.

Yoshisuke Kishida
Chief Editor

July, 1986
Tokyo

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Soil Bin Studies of Tillage-Tine Forces

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Introduction

Field cultivators are becoming popular because they are light in weight; low in cost; durable; easy to manufacture, transport, manoeuvrability, require less repair and maintenance, manipulate soil as desired, and do not disturb soil level. They also do not bury the surface trash which helps prevent water and wind erosion and conserve moisture.

Evaluation of tillage tool performance is the main criteria for the successful design of tillage tool. Hence, tool forces are the basic aspects of tillage tool performance.

Much research has been done in tillage force analysis and measurement. Clyde (1) developed a mobile field test unit and used it for many years. Gill and Vanden Berg (2) described two mobile field dynamometers being used by research agencies in Europe. With the advancement of technology strain-gauge force transducers have been developed and now are being used extensively by several agricultural equipment manufacturers and agricultural experiment stations.

In order to facilitiate the use of strain gauge force transducers soil bins have been developed which permit conducting tests under carefully controlled and uniform soil and operating conditions. In indoor soil bins the isolated component or portion of the tool is to be studied; and the forces acting upon it are measured. For this purpose, ring type force transducers, simple extension force transducers, and extended octagonal ring transducers were developed. The first two could measure only axial force and the latter one can measure biaxial force system which consists of horizontal and vertical components of the force and the moment in the plane of these two force components.

Horizontal component Fx of the resultant force is parallel to the direction of the tractor travel and usually is accepted as the definition of the draft of the implement. It is the part of the force that determines the traction required from the tractor; the part that directly consumes drawbar power and the part which is devoted to useful work by the implement.

The vertical component of the force is also very important. It has the effect of adding load to the tractor rear wheels. It has, therefore, profound effect on the tractive ability of the tractor as well as on its stability and on facility with which it can be steered. No less important is its effect on the implements power to penetrate and maintain depth as well as on the draft of the implement because of the friction forces associated with this vertical force.

The Study

The present study was carried out with extended octagonal ring transducer in the indoor soil bin of the National College of Agricultural Engineering, Silsoe, Bedford, U.K. in 1980 because it could measure horizontal as well as vertical forces and the moment in the plane of these forces. Different rake angles of the tillage-tine were used.

Procedure

Measurement of tillage forces is not so simple but requires delicate instruments which include: extended octagonal ring transducer, amplifier, planimeter, oscillograph, ultraviolet recorder, spirit level, digital voltmeter, batteries, cables, and soil bin.

The force system in tillage studies where the soil failure is symmetrical consists of two perpendicular force components, a horizontal component Fx and a vertical component Fz and the moment My in the plane of these two forces. Because of the symmetrical soil failure the lateral force

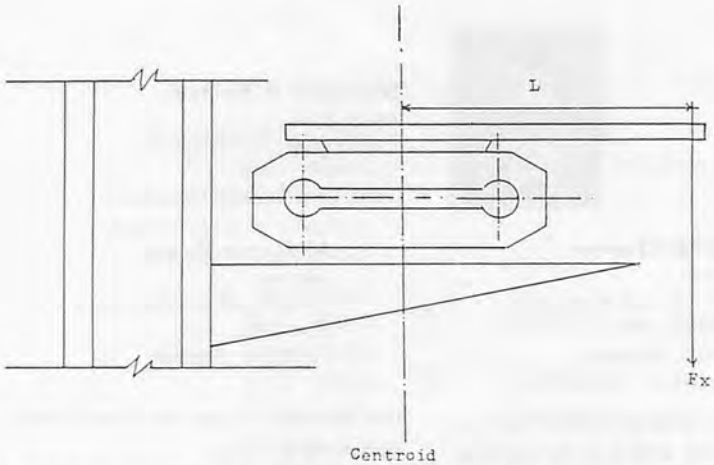

Fig. 1 Horizontal mounting of extended octagonal ring transducer. L=Distance between centroid and horizontal component Fx of the resultant force.

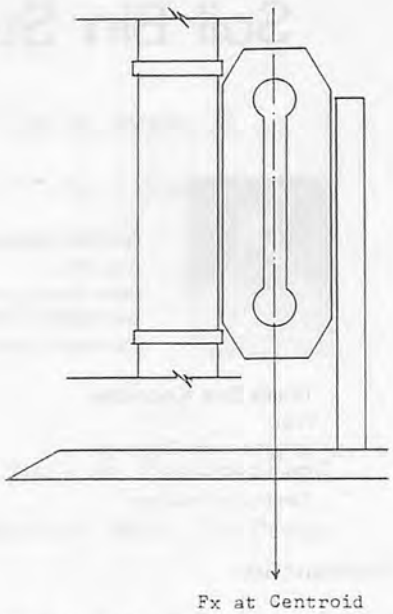

Fig. 2 Vertical mounting of extended octagonal ring transducer.

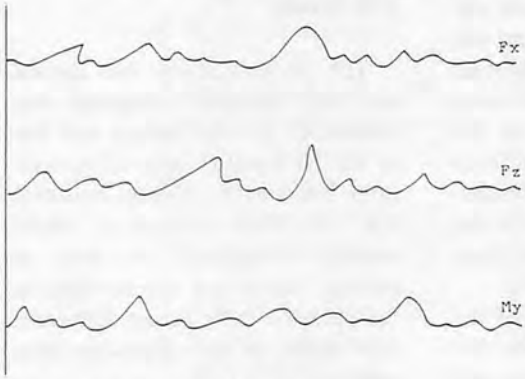

Fig. 3 Wave-like lines (traces).

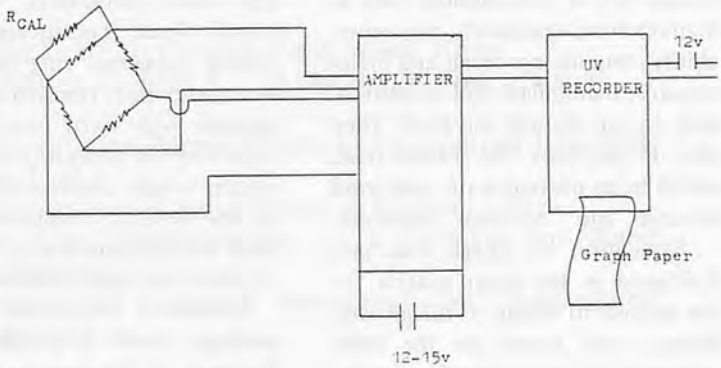

Fig. 4 Basic measuring system.

Fy and the moments Mx and Mz are zero. The extended octagonal ring transducer can simultaneously monitor Fx, Fz and My.

Horizontal mounting (**Fig. 1**) of extended octagonal ring transducer was used to monitor Fx (Channel I) and the vertical mounting (**Fig. 2**) was used to monitor Fz (Channel II). The moment My was monitored in both positions of the transducer. The spirit level was used to check the perpendicularity of the transducer when mounted vertically. The cables of different channels were connected with their respective plugs. The power was supplied through the main source. The voltmeter was connected with the amplifier to give output in mV at different loads suspended vertically on the cantilever beam at different locations. The channel sensitivities were set on the amplifier during each test. The calibration constants were obtained by plotting the outputs against loads. The planimeter was used to record the wave-like lines (traces) (**Fig. 3**) on the oscillograph and their areas as well. The length of each trace was measured. The area of each trace was divided by its length to obtain the height of the trace. The channel sensitivity for each test was multiplied with the height of the trace then divided by the calibration constant to obtain mean force/moment.

The procedure laid down here was followed throughout this experimental work to obtain Fx, Fz and My. The basic measuring system of biaxial forces is shown in **Fig. 4**.

Results and Discussion

The horizontal mounting of the octagonal ring transducer was used to determine the horizontal force Fx and the corresponding moment My. Different loads were suspended at 30 cm and 50 cm away from centroid of beam. The readings were recorded in **Tables 1 and 2**.

The outputs were plotted against loads to obtain the calibration constants for Fx and My (**Figs. 5 and 6**). The linear relationship between outputs and loads suspended at 30 cm and 50 cm away from the centroid was found from these figures and no hysteresis. Due to the effect of Fx the outputs automatically recorded in channel II were used to obtain cross-sensitivity for Fz (**Fig. 7**).

In order to determine the force Fz and the corresponding moment My the extended octagonal ring transducer was suspended vertically (**Fig. 2**). Different loads were suspended at centroid, +10 cm and −10 cm away from the centroid. The observations were recorded in **Tables 3, 4 and 5**. The calibration constants for Fz and My were obtained from **Figs. 8 and 9**. Due to the effect of Fz outputs recorded automatically in channel I were used to determine cross-sensitivity for Fx from **Fig. 10**. Linear relationship between outputs and loads suspended at centroid, +10 cm and −10 cm away from centroid on cantilever beam was found; and no hysteresis.

The summary of results is presented in **Table 6**.

Conclusions

From the present study it is concluded that during horizontal

Table 1 Loading at 30 cm from Centroid.

Load		Moment	Fx (Channel I)	Fz (Channel II)	My (Channel III)
kg	N	N m	Output (mV)	Output (mV)	Output (mV)
20	196.2	58.8	114	10	145
40	392.4	117.72	233	17	311
60	588.6	176.58	354	25	456
80	784.8	235.44	470	35	620
100	981.0	294.3	587	45	785

Table 2 Loading at 50 cm from Centroid.

Load		Moment	Fx (Channel I)	Fz (Channel II)	My (Channel III)
kg.	N	Nm	Output (mV)	Output (mV)	Output (mV)
20	196.2	98.1	117	20	250
40	392.4	196.2	239	25	500
60	588.6	294.3	357	45	768
80	784.8	392.4	478	58	1025
100	981.0	490.0	600	75	1258

Table 3 Loading at 0 cm from Centroid.

Load		Moment at centroid	Fx (Channel I)	Fx (Channel II)	My (Channel III)
kg	N	Nm	Output (mV)	Output (mV)	Output (mV)
20	196.2	0	0	144	3
40	392.4	0	2	288	4
60	588.6	0	4	436	5
80	784.8	0	7	580	6
100	981.0	0	10	723	7

Table 4 Loading at 10 cm from Centroid.

Load		Moment	Fx (Channel I)	Fx (Channel II)	My (Channel III)
kg	N	Nm	Output (mV)	Output (mV)	Output (mV)
20	196.2	19.62	0	147	39
40	392.4	39.24	0	294	75
60	588.6	58.86	5	442	110
80	784.8	78.48	7	589	149
100	981.0	98.1	8	736	190

Table 5 Loading at +10 cm from Centroid.

Load		Moment	Fx (Channel I)	Fz (Channel II)	My (Channel III)
kg	N	Nm	Output (mV)	Output (mV)	Output (mV)
20	196.2	19.62	1	142	48
40	392.4	39.24	4	284	102
60	588.6	58.86	4	428	149
80	784.8	78.48	7	569	197
100	981.0	98.10	9	712	246

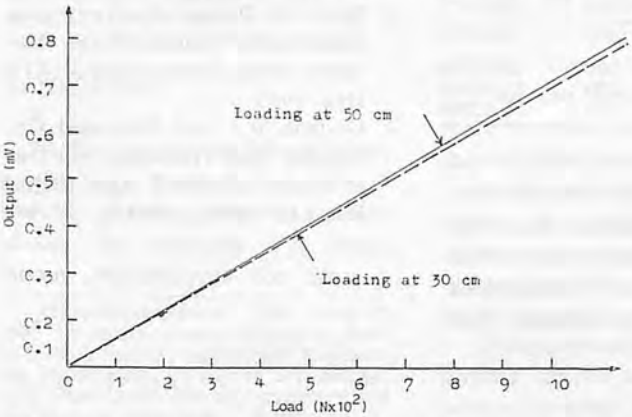

Fig. 5 Calibration curve for horizontal loading.

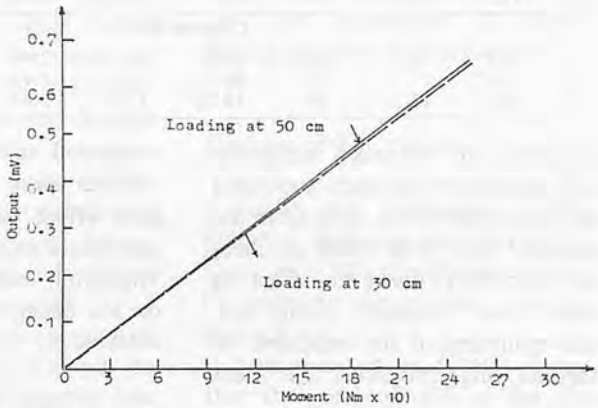

Fig. 6 Calibration curve for moment.

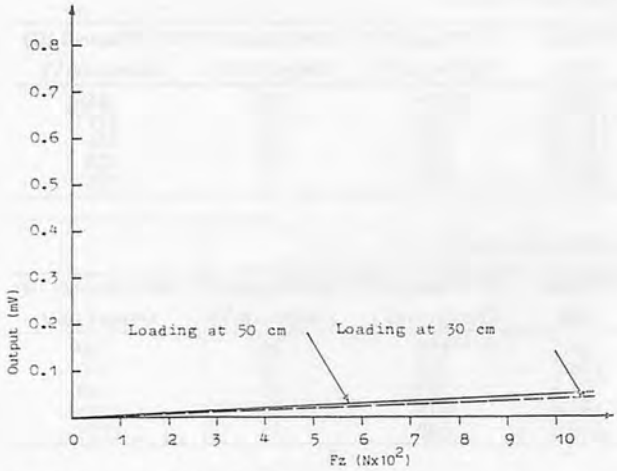

Fig. 7 Cross-sensitivity for Fz.

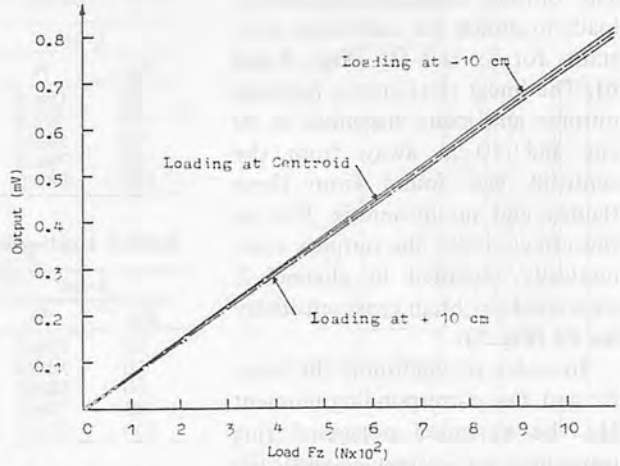

Fig. 8 Calibration curve for Fz at centroid, +10cm and −10cm.

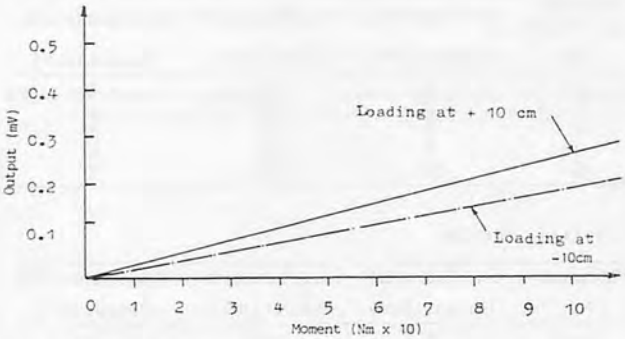

Fig. 9 Calibration curve for moment.

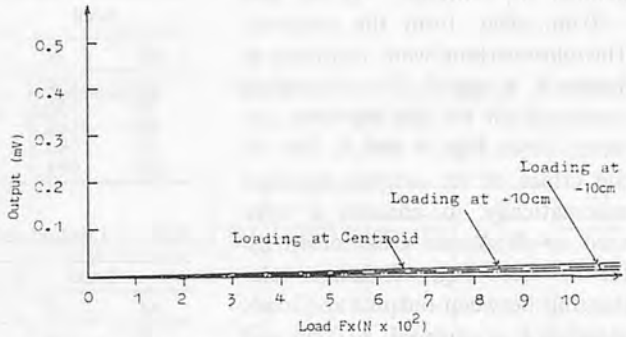

Fig. 10 Cross-sensitivity for Fx at centroid, +10cm and −10cm.

Table 6 Summary of Results

Test No.	Rake angle	Depth of cut cm	Length of trace cm	Area of trace cm	Height of trace cm	Calibration constant mV/N	Sensitivity set on amplifier	Mean force/moment N
				Channel I				
1	67°½	10.2	15	32.8	2.186	0.611	50	179.0
2	90°	17	20	56	2.8	0.611	50	229.1
3	112°	13.5	15	37.5	2.5	0.611	50	204.6
				Channel II				
1	67°½	10.2	15	22.5	1.5	0.75	20	40.0
2	90°	17	20	14	0.7	0.75	20	18.67
3	112°	13.5	15	18	1.2	0.75	20	32.0
				Channel III				
1	67°½	10.2	15	19.5	1.3	2.44	100	53.3 Nm
2	90°	17	20	40	2.0	2.44	100	81.97Nm
3	112°	13.5	15	18.75	1.25	2.44	100	51.23Nm

mounting of extended octagonal ring transducer the loads suspended at 30 cm and 50 cm away from the centroid have little effect on channel sensitivity, hence no effect on mean force. Similarly, during vertical mounting of the extended octagonal ring transducer the loads suspended at certroid, +10 cm and −10 cm away from centroid have little effect on channel sensitivity and, hence no effect on mean force. Therefore, loads can be suspended on the beam at any distance from centroid.

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Drilling of Pelleted Paddy Seeds in Puddled Field

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Abstract

Paddy seeds of variety IR 24 were pelleted using clay loam soil particles smaller than 150 μm and tap water. A concrete mixer was used for soil coating of the paddy seeds. Laboratory tests showed that the density of pelleted paddy seeds increased and found to be suitable for drilling in puddled soil. Field trials of drilling of pelleted paddy seeds of different densities, in separate strips indicated that the seeds with density of about 1.7 g/cc could effectively be imbeded in puddled field when they are allowed to fall freely from about 10 cm height from the seed tubes of a drill. It was observed that there was neither any seed injury nor loss by rats and birds and also they were not affected by the wave action of water.

Introduction

In the purview of labour crisis, particularly because of fast industrial growth, there is need to search for methods by which labour requirements for farming are minimized.

Among paddy growing methods, transplanting is widely practised because of its effective control on infiltration rate and on weed growth. However, in countries with large holdings and high labour costs, manual transplanting is not feasible and either mechanised transplanting or direct paddy drilling in rows will be the alternative. Yet mechanized transplanting is to be popularized in India. There are a number of problems associated with it.

On the other hand, drilled paddy, unlike the transplanted method, does not have enough of a head-start to outgrow the weeds. The placement of seeds under wet-land conditions also poses challenging problems, e.g., displacement of seeds from the straight lines, because of water wave action created in puddled field while drilling. Also, when the seeds are left on the surface of the field, there are chances of seed damage or loss by rats and birds.

Paddy growers in India mainly adopt the manual transplanting method involving lots of labour (more than 25% of the total working hours for paddy cultivation).

Though transplanters (manual or power) can be used, it would be better to adopt still simpler but new method, namely drilling of pelleted paddy seeds in puddled field.

For effective placement or sowing of seeds in puddled field, the density of seeds should be increased to make them to sink in the mud. The pelleting of seeds with soil would raise the density of seeds considerably making them more suitable for sinking in puddled field. Thus, it may solve the above-mentioned problems associated with mechanization of paddy sowing.

The study was undertaken with the following objectives: 1. Preparation of pelleted paddy seeds of different densities; 2. To study the effect of pelleting of seeds on germination; 3. To study the sinking behaviour of different density seeds in the puddled soil; 4. To determine suitable pelleted seeds of required density for direct drilling in the puddled field by field trials; and 5. To work out the cost economies of direct drilling of pelleted paddy seeds.

Review of Literature

Gupta and Vashishtha (1972) reported that the pelleted paddy seeds of 1.245 g/cc density would be suitable for sinking in the puddled soil.

Nakamura et at (1983) found that the yield of 33% of the rice growers who adopted the DSSP sys-

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tem (Direct Seeding with Coated Rice in Submerged Paddy Field) increased to 0.5 t/ha with the first grade quality proof compared with the transplanting cultivation. Some 90% of those who operated DSSP system appreciated the labour saving performance of the DSSP system and 44% of them pointed out the economic advantage of DSSP. They also reported that the income rate for the DSSP is 4% to 10% more than the conventional transplanting method.

Materials and Methods

Paddy seeds of variety IR 24 were used for this study. Clay loam soil particles smaller than 150 μm and tap water were used for the process of pelleting. Soil was taken from fallow plot where no crops were grown, in general. However, the plot was used for conducting student practicals to demonstrate various field operations like ploughing, harrowing, drilling, puddling, etc. A concrete mixer of 0.149m^3 capacity operated by a 3-phase induction motor of 2.2 kW (3hp) was used for soil coating on the paddy seeds.

A scientific weighing balance, a measuring cylinder of 500 cc capacity and toluene solution were used for density determination. A small metallic tray (53.5 x 30 x 23 cm) was used for laboratory tests of different density seeds for their sinking behaviour in puddled soil and germination observations.

Experimental plots were prepared with the help of an International tractor (B-275, 35hp) with paddy puddler. A seven /row modified seed drill was used for drilling the pelleted seeds during field trials.

Pelleting of Paddy Seeds of Different Densitites

The first layer was coated by sprinkling 200 cc of water and feeding 300 g of soil alternatively on the rotating mass of paddy seeds (1 kg) in the rotating drum of concrete mixer. The second and third layers were coated by applying 100 cc and 50 cc of water along with 200 g and 100 g of soil, respectively. Thus for 3 layers, 350 cc of water and 600 g of soil were required. It took 10 min to complete 3- layer coating for 1 kg of seeds.

The quantity of soil used and amount of water sprinkled varied for additional layers of coating. The materials required and time taken for coating of 1 kg of seeds for different layers are shown in **Table 1**.

Determination of Densities

The weights of bare-dry-paddy seeds and of pelleted seeds of four different coatings were taken by the balance and their volumes were measured by the toluene displacement method. The observations and calculated values of density are shown in **Table 2**.

Laboratory Tests

Small samples of bare paddy seeds and pelleted paddy seeds of 3, 5, 7, and 15 layers were tested for germination. The puddled soil condition was created in a metallic tray. The pelleted paddy seeds of different densities were dropped freely from a height of 10 cm from the top surface of the puddled soil forming separate strips. The free water from the top of the settled soil was drained after leaving the tray undisturbed for 24 h. On the 7th day, the seed penetration depth in the soil and the lengths of the sprouts were measured by digging out the seeds carefully from the soil. The observations are given in **Table 3**.

Field Trials

The paddy field was prepared with the help of a tractor-mounted paddy puddler. For direct drilling, recommended seed rate was 45 kg/ha of dry-bare-paddy seeds. On the basis of this rate, the seed drill was calibrated for equivalent quantity of pelleted paddy seeds

Table 1 Material Requirements and Time Taken for Different Layers of Coating on 1 kg Paddy Seeds

Number of layers of coating	Time taken (min)	Soil used (g)	Water sprinkled (cc)
3	10	600	350
5	22	800	450
7	32.7	1000	850
15	56.6	1800	950

Table 2 Observations and Calculated Densities of Bare and Pelleted Paddy Seeds.

Parameters	Bare seeds	Pelleted up to			
		3-layers	5-layers	7-layers	15-layers
Weight (g)	6.231	4.283	7.967	10.401	14.200
Volume (cc)	6.000	3.000	5.000	6.000	6.500
Density (g/cc)	1.040	1.430	1.590	1.735	2.180

Table 3 Average Sinking Depth and Germination of Different Density Paddy Seeds

Layers of coating	Average seed sinking depth (mm)	Average lengths of sprouts (mm)
3	32.6	32.6
5	35.8	30.8
7	38.4	31.4
15	46.0	31.0

Table 4 Estimated Cost of Pelleting Paddy Seeds and Total Cost of Drilling Operation per Hectare for Different Density Paddy Seeds

Types of seed (Layers of coating)	Charges for the mixer unit, Rs/ha					Cost of pelleting the paddy seeds (Rs/ha)	Total cost of drilling the different density paddy seeds (Rs/ha)
	Depreciation	Interest	Repair, maintenance & lubrication	Labour	Electricity		
3	1.69	2.25	3.00	9.38	8.25	24.57	77.57
5	3.71	4.95	6.60	20.63	18.15	54.04	107.04
7	5.51	7.35	9.80	30.63	26.95	80.24	133.24
15	9.56	12.75	17.00	53.13	46.75	139.19	192.19

of different densities. Pelleted paddy seeds of three different densities were sown in the puddled field in separate strips with the help of a tractor-mounted seed drill. The pelleted paddy seeds of 15 layers could not be sown in the field as they were too big to pass through the grooves of the fluted roller of the seed drill without being broken. The equivalent seed rates were 57,63.5 and 69 g/ha for pelleted paddy seeds of 3, 5 and 7 layers, respectively.

Cost Analysis

The following assumptions are made in calculating the costs:
Purchase price of concrete mixer unit with an electric motor = Rs. 9000
Life of the concrete mixer = 10 years
Annual use of mixer = 3600 h
Salvage values of the mixer = Rs. 900
Interest rate = 12% per annum
Repair, maintenance and lubricating charges per year = 10% of the initial cost
Labour charges = Rs. 1.25/h
Electricity charges per unit = 50 paise
Hiring charges of a tractor with seed-drill = Rs. 53/h
Field capacity of the above tractor with seed-drill = 1 ha/h

On the basis of above assumptions, the cost of pelleting the seeds and the total cost of drilling operation /ha for different density seeds were calculated and are given in **Table 4**.

Results and Discussion

The density of 3-layer coated seeds was sufficient to sink the seed to the bottom level of puddled field for drilling just after the puddling operation as the density of puddled soil was 1.245 g/cc.

Under actual field conditions, when a tractor-mounted seed drill is pulled in the puddled field, a water current is created because of the movement of the tractor from one end to the other. The wave action thus created will naturally displace the seeds dropping from the seed tubes of the drill unless they are of sufficient density to reduce this effect. Therefore, higher density seeds were prepared by coating more layers of soil.

The variation in the densities should have been linear in accordance with the additional material used for subsequent layers. The non-linearity relationship was due to the fact that some of the soil remained unutilized by way of sticking to the inside surface of

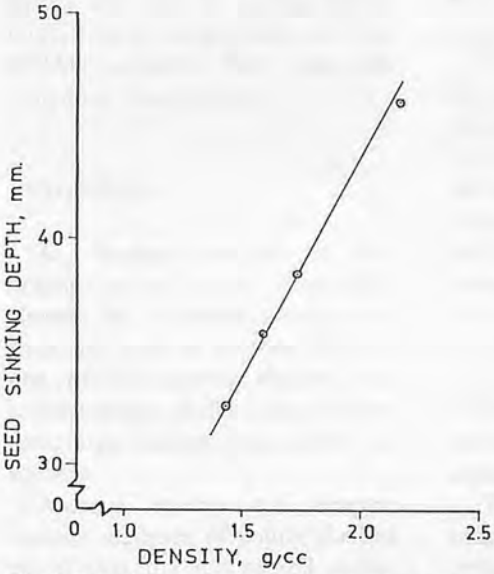

Fig. 1 Behavior of pelleted seeds in puddled soil.

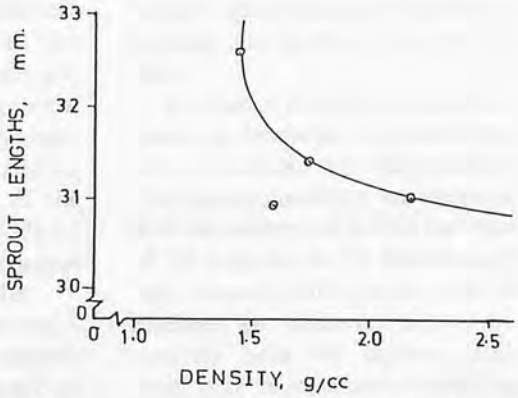

Fig. 2 Germination of pelleted seeds in puddled soil.

the drum.

The relationship between density of pelleted seed and penetration depth is shown in **Fig. 1** and can be expressed in the following form:

$y = 17.7118\ d + 7.48;$

$r^2 = 0.9988$

where, 'y' is sinking depth and 'd' is seed density.

It is observed that the seeds with lower density had longer sprouts than that of higher density seeds (**Fig. 2**). This may be due to the factor governing the growth of sprout shortly after germination viz. porosity of the soil and pressure of the soil column above the seed. The curve in **Fig. 2** indicates that the soil pressure is the dominating factor for growth of the sprout from which it can be concluded that the seeds should sink only up to the depth of 1 to 1.5 cm in the soil.

During the field trials, it was observed that the wave action of water has the least effect on the pelleted seeds of the density, 1.735 g/cc which was apparent from the germination of seeds in lines.

Conclusions

The 7- layer coated seeds of 1.735 g/cc density were appropriate for direct drilling of paddy in the puddled field. The cost of pelleting the seeds required for 1 ha drilling is Rs. 80.24. However, if standing water is maintained just sufficient (minimum possible) in the puddled field, 3- layer coating is sufficient for optimum seed sinking, and faster growth. Also, it is economical. It was observed that the seeds with lower density grew faster than the seeds with higher density. The cost of pelleting the seeds may also be minimized by using simple coating machine with proper stirring and feeding arrangements.

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Optimum Composition of Rubber Rolls for Paddy Shellers

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Abstract

In order to reduce the losses of paddy grains it is necessary to use rubber roll shellers. The life of Indian rubber rolls is short compared to the Japanese rubber rolls. The present study was undertaken in order to develop a suitable composition of rubber rolls. The hardness, resilience, abrasion loss and tensile strength of various rubber mixes were determined as per ASTM standards. The result obtained are discussed here.

Introduction

In modern method of rice milling, paddy is first thoroughly cleaned by a paddy cleaner and then the husk is removed by any one of the existing shellers, i.e., under-run-disc shellers, impact type centrifugal shellers and rubber roll shellers.

Various studies to compare various methods of paddy shelling reveal that the rubber roll sheller gives the maximum head yield and minimum percentage of brokens. The only disadvantage of the rubber roll sheller is its high operating cost and this is mostly due to replacement of the worn rubber layer of the rolls. This cost is heavy because the rubber rolls have to be changed frequently. Storage causes deterioration and shortens their working life. The average life of Indian made rubber rolls is approximately half of the rubber rolls made in Japan.

The main reason for the short life of Indian rubber rolls is lack of proper compounding ingredients in the rubber. Therefore, it is very important to determine the optimum composition of rubber rolls for paddy shellers to improve their performance and life. For the formulation of good rubber compounds, the basic consideration should always be the specification of the finished product, which is determined on the basis of properties expected from the rubber rolls.

The uses of rubber depend on its unique combination of physical properties which can be changed according to need of the product. The present study was undertaken to develop suitable rubber vulcanizates having optimum composition of rubber rolls and to study their hardness, modulus of elasticity and abrasion characteristics.

Review of Literature

The life of rubber rolls manufactured in India is very short. The maximum capacity of a rubber roll is around 267 tons of milled paddy and when it is used in return sheller it rises to 452 tons. Temperature rise in rubber rolls varies from 40°C to 60°C depending upon the variety of grain and quality of the rubber rolls.

A series of microscopic measurement on hardness of rubber rolls were conducted by Nakamura(3). The highest durability was observed with the rubber roll having hardness of 85 degrees. At 90 degree hardness, vibration of rolls or noise of machine was observed due to excessively hard roll surface. Minimum time requirement for hulling was determined with the roll of

hardness of 80 to 90 degrees. On the other hand, the highest power consumption was also observed within this range. Beyond 90 degrees there was a rapid increase of crushed grain and adhesion of carbon to the grain was quite appreciable.

Nakamura(4) reported that the 20°C to 35°C rise in temperature of roll above ambient temperature affected hulling efficiency. This may be due to the decrease in rubber roll hardness as a result of the rise in rubber roll temperature.

The Indian Standard Institution (ISI) has proposed the standards for some of the engineering properties of the rubber rolls (**Table 1**).

Materials and Methods

Formulation of Composition of Rubber Roll

Vulcanized rubber generally includes vulcanizing agent, accelerator, fillers and various other ingredients to improve or modify some of its properties, to facilitate the manufacturing operations and to reduce the cost.

The ingredients are classified according to the part they play in the finished product. This classification is somewhat arbitrary as some of the ingredients have several functions. The principal compounding ingredients are as follows:

Plasticizers or Softeners – Making rubber plastic is an expensive operation which is facilitated by the use of plasticizers or softeners. The important plasticizers are the fatty acids, especially stearic acid.

Vulcanizing Agents – To change the properties of rubber, vulcanization is carried out. The most important vulcanizing agent is sulphur.

Accelerators – Compounding ingredients the presence of which accelerates the process of vulcanization are known as accelerators.

Tensile strength, elasticity, hardness and ageing properties are generally improved in a rubber mix that has been vulcanized in the presence of an accelerator. The zinc oxide is most commonly used accelerator.

Activators – Most accelerators are much more active in the presence of certain substance called activators. These are two broad categories of activators, namely, metal oxides and fatty acids. Representatives of both groups must be present simultaneously. Generally, 3 to 5% of metal oxide and 0.5 to 3% of fatty acids are added in the rubber.

Antioxidants – Antioxidants are negative catalysts which slow down the oxidation of rubber and thus prolong its useful life. Rubber antioxidants are mostly phenols and amines.

Reinforcing Fillers – These fillers improve various physical properties of rubber compounds such as tensile strength, tear and abrasion resistance. By far the important fillers are carbon black and silica.

On the basis of the above properties of compounding ingredients and the properties of rubber roll, a number of compositions of rubber were selected and tested.

The compositions which gave satisfactory results are shown below:

Rubber Mix 'A'

Ingredient: Natural rubber, Styrene-butadiene rubber, H.S. resin, Calcium carbonate, Carbon black, Sulphur, M B T, Zinc oxide and Stearic acid.

Curing: Temperature = 140°C; Pressure = 340kg/cm² (5000 psi); Time A_1 = 30 min; Time A_2 = 60 min.

Rubber Mix 'B'

Ingredient: Natural rubber, Styrene-butadiene rubber, H.S. resin, Lignin, Calcium carbonate, I S A F, Sulphur, M B T, Zinc oxide, and Stearic acid.

Curing: Temperature = 140°C; Pressure = 340kg/cm² (5000 psi); Time B_1 = 30 min; Time B_2 = 60 min.

Rubber Mix 'C'

Ingredient: Natural rubber, Styrene-butadiene rubber, Zinc oxide, Stearic acid, Silica, China clay, P B N A, Sulphur, Diethylene glycol, C.B.S. M B T, and Coumaran Indian resin.

Curing: Temperature = 140°C; Pressure = 340kg/cm² (5000 psi); Time C_1 = 30 min; Time C_2 = 40 min.

Compounding ingredients are usually incorporated in a definite sequence to obtain the most satisfactory results. The order of addition is as follows: Plasticizers, Filler, Accelerator, Activator, Antioxidant and Sulphur.

Preparation of Test Sample

According to the composition and total amount of material needed for the test samples, rubber and other chemicals were weighed.

For mixing of rubber, a laboratory-sized mixing mill (**Fig. 1**) was used. First of all, natural and synthetic rubber were changed into plastic state, i.e., plasticization was done and then the blend of rubber was prepared. Later on, other chemicals were mixed into the rubber in a definite order. The whole mixing process took 30 to 45 min. This rubber mix was cooled for about 60 min.

Table 1 ISI Standards for Rubber Rolls

Properties	Black rubber roll	White rubber roll
Tensile strength IS 3400 (Part I)	120 kg/cm²	90 kg/cm²
Elongation IS 3400 (Part I)	150%	130%
Hardness IS 3400 (Part II)	78-88	77-88
Abrasion index IS 3400 (Part III)	25	20
Heating test	80°C for 2 h	80°C for 2 h

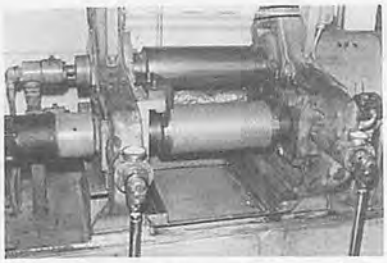

Fig. 1 Mixing mill.

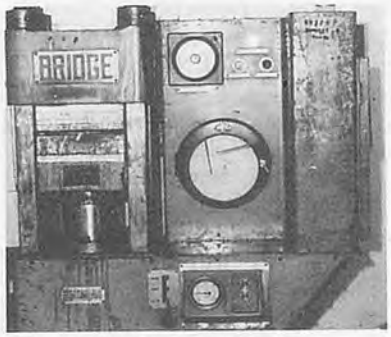

Fig. 2 Hydraulic press-cum-heater.

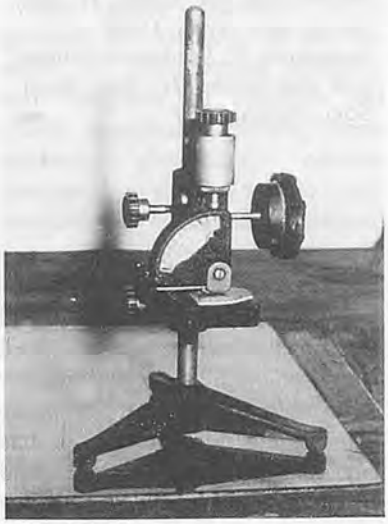

Fig. 3 Shore A durometer.

The mould for test samples were heated up to 140°C in the hydraulic press-cum-heater (Fig. 2). The hot mould was filled with rubber pieces cut from the rubber mix and then covered with the cover plate. Curing was done by hydraulic press-cum-heater at 140°C temperature and 340 kg/cm^2 (500 psi) pressure for required duration. Test pieces were removed from the mould after curing and cooled in water. Subsequently, the test pieces were cut according to their size and shape.

Fig. 4 Wallace Dunlop tripsometer.

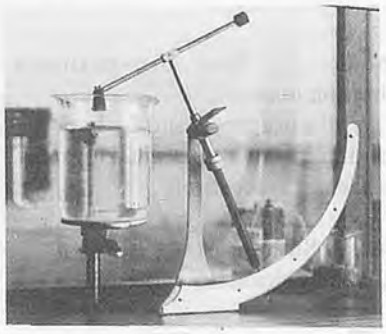

Fig. 5 Fisher-Young grovitometer.

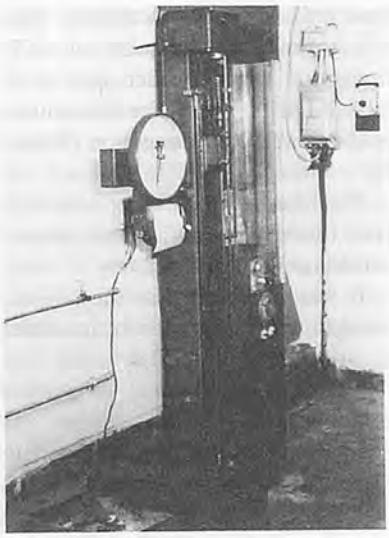

Fig. 6 Ziwick tensile testing machine.

Determination of Properties

Test samples were prepared according to ASTM standard specification for determining the various properties.

Determination of Hardness – Hardness is the resistance to indentation. It represents elastic modulus of the compound. During this study Shore-hardness was measured by Shore A Durometer (Fig. 3) according to ASTMD-676-55T.

Determination of Resilience – Resilience is the ratio of energy output to energy input in a rapid (or instantaneous) full recovery of a deformed specimen. Resilience was determined by Dunlop Tripsometer (Fig. 4).

Determination of Abrasion Loss – Abarsion is the surface loss of a material due to frictional forces. Crydon-Akron Abrasion Tester was used for this purpose.

Fisher-Young Gravitometer (Fig. 5) was used for specific gravity determination of the sample. The temperature of the test was 30° ± 2°C.

$$\text{Abrasion Loss} = \frac{\text{Weight loss in 1000 rev.}}{\text{Density}} \text{cc/1000 rev.}$$

Determination of Tensile Strength – Tensile strength, tensile stress and elongation were measured by 'Zwick Type' tensile machine (Fig. 6) following ASTM designation D412–:51T.

Result and Discussion

Some important properties such as hardness, resilience, abrasion loss and tensile strength of various rubber mixes were determined according to ASTM standards and the results were obtained during the investigation.

Shore Hardness of Rubber Vulcanizates

It was found that the rubber vulcanizates B_2 has a maximum shore hardness and the vulcanizate C_2 has a minimum shore hardness (Table 2). Vulcanizates A_2, B_1

Table 1 Summary of Properties of Rubber Vulcanisates with Composition or Rubber Rolls.

Rubber vulcanisates	Modulus at 200% elongation kg/cm²	Elongation at break %	Tensile strength kg/cm²	Shore hardness °A	Abrasion Loss cc/1000 rev.	Impact resilience %
A_1	75	430	176.33	76.33	1.378	43.0
A_2	115	300	161.33	82.00	1.405	47.9
B_1	65	480	170.00	81.33	1.685	38.0
B_2	100	350	161.00	84.33	1.790	40.0
C_1	68.6	300	99.30	76.33	5.100	60.0
C_2	70.0	310	90.00	74.33	5.790	62.0

Note: A_1 – Rubber roll of A composition with 30 min curing time; A_2 – Rubber roll of A composition with 60 min curing time; B_1 – Rubber roll of B composition with 30 min curing time; B_2 – Rubber roll of B composition with 60 min curing time; C_1 – Rubber roll of C composition with 40 min curing time; and C_2 – Rubber roll of C composition with 60 min curing time.

and B_2 had the shore hardness which was recommended by ISI and the shore hardness A_1 and C_1 are very near to the hardness recommended by ISI for rubber rolls.

In the case of A and B rubber mix, increase in curing time increases the Shore hardness. But in the case of 'C' rubber mix, increase in curing time decreases the Shore hardness (Table 2).

Abrasion Loss and Impact Resilience

The abrasion loss and impact resilience of the vulcanizates increases with the increase in curing time (Table 2). It was also observed that abrasion loss increases with a decrease in tensile strength.

The vulcanizate A_1 gives the minimum abrasion loss and vulcanizates C_2 gives the miximum abrasion loss.

Vulcanizates C_2 and B_1 have the maximum and minimum impact resilience, respectively.

Tensile Strength of Rubber Vulcanizates

The modulus at 200% elongation and tensile strength of rubber vulcanizates were calculated. It was observed that by increasing the curing time, the modulus at 200% elongation can be increased and rubber roll A_2 gives the maximum modulus at 200% elongation (Table 2).

The rubber mix A_1 and C_2 gave the maximum and minimum tensile strength, respectively.

It was observed that the tensile strength decreased with an increase in curing time.

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Storability and Germination of Pre-Harvest Desiccated Paddy

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Abstract

The grains harvested after spraying the rice crop at the cessation of physiological maturity with solutions of common salt (20%), potassium chloride, diammonium phosphate, calcium chloride, pyrites (5-10%) and herbicides (paraquat, dequat, bentaxone, glyphosate) (0.1%) to hasten ripening phase were stored in gunny sack, gunny sack lined inside with polyethylene bag, wooden box, aluminuim vessel, galvanized iron bin and glass bottle and their storability and germinability (after thoroughly washing the grains) were assessed. None of the chemicals used as pre-harvest desiccants at the concentrations studied impaired the storability and germination of paddy grains.

Introduction

The practice of leaving the rice crop for field desiccation after its full maturity causes a loss of 5 to 10% of total production.[1-5] In places where high humidity and monsoonic rain prevail during harvest (e.g., east coast of India) the ripening of rice is considerably delayed and the wet grain after harvest could not be dried. For want of mechanical drying facilities, the farmers store/market the grains under moist conditions and this leads to sprouting and heating of grains with appreciable dry weight loss.[6] To minimise such pre-harvest and harvest losses, field desiccation of rice with certain chemical is practised in areas like Cauvery Delta, India. Appreciable reduction in grain and straw moisture, change in the colour of the glumes and straw from green to yellow, good threshability, high recovery of grains during threshing and advancing harvest at least by a week are some of the beneficial effects of field desiccation of paddy crop.[7-14] Inorganic salt sprays (common salt: 15-20%,[7, 9, 12, 13] potassium chloride, calcium chloride, diammonium phosphate or pyrites 5-10%[10]) and herbicieds (paraquat,[8] diquat,[8] bentazone,[15] glyphosate,[15] at 0.1% a.i.) were used as pre-harvest desiccants on paddy crop. The grains of the chemical desiccated crop harvested in various seasons were stored in different containers and their germinability was assessed.

Materials and Methods

Different varieties of paddy were raised in *kuruvai* and *thaladi* seasons in the field of Paddy Experiment Station, Aduthurai. The recommended cultural practices were followed. Common salt solution at 20%, potassium chloride, clacium chloride, diammonium phosphate and pyrites solutions at 5 and 10% level, 'Gramoxone' (paraquat) and 'Reglone' (diquat) at 0.05 and 0.1% (a.i.) and 'Basalin' (fluchloralin) 'Roundup' (glyphosate) and 'Basagran' (bentazone) at 0.1% level were sprayed (500 l/ha) with a hand sprayer on 27th and 25th day of 50% flowering in *kuruvai* and *thaladi* crop, respectively, harvested after 24 or 48 h, threshed manually, winnowed,

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finish dried to 14% moisture content and stored. Grains from unsprayed control plots were also collected.

Storage

The grains were stored in gunny sack, gunny sack lined inside with polyethylene sheet, wooden box, aluminium vessel, galvanised iron bin and glass bottles and kept indoors for periodical testing for moisture, infestation odour and the change in colour of the grain and kernel. Taking into consideration the storage containers used by farmers and in the laboratories these containers were selected and the grains were fumigated at the start of the experiment.

Germination

After a week of harvest and at monthly intervals, 100 sound grains picked at random from the stored sample were thoroughly washed, kept in sand medium and the germinated seeds counted up to 7 days and expressed as percentage.

Results and Discussion

A progressive reduction in grain moisture occurred during the storage period (**Tables 1 and 2**). Infestation was noticed in the

Table 1 Storability of Paddy Sprayed with Common Salt in Comparison with Control: Variety: IR 20

Container	April		May		June		July		August		September	
	M	G	M	G	M	G	M	G	M	G	M	G
						Sprayed						
A	14.0	91	13.6	92	13.0	88	12.3	99	11.7	90	11.3	93
B	14.0	97	13.7	94	13.0	96	12.7	97	12.2	93	11.7	99
C	14.0	93	13.6	93	13.0	84	12.7	97	12.2	91	11.8	95
D	14.0	90	13.7	90	13.2	86	12.8	96	12.4	92	12.1	92
E	14.0	84	13.6	91	13.4	86	13.0	96	12.6	92	12.2	92
						Unsprayed						
A	14.0	90	13.6	93	13.0	87	12.3	99	11.7	93	11.3	97
B	14.0	90	13.7	94	13.0	93	12.7	97	12.2	92	11.7	90
C	14.0	92	13.6	90	13.0	85	12.7	93	12.2	91	11.8	99
D	14.0	91	13.7	92	13.2	88	12.8	92	12.4	90	12.1	92
E	14.0	86	13.6	90	13.4	88	13.0	94	12.6	91	12.2	89

Container	October		November		December		January		February		March	
	M	G	M	G	M	G	M	G	M	G	M	G
						Sprayed						
A	11.2	92	11.1	93	10.9	87	10.8	94	10.7	93	10.6	89
B	11.6	99	11.5	97	11.3	93	11.1	89	10.9	94	10.9	84
C	11.6	92	11.5	84	11.3	90	11.1	89	10.9	92	10.8	90
D	11.9	90	11.7	89	11.5	88	11.3	86	11.1	97	11.0	99
E	12.0	90	11.8	94	11.6	90	11.4	90	11.3	89	11.2	94
						Unsprayed						
A	11.2	90	11.1	88	10.9	90	10.8	90	10.7	93	10.6	90
B	11.6	95	11.4	88	11.3	92	11.1	93	11.0	94	10.9	93
C	11.6	90	11.5	93	11.3	91	11.1	92	10.9	89	10.8	94
D	11.9	90	11.7	93	11.5	96	11.3	93	11.1	90	11.0	90
E	12.0	92	11.8	90	11.6	89	11.4	97	11.2	91	11.1	89

A = Gunny sack; B = Wooden Box; C = Aluminium vessel; D = Glass bottle; E = Gunny sack lined inside with Polyethylene; M = Moisture content (%) w.b.); G = Germination (%)

Table 2 Storability of Gramoxone-Sprayed Paddy; Variety: IR 20

Stored in	April		May		June		July		August		September		October		November		December	
	M	G	M	G	M	G	M	G	M	G	M	G	M	G	M	G	M	G
								Sprayed										
A	14.0	99	13.3	97	13.2	96	12.5	94	12.2	96	12.1	99	11.9	90	11.7	100	11.2	93
B	14.0	95	13.4	97	13.2	97	12.9	99	12.5	97	12.5	92	12.3	95	12.0	93	11.8	98
C	14.0	92	13.7	94	13.0	97	12.3	99	12.0	85	11.8	86	11.7	93	11.5	94	11.1	95
D	14.0	96	13.4	93	13.0	97	12.0	91	12.0	97	11.5	90	11.6	97	11.4	95	11.0	97
E	14.0	96	13.4	97	13.0	97	12.3	97	12.1	98	11.9	96	11.7	93	11.7	92	11.4	92
F	14.0	92	13.6	95	13.0	97	12.3	96	12.1	89	12.0	92	11.8	95	11.6	94	11.1	95
								Unsprayed										
A	14.0	96	13.6	93	13.3	97	12.2	99	12.1	91	12.0	96	11.8	89	11.6	90	11.1	90
B	14.0	98	13.6	90	13.0	94	12.7	95	12.6	89	12.5	93	12.3	92	12.0	93	11.6	98
C	14.0	95	13.5	94	13.1	98	12.1	94	12.0	97	11.8	89	11.6	90	11.4	98	11.0	99
D	14.0	97	13.4	95	13.1	99	12.6	99	12.6	93	12.4	88	12.3	89	12.0	99	11.5	98
E	14.0	95	13.6	93	13.1	98	12.7	96	12.5	92	12.2	96	12.0	92	12.0	92	11.7	98
F	14.0	97	13.4	98	13.1	98	12.5	97	12.3	93	12.1	93	11.9	89	11.6	92	11.1	94

A = Gunny sack; B = Wooden Box; C = Aluminium vessel; D = Glass bottle; E = Gunny lined inside with polyethylene sheet; F = Galvanized iron box bin; M = Moisture (% w.b.); G = Germination (%)

Table 3 Percent Germination of Paddy Sprayed with Inorganic Salts, Variety: Adt 31

Treatment	Concn.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.
Potassium chloride	5	97	97	94	95	94	90	97	97	95	92	91	92
Potassium chloride	10	95	94	93	92	94	89	90	95	93	90	89	93
Calcium chloride	5	95	98	99	97	95	89	100	98	95	94	93	95
Calcium chloride	10	92	94	96	98	93	90	98	95	91	91	90	91
Diammonium phosphate	5	92	100	97	93	90	92	91	97	90	93	94	92
Diammonium phosphate	10	91	95	92	91	85	90	90	95	91	92	95	92
Pyrites	5	93	93	97	96	89	92	97	97	93	97	92	87
Pyrites	10	90	93	96	93	85	90	95	94	90	95	87	85
Control		98	100	99	97	95	97	96	93	97	95	99	97

Table 4 Percent Germination of Paddy Sprayed with Herbicides

Treatment		Adt 31				Adt 34			
		Oct.	Nov.	Dec.	Jan.	Oct.	Nov.	Dec.	Jan.
Gramoxone	0.1%	95	94	95	92	94	95	96	93
Reglone	0.1%	92	94	97	93	93	93	95	97
Basalin	0.1%	98	95	99	96	94	93	100	93
Roundup	0.1%	99	97	100	94	94	97	98	93
Basagran	0.1%	100	100	100	95	98	98	96	95
Control		99	98	97	94	100	100	100	97

grains stored in gunny sacks (both sprayed and unsprayed) whereas there was no infestation in the grains stored in other containers. Neither any odour formation nor change in the colour of grain and kernel was noticed in the grains stored in any of the containers. Irrespective of the containers in which the grains were stored, the viability of the sprayed and unsprayed lots was well maintained throughout the period of study (one year). Spraying with inorganic salt sprays also did not affect the viability of paddy grains (Table 3).

Similarly, different herbicidal sprays like 'Gramoxone', 'Reglone', 'Basalin', 'Roundup' and 'Basagran' when used as pre-harvest desiccants at 0.1% level had no ill-effect on the germination of paddy grains (Table 4).

The grains of the crop harvested at 24 h of spraying with 'Gramoxone' and 'Reglone' at 0.05 and 0.10% levels registered more or less a similar trend in germination as that noticed in the grains of the crop harvested at 48 h of spraying and the trend in both cases was similar to that noticed in the grains of the unsprayed lot (Table 5). In fact, there was a slight increase in the germination after one or two months after harvest (Table 5). This may be due to the initial dormant condition in some grains.

Mixing wet paddy with 5% common salt as such[16, 17] or with husk powder[18] or dipping the immersed panicles in 5% salt solution,[19] though inhibited germination (in fact, the above methods are recommended to preserve the moist paddy from sprouting, mould growth and heating in storage) initially, the germination was restored after thorough washing. Whenever the grain moisture after harvest is reduced to a level of 12-14% and stored properly to arrest the microbial activity, the germination of seed is well preserved.

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Table 5 Percent Germination of Paddy Sprayed with Farm Chemicals, Variety: IR 20

Treatments (Sprays of)		Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb
					Harvested after 24 h								
Gramoxone	0.05	64	92	95	93	92	93	92	90	89	91	92	90
Gramoxone	0.10	76	93	88	94	93	92	90	87	91	85	89	87
Reglone	0.05	58	88	90	90	88	85	89	89	90	91	90	89
Reglone	0.10	85	95	93	97	96	92	90	85	87	87	89	85
Control		69	99	91	98	97	95	96	97	93	90	93	95
					Harvested after 48 h								
Gramoxone	0.05	71	93	72	93	92	93	90	91	90	90	87	90
Gramoxone	0.10	80	90	79	92	90	91	85	89	88	87	89	89
Reglone	0.05	62	89	92	89	88	90	91	92	90	91	87	87
Reglone	0.10	83	90	82	90	91	87	90	88	89	92	90	85
Control		75	98	93	99	98	99	97	99	97	95	93	96

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Simple and Low Cost On-Farm Paddy Dryer

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Abstract

The Central Plain of Thailand is one of the most important rice bowls in the world at present. It has a vast potential of production of the 2nd rice crop, which is planted and grown in the dry season, because several huge dams and irrigation networks were already constructed and are still under construction. However, the 2nd rice crop is not really popular among rice-growing farmers, because it is harvested at the beginning of the raing season, so its paddy is not easily dried. The ways and means of drying paddy artificially that IRRI and/or Thai Government have been recommending to the farmers are far expensive for the latter.

This paper reports on demonstration experiments that were carried out in 1983 and 1984 to prove that the 2nd paddy crop could be dried up to the moisture content low enough to be stored safely for a long period, by forcing natural air, neither heated nor warmed artificially, through a mass of paddy even in the rainy season. The results achieved came close to being satisfactory.

Preliminary Remarks

The experiment in 1983 was carried out at Kanehanaburi Province in the Central Plain, whereas the experiment in 1984 was undertaken at Nakhorn Pathom Province.

The former was published in the following brochures: (1) RNAM Newsletter, No. 18–Dec. 1983, ISSN 0115-5296; (2) Industry and Technology Development News, Asia and The Pacific, United Nations 1984, No. 15

It was also shown in Technical Exhibition at ESCAP Annual Session in 1984, Tokyo with a video display and on a panel to the participants.

However, the experiment itself was not really perfect because loss of static pressure in a duct of an experimental paddy dryer was abnormally large, removal of paddy moisture was measured by means of a moisture-meter only and replication of experimental process was limited to only twice.

The latter improved on the above defects; accordingly, the accomplished results were more successful. This paper reports only the latter experiment and does not depend upon the former papers.

Introduction

In the Central Plain of Thailand, farmers harvest the 2nd rice crop during June and July which fall within the rainy season. Normally, harvested rice stalks are spread over stubbles in paddy fields so that it may be exposed to sunshine for 3 to 4 days for the drying process. However, this traditional method of natural drying has proved ineffective, since the rainfall often disrupts the natural drying, leaving the partially dried paddy moist.

Not only paddy cannot be dried to a moisture content low enough to be stored safely over a long period of time, but it is sometimes cracked due to rapid absorption of rain water. Furthermore, the cracked kernel is easily crushed into broken rice when milled later.

At present, most farmers are forced to sell their paddy of the 2nd crop to middlemen at a reduced price because deterioration of their paddy, due to a high moisture content, does not provide them with sufficient time to negotiate with the paddy buyers. Consequently, almost all the farmers dare not plant the 2nd rice crop although irrigation water is available in the dry season.

Under this circumstance, the utilization of an on-farm paddy dryer will do much to enhance farmers' bargaining position as well as to decrease post-harvest losses caused by deterioration of highly moist paddy.

The problem and the expectation stated above have been noted by the authorities concerned. Accordingly, lots of research and development activities have been undertaken about on-farm paddy dryers with either kerosene-burning or husk-burning* furnaces, or with solar air-warmers**, and then recommendations have been made to disseminate those dryers up-country. The dryers, however, have not enjoyed much popularity because they are expensive.

Feasibility Study

In the light of the above-mentioned situation, an alternative method of artifical paddy drying has been investigated. This new method forces natural air, which is neither heated nor warmed artificially, through a mass of paddy even in the rainy season, hence lowers drying cost.

First, the following data were collected at Kanchanaburi and Suphanburi Meteorological Stations, which represent the climate at the rice double cropping area in the Central Plain: i) daily precipitation in June and July in the preceding 10 years and ii) temperature and relative humidity, taken at every three hours over the same

* Rice husk burning is much more expensive than kerosene burning in terms of initial cost; moreover, in operation cost also the former is more expensive than the latter, because the former needs more work of feeding fuel than the latter. Also, husk in produced not at farmyards but at rice mills.

**In order to raise, by solar energy, the temperature of airflow forced into a paddy dryer by 2 to 3°C, it is necessary to provide the paddy dryer with a transparent plastic wind tunnel which is larger than the paddy bed of the paddy dryer and must be storm-proof. The new paddy dryer with enlarged paddy bed surely will be more efficient and less expensive than the paddy dryer with the solar air-warmer. Because the depth of a paddy layer on the new paddy bed it is possible to have a thin layer of grains, consequently the air volume forced through the paddy layer will be increased and the horsepower will be decreased.

Table 1A Rainfall Data, Kanchanaburi Meteorological Station, 1971–80

	June		July	
	Precipitation mm	Rainy days	Precipitation mm	Rainy days
1971	75.7	15 (4)	94.1	16
1972	(2) 179.3	18 (3)	64.9	18 (3)–(4)
1973	73.7	10	84.5	16
1974	64.8	19 (2)	(2) 151.9	17
1975	(4) 126.3	14	84.6	20 (1)–(2)
1976	48.2	11	(1) 164.5	17
1977	50.5	10	96.5	18 (3)–(4)
1978	75.8	12	(4) 110.0	20 (1)–(2)
1979	(1) 214.9	14	29.4	11
1980	(3) 135.2	21 (1)	(3) 113.3	13
Selected year	1980		1978	

Table 1B Rainfall Data, Suphanburi Meteorological Station, 1971–80

	June		July	
	Precipitation mm	Rainy days	Precipitation mm	Rainy days
1971	91.8	12	54.4	15 (3)–(5)
1972	111.6	14	71.0	15 (3)–(5)
1973	(2) 180.6	16 (2)	(3) 127.8	15 (3)–(5)
1974	(1) 196.9	15 (3)–(4)	(4) 102.6	21 (1)
1975	(4) 123.4	12	80.7	10
1976	44.5	13	57.4	12
1977	29.1	9	110.7	12
1978	72.6	12	(1) 212.3	19 (2)
1979	87.9	15 (3)–(4)	106.2	9
1980	(3) 132.5	22 (1)	(2) 141.0	14
Selected year	1980		1978	

Table 2 Meteorological Observations at Suphanburi, July 1978

Date	Temperature (°C)						Relative humidity (%)						Rainfall (mm)
	Hours of day						Hours of day						
	1	7	10	13	16	19	1	7	10	13	16	19	
1	27.7	26.5	29.7	32.3	32.5	30.1	78	81	65	54	56	71	.0
2	27.0	26.3	28.4	30.1	31.5	27.0	77	85	74	65	61	83	1.7
3	25.8	25.3	28.7	31.2	31.6	29.5	90	97	75	63	61	72	34.3
4	24.4	24.3	27.4	30.4	32.0	30.8	92	93	82	72	64	72	.0
5	26.6	26.3	29.6	30.5	30.2	28.1	88	90	77	69	75	84	9.4
6	25.5	25.0	28.8	30.5	31.3	26.0	90	92	76	66	63	87	.7
7	25.6	25.5	28.5	30.3	32.0	27.5	93	92	74	70	67	81	.0
8	25.5	25.7	29.5	31.8	31.5	25.8	88	86	68	63	63	92	3.9
9	25.5	26.2	29.5	31.2	32.5	25.8	89	83	72	68	58	90	17.9
10	25.0	25.3	28.0	29.5	31.0	29.0	92	89	80	75	65	78	10.5
11	26.0	25.6	28.6	31.5	31.8	27.5	90	91	76	64	65	81	1.5
12	25.6	26.5	29.0	31.5	32.8	31.4	91	92	78	63	56	62	.0
13	26.4	26.0	29.6	32.5	32.5	30.8	87	90	74	61	60	73	.0
14	27.1	26.3	27.3	32.0	33.3	29.5	90	91	79	64	56	77	7.4
15	25.0	25.5	28.0	30.5	31.5	27.0	92	93	81	67	58	81	.3
16	26.3	26.0	29.7	32.0	33.0	27.7	88	88	71	61	56	74	1.7
17	26.6	26.0	30.1	32.5	34.0	31.5	84	84	63	56	50	69	.0
18	26.2	26.0	31.0	33.0	33.5	28.5	84	84	63	56	54	85	8.5
19	26.0	26.0	29.3	32.6	31.1	28.5	88	85	72	58	65	76	.0
20	26.1	25.8	29.7	31.8	32.0	25.5	91	90	74	62	67	92	25.4
21	26.3	25.3	29.0	31.2	32.5	26.0	86	91	72	65	61	83	19.5
22	26.3	25.4	27.6	30.5	30.5	27.5	88	92	78	67	69	81	.0
23	26.0	25.7	29.0	31.6	26.5	26.5	89	90	72	65	88	88	5.2
24	25.0	25.0	28.8	31.4	32.8	29.2	95	96	78	65	62	78	.0
25	26.8	26.3	30.0	32.1	33.5	26.6	84	84	69	63	58	91	25.9
26	26.5	26.0	30.5	33.0	27.0	26.5	89	88	71	60	84	91	37.5
27	26.8	26.1	28.3	33.0	32.0	30.3	87	83	79	61	67	64	.2
28	26.5	25.8	30.0	32.2	32.4	29.5	82	86	72	64	65	79	.0
29	27.3	26.1	30.1	32.6	29.5	28.5	90	87	68	61	75	81	.8
30	26.5	25.7	30.2	31.5	32.5	30.2	88	94	71	65	61	68	.0
31	26.4	25.6	28.5	29.7	30.7	28.6	86	88	75	72	71	81	.0

period.

Based on the data, the particular months of June and July in separate years were selected as shown in **Tables 1 and 2.** The selected four months had the worst condition during the period of study in terms of paddy drying at each station. These are June 1980 and July 1978 at Kanchanaburi, and June 1980 and July 1978 at Suphanburi.

Secondly, some monographs were collected from Kyoto University, etc. in Japan with regard to paddy equilibrium moisture content corresponding to each relative humidity under various ambient temperatures, from 20°C to 40°C. From these monographs new graphs were prepared as shown in **Fig. 1.** They are available for conversion of every ambient condition, i.e., every combination of the relative humidity and temperature into the paddy equilibrium moisture content corresponding to both items.

Finally, data on **Tables 1 and 2** were translated into **Table 3** which lists paddy equilibrium moisture content at every 3 h on all days in each of the above-mentioned 4 months.

It was expected that on most days in both months at the rice double cropping area, farmers may be able to allow 9 h for forcing natural air for the sake of artificial drying process, as shown in **Table 3.**

Apparatus and Process Used in Experiment

The dryer consists of a gable-roof shaped paddy bed, axial-flow fan and a gasoline engine.

The paddy bed is made up of 10 inclined screen panels, each of which consists of a steel frame (1 400 mm x 900 mm), iron chicken wire (under-ply), aluminium mosquito screen (over-ply) and two steel vertical end-boards. A false floor of the bed measured 12.6 m^2 (= 1.4 m x 0.9 m x 2 x 5).

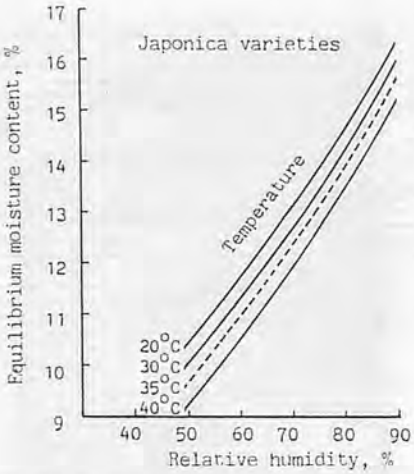


Fig. 1 Equilibrium moisture content and relative humidity.

Two panels were connected with each other at the top ends by arc-welding the form part of a gable-roof. Five of the parts, arranged on a line, were fastened with the two end-boards, which are connected with each other with several threaded tension rods.

The junction of the screen-panels with the end-boards and the ground surface was sealed air-tight. Thus the paddy bed has a plenum chamber below.

The fan was of an axial type with 8 running blades and 9 stationary vanes. Its casting cylinder is of 770 mm diameter. The performance is shown below:

Rotation speed (rpm)	Volume of air-flow (m^3/min)	Static pressure (mm Aq)	Required power (PS)
1,250	200	22	2.0
1,450	230	30	2.9

The fan was driven with a gasoline engine with a continuous rated output of 3.8 PS/800 rpm.

One of the end-borads has a pentagonal air-intake, which was connected with a delivery of the fan with a canvas duct of peculiar shape. The area of the air-intake of the plenum chamber was compatible with the area of the delivery mouth (π (77/2 cm^2 = 4 654 cm^2) **(Figs. 2-5)**

The dryer was efficient because of the following points:

Table 3 Paddy Equilibrium Moisture Content at Suphanburi, July, 1978

Date	Hours of day						No. of hours
	1	7	10	13	16	19	
1	13.8	14.5	12.0	10.4	10.5	12.8	12.
2	13.9	15.4	13.3	12.0	11.3	14.8	9.
3	×	×	13.4	11.6	11.3	12.9	12.
4	×	×	14.6	12.9	11.7	12.9	12.
5	15.7	×	13.7	12.5	13.4	14.9	9.
6	×	×	13.6	12.0	11.6	15.5	9.
7	×	×	13.3	12.6	12.1	14.4	9.
8	15.7	15.4	12.4	11.5	11.5	×	9.
9	16.0	14.8	12.9	12.3	10.8	×	9.
10	×	16.0	14.3	13.4	12.0	13.8	9.
11	×	×	13.6	11.7	11.5	14.4	9.
12	×	×	13.9	11.5	10.5	11.5	12.
13	15.5	×	13.5	11.2	11.1	13.0	10.5
14	×	×	14.1	11.7	10.5	13.6	9.
15	×	×	14.4	12.1	10.9	14.4	9.
16	15.7	15.7	12.8	11.3	10.5	13.3	10.5
17	15.0	15.0	11.7	10.6	9.7	12.9	12.
18	15.5	15.5	11.6	10.5	10.2	15.2	9.
19	15.7	15.2	13.0	10.7	11.9	13.6	9.
20	×	×	13.2	11.4	12.1	×	9.
21	15.3	×	13.0	11.9	11.4	14.8	9.
22	15.7	×	13.9	12.2	12.4	14.4	9.
23	15.9	×	13.0	11.8	15.7	15.7	6.
24	×	×	13.9	11.8	11.3	13.9	9.
25	15.0	15.0	12.5	11.5	10.8	×	9.
26	15.9	15.7	12.7	11.1	15.0	×	6.
27	15.5	14.8	14.1	11.2	12.1	11.8	12.
28	14.7	15.4	12.9	11.7	11.8	14.0	9.
29	×	15.6	12.9	11.2	13.4	14.4	7.5
30	15.7	×	12.8	11.8	11.2	12.4	12.0
31	15.3	15.7	13.4	12.9	12.8	14.4	9.

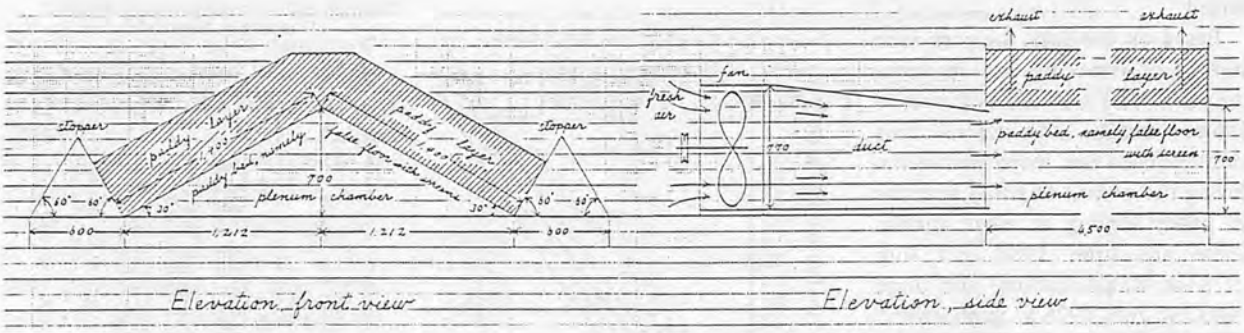
(1) It needed neither burning any fuel nor using a solar air-warmer of a storm-proof transparent wind-tunnel type.

(2) A triangle never transformed, but a rectangle easily transformed into a parallelogram. Therefore, a gable-roof shaped paddy bed needs less materials for fabrication than a horizontal flat bed which is the most prevalent batch type grain dryer.

(3) For experimental purposes, the paddy bed was fabricated from iron/steel and aluminium materials. However, to substantially lower the cost, farmers can make their paddy bed of local materials (wood/bamboo) and some perforated iron sheets for the screen.

(4) An axial flow fan is the most economically efficient of all types of fan/blowers in terms of blowing air-flow of large volume and low pressure.

(5) Even though the experimental



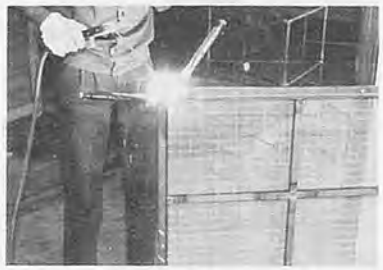


Fig. 3 Welding a screen panel.

Fig. 4 Paddy bed fabricated.

Fig. 5 Forcing natural air through paddy layer with fan/engine.

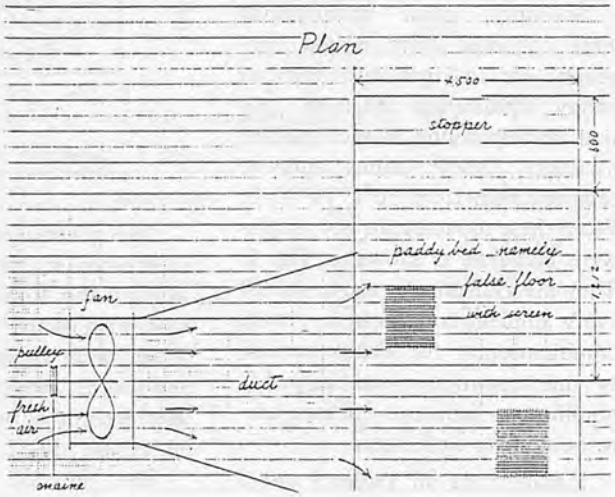


Fig. 2 Layout of paddy dryer.

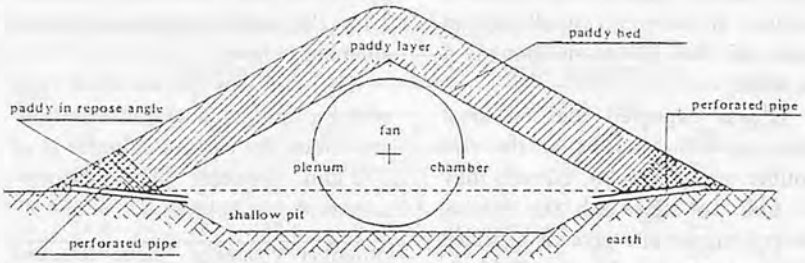


Fig. 6 Revised design for forcing air into repose angle and simplification of duct.

dryer was driven with a gasoline engine, farmers need not buy an engine, because their walking tractors can drive the fans.

Farmers have only to purchase some perforated iron sheets and an axial flow fan from local sources.

Logistics of Experiment

The experiment was conducted seven times from 30 May to 19 July at Agricultural Machinery Center (AMC), KURDI, Kasetsart University, Kamphaengsaen, Nakhorn Pathom Province under the auspices of AMC.

The paddy used for the experiment was supplied by a certain rice mill owner in Kamphaengseen who delivered each time about 2.1 t of moist paddy from the rice mill to AMC, packed in 28 gunny bags, and then dried. After drying they were returned back in the same bags.

Some labourers were engaged in paddy handling work (transportation by truck, loading and unloading paddy into/from the paddy bed, etc.)

The fan and engine operated from late morning until early evening, when the paddy equilibrium moisture content was low enough to dry the partially-dried paddy efficiently. During periods of rainfall and refueling, operations were discontinued.

Additionally, the paddy bed was

Fig. 7 Forming a paddy layer of uniform thickness on an inclined false floor.

covered with a large tarpaulin sheet during rainfall and at night to prevent the paddy from getting wet. However, farmers need not cover their paddy bed, because they can fabricate their paddy dryers under a roof of a simple hut with 4 to 6 posts and no wall.

Findings

Measurements for the experiment were taken of the following parameters:

(1) Meteorological – Temperature (a) and relative humidity (b) were observed with a hygrometer with dry and wet bulbs. Paddy equilibrium moisture content (c) corresponding to (a) and (b) was determined.

(2) Physical – The quantity of used paddy (d) and removal of paddy moisture by drying (e) was weighed with a precision balance (Fig. 8).

The moisture content of paddy (f) was measured with the use of an electric resistance method. To measure both initial and final moisture contents, samples were taken from the above-mentioned 28 bags each. The changes of moisture content during the drying process in the samples were recorded from 3 thin layers (top, middle and bottom) in the whole depth of the paddy layer, at 3 spots on both slopes (left and right) each. Con-

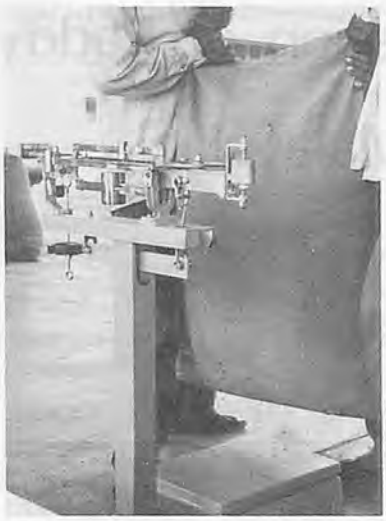


Fig. 8 Precision balance weighs removal of paddy moisture. –Laborers are carefully placing a bag of paddy onto a scale, not to spoil accurate adjustment of the balance.

sequently, 18 samples were recorded once.

Readings of the moisture meter were converted into the correct values of moisture content according to the following formula:

$Yi=1.01 + 0.907Xi$ (Here Yi: correct moisture content, %; Xi: reading of the moisture-meter, %.)

The moisture meter manufactured to suit Japonica rice varieties was calibrated to suit Indica varieties by a drying oven method for this experiment, and thus the above conversion formula was derived.

To determine the volume of airflow, the exhaust flow velocity (g) was measured at slightly above surface of the paddy layer by a thermal anemometer with platinum micro coil.

(3) Apparatus – The quantity of regular gasoline (h) was measured with a measuring glass cylinder, when the engine was fueled or refueled. Operation hours (i) were recorded at every starting and stopping time. The rotation speed of the fan (j) was checked with a tachometer of non-contact type 5 min after starting operation.

Fig. 9 Sampling paddy with a multi-pocket sampling stick.

Summary

The hypothesis that the second crop paddy could be dried up by forcing natural air (neither unheated by burning fuel nor warmed by solar energy) through a mass of paddy even in the rainy season to the moisture content low enough to be stored for a long period, has been proven by the demonstration experiment.

It seems that such a simple on-farm paddy dryer as the experimental apparatus falls within farmers' purchasing capacity if it can be fabricated mainly of local materials except the axial flow fan and some perforated iron sheets.

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Mechanization of Paddy Cultivation in West Malaysia

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Abstract

In a field survey, 120 farmers from three major irrigation schemes in West Malaysia were interviewed. It was found that most of the land preparation and harvesting activities in paddy crop production were done mechanically and the area under direct seeding increased significantly, due mainly to scarce and costly labor and improved timeliness.

Introduction

Malaysia consists of 13 states of which 11 are in West Malaysia and 2 in East Malaysia. The climate is tropical with an average temperature of 21-32°C and average annual rainfall of 3050-4060 mm (1). The agricultural sector of Malaysia provides employment for about 40% of the working population; agricultural exports account for 35% of the total gross export earnings and 23% of the gross domestic product (2). West Malaysia has a total area of 32 million ha and about 22% of it is arable land. The main food crop is paddy. In 1982, 492000 ha of paddy crop produced 1.47 million t, supplying about 90% of the domestic need of rice (3). About 75% of the paddy cultivated area is irrigated. There are four major irrigation schemes and over 600 small irrigation schemes. The largest is the Muda Irrigation Scheme which covers about 25% of the paddy cultivated area (4).

During 1970-80, the cultivated area increased by 30% while total active agricultural population grew by only 20.5% as given in **Table 1** (5). This, coupled with movement of labor out of the agriculture sector to other fast growing sectors (manufacturing, mining, construction and services) of the economy, has created farm labor shortage. This problem is acute in irrigated areas where farmers grow two crops, especially during land preparation-transplanting and harvesting-threshing seasons. In order to cushion the effect of this labor shortage, the use of two and four-wheel tractors for land preparation and combine harvesters for harvesting paddy crops have been introduced.

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Availability of Agricultural Machinery

Local Manufacturing

There are 10 tractor assembly plants and 35 manufacturers of agricultural equipment. Only two manufacturers (Howard Alat Pertanian Sdn. Bhd. and Kian Hup Bengkeo Basi) can be considered medium-scale manufacturers producing rotary tillers, tine tillers, trailers and seed-drills. Other manufacturers have small scale production of hoes, sickles, sprayers, seed-drills and rotary tillers. Agricultural equipment has no import tax in Malaysia and with limited local market and lack of research support facilities, there is very little incentive for their local manufacture.

Table 1 Ratio of Total Active Agricultural Population to Total Cultivated Area

Year	Total active agriculture population	Total cultivated area (ha)	Ratio	
			Person/ha	ha/Person
1970	1,714,600	2,765,036	0.62	1.61
1975	1,923,500	3,173,912	0.61	1.65
1980	2,066,900	3,621,094	0.57	1.75

Source: Fourth Malaysia Plan (1981), Government of Malaysia.

Imports

Most of the agricultural machinery needed in West Malaysia is imported. **Table 2** gives details of items imported during 1978-82. The annual import of 4-wheel tractors has been about 2000 units. Some of the items imported into West Malaysia are exported to East Malaysia and Brunei **(Table 3)**. According to the Department of Agriculture estimates there were 4514 tractors in use for paddy cultivation during 1982 (3). More than 80% of these tractors were 45 to 60 kW in size. In recent years the trend has been the use of 25 to 40 kW tractors.

Table 2 Import of Agricultural Machinery and Equipment

Items	1978	1979	1980	1981	1982
Four wheel tractor	2238	2259	2704	2311	1713
Two wheel tractor	397	431	124	57	529
Combine harvester	35	127	79	170	78
Other soil preparation machinery	430	260	488	652	789
Other harvesting and threshing machinery	83	433	570	632	165
Plough	326	442	557	646	491
Seed planter, fertilizer and manure spreader	99	269	272	344	282
Cultivators, weeders, hoes and harrows	533	1257	532	82	1056

Source: Import and Export Trade in Food and Agricultural Products (1982), Government of Malaysia.

Table 3 Export of Agricultural Machinery and Equipment

Items	1978	1979	1980	1981	1982
Four wheel tractor	173	254	272	597	181
Two wheel tractor	38	20	24	60	42
Combine harvester	–	3	1	8	1
Other harvesting and threshing machinery	25	192	32	28	99
Plough	161	158	8	26	92
Seed planter/fertilizer and manure spreader	14	38	33	19	22
Cultivators, weeders, hoes and harrows	397	778	252	112	175

Source: Import and Export Trade in Food and Agricultural Products (1982) Government of Malaysia.

Agricultural Machinery Ownership

West Malaysia

Based on the Department of Agriculture data for 1982 (3) individual farmers owned 41% of 4-wheel tractors, 65% of 2-wheel tractors and only 14% of combine harvesters **(Table 4)**. Most of the combines (80%) were owned by the contractors. Before 1981, there were more 4-wheel tractors with contractors than individual farmers.

Table 4 Ownership of Agricultural Machinery in West Malaysia, 1982

Owner	4-wheel tractor		2-wheel tractor		Combine harvester	
	Number	%	Number	%	Number	%
Department of Agriculture	478	10.6	140	4.1	17	4.2
Individual farmers	1872	41.4	2255	65.2	58	14.3
Contractors	1549	34.3	697	20.1	323	80.0
Farmers Associations and Cooperatives	615	13.6	368	10.6	6	1.5
Total	4514	100	3460	100	404	100

Major Irrigation Scheme Areas

Three major irrigation schemes, namely, Muda Scheme with 96000 ha in Perlis and Kedah States, Tanjong Karang Scheme with 21180 ha in Selangor State and Kemubu Scheme with 31480 ha in Kelantan State, account for about 40% of the total cultivated area under paddy crop.

Ownership of tractors in three major irrigation scheme areas is shown in **Table 5**. In the Muda area contractors owned the largest share (56%) of the 4-wheel tractors while the 2-wheel tractors were mainly owned by the individual farmers (83%). In the Tanjong Karang area, the number of 4-wheel tractors owned by the contractors and the individual farmers were 49 to 50 units, respectively. In the Kemubu area, farmers associations and cooperatives owned the largest share (38%) of 4-wheel tractors while the majority (62%) of 2-wheel tractors were owned by individual farmers. The total number of 4-wheel tractors in these three irrigation scheme areas (1216) represent only 27% of the total tractor population in paddy cultivation. However, the number of 2-wheel tractors (3174) represents 92% of their total number in paddy cultivation. Most of the combine harvesters are also used mainly in these irrigation scheme areas.

Table 5 Ownership of Tractors in Major Irrigation Scheme Areas, 1982

Owner	Muda		Tanjong Karang		Kemubu	
	4-wheel	2-wheel	4-wheel	2-wheel	4-wheel	2-wheel
Department of Agriculture	2	3	34	32	34	15
Individual farmers	190	1515	50	748	130	316
Contractors	310	230	49	36	151	158
Farmers Associations and Cooperatives	32	88	18	14	193	19

Field Survey

In consultation with the personnel of the Department of Agriculture and the Department of Irrigation and Drainage, one region in each of three irrigation schemes, namely, Hutan Kampong in the Muda Scheme, Sekinchan in the Tanjong Karang Scheme, and Nilam Puri in the Kemubu Scheme, were selected for the survey during 1984 (**Fig. 1**). A total of 120 farmers: 70 in Muda, 25 in Tanjong Karang and 25 in Kemubu, were selected at random from the selected regions of the irrigation schemes as shown in **Table 6** (6).

A questionnaire was prepared using a FAO publication (7) as basis. These questionnaires were placed before the farmers. Since most of the farmers had low literacy level, they usually did not keep any records of their farming operations (**Table 7**). Therefore, most of the information collected is based mainly upon the farmers' recollections.

Farm Size and Ownership of Land

Farm size distribution for the farmers surveyed is given in **Table 8**. The average farm size was 1.9 ha in Muda, 3.0 ha in Tanjong Karang and 1.2 ha in Kemubu. All the farms surveyed in Kemubu were below 3 ha. In Muda 87% and in Tanjong Karang 68% of the farms were below 3 ha in size.

Ownership of farmland by number of farmers as owner, tenant or owner/tenant is given in **Table 9**. Tanjong Karang had the highest percentage (76%) of owner farmers while Muda had the highest percentage (40%) of tenant farmers as well as the highest percentage (23%) of owner cum tenant farmers. Some 72% of the total land area was owned by the farmers in Kemubu, 62% in Tanjong Karang and only 43% in the Muda area (**Table 10**).

Fig. 1 Location of study areas in West Malaysia.

Table 6 Survey Sample Size

Irrigation scheme	Area (ha)	Household number	Sample size
a) Muda	96 000	60 000	70
c) Tanjong Karang	21 180	37 400	25
d) Kemubu	31 480	45 000	25

Table 7 Farmers' Educational Level

Educational level	Muda		Tanjong Karang		Kemubu	
	Number	%	Number	%	Number	%
No formal education	10	14.3	1	4.0	14	56.0
1-3 years	4	5.7	1	4.0	4	16.0
4-6 years	38	54.3	17	68.0	6	24.0
7-9 years	13	18.6	5	20.0	1	4.0
10-12 years	4	5.7	1	4.0	0	0.0
Above 12 years	1	1.4	0	0.0	0	0.0
Total	70	100.0	25	100.0	25	100.0

Table 8 Farm Size Distribution

Farm size (ha)	Muda		Tanjong Karang		Kemubu	
	Number	%	Number	%	Number	%
Below 1	20	28.6	1	4.0	10	40.0
1-2	17	24.3	9	36.0	12	48.0
2-3	24	34.3	7	28.0	3	12.0
3-4	5	7.2	5	20.0	0	0.0
4-5	2	2.8	2	8.0	0	0.0
Above 5	2	2.8	1	4.0	0	0.0
Total	70	100.0	25	100.0	25	100.0

Table 9 Tenure Status of Farmers' by Ownership

Status of farmer	Muda		Tanjong Karang		Kemubu	
	Number	%	Number	%	Number	%
Owner	26	37.1	19	76.0	15	60.0
Tenant	28	40.0	4	16.0	6	24.0
Owner/Tenant	16	22.9	2	8.0	4	16.0
Total	70	100.0	25	100.0	25	100.0

Table 10 Percentage of Land Ownership by Land Area

Status	Muda		Tanjong Karang		Kemubu	
	Area(ha)	%	Area(ha)	%	Area(ha)	%
Owner	55.4	42.7	46.5	62.0	21.3	72.0
Tenant	74.1	57.3	28.5	38.0	8.3	28.0
Total	129.5	100.0	75.0	100.0	29.6	100.0

Mechanization of Field Operations

Land preparation – much of the land preparation in irrigation scheme areas is done mechanically using 4-wheel and 2-wheel tractors. The most common equipment used was the rotary tiller. Land was usually prepared under wet conditions. In

some fields where soils were too soft, especially in coastal areas in the Kemubu Scheme, land preparation by the use of animals and man was practiced. Farmers also used animals or manual labor for land preparation when their fields were not accessible by a tractor or were too small in area. There were only five farmers, all in the Kemubu area, who did not use tractors for plowing.

Out of a total of 120 farmers surveyed, 115 of them (96%) used tractors for tillage. The most common reasons for using tractors (owned or hired) for land preparation were: faster than animal plowing, better quality tillage, shortage of and costly labor, need for double cropping, allows more time for non-farm work and because other farmers were also using tractors **(Table 11)**. Only 13 farmers (11%) cited cheaper cost as a reason for mechanical tillage.

The rates for plowing charged by the contractors varied from area to area. The average rate of charge per ha was U.S. $37 (31-44) for Muda, $33 (21-41) for Tanjong Karang, and $ 31 (28-38) for the Kemubu area. The payment for tractor hire services was mainly made in cash by the farmers, Muda (75%), Tanjong Karang (92%), and Kemubu (68%).

Harvesting – The use of combine harvesters was introduced into Malaysia during the mid-1970s. The use of combine havesting has expanded very rapidly. Much of the rice crop in Muda (with 330 combines and Sekinchan in Tanjong Karang with 58 combines) is harvested with the use of combines (8). The Kemubu area has only 16 medium-sized combines operated by the Department of Agriculture. However, some of the contractors for the Muda and Tanjong Karong areas take their combines to the Kemubu area during harvesing season.

During the survey it was found that 97 farmers (81%) who used combines for harvesting their crops cited labor being costly and scarce, faster and cheaper than manual harvesting as the main reasons **(Table 12)**. Another reason given was that combine harvesting provided them with more time for non-farm work.

All 23 farmers who did not use combines for harvesting were in the Kemubu area. Nineteen of them said that no combines were available for rent in their area. Other reasons cited for not using combines were, fields too small, no labor shortage, too expensive to hire a combine, fields not accessible to combines and being satisfied with manual harvesting **(Table 13)**.

The charges for combine rent were about the same in all three schemes. The average charge was about $92/ha with a range of $81-103. Payment of these charges was mostly by cash. The large combines had average field capacities varying from 0.67 to 0.85 ha/h.

Two major problems with the use of combines in wet rice fields were trafficability and creation of deep ruts. These ruts create tremendous problems at the time of land preparation, especially when using a 2-wheel tractor or even a small 4-wheel tractor.

Planting – In addition to land preparation and harvesting the other peak period demanding labor in paddy cultivation is transplanting. Due to the scarcity and high cost of labor, a number of farmers have switched to direct seed planting instead of transplanting in the

Table 11 Reasons for Hiring Tractor for Plowing

Reason	Muda		Tanjong Karang		Kemubu	
	Number of farmers	%	Number of farmers	%	Number of farmers	%
No. of respondents	70		25		20	
Faster work	67	95.7	25	100.0	5	25.0
Better tillage	58	82.9	25	100.0	10	50.0
Cheaper plowing	7	10.0	5	20.0	1	5.0
Shortage and costly labour	45	64.3	25	100.0	2	10.0
Others are using	5	7.2	18	72.0	3	15.0
More non-farm work	19	27.1	10	40.0	1	5.0
Need for double cropping	16	22.9	25	100.0	5	25.0

Table 12 Reasons for Using Combine Harvesting

Reason	Muda		Tanjong Karang		Kemubu
	Number of farmers	%	Number of farmers	%	Number of farmers
No. of respondents	70		25		2
Labour shortage and costly	70	100.0	25	100.0	2
Faster than manual	57	81.4	25	100.0	2
Cheaper than manual	44	62.9	19	76.0	2
Can do more non-farm work	12	17.1	10	40.0	1

Table 13 Reasons for not Using Combine Harvesting (Kemubu only)

Reason	Number of farmers	%
No. of respondents	23	
Area too small	14	60.9
Fields not accessible	5	21.7
No such service available	19	82.6
No labour shortage	18	78.3
Too expensive to hire a combine	15	65.2
Statisfied with manual harvesting	4	17.4

Tanjong Karang and Muda areas.

In the Tanjong Karang area, direct seed planting was started in 1973, when a farmer manually seeded pregerminated seeds in furrows. At present, a number of local manufacturers are producing seed-planters. In 1982, 2364 ha of paddy crop (11%) was direct-seeded. In this area, immediately after harvesting, the paddy stubbles are cut, dried and burned. First application of herbicide is followed by rotary tilling under dry soil conditions. After 7 to 10 days, a second application of herbicide is made depending upon weed infestation and is followed by rotary tilling and seeding in one operation using a 4-wheel tractor. Dry seeds are planted in hills (about 12 seeds per hill) 30 cm apart. Most common row-to-row spacing is also 30 cm.

In the Muda area direct seeding was started in 1977 on a 9-ha pilot farm . By the second season of 1982, direct seeded area increased to 18575 ha, representing about 20% of the area under paddy crop (8). The common practice is to prepare land under wet conditions, usually by rotary tilling twice and levelling and then broadcast the pre-germinated seeds manually.

Although many farmers have adopted the direct seeding method of planting, the majority of the farmers still use the traditional method of manual transplanting where water control is poor, less time available for land preparation, poor crop care, competition from weeds and uneven crop stand.

Summary

The market for large agricultural machines like tractors and combines in Malaysia is small. At present these are all imported. The ownership of tractors is mainly by individual farmers and contractors. It is expected that the ownership of tractors in the future will shift more to individual farmers. The majority of the combines are owned by contractors and are expected to remain so in the future.

Much of the land preparation in the irrigation scheme areas surveyed, was done mechanically using 4-wheel and 2-wheel tractors, usually under wet conditions using rotary tillers. The main reasons for mechanical tillage were: fast operation enabling double cropping (timeliness), better quality tillage, shortage and costly labor, and more time for non-farm activities.

Much of the paddy crop in Muda and Tanjong Karang was mechanically harvested using combines. Main reasons for using combines included scarce and costly labor, faster and cheaper than manual harvesting and more time for non-farm work.

Due to scarcity of labor and its high cost, a number of farmers have switched to direct seeding in place of transplanting.

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Losses of Rice during Milling in Commercial Rice Mills of Sri Lanka

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Abstract

This study was conducted to evaluate three main types of commercial rice mills, namely; the modern rice mill, semi-modern rice mill, and the traditional steel huller mill used for small scale rice milling in Sri Lanka. The evaluation was based on milling quality and milling losses.

The total milling out-turn of the modern rice mill was 69.2% while that of the semi-modern and traditional huller mill were 68.8 and 67.5%, respectively. The modern rice mill gave the highest head rice yield of 66.1%, and the traditional huller mill gave the lowest value of 60.3%. The impurities in milled rice was 0.3% for the modern rice mill, 0.5% for the semi-modern rice mill, and 0.7% for the traditional huller mill. The quantity of bran received from the traditional huller mill was high but low in quality.

Introduction

The paddy/rice industry in Sri Lanka has increased its activities in the the recent past. The objective of reaching self-sufficiency in rice has resulted in increased rice production. However, storage and processing capacities are barely sufficient to handle the increased production. This coupled with other losses during the post harvest operation makes the rice production system inefficient.

Munasinghe (1979) has estimated that of the total post-production paddy losses in Sri Lanka, about 2-5% occur during milling, involving the removal of husk and bran from the paddy grain in order to produce edible rice. Losses during milling are mainly due to the adoption of diverse milling techniques, some of which are traditional.

The milling process is done with equipment ranging from the simplest pestle and mortar to the large complex modern systems. Since large quantities of paddy are lost during the milling process, milling of paddy requires properly designed efficiently operated equipment.

The main commercial rice mills in Sri Lanka consist of traditional huller mills, semi-modern and modern rice mills. A comprehensive evaluation of different rice mills is important with a view to improving and eliminating the non-uniformity of milling techniques. This would also help in obtaining a higher yield of good quality edible rice.

Materials and Method

Sample Preparation

A homogeneous bulk sample of paddy (variety BG11-11) was used for the experiment. All paddy samples were parboiled under similar conditions.

Paddy was soaked in cold water for 45 h. The water used for soaking was drained off and steamed for 15 min. A batch type mechanical drier of 2.5 t capacity was used for drying. The time required to dry the parboiled paddy was 6 h without tempering. Tempering was done for about 14 h. After drying, the paddy was transferred into several paddy bins for mixing. Before sampling, the paddy was cleaned using a single action aspirator precleaner. Cleaned paddy was then transferred into gunny bags and samples of 500 kg were prepared.

Laboratory Paddy Test

Representative samples of paddy before and after parboiling were milled by taking 25 g lots from each bag of paddy used for the experiment. These 25 g samples were analyzed in the laboratory for the following.

1) Moisture content.
2) Impurities and foreign matters.
3) Varietal mixing.
4) Empty and partly filled grains.

5) Sun-checked grains.
6) Milling quality of paddy.

Selection of Rice Mills

The rice mills selected for the study was based on the types of milling machinery used. The traditional huller mill consisted of two steel hullers with one winnowing fan and no paddy /rice handling equipment. Manual methods were used to handle paddy and rice. The semi-modern rice mill consisted of one paddy pre-cleaner, one rubber roll sheller for husking, two steel hullers for polishing, one winnowing fan and two elevators. The modern rice mill used in the study consisted of a paddy pre-cleaner, two rubber roll shellers, one tray type paddy separator, two vertical cone polishers and elevators.

Experimental Procedure

A trial milling run was carried out before each test run using a similar quantity of paddy that was to be used in the experiment. This allowed the proper adjustments of processing units, filling of the empty spaces in the conveying system, flushing of previous paddy/ rice and making sure that the mill was in good condition for the experiment. A prepared sample of paddy for each test run was fed into the rice mill after each trial run. The following observations were recorded.

(a) Weight of paddy
(b) Weight of polished rice
(c) Weight of bran
(d) Time taken for the different milling operations

The degree of polish given to the rice was fixed at about 7.5%. This was assessed by visual comparison with the rice from a standard rice sample prepared in the laboratory rice mill.

Laboratory Analysis of Milled Rice

Representative samples of milled rice from each replicate were analyzed in the laboratory for head rice yield, percentage of brokens and percentage of impurities. Impurities were separated from rice using a small wire mesh.

Results and Discussions

Milling Quality of Paddy

The results of the laboratory analysis of paddy samples, both in raw and parboiled form, are given in **Table 1**. Although the percentage of sun-checked grains was high in raw paddy, it decreased after parboiling. The cleaning operation after parboiling resulted in a decrease in the percentage of impurities such as empties and partly filled grains in comparison to the raw paddy.

The total milling out-turn of raw paddy was slightly higher than that of parboiled paddy. The head rice yield was 26% in the raw paddy and 68% in the parboiled paddy. Only 3% of brokens were observed in parboiled paddy while in raw paddy 59% of brokens were observed.

Total Milling Out-turn

Table 2 shows the total milling out-turn of the different types of rice mills. The differences in total milling out-turn among the laboratory rice mill, the modern rice mill, the semi-modern rice mill and the traditional huller mill were significant at 5%.

The milling out-turn of the laboratory rice mill was 69.6% at 7.5% bran removal. This milling out-turn can be considered to be the potential milling out-turn. However, such a high milling out-turn cannot be expected under commercial scale because of their lower rate of efficiency.

The milling out-turn of the semi-modern rice mill was 68.7% and that of the traditional huller mill was 67.5% (**Fig. 1**). Among the commercial rice mills, the highest total milling out-turn was observed in the modern rice mill and the lowest milling out-turn was in the traditional huller mill.

The observed value for the milling out-turn of the modern rice mill disagreed with the observations of Bhole and Bal (1973) and FAO (1980), but agreed with the observations of Wimberly (1972). This difference of milling out-turn may be due to the difference in the degree of polish given to the brown rice. As the degree of polish increases, the milling out-turn automatically decreases. The degree of polish given in the experiment was as high as 7.5%.

In the study of FAO (1980),

Table 1 Quality Test of Paddy, %.

Quality criteria	Raw paddy	Parboiled paddy
Moisture conent	13.9	13.4
Impurities	2.2	0.4
Varietal mix	2.9	3.1
Sun-checked grains	73.8	18.7
Empties and partly filled grains	2.7	0.9
Total milling outturn	70.5	69.6
Head rice yield	26.8	68.2
Brokens	59.3	3.3
Bran removal	7.4	7.5

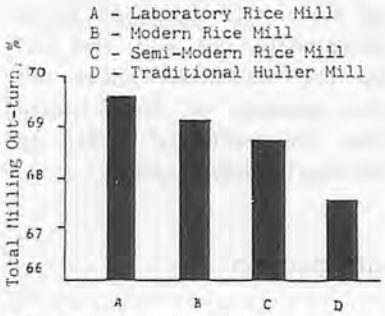

Fig. 1 Total milling outturn.

Table 2 Milling Quality of Different Types of Rice Mills, %.

Quality criteria	L.R.M	M.R.M	S.M.R.M	T.H.M
Total milling out-turn	69.6	69.2	68.8	67.5
Head rice yield	68.2	66.1	65.0	60.3
Brokens	3.3	4.4	5.0	10.8
Impurities	–	0.3	0.5	0.7
Amount of bran (kg)	–	86.9	135.5	130.8

the degree of polish was 5-6%. The degree of polish was not reported by Bhole and Bal (1973).

In the traditional huller mill, a 1.6% lower rice out-turn was recorded than that in the modern rice mill. Although a 0.4% lower milling out-turn was recorded in the semi-modern rice mill than that of the modern rice mill, the difference was non-significant (**Table 3**). In other words, a loss of 1.6 kg of rice for each 100 kg of paddy occured when the traditional huller mills were used.

Table 3 Comparison of Milling Qualiy of Rice Mills, %.

Quality criteria	LRM-THM	LRM-SMRM	LRM-MRM	MRM-THM	MRM-SMRM	SMRM-THM
Different in milling out-turn	** 2.1	* 0.8	NS 0.4	** 1.7	NS 0.4	** 1.3
Different in head rice yield	** 7.9	** 3.2	** 2.1	** 5.8	* 1.1	** 4.7
Different in broken grains	** 7.5	** 1.7	** 1.1	** 6.4	* 0.6	** 5.8
Different of impurities in milled rice	–	–	–	** 0.4	* 0.2	** 0.2

LRM - Laboratory rice mill; MRM - Modern rice mill; SMRM - Semi-modern rice mill;; THM - Traditional huller mill, **- Significant at 1 percent; *- Significant at 5 percent; NS - Non-significant.

Head Rice Yield

The head rice percentage of milled rice under different milling conditions are given in **Table 2**. The head rice yields were significant at 0.1%.

The highest head rice yield of 68.2% was obtained from the laboratory rice mill while the lowest value of 60.3% was obtained from the traditional huller mill. The head rice yield of the modern rice mill was 66.1% against a potential head rice yield of 68.2% and that of the semi-modern rice mill was about 65.0% (**Fig 2**). The value obtained from the traditional huller mill agreed with the observation of Ruiten (1971). **Table 3** shows the differences of the head rice yield among different type of rice mills.

The value for the head rice yield between the modern rice mill and semi-modern rice mill was significant at 5% while the values between the modern rice mill and traditional rice mill, as well as the semi-modern rice mill and traditional rice mill was significant at 1%.

Fig. 2 Head rice yield.

The head rice yield of 66.1% obtained from the modern rice mill was the highest value that can be expected under the commercial scale. In comparison with this value, a loss of 5.9% rice yield occurs from the use of the traditional huller mill and 11% from the use of the semi-modern rice mill, for milling paddy.

Percentage of Brokens

The percentage of broken grains in milled rice showed a wide variation and was significant at 0.1%. The values of broken grains for different mills are shown in **Table 2**.

In the laboratory rice mill, the percentage of brokens are as low as 3.3 while that for the traditional huller mill is as high as 10.8 (**Fig. 3**). The broken grains in milled rice of the modern rice mill was 4.4% and that of the semi-modern rice mill was 5.0%. The percentage of brokens of the modern rice mill agreed with observations of Bhole and Bal (1973). The differences in the percentage of brokens among the rice mills are given in **Table 3**.

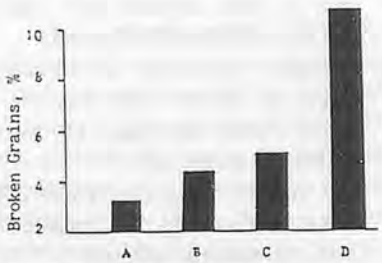

Fig. 3 Rate of broken grains.

The results indicate that a higher percentage of brokens (6.4%) were recorded in the traditional huller mill than the modern rice mill and a higher percentage of brokens (4.8%) were recorded in the traditional huller mill than the semi-modern rice mill. The difference in the percentage of brokens between the modern rice mill and the semi-modern rice mill was only 0.6%.

In the traditional huller mill, both operations of hulling and polishing, are done with a steel huller. During the milling operation the paddy grains are subjected to excessive pressure and friction. As a result, grains tend to break and the percentage of brokens in milled rice increased in the traditional huller mill.

On the other hand, both operations of milling (shelling and polishing) are done separately in the modern rice mills and the semi-modern type rice mills although different equipment is used in the two mills. Rubber roll shellers were used for shelling paddy both in the modern and semi-modern types. The tendency for grains to break in the rubber roll sheller is minimum. Therefore, the percentage of brokens in the traditional huller mill was higher than that of the modern and semi-modern rice mill.

Most rice consumers in Sri Lanka separate broken grains from milled rice before cooking. Rice with a high percentage of brokens becomes sticky when cooked and has a poor consumer preference.

The quality of milled rice in the traditional huller mill was lower than that of modern and semi-modern rice mill.

Impurities in Milled Rice

The percentage of impurities in milled rice from the different rice mills are indicated in **Table** 2. The percentage of impurities in milled rice of the traditional huller mill was 0.7% and that of semi-modern and modern rice mills were 0.5% and 0.3%, respectively.

A comparison of percentage of impurities in milled rice is shown in **Table** 3. The impurity content found in milled rice obtained by the traditional rice mill was 0.4% higher than that of the modern rice mill.

In the case of the modern rice mill, a major impurity was pure bran. In the traditional mill, a major impurity was husk. The husk should be separated by winnowing before cooking. A high percentage of impurity in the milled rice decreases the percentage of edible rice. Therefore, rice from the traditional huller mill has a low market value than that of the modern rice mill. In other words, a loss of 0.4 kg of rice per every 100 kg of rice can be expected when the traditional huller is used.

In the modern rice mill, husk and bran are separated by aspiration before and after polishing. Therefore, the polished rice was free from husk but contained a little quantity of bran. Although the husk is separated after polishing with a winnowing fan in traditional milling, a certain amount of husk still remains in the milled rice.

Quality of By-products

The bran obtained from the modern rice mill was in a pure condition and can be categorized as grade one bran. In the traditional huller mill, the bran is not pure. The bran from the traditional huller mill was mixed with husk. The husk has to be separated from bran before marketing. The bran of the traditional huller mill could then be categorized as grade two bran.

The quantities of bran from the different rice mills are given in **Table** 2. The amount of bran after separation is given for the traditional huller mill. The quantity of bran is higher in the semi-modern rice mill than in the traditional huller mill and the modern rice mill. The difference was 4.7 kg between the semi-modern rice mill and traditional huller mill, and 43.9 kg between the traditional huller mill and modern rice mill. The bran obtained by the traditional rice mill was higher in quantity but lower in quality compared to the modern rice mill. The low quality results in a lower price in the market.

Conclusions

1. This study indicated that the quantity and quality of rice as well as the by-products of milling are decreased by using the traditional huller mill.
2. The highest total milling outturn of about 69% could be obtained from the modern rice mill when compared to the semi-modern and traditional rice mill.
3. There is a difference of about 0.4% in the total milling outturn of the modern rice mill and the semi-modern rice mill. There is a marked difference of about 1.6% in the total milling outturn of the modern rice mill and the traditional huller mill.
4. A higher percentage of broken grains of about 10% was observed with the use of the traditional huller mill.
5. The highest head rice yield of about 60% could be obtained from the modern rice mill.
6. A considerable amount of impurities in rice was found with the use of the traditional huller mill.
7. High quality bran could be obtained from the modern rice mill. The use of traditional huller mill results in poor quality bran.

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Mechanization of Small Farms in Tropical Africa

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Abstract

The main theme in the appropriate mechanization of small farms, is that the technology should provide financial incentives and be within the purchasing power of small farmers. The small farmer is a hand tool user in tropical Africa. Because of the arduous nature of hand work, especially in primary tillage, the hand farmer favours the concept of minimum tillage. Also, due to the severe limitations and the farmer's inability to control nature, he has, therefore, evolved rather strict systems of cultivation practices.

The tools of the small farmer are inexpensive and easy to repair but cannot keep a true sharp edge because they are made out of scrap metals.

Animal power is new in tropical Africa, except for Ethiopia. It has gained much acceptance in Francophone countries of West Africa and the Gambia, and the countries of Eastern Africa. This acceptance has been due mainly to the training programmes and extension services instituted by the governments of these countries.

If the hand farmer of tropical Africa is to become more productive, he must have access to improved tools. He must have tools which permit him to do his work more effectively, not just to save labour, but to do more work with greater accuracy, speed and ease.

Before any attempt is made to introduce innovations the existing cultivation pattern must be sufficiently analysed to define both its advantages and disadvantages. There is a paucity of locally tested innovations recommendable to the small farmer with limited resources.

At this stage of development, more systematic and earnest attension need to be focussed on the needs of the emerging commercially-oriented hand and animal powered farmer. He can be assisted by the wise application of selected units of improved hand, animal and engine-powered systems, to overcome traditional constraints, and to eliminate bottlenecks as they develop in his intensification programme.

Introduction

African economies are primarily agricultural, and a key to economic development for nations in tropical Africa is to raise the productivity of the agricultural sector. Agricultural production may be raised by either increasing the land already under cultivation or by mechanization. Mechanization is an important input which facilitates increasing agricultural productivity, but it is impracticable unless there is also means for profitably disposing of the resulting increases, through commercial outlets. Thus, the mechanization of agriculture and the development of commercial and social organizations are concomitant factors in the economic development of tropical Africa.

The way to increase production and productivity in tropical Africa is a problem which requires careful review and considerable shifts in agricultural policies and production programmes. In the first place, the land tenure structure in tropical Africa shows an over-whelming mumber of small holdings. Secondly, the agricultural population which comprises a very large portion of the rural population is comparatively the poorest segmnent of the African society. In addition, a large percentage of the population has benefited only marginally from recent development in agricultural production technology. Major benefits, even in the recent seed-fertilizer technology have gone mainly to the bigger farmers. Thus, the gap batween the rural and urban sectors will continue to widen unless determined and continuous efforts are made to remedy the present situation.

This highlights the need for

emphasis on the small-farm sector in the agriculture of tropical Africa. The small farm worker offers considerable potential for increasing the agricultural output and income of the farming and agriculture-based community, and thus will help reduce poverty and under-employment. Although these small farms individually are small in size, together they constitute a major portion of the total agricultural output.

The development and adoption of an appropriate mechanization scheme to suit varying conditions would considerably increase their productivity and incomes. Even a small increase in productivity on individual small farms would add up to a substantial increase in the gross production. At present, there is a vast potential for bringing land under cultivation in tropical Africa at comparatively low costs. This land can be added to increase the size of small farms and to make them viable and capable of adopting improved technology. Even then, a vast majority of farms will still remain small and their production problems will also have to be studied, appreciated and where possible, solved.

The Small Farm and its Mechanization

It is important to define the term "small farm". It is indeed difficult to give a precise definition of a small farm; but its definition depends on a number of factors like the nature of the soil, rainfall, irrigation facilities, crops grown, proximity to the market, credit and marketing facilities and management know-how. A definition that could be easily applicable is that, a small farm is a unit of land which under given agro-climatic conditions cannot afford to invest in the elements of modern production technology particularly, in respect of lumpy resources. The F.A.O's definition of the small farm is; "Those who are socially, economically or culturally marginal. They constitute groups with limited or no access to productive resources and technology, or to credit and with little or no bargaining power on the market."(1) This definition for the purposes of this paper will suffice.

The first answer to the mechanization of small farms lies in changing their organizational structure. Through the introduction of corporate or cooperative farming, several of the problems of small size can be solved. In this case, it will remove small farms but not the small farmers. In other words, small farmers will collectively operate large enough farms to absorb all the elements of improved production technology. This at any rate cannot solve the size problem of all small farms due to their scattered nature and varying socio-economic conditions and values.

Thus attention should be focussed on the appropriate mechanazation suitable to small indivudual farms for achieving their full potential in production. Appropriate mechanization for small farms must fulfil the following criteria:

(1) It should provide incentive to small farmers for its adoption, that is, it should bring adequate economic returns to them. Farmers are usually responsive to new technology if they are convinced of its benefits;

(ii) It should be within the purchasing power of small farmers. If the technology is too expensive, it would not be so readily taken up by small farmers unless necessary easy low-cost-credit facilities are also made available to them;

(iii) The new technology should also be made available to small farmers preferably at or near their farms;

(iv) It should not only be economical in the abstract sense but should be appropriate to the size of the holding;

(v) It should be dependable and should not involve fewer risks. As small farms are usually operating at subsistence level, they have very little risk absorbing capacity;

(vi) It should be simple to operate, easy to understand and does not require much change in the existing farming systems.

(vii) Mechanization technology may be very appropriate for improving land or labour productivity, but if the need for easy and low-cost repair facilities are not forth coming to ensure dependability, the adoption of this technology would not meet the needs of the farmer.

(viii) In some cases the introduction of an appropriate technology would demand, as a complement to it, the availability of other agricultural inputs. Therefore, it is essential that complementary inputs are provided. Otherwise, the technology might result in lowering rather than increasing yields and hence its adoption would fail.

The above are the main guidelines that determine whether mechanization is appropriate for exploiting the full potential of small farms. However, one point should be stressed, particularly for those dealing with or are responsible for adaptive research. The technology that is recommended to the farmers should evolve through trials and tests under local conditions. Only very seldom can imported technology from countries outside tropical Africa where climate, economic, social and political conditions are different, succeed.

Traditional Equipment and Tools

While the vital roles of labour supply in tropical African agriculture is gradually receiving more attention, inadequate recognition of its importance has been a prominent cause of failure of many past efforts to increase output. Efforts to get farmers to plant earlier have repeatedly failed because there was not enough labour available at the recommended time, and no provisions have been made to introduce implements to relieve the labour bottlenecks. Improved farming systems in tropical Africa should be labour intensive due to shortage of capital and under-employment of labour. It is, therefore, important to identify the nature and seriousness of peak labour requirements. In areas where the growing season is short, owing to the pattern of rainfall, or where the hoe is the only implement, both sowing and weeding frequently constitute a single bottleneck, since the weed problem tends to become acute before all the land is sown. Sometimes the preparation of the land, rather than sowing and weeding, is the bottleneck. Where there is considerable rainfall, and a lot of bush, the clearing of the land for cultivation may be the limiting factor, at least for crops grown at the head of a rotation.

In tropical Africa, the typical small farmer is a hand tool user. While a great variety of hand tools exists, there is a remarkable similarity in tools among countries and regions. Because of the arduous nature of hand work, especially in primary tillage, the hand farmer favours the concept of minimum tillage. Where there are distinct dry and wet seasons with hard soils, intense rainfall and critical planting times, the farmer has to compensate to get his crops in no time and to plant a sufficient quantity to feed his family. As a result of the severe limitations and his inability to control nature, he has evolved rather strict systems of cultivation practices which assure him a food supply with the least risk of failure.

The tools of the small farmer are made generally by local artisans; they are inexpensive and easy to repair. Farmers who seldom know about anything better, are satisfied and make up for deficiencies in design and materials by increasing human efforts or by improving dexterity. Most tools are made out of scrap metal; rural blacksmiths seldom know how to temper metal so that it will keep a true sharp edge. Tools soon become dull, are seldom sharpened, and farmers continue to use them until they are worn beyond use.

Considerable improvement can be made in present designs if metal parts are made of properly tempered high-carbon steel which lasts longer and holds a cutting edge. Design improvements for all tools should consider balance, manipulation and weight. Tools which effectively utilize man's strength, without being too heavy or causing undue fatigue, would be a marked advance toward greater efficiency. The hand labour economy represents a system of farming which has evolved over generations to meet the basic needs of the people of tropical Africa. The system maintains a balance, and the people have confidence in its capacity to provide a sufficiency for survival.

Animal power is relatively new for most parts of tropical Africa; only in Ethiopia is there a long tradition of using oxen. In Nigeria and Ghana, the first government support for animal powers was initiated in the 1920s and 1930s. In Francophone countries, emphasis on animals for farm power began in the 1930s; and more emphasis has been placed on improved animal-power in the Francophone countries of West Africa. In Gambia, a seires of programmes and schools for training farmers and animals was started in the late 1950s[2]. These have been relatively successful in assisting subsistence farmers to enter the commercial agriculture stage. In Tanzania and elsewhere in East Africa, ox-ploughing schools were established to train farmers and oxen in this new technique, but continuous government support was necessary to maintain farmers' interest.

The application of engine power enables man to become a director of almost unlimited power. However, engine power is costly and, in order to utilize this power economically, high management and technical skills must be employed along with other inputs. The greater problem here is rational selection, operation and maintenance of the machine system so that the costs do not exceed the benefits. For the small farmers, this is a difficult requirement since the prices for their crops and the size of their holdings restrict their potential income. Al Le Quinio (1967) points out, "in French speaking West Africa, they have found that mechanization can only be profitable when applied to export crops."[3]

African countries are using several approaches to introduce engine-powered agriculture into their communities. For the small farmer who wishes to hire machinery, several governments provide tractor hire services; a few larger farmers or contractors do custom work for others; cooperatives are formed to offer machinery services, or several farmers form private machinery groups. Engine power mechanization can range from a single operation of ploughing to a complete mechanized system. There are very few examples of the latter in African agriculture even on commercial plantations. Most hand-powered farmers find it to their advantage to utilise engine

power only when it offers a specific proven advantage.

Improved Tools and Equipment

In developing countries of tropical Africa, more and better machinery is needed, not as labour-saving devices, but to increase the productivity of the small as well as the large farmer. It should be realized that for many decades to come, the bulk of all farmers in tropical Africa will be using hand and animal-powered tools and practices; along with improved tools and machines that could be introduced on a broader and cheaper scale.

Government officials, planners and administrators must be well informed if they are to deal with present practical reality rather than with theoretical goals. These officials must be cognisant of the improved tools currently available within tropical Africa and from other regions. For example, tools that are presently performing satisfactorily under similar conditions in Asia and in the Far and Near East may be suitable for use in parts of Africa. There are tools which can be easily introduced to improve present traditional practices, but tests must be conducted and tools evaluated under carefully controlled programmes of adaptive research and farm trials to ascertain their suitability and profitability to small farmers.

At the present time, engine and mechanical power available to the farmers of tropical Africa averages only a fraction of the more than 1 hp/ha utilized by farmers in Europe and the United States. This lack of power makes it difficult to prepare seedbeds efficiently and with timeliness, to place seed and fertilizer accurately, use improved tools and methods to control weeds, apply pesticides, all of which can contribute markedly to improve yields and to the economic utilization of mechanization inputs.

There is a large latent demand for improved tools and machines in the countries of tropical Africa. Studies, surveys and research projects have shown that the small African farmer is not against change. They do not request different tools because they do not know of anything better. Hence, they continue to use what they have.

In discussing animal-powered or engine-powered agriculture in the tropics, it must be kept in mind that within each level of mechanization there are necessarily degrees of application of hand-power. Rarely, if at all, is there what can be called a pure animal-powered system or a pure engine-powered system. Even very advanced systems using large tractors retain the use of hand-power and animal-power in complementary operations.

If the hand-powered tropical African farmer is to become more productive, he must have access to improved tools. He must have tools which permit him to do his work more effectively, not just save labour, but to do more work with greater accuracy, speed and ease.

Animal power is important to the further development of agriculture in tropical Africa. In many of the countries its use and improvement tends to be overlooked although very satisfactory improved basic animal-drawn tools are available for promotion. It is evident as with hand tools that farmers need better equipment in most areas.

For the hand farmer, primary tillage and timely land preparation remains the critical task. Animal power with its ability to break, turn or ridge larger areas more quickly, has enabled the farmer to overcome some of this bottleneck. However, if the plough is his only tool, he is immediately confronted with another serious problem; he cannot look after and weed by hand all the land he can till and plant with animal power. Weeding becomes the limiting factor in intensified expanded animal-powered production, when all operations subsequent to tillage must be done by hand.

For the capable and progressive farmer, a better choice would be one of the multiple-purpose tool frames or tool bars which are available in both Western and Eastern Africa. The farmers like these tools and want to buy them, but they need assistance since the cost of the implement is beyond their resources. However, merely providing the tools on credit is not enough. An intensified training programme and supervised credit and farm-planning service are required to make sure the improved farmer and implement systems are put to work to raise better crops on more land with greater labour uitlization.

Because of the shortcomings of many small power units, officials, engineers and agronomists alike, tend to conclude that the small tiller or tractor is not suitable and has no place in the small cultivator's farming programme. There is a great deal of controversy over small engine-powered equipment, whether it fits into the agriculture of developing countries and just what kind of farmers, if any, should use it.(4) There is ample evidence, however, to show that certain small tractors can be beneficial and can do many tasks more economically than hand or animal power, especially in wet land preparations,(5) for example, power tillers or single-axle tractors. Tests also have been made by several models which have proved suitable for dry upland cultivation. These units can be used for farm work and are durable and simple enough to withstand severe operating condi-

tions, with a minimum of maintenance and care.

At this stage of development in tropical Africa, there is perhaps a need to be very cautious and selective in introducing small power units into the agricultural sector because of the small farmer's traditional lack of mechanical background and because of the shortage of adequate sales and service facilities to support him in rural areas. Unless the distributor has trained staff and locally-based unit equipped to back up any machinery sold, it becomes unwise for the average farmer to invest in any tool that he or the local blacksmith cannot repair and maintain.

The econimic value of small 4-wheel tractors has not been clearly established in tropical Africa. There are a few machines adequately designed which can be adapted to local conditions to perform effectively. However, they need to be carefully selected, tested and evaluated before any attempt is made to introduce them on a mass scale.

The Future Trend

If agricultural production is to be improved for the small African farmers, they must be informed about better tools and methods of using them. There are several ways in which improved hand-operated tools can assist small farmers and increase their efficiency. The first is to increase yields and producitvity of relatively scarce inputs by making efficient use of available resources. The second is to expand the size of operation to utilize fully available manual labour and tools within the energy limits of the best known farming system. This can be done by specializing in high-value crops or by diversifying to spread labour and resources over the entire year rather than concentrating on a single crop or season.

Before any attempt is made to introduce innovations the existing cultivation pattern must be sufficiently analyzed to define both its advantages and disadvantages. There is a paucity of locally-tested innovations recommendable to the small farmer with limited resources. This lack of tried and proven techniques has caused the extension service and agricultural advisers to make serious mistakes in the past in trying to tell African farmers how to improve their practices. Many technicians lack actual farm experience and, consequently, cannot gain the farmer's confidence. There is very little communication between the farmer and those responsible for planning and making decisions.

All national governments and regional bodies should become more aware of what is happening at the farm level and why farmers do certain things and avoid others. Steps should be taken to provide a supply of hand-operated machinery and equipment for the small farmer, since, for a long time to come, a substantial portion of African agricultural production will come from individuals who cannot afford to mechanize in any other way. Even if the traditional farmers are responsive to economic incentives, they do not search out new methods or inputs. Farmers' expectations must be changed; they must be alert, and they must also aspire to seek new possibilities to improve their position.

In an attempt to promote better tools, the extension services of the Ministries of Agriculture must be an active and constant participant in their respective localities. First, there must be many good extension agents in regular contact with farmers. This is a major problem in tropical Africa because of the scarcity of trained people and the shortage of funds to allocate to agricultural services. Secondly, extension agents must be convinced of the merits of the improved tools and practices they are demonstrating to farmers. Thirdly, they must get out into the field and work confidently with the farmers. To succeed, the improved tools must be integral parts of an overall programme; so the farmer accepts the tools as part of a package of improved farming practices. Also, there must be training programmes for the local artisans, who should be taught to repair and maintain such improved tools and equipment. The training programmes must be short and intensive to teach one specific thing; and there must be follow-up visits to the place of business. This is also just as true for farmers.

Much can be done to improve farmers' farming ability by increasing their knowledge of the basic services of agriculture. This can be done by helping them to develop new skills, by providing essential government services beyond the limits of their own resources, by creating favourable markets and incentives and by considering their needs.

There is much evidence to show that jobs such as seedbed preparation, general cultivation, plant protection, harvesting, threshing, water-pumping and land reclamation can be done more efficiently and with greater productivity by using tractors and engine-powered machinery rather than traditional hand-operated or animal-drawn implement. The question is not whether engine-powered machines are to be introduced into the agriculture of tropical Africa, but rather the nature, degree and pace at which they can be introduced to maintain economic efficiency in the farming system without causing serious social disruption.

Gradual and selective mechanization fitted to the needs and resources of each country will

permit the necessary time lag for sufficient progress to be made in the development of small industries. Surplus farm labour then can be absorbed into new and more attractive employment. When mechanization is chosen to complement, it also creates new labour opportunities in agriculture by bringing new land into production and by increasing overall crop production and yields.

Mechanization can be used as an analytical concept by categorizing forms of mechanical assistance into hand-, animal- and engine-powered farming. These three categories, when transferred into the dynamic process of economic development broaden into six formations;

(i) Three processes of improvement: in hand-powered implements, in animal-powered, and in engine-powered implements and;

(ii) Three processes of transition: from hand-powered to animal-powered technology, from animal-powered to engine-powerd technology and from hand-powered directly to engine-powered technology. (A reversal of the process is also possible).

An important principle in the analysis of agricultural mechanization is that of appropriateness. The case for reverting from tractor-power to oxen illustrates this principle; following careful analysis the Tanzanian government, for example, concluded that engine-powered technology was inappropriate to the current level of development in most of their economy. Thus, it should not be assumed that there is a natural sequence from hand-power through animal-power to engine-power. There are situations where conditions are appropriate to eliminate the animal-power stage by moving directly from hand- to engine-powered technology. However, a whole series of agricultural and general advances must be made before mechanization can be logically introduced.[6]

In other situations no shift is appropriate. Thus, forms of power cannot be arbitrarily related to levels of economic development. Rather, the developing economy should attempt to realize optimal returns, from total available resources, employing livels of power appropriate to the economic situation.

At this stage of development, more systematic and earnest attention needs to be focussed on the needs of the emerging commercially-oriented hand- and animal-powered farmer. He can be assisted by the wise application of selected units of improved hand-, animal- and engine-powered systems, to overcome traditional constraints, and to eliminate bottlenecks as they develop in his intensification programme.

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Agricultural Mechanization as a Catalyst for Rural Development

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Abstract

This paper discusses the role of agricultural mechanization in rural development. First, the problems of the rural poor are examined. The concepts and principles of agricultural mechanization are then explained. Results from relevant case studies are presented in discussing the potential impact of agricultural mechanization in rural development. It is finally argued that an integrated approach to agricultural development and rural development vis-à-vis a community-based agricultural mechanization is the surest path to a balanced economic development and socio-political stability in Nigeria.

Introduction

An assessment[1] of the overall performance of the agricultural sector over the past two decades points conclusively to its declining contribution to the Gross Domestic Product even though the value added by the sector has been rising in absolute terms. Nigerian agricultural export as a percentage of the total exports has steadily been declining[2]. This pathetic situation, given the primary role of agriculture in the socio-economic development of the country, is largely, but not exclusively due to the predominant contribution of petroleum to the Gross Domestic Product over the same period.

The huge wealth the oil industry has brought and, hopefully, will continue to bring to the nation is most welcome. However, the inability of the country to effectively utilize part of this wealth in increasing and sustaining agricultural productivity and enhancing rural development is most unfortunate, to say the least. The disparity in average incomes in urban and rural areas of Nigeria has been well documented[2]. A greater imbalance even exists between infrastructural developments in urban and rural areas, to the disadvantage of the latter and the detriment of the entire nation. These and other factors are responsible for the depopulation of our rural areas and the consequent over-crowding of our urban centres.

Rural Development

Rural development has been defined as:

(i) a process of not only increasing the level of per capita income in the rural area, but also the standard of living of the rural population; the standard of living depending on such factors as food and nutrition level, health, education, housing, recreation and security[3];

(ii) development of the rural people in such a continuous manner as to enable them to most effectively and efficiently utilize their intellect, technology and other resources for further development of both themselves and their resources[4];

(iii) part of the general economic development, which in itself is an increase in the material and non-material well-being of the people over time[5]; and

(iv) the process of rural modernization and the monetization of the rural society, leading to its transition from traditional isolation to integration with the national economy[6].

Thus the crucial element of rural development is the conception and implementation of any project that addresses itself to the solution of the most urgent problem in the rural areas – the problem of rural poverty. Rural development implies a focus on poverty. The process of rural development must integrate the rural poor into the social, political and economic life of the country.

The characteristics of the rural poor have been summarized[7] as follows:

(i) their standard of living is static

at best or declining;

(ii) they are generally engaged in agriculture working small plots of land either for themselves or as landless workers;

(iii) most are engaged in subsistence farming or generate only small marketable surplusess;

(iv) their family cash incomes are unlikely to exceed more than a few tens of Naira a year;

(v) they are mostly located in areas poorly served by almost all public amenities; and

(vi) among the rural poor there is generally considerable resistance to any change which involves financial risk.

These six characteristics of the rural poor clearly define the problems of the rural sector of the economy. Any programme aimed at alleviating these problems must of necessity be addressed to increasing and sustaining the productivity and incomes of the rural people. And since most of the rural population are involved in agriculture, their productive capacity can best be increased by increasing agricultural productivity.

The main objective of this paper is to show that the basic problems of the rural people can be alleviated by an appropriate mechanization of the Nigerian agriculture. The problems of poverty in rural areas cannot, of course, be completely solved by agricultural mechanization alone but a dynamic expansion of the non-agricultural sectors is also essential in order to provide employment opportunities for the ever increasing population.

Concepts and Principles

Agricultural mechanization is defined as the process of development and introduction of mechanized assistance of all forms and at any level of sophistication in agricultural production in order to reduce human drudgery, improve timeliness and efficiency of various farm operations, bring more land under cultivation, preserve the quality of agricultural products, provide better rural living conditions and markedly advance the economic growth of the rural sector. Thus, agricultural mechanization means more than the availability and use of tractors and modern equipment in agriculture. It does not necessarily imply large-scale mechanized farming.

Progress in successful introduction of mechanized methods in agriculture in Nigeria and other developing countries has been hampered by some arguments against agricultural mechanization. It is argued that since most of the motor-powered farm machinery being proposed for the developing countries were designed largely for the labour-scarce, capital-abundant economies of the developed world, introduction of such a sophisticated technology and labour-saving machinery into the socio-economic environment of an under-developed country "will almost certainly constitute bad economies and will bring with it the seeds of social discontent"[8]. Due to some apparent limitations posed by fragmentation of holdings; lack of capital, adverse cultural practices and crop types; illiteracy of majority of the farming population; inadequate infrastructural and maintenance facilities; unavailability of spare parts and the lack of sufficient trained manpower to cope with a foreign technology, the protagonists of agricultural mechanization recommend improvement in hand tools and the introduction of effective land reform.

In Nigeria, with the current disposition of both the public and private sectors towards technological advancement, the real issue is not whether mechanization should be introduced into the agricultural processes or not. The more important decisions should be made, based on systematic analyses and experimentation,[9,10] on how to promote mechanization, what operations and crops should be mechanized and what is the best approach to adopt in achieving the desired mechanization in each ecological zone of the country.

Agricultural mechanization is an inevitable consequence of any nation's desire to industrialize. It is often stated, and correctly too, that the spectacular achievements of agricultural mechanization in North America[11] and Japan[12] were largely due to the existence of viable industries and export economies. In the absence of such favourable conditions agriculture becomes the base for industry and both must grow simultaneously, each one complimenting the other. This fundamental interdependence has been stated as a maxim[13] as follows: agriculture supports industry and industry develops agriculture.

Potential Benefits

The major benefits of agricultural mechanization include:

(i) increased productivity of the land;

(ii) increased economic returns to the farmer;

(iii) improved timeliness and precision of operations;

(iv) reduced losses and improved quality of food products;

(v) improvement of the working environment;

(vi) reduction of the drudgery of farm work;

(vii) improved dignity of the farmer; and

(viii) increased agro-business activities.

Some of these banefits will be discussed quantitatively using relevant case studies. Efforts to ensure that the majority of the rural population participate fully in the generation and enjoyment of such benefits will justify agricultural mecha-

nization as an effective strategy for integrated agricultural and rural development in Nigeria.

Increased Agricultural Production

Mechanization of crop production increases total production by improving yields, expanding the agricultural area and increasing land use intensities. Optimum yields, especially from the new high yielding varieties, are dependent upon a package of inputs and practices being applied and performed in a precise and timely fashion. These facts are demonstrated with the results shown in **Tables 1 and 2**[14].

It is shown in **Table 1** that the application of appropriate mechanization inputs more than doubled the increase in wheat production achieved from using only fertilizer and improved seeds. **Table 2** shows that the percentage increase in the yields of rice, maize, wheat, sugarcane and oil seed ranged from 16.9 to 32.0% as a result of using tractorized cultivation instead of bullock cultivation. However, there was a decrease in the yield of cotton as a result of using tractorized cultivation instead of bullock cultivation. This single exception emphasizes the need for judicious choice and efficient application of mechanized methods.

Increase in Rural Income

The potential impact of agricultural mechanization on farmer's incomes is shown in **Table 3**, based on a study[15] in Senegal, West Africa. Estimated income per farmer in an irrigated rice system increased from ₦1,363.18* when all operations were hand-powered and the average size of farm was 0.25 ha to ₦3,576.97 when cultivation and threshing were mechanized and average size of farm was 0.8 ha. Increasing the average size of farm from 0.8 to 4.0 ha and using the same level of mechanization further increased the estimated income per farmer to ₦17,784.86.

*As a rough estimate, 1₦=US$1.4681

Table 1 Comparison of Average Incomes in Urban and Rural Areas in Nigeria

Occupational groups	Average incomes (₦)					
	1963			1970		
	Urban	Rural	Rural/ Urban	Urban	Rural	Rural/ Urban
Professional management and technical	3,686	974	0.26	3,930	1,034	0.26
Clerical and minor professional	476	308	0.65	628	380	0.61
Skilled and semi-skilled	328	196	0.60	476	274	0.58
Unskilled	160	102	0.64	190	112	0.59
Farmers	160	102	0.64	148	94	0.44

Source of Data: Olatunbosun (1975)

Table 2 Comparative Crop Yields Between Tractor and Bullock Cultivation (a)

Crop	Crop yield, kg/ha		Per cent increase due to tractorized operation
	Tractor cultivation	Bullock cultivation	
Rice	2275.5	1941.0	17.1
Maize	1926.4	1463.8	31.6
Wheat	1551.2	1176.9	32.0
Sugarcane	9553.6	8176.0	16.9
Cotton	959.8	1201.8	20.1
Oilseed	1080.8	896.0	20.6

Average % increase in yield for all six crops due to tractorized cultivation = 16.4.

(a) Calculations based on data from a farming district in India[14].

Table 3 Comparison of Farmers' Incomes in Mechanized and Non-Mechanized Irrigated Rice Farms(a)

Item of comparison per farmer per year	Mechanized		Non-Mechanized
	0.8 ha	4.0 ha	0.25 ha
Rice paddy output, kg	3,300	16,500	1,250
Total cost of production, ₦	322.06	1,328.88	75.07
Subsidized cost, ₦	146.81	695.14	36.82
Paddy rice sale, ₦	3,723.78	18,480.00	1,400.00
Calculated revenue without subsidy(b), ₦	3,401.72	17,151.89	1,324.92
Calculated revenue with subsidy (b), ₦	3,576.97	17,784.86	1,363.18

(a) Data from a study[15] in Senegal, West Africa. (b) Calculated from (a).

Increase in Labour Productivity and Labour Utilization

One of the most regrettable misconceptions about agricultural mechanization is the belief that the introduction of mechanized methods in agriculture aggravates the unemployment problem in rural areas. However, if the analyses are not restricted to labour requirements per hectare, if a difference is made between family labour and hired labour, and if mechanization is accompanied by increase in the cultivated land; provision of adequate infrastructural facilities; and by establishment of agro-industrial projects, it will become evident that agricultural mechanization actually enhances employment in the rural areas.

Table 4, based on data from Brazil[16], shows that family labour used per year, hired labour used per year and total labour used per year all increased as the degree of mechanization and farm size increased. However, total labour per hectare of land cultivated declined with an increase in the degree of mechanization. **Table 5**, based on data from Philippines[17], shows that on per hectare basis there was only an increase in hired labour for rice and maize farms when tractor-powered farm implements were

Table 4 Selected Farm Performance Indices by Degree of Mechanization (Associated with Increase in Farm Size)(a)

Performance criteria	Performance indices(b)			
	Degree of mechanization by machine cost index per ha			
	Up to 100	Up to 200	200-400	400 or more
Farm size	100	174	350	173
Land-use intensity	100	126	132	153
Family labour used per year	100	124	126	104
Hired labour used per year	100	1275	2300	1600
Total labour used per year	100	143	162	128
Total labour used per hectare	100	55	36	44
Total operating cost per ha	100	284	333	522
Wheat yield per ha	100	124	123	126
Revenue per ha	100	171	178	253
Labour productivity as revenue per man-hour	100	302	670	634

(a) Computed from data on Farm Mechanization in Southern Brazil[16].
(b) Each index represents the value of each item as a percentage of the value of the least mechanized system.

Table 5 Comparative Labour Utilization and Productivity Between Animal-powered and Tractor-powered Rice and Maize Farms(a)

Items of comparison (Average of farms)	Rice farms		Maize farms	
	Animal-powered	Tractor-powered	Animal-powered	Tractor-powered
Farm size, ha	2.50	13.14	13.94	6.25
Labour per ha (man-days/ha)				
Family	41.0	6.3	26.30	12.1
Hired	43.5	58.2	16.60	20.7
Total	84.5	64.5	42.90	32.8
Labour per farm (man-days/farm)				
Family	102.50	82.78	103.62	75.65
Hired labour	108.75	764.75	65.40	129.38
Total	211.25	847.53	169.02	205.01
Crop production, kg/ha	4,875	5,585	2,325	4,060
Total crop production, kg/farm	12,188	73,387	9,161	25,375
Labour productivity (kg/man-days)	57.7	86.6	54.2	123.78

(a) Based on data from Philippines[17].

Table 6 Advantages of Mechanized Rice Processing Calculated as Percent Increase over Traditional Method of Processing(a)

Item	Increase, %			
	Small mill	Large mill	Small bulk facility	Large bulk facility
Milled rice output	4	11	14	18
Market price	13	20	24	25
Value of output	17	32	41	47
Value added	79	154	196	223

(a) Calculations based on data from Indonesia[18].

used compared to when animal-powered implements were used; while on per farm basis there were increases in total labour as well as hired labour due to tractor-mechanization.

For both examples presented above, there were very significant increases in labour productivity due to agricultural mechanization. Some of these increases could be attributed to higher rates of work achieved by tractorized equipment and by higher labour efficiencies.

Economic Benefits of Improved Storage and Processing Facilities

It was estimated in 1975[2] that the cost of food wastes in Nigeria due to inefficient distribution and market systems was about ₦400 million per annum. Improved processing, storage and transport facilities for agricultural products, which are essential elements of agricultural mechanization, will minimize such drain in our national income. Additional benefits will also accrue if facilities for processing and storage of agricultural products are established in rural areas.

The economic benefits of mechanized modern processing over traditional hand method of processing are presented in **Table 6**, based on data from Indonesia[18]. In another illustrative analysis, using data from Cameroon, Teel (1976)[18] estimated the percent economic return from using a small rice mill (500 kg/h) to be 21% while the figure was 61% for a large rice mill (4500 kg/h).

Stimulation of Rural Industrialization and Infrastructural Development

The economic and social benefits of rural industrialization are immense. However, since its success depends on modernizing the rural environment by provision of adequate road; water; electricity; educational and health facilities, a national policy to encourage the establishment of agro-business projects in rural areas should also emphasize and implement infrastructural development in rural areas.

To illustrate the points made above, the economic and social benefits from an irrigated agricultural project[19] in Bornu State of Nigeria are quantitatively summarized in **Table 7**. Apart from the increased agricultural production which will assist in the realization of our national goal for self-sufficiency in food production and also help to conserve foreign exchange, agricultural mechanization projects such as this would foster

Table 7 Economic and Social Benefits of Irrigated Project[a]

Item	Pre-Project (Before July 1979)	Post-Project (By July 1980)	
Average house-hold income, ₦	51.35	2,238.00	
Estimated population, number	200	1500	
Number of shops, excluding stalls for petty traders	0	100	
Rice production, t	187	1680	(81,570)[b]
Sorghum production, t	50	312	(8,460)[b]
Rural industrialization (number of rice mills, flour mills, feed mills)	0	4	
Dairy farm	0	1	
Large-scale poultry production farm	0	1	
Modern abbatoir	0	1	
Road development (time to cover a distance of 140 km, from Maiduguri to project area), h	12	1	
Number of schools	0	2	
Water supply (number of bore-holes)	0	50	
Rural electrification (Electric power available in mega watts)	0	31	
Health care facilities (number of clinics)	0	3	
Number of co-operative societies	0	1	

(a) Summarized from data and information on a project[19] in Bornu State of Nigeria.
(b) Projected production by 1985 using conservative estimates.

rural industrialization and enhance the development in rural areas of road, water, electricity and heath facilities. Because of such increased economic activities and modernization of the rural environment, employment opportunities in the rural areas are bound to increase.

Agricultural mechanization will also foster indigenous design and manufacture of agricultural equipment which would generate additional benefits, such as job creation, reduction of import, increase in export, lower sale price of farm equipment and increase in national income.

Concluding Remarks

In spite of the "oil boom" and the "Operation Feed the Nation", our rural population continues to eke out an existence in the most abject conditions of material deprivation. Sharp inequalities in the distribution of income and wealth within the country exist. The contribution of our agricultural sector to the national income and economic growth becomes less and less important. Our national slogan for self-sufficiency in food production continues to remind us of the worsening imbalance in food production and population growth.

This paper has drawn attention to the potential benefits of agricultural mechanization as a strategy for rural development. Agricultural mechanization increases agricultural production, improves the productivity and income of the rural population and attracts industries to the rural areas. By stimulating rural development, agricultural mechanization will enhance a more balanced economic growth in the country. Agricultural mechanization is also a vehicle for social justice since amenities and infrastructural development will be spread more evenly in the country. It will check rising cost of food items, conserve foreign exchange by minimizing food importation, banish malnutrition and hunger in Nigeria – a country so blessed with natural, mineral and human resources.

For these benefits to be realized, the technological and economic dualism which has shaped our past development plans must be moderated. It is no longer acceptable in human terms nor responsible in political terms to deny the rural population the benefits of technological advances in engineering and agriculture on the flimsy excuse that such technological packages are inappropriate for our conservative, illiterate and poor rural dwellers while those in the urban centres are treated with assortments of very expensive and highly sophisticated imported electronic appliances and gadgets. The statement that poverty anywhere constitutes a danger to prosperity everywhere must be taken more seriously by everyone in Nigeria.

If Nigeria is to achieve a meaningful and effective economic growth, a national strategy which integrates agricultural development and rural development vis-à-vis a community-based agricultural mechanization must be developed and implemented. The underlying principles and the organizational structure for such an integrated approach have been presented elsewhere[20]. Nigerian agricultural engineers[21,22,23] have accepted the challenge to design and develop indigenous machines suitable for crop production, storage and processing. The National Mechanization Centre established at Ilorin must become operational and further government encouragements are needed in promoting agricultural mechanization and rural industrialization in Nigeria. Establishing colleges and universities of science and technology in each and every state in Nigeria will be justified in few years to come if and only if these establishment assist in rural, as well as urban, industrialization in Nigeria.

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Influence of Natural Resources on Agricultural Mechanization

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Introduction

The natural resources are characterized in great variability and complexity. They represent the prime resources in agriculture. Their specific characters give the light of content of technology of mechanization that must correspond to the conditions of soil (relief, resistance, and size of plot); the restrictions imposed by the crop varieties and hybrids; the climate (that influence the plant evolution and also the time of execution of agricultural operations), and the quantity of solar heat and light that determines the structure of crops (Fig.1).

The solar energy, without which the existence of life is practically impossible, can be characterized under heat and light, that facilitiate the process of photosynthesis. Plants survive due to the quantity of annual heat and luminosity. This resource is territorial and limited by the fact that it permits or eliminates certain crops in favourable zones and not the others.

Under natural resources come plants and animals. The biological power of photosynthesis constitutes a distinguished resource of agriculture. The introduction of modern crop varieties and hybrids has revolutionised vegetal production per hectare, resistance of plants against disease and insect contributes toward higher economical efficiency of mechanization.

In the category of natural resources, irrigation water is also included. The layout of natural rivers, their flow, slope, discharge and quality of water have an effect on the nature of irrigation, all of which influence the economy of irrigation

Land, with some limits on fer-

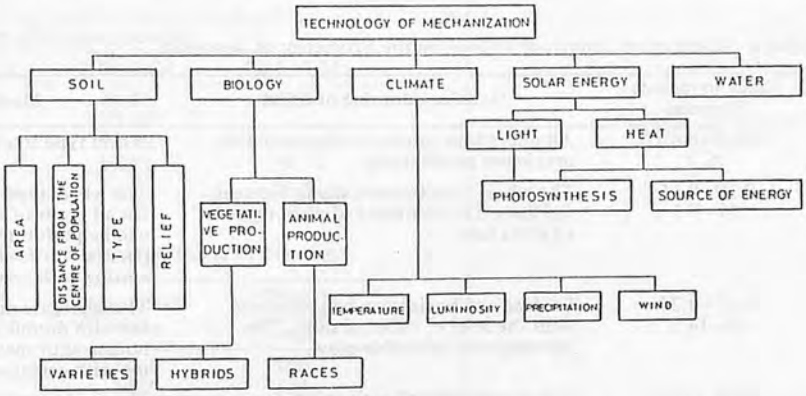

Fig. 1 Natural resources of agriculture which influence the technology of mechanization.

tility, represents the central object of study of natural resources in agriculture. Land in agriculture embraces the objective of labour and the means of labour acting on crops and making necessary those substances for existence and development. Land can be studied from many points of view such as:

i) Area at country and farm unit level, which tells the specific type of machines;
ii) Relief which influences the system of machines from the position of relief (plain and slope lands);
iii) Texture as the active parts of machines are opposed by different soil resistances at the time of movement, and
iv) Fertility, as regards the application of manure and fertilizers, etc.

These principal components distinguish land resources in agriculture. It is not only a place of production but also the active source on which still depends the process of production in agriculture.

These important resources are the subjects of study in this paper.

Material and Method

The study was performed in the Socialist Republic of Romania, at a station of farm mechanization, 15 km from Bucharest, named Stafanesti, having an area about 10 500 ha. The soil was brown-red and its texture varied from medium to heavy. The terrain was almost level and favourable for execution of all types of mechanical operations. The irrigated land was 4 000 ha. The important crops grown on this area: were wheat, corn sugarbeet, soybeans, oilseeds, and legumes. The farm area was covered under cropping pattern 70% wheat and corn, 18% sunflower, soybeans and sugarbeet, and the remaining 12%, legumes and forage crops. All operations were mechanized relating to crops like cereals, corn, sunflower, and soybeans. Problems used to arise at the time of harvest and transport, especially in autumn due to rush of field activities. The study was undertaken from 1975 to 1979 with an objective to observe the influence of natural resources on machinery technology.

The country as a whole is quite developed and farm under study was absolutely state-owned and completely mechanized where man-mechanical combinations did all farm activities.

The soil gradients and soil characteristics were properly maintained and data were available. The recall data were collected for soil resistance and soil slope to verify the past reference work. The on-farm, in-depth observations were taken to examine the hypothesis under test. The natural resources have direct effect on the cultivation of crops, especially the economics of production that determines the mechanization management in its true sense and applicability. The cost of production was examined as influenced by the grade of soil surface and resistence of soil influencing machine use.

Almost all the constants and variable were taken care of including conditions of work and crop environments. The data were analysed and discussed.

Results and Discussions

The relief of terrain constitutes a very important factor of influence on the process of mechanization. Its variation not only affects the work of aggregates and consumption of combustible, but also replacement of one system of machine with another. The slope land requires special system of machines for its own conditions of operations as compared to plain lands (**Table 1**). The plain lands or

Table 1 Influence of Topography/Slope on the Efficiency of Aggregate.

Grade in radians (Degrees)	Machine adopting position	Machine unit used	Productivity Unit
Less than 0.10 (6°)	All operations can be mechanized with maximum productivity	Wheel type tractors	1.00
0.10–0.15 (6–9°)	The wheel type tractors slip in between the lines. The combines of plain registered great loss.	The wheel type tractors can be used for all types of operations. The weeding can be performed by special tractor parallel to the curve of slope. The harvesting with cereal combines.	0.91
0.15–0.24 (9–14°)	Weeding and hoeing can be performed with the level of curve of slope. The plowing with reversible plow.	The aggregate made by wheel type tractor with double action. Weeding and hoeing with special tractors. The harvesting with cereal combines.	0.80
0.24–0.34 (14–20°)	Can be mechanized with cultivators.	The aggregate with special tractor (track type tractors).	0.60
0.34–0.46 (20–27°)	Only for forage crops.	Track type tractors.	0.50

with little grade below 0.10 radians could be mechanized for all types of operations with general use tractors. As in **Table 1**, the cereal crops could not be mechanized when the grade is from 0.24 to 0.34 radians. Only forage crops could be grown on areas with higher grades.

The capacity of operation of aggregates and the consumption of combustibles affected the speed of tractor on the grade. Its value depended upon the angle of grade and the weight of tractor. The influence of grade was not universal as the aggregate moved on the line of grade. The productivity of labour decreased as the grade increased.

Considering the influence of grade, the cultivated land was divided into five zones as shown in **Table 1**. The increase in the grade on the other side influenced the effective time of operation. To execute the same amount of work required the necessary time to complete the operation that was reduced by the reduction in speed on the grade and smaller width of operation of aggregate. In **Table 1**, the plain land with a grade up to 0.10 radians was taken as a unit where all types of operations could be executed with maximum efficiency by general use tractors. All other grades were compared with this grade. In case of grades from 0.34 to 0.46 radians the efficiency of aggregate decreased to 50%.

The other factor studied was the cost of production. As the grade increased the cost increased proportionally, and the efficiency of mechanization decreased. The causes of increase in production cost relating to increase in grade were:

a. Complex and costly machines were used, e.g., track-type tractors, and combine harvesters.
b. Capacity of aggregates decreased but increased the consumption of combustibles due to: reduction in the width of operation; smaller plot size; and high energy per unit of work.
c. The machines that operated on the grade had greater physical efforts which increased the cost of repair and maintenance; and
d. The specific climatic conditions reduced the period of annual use of machines and had negative influence on the purchase cost of machines.

The cost of production per hectare was computed considering the grade of land (**Table 2**). The costs increased proportionally as the grade increased in the case of wheat, corn (grain), and corn (silo). But the grade has no effect on the costs for forage (hay), and forage (silo).

The operations where the active parts of machines came in contact with soil, the movement of aggregates was opposed by resistance force, which influenced the productivity of aggregate and consumption of combustibles. The power consumed to overcome the resistance reduced the effective force of power unit which could be utilised for useful operations, hence negative influence on the capacity of aggregates.

From resistance point of view, the soils of Romania were divided into three groups:

Soil type	Specific resistance
Soft soil up to	4.10^4 N/m²
Middle soil	4.10 to 6.10^4 N/m²
Heavy soil	greater than 6.10^4 N/m²

The influence of soil resistance on the efficiency of means of mechanization is important and was determined (**Table 2**). The two factors were studied, first, the capacity of aggregates per shift (8 work hours) in hectares. The aggregate was formed from tractor U-650 (47.8 kW or 65 hp) and mounted mouldboard plow with three

Table 2 Variation in Cost of Production of Different Crops in the Function of Grade/Slope (US$/ha)

Crops	Grade/slope of terrain (radians)			
	0.00–0.10	0.10–0.15	0.15–0.24	0.24–0.34
Wheat	65.54	67.54	80.81	107.54
Corn (grain)	76.83	92.45	105.00	–
Corn (silo)	84.54	97.54	110.18	–
Forage (hay)	86.36	86.36	88.81	99.72
Forage (silo)	28.63	28.63	31.90	41.81

Table 3 Influence of Soil Resistance over the Capacity and Direct Cost of Plowing.

Type of soil	Specific resistance N/cm² x 10^4	Capacity of plowing ha/shift	Direct cost US$/ha	Percent of soft soil
Soft	3	5.1	7.20	100
Middle	6	4.1	8.92	124
Heavy	9	3.5	11.26	156
Very heavy	12	2.9	11.59	161

Note: The costs are converted from Romanian currency Lei to US $, the approximate value of 1 US $ is equal to 11 Lei.

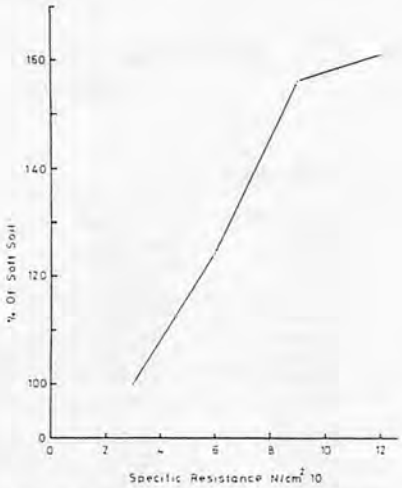

Fig. 2 Increase of direct cost of plowing for varying soil resistances.

bottoms. The soft soil was taken as the base with maximum output, and all other types of soil were compared with the soft soil. The soft soil with specific resistance of $3.10^4 N/m^2$ had the capacity of plowing of 5.1 ha/shift, and the heavy soil with specific resistance of $12.10^4 N/m^2$ the capacity of operations was reduced to 2.9 ha/shift. The second factor considered was the direct cost of plowing which is given in Fig.2.

From Fig. 2 and Table 3, the costs derived proportionally increased from soft soil to heavy soil, but had very little increase when crossing the specific resistance from 9 to $12.10^4 N/m^2$.

Conclusions and Suggestions

1. The cost of production increased as the grade/slope increased;
2. The plowing capacity decreased with the increase in specific resistance;
3. The cost of plowing increased with increase in specific resistance.

In the light of the above conclusions it is suggested that:

1. The aggregate (tractor and implement unit) should operate parallel to the curve of grade so as to minimize the supplementary resistance,
2. Cropping pattern should be managed by considering the effects of relief/slope; and
3. Corresponding aggregate power unit should be used accordingly.

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Intensity of Tillage Operation in Bangladesh

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Abstract

Shortage of power and uncertainty of the climatic conditions in Bangladesh limit the farmers' ability to prepare land at the optimum moisture content of soil and at the optimum time available. Too early or too late rain disturbs the timeliness of various tilling operations. This results in a low productivity per unit of land. Whereas, to meet the increasing demand of food and fibre of the country, cropping intensity should be increased substantially. This goal can be best achieved by intensifying the tillage operations from the present average level of approximately 152% to 167% throughout the dry and wet seasons using the modern farming technologies.

Introduction

Bangladesh has about 9.1 million ha of cultivable land on which important crops like rice, jute, wheat, sugarcane, potato, tobacco, cotton, oil seeds and peas are grown. By using early maturing high yielding variety it is possible to grow all the crops 2 to 3 times in a year. The essential factors here are effectiveness and timeliness of land preparation. By preparing the land in time and giving sufficient time for vegetative growth, it is possible to get the maximum crop yields. The traditional systems of land preparation includes ploughing, harrowing, levelling, mulching, etc. Among these operations ploughing and harrowing are the basic operations, which incurs 57% of the total cost and consumes 53% of the total field work in crop production (Sharov, 1981). In order to produce the crops all year round it is necessary to intensify the tillage operations both in dry and wet soil conditions in Bangladesh.

Mathematical Analysis of Tillage Intensity

Intensity of tillage operations for crop production can be computed by the following formula:

$$I = \sum_{i=1}^{n} \frac{m_i F_i}{F_a} 100 \qquad (1)$$

where

I = intensity of tillage operation (%); F_a = net cropped area, ha; F_i = area of i-unit of plots (i=1, 2, 3, ...); m_i = times of utilization of i-unit of plots (m_i-1, 2, 3. ...); n=number of plots.

Intensity of tillage operations can be increased by introducing modern technologies in land preparation under Bangladesh conditions. A chronological intensity of tillage operations is shown in **Table 1**.

Technology of Tillage Operations

Table 1 Yearly Tillage Intensity

(Unit: million ha)

Years	Total cultivable area	Net cropped area	Total cropped area having utilization of i-unit of plots	Intensity of tillage operations (%)
1974-75	9.1	8.46	12.31	145.54
1975-76	9.1	8.52	12.66	148.55
1976-77	9.1	8.31	12.37	148.90
1977-78	9.1	8.41	12.68	150.77
1978-79	9.1	8.46	12.95	153.02
1979-80	9.1	8.49		153.10
1980-81	9.1	8.60	13.22	153.72
1981-82	9.1	8.62	13.27	153.94
1982-83	9.1	8.65	13.38	154.68
1983-84	9.1	8.69	13.31	153.16

Source: Statistical Pocketbook of Bangladesh, Government of the People's Republic of Bangladesh, Bangladesh Bureau of Statistics, Dhaka, 1984-85.

The main purposes of tillage operations are: to increase soil fertility, to destroy the harmful materials, to circulate air freely and to retain the moisture content in the soil for successful crop production. Tillage operations can be grouped into primary and secondary tillage. Primary tillage operation includes opening the furrow at a depth of 10-22 cm, invert the soil slices and to burry the weeds and plant residues under soil. For getting quality land preparation and higher yield it is better to till the land between September to October rather in December if the conditions of soils permit. Primary tillage operations are followed by secondary tillage operations to break up clods and to prepare land suitable for sowing of seeds. These operations are accomplished by three phases – one of them is conducted at the beginning of April and November. The second phase begins after 10-15 days of the first and third phase begins 3-5 days before sowing of seeds.

The nature of tillage operations depends mostly upon the types of crops grown and their growing period. The technological systems of crop production are divided, generally, into three phases – tilling period, vegetation period and harvesting period. Ploughing, harrowing, manuring, etc are done during tilling period which are followed by sowing and planting operations. The calendar of technological systems of crop production in Bangladesh is shown in **Fig. 1**.

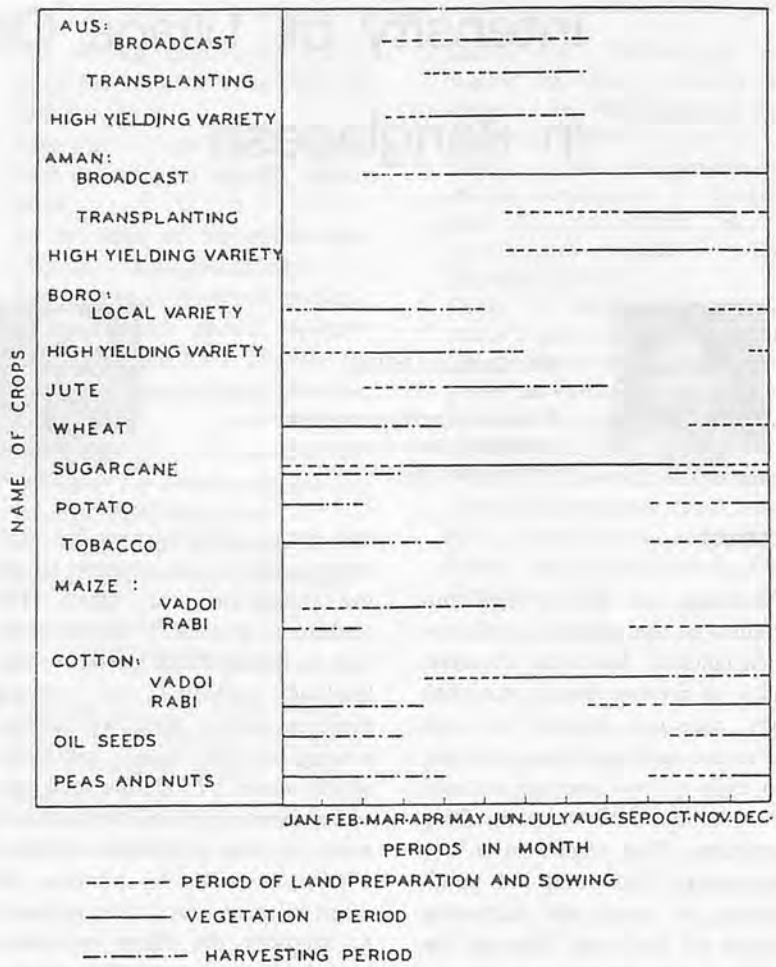

Fig. 1 Periods of various field operations for crop production in Bangladesh.

Means of Tillage Operations

Tillage operations in Bangladesh are accomplished in dry and wet soil conditions. For these operations active and passive tillage implements are used. Rotary tiller with horizontal drum are very popular in Bangladesh for puddling operations. About 30 to 35% of the total rice area of Bangladesh are cultivated by rotary cultivator submerged under 7 to 10 cm of water. About 65 to 70% land for jute, sugarcane, broadcast aus and aman rice cultivation are prepared in dry soil condition with the help of passive tillage implements (Uddin, M.S., 1984).

A list of foreign-made tillage machinery popular in Bangladesh is shown in **Table 2**.

Discussion and Conclusion

The cultivable land in Bangladesh belongs to the Government and largely to the private sector, i.e., the farmers. The Government-controlled farms are used mainly for research and demonstration purposes but the private sector is responsible for producing the bulk of the crops for the Government and the local people. The private owners are taking greater initiative for producing crops 2 to 3 times in a year. But studies have revealed that the private sector is generally suffering from lack of modern techniques and technologies in all stages of crop production and processing. Particularly the shortage of draft power is hindering the increase in land utilization in the private sector.

With the increase of land utilization Bangladesh cannot overcome the chronic food deficit prevailing in recent years. An analysis of Government plan shows that by the year 1986-87 Bangladesh has to

Table 2 Tillage Machinery Used in Bangladesh

Name of tillage operations	Makes and model	Country of production	Technical characteristics		
			Width of cut (m)	Depth of tilling (m)	Tractors used
Ploughing	International mounted mouldboard plough Model: 420, 440, 450 (2 to 5 bottoms)	USA	0.40 (for one bottom)	0.30	INI-2000 (25 kW)
	Semi-mounted mouldboard plough Model: 510, 720 (3 to 5 bottoms)	USA	0.40 (for one bottom)	0.30	FORD-3000 (35 kW)
	MF 43-10 (2 to 3 bottoms)	India	0.90 (for one bottom)	0.30	MF-135 (35 kW) Escort-335 (26kW) Good Earth-26 (20 kW)
Harrowing	Model No. SR-1266, 1268, 1270 (Mounted)	USA	3.8 to 5	–	International, Jone Deer, etc
	Model: R-5, R-7, R-9, R-11, R-13	USA	1.9 to 4.9	–	International, Jone Deer, etc (25-35 kW)
For puddling operation	Mitsubishi (Mounted 20 to 30 tines, Rotor diameter 0.46m, 182 to 498 RPM)	Japan	0.83 to 1.43	–	Power tiller Yanmar, Kubota, etc (5-10 kW)
	Utility Tool and Body (24 to 66 tines, 145 to 220 RPM).	USA	1.2 to 2.1	–	–

double the food production, i.e., by an amount of 13.5 million t over the bench level 13.5 million t (1984-85) on the same limited cultivable land to make the country self-sufficient. Under the present conditions, yields of food grains amounts to 1.9 t/ha annually. This requires an additional cropped area of about 7.10 million ha and a total of 14.20 million ha by the year 1986-87. Whereas in the past decade (1974-84) the average net cropped area, area of land utilization and intensity of tillage operations were 8.52 million ha, 12.92 million ha and about 152% respectively (**Table 1**). Hence, the only possible way to make Bangladesh self-sufficient in food production by 1986-87 is to increase intensity of land utilization and tillage operations to approximately 167%. This will surely require modernization of some agricultural operations.

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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. The requests from the readers for publishing the whole contents among the articles introduced here may also be sent to editorial staff. Regarding the article of many requests, the publication of whole contents will be reconsidered.

Predicting Dryer Performance Using Similitude Analysis:

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A simple relationship based on the principles of dimensional analysis was developed to predict fuel consumption per unit capacity of a dryer. The relationship was developed from data obtained during full scale drying tests for three types of grain (wheat, barley and corn) and one type of oilseed (canola) in two different makes of grain dryers (mixed air flow type and cross flow air recirculating type). Grain's ability to loose moisture was taken as a pertinent variable to incorporate different grains. Humidity ratio of drying air was used to incorporate two types of dryers. An excellent correlation coefficient showed that with one empirical model the performance of a dryer can be predicted under varying drying conditions. ■■

Design, Development and Field Evaluation of a Oscillatory Potato Digger

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Introduction

Potato is an important food and vegetable crop in India. The area planted to potato is 0.528 million hectares. Planting and harvesting are the two most labour-consuming operations for the production of this crop. It is estimated that it requires about 600 man-h per ha for manual digging of potatoes as against an animal-drawn potato plough which reduces the labour requirement to about 300 man-h per ha and a tractor-operated digger 80 to 90 man-h per ha, depending upon whether it is a single- or two-row digger.

An elevator-type digger uses a fixed type digging blade. The draft of such a tool is comparatively higher and is comparable with that of a plough. It has been established that if a soil-working tool can be oscillated/vibrated, it offers several advantages. Some of these advantages can be enumerated as follows:

1. Reduction in draft.
2. Better soil-fragmentation.
3. High energy utilization efficiency in relation to final soil condition produced.
4. Reduced adhesion and better scouring of soil over the soil working components.
5. Reduced tool wear.
6. Reduced tractor-wheel ballasting and less soil compaction.

Taking the above mentioned advantages of an oscillating soil working tool, an improved model of a single-row, tractor-mounted oscillatory potato digger was developed and the field testing of the unit revealed that it offered advantages in terms of reduced draft and adequate exposure of tubers.

Oscillatory Potato Digger

Figs. 1 through 3 show the details of the tractor-mounted, single-row oscillatory potato digger. As apparent from these figures the prototype comprises a digging blade with the lifter rods welded at the rear, a frame, power transmission system, crankshaft with eccentrics, connecting rod, side links as well as balancing weight.

Power Transmission

The digger is mounted on the three-point linkage of the tractor. The power is transmitted from the tractor pto shaft to a gearbox with bevel gear and pinion. The gearbox has a speed reduction ratio of 4.5. The output shaft of the gearbox operates at a speed of 120 rpm corresponding to the tractor pto speed of 540 rpm. A sprocket with 44 teeth is mounted on the output shaft of the gearbox which transmits the power to another sprocket with 11 teeth mounted on an eccentric (crank) shaft by means of a standard roller chain. The eccentric shaft operates at a speed of about 480 rpm corresponding to the tractor pto speed of 540 rpm which has been mounted on two self-aligning ball bearings. An eccentric is provided at both ends of this shaft. Two connecting rods, one for each eccentric, transmit the power to the front oscillating links. Each of the front oscillating

Fig. 1 Single-row tractor-mounted oscillatory potato digger.

Fig. 2 Frame and other components of the digger.

Fig. 3 Flywheel and the balancing weights.

links has been pivoted in the centre. On the lower end of each link a bush has been provided which is mounted on a pin on either side of the oscillatory digging blade. The rear end of the blade is also connected to the two rear oscillating links which are pivoted at the upper end. The main components of the digger are described as follows:

Frame

The frame of the oscillatory digger is made of M.S. box section of 50x50 mm. On the frame are mounted the gearbox, hitching linkage, eccentric shaft as well as the side links with which the oscillatory blade is suspended. The position of the hitch brace is adjusted with respect to the toolbox in order to align the digging blade. Vertical studs have been connected to a M.S. box section and can be moved inside another hollow M.S. box section to adjust the position of the oscillatory blade with respect to the tractor wheel track for smooth operation.

Blade

The blade of the digger is made of high carbon steel. It has a width of 57 cm, length of 26 cm and a tickness of 8 mm. At the rear of the blade, lifter rods have been provided. The soil potato mass is cut by the front sharp edge of the blade. As the blade is oscillated and the material is shifted over the lifter rods which try to lift it and separate the potatoes from the soil. The blade is oscillated back and forth with the kinetic linkage as shown in the figure. Four pins have been provided, two at each side of the blade to mount it on the side links.

Balancing Weight

In order to balance the inertia forces resulting from the rotary and reciprocating masses, balancing weights have been provided as shown in the figure. Two specially designed fly-wheels have been provided. These flywheels are essentially high moment of inertia rotors which helps in absorbing and storing the kinetic energy and releasing the same when required, with marginal decrease in the shaft speed. The flywheels are also intended to control the torsional vibrations and in stabilizing the energy cycles.

Field Performance Evaluation

To evaluate the functional performance of the oscillatory potato digger the following tests were conducted: draft measurement; extent of tuber exposition; and extent of tuber damage.

Measurement of Draft

Measurement of the draft was done with the help of Amsler Hydraulic Recording Dynamometer. Fig. 4 shows the arrangement used for the measurement of the draft. Tables 1 and 2 give the results of

Fig. 4 Potato crop ready for harvest.

Table 1 Draft Requirements of the Oscillatory Potato Digger at Varying Forward Speeds and Velocity Ratios (Frequency of oscillations = 8 cps; Amplitude of oscillation = 2 cm)

Forward speed (cm/s)	Draft (kg)
37.50	82
51.38	89
55.55	93
62.50	95
69.44	100
77.77	105

Cps. = Cycles per second.

Table 2 Draft Requirements of the Oscillatory Potato Digger at Varying Frequencies and Velocity ratios (Forward speed = 74.58 cm/s; Amplitude of oscillations = 2cm)

Frequency (Cps)	Draft (kg)
0	201.25
2	160
4	140
6	110
8	90

the draft requirements at varying frequencies and velocity ratios and varying forward speeds and varying velocity ratios, respectively.

Exposition of Tubers

The tests to determine the extent of unexposed tubers were conducted at different frequencies starting from 0 to 8 as well as at different forward speeds in the range of 35.7 cm/sec to 74.58 cm/sec. A ridge of 100 m length was selected for each test and the depth of cut was kept constant at 14 cm. The results of the functional performance test in terms of the percent exposed and unexposed tubers at varying forward speeds and velocity ratios are shown in **Tables 3** and **4**.

Potato Damage

Two types of tuber damages were observed. These were: the cut tubers and the skinned tubers. The percentage of cut tuber damage was based on the total weight and number of the tubers in each sample.

The percentages of cut tubers under both conditions of varying forward speed and constant forward speed are shown in **Tables 5** and **6**.

It is evident from these two tables that with the increase in forward speed and frequency of oscillations the skinning damage also increased in both cases. The average skinning damage in the former was 4% and, in latter, it was 5%.

Fig. 5 Measurement of draft in the field.

Fig. 6 Exposure of potatoes.

Table 3 Extent of Unexposed Tubers at Varying Forward Speeds at Constant Frequency of Oscillations of 8 Cps and Amplitude of 2 cm. (Potato variety: Kufri Chandramukhi; Depth of cut = 14 cm)

Forward speed (cm/s)	Cut tubers (%)	Unexposed tubers (%)
35.70	0.3	6.60
36.64	0.5	6.80
42.75	0.6	7.50
47.11	0.4	8.30
74.58	0.7	14.14

Table 4 Extent of Unexposed Tubers at Varying Frequencies of Oscillations and at a Constant Forward Speed of 74.58 cm/s and Amplitude of Oscillation of 2 cm (Potato variety: Kufti Chandramukhi; Depth of cut = 14 cm)

Frequency (Cps)	Cut tubers (%)	Unexposed tubers (%)
0	0.4	49.94
2	0.6	40.06
4	0.7	25.85
5.87	0.8	15.64
8	0.9	14.14

Table 5 Extent of Skinning Damage at Varying Forward Speeds and at Constant Frequency of Oscillation of 8 Cps and Amplitude of 2 cm (Potato variety: Kufri Chandramukhi; Depth of cut = 14cm)

Forward Speed (cm/s)	Skinning damage (%)
35.70	2.38
36.64	4.00
42.75	3.33
47.11	5.37
74.58	5.00

Table 6 Extent of Skinning Damage at Varying Frequencies of Oscillations at a Constant Forward Speed of 74.58 cm/s and Amplitude of Oscillation of 2 cm (Potato variety: Kufri Chandramukhi; Depth of cut = 15 cm)

Frequency (Cps)	Skinning damage (%)
0	3.45
2	4.90
4	4.80
5.87	6.25
8	5

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Maintenance of Tree-Crop Plantations Using a Portable Motorized Weeder

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Abtract

Nigeria is currently experiencing a decline in the production of cocoa, rubber, palm oil and other tree crop products. One of the reasons for this decline has been attributed to problems of weed control during new plantation establishment. The success of those measures designed to arrest the decline, replanting, rehabilitation and new planting programmes depends largely on a solution to the weed control problem. It is, therefore, important to select, adapt or develop appropriate weeding machines for tree crop plantations under peasant management in Nigeria.

Three models of a shoulder-suspended, hand-guided rotary mower were, therefore, selected for evaluation and comparison with hand slashing using field capacities and weeding costs as indices. They were code-named MB (big machine, 1.86 kW), MM (medium machine, 1.49 kW) and MS (small machine, 1.12 kW).

Machine field capacities were 62-131% higher than hand weeding and are highly significant. The average weeding capacities, in ares/h, were 3.06, 3.30, 2.32, and 1.43 for MB, MM, MS and hand (HD), respectively. Weeding costs were also cheaper than hand and the averages were 14.81, 14.00, 18.25, and 18.17 ₦/ha.

These machines, particularly model MM, are recommended for integration into the various tree-crop improvement programmes in Southern Nigeria.

Introduction

The current decline noticed in rubber(7), palm oil (1, 3, 5) and cocoa production in Nigeria owes partly to weed control problems during plantation establishment. These crops, like other plantation crops have wide spacings between rows requiring two to four weedings per annum during the period of establishment which varies from 3-7 years. The cost of such weed control constitutes 20% of the total establishment cost for cocoa (9), 33-61% for oil palm(3, 9), 12.2% for rubber(9) and 12-40% for other fruit trees.

At present (1979), no chemical weed control has been recommended by any of the tree crop research institutes in Nigeria.

The inaccessibility of some tree-crop plantations due to weed infestation after establishment also contributes to the tremendously high wastages experienced during the production years. Idusogie et al (4) estimated such wastages for some of the crops as follows: 5% of palm oil or 26016 t amounting to ₦3.9 millions; 10% of fruits or 16336 t amounting to ₦3.35 millions; 5% of plantains or 60543 t amounting to ₦5.05 millions are wasted at the producer-level in Nigeria annually. The corresponding wastages for cocoa and rubber are low and probably secondary to those due to pests, diseases and partial recovery of harvests.

As a result of rural-urban migration, a complete neglect or half-hearted and improper maintenance of peasant-owned tree crop plantations is apparent in many developing countries. This neglect would be reduced if efficient and appropriate weeding machines exist. Poorly-managed plantations are more susceptible to pest and disease attacks and losses of already established tree.

The success of replanting rehabilitation and new planting programmes depends largely on subsequent field maintenance. It is, therefore, the objective of this paper to select portable motorized weeders and evaluate their performances in terms of field capacities, weeding costs and compatibility with the resource levels of the user.

Materials and Methods

Description and Specifications of Trial Machines

Three models of a rice reaping machine similar in many respects to a brush cutter were purchased from Japan in 1973. They were powered by micro-petrol engines; the smallest (MS) has a power rating of 1.12 kW, medium-sized machine (MM) has 1.49 kW while the biggest (MB) has 1.86 kW. Their landed costs were ₦55.17, ₦58.15, ₦65.61, respectively. The brush cutters manufactured in the USA have a minimum power rating of 2.34 kW and cost $187 (115) in 1973. The cost differential favours the selection of the Japanese models for trials on peasant farms. Furthermore, the Japanese models have been developed with the objective to completely mechanize small rice farms, consequently, several complementary implements are available. For example, post-hole digger, blade and saw grinder, water pump and L-shaped rotary cultivator are optional attachments.

These machines are suspended from the shoulders and operated in the standing position (Fig. 1). Operation can be in the horizontal plane, cutting a swath of about 2 m, or in the vertical plane to a height of 2.1 m. Thus, they are suitable for simultaneous weeding and pruning. Carrying weights vary from 5.4-10 kg and overall lengths are 160 cm for the MB and 170 cm for the MM and MS. A rigid shaft rotating in its pipe shield and coupled by a centrifugal clutch, transmits power from the engine to a three-blade or saw-type rotary cutter.

Fig. 1 Weeding in the rubber plantation.

The engine characteristics are 2 stroke cycle, single cylinder; 50.2, 35.0, and 27.2 cc displacements; fly-wheel magneto ignition; petrol/oil mixture of 25:1; compression ratio 8:1; air cooled.

The field capacity of a hand-guided weeding machine is influenced by the horse-power available, operator's skill, experience and attitude, surface configuration and obstructions and the type of weed. Climbers and, particularly cover crops in rubber and oil palm plantations, tend to entangle the cutters thereby increasing idle time.

Field Experimentation

Four field hands were employed throughout the experiment; two (SA and MO) had 8 years of formal education, the others had none.

Slashing of weeds in cocoa field was in collaboration with a farmer 28 km South-East of Ibadan. The trees were about 26 years old and rather poorly maintained. The slashing of weeds in oil palm and rubber fields were carried out on the University of Ibadan groves covering 2.2 and 1.4 ha, respectively. The mean weed height in these plantations was 76 cm.

The area assigned to an operator at each weeding was 0.06 ha which was considered convenient for cutlassing at 16 man-days per hectare. The weeding time was recorded and used in estimating the field capacity of the machine used in ares/h (100 ares = 1 ha).

The experiment was a split plot design in ramdomized complete blocks with the type of corp being weeded as blocks, weeding equipment as the main treatment, the operator as the subtreatment and 3 replications. There were 3 test crops, namely; cocoa, rubber and oil palm; 4 weeding equipments, MB, MM, MS and cutlass (HD); and 4 operators disignated as SA, KS, RO, and MO. Thus there were 48 plots of 0.06 ha each for each crop(block). Each of the statistic in **Table 1** is an average of 12 weeding trials (that is, 4 operators at 3 trials each) on a particular crop and machine in a period of 4 years. Field capacities are not expected to be influenced by the type of crop being weeded since the crop spacings (the least being 3.05 x 4.57 m for rubber) are such that machine sweep is unrestricted.

Cost Calculation

The data for weeding cost analysis (**Table 3**) were calculated from the field capacity records and by considering the following additional cost components.

1. Operating cost which includes fuel cost, machine operators wages in the time estimated to complete 1 ha and maintenance and repair costs which were spread proportionately over all recorded uses of the machine.
2. Ownership cost which consists mainly of depreciation calculated by the straight line method. A life of 3 years or 1200 h was assumed (6). The other cost items usually attached to ownership such as insurance, storage, interest on investment, were excluded due to the small size of machine and low initial cost.

The rates employed were as follows:

1. Labour cost was at the rate of ₦2.00 per 8-h day or ₦0.25/h (US$1 = ₦0.62).
2. The initial landed cost of the machines were ₦65.61, ₦58.15, ₦55.17, for then MB, MM, and MS models.
3. Maintenance and repair costs are usually assumed as 20% of initial cost in Nigeria(8). The final costs of machines of ₦78.73, ₦69.78, ₦66.20 are strictly for comparison as they

do not reflect the local commercial values which may include a profit margin of 300-500%. Hourly costs based on the assumed machine life-span were ₦0.0656, ₦0.0582, ₦0.0552.

4. One set of mowing blades, consisting of three 3 x 25 x 115 mm mild steel flat bars, each reversible and having four cutting edges was used in weeding 1 ha. The estimated cost was ₦1.65.
5. Fuel cost was ₦0.095 per litre.

Thus the weeding cost per hectare was calculated as:

Weeding cost, ₦/ha = 1.65(4) + 0.095(5) x litres of fuel + [(1) + (3)] x machine hours employed

Results and Discussions

The basic data on field capacities are summarized in **Table 1**. With an operator contributing a reading on every treatment and for each crop, the range of field capacities were 2.02-4.34; 1.91-5.14; 1.41-3.37 and 1.09-1.95 ares/h for the MB, MM, MS, and cutlass (HD). The wide range exhibited with machines reflect definite differences in the experience, skill and attitude of the operators. The highest field capacity in cutlass weeding is lower than the lowest field capacity for the MB and MM fore-shadowing the highly significant advantage **(Table 1)** of machine weeding in tree crop plantations. Machine averages were 62-131% higher than cutlass (2.32-3.30 ares/h compared with 1.43 ares/h). However, the data indicates a potential of up to 164%; the highest capacities on record are 5.14 ares/h for machine(MM) and 1.95 ares/h for cutlassing. The machine model MM was 8-42% superior to the other models. Every operator was able to weed 3 ares/h with the MM but just over 2 ares/h with the MB and MS. The interaction of light weight and lower operator stress with high horsepower appears conductive to the superiority of model MM in this investigation. In an earlier study with these machines on maize production (2) when manoeuvrability was important the lighter model MS was comparable or slightly better than the MM.

The crops, as was expected, do not have a significant effect on machine outputs. Machine field capacities varied among and within operators, but all operators performed similarly when using the cutlass **(Table 2 col. 5)**. Variations in machine output with a particular operator are not sifnificant in many instances **(Table 2)**, particularly with RO and MO.

This consistency within an operator indicates that the influence of available horsepower on field capacity may be masked by geometric similarities among hand-guided motorized machines. Similar outputs were also noted among some operators when using particular machines, suggesting that the educational background probably did not matter when an operating machine is compatible. Differences in the absolute values probably reflect operator attitude and work capacity. The overall performances of the operators are significantly different.

Considering weeding costs **(Table 3)** machine model MM is again 6-30% cheaper in use than the

Table 1 Effect of Different Operators on Performance of Different Weeding Machines under Cocoa, Rubber and Oil Palm

Item	MB	MM	MS	HD	Crop Mean*
Cocoa	3.03	3.43	1.95	1.48	2.48e
Rubber	3.44	3.69	2.37	1.35	2.71e
Oil Palm**	2.71	2.79	2.65	1.45	2.40e
Machine Mean*	3.06b	3.30a	2.32c	1.43d	

* Means having the same letters are not significant at the 5 percent level.
** Three were 12 trials covering a period of four years.

Table 2 Effect of Different Crops on Machine Output (Field Capacity) by Four Operators, ares/h.

Operator	MB	MM	MS	HD	Operator mean
SA	3.66ab(d)	4.01a(d)	2.61bc(d)	2.63c(d)	2.98(d)
KS	3.05ab(e)	3.13a(ef)	2.02bc(e)	1.65c(d)	2.46(e)
RO	2.80a(e)	2.60a(f)	2.04ac(e)	1.26c(d)	2.18(f)
MO	2.72a(e)	3.47a(de)	2.61a(d)	1.15b(d)	2.49(g)

Note: 1. Means having the same letters are not significant at the 5% level. 2. Letters for vertical tests (comparing two operator means under the same machine) are in parenthesis. 3. The horizontal tests compare two machine means under the same operator. 4. Each data is the average of 9 trials covering 4 years.

Table 3 Effect of Different Operators on Weeding Cost of Different Machines under Cocoa, Rubber and Oil Palm

Unit: ₦/ha

Item	MB	MM	MS	HD	Crop mean
Cocoa	14.67	14.35	19.53	17.80	16.59c
Rubber	13.41	12.45	17.94	18.83	15.66c
Oil palm	16.35	15.21	17.27	17.88	16.68C
Machine mean	14.81a	14.00a	18.25b	18.17b	

Note: Each data is the average of all trials on a crop for a machine by all operators. Approximate exchange rate in 1979 was US$ = ₦0.62.

Table 4 Effect of Different Crops on Machine Weeding Cost by Four Operators

Unit: ₦/ha

Operator	MB	MM	MS	HD	Operator mean
SA	12.48d(a)	11.52d(b)	16.08d(b)	15.43d(b)	13.88(c)
KS	15.11f(a)	12.70f(b)	20.41e(a)	15.47f(b)	15.92(b)
RO	15.98h(a)	18.59h(a)	21.76g(a)	20.02gh(a)	19.09(a)
MO	15.67k(a)	13.20k(b)	14.74k(b)	21.75j(a)	16.34(b)

Note: Each data is the average cost of weeding for all crops by an operator using a particular machine.

other models (MB and MS) and cutlass. The average cost per ha are ₦14.00, ₦14.81, ₦18.25 and ₦18.17 for the MM, MB, MS and HD, respectively. Both MM and MB models are statistically cheaper for use in weeding tree-crop plantations. The other model (MS) is similar to cutlass. Geometric similarities among machine models, however, suggest caution in accepting the foregoing observation. Factors like the types of weeds and their stage of development (76 cm in this study) causing frequent cloggings of a machine; low available horsepower; and contemptuous attitude of the operators to a particular model (MS) probably influenced the results. With timely weeding (shorter weeds say 30 cm maximum) and a positive attitude of the operator, machine model MS could have similar capacities and weeding costs with the MM and MB. In the earlier experiment with maize the MM was cheapest but the result was not statistically significant (₦29.87 compared with ₦33.41(MB) and ₦31.28 (MS)) being only 5-12% cheaper. Also in that study the cost of weeding maize by the MB and MM doubled the corresponding costs for weeding tree crops, but for the MS it was only 1.71 times, implying the possible interaction of the factors (shorter weeds, more positive attitude due to better manoeuvrability) stated.

Furthermore, it is possible for an operator to achieve a given weeding output with a machine at a low or high rate of fuel comsumption. Thus, field capacities and weeding costs may not follow the same trend. Field capacities may be significantly different while weeding costs are similar and vice versa. Considering **Tables 2 and 4**, this expectation occurred among all the operators (vertical comparisons, treatments MB/SA; MS/SA; MM/KS; MM/RO; and MS/MO) but with only one machine (horizontal comparisons, treatment MS/SA, MS/RO and MS/MO. Machine model MS should, therefore, not be recommended for weeding tree-crop plantations in Nigeria.

The 95% conficence intervals is given by the respective means ± 0.14 ares/h for field capacities and ± ₦2.28 for weeding costs.

Conclusion

1. Machine field capacities are 62-131% higher than cutlassing and are highly significant. The average weeding capacities in ares/h were 3.06, 3.30, 2.32 and 1.43 for MB, MM, MS and HD.
2. The cost of weeding by machines was cheaper than weeding by cutlass being significant even at the 1% level. Cost averages are ₦14.00, ₦14.81, ₦18.25 and ₦18.17 for the MM, MB, MS and HD.
3. In terms of both field capacity and weeding cost, the machine model MM is superior to other models and cutlass weeding.
4. The 95% confidence interval is given by the coresponding means ± 0.14 ares/h for field capacities and 2.28 ₦/h for weeding costs.
5. These weeding machines are recommended for intergration into the replanting, rehabilitation and new planting programmes for cocoa, rubber and oil palm in southern Nigeria.

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Agricultural Structure Problems in Tropical Countries

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Introduction

The most important construction materials anywhere in the world are: concrete, steel, masonry and wood. In respect to tropical countries there is a considerable reduction of durability in most of these materials, usually because of high temperatures and high humidities. These climatic conditions are excellent for developing bacteria and fungi that attack the material causing a progressive deterioration. At other times it is just the climate that affect the structure.

The climatic conditions in tropical regions are briefly enumerated as follows: temperature range: 20°C–48°C; relative humidity: 20%–70%; region between tropics of Capricornius and Cancer; types of climate within the tropics: tropical, sub-tropical, arid, semi-arid, and equatorial.

Problems with Concrete

In the last two centuries most of the large structures with big lateral and concentrated loads were in concrete and reinforced concrete. We can find concrete in structures of storage and other agricultural structures and these have been the most usable in tropical countries. However, in spite of the economic advantages of the concrete, there are some problems.

Studies in Concreting

Some laboratory tests indicate that there is a critical temperature of the concrete (about 30°C) at which compressive strength of concrete is at its minimum. At the age of 56 and 90 days this minimum was found to be 8-15% lower than the strength of similar concrete made under standard conditions. The value of this critical temperature most probably depends upon the characteristics of the concrete, evaporation, and other conditions. These investigations and experiences indicate that the quality of concrete is adversely affected by high temperature during mixing and placing. It has been observed by Learch,[1] Tuthill[1] and Blakey[1] that, concrete cast at elevated temperature tends to crack at very early age. Through the early cracks, developed sometimes also in temperate climates, it has been generally agreed that hot and wet weather conditions are particularly inductive in this respect. This phenomenon is called plastic shrinkage cracks. Some authors say that it occurs because of the rapid drying in flat surfaces, and it develops within the first few hours after placing, shortly after the sheen disappears from the surface of the concrete (Fig. 1).

The rate of evaporation of water from the surface of concrete is affected by temperature and relative humidity of the air, wind velocity and temperature of concrete. The bleeding phenomena should also be considered in connection with the effect of evaporation. Differences of opinion exist with regard to the effect of hot weather concreting upon the compressive strength of concrete. There is a general agreement as to the beneficial effect of higher than normal temperature on strength at very early ages, but dissension prevails as to its influence on strength at 28 days and later (Fig. 2).

In such a tropical climate the hardening of concrete is much more rapid than in low temperature and cool climates and this takes place mainly during the first days after placing. For lean concretes, improvement in strength is relatively greater than for concretes containing more cement.

Deterioration of Concrete

The most common forms in which deterioration manifests itself can be stated as follows:

1) Excessive deflection of structural members (Fig. 3); 2) Cracking of concrete along lines coincident with reinforcement; and 3) Corrosion of the reinforcing located below such cracks; in the cases of reinforced

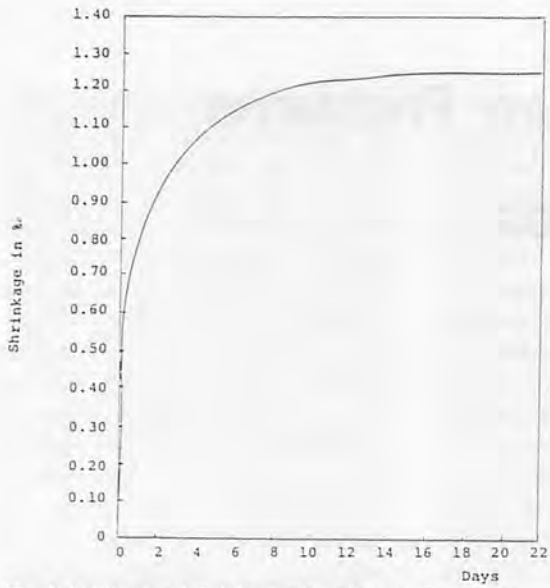

Fig. 1 Incidence of shrinkage after placing of concrete.

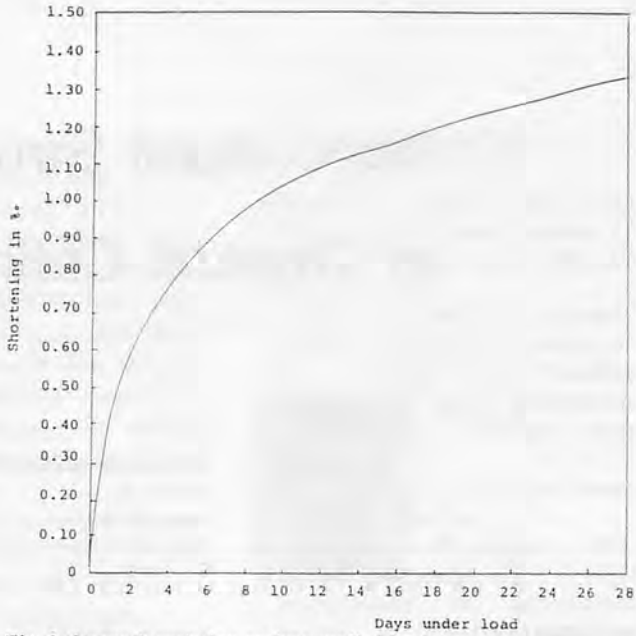

Fig. 2 Strength variation against applied load.

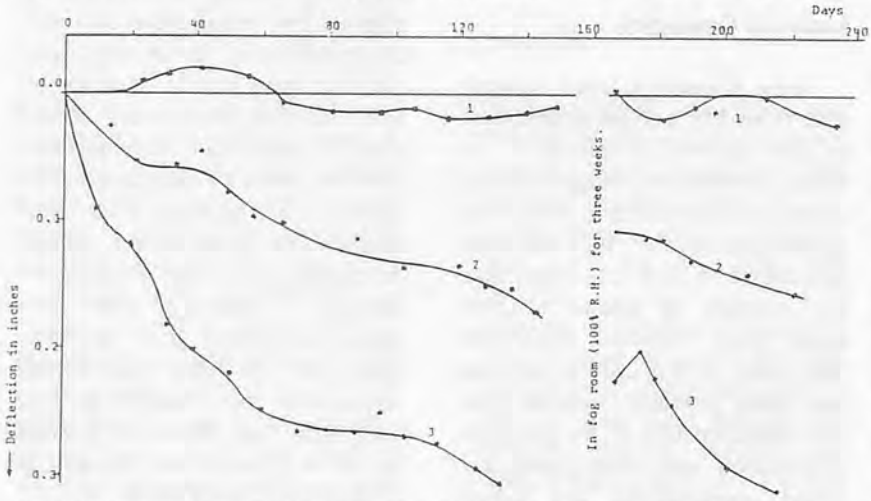

Fig. 3 Deflections in concrete beams made with shrinking and with normal aggregates.

concrete exposed to the weather, particularly if the sections are light, cracks were often wide open and in some cases, spalling of the cover concrete occurred. This is due to corrosion of the underlying steel, the formation of the corrosion product resulting in development of bursting pressure; and 4) Severe crazing of concrete surface.

The probability that excessive shrinkage, the only remaining form of large dimensional change, should be the cause was, at first, discounted because changes of such an order had not been reported in the literature. However, this shows that all the phenomenon mentioned could in fact be explained in this way: for instance, in the case of a simple concrete beam in which the concrete shrinks excessively, there would be a tendency for the overall length to decrease. However, where there is reinforcement, shrinkage would be restrained due to bond, and, therefore, in the tension zone there would be less reduction in length than in the compression zone. Consequently, the beam would deflect, the process being progressive from the time that shrinkage started to occur. If this shrinkage were associated with the drying out, the deflection could be expected to be progressive during the period between casting and drying to the equilibrium moisture content.

If a body like steel which is not subject to shrinkage is embedded in the concrete, and the concrete shrinks, tensile stresses will be set up in the concrete, if these should exceed the tensile strength at any section, a crack would form. Since the cover concrete is the thinnest section, failure would occur there in the first instance. If water enters such a crack (due to movement in the concrete), and reaches steel which is no longer protected, corrosion could be expected to occur.

Influence of Temperature on Corrosion in Reinforcement

Test of corrosion of mild steel submerged in calcium hydroxide solutions of various pHs, which served as a preliminary to an investigation on the effect of climate upon corrosion of reinforcement, are reported. They indicate that though increase of temperature in the range of 20°C to 60°C makes steel more vulnerable to corrosion, the effect is much less pronounced in temperate climates. (From report of Dr. R. Shalon, Professor of Civil Engineering, Building Research Station, Technion Institute of Technology, Israel: "Preliminary tests on effect of temperature upon corrosion of reinforcement").

It has been known that unprotected steel corrodes more in hot

countries than in temperate ones. It has also been noted that damage in reinforced concrete structures due to corrosion of the reinforcement has been met with in warm rather than in cold climate. The influence of climate is a result of a great number of factors. The faculty of concrete to protect steel, which depends mainly on its alkalinity and density, is affected by climatic conditions (porosity of concrete, depth of carbonation and humidity). On the other hand, the rate of corrosion, under given conditions, would be accelerated at elevated temperatures, while the solubility of oxygen in solution is reduced.

In conclusion, we must add the following:

1) We have no definition for "good" conditions for concreting in any climate. These depend on various factors such as the temperature of the air and the concrete, relative humidity, wind velocity, vapour pressure, mix properties and composition. The climatic factors influence the structure formation of the concrete as well as its capillary system, strength, permeability and durability;

2) The properties of good concrete made under hot-climate conditions may be: absence of cracks, low shrinkage and low reduction in strength, permeability and durability as not more than 5% after 28 days or not more than 10% after 30 days compared with laboratory-cured concrete.

3) A rough relationship between the predominant climatic factors can be proposed from experience as in **Fig. 4**.

This relationship should represent an approximate humidity balance between atmosphere and concrete surface. Line I refers to still air and normal concrete with a cement content of 30 kg/m^3, while line II refers to normal concrete made with early-strength cement with a cement content of 400 kg/m^3 and a wind velocity of approximately 10 m/s (other proportions and conditions and different types of cement other than Portland, necessitate correction).

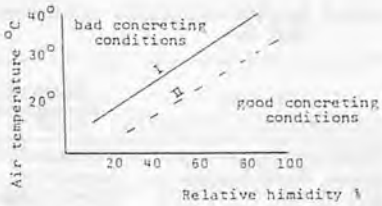

Fig. 4 Air temperature and relative humidity.

It is important to divide the maturing time into two periods. The first period is that of mixing, placing, compacting and the lapse preceding noticeable evaporation. This period (approx. the first 4-6 h) is decisive with regard to structure formation and strength. In a hot climate, during the first period, the concrete would require lower temperature and good concreting conditions for maturing, as well as suitable protection. Similar precautions are known from the steam-curing practice (holding period). In these circumstances both harmful volume changes and cracks are avoided, and the steam-cured concrete reaches maximum strength (60-70%) immediately and 100% of the strength of normal 28-day concrete after 28 days. The second period is that of hardening of the concrete structure; the concrete surface should be either watered or protected. **(Fig. 5)**.

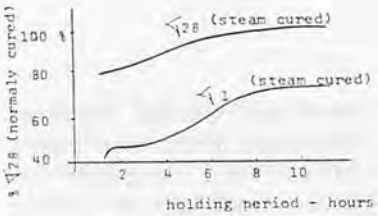

Fig. 5 Steam-curing practices.

Thermal Stresses in Concrete - Masonry Structures

Expansion of Roof and Walls

This point is interesting principally because of the existence of structures of concrete-masonry (more economical) in tropical countries.

The theoretical analysis has always assumed that the roof of a building expands in relation to the walls in consequence of a temperature difference ΔT.

A shearing force applied at the joint equalizes the strain at the top of the wall and the roof. The wall was assumed free at all other boundaries.

It would like to point out that:

1) The lower edge of the wall is always restrained, in some measure, against horizontal movement either by the foundations or by an intermediate floor. Full restraint will reduce the stress at the upper edge of the wall considerably.

2) Due to the eccentric shear force, the wall will tend to curve upwards. The weight of the wall

and some parts of the roof load will counteract and tend to decrease the stresses of the upper edge of the wall.

3) In all computations a symmetrical roof expansion seems to have been assumed. But

opposite walls always heat differently in relation to the roof. The stress distribution may in fact be antisymmetrical and not symmetrical as assumed. All points discussed until now tend to reduce the stress at the upper edge of the wall. The theoretical value assumed in most of the literature for strains at this point seems to be too high. Of course, the relative results of the tests are not qualitatively affected by these comments.

4) The next point that should be stressed is that part of the walls

tested had openings. The stress distribution in such walls is quite different and comparison of stresses with a wall without openings does not give a true picture of stresses.

5) In hot countries the season of construction is a very important factor and its influence should be studied. A building constructed in winter will expand under a temperature difference of 10-30°C. The expansion is generally restrained at or about ground level and this will again produce tension at the upper wall edge in addition to the stresses computed by studies in the Civil Engineering Dept., California Polytechnic State University.

6) Differential shrinkage of masonry walls and concrete roof may be another important factor and should be further studied.

Analysis of Steel Structures

Steel is used in structures of storage and also in dairy industries and drying systems. Regarding the advantages of the steel structures we can say that this is an easily managed structure, although at the request of specialized workers. The construction of steel building is also good where there is a problem with transportation of materials.

But, the steel structure in tropical countries has a really big problem because of the high relative humidity causing corrosion in junctions and welding bands **(Table 1 and Fig. 6)**.

Table 1 Relative Corrodibility of Atmospheres at 20 Locations throughout the World (Ref. 5).

Location	Type of atmosphere	Weight loss (g)			Relative corrodibility
		Max	Min	Mean	
Khartoum, Egypt	Dry inland	0.28	0.05	0.16	1
Abisco, North Sweden	Unpolluted	0.72	0.34	0.46	3
Aro, Nigeria	Tropical inland	1.53	0.74	1.19	8
Singapore, Malaya	Trop. marine	1.74	1.05	1.36	9
Basrah, Iran	Dry inland	2.17	0.68	1.39	9
Apapa, Nigeria	Trop. marine	2.94	1.47	2.29	15
State College, Pa.	Rural			3.75	25
South Bend, Pa.	Semi-rural			4.27	29
Berlin, Germany	Semi-industrial	4.83	4.55	4.71	32
Llanwrtyd Wells, British Isles	Semi-marine	6.22	3.40	5.23	35
Kure Beach, N.C.	Marine			5.78	38
Calshot, British Isles	Marine	7.19	4.22	6.10	41
Sandy Hook, N.J.	Marine, semi-industrial			7.34	50
Congella, South Africa	Marine	11.13	5.61	7.34	50
Kearny, N.J.	Industrial-Marine			7.75	52
Motherwell, British Isles	Industrial	9.39	6.57	8.17	55
Vandergrift, Pa.	Industrial			8.34	56
Pittsburgh, Pa.	Industrial			9.65	65
Sheffield, British Isles	Industrial	13.40	8.74	11.53	78
Frodingham, British Isles	Industrial	23.40	10.37	14.81	100

Losses of weight of 5.1 by 10.2 cm (2 by 4 in.) specimens of open-hearth iron (0.007 % copper) used as criteria (1.03 dm^2 of surface).

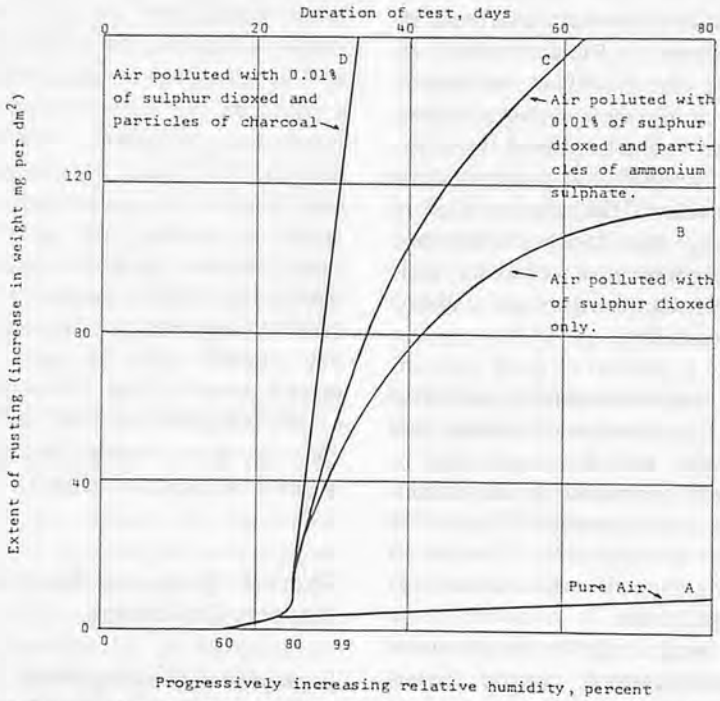

Fig. 6 Influence of humidity and atmosphere pollution on rusting of mild steel.

Corrosion Analysis

The presence of moisture is essential for natural corrosion at normal temperatures, as it is well known that dry air does not have a corroding effect on metal except at elevated temperatures. The effect of the relative humidity and temperature of the air is illustrated by the durability of metals subjected to corrosion in the atmosphere of warm dry regions, in contrast with the rapid rusting that occurs under similar exposure in the humid atmosphere.

Atmospheric corrosion is characterized by the presence of oxygen in excess, moisture being present only part of the time. The metal is wetted and dried alternately and is subjected to the sunlight and variable weather. Metal roofing, fence wires and steel tanks are examples of material used under these conditions. At least 80% of the steel in use is subjected to these conditions.

Under these climatic factors, the main controlling variables are:

the proportion of the time in which the material is wetted, the foreign matter in the air in contact with the metal surface and the composition of the metal. Composition is of greater importance in atmospheric corrosion than where the metal is immersed continuously in water or buried in soil. Impurities in the air, and local weather conditions, determine the life of the metal. Dust particles that settle on clean metal from air exert a marked influence in accelerating corrosion in the atmosphere. This occurs even where the humidity is considerably below saturation and is associated with the hygroscopic character of the dust or rust particles.

Biological Influences on the Lifetime of Steel

Certain primitive organisms in direct contact with steel influence the rate of metallic corrosion. There is some evidence that corrosion under or near these organisms may be caused because of the amino acids or other active chemical reagents originating from the organisms. In the metallurgical interest these organisms are conveniently classified according to their ability or inability to develop or sustain growth in an environment in which the concentration of free (or dissolved) oxygen is high or low (or non-existent).

Wood Structures

In the case of wood structures exposed to variable tropical weather, the most important problem is the gradative ruin of the structure because of fungus attack. Fungus organisms develop under high humidity conditions and hot climate. They destroy the badic conformation of the wood causing a kind of internal "cracking" problem. This is the direct cause of the reduction in work tension limit of the timber members.

Since wood is a non-synthetic material, although treated with special kinds of substances, it has a life time limited in standard conditions (much less in humid conditions).

Literature on the influence of weather conditions in timber structures pertain only to small considerations in deflection in beams and tension in compressed members. The first consideration is due to the internal stress and fatigue of the structure because of the change from hot humid climate to wet climate. The contorsion of the internal and external fibers of the wood cause the cracking problem mentioned above. The second one refers to fissures along pile systems.

Conclusions

The Problem: Physical Loading

The structural engineer has been accustomed to think that if a structure is to withstand mechanical loading, then it will be good enough to ensure soundness against physical loading, i.e., thermal or himidity stresses. This thinking has now changed and this was brought about by three main factors:

1) Materials – The traditional materials, such as brick and wood, have a low coefficient of thermal expansion (about half that of concrete); concrete, steel and reinforced concrete have a high coefficient, resulting in higher deformations and higher stresses due to them.
2) Statical character – The structures in use at present are more and more monolithic, i.e., statically indeterminate, so that temperature and humidity changes are bound to cause higher stresses.
3) Locality – In countries where building has gone on for hundreds of years with accumulated knowhow, results have been ensured. But building in new regions now, with no past experience and with higher physical loads than we were accustomed calls for more detailed study.

Steps toward Solution

The mechanical loads are defined by standard specifications which enable designers to design any building without resource to special measurements or surveys. For physical loads such information is lacking, so that the first necessary step is to gather facts to which a considerable amount of studies have been devoted.

The second step is theory. From facts, i.e., data obtained by measurement, experiment and observation, general theories and laws have to be worked out, enabling the designer to deal with any particular problem.

The third stage is devising new methods for either avoiding the stresses or withstanding them, by suitably strengthening the structures.

The final step is trial of the proposed methods. This can be done by laboratory experiments and by observation on full-scale structures built by the new methods.

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Delivery System for Farm Machinery Technology in India

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Abstract

Improved agricultural implements and machinery have helped the farmers in efficient utilization of seeds, fertilizers and chemical, reducing human drudgery, timely farming operations and increasing the productivity of land. But still the majority of the farmers are using traditional hand tools and implements. Efforts of various research and development institutions, industry promoting agencies and financing bodies were reviewed. It is essential to provide the suitable implements and machines to the farmers so that the full advantage of other inputs may be derived by them.

Introduction

The delivery system for technology defines the effective media through which the relevant technology is transferred from souce of origin to the end user. There are two approaches in the transfer of technology to the user: demand pull and technology push. In the former case the users of technology make the effort to avail themselves of the technology from the manufacturers or research and development intstitutions. In the latter case, however, concerted efforts are required to create awareness amongst the prospective users about the utility and economics of the technology. The improved agricultural implements and machinery, by and large, fall under technology push category.

With the introduction of high yielding varieties and intensive cultivation practices, the demand for improved agricultural machinery has increased considerably (**Tables 1 and 2**). These have been accepted by progressive farmers as one of the essential inputs for efficient and effective utilization of seeds, fertilizer and chemicals, reducing human drudgery and timely farming operations. But majority of the farmers in villages are still using the traditional age-old implements. There is need to review and analyse the problems associated with low adoption of the improved technology.

Research and Development Efforts

A number of research and development (R and D) organisations are engaged in undertakeing the improvement of existing designs of agricultural machinery and developing new machines suitable for various farm operations and farming systems (2). These activities started in India in the late 19th century when horse-drawn machinery were imported from European countries. Activities at that time were in the hands of British officers and their line of thinking was very much influenced by the development in Europe. By 1930 many bullock-drawn ploughs were developed. After the independence, the Government of India decided to survey the indigenous implements being used by the farmers in the country with a view to improving their efficiency and developing new machines.

Research and development activities gained momentum after the establishment of agricultural universities in 1960s. Initial emphasis was confined to the development of tillage equipment but gradually expanded to seed drills, seed-cum-fertilizer drills and threshers. To date more than 380 farm implements and post harvest equipment have been developed by various R and D institutions numbering about 45. However, the commercial production of these machines has been low (25%) (3). Efforts to develop better implements and machines are still continuing with the hope that these will be taken up for commercialization.

The Indian Council of Agricultural Research (ICAR) through its research institutes and research

Table 1 All India Agricultural Machinery and Implements (Unit: 1,000)

Items	1961	1966	1972	1977
Bullock and manually operated implements				
Wooden plough	38372	39923	39294	40766
Iron plough	2298	3523	5359	6258
Blade harrow or bakhar			11738	11497
Wet land puddler	N.C.	2724*	1694	2056
Earth levellers or scrapers			3731	8728
Seed drills/sowing device	N.C.	1135	4049	4822
Cart (animal drawn)	12072	12697	12960	12742
Maize shellers	N.C.	N.C.	175	226
Sugarcane crushers				
Worked by power	33	45	87	987
Worked by bullocks	590	650	681	673
Spayers and dusters	N.C.	211*	448	559
Pump sets used for irrigation and persian wheels				
Oil engines with pump sets	230	471*	1557	2162
Electric pump sets	160	415	1618	2313
Persian wheels	600	680	638	621
Tractor-operated implements				
Mouldboard plough and disc plough	N.C.	N.C.	57	81
Disc harrow	N.C.	N.C.	56	105
Cultivators or tillers	N.C.	N.C.	81	149
Levellers or scrapers	N.C.	N.C.	49	96
Seed-cum-fertilizer drills	N.C.	N.C.	25	36
Seed planter	N.C.	N.C.	9	16
Rotavator	N.C.	N.C.	6	9
Trailer	N.C.	N.C.	55	117
Other tractor operated implements	N.C.	N.C.	18	21
Power driven machines and miscellaneous equipments				
Wheat threshers	N.C.	349*	183	350
Paddy threshers	N.C.		14	17
Threshers for other crops	N.C.		10	10
Maize shellers	N.C.	N.C.	16	17.2
Harvester combines	N.C.	N.C.	N.C.	1268
Power chaff cutters	N.C.	N.C.	142	200
Other power operated equipment	N.C.	N.C.	34	38

* Figures for 1972 Census are not strictly comparable with 1961 and 1966 Censuses in respect of these implements. N.C. = Data not collected.
Source: 1. Indian Agriculture in Brief, Sixteenth Edition; Directorate of Economics and Statistics, Ministry of Agriculture. 2. Machinery Division, Ministry of Agriculture, Dept. of Agriculture and Co-operation, New Delhi.

Table 2 All India Annual Indigenous Production and Import of Tractors (Unit: Number)

Sl. No.	Year	Indigenous production	Import	Total
1.	1961–62	880	2 997	3 877
2.	1962–63	1 414	2 616	4 080
3.	1963–64	1 983	2 346	4 329
4.	1964–65	4 323	2 323	6 646
5.	1965–66	5 714	1 989	7 703
6.	1966–67	8 816	2 591	11 407
7.	1967–68	11 394	4 038	15 432
8.	1968–69	15 466	4 726	20 192
9.	1969–70	18 120	10 478	28 598
10.	1970–71	20 099	13 300	33 399
11.	1971–72	17 100	19 739	37 839
12.	1972–73	20 802	1 000	21 802
13	1973–74	24 425	1 000	25 425
14.	1974–75	31 088	793*	31 881
15.	1975–76	33 252	1 100*	34 352
16.	1976–77	33 146	2 920*	36 066
17.	1977–78	40 946	N.A;	40 946
18.	1978–79	54 728	N.A.	54 728
19.	1979–80	62 696	N.A.	62 696
20.	1980–81	69 501	N.A.	69 501
21.	1981–82	81 472	N.A.	81 472

* Under IDA Project/World Bank Project. N.A. = Not available. Source: Statistical Supplement, Machinery Division, Government of India, Ministry of Agriculture, Dept. of Agriculture and Co-operation, New Delhi.

centres, agricultural universities and Council for Scientific and Industrial Research (CSIR) are the main organisations responsible for R and D activities. In addition, farm machinery manufacturers and few private individuals have also made significant contributions in the development of improved farm equipment. These organisations are trying to transfer technology to the farmers through their own limited extension network and, therefore, the impact is felt in selective locations only. The CSIR has established 10 poly-technology transfer centres in different states to deliver technology. The National Research and Development Corporation of India (NRDC) is the sole agent for the commercial exploitation of technologies developed in the country.

The efforts of the extension network of ICAR and agricultural universities have helped researchers in establishing the techno-economic viability of the technologies. For wider adoption of the technologies by the farmers, however, concerted attempt has not been made to involve rural artisans through rural development agencies – either administered by governmental or voluntary organisations, for introduction and popularization of farm machinery. The adoption of technology, therefore, has been slow. If the improved farm equipment and technical knowhow associated with it is to be promoted among farmers, the existing industry and rural development agencies may have to be actively involved.

Production and Popularization Agencies

Technology Transfer and Farm Machinery Production

Farm equipment are produced by village artisans and small-scale manufacturers on custom-built methods. Medium-and large-

scale industries numbering about 1474 produce on mass production techniques. Such items as tractors, power tillers, diesel engines, irrigation equipment, plant protection machinery, land development equipment, post harvest machinery and dairy equipment, electric motors, etc. Bullock-drawn and power-operated machinery requiring simple manufacturing technology such as ploughs, cultivators, disc harrows, levellers, seed drills and planters, weeders, sprayers and dusters, threshers groundnut digger shaker, potato digger, groundnut decorticator, etc. are produced by small scale industries numbering more than 8000. These units are scattered over the country with a concentration in selected pockets over the northern, western and southern regions (4). In addition, there is a large number of unregistered units located in sub-urban and rural areas whose numbers are not known but estimated to be around 3000. These units undertake repair, maintenance of farm machinery besides fabrication of threshers, seeding devices, harrows, cultivators, trolley, etc.

Village artisans numbering more than a million, although, fabricate simple hand tools and bullock-drawn implements, such as spades, pick axe, rakes, weeders, hand hoe, sickles, ploughs, blade harrows, bullock cart, etc. meet about 80% of the farm machinery requirement in the country.

Thus the small scale industries and village artisans (blacksmith and carpenters) fabricate the bulk of the farm machinery in use in the country. The designs are mostly copied from existing machines being marketed. During copying many of the critical dimensions of the machine components were ignored resulting in poor performance. The village artisans are still engaged in the fabrication of traditional farm tools. They lack in modern production facilities and, hence, low production and poor quality of products and high cost (5).

Table 3 List of Technical Institute/Training Centres

	List of Technical Institutes/Training Centres.	
1.	Conventional Universities	119
2.	Agricultural Universities	23
3.	Indian Institute of Technology	5
4.	Engineering Colleges	150
5.	Polytechniques	350
6.	Industrial Training Institutes	831
7.	Trainers Training Centre	7
8.	Farm Science Centre	100
9.	Small Industries Services Institutes and Extension Centres	80
10.	Poly-Technology Transfer Centre	10
11.	Tractor Testing Station	3
12.	Extension Training Centre	3
13.	Village Level Workers Training Centre	44

The technology of improved designs available at the R and D centres are being delivered to only a few selected artisans and manufacturers through the limited regional and national extension services. The Agro-Industrial Development Corporations. established in 18 states have the major responsibility of production of improved implements and machines developed at the ICAR research institutions centres and agricultural universities.

The Ministry of Industries has the major responsibility of promoting the small scale industries and village industries through the Small Industries Development Organisation (SIDO) and District Industries Centres (DIC) which provide technical and financial support to small scale industries and village industries (6, 7). These agencies, however, have hardly been represented by engineers with experience in farm machinery and, therefore, farm machinery industries do not get their due place in their programmes.

In addition to the agencies mentioned above, there are the Small Industries Services Institute (SISI), Khadi and Village Industries Commission (KVIC), National Research and Development Corporation (NRDC) of India, Polytechnology Transfer Centres, Appropriate Technology Groups, Rural Engineering Centres, Rural Development Organisations, Private Industrial Houses, voluntary organizations which assist the small scale manufacturers and village artisans by way of training, providing raw materials and in getting financial credit through the credit institutions (7, 8, 9, and 10) (Table 3)

The Regional Network for Agricultural Machinery (RNAM), a Programme of Economic and Social Commission for Asia and the Pacific (ESCAP) financed by United Nations Development Programme (UNDP) is making effort to promote the production of improved implements and machinery through mutual cooperation amongst the developing countries. There are eight countries, namely; India, Indonesia, Iran, Pakistan, Philippines, Sri Lanka, Republic of Korea and Thailand participating in the programme (5). The Central Institute of Agricultural Engineering (CIAE), Bhopal, is coordinating the RNAM activities in India.

Popularization and Adaption

The popularization of farm equipment is done by various extension agencies through display, demonstration, training and other audio-visual aids. To achieve accelerated adoption of new technology efforts are required

i) For demonstration to farmers with a view to creating awareness about its utility and effectiveness;

ii) To assess the demand of the technology to select the suitable mode of commercial production;

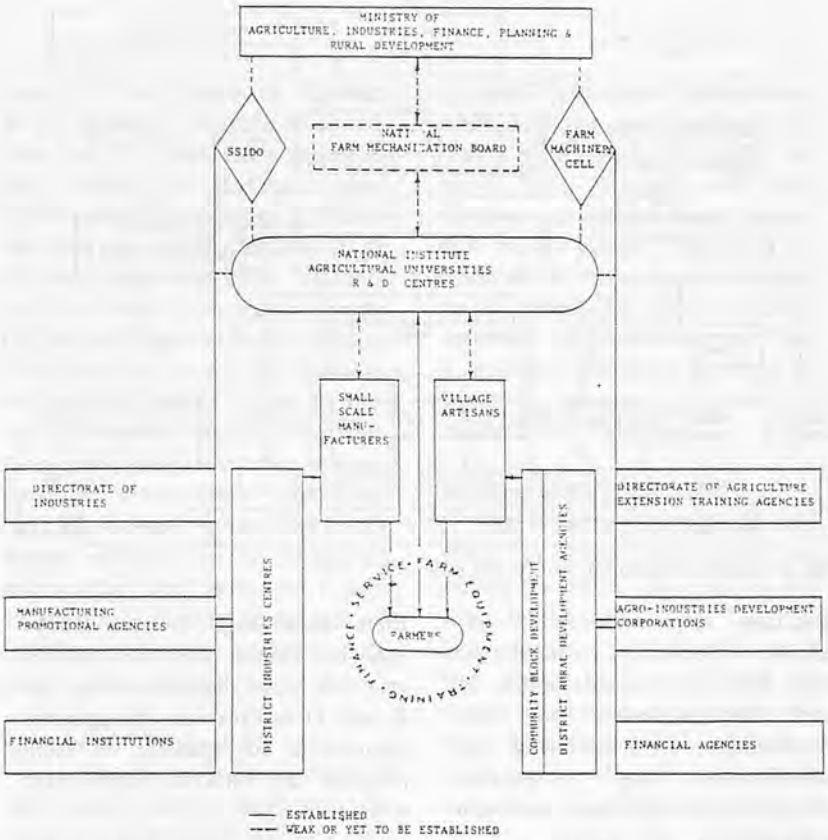

Fig. 1 National, state and district level coordination in manufacture and promotion of farm machinery.

iii) To transfer technology to manufacturers and rural artisans for commercial production; and

iv) To train farmers in operation, maintenance and repair.

The above activities are being undertaken by various agencies in the country within their resource constraints (Fig. 1).

Indian Council of Agricultural Research (ICAR)

The ICAR although primarily responsible for education, research and development programmes in the country in agriculture, horticulture, fisheries, animal husbandry and forestry, has established farm science centre (Krishi Vigyan Kendrra) and trainers training centre to transfer rrelevant technologies to the users through research institutes/centres and agricultural universities. The technology from the research organisations is also being transferred under the Lab- to-Land Programme to few adopted farmers.

The All India Coordinated Scheme on Farm Implements and Machinery with coordinating centre at CIAE, Bhopal has the unique advantage of having research and development, prototype production workshop, feasibility testing under actual field conditions, training of village artisans and establishment of linkages with the small scale manufacturers in one scheme. The Scheme has centres located at Bhopal, Coimbatore, Hyderabad, Ludhiana, Pune, Shillong, Jhansi, Lucknow, Ranchi, Udaipur, Junagadh, Kharagpur, Hissar, Jabalpur, Pantnagar and Vellanikkara (Fig. 2). Thus R and D and prototype manufacturing responsibilities rests with ICAR.

Ministry of Agriculture and Rural Development

The Department of Agriculture and Cooperation, Ministry of Agriculture coordinates the farm machinery production and popularization programmes of the State

Fig. 2 All India coordinated scheme on farm implements and machinery.

Government being undertaken through agro-industrial development corporations. The Ministry also decides the policies with regard to import of farm equipment in the country. There are 3 Tractor Testing and Training Stations (TTTS) located at Budhi, Hissar and Anantpur. In addition to testing of tractor and agricultural machinery, these stations provide training to farmers, rural youths, artisans and technicians in various farm machinery operation, repair maintenance and manufacturing. The Extension Training Centres (ETC) are located at Nilokheri (Haryana), Rajendranagar (Hyderabad) and Anand (Gujarat). These centres also provide training to farmers and artisans. Hence, the Department of Agriculture and Cooperation is the nodal agency responsible for industrial extension and large scale popularization of the newly developed and proven implements and machines. In reality, the task is big and has to be carried out in cooperation with State Government and their agencies.

The Ministry of Rural Development finances the majority of the development programmes related to farmers, village artisans and rural youths being undertaken by various governmental, private and voluntary organizations (8). The ministry

is in the process of establishing a Council for Advancement of Rural Technology (CART) which will monitor the information and disseminate the same to rural people through existing development agencies.

Rural Engineering and Rural Technology Centres

A large number of rural engineering and rural technology centres sponsored by the Department of Science and Technology, Ministry of Industries, Ministry of Rural Development, Khadi and Village Industries Commission, Private Industrial Houses, charitable trusts, voluntary organizations such as Consortium on Rural Technology (CORT), religious institutions, etc. have established training centres for upgrading/improving the skills of the rural people (9). These programmes are also being operated in small measures by the Indian Institute of Technology (IITs), Rural Engineering Institutions, Rural Polytechnics and Industrial Training Institutes (ITIs) and private organizations.

State Government

As mentioned earlier, the major responsibility of popularization of improved agricultural implements and machinery rests with the Directorate of Agriculture of the State Governments. The Directorate of Agriculture/Agricultural Engineering executes the programmes of popularization through its extension network. The States which provide technical functionary up to block level have the advantage of transfering technology to the farmers in the village. The Agricultural Engineering Cooperative and Marketing Federation (ENCOFED) in Tamil Nadu and Farm Machinery Cooperative Societies it block level in states like Gujarat, have helped the farmers in adopting farm technology. The states having inadequate infrastructure in extension services, contributed very little in popularization of small farm implements and their involvement in encouraging the manufacturers and distribution of agricultural machines has been minimal.

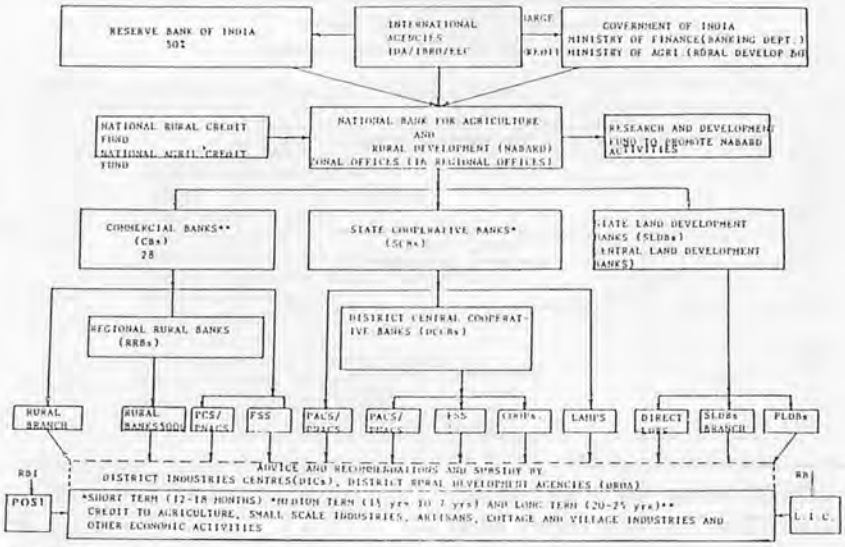

Fig. 3 Organized sources of rural credit financing.

Private and Voluntary Organizations

Tractor and farm machinery manufacturers, charitable trusts, industrial houses, youth clubs, religious institutions, and private rural engineering institutions have established training and extension service centres for the benefit of rural people to improve their living standard by helping them, to increase the agricultural productivity and establishing village industries. The Ministry of Rural Development also provides funds for strengthening the training facilities and stipend to the trainees under Integrated Rural Development Programme (IRDP) and Training of Rural Youths for Self Employment (TRYSEM) Programmes. The effort of the various rural development agencies is appreciable, however, they work in isolation and are not fully aware of the improved implements and machinery developed by the R and D centres. The R and D centres have also not made concerted efforts to transfer their technology to the above agencies. Hence, it is desirable to establish good liaison among the R and D centres and the agencies responsible for transfer of technologies at national and state levels.

Credit Facilities

The adoption of new technology depends upon the financial resources available for the farmers/artisans and small scale manufactures. Initial investment on new improved implements and machinery will definitely cost more than the traditional tools used by the farmers, and, therefore, additional financial resources must be provided for adoption of the new technology (Fig. 3). The various means available for increasing the financial resources are as follows: own capital, friends, relations, village money lenders, traders, commission agents, cooperative credit societies, commercial banks, rural banks, land development banks, and Government development programmes.

The Government of India has recently established the National Bank for Agricultural and Rual Development (NABARD), a new significant statutory financial institution to operate as Rural Reserve Bank (11). This has started functioning from July 12, 1982 and has

regional offices located at 16 places in the country. The NABARD will take over the entire undertaking of the Agricultural Refinance and Development Corporation (ARDC) and also replaces the Reserve Bank of India in the matter of refinancing the State Corporation Banks (SCBs) and Regional Banks (RRBs). It will provide, by way of refinance, to banks all kinds of production and investment credit to agriculture, small scale industries, artisans, cottage and village industries, handicrafts and other allied economic activities in an integrated manner for short term loan (up to 18 months), medium term loan (18 months to 7 years) and long term credit (up to 20-25 years.)

Commercial Banks (CBs)

All the 28 nationalized banks in the country provide short term (for working capital) and medium term (for capital goods) loan to farmers, rural artisans and small scale industries through their 19 942 rural branches.

Loans are available for the purchase of tractors and farm machinery against hypothetication to the banks and for the land development and creation of irrigation facilities against the mortgage of land. The banks also provide indirect finances to farmers through the rural development programmes, credit societies and rural electrification programmes. A number of banks have initiated lead bank schemes for employment generation in the villages. The loans are finalized in the villages through credit camps and credit workshop organized in selected areas. **Table** 4 indicates the credit provided by banks for purchase of agricultural machinery.

Table 4 Distribution of Farm Machinery Manufacturers in India

Item	Number
Agricultural tractors	15
Power tillers	7
Agricultural hand tools, implements and machinery	6981
Combines	4
Tractor parts accessories of agricultural machinery	546
Earth moving machinery and parts	188
Diesel oil engines	524
Irrigation pumps	193
Bullock cart, push cart, hand carts etc.	962
Tractor trailor	126
Village artisans	1 million

Source: Development Commissioner, Ministry of Industries, Government of India, 1972.

Regional Rural Banks (RRBs)

The Regional Rural Banks initiated in 1976 supplements the efforts of other financial institutions in the rural areas. They are like scheduled commercial banks but confine to district where primary credit societies (which are base line societies) at villages or block levels, do not exist or are very weak. The RRBs are sponsored by the commercial banks with central and state Governments additional financial contributions. The RRBs extend credit facilities to people with meagre resources such as small and medium farmers, labourers, artisans, etc. In December, 1980 there were 120 RRBs with a network of 5,000 branches in the country.

State Cooperative Banks (SCBs)

State Cooperative Banks are apex cooperative banks in the State. They guide, control and finance the District Central Bank and Cooperative Institutions in the state. Where CCBs have not been established they directly deal with base line banks. The SCBs are financed by NABARD. These banks provide short term (crop loans) and medium term loans to the farmers/artisans through Central Cooperative Banks located at District/Towns and through the Primary Agricultural Credit Soceity (PACSs), Primary Non-Agricultural Credit Societies (PNACSs), Farmer Service Societies established at the village level by groups of villagers.

Central Cooperative Banks (CCBs)

The Central Cooperative Banks are the middle level functionary between SCBs and Primary Credit Societies at Village level. These operate a town/tehsil and district levels and guide and finance Primary Agricultural Credit Societies (PACSs) and Primary Non-Agricultural Credit Societies (PACSs). The Central Cooperative Banks are the federation of the primary credit societies in specified areas. There are two types of CCBs – one which deals directly with the primary credit societies and individual member. The funds to the societies are available through share capital and reserve deposits from current, fixed, and saving funds, deposits from primary societies, loans and overdraft from State Bank Groups, funds from municipalities and boards, etc.

Primary Agricultural Credit Societies (PACSs)

The Primary Agricultural Credit Societies work at the village level and form the base of the credit financing. The societies are formed initially with a minimum of 10 members. The funds are made available to these societies through share capital, entrance fees, deposits from the members, loan from the Central Cooperative Bank/RRBs and the Government.

State Land Development Banks (SLDBs)

This is an organization similar to State Cooperative Banks and extend term loans for the purchase of capital goods such as tractors, pumps, engines, threshers, etc. These Banks have Primary Land Development Banks (PLDBs) having membership of individual farmers. The credits not covered under PACSs are taken care by these banks.

Reasons for Low Adoption of the Technology

The majority of small and marginal farmers are still using traditional hand tools and implements. The improved technology could be made available to only few selected group of farmers. Perhaps, all the agencies engaged in the delivery of technology could not achieve the desired objectives due to sheer magnitude of the recipient of the technology, inadequate institutional framework coupled with poor coordination in the delivery system and scarce input resources on the part of farmers. It is in this context that the low adoption of the technology is examined.

Institutional Framework and Coordination

An examination of the various agencies involved in the promotion of technology shows that the programmes are being executed primarily by the following ministries: Research and development – Ministry of Agriculture and Ministry of Science and Technology: Promotion of small scale industries and village industries – Ministry of Industries; Popularization of improved farm equipment – Ministry of Agriculture, and Ministry of Rural Development.

The various departments, institutions/organizations belonging to above ministries work in isolation without proper coordination at the appex level which makes monitoring and dissemination of technoloty difficult, hence adoption is slow. Revitalization of National Farm Machinery Board (NFMB) under the Ministry of Agriculture and efforts to establish the Council for Advancement of Rural Technology (CART) under Ministry of Rural Development are some of the steps taken by the government to effect coordination amongst various agencies.

At the delivery end, there is a weak linkage among the research institutions, small farm machinery manufacturers/village artisans, extension agencies and farmers. The Small Industries Development Corporations and the District Industries Centres which are the functionaries of the Ministry of Industries for the promotion of industries in a district, including village industries, have no effective machinery below the district level to serve the rural artisans. If the adoption of technology is to be accelerated among the farmers, the village artisans must be involved in fabrication, repair, maintenance and supply of farm machinery. A centralized unit like Agro Industries Development Corporation, howsoever big, cannot serve the masses and, therefore, some area based specific decentralized units should be created at the rural level. The State Government whose contribution in popularization of farm machinery has been minimal must create infrastructures at district and block level, which will coordinate and extend the assistance to manufacturers and village artisans in the production and distribution of machinery.

Techno-economic Viability of the Technology

The R and D centres try to establish the techno-economic viability of the technology through their limited trials and field evaluation. Experience has shown that the small scale manufacturers are generally reluctant to manufacture new farm equipment, particularly hand tools and implements, due to rather low margins of profits, although, their suitability are established during extensive field evaluation on farmers' fields. This is attributed to the fact that assessment on demand of the farm machines is seldom estimated by the R and D centres.

Market Research

Due to socio-economic, agro-ecological and technological diversity in India, the forecast for demand of agricultural machinery is difficult to predict with any accuracy. This responsibility rests with the State Government to assess the implements and machinery requirements of the farmers. However, the information is hardly made available to the manufacturers and, therefore, they have their own methods of estimating the demands. The National Council for Applied Economics Research (CNAER) has made some studies with regards to tractors and farm machines but the information is again location specific. The research engineers attempt to assess the demands of the new farm machines developed by their organizations. The ICAR has established 16 feasibility test centres throughout the country under the All India Coordinated Scheme on farm implements and machinery. Under the Scheme the scientists are expected to test the farm machines on the farmers' field and also assess the demands of the farmers and these are passed on to the manufacturers while transfering the technology. As the operational area of these centres is limited, their forecasting has a limited accuracy.

Tractors, power tillers, electric motors, diesel engines and pumps are generally manufactured by large scale and medium-scale manufacturers in organized sectors and they have very well organized distributors throughout the country. These agencies survey the market and communicate to the manufacturers. It is also observed that in 95% of the cases the tractors and large machines are purchased through the bank loans and the processing of loans to the farmers gives ample opportunity for the agents/distributors to provide the information to the manufacturers. Invariably such establishment's resources are under-utilized and, therefore, earn low profit. There has been 40-

60% reduction in tractor production this year due to credit squeeze imposed by the rural banks.

Plough, harrow, cultivators, seed drills, threshers, etc are manufactured by small-scale manufacturers. These units are either located in urban/sub-urban or rural areas. The demands of such farm machines are very much influenced by the credit policy of the Government, level of mechanization of the region and the impact of extension agencies on the farmers. These manufacturers are invariably selling their product directly to the farmers and do not appoint any dealer/distributor. The market assessment of these manufacturers depends entirely on personal contact with the farmers. It is not very uncommon to fabricate seed drill, thresher, trolley, cultivator on the customers demand. The manufacturers who are located in rural areas/sub-urban areas have better contact with the farmers and, therefore, better market assessment. The manufacturers located in the cities suffer totally from the lack of this information. Their production has no relationship with the demand factor, hence their meagre resources either get locked up by over-production or they earn less profit because of low turn over.

The village artisans mainly fabricate traditional tools and implements like spade, hand hoe, country plough, blade harrow, yokes, planks, sickles, bullock carts, etc and meet about 80% of the requirements of the farmers/villagers. As the sale of such implements is restricted to few villages only, the assessment of the requirement is based on personal contacts only. In a majority of the cases, the tools/implements are custom-made.

On the other hand, the village artisans who are engaged in fabrication of improved implements, try to assess the market demands based on the information supplied by the extension agencies.

Village Artisans

The village artisans who are engaged in the fabrication of traditional hand tools and implements in the villages are in a better position to assess the market of the farm implements with their proximity to service areas and personal contact with the farmers. But they are not well equipped to fabricate improved implements with their limited fabrication facilities and poor skill. They learn the fabrication skill through their family trade and have no formal training in using modern hand tools and workshop equipment. The technology of the improved farm implements is also seldom made available to them. Most of the training facilities to upgrade their skills are available in cities.

Raw Materials

The Small Industries Development Corporation and District Industries Centre assess the raw material requirements of the small scale industries and village artisans and provide them at reasonable price. However, due to large demands from non-agricultural industries, these agencies find it difficult to meet all the requirements. The agencies are also not equipped to supply smaller quantity of special steels like carbon steels to small industries and village artisans. Furthermore, the procedure followed in obtaining the permit for getting the raw materials through the District Industries Centres (DIC) is too complicated for the illiterate/semi-literate village artisans.

Demonstration, Sale and Service

The adoption of new technology is very much influenced by the level of formal education of the farmers and artisans. A report published in 1971 underlines the attitude of the illiterate farmers: "The rate of adoption of improved implements for those in high literacy ability category was approximately eight times that of illiterates (12)." This calls for extensive education and training of farmers in new technology. The centres responsible for training of farmers such as Farmers Training Centre (FTC), Farm Science Centres (Krishi Vigyan Kendra), etc are generally located in the cities. Furthermore, their numbers are very few as compared to their population. Thus only a few privileged class of farmers could avail of the training opportunities. If a meaningful training programmes is to be planned for larger participation of the farmers, these will have to be at the block level.

It is not only training and demonstration which are essential preconditions for large scale adoption of the technology but also availability of good quality equipment and reliable service facilities at rural level. Studies indicate that even in the best mechanized district like Ludhiana (Punjab), farmers are compelled to travel from 12-23 km distance for repair and maintenance of tractor and diesel engines. In other states they may have to travel even up to 50 km or more for service facilities with only bullock-cart transport available in the area (4).

Financial Resource Constraints

The major constraints with farmers for adopting improved agricultural machinery is their limited financial resources. In the village the payments are made to the village artisans in kind for buying hand tools and implements. Some of the implements purchased from the local market is, of course, in cash but the amount is small. The implements purchased from the manufacturers is always in cash, which puts the farmers in vulnerable financial constraint.

There are credit facilities available in the villages for the purchase of agricultural inputs including farm machinery through the

farmers' credit societies: Regional Rural Banks, Land Development Banks and Commercial Banks. The farmers generally obtain credit through these agencies for the purchase of tractor, irrigation pump, diesel engine and other agricultural machines which have quality certification from the government agencies. But the procedure to obtain credit from the above agencies is complicated for the illiterate farmers and artisans to follow. It requires a lot of efforts to pursue the bank authorities for sanctioning the loan. Studies have indicated that it takes 3-6 months to get the loan from the credit societies and banks (13). Only few educated and rich farmers have been able to get the loan from the organized credit institutions. More than 40% of the total credit is still being obtained from the village money lenders/traders/commission agents/relatives. The Ministry of Rural Development has realised this fact and has advised the banks and credit societies to simplify the procedure for advancing the loans. They have even advised the banks officials to visit the blocks and villages for sanctioning of loans. But the success of the whole rural credit will depend upon the sincerity and honesty of the implementing agencies and also on the farmers education and awareness of the national programmes.

Conclusion

Adequate infrastructure to carry out research and development activities in farm machinery is available in the country. The research organizations have made considerable contributions in developing improved implements and machinery.

Due to poor coordination between R and D institutions and industry promoting agencies, the transfer of technology of improved designs of farm machinery to the manufacturers has been rather slow. The R and D institutions have been able to establish linkages with only few local manufacturers.

The village artisans who still supply the bulk of the traditional farm hand tools and implements to the farmers could not be provided the technology of improved designs due to inadequate infrastructure for transfer of technology other than the district headquarters.

Most of the training institutions for providing training to the farmers and village artisans are located in cities which are neither adequate for larger rural population nor easily approachable due to different city environment for illiterate/semi-literate farmers and artisans.

The success of rural development programmes, particularly government efforts to provide additional financial resources for the adoption of improved technology to the farmers and village artisans and to alleviate their backwardness, will depend upon their education and awareness of such programmes.

Therefore, there is a need to have effective delivery system of technology at village or block level which will execute the national development programme effectively.

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William A. Stout Has Been Awarded the 1986 Kishida International Award

William A. Stout, Professor of Engineering, Texas A & M University, College station, has been awarded the 1986 Kishida International Award by the American Society of Agricultural Engineers (ASAE).

The award was presented during the Society's 1986 Summer Meeting, June 29–July 2, California State Polytechnic University, San Luis Obispo.

The Kishida International Award is presented annually to a member of ASAE for "outstanding contributions to food and fiber production, improved living and education of people outside the United States of America."

Established in 1978, the award is sponsored by Shin-Norinsha Co., Ltd. of Japan, publisher of Agricultural Mechanization in Asia Africa and Latin America magazine and other publications. It is named after Yoshikuni Kishida, founder of the publishing firm and widely acclaimed pioneer in agricultural mechanization in Japan and Asia.

Stout was presented the award to recognize his "extensive worldwide service as an authority in mechanization and alternate energy programs," according to his citation. He has devoted over 25 years to programs of assistance for developing countries in Asia, Africa, and South America.

He is a registered Professional Engineer in both Michigan and Texas. An elected member of several honorary societies, Stout previously headed Michigan State's agricultural engineering department, chaired ASAE's Power and Machinery Division, and served on numerous ASAE sectional and national committees.

Over half of the 150 documents authored by Stout have been directed toward international work. Included are internationally oriented books such as Energy for World Agriculture, Equipment for Rice Production, and Agricultural Mechanization in Equatorial Africa. Stout is also a world-class educator who has helped to develop international students and has worked with educational institutions in developing countries to improve their teaching and training programs.

The honoree's doctorate and masters are from Michigan State University; his bachelor of science is from University of Nebraska.

Stout is a 1949 graduate of Perkins County High School, Grant, Nebraska. He and his wife Rita are the parents of two children.

Dr. Jun Sakai Was Awarded by Japan Minister of Foreign Affairs

Dr. Jun Sakai was awarded by Japan Minister of Foreign Affairs for his meritorious service in the promotion of international technical cooperation. The ceremoney

of awarding his honor was held on the 8th July, 1986, in the Ministry of Foreign Affairs, Tokyo. The Minister Shintaro Abe gave a testimonial and a silver cup to him. This awarding is the first case in the agricultural machinery sector in Japan.

He is a well-known professor of agricultural machinery, Kyushu University, Japan, and a co-editor of AMA.

He has contributed commendable service as a part-time lecturer since 1966 to give lectures, practices and symposiums to more than three hundred foreign trainees in total in Tsukuba International Agriculture Training Center (TIATC) under Japan International Cooperation Agency (JICA). His teaching subjects in TIATC for the last twenty years were Power Tiller Engineering, Hand Tractor Engineering, Rotary Tillage Engineering, Historical Development Currents of Farm Machinery in Japan, R&D Design and Manufacturing Practice of Farm Machines such as Alternative Gas-fuel Producers, Plows, Iron Wheels, Rakes, Cage Wheels and Hand Tractor Components etc. He advised and guided also to the establishment of Farm Machinery Design Course, which started in 1983, besides Rice Production and Mechanization Course in TIATC.

In addition, he served to many international cooperation businesses in Japan and several Asian and African countries as an agricultural engineering expert in UNESCO or JICA. ■■

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Machines for Moving the Earth
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(Netherlands)

By A.N. Zelenin, V.I. Balovnev, I.P. Kerov

This Book describes fundamentals of the theory of soil loosening, mathematical and scale modeling of working processes of machines and methods for forecasting machine parameters. The book will be useful to engineers and technicians engaged in design and development of machines for earthwork.

Size: 24 x 16 cm, 555 pp, cloth-bound

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Published by A.A. Balkema, P. O. Box 1675, Rotterdam, Netherlands

Theory of Surfaces of Plow bottoms
[Russian Translation Series, 38]
(Netherlands)

By L.V. Gyachev

This book is divided into three parts. The first part deals with the kinematics and dynamics of motion of a slice over the working surface of the frame. The trajectories of particles of the slice in different phases of its motion and the forces acting on the slice and the body of the plow are considered.

The second part proposes methods of designing working surfaces of plow bottoms for particular geometrical conditions and methods of testing existing moldboard forms.

The third part describes a method of designing linear surfaces for a given limiting trajectory of the slice and the results of trials. The theory is used to solve practical problems: setting parameters and designing the working surfaces of the plow for high plowing speeds and earthing.

The book is intended for specialists investigating into soil working processes and designers of soil-working machines. It may also be useful for students of the institutes of mechanization of agriculture and agricultural machine building.

Size: 24 cm x 16 cm, 294 pp, cloth-bound

Price: US$28.50

Published by A.A. Balkema

Testing of Agricultural Technological Processes – A Systems Approach
[Russian Translations Series, 39]
(Netherlands)

By S.V. Kardashevskii, L.V. Pogorelyi, G.M. Fudiman, P.I. Lobko and V.V. Brei

The authors have examined organizational and technological principles and scientific methods of testing agricultural technological processes. They discuss in detail modern methods of agricultural technological evaluation, power rating, operational and technological evaluation and economic estimation of agricultural machines and complexes. They also describe methods for estimating the reliability of agricultural machines and the working conditions for machine operators.

The authors have introduced the fundamental principles of systems analysis and methods for forecasting the effectiveness of an agricultural technological process in the testing stage.

The book will be useful for engineers and technicians involved in the research and development, and testing of agricultural technological processes.

Size: 24 cm x 16 cm, 299 pp, cloth-bound.

Price: US$30.00

Published by A.A. Balkema

Keyguide to Information Sources in Agricultural Engineering
(U.K.)

By Bryan Morgan

A guide to the bibliographical and organizational sources of information in agricultural engineering; this book also outlines the history and development of the subject. It places the literature of agricultural engineering in the context of the wider engineering literature and links it to related subject areas such as agriculture and the environmental sciences. It will be used by researchers, librarians and information officers, both in agricultural engineering itself, and in related areas as an approach to the specific subject.

Part I, in narrative form, is a general survey of agricultural engineering: its history, scope and literature. It selects and describes the most useful textbooks and monographs; other literature, such as journals, reports, standards, directories, abstracting and indexing services and conference papers; and computerized databases. It explains the organization of the various information sources, and the ways in which they may be used. Part II is an annotated bibliography and Part III is a directory of selected organizations from around the world from whom agricultural engineering information may be ob-

tained.

Size: 24 cm × 16 cm, 210 pp, cloth-bound.

Price: £21.50

Published by Mansell Publishing Limited 6 All Saints Street, London, U.K.

The Design and Manufacture of Animal-Drawn Carts

(U.K.)

By Ian Barwell and Gordon Hathway

The ILO and UNCHS/HABITAT have initiated the preparation of a series of technical memoranda on low-cost vehicles. The purpose of these studies is to provide a simple guide to the design and manufacture of these vehicles so that (a) the technology is made known to a wide audience, including decision-makers and planners who should be aware of the potential range of proven low-cost vehicles, and (b) producers are provided with information and guidelines on the design and manufacturing procedures which can be employed in various circumstances and at different scales of production. The first technical memorandum in the series relates to animal-drawn carts.

While animal-drawn carts have been used for hundreds of years in many countries, there have been few attempts to explain the principles of good design or to describe suitable manufacturing methods using contemporary materials and technologies. In a few countries, traditional cart-construction skills are still available, but in many others no such body of knowledge is to be found. This prevents the widespread use of abundant draught-animal power for transport.

Animal-drawn carts have considerable potential for widespread use because they are (a) capable of meeting local transport needs efficiently, (b) not restricted to use on motorable roads, (c) affordable and socially acceptable, (d) powered by renewable sources of energy, and (e) suitable for production and maintenance using mainly local resources. Generally, animal drawn carts can play an important role in providing efficient and cheap transportation to move farm produce and inputs, water for domestic and productive use, building materials, commercial goods, solid waste, etc. Furtheremore, local production of vehicles can offer opportunities for generating new employment openings in both the formal and informal sectors.

It is often suggested that efforts should be focused on promoting mechanized, rather than animal-based, means of transport. However, the widespread use of motorized vehicles is dependant on the users' ability to find the necessary financial resources and on the existence of motorable roads and technical support services. Moreover, in many countries, the costs of importing oil are a limiting factor. Thus, while a steady growth in mechanization of transport is inevitable, animal-drawn transport can still play a significant role.

Size: 30 × 21 cm, 72 pp, soft cover

Price: £7.95

Published by Intermediate Technology Publications, 9 King Street, London WC2E 8HW, U.K.

Irrigation Engineering – A Section of Transactions of the ASAE Nos. 1 & 2

(U.S.A.)

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- Furrow Firming for Control of Irrigation Advance Rates
- Surge Flow Border Irrigation Using an Automatic Drop Gate
- Performance of Low Pressure Center Pivot Irrigation Systems
- Hydraulic Ram Use for Sprinkle Irrigation

Size: 29 x 21 cm, soft cover

Price: US$22.00 (1986 Subscription)

Published by the American Society of Agricultural Engineers 2950 Niles Road, St. Joseph, MI 49085-9659, U.S.A.

A Guide to Professional Registration for Agricultural Engineers

(U.S.A.)

Prepared by: ASAE Engineering Registration Committee A-414

This booklet has been prepared primarily as a study guide for those who are preparing to write an examination to become registered as agricultural engineers. The infor-

mation may also be useful as a review for those already practicing in a professional role and for students as they plan for registration as a normal part of their career development. In any case, this material is intended to be a review of and a guide to solving typical problems found in the Principles and Practices Examinations for Agricultural Engineers with emphasis on the scheme used in scoring.

Registration of Professional Engineers is a legai function of each state. Each of the several states has a legally constituted board to administer the examination process as well as other related matters. At this writing, all boards use examinations prepared by the National Council of Engineering Examiners in their registration procedures. This insures uniformity among the states in the examination process.

All questions regarding specific procedures should be referred to the board in the state in which an individual desires to become registered. A list of the boards is included in Appendix II.

With one exception the sample problems contained in this manual were used in the Agricultural Engineering examination administered by the boards of most states in a recent year. They have been released by the National Council of Engineering Examiners (NCEE) and will not be used in any future examination. The problems and their solutions were initially chosen from many solicited from Registered Agricultural Engineers by the ASAE Professional Registration Committee (A-414).

Examination questions for Agricultural Engineering are grouped in nine (9) subject matter areas as explained elsewhere in this manual. Individuals preparing for the Principles and Practices Examination will find it useful to work the problems in the area of maximum expertise and several in other areas of lesser competence in order to meet the requirements of the examination process.

Size: 28 x 22 cm, 119 pp, soft cover

Price: US$15.00

Published by American Society of Agricultural Engineers ■■

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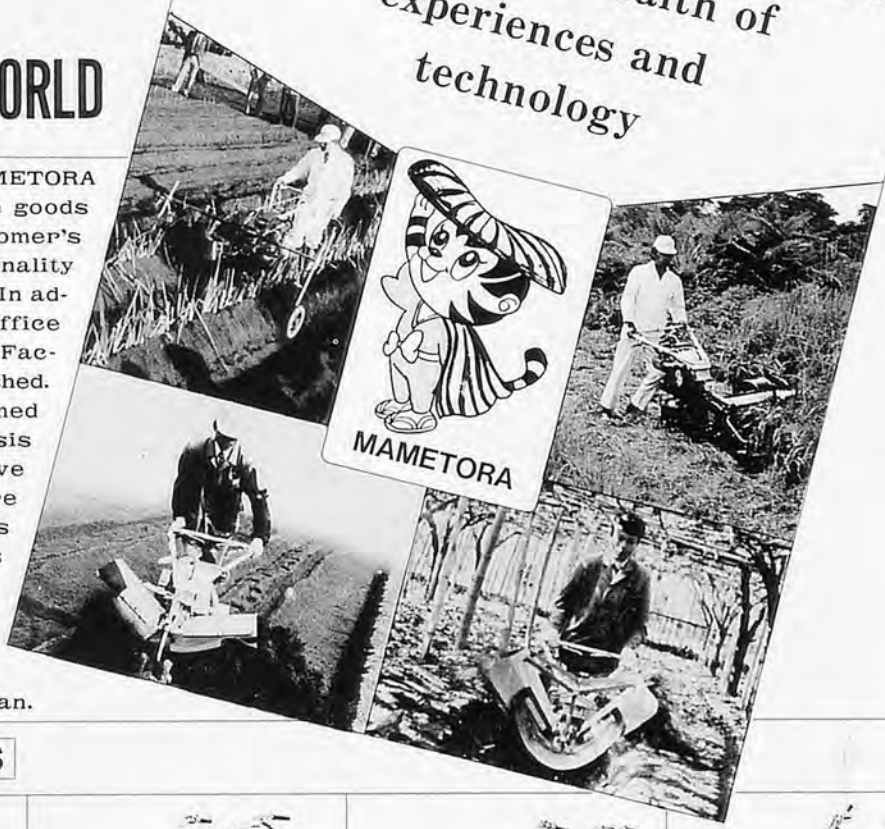

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