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VOL.26, NO.2, SPRING 1995

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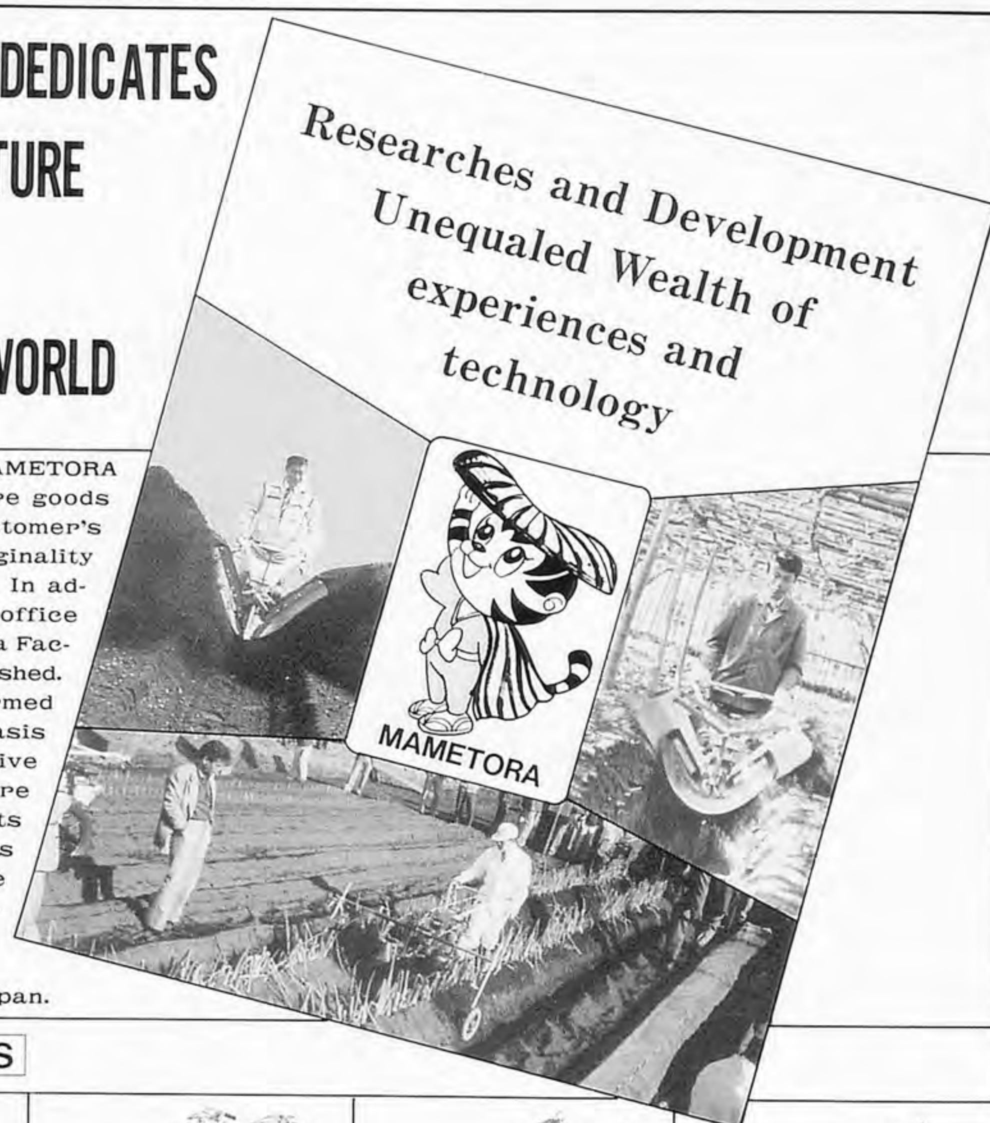

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This publication, published quarterly, has an objective to promote agricultural mechanization in developing countries. Its readers consist of so many people in various fields such as farmers, dealers, manufacturers, researchers, government officials, students, etc. not only in Asia but also in the whole world. To enrich contents and to reflect many opinions, we want contributors for Agricultural Mechanization in Asia" Africa and Latin America. Articles, comments, investigations, reports and so on will be received with open arms. If you hope to contribute, contact us without delay.

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EDITORIAL

It is only six years left before we enter into the 21st century. An ideological confrontation between capitalism and communism being eased, the world seemed to be released from tension. Yet in spite of all our expectations, still many regional conflicts are breaking out today. In those region, it would be difficult for the farmers to continue the stabilized farming. Under population explosion, unless food production will grow to the necessary extent, there will be a large anxiety for the future tragic situation. Even at the present the people suffering extreme poverty are estimated to be more than one billion, which keeps on increasing.

Under the principle of competition, the gap of productivity including agriculture and the gap between the rich and the poor are more and more expanding. Though the principle of competition might be necessary for the progress of mankind, it is a severe principle for many of the weak at the same time. The same thing can be said of agriculture. The world level competition might be agreeable for the farmers in North America and Australia who can use vast land and develop a large scale farming. It is, however, the matter of life and death for a majority of small scale farmers in the world.

Agricultural policy in Japan after World War II gives us some suggestions. Considering the existence of many small scale farmers, the government decided the price of rice on the basis of production cost of average size farmers.

Such kind of policy needs to be considered today in the world level. Since all the world population can't be supported only by large scale farmers, we essentially need the power of small farmers, too. The system that enables to raise the income of small farmers must be considered. We, Agricultural engineers, need to develop and supply a series of agricultural mechanization technology that will have a long effect in increasing productivity in developing countries.

Yoshisuke Kishida
Chief Editor

Tokyo, Japan
April, 1995

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Gear Ratios for Minimum Size (Weight) Compound Gear Trains


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Abstract

The problem of minimization of the overall size (weight), through the manipulation of the gear ratios of meshing pinion-gear sets that compose a compound gear train of arbitrary number of stages, is formulated and solved. The resultant mathematical expression is evaluated for the special case of a gear train in which the face widths of all the gears wheels are equal and again for the special case of a gear train in which the radii of all the pinions are equal in addition to the face widths of all the gears wheels being equal. Since the gear ratio of a train is not a function of the modules of the component gears, in an attempt to minimize the weight of a gear train through manipulation of gear ratios, the module, as such, is of no relevance.

Introduction

Hunt and Garver (1973) state in their book that on many farm machines there are more mechanisms to transmit power than there are to perform functional operations. Indeed mechanisms for the transmission of power are almost ubiquitous on farm as well as other types of machines. Raney and Butler (1959) asserted that power-train failures could not be tolerated; either the mechanism performs effectively or not at all. Given these implications of the importance of power-trains, their design should command substantial currency in the domain of agricultural machinery design.

Of the many power transmission mechanisms available, gear drives are probably the most versatile, being almost unlimited in terms of power transmission capacity and speed of operation. Commonly, gear drives take the form of multi-stage compound trains composed of spur or helical gear wheels. This paper is concerned with one, often desirable, design aspect of such a gear train; the minimization of gear train size (weight) through manipulation of gear ratios of the meshing pinion-gear pairs. Essentially, this is a generalization of an earlier presentation by Fazekas (1975).

Analysis

Assumptions and Definitions

The compound gear train of arbitrary number of stages (n) whose size (weight) is to be minimized is illustrated schematically in **Figure 1**. The assumption made in this paper are as follows;

1. That gear tooth face widths (b) and radii of pinion gears (R_{2j-1}, for $j=1,2,3,\ldots,n$) shall be determined so as to be consistent with strength requirements and conform to standard gear design practice.
2. That all the gear wheels in the train are made of the same material, of mass density (ϱ). This is quite a common practice.
3. That the overall gear ratio (K) is predetermined and is, therefore, not a variable in the context of weight minimization.

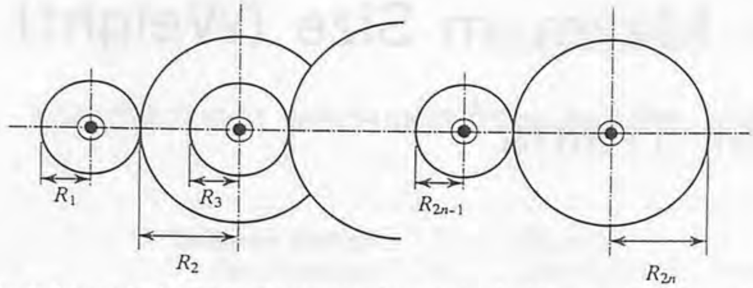

Fig. 1 Schematic illustration of a compound gear train of arbitrary number of stages (n).

It is also a common practice that the face widths of a pinion and a larger gear in mesh are made equal. Symbolically, we may write;

$$b_{2j-1} = b_{2j};\ j = 1,2,3,...,n \quad (1)$$

Furthermore, it should now be evident that here minimization of size (weight) refers to the manipulation of the gear ratios of meshing pinion-gear sets so as to achieve a gear train of minimum size (weight). In other words, face widths and pinion gear radii shall not be considered as agents of weight minimization.

Formulation and Solution of the Minimization Problem

Only external helical or spur gears, in a compound gear train such as that illustrated in **Fig. 1**, are considered here. The basis of the analysis that follows is the proposition that overall size, weight, and costs of a gear train are directly proportional to the total weight of gear blanks, if the blanks are considered to be, or if they actually are, solid. Considering face width (b_i) and pitch radius (R_i) of the ith gear wheel, the total weight (W_n) of an (n) stage compound gear train is;

$$W_n = C\pi\varrho \sum_{i=1}^{2n} b_i R_i^2 \quad (2)$$

where (C) is a constant of proportionality. The odd suffices ($i = 2j-1,\ for\ j = 1,2,3,...,n$) refer to pinions while the even suffices ($i = 2j$, for $j = 1,2,3,...,n$) refer to the larger gears. The overall gear ratio (K) which is a constant for a given problem is so defined that;

$$K = \frac{product\ of\ pinion\ speeds}{product\ of\ larger\ gear\ speeds}$$

and

$$K = K_1 K_2 ... K_j ... K_n = \prod_{j=1}^{n} K_j \quad (3)$$

where (Kj) denotes the gear ratio of the jth stage. The problem of weight minimization is symmetrical and it does not matter which end of the gear train is regarded as the input end. However, in most practical applications the pinion is the driver. Then the overall gear ratio would be defined as

$$K = \frac{output\ speed}{input\ speed};\ 0 < K \leqslant 1$$

and

$$K_j = \frac{R_{2j-1}}{R_{2j}};\ J = 1, 2, 3,..., n \quad (4)$$

The normalized relative weight (Gn) is now defined as;

$$G_n = \frac{W_n}{C\pi\varrho b_1 R_1^2} \quad (5)$$

and from Eqns. (2) and (5), one finds

$$G_n = \sum_{i=1}^{2n} \left[\frac{b_i R_i^2}{b_1 R_1^2}\right] \quad (6)$$

Now, in accordance with Eqn. (4), one may write

$$\frac{R_{2j}}{R_1} = \frac{R_{2j-1}}{R_1}\left(\frac{R_{2j}}{R_{2j-1}}\right)$$

$$= \frac{R_{2j-1}}{R_1}\left(\frac{1}{K_j}\right) \quad (8)$$

and furthermore, in accordance with Eqn. (1), one may write

$$\frac{b_{2j}}{b_1} = \frac{b_{2j-1}}{b_1} \quad (8)$$

Therefore, by using Eqns. (7) and (8) along with Eqn. (6) one finds that

$$G_n = \sum_{j=1}^{n} \left\{\left(\frac{b_{2j-1}}{b_1}\right)\left(\frac{R_{2j-1}}{R_1}\right)^2 \times \left[1 + \left(\frac{1}{K_j}\right)^2\right]\right\} \quad (9)$$

Now the minimization problem may be stated as follows;

Minimize

$$G_n = \sum_{j=1}^{n} \left\{\left(\frac{b_{2j-1}}{b_1}\right)\left(\frac{R_{2j-1}}{R_1}\right)^2 \times \left[1 + \left(\frac{1}{K_j}\right)^2\right]\right\}$$

subject to the constraint;

$$\left\{\prod_{j=1}^{n} K_j\right\} - K = 0$$

On using the Lagrange multiplier (λ), the function

$$F = G_n + \lambda K \quad (10)$$

may be considered whose relevant partial derivatives will be zero when G_n is minimum (Grossman, 1977). Thus, one obtains;

$$\frac{\partial}{\partial K_j} = 0 = -\left(\frac{2}{K_j^3}\right)\left(\frac{b_{2j-1}}{b_1}\right) \times \left(\frac{R_{2j-1}}{R_1}\right)^2 + \frac{\lambda K}{K_j} \quad (11)$$

or

$$\left(\frac{1}{K_j^2}\right)\left(\frac{b_{2j-1}}{b_1}\right)\left(\frac{R_{2j-1}}{R_1}\right)^2 = \frac{\lambda K}{2}$$

$= a\ constant$

and on letting $j=1$ in Eqn. (11), one obtains;

$$(\frac{1}{K_1})^2 = \frac{\lambda K}{2} = a\ constant \qquad (12)$$

Thus, by using Eqns (11) and (12), the condition for minimum G_n, within the assumptions made in this analysis, may be stated as follows;

$$(\frac{b_{2j-1}}{b_1})(\frac{R_{2j-1}}{R_1})^2 = (\frac{K_j}{K_1})^2 \qquad (13)$$

Discussion

The Case of Gear Train with Constant Face Width

Face width of gear teeth (b) is not standardized but according to Juvinall (1983) it is common practice to adopt the range

$$9m < b < 14m \qquad (14)$$

where m is the module. One thing the inequality in (14) indicates clearly is that the face width may be the same even for gear wheels of different modules (and, therefore, gear wheels that do not mesh). It is, therefore, feasible that in some applications all the gear wheels that compose the train may be of equal face width. Imposing this constraint onto Eqn. (13), one finds that;

$$(\frac{R_{2j-1}}{R_1})^2 = (\frac{K_j}{K_1})^2 \qquad (15)$$

or

$$(\frac{K_1}{R_1}) = (\frac{K_j}{R_{2j-1}})$$

and the use of Eqn. (15) along with Eqn. (4) leads to the result

$$R_{2j} = R_2 = a\ constant \qquad (16)$$

which is the condition for achievement of a gear train with minimum normalized relative weight (G_{no}) in the case of constant face width. The normalized relative weight would then be

$$G_n = G_{no}$$
$$= (\frac{1}{K_1})^2 \sum_{j=1}^{n} (K_j^{\,2} + 1) \qquad (17)$$

The Case of Constant Face Width and Constant Pinion Radii

As was seen in the preceding sub-section, to attain minimum weight with a gear train of constant face width requires the radii of the larger gear wheels in each meshing set of pinion and larger wheel to be constant. Now if a further constraint of constant pinion radii is imposed, minimization of gear train weight requires that the gear ratios for each pair of meshing pinion and larger wheel should remain constant throughout the train. Then it follows that;

$$G_n = G_{no}$$
$$= \sum_{j=1}^{n} ((\frac{1}{K_1})^2 + 1) \qquad (18)$$

which is the result obtained by Fazekas (1975) when he assumed a gear train of constant face width, pinion radii and module. It can be seen here that this result need not be restricted to gear trains of constant module. Indeed, a fundamental issue is involved here which can be demonstrated rather trivially but with dramatic implication.

Consider a meshing pinion-gear set with R_p, Z_p, m_p and R_g, Z_g, m_g as the pitch radii, numbers of gear teeth, and modules of the pinion and gear, respectively. Since the concept of conjugate action is based on a consideration of the pitch point (point of contact of the pitch circles of the meshing gear wheels), the basic definition of gear ratio is

$$\frac{\omega_g}{\omega_p} = \frac{R_p}{R_g} \qquad (19)$$

where ω denotes angular velocity. Now, from the definition of module

$$R_p = \frac{m_p Z_p}{2} \text{ and } R_g = \frac{m_g Z_g}{2} \qquad (20)$$

Therefore,

$$\frac{\omega_g}{\omega_p} = \frac{R_p}{R_g} = \frac{m_p Z_p}{m_g Z_g} \qquad (21)$$

But since the modules of meshing gear wheels must be equal, they cancel out in Eqn. (21) thus demonstrating that gear ratio is not a function of module. Therefore, in an attempt to minimize gear train size (weight) through manipulation of gear ratios, the modules of the component gear wheels, as such, should be of no consequence.

The "First" Pinion in the Gear Train

Throughout the analysis, it has been seen that the size of the "first" pinion in the gear train, represented by (R_1) and (b_1), plays an important part. The minimization problem was formulated in terms of the normalized relative weight (G_n) which must be multiplied by the weight of the "first" pinion in order to obtain the actual weight of the gear train. Therefore, the weight of the "first" pinion should be the minimum possible.

It should be mentioned here that in practice there are available certain design guidelines that limit the size of the smallest pinion in a gear train. One should expect such limits to depend on the quality of gear materials, which improves with time. Many texts and handbooks recommend that the number of teeth on the smallest pinion should not be less that 14. However, Hunt and Garver (1973) include pinions with 10 teeth in their tables and one of the authors (Professor Sakai), when he worked as a machine design engineer in industry, designed a power tiller transmission mechanism with the smallest pinion having only 9 teeth. It worked.

Conclusions

1. The condition for the achievement of a gear train of minimum size (weight) through manipulation of gear ratios of the meshing pinion-gear sets has been derived. The mathematical expression so derived relates the face widths and pitch radii to the gear ratios of meshing pinion-gear sets in a compound gear train of arbitrary number of stages. In deriving that expression it was assumed that the mass density of all the gear wheels in the train was the same, that the overall gear ratio of the train was predetermined, and that the face widths of meshing gear wheels were equal.

2. The derived condition for achievement of a gear train of minimum size (weight) was evaluated for two special cases. In one case, it was assumed that the face widths of all the gear wheels in the train were equal. Then, it was shown, that a minimum size (weight) for such a train would be achieved when the pitch radii of all the larger gears of meshing pinion-gear sets are made equal. In the other case, it was assumed that the pitch radii of all the pinions in the train were equal in addition to the face widths of all the gear wheels in the train being equal. Then, it was shown, that minimum size (weight) for such a train would be achieved when the gear ratios of all the stages of the train were made equal. Further, it was demonstrated that in any case, in an attempt to minimize the weight of a gear train through manipulation of gear ratios, the modules of the gears that compose the train should be of no consequence.

3. Only one, among many, that the aspects of gear train design, some of which may have conflicting implications, has been dealt with in this paper. Other aspects include bulk and surface strengths of gear teeth and the inertia of the train, with or without the prime mover and the load. Ultimately, an optimization approach that takes into account all the relevant aspects, possibly including minimization of gear train size (weight), is probably the most effective approach.

REFERENCES

1. Fazekas, G. A. (1975). Optimal speed ratio of constant pitch gearing. Transaction of the ASME, Series B; Journal of Engineering for Industry 97(4).
2. Grossman, Stanley I. (1977). Calculus; chapter 18. Academic Press. New York, San Francisco, and London.
3. Hunt, Donnell R. and Lester W. Garver (1973). Farm machinery mechanisms; chapter 12. The Iowa State University Press. Ames, Iowa, USA.
4. Juvinall, Robert C. (1983). Fundamentals of Machine Component Design; chapter 15. John Wiley and Sons. New York, Chichester, Brisbane, Toronto, and Singapore.
5. Raney, Russell R. and Karl D. Butler (1959). Criteria for the Design and Development of Farm Equipment. Agricultural Engineering 40(3); pp. 137-141. ■■

Rotary Tiller Cum-ridger for Vertisol

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Abstract

An experimental rotary tiller cum-ridger that combines active and passive elements was field tested. In order to evaluate the performance of the unit, various soil physical properties were studied as they are regarded key to soil fertility, crop production and water movement in the soil. The rotary tiller cum-ridger was compared with the manual operation for accomplishing the same work with respect to time the and cost of operation. It has been found that the rotary tiller cum-ridger has 93.75% saving in time and 19.43% saving in cost when compared to manual operation.

Introduction

The development and performance evaluation of a tiller cum-ridger was identified as a necessity in view of the changes in agrarian and socio-economic situations taking place in Tamil Nadu. Since human labour force is becoming more expensive and the bovine population is declining, the tiller cum-ridger is essential for the vertisol farmers to remove the drudgery involved by manual operation as well as to hasten the furrow forming operation for irrigating the standing crop.

Generally, vertisols are problem posing areas where, due to hard nature of the soil, the requirement of labour is greater and also causes drudgery working in vertisols than in other types of soil.

Normally, paddy is grown in this type of soil, such as in delta regions of Tanjore districts. After the harvest of paddy, cotton is sown and the field is kept untreated for some period. In the meantime, the soil becomes very hard and large cracks are formed in the field due to lack of water. To irrigate the crop a furrow has to be formed in between the rows. Forming furrows is very tedious and time consuming on the part of the farm workers. Hence, it was thought to develop a combination tillage tool, which consisted of both active and passive tillage elements. The active tillage elements are forward rotating and resulted in negative draft, hence the overall draft requirement was reduced considerably.

Review of Literature

Kaufman and Butler (1967) suggested that by reducing the increment of cut, by increasing the rotor speed or by decreasing the travel speed, increased the vertical and horizontal uniformity of incorporation. Increasing the rake angle increased the vertical uniformity of incorporation.

Chamen et al (1979) designed a p.t.o. driven primary tillage tool that included passive rigid chisel tynes to keep the machine in the soil in reaction to forward and upward forces created by the rotor blades. Net energy requirements for this machine were 50% less than a mould board plough operating at the same depth.

Hendrick (1980) designed and tested a powered rotary chisel with a single rotor and compared the power requirements with that of rigid chisel. Results showed that the powered configuration required 15% less power. He assumed a power transmission efficiency of 49 per cent for drawbar operations and predicted that the combination machine required 45% less engine power. The powered rotary chisel also disturbed a greater volume of soil and caused greater soil breakdown than the rigid chisel.

He suggested a practical lower limit of the velocity ratio λ to be 2.5

$$\lambda = \frac{V_p}{V_f}$$

where

V_p - peripheral velocity of blade tip, m/sec.

V_f - forward velocity of machine, m/sec.

Hendrik estimated an overall average power transmission efficiency of 82% for p.t.o. powered active tillage elements and 49% for drawbar passive tillage elements.

Kononuchenko et al (1988) described a prototype of a rotary cultivator used for ridging up potatoes after planting in shallow ridges. Its operational speed is 1-1.2 ha/h; it is suitable for most soils. Trials showed a satisfactory formation of ridges by the implement, with their profile well maintained until the harvest. This was reflected by an increase in yield.

Ade and Pezzi (1989) tested a rotary cultivator with 3 rotors equipped with different shapes of blades to study the influence of forward and rotational speed on power requirement, fuel consumption and quality of work. The tests showed that an increase in pitch due to a decrease in rotational speed results in a decrease in the energy requirement. The same effect is obtained by raising the pitch by increasing the forward speed, in this case the power requirement increases. In all cases the most favourable conditions regarding specific energy consumption and the work rate were low rotational speed and high forward speed. The results regarding energy consumption were achieved with shaped knife blades. The rear shield setting influenced the quality of work more than the rotational speed and the shape of the blades.

Desa (1989) suggested that for each combinajtion of forward and rotor speed there was significant increase in power consumption as cutting width increased. In terms of specific power, however, the wider the cutting widths, the lower the specific power values. The highest degree of soil pulverization was caused by the smallest width at the smallest bite length.

Destain and Houmy (1990) analyzed the motion of a rotary cultivator at a higher ratio of peripheral to forward velocity, which led to closer passage of rotating tynes in the soil. This resulted in more homogenous soil, which had smaller total mean porosity.

Shinners et al (1990) designed an experimental tillage tool that combines active (rotary) and passive chisel elements which was field tested. Because the active elements were forward rotating and resulted in a negative draft, overall draft requirements of the total tool were considerably reduced. A combination tool with two active and two passive elements required 87% less draft power than a tool with four passive elements, although total power was similar. Based on assumed power transmission efficiencies, the combination tool was predicted to be 34% more energy efficient than a similar passive tillage tool. Wheel slip was 57% less for a two active, two passive element tool compared to a four passive element configuration. Therefore, the combination tool was not only more energy efficient, but was also more productive.

The potential benefits of combining active and passive tillage elements are:

1) Power for tilling the soil can be transmitted to the tillage elements through a mechanical power train more efficiently than through the tyre-soil interface;

2) The negative draft of the active elements can be used to provide some or all the draft of the passive elements;

3) Reduced draft of tillage tool will result in less wheel slip and improve field productivity;

4) Reduced draft of tillage tool will allow operation to be performed in more difficult traction condition; and

5) Reduced draft of the tillage tool will allow the use of lighter tractor, i.e. power tiller to reduce soil compaction and to reduce the cost.

Unit Description

The rotary tiller cum-ridger **(Fig. 1)** consists of the following major components:

a) Two knife like chisels. Each one has been fixed at both ends of rotovator unit at a spacing of 50 cm between them;

b) Rotary cutting blade. Eleven such blades were fixed for effective soil manipulation and pulverization having total width of operation of 33 cm; and

c) Ridger. Forming furrows on the loosened soil. Having a width of operation of 30 cm and maximum depth of operation of 20 cm.

The components have been found necessary to accomplish soil separation, pulverization and furrow formation.

Normally, when a rotary cultivator works on a dry hard soil, which has clods of bigger size, the rotary blades while manipulating the soil uproots the plant nearby, when operated in between the rows. To prevent this up-rooting of plants, a knife like chisel, at both ends was thought to be use-

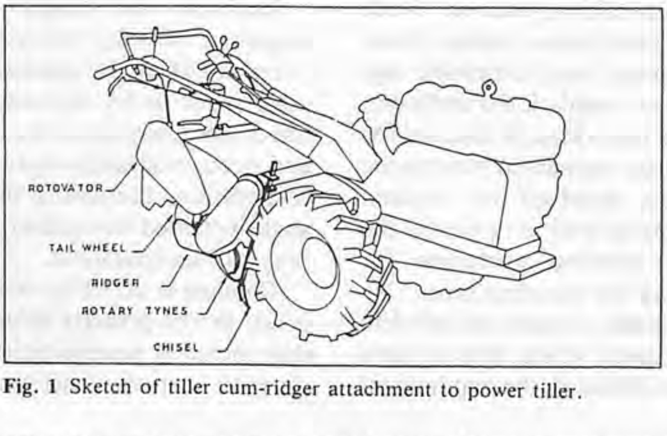

Fig. 1 Sketch of tiller cum-ridger attachment to power tiller.

ful. Thus this knife-like chisel is meant to cut large clods and in turn prevents the crops from being uprooted.

Generally, straight tynes are recommended and are more suitable for dry, hard soils, for better manipulation and pulverization.

A ridger attachment has been fixed at the rear of the rotovator housing, i.e., in front of the tail wheel. As the rotary blades manipulate and loosen the soil, the ridger behind it forms furrows in a relatively loose soil, which does not require much draft. Thus a furrow is obtained for irrigation in between the rows of plants.

Since various operations are combined in one single operation, it forms a combination tillage tool, which comprises of both active and passive elements, and the draft requirements is reduced, thereby minimising the number of passes and cost of operation (Shinners, et al 1990).

Experimental Procedure

The unit was tested for its performance in the vertisols (black cotton soil) in the wetlands, Tamil Nadu Agricultural University Campus. The different parameters of this testing are as follows:

a) Moisture content, (%) dry basis: 8.2, 10.8, 12.2 and 14.5
b) Depths of operation, cm: 8, 14 and 20
c) Rotary blade speed, rpm: 220 and 323

Each test was conducted over a 50-m test course. The testing was done at two different rotor speeds, three different depths of operation and four different moisture content levels, as the moisture content varied in the same field from day-to-day.

For each test run the time required to cover the 50-m test course and the quantity of fuel consumed were recorded.

Performance Evaluation

In order to evaluate the performance of the unit, various soil physical properties were studied. Soil physical properties are regarded as the key to soil fertility and crop production. The physical condition of the soil requlates the movement of water in the furrow without any loss to the surrounding deep cracks, formed in the field due to the dry condition of the soil.

Evaluation in the field consisted of sieve analysis and infiltration test. By sieve analysis the clod size distribution, uniformity coefficient and mean-mass diameter were determined. Infiltration test was done using a double ring infiltrometer.

Evaluation in the laboratory was done using soil core samples taken at surface soil (0-10 cm depth) and sub-surface soil (10-20 cm depth) with the help of soil core sampler. The soil properties like hydraulic conductivity, bulk density and total porosity (capillary and non-capillary porosity) were determined.

Results

Effect of Depth of Operation on Specific Fuel Consumption

From **Fig. 2** at a particular moisture content say, 8.2% and at the rotor speed of 220 rpm, the specific fuel consumption increased from 0.245 to 0.283 kg/bhp-h as the depth of operation increased from 8 cm to 20 cm. At the same moisture content,

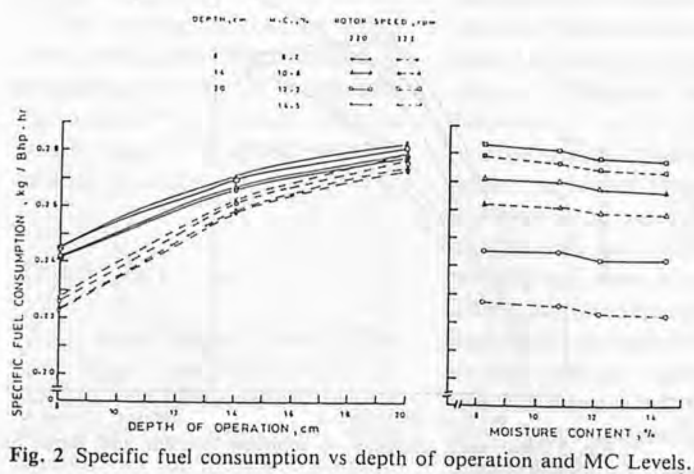

Fig. 2 Specific fuel consumption vs depth of operation and MC Levels.

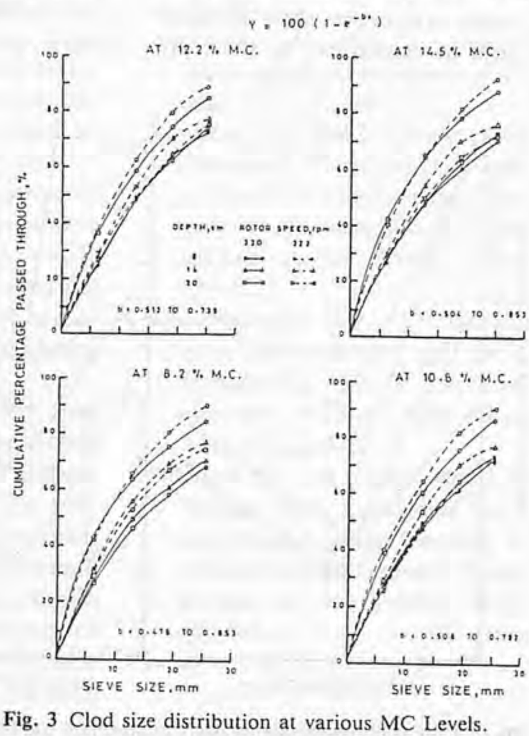

Fig. 3 Clod size distribution at various MC Levels.

at the rotor speed of 323 rpm, the specific fuel consumption increased from 0.227 to 0.28 kg/bhp-h as the depth of operation increased, in a relatively greater fashion than that of at 220 rpm. But it was found that at all moisture content levels, the specific fuel consumption decreased considerably as the rotor speed increased from 220 rpm to 323 rpm.

Effect of Moisture Content of Soil on Specific Fuel Consumption

From **Fig. 2** at a particular depth of operation, say, 20 cm and at 220 rpm rotor speed, the specific fuel consumjption decreased from 0.283 to 14.5% At the same depth of operation, at 323 rpm rotor speed, the specific fuel consumption decreased as the moisture content increased. But it was found that at all depths of operation, the specific fuel consumption was increased from 220 rpm to 323 rpm. It was also determined that at lower depths of operation, specific fuel consumption was reduced in a relatively greater proportion than at higher depth of operation, as the rotor speed was increased from 220 to 323 rpm.

Clod Size Distribution

Fig. 3 shows the clod size distribution at 8.2, 10.8, 12.2 and 14.5% moisture content which indicates that at any depth of operation and rotor speed, the cumulative per cent of soil passing through increases as the sieve size increases. However. the increase was in greater proportion at lower depth of operation (8 cm) than that of at 20 cm, for a particular rotor speed. Also, the cumulative per cent of soil passing through increased as the sieve size increased, but the increase was in greater proportion at higher rotor speed (323 rpm) than at 220 rpm, at a particular depth of operation. This trend of distribution was almost the same for all moisture content levels.

At all moisture content levels, the cumulative per cent of soil passing through was maximum at lower depth of operation and at higher rotor speed. That is, the pulverization effect was maximum at 8 cm depth of operation and at rotor speed of 323 rpm **(Fig. 3)**.

At all depths of operation and at all moisture content levels, the uniformity coefficient **(Fig. 4)** and mean-mass diameter **(Fig. 5)** proportionally decreased as the rotor speed increased from 220 to 323 rpm. This implies more pulverization effect at higher rpm.

At 20 cm depth of operation and at 220 rpm, the initial infiltration rate was maximum (30 cm/h) and the final infiltration rate was quite high (4 cm/h), which is considered optimum for irrigating in furrows **(Fig. 6)**.

Irrespective of the depths of operation and rotor speeds, hydraulic conductivity is more in surface soil (0-10 cm depth) than sub-surface soil (10-20 cm depth). And it is greater at higher rotor speed than at lower rpm **(Fig. 6)**.

Irrespective of the depths of operation and rotor speeds, the bulk density of the soil is greater in sub-surface soil than in surface soil **(Fig. 6)**. From **Fig. 7**, at lower depths of operation, in sub-surface soil the total porosity was very much less than the surface soils, for both rotor speeds. But at higher depths of operation, in sub-surface soil the total porosity was

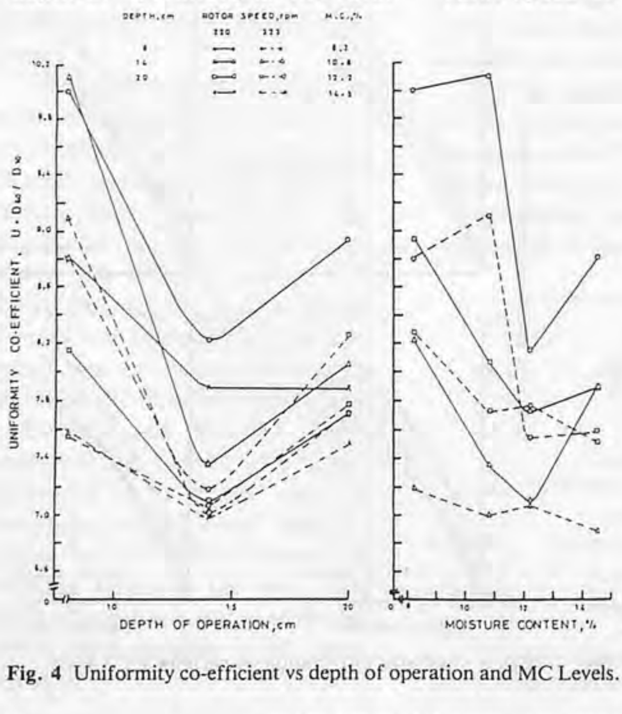

Fig. 4 Uniformity co-efficient vs depth of operation and MC Levels.

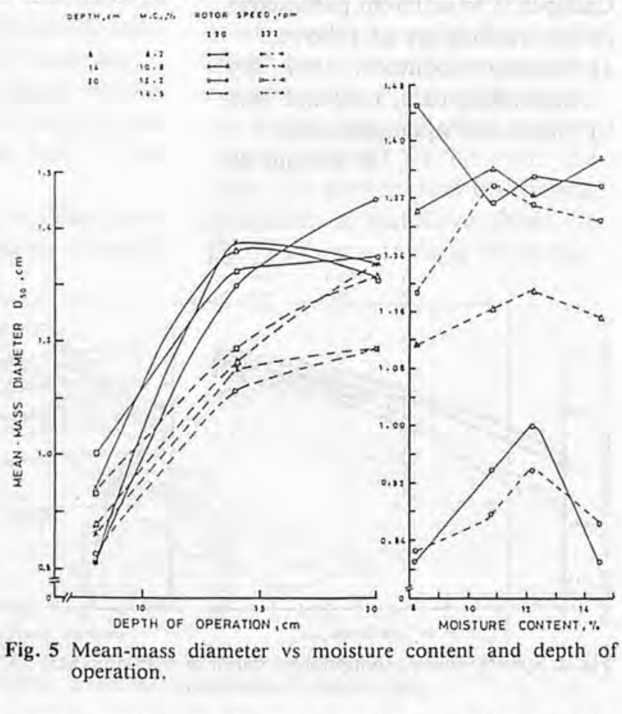

Fig. 5 Mean-mass diameter vs moisture content and depth of operation.

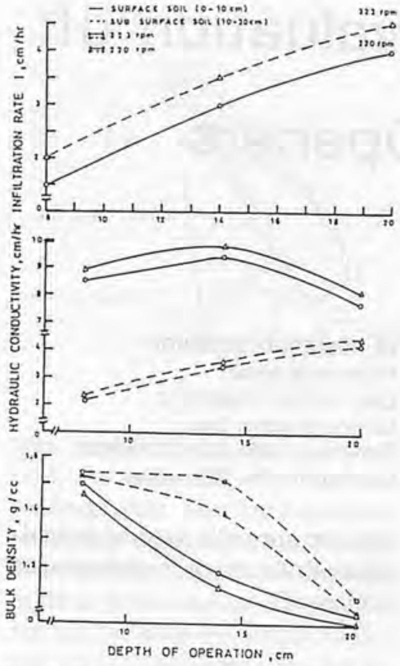

Fig. 6 Depth of operation vs infiltration rate, hydraulic conductivity and bulk density.

very much higher than the surface soils, for both rotor speeds.

Roto-tiller Cum-ridger vs. Manual Operation

Savings in Time

The saving in time by using rotary tiller cum ridger instead of manual operation, for accomplishing the same work was 375 man-h/ha, which comes to about 93.75% savings in time.

Saving in Cost

The savings in cost by using rotary tiller cum ridger instead of manual operation, for acomplishing the same work was Rs. 204/ha which comes to about 19.43% savings in cost.

Conclusion

An experimental rotary tiller cum ridger was field tested. To evaluate the performance, various soil physical properties were studied. At all moisture content

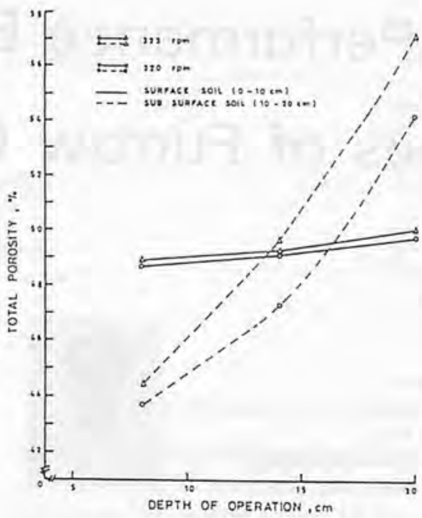

Fig. 7 Depth of operation vs total porosity.

levels and at all depths of operation, the specific fuel consumption decreased considereably as the rotor speed increased from 220 to 323 rpm. At all moisture content levels, the cumulative per cent of soil passing through was maximum at lower depth of operation and at higher rotor speed.

Pulverization effect was greater at higher rpm because at all depths of operation and at all moisture content levels, the uniformity coefficient and mean-mass diameter proportionally decreased as the rotor speed increased from 220 to 323 rpm.

At 20 cm depth of operation and at 220 rpm, the initial infiltration rate was minimum (30 cm/h) and the final infiltration rate was quite high (4 cm/h), which is considered optimum for irrigating furrows.

Hydraulic conductivity was greater at higher rotor speed than at lower rotor speed. Bulk density of the soil was greater in sub-surface soil than in surface soil. The total porosity was very much higher in sub-surface soil than in surface soil at higher depth of operation and it was the reverse in lower depth of operation, for both rotor speeds.

The rotary tiller cum-ridger was compared with manual operation for accomplishing the same work, with respect to time and cost of operation. Savings in time was 375 man-h/ha, which comes to about 93.75% saving in time. Savings in cost was Rs.204/ha, which comes to about 19.43% savings in cost.

REFERENCES

Ade, G. and F. Pezzi. 1989. Tests on rotary tillers equipped with different blades. Agrl. Engg. Abs. 14(12): 495.

Chamen, W.C.T., R.E. Cope and D.E. Patterson. 1979. Development and performance of a high output rotary digger. Journal of Agrl. Engg. Res. 24: 301-308.

Desa, A. 1989. A width of cut analysis on the performance of a rotary strip tiller. Agrl. Engg. Abs. 14(9): 343.

Destain, M.F. and K. Houmy. 1990. Effects of design and Kinematic parameters of rotary cultivators on soil structure. Soil tillage research. 17: 291-301.

Hendrick, J.G. 1980. A powered rotary chisel. Transactions of the ASAE 23(6): 1349-1352.

Kaufman, L.C. and B.J. Butler. 1967. Increment of cut-and-rake angle interaction during granular incorporation by rotary tillage. Transactions of the ASAE. 10(6): 718-722.

Kononuchenko, N.V., D.P. Belchik, A.A. Meleshkevich and A.A. Bogushevich. 1988. A new rotary cultivator KUK-4. Agrl. Engg. Abs. 13(12): 477.

Shinners, K.J., R. Alcock and J.K. Wilkes. 1990. Combining active and passive tillage elements to reduce draft requirements. Transactions of the ASAE 33(2): 400-404. ■■

Comparative Performance Evaluation of Different Types of Furrow Openers

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Abstract

Hoe, shoe, wedge, single disc and double disc types of furrow openers were evaluated in the field and their performance compared. Performance of single disc furrow opener was better having the highest performance index and lowest unit draft among the furrow openers compared. The average power requirement of "gorru" (country seed drill) fitted with three single disc openers was 56.57 W as against 183.94 W for the gorru fitted with three wedge type furrow openers which are used at present. In general, addition of dead weight reduced the performance index of all the furrow openers.

Introduction

Hoe type furrow opener is better adapted for cultivation of compact and lumpy soils than shoe type furrow opener. The hoe opener is operationally inferior to the shoe opener except in cultivated field previously well prepared for drilling (Bernacki et al., 1972). Hoe openers are used in the animal-drawn drills due to simplicity of construction, low cost, low draft and precision placement of seed and fertilizer (Tanjdon et al., 1984). The hoe opener often gives trouble by clogging when used in trashy ground. The single disc opener gives good penetration, cuts trash well and does not easily clog. The double disc opener is suitable for high tractor speeds and for trashy land (Smith and Wilkes, 1979).

The draft of shoe type furrow opener with bullock drawn cup type seed drill and seed cum fertilizer drill were determined to be 74.2 kg and 54 kg, respectively, for a furrow depth of 50 mm. The double disc type furrow openers fitted with ball bearings and bush bearings were compared. There was no appreciable difference in the draft, the difference being only 0.84 kg. per opener (Anon, 1983). A single row drill using double disc opener was developed to accomplish sowing of wheat without field preparation. Moisture retention, available moisture and moisture depletion during stress periods were high in this no-tillage treatment. This system required the least energy and cost of production while these requirements were about 1.5 times higher in the coventional system (Sharma et al., 1984). Therefore, field tests were conducted with different types of furrow openers viz., hoe, shoe, wedge, single disc and double disc type furrow openers that are normally used in animal-drawn drills and their performance compared.

Materials and Methods

Hoe, shoe, wedge, single disc and double disc types of furrow openers taken for these comparative study are shown in **Fig. 1**. Three furrow openers in each type were fitted to a gorru (country seed drill) frame **(Fig. 2)**. A power tiller was used as prime-mover to pull the gorru. The field tests were conducted in block soil having 15.80% moisture content (dry basis) and 114.2 kg/m^3 bulk density. Each furrow opener was tested with 0, 78.5, 157, 245 N dead load on the gorru frame. Two replications were made. The field speed was maintained constant throughout the tests. The time taken to cover a 30-m distance

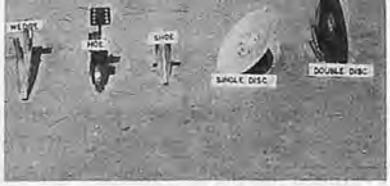

Fig. 1 Different types of furrow openers compared.

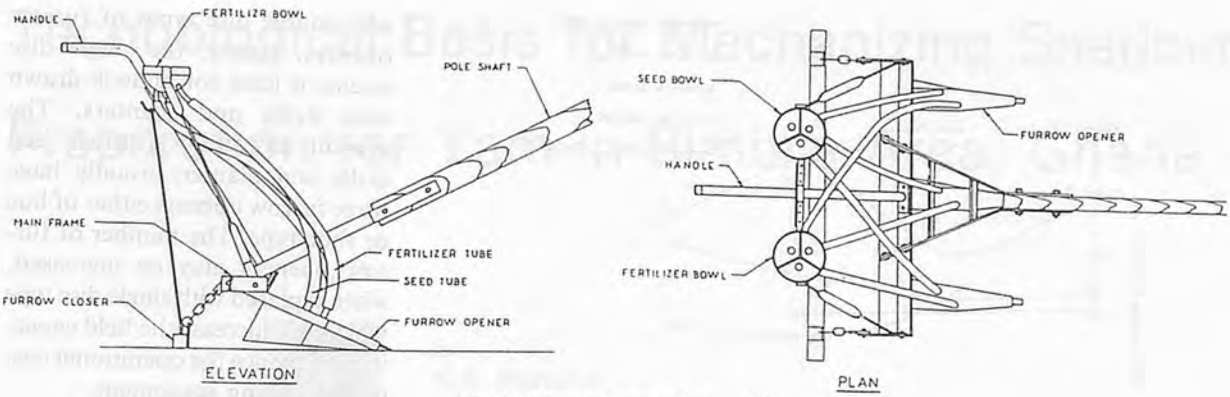

Fig. 2 Tnau improved "gorru."

was measured for each replication. At each test, 6 to 12 pull readings were taken by a hydraulic dynamometer. The furrow dimensions were taken at random in three different places along the furrow for each test and the average was taken From the average pull, draft, unit draft and power were calculated.

The authors developed a performance index concept to compare the furrow openers. In general, the performance index of any machine is directly proportional to work output and quality of work and is inversely proportional to the energy input. In the case of furrow openers, work output was taken as the average furrow cross sectional area, quality of work was taken as a measure of uniformity of furrow depth and energy input was taken as the power. Hence, the performance index (PI) was determined for each type of furrow opener by the following expression:

$$PI = k \times 1/2 \times w \times \bar{d} \times [1 - \sum_{n=1}^{n} (d_1 - \bar{d}) / n\bar{d}] / (D \times S)$$

Where
k is the proportionality constant
w is the average furrow width, mm
$\bar{d}$ is the average furrow depth, mm
d_1 is the observed furrow depth, mm
n is the number of observations
D is the average draft, N
and S is the average field speed, m/s

Results and Discussion

Unit draft varied linearly with the increasing dead loads for the wedge and shoe type furrow openers (Fig. 3). The dead load has an increasing effect on the unit

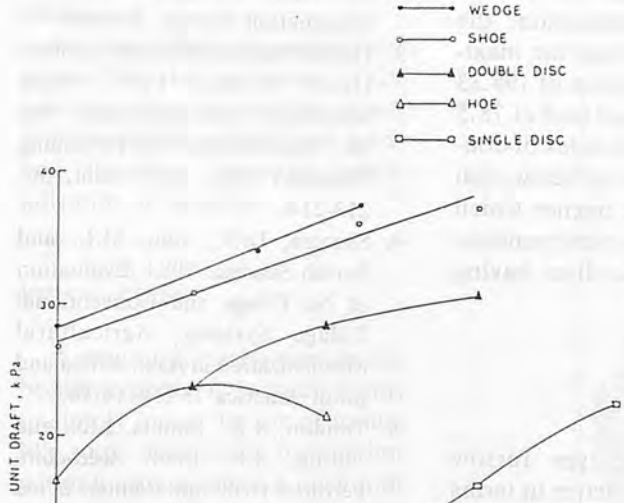

Fig. 3 Unit draft of furrow openers at varying dead weight.

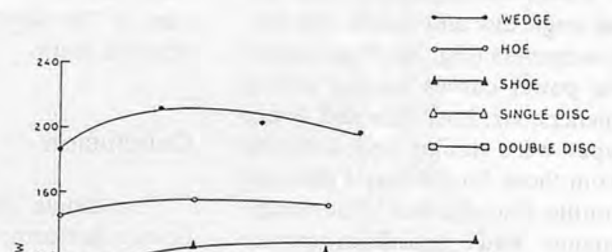

Fig. 4 Dead weight vs power.

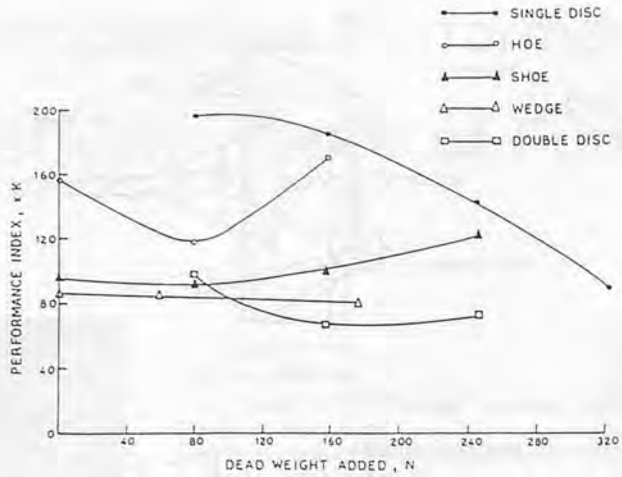

Fig. 5 Dead weight vs performance index.

draft for all the furrow openers except for the hoe type furrow opener that too beyond 80 N which might be due to local soil variations. In the case of single disc furrow opener, unit draft remained minimum around 11 kPa with 80 N to 160 N dead load. Beyond 160 N the unit draft of the single disc opener increased as the dead load was increased. In this region even with the increased dead load, the furrow size might not have increased. The unit draft of the single disc opener was appreciably in the lesser range when compared to all other openers at all dead loads. The wedge opener had a maximum unit draft among all the openers.

Power was apparently lesser for the single disc and double disc furrow openers **(Fig. 4)**. The trend of the power curves for the sliding openers, viz. hoe, shoe and wedge types were similar and different from those for the single disc and double disc openers. The wedge opener had maximum power among all openers tested.

The performance index of the furrow openers were determined and compared at different dead loads **(Fig. 5)**. The single disc opener had the maximum performance index except beyond 240 N dead load. Wedge and double disc openers had the minimum performance index. Addition of dead load had the effect of reducing the performance index except in the case of hoe and shoe openers in which case the performance index increased beyond a dead load of 80 N and 160 N, respectively. Of all the furrow openers under comparison, the single disc opener had the maximum performance index of 198.33 with a minimum dead load of 78.5 N. The performance index of double disc opener was far below than that of single disc opener which might be due to the poor penetration of the double discs having zero tilt angle.

Conclusion

The single disc type furrow opener performed better in terms of minimum draft, minimum power and maximum performance index in the field study conducted with hoe, shoe, wedge, single disc and double disc types of furrow openers. Hence, the single disc opener is ideal for bullock-drawn seed drills and planters. The present day bullock-drawn seed drills and planters usually have three furrow openers either of hoe or shoe type. The number of furrow openers may be increased, when replaced with single disc type which will increase the field capacity and reduce the operational cost of the sowing equipment.

REFERENCES

1. Anonymous, 1983. Progress Report 1971-82. Co-ordinated Scheme for Research and Development of Farm Implements and Machinery and Production of Prototypes and their Evaluation under Different Agro-Climatic Conditions (ICAR), Coimbatore Centre, pp. 27-29.
2. Bernacki, H., Haman, J. and Kanafojski, Cz. 1972. Agricultural Machines — Theory and Construction. National Technical Information Service, Warsaw.
3. Harris Pearson Smith and Lambert Henry Wilkes. 1977. Farm Machinery and Equipment. 6th Ed., Tata McGrow Hill Publishing Company Ltd., New Delhi, pp. 213-214.
4. Sharma, D.N., Jain, M.L. and Suresh Sharma. 1984. Evaluation of No-Tillage and Conventional Tillage Systems. Agricultural Mechanization in Asia, Africa and Latin America 15 (3): 14-18.
5. Tandon, S.K., Shukla, L.N. and Verma, S.R. 1984. Seed-cum-Fertilizer Drills and Planters in use in Punjab. Agricultural Engineering Tp-day 8 (5): 4-14.

Technological Basis for Mechanizing Seedbed Preparation for Yam in Bimbila Area, Ghana

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Abstract

Seedbed preparation of any kind at any level of mechanization has to consider the very basic technological basis which includes the physical properties of the soil and the implements used.

In this paper the basic physical properties of soil at Bimbila area which is a major yam growing area in Ghana has been studied and related to the parameters of yam seedbed.

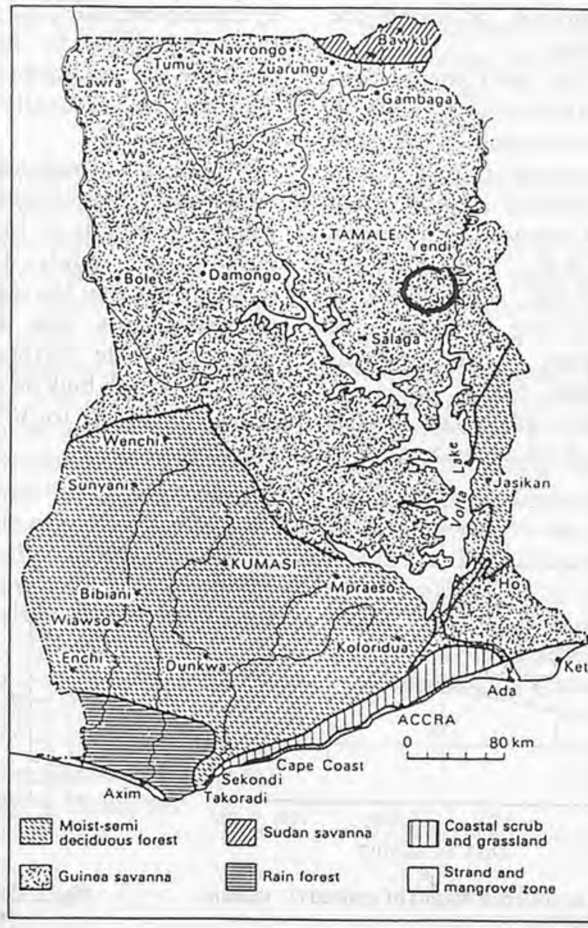
Having defined the parameters of seedbed, they give some of the corresponding parameters of any implement for raising yam seedbed, therefore improving mechanization in practice.

Introduction

Agricultural mechanization has been interpreted in so many forms to simply imply the use of inputs like tools to increase production per unit area of land. A farm tool or equipment does not, per se, increase production but acts as a device to bring about desirable results in production. That is to say, it is only when farm equipment is combined with the techniques of its economic usage that it constitutes agricultural mechanization.

Generally, farm equipment are divided into two main groups: power and farm implements. Humans, animal and tractor are the most common sources of farm power and the cutlass, hoe, plough, or harvester represent the farm implements.

The integration of the different types of farm power and farm implements determines the development of mechanization. For example, where human power is aggregated with any implement, this is classified as the first stage of mechanization. In general,



there is an extreme variation in the level of mechanization and the range of equipment used may vary from simplest manually operated hoe to the more sophisticated combine harvester.

The gradual development of mechanization has revealed that with hand tools like the hoe, man can only produce to support five other people, nine with the use of animal power and with the advent of modern farm equipment like the tractor, the figure has been increasing to unimaginable level. The mechanization sequence among the European nations, in historical perspective, (according to the World Bank, 1986) was from muscular energy to animal traction and thence to tractorization[1]. Since we know that manual aggregation with tools can support the least, it will be very important to improve the technological approach of using the manual power.

One of the most energy consuming agricultural activities is seedbed preparation. In Ghana, seedbed preparation for yams involves the raising of soil conical platforms (mounds) with heights that range 0.40... 0.80 m by the use of the hoe. This could be classified as the first stage of mechanization whose problems are discussed below. It is recommended to place yam settings at about 0.10... 0.15 m deep below the topmost surface of the mound.[2]

Field observation in the Nanumba district at Bimbila reveals that a large number of yams became exposed to the atmosphere at maturity when planted at the required depth but where planting depth is relatively deeper, it results in breakage of the ends of the yams during harvest at the dry season, giving rise to post harvest losses.

Yams planted on flat lands, too, give rise to breakages at harvest and reduce the commercial value of the crop. Some work has been done by Kang[3] to substantiate the necessity of planting yams on mounds in Nigeria.

Presenting the results in a graphical form as in **Fig. 1**, it is clear that the height of mounds is a major factor influencing yields. Agronomically, one can say that by raising beds the pore spaces in the soil is likely to increase or facilitate the expansion of tubers deeply and laterally during growth.

The height of mounds also indicates that it is preferable to plant yams on mounds or raised beds than on flat lands. Denisov[4] recommends that the soil must be pulverized to a bulk density of 900 kg/m^3. He further emphasizes that a high bulk density could reduce the yield to 30% of the expected yield.

To consider the rain pattern in the North, one would notice that there is always a particular 3...4 weeks where rains are very heavy and, therefore, give rise to flooding on the fields. Even though the degree of floods or saturation on the fields will depend on the topography and the drainage level of the field, it is observed for sure that fields in Bimbila area have not received adequate land reclamation to avoid the situation where one can hardly see floods. Yams grow badly in flooded areas, hence need platforms or mounds to avoid the saturation zone at this period for better growth.

In order to achieve the main objective of yam production in the country, a study was undertaken to come out with the appropriate geometrical dimensions of the yam mounds. Therefore, within the programme of the study, we looked at some of the physical properties of the soil which would include porosity and internal friction and some characteristics of yams.

Porosity ϵ is generally defined as the ratio of the volume of voids "V_p" of a given soil aggregated to the volume of solid substance V_r of the sample. That is $\epsilon = (V_p/V_t)$

Table 1. Results of Field Experiment for the Definition of Internal Friction of Soil Aggregate

No	h,m	L,m	$\phi°$	$f1 = tg\phi$
1	0.185	0.250	47°43'	1.11
2	0.326	0.441	47°50'	1.09
3	0.133	0.520	48°30'	1.13

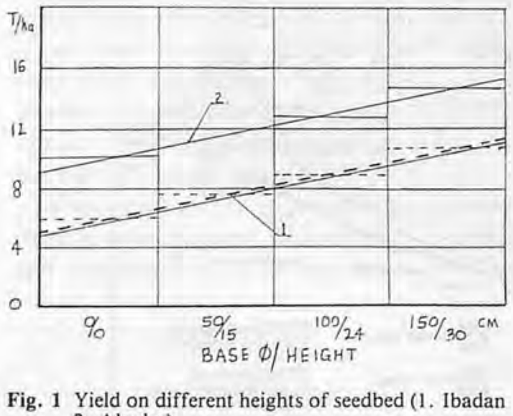


Fig. 1 Yield on different heights of seedbed (1. Ibadan 2. Alagba).

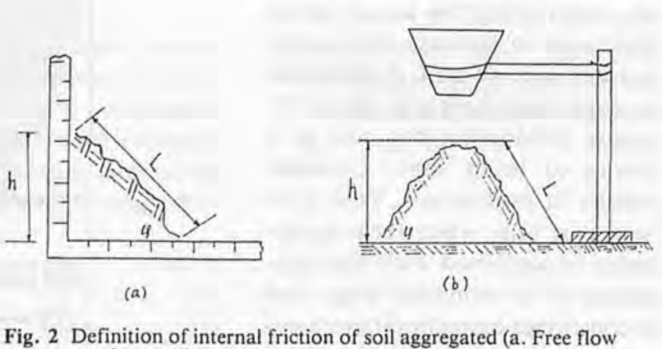


Fig. 2 Definition of internal friction of soil aggregated (a. Free flow against wall method, b. Heaping method).

In Bimbila area unploughed fields with 16% moisture content were found to have an average coefficient of porosity of 0.15... 0.25. The average coefficient of porosity has been defined in this study in such fields after ploughing, to be 0.30 ... 0.40. This, therefore, means that any tillage operation may increase the bulk volume of voids to about 12 ... 21%.

Coefficient of internal friction of soil aggregates was conducted under the same field condition as above using the free flow or heaping methods with a scaled stand of an efficiency level of 0.005 m **(Fig. 2)**.

The results in the **Table 1** are derived from a simple geometrical equation below:

$\phi^{\circ} = \arcsin(h/L)$

where,

h - height of slope of the heaped soil.

L - Length of slope of the heaped soil.

The experiment concludes that the average internal frictional angle of soil in Bimbila, a yam growing area, during seedbed preparation period with moisture content of 16 ... 17% ranges from 47 ... 48°.

In order to theoretically substantiate the necessary mound height, we had to further carry out an experiment on dimensional analysis of a commonly grown variety of yam in Bimbila. The main characteristics (which is the length) was determined by using the methods based on probability theory and mathematical statistics. For this reason, a statistical analysis was carried out on sets of 100 tubers harvested on farms and the arithmetic mean x 0.440 m, variance σ^2 0.0066^2 m and standard deviation σ 0.0816 m were obtained. To elucidate the law of the distribution of the dimensional characteristics of yam tubers, a dependence curve P(x)

$$P(x) = \frac{1}{(\sqrt{(2n)})\sigma} \exp(-(x - x)^2/2\sigma^2$$

The general laws of normal distribution in relation to the parameters of population as in any case, the height holds for the estimates characteristing the region as $x + 3\sigma \approx 100\%$ which indicates the probability of occurrence. In agricultural practice it is generally satisfactory to use the level where $x + 2\sigma$ of 95% probability which will give us a maximum height of yam tubers to equal 0,60 m. To consider the minimum depth of planting 0.10 as recommended earlier[(2)] we expect a minimum height of a mound to be 0.70 m.

Results

Having had from our experiments and calculations for internal frictional angle of soil and the approximate height of mound, the geometrical figure of mound is presented in **Fig. 3**.

Considering that the cross-section of the mound has a trapezoidal or a triangular shape which is not tapered to a point and characterised by the internal frictional angle of soil or the natural slope with about 0.25 m top width as shown in the figure, then "h" can be derived by the following formulae:

$$tg\phi = \frac{2h}{0.25}$$

and the base diameter will be as follows: $Bm = 2HaCtg\phi$

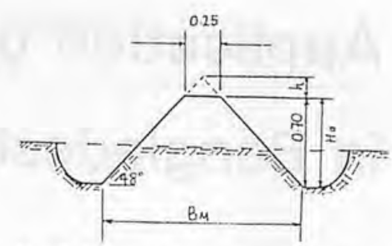


Fig. 3 Cross-section of the mound for yam planting.

Conclusions

(1) Yams should be planted on mounds in Bimbila area because of the compactness of the soil and depth of top soil.

(2) The recommended height of a mound is 0.70 m.

(3) The major technological basis for preparing seedbed in the form of mound for yams so as to check excessive erosion and exposure of tubers at maturity through surface run off are the coefficient of porosity and the internal frictional angle ϕ of the soil.

REFERENCES

1. World Bank 1986. Agricultural Mechanization Issues and Policies. Report No. 6470-Washington D.C. 1986.
2. Agricultural Extension Hand Book - ESc-hon/TS G.G.A.D.P. 1977 p.112-113.
3. Kang B.T., Wilson I.B. Effect of mound size and fertilizer or Guinea yam in South Nigeria. Plant and Soil: The Hague/Boston - London 1981 vol. 61 No. 3 p.319.
4. Denisov P.V., Bases of utility of soil in the tropics and sub-tropics. Krasnodar, 1977 p.271. ■■

Application of Wind Energy for Irrigation in Bangladesh

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Abstract

Modern technologies for extracting wind energy more effectively are being applied in recent years. The financial budget for research in wind energy is increasing every year in many developing and developed countries. The research result on wind energy in Bangladesh is not encouraging. In this paper, the wind data collected from meteorological stations are analysed and presented. The wind speed in some regions of Bangladesh is satisfactory for operating pumps and for generation of electricity. The wind turbine may be useful to drive manually operated irrigation pumps. The performance of sailwing rotor coupled to a diaphragm pump was found to be satisfactory.

Introduction

Bangladesh is situated between 20°34' and 26°38'N latitudes' and 88°01' and 92°41'E longitudes with nearly 120 million people living on 144 000 km^2 area.

The prospect of wind energy as an alternative source of energy in Bangladesh needs to be examined because the oil and gas reserve of the country are very small. A relatively small coal deposit exists at a depth of 600 m to 900 m below the earth's surface. Hydroelectric energy is also limited and expensive.

Bangladesh farming needs adequate supply of irrigation water at the right time and right quantities. A recent study shows that 36 730 low life pumps of 12 m head and 0.066 m^3/s surface water potential for a total of 54 700 pumps of 0.066 m^3/s capacity. About 50% of these pumps operate at a head of 6 m or less, depending on the terrain of the country. For driving these pumps, either diesel engines or electric motors are used. These pumps can be driven with the help of windmills. Also, the domestic wind power plants may be applicable to many areas in Bangladesh. For selecting the size and type of wind machine, the information about wind speed, direction and its duration should be known. The meteorological department can give the preliminary information for identifying the prospective areas of wind power in Bangladesh.

At present, there are many types of wind turbines for extracting energy from the wind. Among these, The horizontal axis wind turbines are used for pumping water and for generation of electricity. In early 1960, attention was given to the vertical axis wind turbines for the same purposes. Among these, the savonius rotor Darrieus rotos, Sailwing rotor etc. are important. However, the performance of rotors depends on the design and ratio of the rotor tip speed to the wind speed.

In this paper, an attempt has been made to investigate the application of wind energy for irrigation and generation of electricity in different regions of Bangladesh.

Wind Data

The national economy of Bangladesh depends on the improvement of the agriculture sector. The utilization of wind energy for irrigation will be helpful for the development of the economy. In Bangladesh, winds are available mainly during the monsoon season and around one to two months before and after the monsoons. Starting from late October to the middle of February, winds either remain calm or too low to be of any use by a windmill. Except for the above mentioned period of four months, a windmill, if properly designed and located, can supply enough energy. The peak rainfall occurs in the country during the months of June, July and August. But the peak wind speed occurs one to two months, and, in some cases, three months before the peak rainfall occurs. One of the advantages is that the peak winds are available during the hottest and the driest months of March, April and May. During this period windmills may be used for pumping water for irrigation if it had been previously stored in a reservoir during the monsoon season.

During the operating seasons, subsoil water from shallow wells can also be pumped by low lift pumps run by windmills. Wind power can also be incorporated in electricity grid on a substantial basis and could add reliability and consistency to the electricity generated by the Kaptai hydro-electric power station during the dry season. This is due to the fact that during the dry season required water head becomes rather low for total utilization of all the generators. Thus power generation has to be curtailed during this period. Hence this deficit power can be complemented with the help of wind power plants.

Table 1. Prospective Locations of Windmills, Bangladesh

Location	Potential Months for Extracting Wind Power	Average Wind Speed m/s
Chittagong	March to September	3.53
Dhaka	March to October	3.19
Khepupara	February to September	3.11
Comilla	March to September	2.78
Teknaf	June to September	2.25
Jessore	April to September	2.11
Cox's Bazar	May to August	2.00
Hatiya	April to July	1.89
Dinajpur	March to August	2.03
Rangamati	April and May	1.88

Among the different areas considered in Bangladesh, some locations have been found suitable for wind power generation (**Table 1**).

The wind power in an area determines the size and shape of the rotor appropriate to that location. The wind data from the meteorological stations give an estimation of available wind power. The wind data analysed here are the average of the data recorded during the period 1976 to 1986. **Fig. 1** shows the speed duration curve for six different locations in Bangladesh. The wind speed in Chittagong is 5 knots (2.57 m/s) or more for 4 000 h a year. At this available speed a wind plant can be operated both for generation of electricity and for driving pumps. A vertical wind rotor of swept area 100 m^2 can produce about 2 kW power at this wind speed. In comparison, at Cox's Bazar the wind speed is 5 knots (2.57 m/s) or more for about 2 000 h a year. This speed may not be recommended for generation of electricity.

The wind power per unit area of approach is proportional to the cube of wind speed [3] and it can be expressed as $P/A = 0.0577V^3$ where P/A is in watt/m^2 and V is in mph. This wind power represents the strength of wind. Theoretically a maximum of 59% of this power can be extracted. The wind power P/A is plotted in **Fig. 2** to show the strength of wind is six locations in Bangladesh. It shows that in Chittagong the wind power is nearly 150 watt/m^2 for 2 000 h in a year.

Choosing a suitable rotor size, useful amounts of energy can be harnessed for electricity and for driving pumps. **Fig. 2** also shows

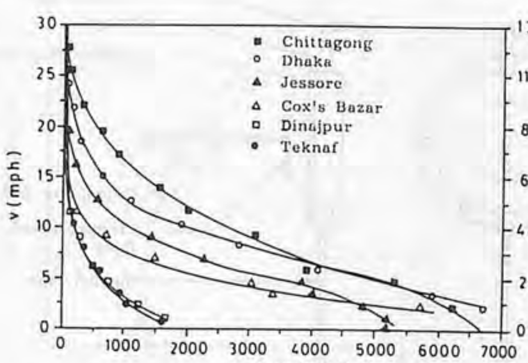

Fig. 1 Velocity duration curve.

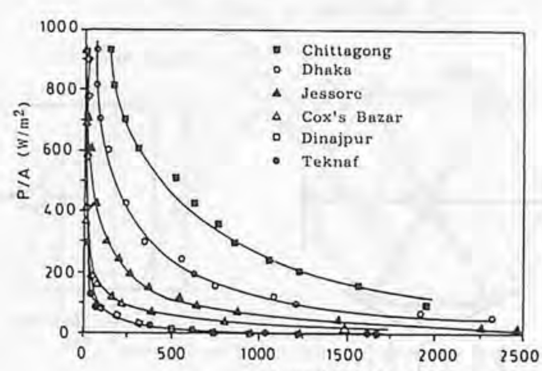

Fig. 2 Wind power in six regions of Bangladesh.

that in Cox's Bazar the wind power is about 50 watt/m^2 or more during 1 000 h a year. This may be useful for driving shallow tubewells for lifting water. The wind data at other locations also show similar strength of wind energy. The wind speed is expected to be at higher order in islands and coastal areas in the country. The installation of wind powered machines at the coastal and island areas will be useful for lifting water and for generation of electricity.

Sailwing Rotor

The sailwing rotor is an old device of vertical axis rotor, which is easy to make using indigenous material. A typical rotor of this kind is shown in **Fig. 3** with six sail frames and two sails. Six arms are equally spaced and welded to a plate of 300 mm diameter and 6.35 mm thickness. The plate is fitted on the top of a 31.75 mm outer diameter steel pipe. Similarly, another six arms are fitted at the bottom of the pipe, on another circular plate of same type. The length of each arm is 1.52 m. The steel pipe which acts as a vertical shaft is also 1.52 m long. The arms are made of 25.4 mm outside diameter and 1.59 mm thickness steel conduit pipe. Six sail frames are also made of steel conduit pipe of 19.1 mm outside diameter and 1.59 mm thickness. The height of each sail frame is 1.3 m and the length of its extended parts are 0.90 m. These sail frames are fitted to the outer ends of the rotor arms. Each sail is fitted to two rotor arms. Six sails made of jute sack instead of costly canvas are fitted to the sail frames. The dimensions of each sail is 1.22 m × 0.76 m **(Fig. 4)**.

The rotor is supported with the help of a 31.8 mm × 31.8 mm × 6.35 mm angle frames and all structures are made of steel frames. A standard ball bearing is used at the top of the vertical shaft which is fastened to the cross angle frame by bearing casing and bolts. The shaft is extended through the thrust bearing by 200 mm to fit a crank. The crank is made of a 9.33 mm diameter, 76.2 mm long mild steel rod, half of which is threaded. The rod is threaded to keep the connecting rod in position by using two nuts. The crank is joined eccentrically to the shaft by arc welding. In this way a belt and pulley mechanism is avoided. The length of stroke is 38.1 mm.

A diaphragm pump **(Fig. 5)**, manufactured locally, is connected to the crank by a 0.60 m long and 7.94 mm mild steel rod. A circular metal piece of 25.4 mm diameter and 11.1 mm thickness, having a 11.1 mm diameter hole at the center is fitted at one end of the connecting rod. This end is connected to the crank and the other end is welded to a 127 mm diameter and 6.25 mm thick mild

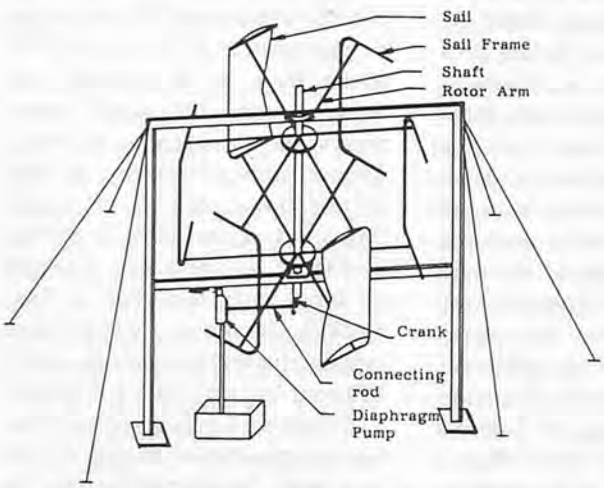

Fig. 3 Schematic diagram of sailwing rotor showing only two sails.

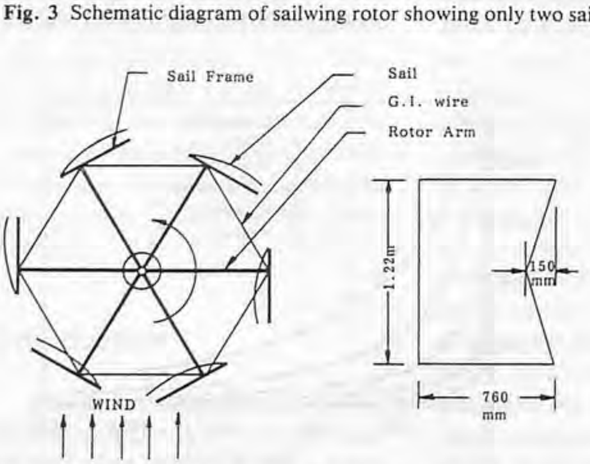

Fig. 4 Changing position of sail and dimension of sail.

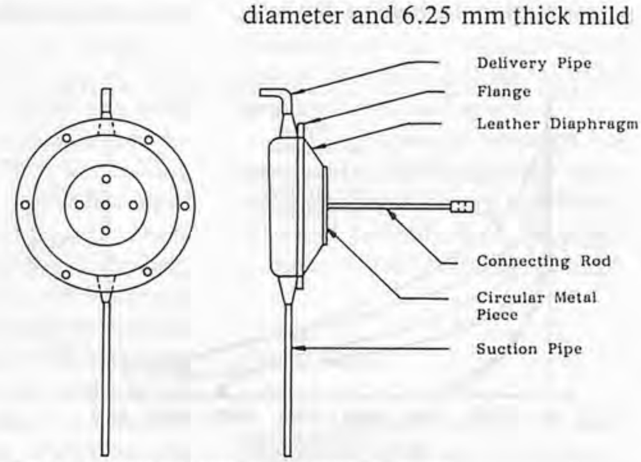

Fig. 5 Schematic diagram of diaphragm pump.

steel plate. This plate is fitted to the diaphragm by bolts. Instead of the usual preshaped rubber diaphragm, a leather diaphragm is used which has greater strength and longer life then the rubber diaphragm. Anybody can replace the leather diaphragm without going to the manufacturer by using the ordinary soft leather used for making shoes. The diameter of the diaphragm is 190 mm. The pump is fixed to the lower cross frames by steel angles and bolts.

The whole structure is kept in position by 2 mm diameter, galvanized iron wires.

Discussion and Conclusion

The wind data presented here are not very prospective, but its use for lifting water and for generating electricity may solve energy problem in the country to some extent. In most of the areas in Bangladesh, the pumping head is less than 6 m which is appropriate for using diaphragm pumps and the manpowered pumps. For these pumps the available wind power in the country can produce good results with a suitable rotor. The use of locally available materials and technology can produce satisfactory wind pumping unit for lifting water.

In coastal areas, island and isolated villages the wind speed is expected to be reasonably sufficient for installng wind plant for electricity. In many areas the transmission of electricity is either expensive or impossible. The installation of wind plant for generating electricity will be very useful for such areas. The power requirement for an isolated village or island may be caculated for selecting or designing a suitable rotor. Wind plants should be made popular to the users, and the owners should be encouraged to make it with locally available materials.

The sailwing rotor along with the pump described in this paper is installed at a location where the wind speed did never exceed 6 mph (2.68 m/s). The variations in the discharge of the diaphragm pump with wind speed are shown in **Fig. 6.** It was observed that for this system the starting wind speed is about 3.35 mph (1.5 m/s). This is encouraging from the point of view that most areas in Bangladesh have low wind speeds. The discharge was found to be higher for lower lift at a given wind speed. With the increase in wind speed, the discharge increases for both the lifts, but the rate of increase is lower at higher wind speeds. It appears that if the wind speed is increased further, the discharge approaches some maximum value. By extrapolation, the maximum discharge for 1.5 m lift may be of the order of little more than 5 min, whereas for 1.2 m lift it will be much higher than 6 min.

The overall efficiency of the system, η, is plotted against the water discharge rate, Q (**Fig. 7**). Overall efficiency is defined as:

$$\eta = \frac{gHQP_w}{\frac{1}{2}pAV^3}$$

where,

Q = water discharge rate, m^3/s
p_w = water density, kg/m^3
H = total head, m
p = air density, kg/m^3
V = wind speed, m/s

The overall efficiency is obviously the product of the rotor efficiency, η_r, and the pump efficiency, η_p. From **Fig. 7**, it is found that overall efficiency increases from zero to a maximum value and then decreases with an increase in Q. A maximum of about 5% is obtained at a Q of about 2 min. Considering that overall efficiency is the product of η_r and η_p and that diaphragm pumps, in general, are of lower efficiency, 5% overall efficiency is quite encouraging. Again, attention may be drawn to the fact that the maximum value of η occurs at lower values of Q, i.e., at lower wind speeds. This observation is important considering the low average wind speed in Bangladesh over a good portion of the year. It was also found that for the same discharge, η is in general slightly higher for the lower lift.

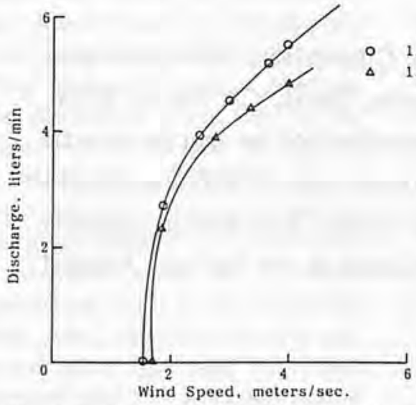

Fig. 6 Variation of water discharge with wind speed.

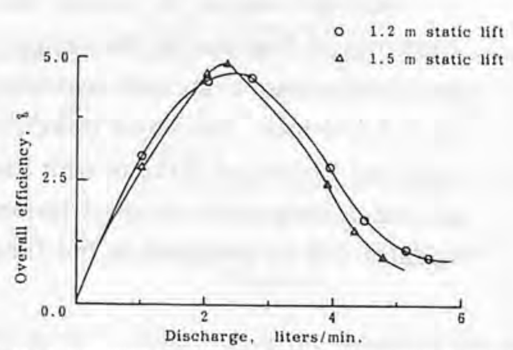

Fig. 7 Variation of overall efficiency with water discharge.

Further investigation is needed before commenting on large-scale utilization of this type of wind turbine for irrigation purposes in the rural areas of Bangladesh. The effects of wide variation of suction head on the discharge are to be investigated. The delivery head should also be varied. The number of sails may have some effect on the overall performance. Other types of positive displacement pumps may be tried.

The following points should be considered for the design and operation of the windmills.

i. The windmills should operate automatically, i.e., the safety system of the windmill will activate when the wind speed exceeds a certain limit;

ii. The maintenance should be minimum and simple. The rotor should not endanger the people standing on the ground;

iii. Instead of cloth sails, polythene can be used. If possible metal blades should be used;

iv. Low or medium speed rotors should be preferred for pumping water; and

V. The windmills should be strong enough so that they cannot be damaged easily. If possible, gearing should be avoided. Locally available materials such as hard wood or bamboo should preferably be used.

REFERENCES

1. Gerhard Dedorath, Bonn, "Can the Crisis be Solved with Renewable Energy", Applied Geography and Development, Vol.20, Institute for Scientific Cooperation, Tubingen, Germany, 1982.
2. Islam, S.M.N., Khan, M.H. and Islam, M.Q., "An Overview of Wind Energy and its Prospects in Bangladesh", Conference Proceedings of Energex, 1988, Tripoli, Libya.
3. Beurskens, H.J.M., "Feasibility Study of Windmills for Water Supply in Mara Region, Tanzania", SWD publications, P.O. Box 85, Amersfoort, The Netherlands, March 1978.

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Design and Development of an Animal-drawn, Engine-operated Reaper

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Abstract

An animal-drawn reaper with an engine-operated cutting and conveying mechanism was designed and fabricated for harvesting wheat and paddy crops. The reaper was tested on wheat crop and the capacity was 0.27 ha/h with an observed field efficiency of 84.36%. The machine performed satisfactorily. However, field trials indicated that further improvement in the power transmission system is needed.

Introduction

Most of the cereal crops are generally harvested by sickle which is quite tedious and labour-intensive job. During the peak season of harvesting, farmers have to face the difficulty of getting their crop timely reaped due to shortage of agricultural labourers. Mechanical harvesting could well be the answer to overcome the above problem. About 75% of the farming operation is done on small and marginal holding size. Therefore, a machine such as combine harvesters could not be used with ease. Also, the use of tractor and power tiller operated harvesters are confined only to farmers owning tractors and power tillers. A large number of such farmers have started using diesel engines of 5-8 hp for irrigation purposes. It was, therefore, felt necessary to develop a reaper which could utilize bullock power in combination with a diesel engine. Keeping in view the above fact, an animal-drawn, engine-operated reaper was designed and developed at the Department of Farm Machinery and Power at G B P U A and T. Pantnagar (**Fig. 1**).

Design of the Reaper

The reaper consisted of four major component parts: power transmission unit, crop supporting unit, crop cutting unit and crop dividing and lifting unit. The system of the reaper are power transmission, lugged conveyer belt, cutterbar, crank drive, Pitman, arm and bevel gears.

Design of Power Transmission

Design of counter shaft — The torque at the engine shaft (T) can be calculated as:

$$T = HP \times 4\,500 \ / \ 2\pi N \qquad \text{eqn (1)}$$
$$= 119.36 \text{ kg-cm}$$

A 5-hp engine running at 3 000 rpm was used as prime mover. The countershaft pulley has 900 rpm which is 1/3.333 rd of the engine speed. Hence, the torque transmitted to the countershaft will be 3.333 times more than engine shaft.

The torque on the counter shaft (T_c)

$$T_c = 119.36 \times 3.333$$
$$= 397.86 \text{ kg-cm}$$

Tension in the belt between engine and counter shaft pulley:

Torque on the engine shaft:

$$= (T_1 - T_2) \times r \qquad \text{eqn (2)}$$
$$T_1 - T_2 = 32.32 \text{ kgf}$$

where,

T_1 = Tension of the tight side, kgf

T_2 = Tension of slack side, kgf

r = Radius of pulley on engine shaft, 3.81 cm

Ratio of the tensions:

$$= T_1/T_2 = e\mu e\theta \qquad \text{eqn (3)}$$
$$\text{and } \mu e = \mu/(\sin\beta/2) \qquad \text{eqn (4)}$$

where,

μ = Coefficient of friction, 0.3

θ = Angle of contact, rad

β = Groove angle of the pulley, 38 degree

Substituting the values we get μe as 0.92.

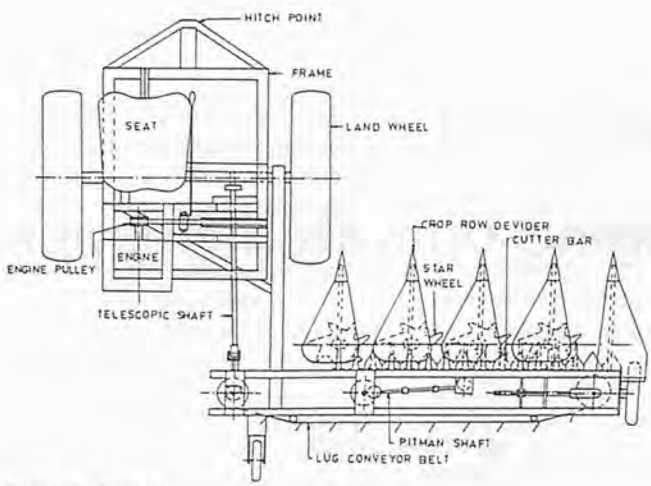

Fig. 1 Bullock drawn engine-operated reaper.

Angle of contact (θ)

$= \pi - 2\sin^{-1}((D_2 - D_1)/2C)$ eqn (5)

$= 2.66$ rad

where,

D_1 = Diameter of smaller pulley, 7.62 cm

D_2 = Diameter of larger pulley, 25.4 cm

C = Centre to centre distance between the shafts, 37 cm

again substituting the values of μe and θ in eqn (3) we get

$T_1/T_2 = 11.56$.

Solving for T_1 and T_2, we get the values as 34.28 and 2.98 kgf, respectively.

Total belt tension $= T_1 + T_2 =$ 37.24 kgf.

Bending moment of the counter shaft (bmc_1):

$= WL/4$ eqn (6)

where,

W = total tension acting on the shaft, 37.24 kgf

L = length of the shaft supported between the bearings, 13.5 cm

Neglecting the weight of pulley and substituting the values, we get bmc_1 as 125.68 kg-cm.

Tension of the belt between counter shaft and secondary shaft can be calculated by using eqn (2) as $T_2 - T_4$ as 104.42 kgf.

Similarly, the ratio of the tensions (T_3/T_4) as 11.56:

Solving for T_3 and T_4 we get the values as 114.22 and 9.88 kgf, respectively.

Total tension $= T_3 + T_4 = 124$ kgf:

The section of the counter shaft with the small pulley can be considered as a cantilever beam with a span of 10 cm. Therefore, the bending moment of this section (bmc_2)

bmc_2 = Total tension × length of cantilever ...eqn (7)

$= 124 \times 10 = 1\,240$ kg-cm

Equivalent twisting moment (T_e)

$= \sqrt{M^2 + T^2}$ ...eqn (8)

where,

M = bending moment of the countershaft, 1 240 kg-cm

T = torque on the countershaft, 397.86 kg-cm

Substituting the values we get T_e

$= 1\,302.26$ kg-cm

Diameter of counter shaft (d)

$= 3\sqrt{16T_e/\pi f_s}$ ...eqn (9)

where,

T_e = equivalent twisting moment, 1 302.26 kg-cm

d = diameter of the shaft, cm

f_s = shear stress, kg/cm^2

Putting the values we get shaft diameter as 2.28 cm

Equivalent bending moment (M_e)

$= 1/2(M + \sqrt{M^2 + T^2})$ ...eqn (10)

$= 1\,271.13$ kg-cm

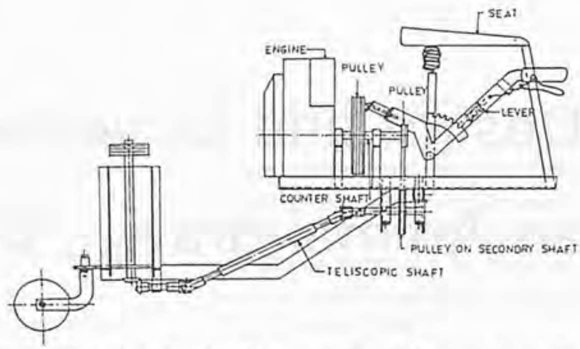

Fig. 2 End view showing the arrangement of power transmitting unit.

Diameter of counter shaft (d)

$= 3\sqrt{32M_e/\pi f_t}$ ...eqn (11)

where,

M_e = equivalent bending moment, 1 271.13 kg-cm

d = diameter of the shaft, cm

f_t = tensile strength, kg/cm^2

Putting the values we get diameter as 2.26 cm.

A shaft diameter of 2.5 cm was chosen due to ease of availability and also to fit a ball bearing of standard size 2.50 cm inner diameter (NBC 125).

Design of secondary shaft — The speed of the secondary shaft is 50% less than the counter shaft. Hence the torque transmitted to the secondary shaft will be double the torque of the counter shaft.

Torque on the secondary shaft:

$(T_s) = 397.86 \times 2 = 795.72$ kg-cm

Bending moment of secondary shaft (bms), considering:

W = total tension acting on the shaft, 124 kgf

L = length of the shaft between the support, 19 cm

we get, bms, as 589 kg-cm

Equivalent twisting moment (T_e) can be calculated by using the eqn (8) as 989.99 kg-cm = 990 kg-cm (say):

The shaft diameter (d):

= 2.08 cm using eqn (9)

Equivalent bending moment (M_e) as 789.5 kg-cm using eqn (10):

Using eqn (11), we get shaft diameter (d) as 1.93 cm.

A shaft diameter of 2.5 cm was chosen due to the ease of availability and to fit standard size of bearing (NBC 125).

Design of vertical shaft — The speed of the secondary shaft and a vertical shaft used for driving conveyer belts is similar and hence the torque transmitted.
Torque on the vertical shaft (T_v) = 795.72 kg-cm:
$T_v = (T_5 - T_6)\,r$ as eqn (2)
where, considering the radius of pulley as 6.35 cm, we get
$T_5 - T_6 = 125.31$ kgf.
Ratio of the tensions (T_5/T_6) = 11.56 (as calculated by eqn (3))
solving for T_5 and T_6 we get the values as 137.17 and 11.86 kgf
Total belt tension ($T_5 + T_6$) = 149 kgf:
Bending moment to the vertical shaft (bmv):
bmv = total belt tension × overhung
= 149 × 6 = 894 kg-cm
Equivalent twisting moment (T_e) = 1 195.71 kg-cm (using eqn (8))
diameter of shaft (d) = 2.21 cm (using eqn (9)).
Equivalent bending moment (M_e) = 1 044.1 kg-cm (using eqn (10)).
The diameter of the shaft (d) is 2.11 cm (using eqn (11)).
A shaft diameter of 2.5 cm was choosen to fit a bearing of 2.5 cm internal diameter (NBC 125).

Design of shaft driving crank — The speed of the driven shaft is 1/1.25 the speed of driver shaft, hence, the torque will be 1.25 times more.
Torque on the driven shaft (T_d) = 636.57 kg-cm
Bending moment of the shaft (bmd)
bmd = total belt tension × overhung
= 148.75 × = 892.5 kg-cm
Equivalent twisting moment (T_e) = 1 096.25 kg-cm (using eqn (8))
we get the shaft diameter as 2.15 cm (using eqn (9))
Equivalent bending moment (M_e) = 994.37 kg-cm (using eqn (10))
The shaft diameter can be found as 2.08 cm (using eqn (11))
In order to use a ball bearing of size 2.50 cm internal diameter (NBC 125), the shaft diameter was chosen as 2.50 cm

Design of Telescopic Shaft — A telescopic shaft was used to transmit power of secondary shaft to bevel gears.
Torque transmitted by the telescopic shaft (T_{ts}):
T_{ts} = Torque on the secondary shaft (T_s)
= 795.72 kg-cm
The telescopic shaft was designed purely for torsion.
Using eqn (9) the diameter was 1.93 cm (say 2.0 cm).

A square shaft (hollow section) of 2 × 2 cm size was chosen. This shaft provided an area of cross-section of 4 cm^2 which is about 21% more than the cross-sectional area of a 2.0 cm diameter shaft.

Selection of pulleys — Double v-grooved cast iron pulleys were selected for meeting the speed requirement of various components. The diameter of the pulleys used are given below.
Pulley on the engine shaft = 7.62 cm (3.0 in.).
counter shaft pullies:
Larger pulley = 25.4 cm (10.0 in.).
Smaller pulley = 7.62 cm (3.0 in.).
Pulley on the secondary shaft = 15.24 cm (6.0 in.).
Pulley on the vertical shaft = 12.7 cm (5.0 in.).
Pulley on the shaft driving crank = 10.16 cm (4.0 in.).

Design of v-belts for power transmission — Length of belt between engine pulley and counter shaft pulley (L_1)

$$L_1 = 2C + \pi/2\,(D + d) + (D - d)^2/4C \quad \text{...eqn (12)}$$

where,
C = center to centre distance between the shafts, 37 cm
D = diameter of the larger pulley, 25.4 cm
d = diameter of the smaller pulley, 7.62 cm
L_1 = length of the v-belt, cm

Putting the value in above eqn we get L_1 as 128.0 cm (50.39 in.). A standard size of v-belt B 51 was selected. An idler was provided to adjust the proper tension of the belt.

Similarly, the length of the belt between counter shaft and secondary shaft as well as between vertical shaft and shaft driving the crank was calculated as 91.0 cm (36 in.) and 148.21 cm (58.35 in.), respectively. A standard size of belt B 36 and B 58 was selected for transmitting power between these shafts. For proper tension grooves were provided to adjust the central distance between these shafts.

Determination of Designed Horse Power Required

It is assumed that the machine is light duty as it is to be used not more than 6 h a day. The service factor is taken as 1.0. Therefore, the designed horse power (hpd) = 5 × 1.0 = 5.0 hp. The B-section v-belts were selected for power transmission.

$$\text{Velocity ratio } (V_r) = N_1/N_2 \quad \text{...eqn (13)}$$
$$= 3.33$$

where,
N_1 = engine speed, 3 000 rpm
N_2 = counter shaft pulley speed, 900 rpm
The size of pulley on the counter shaft can be given as:

$$D_2 = D_1\,(1 - s)(V_r) \quad \text{...eqn (14)}$$

where,
D_1 = diameter of pulley on engine, 7.62 cm
D_2 = diameter of pulley on counter shaft, cm
s = slip factor, 0.01 to 0.03
substituting the values we get D_2 = 25.0 cm.

The next available size of

pulley is 25.4 cm (10 in.), therefore, a 10 in diameter of pulley was chosen for power transmission from engine to counter shaft.

Belt speed (V)

$= \pi D_1 N_1/100$ eqn (15)

where,

D_1 = diameter of pulley on engine shaft, 7.62 cm

N_1 = speed of the engine, 3 000 rpm

Substituting the values in eqn, we get V = 11.96 m/s (12 m/s say).

Determination of Angle of Contact (θ)

The value for angle of contact was adopted 2.66 as calculated before by using the eqn (5). The value of contact angle should be greater than or equal to 2.1 rad. Therefore, the calculated value of contact angle is satisfactory.

Determination of Maximum V-belt Tension

Horse power $= (F_1 - F_2)V/75$ ...eqn (16)

where,

F_1 = tension of tight side, kgf

F_2 = tension of slack side, kgf

V = belt speed, m/s.

Substituting the values, we get $F_1 - F_2 = 31.25$ kgf and $F_1/F_2 = 11.36$ as calculated earlier by eqn 4 and 5. Solving for F_1 and F_2 we get the values as 34.21 and 2.96 kgf, respectively. Therefore, maximam belt tension (34.21 kgf) was adopted for the design.

Determination of Number of Belts Required

The number of belt required can be calculated as:

$n \geqslant F_1/((f_t - wv^2/g) \times AC_1C_2)$ ...eqn (17)

where,

n = number of belt required

A = area of x-section of belt ($1.4\ cm^2$ for B-section v-belt)

C_1 = arc of contact factor (0.96)

C_2 = belt length correction factor (0.88)

f_t = tensile stress ($15\ kg/cm^2$)

g = acceleration due to gravity ($981\ cm/s^2$)

v = belt speed (cm/s)

w = weight density of the belt material, $1.14\ gm/cm^3$.

Putting the values we get n = 2.0. Therefore, 2 v-belts will be required.

Design of Bevel Gears

Design requirements:

a) speed ratio is 1 : 1
b) speed of driver gear is 450 rpm
c) horse power to be transmitted is 5 hp
d) gear material is cast steel having minimum tensile strength of $55\ kg/cm^2$
e) tensile stress for steel (σ_c) is $20\,000\ kg/cm^2$
f) modulus of elasticity of steel is $2.06 \times 10^6\ kg/cm^2$
g) ratio of cone distance to face width (R/b) is 3
h) load distribution factor (K_m) is 1
i) service factor (N_{sf}) is 1
j) designed tensile strength for cast steel (σ_b) is $5\,500\ kg/cm^2$

Speed of gear (N_g) = speed of pinion (N_p) = 450 rpm

Ng = Np = 450 rpm

Torque transmitted (Mt)

$= (HP \times 4\,500)/2\pi Ng$ (as in eqn 1)

= 795.7 kg-cm

Diameter ratio of gear and pinion (i) $= Z_1/Z_2 = 1$ eqn (18)

Cone distance (R)

$= \phi_y\sqrt{(i^2+1^2)}\ 3\sqrt{((0.72/(\phi_y - 0.5)\sigma_c))^2 \times (EM_t/i)}$ ...eqn (19)

= 2.961 = 3.0 cm (say)

also

$R = \sqrt{(r_g)^2 + (r_p)^2}$

where, r_g and r_p = radius of gear and pinion.

Therefore, putting the value we get $r_g = r_p = 2.12$ cm

Diameter of pinion (Dp) and gear (Dg) = 4.30 cm (say).

Module of the gear (m) $= D_p/T_p$ = 4.0 mm.

where, T_p = number of teeth on pinion = 11.

Pitch angle ($\tan\delta_1$) $= (D_p/D_g) = (Z_1/Z_2) = 1.0$ ... eqn (22)

Therefore, $\delta_1 = 45$ degrees

Formative number of teeth (Z_v) $= T_p/\text{Cos}45 = 16$.

Line velocity (V_m) $= \pi DN/100$ = 1.01 m/s.

Velocity factor (C_v) for a gear velocity of $\leqslant 5$ m/s.

$C_v = (3.50 + V_m^{0.5})/3.50$ ...eqn (23)

= 1.28

Transmitted load (F_t)

= (Horse power × 4 500)/V_m ...eqn (24)

= 370.18 kg

Dynamic load

$= C_v \times N_{sf} \times k_m \times F_t$ ...eqn (25)

= 1.28 × 1 × 1 × 370.18

= 474 kg

Form factor (Y) $= \pi y = 0.295$

where, y = Lewise form factor (0.094 for 20 degree full depth form).

Face width (b) + R/3 = 0.3R

Using Lewise eqn Fs

$= \sigma_b\ b\ Y(1-(b/R))m$ ...eqn (26)

b = 1.0 cm (adopted for design)

where,

Fs = dynamic load, 474 kg

σ_b = tensile strength of cast steel, $5\,500\ kg/cm^2$

b = face width, cm

m = module, 0.4 cm

Y = form factor, 0.295

Check for face width (b) = 0.3R = 0.3 × 3 = 0.9 cm.

Since the calculated value of 'b' is more, hence design is safe.
Tooth angle:
$= Bg = Bp = 45$ degree
outer diameter
$= Og = Op = D + (2Cos\delta_1)$
$= 5.71$
Normal depth of addendum
$= A_p = A_g = m = 0.4$ cm
Normal depth of dedendum
$= B_p = B_g = 1.157$ m
$= 0.46$ cm
Whole depth of tooth
$= H_p = H_g = 2.157$ m
$= 0.86$ cm
Length of pitch cone
$= l_g = l_p = D_g/(2Sin\beta_g)$
$= 3.04$ cm
Normal dedendum angle
$= tan\phi_g = 1.157 \times m)/1$
$= 0.151$
$\phi_g = 8.58$ degree
Width of tooth
$= 8 \times m = 3.20$ cm

Crop Conveying and Supporting Unit

Design of lugged conveyer belt — Considering the power requirement for cutting and conveying (0.77 hp/m length of cutterbar, Devnani, 1985) and also the limitation on working length for offset purpose, the length of cutterbar was kept at 116 cm. The length of vertical conveying was kept at 149 cm. Two lugged conveyor belts passing over 10.5 cm diameter pullies were used which conveyed the cut crop to one end of the machine with the help of star wheels.

Determination of length of conveyer belt — The length of flat belt was calculated by using the eqn (12) as 331 cm.

Pitch of lugs (P)
$= (\pi \times D_{os})/N_s$
(Devnani 1985) eqn (27)
$= 12.34$ cm

where,
D_{os} = outer diameter of star wheels, 27.5 cm
N_s = Number of arms on star wheels, 7.0

Crop Cutting Unit

A standard reciprocating type cutterbar of length 116 cm was selected with a stroke length of 7.62 cm for the machine.

Design of crank — The recommended strokes of cutterbar for harvesting wheat crop ranges between 400 to 500. A crank mechanism having crank speed of 500 rpm and stroke length 7.62 provided reciprocatory motion to the cutterbar. Design of crank journal.

Torque transmitted by crank (T_c)
$= (HP \times 4\,500)/2\pi N$ as eqn (1)
$= 636$ kg-cm

Innertia forces (Fh) due to crank rotation (Bainer etal 1963).

$$Fh = ((W_s + W_2)/g)\ R\omega^2\ (Cos\phi_c + (K_s/R)Sin\phi_c - K\ Cos2\phi_c) \quad \text{...eqn (28)}$$

where,
Fh = innertia force due to slider and the pitman weight at the slider, kg
g = acceleration due to gravity, cm/s^2
R = radius of crank, cm
s = height of crankshaft above plane of connection between slider to pitman (@ 2.0 cm)
W_s = weight of slider, kg
W_2 = weight of pitman acting at slider, kg
ω = angular velocity of crank, rad/s
ϕ_c = angle of crank rotation
also $K = R/\sqrt{(L^2 - S^2)}$
$= 0.095$
where, L = length of pitman, cm (taking L as 40 cm).

The weight of the slider and pitman was computed by considering specific weight and the length of material used. The slider was made from 25 × 5 mm size flat having sp. weight of 1 kg/m. Taking sp. weight of mild steel as 7.85 $kg\text{-}cm^3$, the weight of slider including knife section and crank may be taken as 3.5 kg and 0.8 kg, respectively. Taking for maximum value of F_h as 45 degree substituting the values in eqn (28) we get F_h as 29 kg.

The tangential component of innertia force (F_t) due to slider movement acting over the crank can be calculated as,

$$F_t = F_h Sin(\phi_c - \phi_p)/Cos\phi_p \quad \text{...eqn (29)}$$
$$= 10.63 \text{ kg}$$

where, ϕ_p = angle of pitman above horizontal (taking as 25.7°)
Torque produced due to tangential component of innertia force:
$(T_{ti}) = F_t \times$ radius of crank = 40.5 kg-cm
Total torque acting on the crank
$= 636 + 40.5 = 676.5$ kg-cm
The journal diameter can be calculated by eqn (9) as 1.83 cm
A diameter of 25 cm was selected to facilitate the use of a ball bearing having internal diameter of 25 cm (NBC 125).

Design of crank pin — The dimension of the crank pin which is assumed to be a cantilever beam will depend upon the strength required to withstand all the forces acting on it.

Torque transmitted at the pin (T_{pin}) = T_c = 636 kg-cm
load due to torque = T_{pin}/R = 167 kg
where, R = radius of crank, 3.81 cm
Centrifugal force due to crank rotation (F_c)

$$F_c = ((W_c + W_1)/g)R\omega^2 \quad \text{...eqn (30)}$$
$$= 34.16 \text{ kg}$$

where,
W_c = weight of the crank (0.8 kg)
W_1 = weight of the pitman (1.20 kg)
ω = angular velocity of crank,

9.81 cm/s^2

R = crank radius, 0.0381 m

A component of innertia force (F_s) due to slider movement which is also acting on the crank,

$$F_s = F_h \text{Cos}(\phi_c - \phi_p)/\text{Cos}\phi_p \qquad \text{eqn (31)}$$
$$= 31.18 \text{ kg}$$

therefore, total centrifugal force = 34.16 + 31.18 = 65.34 kg

Total force acting on the pin

= load due to torque + total centrifugal force

= 167 + 65.34 = 232.34 kg

Taking length of the pin as 4 cm and considering the force to be acting at the centre

Bending moment = force × distance = 232.34 × 2 = 464.68 kg-cm

therefore, the pin diameter was calculated by eqn (11) as 1.62 cm A pin diameter of 25 mm was selected to fit a ball bearing of internal diameter 25 mm (NBC 125).

Design of Pitman arm — The Pitman arm acts like a connecting rod of an I.C. engine. The Pitman arm is subjected to both tensile and compressive loads alternatively. It may fail in buckling or in tension (Pandya et al 1976). Using Euler's equation for designing the Pitman arm:

$$P_c = (n\pi^2 EI)/L^2 \qquad \text{...eqn (32)}$$

where,

E = modulus of elasticity, taking 21.5 × 10^5 kg/cm^2

I = second moment of innertia, $(\pi/64)d^4)$, cm^4

L = length of pitman, considering 40 cm

n = end fixity coefficient (taking 1 for both end fixed)

P_c = critical load, 232.34 kg

Taking a factor of safety of 8, and putting the value we get the diameter as 1.30 cm.

The diameter of the pitman shaft is chosen as 2.0 cm.

Checking for tensile strength

Tensile strength of the Pitman arm can be calculated as

$$P = (\pi/4)d^2 f_s \qquad \text{eqn (33)}$$
$$= 72.36 \text{ kg/cm}^2$$

where,

f_s = tensile stress, kg/cm^2

d = diameter of pitman, 2.0 cm

P = critical load, 227.34 kg

The pitman shaft is a mild steel shaft and, therefore, the stress is well within the permissible tensile stress of 1 120 $kg\text{-}cm^2$. Hence, the selected pitman diameter of 2.0 cm is safe.

Crop Dividing and Lifting Unit

The crop dividing and lifting unit (**Fig. 3**) is provided to divide the crop, lift the lodged crop and to guide the crop towards the cutterbar. The machine consisted of five such units. Each unit is 50 cm long spaced at 30 cm apart. At the upper end of each unit aluminum star wheels are mounted which convey the cut crop to one end of the machine.

Performance of Different Machine Systems

The field evaluation of the reaper indicated that the machine performed satisfactorily except an occasional slippage of bevel gears. Since the bevel gears were not enclosed in a gear box and only lubricated by multi-purpose grease, there was misalignment resulting into slippage of gear teeth. It is, therefore, felt necessary that a gear box be provided to prevent slippage of bevel gears. Initial training of the bullocks is also essential in order to acquaint them with engine noise. The working of cutterbar, conveying mechanism and power transmission systems were found satisfactory. The field capacity of the machine was 0.22 ha/h in wheat crop with a field efficiency of about 84.36%. The draft at no load and load conditions were recorded at 62.9 kg and 42.68 kg, respectively. The fuel consumption was about 1.0 ℓ/h.

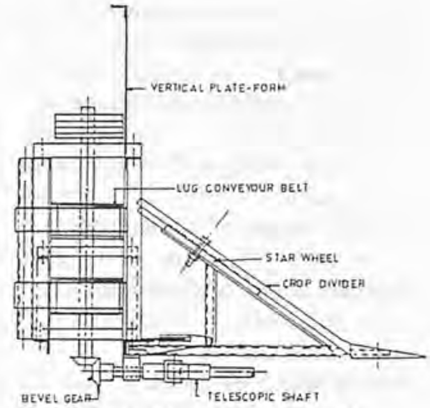

Fig. 3 Crop dividing and lifting unit.

REFERENCES

1. Devnani, R.S. and Pandey, M.M. 1985. Design, development and field evaluation of vertical conveyer reaper windrower, AMA, 16(2): 41.
2. Elfes, I.E. 1954. Design, development of a high speed mower, Agric. Engng, 35(3): 147.
3. Garg, I.K.; Verma, V.K. and Singh, S. 1984. A poewr tiller mounted vertical conveyer reaper windrower. AMA, 15(40).
4. Singh, M.S. 1981. Design, development and testing of an animal drawn harvester, AMA, 12(1): 22.
5. Singh, T.P. 1986. Development of a bullock drawn engine operated reaper. Unpublished M Tech thesis, Farm Machinery Dept. GBPUA&T, Pantnagar, India.
6. Sharma, P.C. and Agrawal, D.K. A text book of machine design, 4th edition, Katson Publishing House, Ludhiana, India.

A Groundnut Harvesting Machine for Northern Nigeria

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Abstract

Groundnuts was a major export crop in Nigeria. A large scale production rehabilitation of the crop is being carried out and a harvesting machine that could be locally manufactured would be an asset. A machine is proposed which consists of a digging share followed by a flexible disc lifter consisting of two reinforced plastic discs which grip the loosened plant just above the soil surface. As the discs rotate at approximately ground speed, they lift the plant and presents the roots and pods to a rotor to which is fitted a series of fingers made of steel spring wire. A series of laboratory and rig tests were varied out using the local varieties of groundnuts on the lifting discs and the pod stripper. The results showed that a system appropriate machine suitable for local manufacture and capable of carrying out all the harvesting operations is feasible. In the sandy dry soil condition prevailing, it will require approximately 10 kW power input at 1 kmph with little pod and haulm loss. A possible design of a full scale machine is suggested.

Introduction

Up to the mid-70s, Nigeria was a major producer and exporter of groundnuts. The effects of petroleum discovery at the time, the 1975 groundnut resette epidemic and the success in mechanized production of other oil seed crops in Europe, such as oil seed rape and sunflower, were some of the main factors that lead to the sharp decline in the production of the crop and, consequently, a complete halt in its export (5) (**Fig. 1**). One of the main problems faced by an oilseed programme to rehabilitate groundnut production in large scale, to satisfy the local needs and to restimulate export, is the heavy losses due to late harvesting, an indirect result of the general lack of manual labour during the short critical harvesting period. This makes it desirable that new methods and machinery are introduced. After carefully studying the farming system, the crop harvesting operations, and the

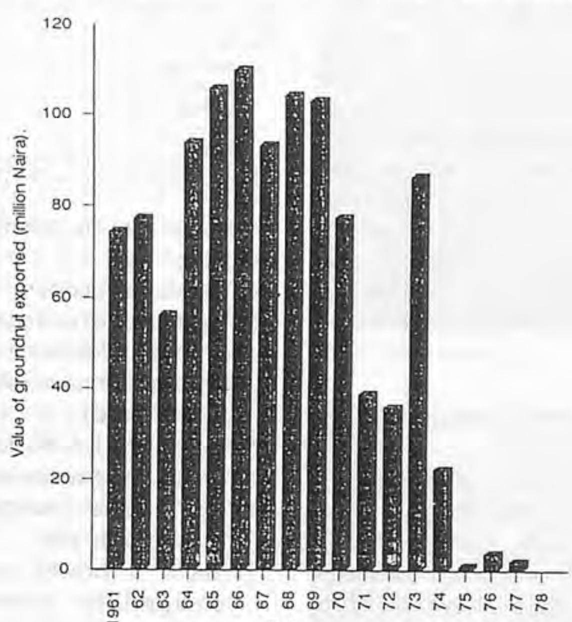

Fig. 1 Summary of export contribution of groundnuts to Nigeria foreign trade 1961-1978.

machine manufacturing factors involved (2), three basic needs became apparent:

1. Manual labour requirement had to be reduced;
2. Weather risk at harvest had to be reduced by introducing higher harvesting rates; and
3. The harvesting machinery had to be suitable for local manufacture and maintenance.

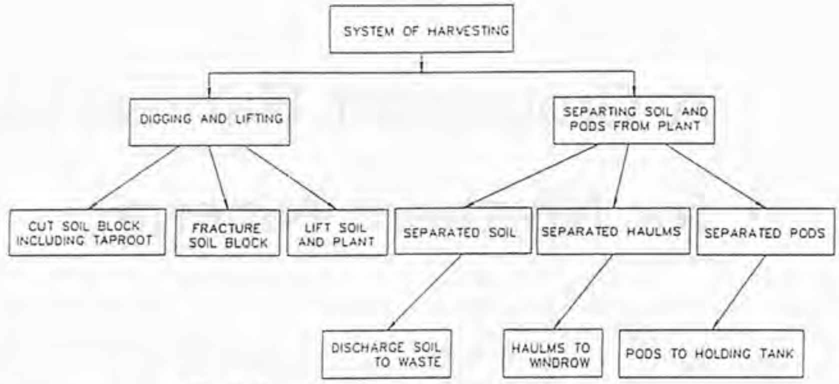

Fig. 2 Function chart for groundnut harvesting.

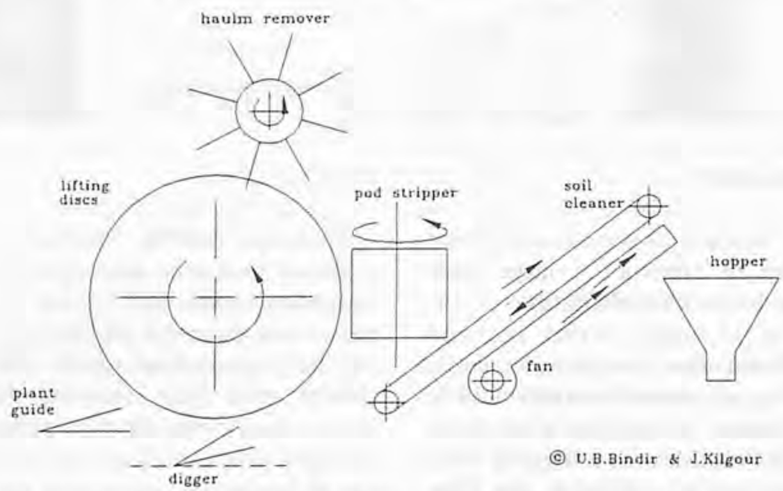

Fig. 3 Schematic diagram of the proposed groundnut harvesting machine.

Groundnut Harvesting Operation, Existing Methods and their Problems

Groundnut harvesting operations could typically be summarized as in **Fig. 2**. In Nigeria, manual harvesting is customary; some farmers use animal power for digging, but even that is rarely used. In highly mechanized methods (such as used in the U.S.A. and Australia), tractor powered digger shaker windrowers and combine harvesters are used.

In the Nigerian context, constraints on production due to manual labour shortage (mainly due to overlap of harvesting period with other staple food crops **Table 1**) exist in all the crop producing areas. On the other hand, existing harvesting machines are mainly unsuitable because they are expensive (requiring large sums of "hard currency or foreign exchange" to buy and maintain), are economically unsuitable to small/medium farm holdings and require highly skilled operators.

Table 1. Harvest Seasons for Common Crops Grown in Groundnut Belt

Crop	Normal harvest season				
	Aug.	Sept.	Oct.	Nov.	Dec.
Guinea corn				*******	*******
Millet	*******	*******	*******		
Groundnuts			*******	*******	*******
Cowpea (beans)				*******	*******
Cassava			*******	*******	*******
Rice			*******	*******	*******
Maize		*******	*******	*******	

Source: Own survey, 1988 (2).

The Machine Design

The following main machine specification were listed as a design guide. The machine should:

1) Harvest crop at a higher rate than the manual method which is 0.1 ha/man/day for digging (7);
2) Carry out as many harvesting operations as possible in one pass;
3) Use fewer people;
4) Be able to leave haulms in good condition for hay making (the hay has a reasonable haulm as animal feed);
5) Be compatible to local manufacture and maintenance;
6) Be "simple" to operate and safe to use; and
7) Have a power requirement compatible with existing tractors.

Existing techniques and machine methods were investigated to determine if systems could be adapted for Nigerian conditions. Attributes of the once-over harvesting method (1, 4, 6, 10) was favoured to single operation methods because of the short time available to harvest the crop for a reasonable quality. The existing once-over harvesting techniques generally would be too complicated for the Nigerian manufacturer, mostly being too large in size and high in cost. Thus a harvesting machine consisting of four major units was proposed **(Fig. 3)**. It is relatively simple, could be locally manufactured, has few moving parts (therefore will have low maintenance cost), can carry out all the harvesting operations in one pass and will leave the haulms in good condition for hay making.

Machine Description and Tests

The machine (**Fig. 3**) consists of a digging share followed by a flexible disc lifter which grips the loosened plant just above the soil surface. As the discs rotate, they lift the plant and present the roots and pods to a rotor to which is fitted with a series of fingers made of steel spring wire. While the haulms are discarded in whole, the pods are transfered on to a wire-mesh conveyor belt with openings large enough to clean the soil particles without loosing pods. The pods are finally separated from the small amount of dirt by a fan and then finally collected in a sack.

The principal parts of the machine consist of the lifting and stripping units. These were constructed to full scale and tested in the laboratory. The lifter consist of two 3 mm thick flexible fibre reinforced plastic (FRP) discs of one meter diameter each. The discs are supported on two half shafts connected together by a universal joint so that they can rotate at the same speed while tilted at an angle. This lead to an arrangement with 100 mm discs centre to centre clearance with one circumferential part of the discs open to allow for plants feed and the opposite part forced closed to grip the plant during pod stripping (**Fig. 4**). A set of levered FRP leaf springs and small polyethylene rollers were used to vary the extent of touching or opening of the discs.

The stripper consists of a vertical rotating drum (made of 1.5 mm thick mild steel sheets) of diameter 300 mm on which are mounted 12 columns of pod stripping metal fingers 165 mm long each. These fingers were arranged in a way to allow the finger clearance to be varied with respect to the pod size to give a combing effect. The lifter was tested in Silsoe, U.K., on a setup consisting of a field simulator on which were mounted groundnut plants. This arrangement allowed the relative speeds of the lifter and the machine forward speed to be varied. The lifter/stripper test-rig arrangement (**Figs. 5** and **6**) was then installed in Maiduguri, Nigeria, where it was tested on local groundnut plants. It was fitted with an electric motor/v-belt transmission arrangement to give a range of speed settings.

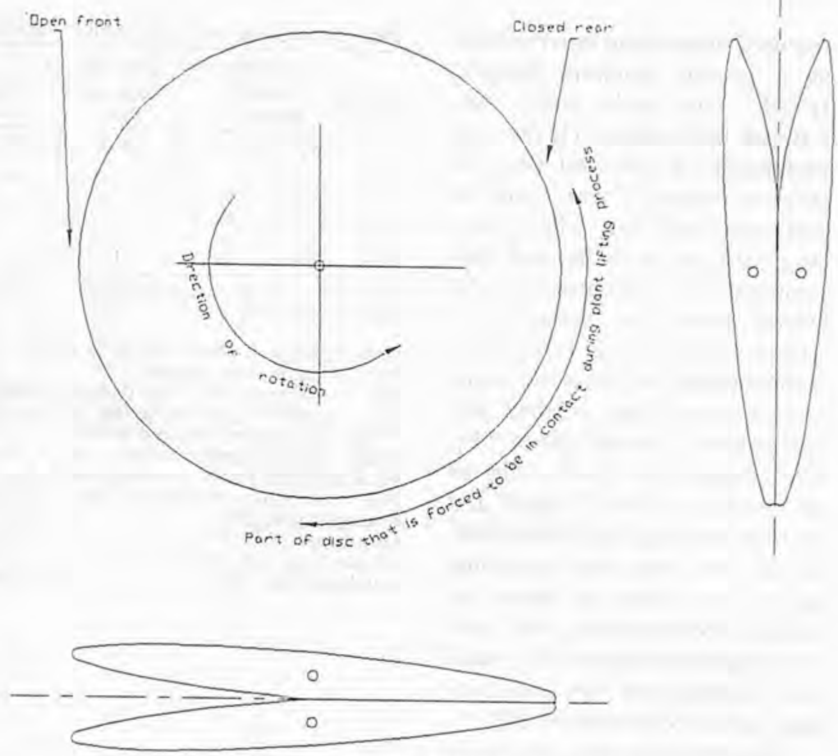

Fig. 4 Scheme showing lifting discs assembly.

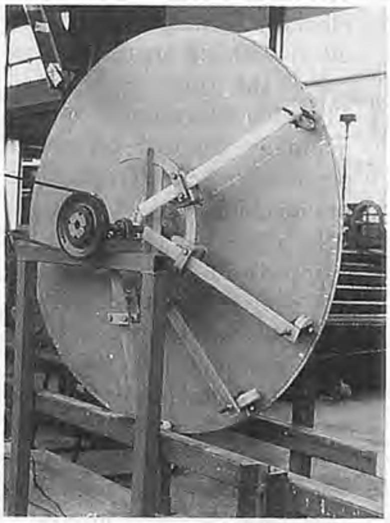

Fig. 5 Lifter assembly.

Fig. 6 Test-rig assembly.

Field Tests

The experiment involved feeding freshly harvested plants in the required orientation into the lifter at a pre-set machine forward speed. The pods were then stripped by the rotor. Of the total pod input TP_i per test run, the stripped material was collected and separated into whole pods W_p; damaged pods D_p and contaminants C_t (unmatured pods; leaves; roots and stems). Unstripped whole pods UW_p were manually removed from the plants and all these were weighed and expressed as a percentage of TP_i. The appropriate relationship of the machine forward speed and the lifter rotating speed was determined, and four pod stripping speeds were used to asses the machine performance, viz, pod stripping effectiveness PS_e; total pod stripping loss TP_l and stripping power consumption SP_c.

The definitions and calculations were as follows:

1. The required orientation to lift plants is straight (radial to discs) with no stems hanging out of the lifter.
2. TP_i is the total number of pods manually counted on plants per/test run before feeding into the machine.
3. PS_e (%) = [(total pods stripped)/TP_i] × 100.
4. TP_l (%) = [(stripped broken pods) + (unstripped pods) / total pod input] × 100.
5. SP_c is the total power required to strip pods, break up plant stems and roots in the stripping volume, and power required to overcome the rotor inertia.

Results and Discussion

A summary of the experimental results are presented in **Table 2**. An individual parameter analysis of variance was performed on each set of data. Comparison of the means was performed using the normal significant test method (F-test followed by the LSD calculation).

Table 2. Summary of Experimental Results

Stripper speed rpm	Averages per 3 test runs (g) Stripped material			Total pod input		Total pod loss							
	Wp	Dp	Ct	UWp	Wp+Dp+UWp	UWp+Dp	TSO	PSe	%D	%US	%Ct	TP_l%	Pc Watts
150	104	4	27	9.5	117.5	13.5	140	88	1	11	29	12.2	190
200	101	1.5	40	8	110.5	9.5	144	94	.7	5.5	27	6.4	223
250	62	0	38	7	69	7	127	92	0	8.3	34	8.3	287
300	96	0	46	7	103	7	137	95	0	4.8	31	4.8	319

On test-rig setting of: Lifting speed Ls = 1 kmph, Finger settings Fs = 7.5 mm, Plants per test-run = 6.

Nomenclature of abbreviations in table:
Wp - clean pods stripped
Dp - stripped but visibly damaged pods
Ct - other stripped materials such as leaves and stems
UWp - unstripped matured pods
TSO - total stripped output = Wt + Dp + Ct
Pc is stripping power consumption (watts)
PSe = stripping effectiveness (%) = Wp/(Total pod input) × 100
Damaged pods (%) = Dp/(Total pod input) × 100
Unstripped pods (%) = US/(Total pod input) × 100
Matter (non pod) stripped (%) = Ct/TSO × 100
Total pod loss (%) = (UWp + Dp)/(Total pod input) × 100

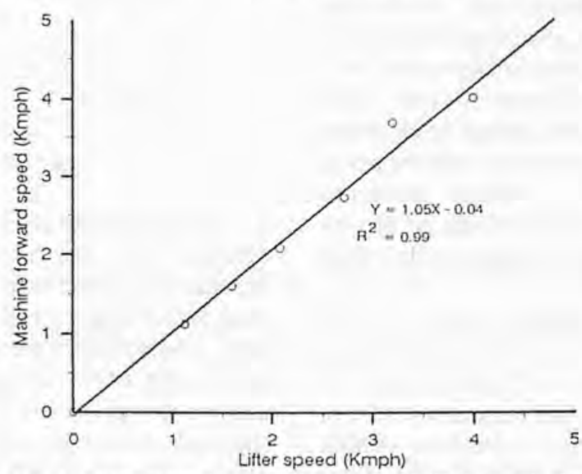

Fig. 7 Relationship between forward and lifter speeds for required plant lift mode.

Plant Required Lifting Orientation

The relationship of the machine forward speed and the lifter speed to give the required plant lifting orientation is shown in **Fig. 7**. The relationship is given by a linear equation (Y = 1.05X − 0.04) indicating that the lifter speed should be approximately equal to the machine forward speed for the required plant lifting orientation. This simply means that the plant should not be lifted at an angle to ensure that the plant is wholly gripped in the lifter, otherwise, a reasonable amount of the plant stems will be exposed out of the lifter leading to more leafy contaminants being stripped. This will make cleaning the pods more difficult. The power requirement of the stripper is also likely to increase due to the effects of the exposed stems and increased trash in the cleaner section. Another reason is that at the fresh state, pods might be easily broken and lost in the soil if the plant is subjected to lateral movements at lifting.

Rig Tests

A forward speed of 1 kmph and

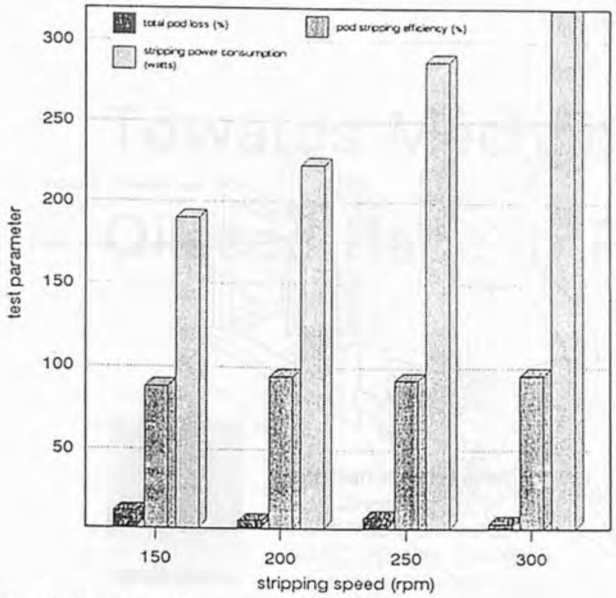

Fig. 8 Test-rig performance data summary.

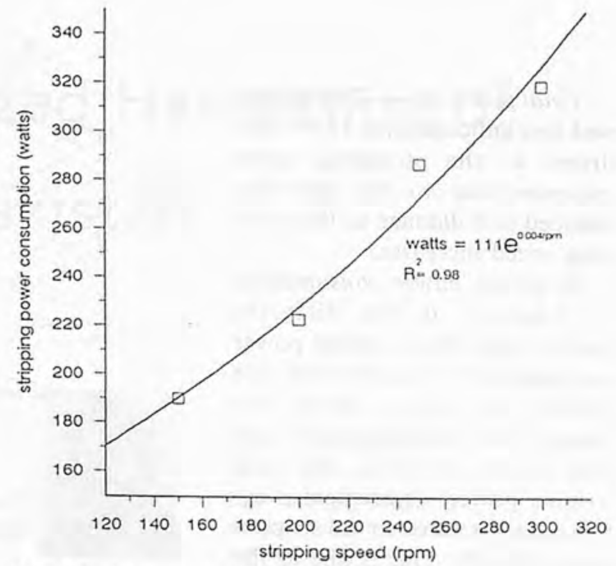

Fig. 9 Stripper power (overall) requirement.

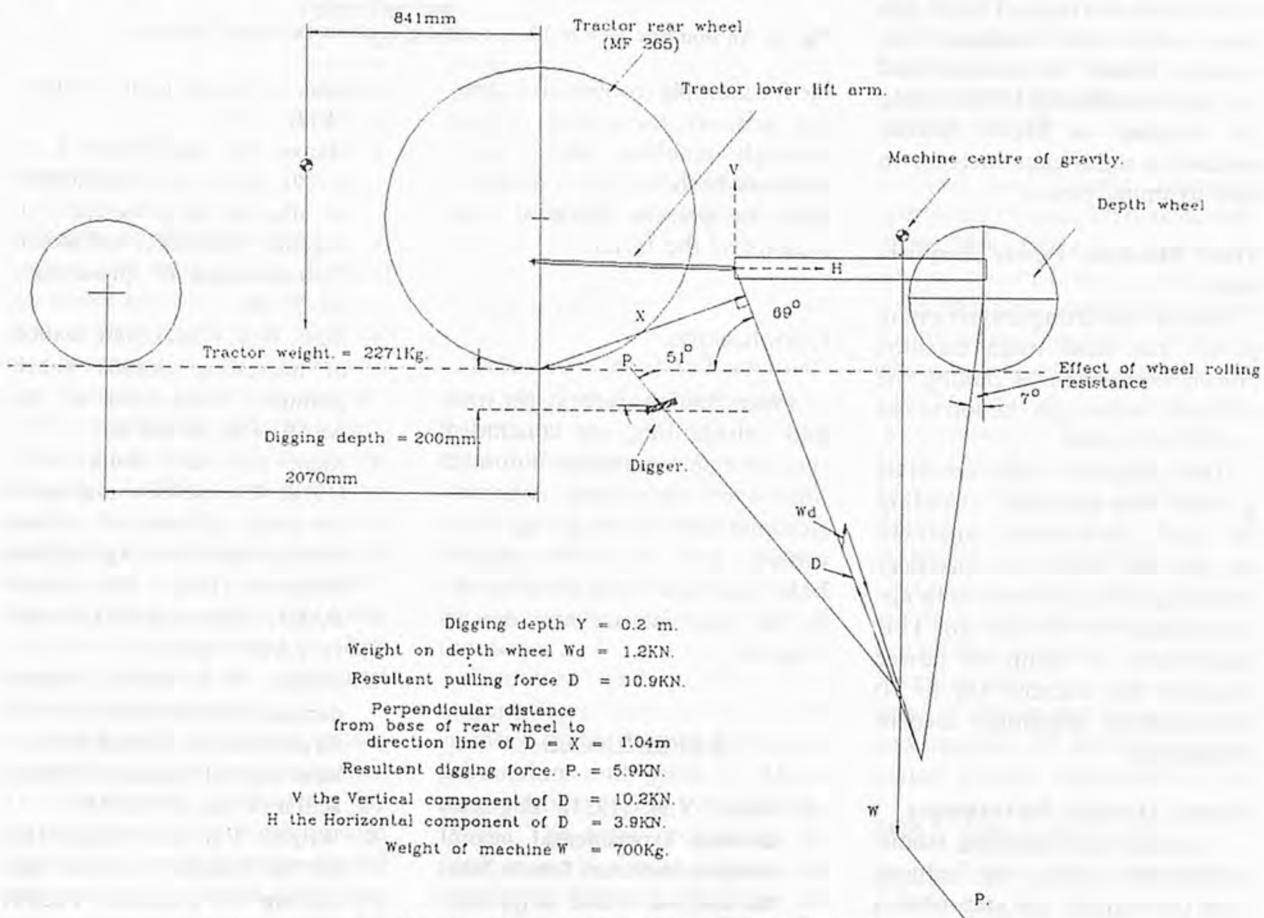

Fig. 10 The machine draft requirement analysis.

lifter speed of 1 kmph was chosen (at higher speeds it was assumed that pod loss at digging will be high, especially due to the uneven soil surface); and stripping speeds of 150, 200, 250, and 300 revolutions per minute were selected (based on the pod fracture safe impact velocity (8)) with a stripping finger spacing of 7.5 mm. The rig performance data is summarized in **Fig. 8**.

Pod stipping effectiveness — On all machine settings, it generally exceeds 80% and increases with increase in stripping speed for the range of stripping speeds tested.

Total pod loss — The highest pod loss indicated was 15%. This drops as the stripping speed increases due to the observed reduced pod damage as the stripping speed increases.

Stripping power consumption — Analysis of the different components of the overall power consumption indicated that the actual plant stipping power consumption is independent of stripping speed. However, the total stripper power requirement is exponentially related to the stripper speed (**Fig. 9**). This is due to the stripper rotor behaving like a fan as the speed increases. Thus it was clear that the pod stripping effectiveness "could" be increased and the pod loss reduced by operating the stripper at higher speeds without a significant increase in pod stripping power.

Total Machine Power Requirement

Besides the lifting and stripping power, the other main machine power requirement is pulling the lifting share through the soil to cut and lift the plant.

The total power requirement of a single row machine, including the draft requirement analyzed using an MF 265 tractor specification (**Fig. 10**) is predicted to be approximately 10 kW (13 hp). This requirement is within the power range of the tractors (30 to 70 horse power) commonly used in Nigeria (2).

Overall Machine Performance

In the present condition, labour requirement could be reduced from the manual 200 man-hour/t (2) to 20 man-h/t at a capacity of 0.7 t per day using two operators. Pod loss will be reduced from as high as 50% (2) down to 15%. Haulm loss due to late harvesting could completely be eliminated. Theoretical cost analysis (2) of the machine indicates that it is suitable for multiple (cooperative farming groups) ownership or use through machine service hire schemes both of which accomodate the present financial constraints of the farmers.

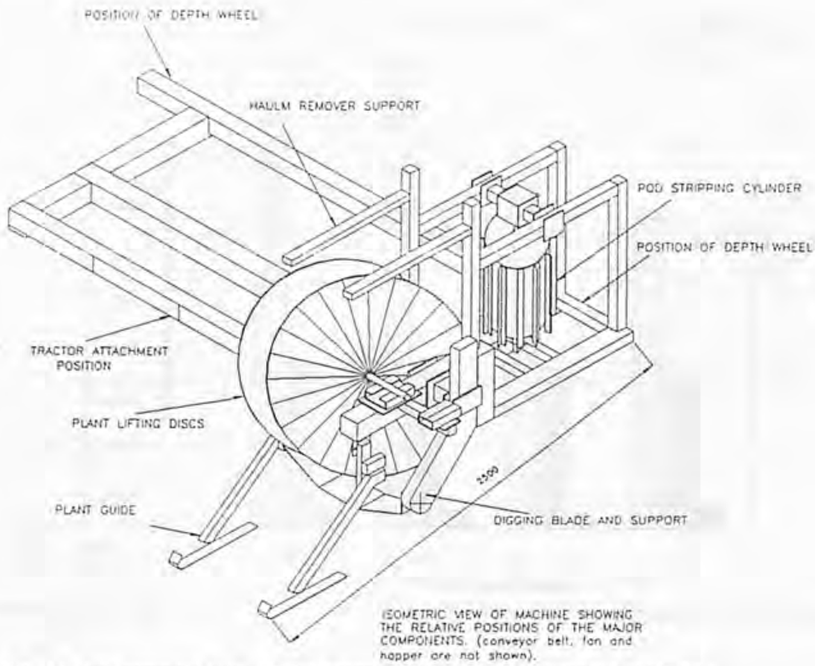

Fig. 11 An isometric view of the proposed groundnut harvesting machine.

Conclusions

From the laboratory, rig tests and calculations, we concluded that a single row tractor mounted once-over harvesting machine (schematically shown in **Fig. 11**) is possible and would be suitable both technically and economically for manufacture and use in Nigeria.

REFERENCES

1. Baker, V.H. (1951). Engineers develop experimental peanut combine harvester, Peanut Journal and Nut World 30 (3): 21.
2. Bindir, U.B. (1991). A groundnut harvesting machine for Nigeria. An unpublished PhD. Dissertation. Cranfield Institute of Technology, U.K.
4. Hwang, Y. (1983) Development of peanut combine harvester. Agricultural Mechanization in Asia, Africa and Latin America. 14 (2), 11-16.
5. Manzo, S.K. and Misari, S.M. (1989). Status and management of aflatoxin in groundnuts in Nigeria. ICRISAT, Aflatoxin Contamination of Groundnut. pp. 77-90.
6. Mills, W.T. (1961). New method of harvesting virginia bunch peanuts, Transaction of the ASAE. 426, 27 and 30.
7. Kaul, R.N. and Musa, H.L. (1978). Comparative evaluation of some groundnut lifting devices. Institute of Agricultural Research (IAR), Test report DAE3, Ahmadu Bello University, Zaria, Nigeria.
8. Turner, W.K. (1967). Impact damage to peanuts and it's effects on germination, seedling development and milling quality, Transaction of the ASAE. 248.
9. Wright, F.S. and Steel, J.L. (1979). Potential for direct harvesting of peanuts, Peanut Science 6 (1): 37-42.
10. Wright, F.S. (1973). Machine for direct harvesting for virginia type peanuts, Abstract, Journal of American Peanut Resource Education Association 5 (1): 196-197.

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Towards Mechanized Harvesting of Oilseed Rape in Pakistan

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Abstract

Rapeseed (B. *Campestris*, B. *Napus*) and mustard (B. *Juncea*) are major oilseed crops traditionally grown in Pakistan. One of the major constraints associated with low rapeseed yield and area has been the shortage of farm labour needed at the time of harvesting this crop. To help develop an economically viable mechanized package for rapeseed harvesting in the country, a number of harvesting, threshing and combining machines were evaluated for their suitability during the 1990 and 1991 rapeseed harvest.

Among all the systems tested, a combination of harvesting with JF windrower, collection by manual labour and threshing with the Naeem thresher was found most economical than other systems tested. Harvesting with the whole crop harvester (WCH) equipped with standard table and a combination of harvesting with JF windrower, collection by manual labour and threshing with WCH based thresher also gave promising results but their cost of harvesting and threshing was higher than the previous system.

Introduction

Pakistan is faced with a serious shortage of edible oil as its domestic production is sufficient only to meet 30% of the total consumption (Ahmad and Hanif, 1986). Thus the country is constrained to import edible oil in large quantities involving huge expenditure in foreign exchange to make up for the deficit.

Rapeseed and mustard are major oilseed crops grown in the country. **Table 1** gives the area, production and yield of these crops from 1980-1990 (Anon, 1990). The total production of these crops is almost stagnant as shown in **Table 1**. Because of competition for land traditionally devoted to growing wheat and grain legumes, it is difficult to devote additional cultivated land to oilseed crops. Therefore, prudent efforts are needed to increase per hectare yield instead.

Harvesting is one of the most difficult and labour intensive operations in rapeseed production. Proper harvesting time is important to obtain higher grain yield from the crop. Early harvesting results in poor grain development, whereas, delayed harvesting causes loss in yield due to shattering (Mohammad, 1986). At present, 100% of the rapeseed crop is harvested manually, threshed by tractor treading and winnowed manually. Since wheat harvesting also occurs during the period of rapeseed harvesting and threshing, availability of labour is becoming a serious bottleneck. The requirement of timely harvesting of crop and scarcity of labour are two major factors necessitating the

Table 1. Area, Production and Yield of Rapeseed and Mustard in Pakistan (1980-81 to 1989-90)

Year	Area (1 000 ha)	Production (1 000 t)	Yield (kg/ha)
1980-81	417	253	611
1981-82	391	239	611
1982-83	386	246	638
1983-84	313	217	693
1984-85	347	235	677
1985-86	351	250	712
1986-87	303	213	701
1987-88	269	204	759
1988-89	334	249	746
1989-90	307	233	767

need for mechanizing harvesting and threshing operations of these crops.

The Barani Agricultural Research and Development (BARD) project at the Pakistan Agricultural Research Council procured a locally manufactured reaper model RE 2000 and tested it on rapeseed. Some modifications were suggested to be incorporated before further field evaluation. BARD also imported Alvin Blanch type multicrop thresher and tested it on rapeseed in 1988. It was reported that the machine was not suitable for crop maximization programme due to its low crop processing capabilities (Anon, 1989).

Materials and Methods

The potential machines for rapeseed harvesting (PECO reaper, JF windrower and Swift Current (SC) reaper), threshing (WCH based thresher and Naeem thresher) and combining (MF8 combine and whole crop harvester (WCH) with standard and pick-up tables) were identified and field tested during the 1990 rapeseed harvest. Design modifications on the basis of 1990 test results were incorporated in the Naeem thresher, whole crop harvester and SC reaper before their field evaluation during the 1991 rapeseed harvest. The machines/methods evaluated individually, were grouped in the following systems:

Conventional System

Hand cutting + Hand collection + Tractor treading followed by manual winnowing was used as control treatment.

Partially Mechanized System

(Mechanical reaping + Hand collection + Conventional and machine threshing)

a) PECO reaper + Manual collection + Conventional threshing (PMT)
b) PECO reaper + Manual collection + WCh based thresher (PMW)
c) PECO reaper + Manual collection + Naeem thresher (PMN)
d) JF windrower + Manual collection + Naeem thresher (JMT)
e) JF windrower + Manual collection + WCH based thresher (JMW)
f) JF windrower + Manual collection + Naeem thresher (JMN)
g) Swift Current reaper + Manual collection + Conventional threshing (SMT)
h) Swift Current reaper + Manual collection + WCH based thresher (SMW)
i) Swift Current reaper + Manual collection + Naeem thresher (SMN)

Fully Mechanized System

a) (Mechanical reaping + Mechanical pick up + Mechanical threshing)
  i) Swift Current reaper + MF combine with pick-up table (SMF)
  ii) Swift Current reaper + Whole Crop Harvester with pick-up table (SWC)
  iii) JF windrower + MF combine with pick-up table (JMF)
  iv) JF windrower + Whole Crop Harvester with pick-up table (JWC)
b) Direct Combining
  i) MF combine (MF)
  ii) Whole Crop Harvester (WCH)

Evaluation Criteria for Harvesting, Threshing and Combining Machines

The PECO reaper, JF windrower, SC reaper, WCH based thresher, Naeem thresher, whole crop harvester and MF8 combine were evaluated for their performance using the following criteria:

a) Grain losses
  i. Shattering losses, % (reapers and combines)
  ii. Conveying losses, % (reapers only)
  iii. Threshing losses, % (combines and threshers)
b) Field capacity, ha/h (reapers and combines)
c) Output capacity, kg/h (combines and threshers)
d) Cleaning efficiency, % (combines and threshers)
e) Threshing efficiency, % (combines and threshers)
f) Economics of operation
  i. Cost of operation, Rs/h
  ii. Cost (percentage per hectare of gross margin)

Field Performance Test

Standard test data sheets were adapted for data recording during the field evaluation of selected harvesting, threshing and combining machines on rapeseed variety 'Wastar'.

Pre-harvest parameters — The area of test field, crop condition, i.e., crop variety, plant height, plant density, mode of planting and grain yield were recorded before the start of harvesting. Grain straw ratio and length of harvested crop were recorded before the start of threshing.

Machine operation parameters — The machine operation losses during testing were based on the quantity of grain recovered after machine operation in the field. Machine operation losses in reapers included shattering, conveying and uncut losses. It is expressed as:

$$M_L = S_L + C_L + U_L \qquad (1)$$

where:

M_L = Machine operation losses, %
S_L = Shattering losses, %
C_L = Conveying losses, %

U_L = Uncut losses, %

Manual gathering and bundling of reaper harvested crop was carried out and gathering and bundling losses as percent of grain yield was also recorded.

Machine operation losses for thresher included fan and thrower losses, whereas, for combines it included shattering, uncut, separation and cleaning losses. It is expressed as:

$$M_L = S_L + U_L + S + C \quad (2)$$

where:
M_L = Machine operation losses, %
S_L = Shattering losses, %
U_L = Uncut losses, %
S = Separation losses, %
C = Cleaning losses, %

Field capacity of harvesting and combining machines were calculated using the following formula:

$$C_T = A/T \quad (3)$$

where:
C_T = Field capacity, ha/h
A = Area harvested, ha
T = Total field time, h

Whereas, threshing capacity for threshers was expressed as:

$$C = Wc/T \quad (4)$$

where:
C = Threshing capacity, kg/h
W_C = Weight of clean threshed grain, kg
T = Total time, h

Cleaning efficiency for threshers and combines were computed using the following formula:

$$C_E = (I/J) \times 100 \quad (5)$$

where:
C_E = Cleaning efficiency, %
I = Weight of whole grain at main outlet, g
J = Weight of whole material at main outlet, g

Whereas, threshing efficiency is expressed as:

$$T_S = 100 - Lut \quad (6)$$

where:
Ts = Threshing efficiency, %
Lut = Percentage of unthreshed grains, %

The field performance of reapers was compared with an manual harvesting using sickle, whereas, the performance of threshers was compared with traditional threshing (tractor treading and manual winnowing) in terms of grain losses, labour requirement and total cost.

Labour Requirement

The total man-hours for the labourers required during harvesting, threshing and combining machine operation were recorded.

Cost of Operation

The total cost of MF8 combine, whole crop harvester, reapers, threshers and tractor costs are divided into two categories: fixed costs and operating costs. Fixed costs are related to ownership and occur regardless of whether or not the machine is used. Fixed costs per hour are inversely proportional to the amount of annual use. Operating costs are directly related to the amount of use and include repairs and maintenance, fuel and lubricants and servicing (Hunt, 1973).

Results and Discussions

Manual Harvesting

Manual harvesting of rapeseed was carried out as a control treatment. Total losses, including shattering, uncut, gathering and bundling averaged at 9.25%. The average capacity of manual labourer was 0.006 ha/man-h.

Field Performance of Reapers

The PECO reaper, JF windrower and SC reaper were identified as potential machines for rapeseed harvesting. The field capacity of PECO reaper averaged 0.062 ha/h with an average field efficiency of 30%. Total losses, including machine shattering, gathering and bundling losses averaged 10.78%. The major component of these losses was shattering losses which accounted for 56.9% of total losses.

The average field capacity of JF windrower was 0.26 ha/h with an average field efficiency of 61.9%. Total losses as percentage of crop yield averaged 12.88%. The major component of these losses was conveying losses which accounted for 60.3% of total losses.

The field capacity of SC reaper averaged 0.31 ha/h with an average field efficiency of 81.5%. Total losses, including machine shattering, uncut, gathering and bundling losses averaged 12.84%. The major component of these losses was shattering losses during harvesting which accounted for 72.4% of total losses.

The average labour requirement (unskilled) for machine operation was 32, 4 and 3 man-h/ha for the PECO reaper, JF windrower and SC reaper, respectively. Whereas, the average labour required for gathering and bundling for PECO reaper, JF windrower and SC reaper harvested crop was 92, 54 and 60 man-h/ha, respectively.

Traditional Threshing

Tractor treading followed by manual winnowing was the method used in traditional threshing system. Total grain losses in the system were 12%. The total labour requirement (unskilled) for tractor treading and manual cleaning and bagging was 95 and 71 man-h/ha, respectively. The labour requirement (skilled) for traditional threshing was 7 man-h/ha and 6 tractor-h/ha were also needed during treading operation.

Field Performance of Threshers

The WCH-based thresher and Naeem thresher were identified and field tested for rapeseed threshing. Test results showed that WCH-based thresher had a threshing capacity of 264 kg/h with total grain losses of 7.9%. The major component of these losses was separation losses during threshing which accounted for 67.1% of the total losses. The cleaning and threshing efficiency was 98 and 98.9%, respectively.

The threshing capacity of the Naeem thresher was 248 kg/h with total grain losses of 3.6%. The cleaning and threshing efficiency was 90.3 and 98.9%, respectively.

Labour requirement (skilled and unskilled) for the WCh-based thresher and Naeem thresher was 15 and 24 man-h/ha, respectively. This shows that WCH-based thresher required only 62% of the labour needed to operate the Naeem thresher.

Field Performance of Combines

Whole crop harvester (WCH) and MF8 combine were identified as potential machines and both machines were tested with standard and pick-up tables as well.

The field capacity of WCH with standard table was 0.17 ha/h with field efficiency of 75.7%. Total machine losses averaged at 13.5%. Machine shattering and cleaning losses (as percentage of grain yield) were 6.35 and 7.11%, respectively. The cleaning and threshing efficiency were 87.9 and 99.5%, respectively. On an average, total labour requirement (skilled and unskilled) was 12 man-h/ha.

The average field capacity of WCH to pick-up SC reaper and JF windrower harvested crop was 0.11 and 0.19 ha/h with field efficiencies of 52.7 and 66.1%, respectively. Total machine losses to pick-up the SC reaper and JF windrower harvested crop was 18.96 and 11.48%, respectively. On an average, the total labour requirement (skilled and unskilled) to pick-up and process SC reaper and JF windrower harvested crop was 18 and 10 man-h/ha, respectively.

The field capacity of the MF8 combine with standard table averaged 0.39 ha/h with an average field efficiency of 72.4%. Total machine losses averaged 16.8%. The major component of these losses were shattering losses which accounted for 65.3% of the total losses. The cleaning efficiency averaged 93.7% with an average threshing efficiency of 94.6%. Six man-h were required to harvest one ha of rapeseed with MF8 combine using standard table.

The MF8 combine was also tested with pick-up table to pick-up SC reaper and JF windrower harvested crop. The average field capacity of the combine to pick-up SC reaper and JF windrower harvested crop averaged 0.21 and 0.57 ha/h with field efficiencies of 70.6 and 84.8%, respectively. Total machine losses to pick-up SC reaper and JF windrower harvested crop were 10.38 and 11.4%, respectively. The major component of these losses were machine shattering losses which accounted for 72.5 and 81.3% of total losses during pick-up of SC reaper and JF windrower harvested crop, respectively. On average, the total labour requirement (skilled and unskilled) was 10 and 4 man-h/ha to pick-up SC reaper and JF windrower harvested crop, respectively.

Cost of Operation

Cost analysis of different systems was done according to prevailing economic conditions during the field test.

The total cost per ha of manual harvesting, excluding and including grain losses were Rs. 750 and Rs. 2 374, respectively.

Test results show that the total cost of traditional threshing per ha, excluding and including grain losses were Rs. 1 467 and Rs. 2 934, respectively.

Total fixed costs per hour of PECO reaper, JF windrower, SC reaper, WCH-based thresher and Naeem thresher were Rs. 94, Rs. 570, Rs. 153 and Rs. 97, respectively. The total cost per ha of PECO reaper, JF windrower and SC reaper, excluding grain losses, were Rs. 2 192, Rs. 663 and Rs. 1 960, whereas, including grain losses these were Rs. 3 289, Rs. 1 854 and Rs. 3 267, respectively. The total cost per ha of WCH based thresher and Naeem thresher, excluding grain losses, was Rs. 1 060 and Rs. 841, whereas, including grain losses these were Rs. 1 865 and Rs. 1 209, respectively.

The total cost per ha of whole crop harvester using standard table, excluding and including grain losses, were Rs. 1 961 and Rs. 3 332, respectively. The total cost per ha using pick-up table to pick up SC reaper harvested crop, excluding and including grain losses were Rs. 3 028 and Rs. 4 958, respectively, whereas, the total cost to pick up the JF windrower harvested crop, excluding and including grain losses, were Rs. 1 750 and Rs. 2 919, respectively.

The total cost per ha of MF8 combine using standard table, excluding and including grain losses, were Rs. 3 180 and Rs. 4 891, respectively. The total cost per ha of the MF8 combine using a pick-up table to pick up SC reaper harvested crop, excluding and including grain losses, were Rs. 5 891 and Rs. 6 947, respectively, whereas, the total cost to pick JF windrower harvested crop, excluding and including grain losses, were Rs. 2 175 and Rs. 3 336/ha, respectively.

Table 2. Comparison of Grain Losses of All Systems Selected for Rapeseed Harvesting and Threshing (percent of crop yield)

Systems	Shattering losses	Uncut losses	Conveying losses	Processing losses		Gathering & bundling losses	Threshing losses	Total losses
				Separation losses	Cleaning losses			
Conventional System	5.47	0.69	0.00	0.00	0.00	3.43	12.00	21.59
Partially mechanized								
PMT	6.13	1.53	0.00	0.00	0.00	3.12	12.00	22.78
PMW	6.13	1.53	0.00	0.00	0.00	3.12	7.90	18.68
PMN	6.13	1.53	0.00	0.00	0.00	3.12	3.60	14.38
JMT	4.30	0.00	5.44	0.00	0.00	1.96	12.00	23.70
JMW	4.30	0.00	5.44	0.00	0.00	1.96	7.90	19.60
JMN	4.30	0.00	5.44	0.00	0.00	1.96	3.60	15.30
SMT	9.29	1.14	0.00	0.00	0.00	2.41	12.00	24.84
SMW	9.29	1.14	0.00	0.00	0.00	2.41	7.90	20.74
SMN	9.29	1.14	0.00	0.00	0.00	2.41	3.60	16.44
Fully mechanized								
SMF	16.81	1.14	0.00	2.86	0.00	0.00	0.00	20.81
SWC	17.24	1.14	0.00	0.00	11.01	0.00	0.00	29.39
JMF	13.64	0.00	5.44	2.06	0.00	0.00	0.00	21.14
JWC	9.96	0.00	5.44	0.00	5.82	0.00	0.00	21.22
MF	10.97	0.00	0.00	5.83	0.00	0.00	0.00	16.82
WCH	6.35	0.00	0.00	0.00	7.11	0.00	0.00	13.46

Table 3. Comparison of Labour Requirement of All Systems Selected for Rapeseed Harvesting and Threshing (man-h/ha)

Systems	Unskilled labour	Skilled labour	Total labour
Conventional system	316	7	323
Partially mechanized			
PMT	290	23	313
PMW	184	36	220
PMN	241	55	296
JMT	224	11	235
JMW	68	9	77
JMN	76	10	87
SMT	229	10	239
SMW	73	8	81
SMN	81	9	90
Fully mechanized			
SMF	6	6	12
SWC	12	12	24
JMF	6	6	12
JWC	9	9	18
MF	3	3	6
WCH	6	6	12

Comparison of Systems

Comparison of Losses

Table 2 shows the comparison of losses in all the systems. Losses were greatest in the fully mechanized system, i.e., SC harvest and picking by whole crop harvester using pick-up table and least in direct combining with the whole crop harvester. Shattering losses were greatest in the fully mechanized system (SC harvest and picking by whole crop harvester using pick-up table), i.e., 17.24%.

Comparison of Labor Requirement

Table 3 shows the comparison of total labour requirements for all the systems. Direct combining with the MF8 combine required only 6 man-h/ha as compared to other systems which had high labour requirements, i.e., 323, 313, 220, 296, 235, 77, 87, 239, 81, 90, 12, 24, 12, 18 and 12 man-h/ha for conventional, PMT, PMW, PMN, JMT, JMW, JMN, SMT, SMW, SMN, SMF, SWC, JMF, JWC and WCH systems, respectively. This shows that direct combining with the MF8 combine could be possibly used in regions where labour is in short supply.

Table 4. Comparison of Costs of All Systems Selected for Rapeseed Harvesting and Threshing

Systems	Av. grain yield (kg/ha)	Total cost (Rs/ha)		Total cost (Rs/t)		Cost*	
		Excluding grain losses	Including grain losses	Excluding grain losses	Including grain losses	Excluding grain losses	Including grain losses
Conventional system	2 052	2 217	5 308	1 180	2 712	14.9	35.7
Partially mechanized							
PMT	1 404	4 119	6 683	2 759	4 411	39.1	63.5
PMW	1 404	3 712	5 614	2 644	3 999	35.3	53.3
PMN	1 404	3 493	4 958	2 484	3 532	33.2	47.1
JMT	1 404	2 400	5 058	1 534	3 253	23.6	49.7
JMW	1 404	1 993	3 989	1 419	2 841	19.6	39.2
JMN	1 404	1 775	3 333	1 264	2 374	17.4	32.7
SMT	1 404	3 727	6 501	2 480	4 281	36.6	63.9
SMW	1 404	3 320	5 432	2 365	3 869	32.6	53.4
SMN	1 404	3 102	4 776	2 210	3 402	30.5	46.9
Fully mechanized							
SMF	1 404	7 851	10 214	5 592	7 275	77.1	100.3
SWC	1 404	4 988	8 225	3 553	5 858	49.0	80.8
JMF	1 404	2 838	5 196	2 021	3 697	27.9	51.0
SWC	1 404	2 413	4 773	1 718	3 400	23.7	46.9
MF	1 404	3 180	4 891	2 265	2 484	31.2	48.0
WCH	1 404	1 961	3 332	1 397	2 373	19.3	32.7

*Cost (percentage per hectare of gross margin).
Note: Market price of rapeseed grains at Rs. 7.25 per kg.

Comparison of Cost

The cost comparison of the systems was carried out in order to assess their economic viability. The cost of all systems was calculated in terms of area harvested and weight of seed recovered basis and expressed as Rs/ha and Rs/t (**Table 4**). Results show that total harvest cost per ha with the JMN system, i.e., JF windrower harvesting followed by manual collection and threshing with Naeem thresher excluding grain losses was Rs. 1 775 as compared to Rs. 1 961 for the whole crop harvester with the standard table. The total cost for all other systems was higher than these values.

Conclusions

The data obtained during this

study allowed the following interim conclusions:

1. The average grain losses using the whole crop harvester with standard table was 13.46% compared to 15.3% in JMN system. In other systems, higher grain losses than the WCH and JMN systems were observed.

2. The labour requirement using the MF8 combine with a standard table was 6 man-h/ha compared to 12 man-h/ha for WCH, SMF and JMF systems, while for other systems, it ranged from 24 to 323 man-h/ha.

3. Comparison of costs (percentage per ha of gross margin) showed that JMN, WCH and JMW systems were comparable in economic terms.

4. The JMN system can be economically viable depending on prevailing economic conditions during the study. However, if the performance of whole crop harvester with standard table, JF windrower and WCH-based thresher was improved further then WCH and JMW packaged could possibly be used successfully and economically for mechanical harvesting and threshing of rapeseed in Pakistan.

REFERENCES

1. Ahmad, M. and Hanif, M., (1985). Policy of increasing edible oil production in Pakistan. Proceedings of the National Seminar on Oilseed Research and Development in Pakistan, held in Islamabed, May 7-9, 1985: 19-28
2. Anon (1989), BARD Annual Report 1987-88. Pakistan Agricultural Research Council, Islamabad.
3. Anon (1990). Agricultural Statistics of Pakistan. Ministry of Food, Agriculture and Co-operatives, Food and Agriculture Division (Planning Unit, Govt. of Pakistan.
4. Hunt, D., (1973). Farm power and machinery management, laboratory manual and workbook, Iowa State University Press, Ames, Iowa.
5. Mohammad, A., (1985). Oilseed research and development in Pakistan—a perspective. Proceedings of the National Seminar on Oilseed Research and Development in Pakistan, held in Islamabad, May 7-9, 1985: 3-15.

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The editorial staff of AMA introducing some changes in editorial policy and requests contributors of articles for publication to observe following changes in order to improve communication process. These changes will play key role in facilitating the editorial process.

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Testing and Evaluation of Hold-on Paddy Thresher

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Abstract

Paddy harvesting in Pakistan is done by beating paddy bundles against clay mounds or logs and by treading under animal feet/tractor tyres. The conventional practice not only consumes more time but also results in higher grain losses.

A hold-on paddy thresher imported from Korea was evaluated for its field performance and economics. Basmati-385 paddy variety was used in this study. The thresher gave the highest output of 537 kg/h with threshing efficiency of 99.2% at cylinder speed of 500 rpm and feed rate of 1 300 kg/h. At this combination of variables, the total machine losses and grain damage were 2.64% and 0.4%, respectively. Operating cost of thresher was Rs. 196 per ton as compared to Rs. 350 per ton for manual threshing.

Introduction

Rice, the number two food staple in Pakistan is grown on an area of two million ha with an annual production of three million t (1). Its cultivation is mainly concentrated in four distinct agro-ecological zones. It earns the highest foreign exchange which is 20% of the total export of the country or 50% of the export of agricultural products (2).

Despite Government efforts to increase the supply of inputs such as quality seed, fertilizer and pesticide/herbicide, the average rice production is stagnant or even declining during the last decade **(Table 1)**. One of the main reasons for this low yield is non-availability of suitable farm machines for transplanting, harvesting and threshing operations in rice production.

In Punjab, manually harvested crop in the form of bundles is beaten against clay mounds or logs to remove grains from panicles. The same is practiced in NWFP and Baluchistan. But in Sind, the manually harvested paddy crop is spread in the field and left for two days to dry. Then animals/tractors are moved on the crop and thus threshing is carried out by treading under the animal feet/tractor tyres. The conventional paddy threshing methods are not only time consuming and laborious but also results in more grain losses. Grain losses up to 7.93% have been observed in Punjab (3) whereas these losses are even higher alongwith deterioration in quality of paddy in Sind.

In order to mechanize paddy threshing operation in the country, efforts are being made (since 1976) with the importation of standard

Table 1. Area, Production, and Paddy Yield

Year	Area (000 ha)	Production (000 t)	Yield (kg/ha)
1980-81	1 933.1	3 123.2	1 616
1981-82	1 976.0	3 429.7	1 736
1982-83	1 978.1	3 444.7	1 741
1983-84	1 998.5	3 339.5	1 671
1984-85	1 998.5	3 315.2	1 659
1985-86	1 863.2	2 918.9	1 567
1986-87	2 065.6	3 486.3	1 688
1987-88	1 963.0	3 240.9	1 651
1988-89	2 041.7	3 200.2	1 567
1989-90	2 106.9	3 220.1	1 528

Source: Agricultural Statistics of Pakistan 1989-90, Government of Pakistan, Ministry of Food, Agriculture and Co-operative, Food and Agriculture Division (Economic Wing), Islamabad.

axial flow thresher by IRRI-PAK, Agricultural Machinery Programme from the Philippines (4). Its output was 260 kg/h. Three manufacturers offered this machine in the market but it was not accepted by the farmers as it was too small for their need (5). IRRI-PAK latter improved the output of the thresher by developing its tractor PTO version but it was still unpopular because of bruising of paddy straw.

A Buk Sung power grain thresher of hold-on type was imported by the Farm Machinery Institute (FMI), of Pakistan Agricultural Research Council (PARC) in 1983 from the Republic of Korea under Regional Network for Agricultural Machinery (RNAM), Mutual Exchange Prototype Programme. It had a wire loop type threshing drum. In this thresher, the crop was carried into the threshing drum by chain conveyor in such a fashion that only panicles entered into the drum and are threshed while the straw came out absolutely untouched.

This thresher was tested for threshing two different paddy varieties, i.e., Basmati-370 and IRRI-6 during 1983. The threshing capacity of the machine was determined as 260 kg/h for Basmati-370 and 360 kg/h for IRRI-6 (6). This much capacity is generally considered to be low for a threshing machine in Pakistan. Farmers appreciated the thresher working for its straw saving capability but rejected it for its low capacity.

In 1983-84, the government encouraged the use of combine harvesters for wheat crop through liberal import and credit policy. These combines were also used to harvest paddy crop. At present there are about 500 self-propelled combines in the country mainly concentrated in Punjab and are being used to harvest 20% of paddy area of Punjab. The main problems with combine harvesting are formation of deep ruts by their wheels whilw working in wet condition, wastage of straw due to cutting of crop at 20 cm height and higher percentage of breakage of rice at milling (7).

Realizing the need for suitable thresher under Pakistani condition, the FMI continued its research for a hold-on type thresher of 0.5 t or higher capacity and finally imported one unit of this thresher from the Republic of Korea with financial support of RNAM. This study was undertaken to evaluate the field performance and economics of this thresher before its adaptation and introduction in the country.

Objectives

The overall objective of this study was to evaluate the field performance and economics of hold-on type Korean thresher (Model NJ 810).

The specific objectives were:

1. Familiarization on the agro-technical aspects of the machine, which include:
   - i) Sphere of appliciation,
   - ii) Main technical specifications,
   - iii) Principle of construction and
   - iv) Adjustments and operations.
2. Comparison of performance and economics of the mechanical threshing with conventional method of threshing.

Material and Methods

Hold-on type Korean thresher (Model NJ 810) was used in this study. At FMI, base structure for mounting of thresher and power unit (engine), power transmission systems, mounting of transport wheels, and the toeing hitch for its transportation were designed and developed (**Figs. 1** and **2**).

Fig. 1 Hold-on paddy thresher (imported version).

Fig. 2 Hold-on paddy thresher (FMI-modified version) shows the new base structure, tray modification, power transmission changes, addition of transport wheels and toeing hitches.

The thresher is powered through 12 hp Dung Fang diesel engine. Power from engine to threshing drum and other components is transmitted by V-belts /chain and sprocket system (**Figs. 3** and **4**). The crop is fed horizontally into the machine. It is carried with the help of chain conveyor into the threshing drum (wire loop type). The panicles flow axially through the drum while straw passes through the chain conveyor. Here the grains are separated from the straws which are discharged away from the thresher with the help of humped V-belt running over a guide. Complete threshing takes place by rubbing of the panicles between the wire loops of drum and concave bars.

The threshed paddy and chaff (broken pieces of straw) fall down through concave openings. During falling they receive an air blast coming from chaff blower. The chaff is blown out while the grains fall over a horizontal auger. The

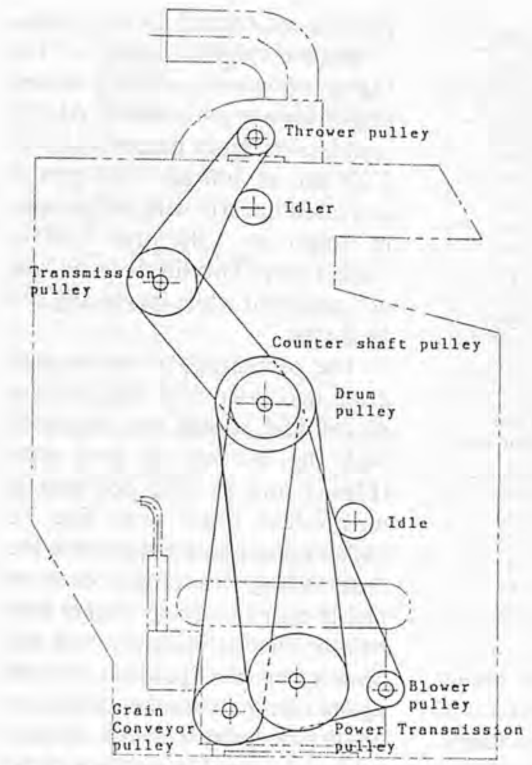

Fig. 3 Schematic of the power transmission assembly (engine end).

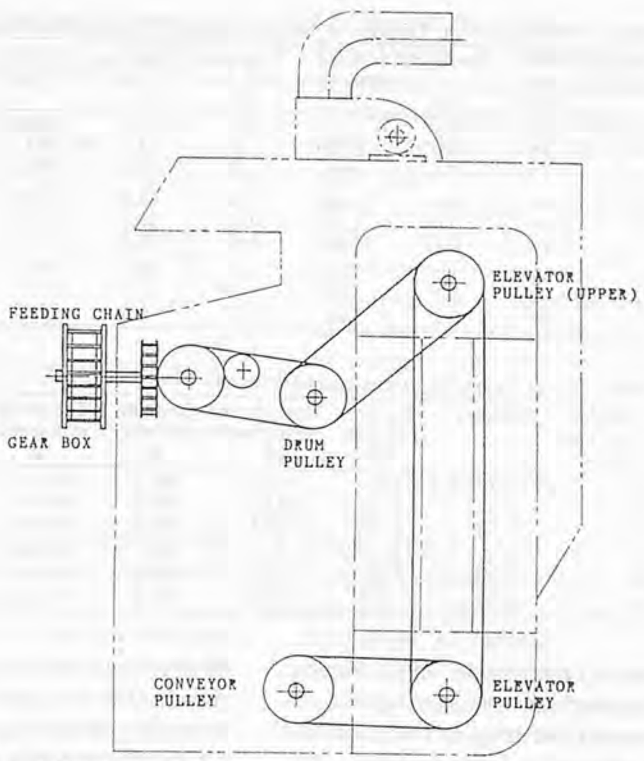

Fig. 4 Schematic of power transmission assembly (grain elevator end).

large pieces of straw from drum is sucked by upper blower which also through these pieces away from the thresher. The horizontal auger conveys the grain to the rear side of thresher. From rear side, grains are collected by a bucket elevator. The bucket elevator elevates the grains to the bagging point and discharges into a bag mounted on the thresher through a hook.

Initial testing of the thresher was carried out at a farmer's field near Narowal. In this testing higher slippage up to 30% of threshing drum was observed. To reduce this slippage, power fromengine to counter shaft was transmitted by double B-section V-belt and from counter shaft to drum shaft by single C-sectin V-belt. The field performance of the thresher was then measured by varying thresher cylinder speeds and crop feed rates as given below.

1. Threshing cylinder speed:
   C1 = 450 rpm (15.5 m/s),
   C2 = 500 rpm (17.3 m/s),
   C3 = 550 rpm (19.0 m/s).
2. Crop feed rate:
   F1 = Low (441-550 kg/h),
   F2 = Medium (720-737 kg/h),
   F3 = High (1 163-1 348 kg/h).

Data was recorded for pre-harvest and machine operatoin parameters in the final testing at Daska. Pre-harvest parameters included grain straw ratio and length of harvested crop. The fuel consumption at various time elements (total time, total threshing times, time losses); weight of threshed, unthreshed, damaged and blown grains and whole material; and labour requirement were included in machine operating parameters. Measurements of grain losses by manual threshing were also recorded. Calculatoins were made for threshing and cleaning efficiencies, percent of damaged and grain losses and economics of mechanical and manual threshing. Details on data collection and calculation are given in the FMI thresher test report.

Results and Discussion

Tables 2 and **3** show the values of machine operating parameters at different cylinder speeds and feed rates. Very little variation was observed for cleaning and threshing efficiency at different cylinder speeds and feed rates. Maximum threshing efficiency of 99.66% was obtained at cylinder speed of 550 rpm and was minimum at 450 rpm. Threshing efficiency decreased with the increase of feed rates. This is due to the fact that at high feeding rate, more materials pass through the same cylinder length, while less time is proviced for threshing all the materials.

Similarly, cleaning efficiency also increased with the increase of drum speeds and decreased with the increase of feed rates **(Figs. 5** and **6)** although the difference was

Table 2. Performance of Thresher at Three Different Cylinder Speeds and Feed Rates

Cylinder Speed	Feed rate kg/h	Breakage %	Blown grain loss %	Unthresh grain loss %	Cleaning efficiency %	Threshing efficiency %	Total machine loss %
C1	F1	0.6	1.23	0.55	98.6	99.45	1.78
	F2	0.4	1.23	0.83	98.2	99.17	2.18
	F3	0.4	1.23	0.98	98.0	99.02	2.41
C2	F1	1.0	1.85	0.58	98.8	99.42	2.43
	F2	0.6	1.90	0.67	98.2	99.33	2.57
	F3	0.4	1.84	0.80	98.8	99.20	2.64
C3	F1	1.2	3.00	0.15	98.7	99.85	3.15
	F2	0.7	2.92	0.35	99.2	99.65	3.27
	F3	0.8	3.03	0.51	98.8	99.49	3.54

Table 3. Mean Values of Losses and Efficiencies

Cylinder Speeds/Feed Rates	Breakage %	Blown grain loss %	Unthresher grain loss %	Cleaning efficiency %	Threshing efficiency %	Total machine loss %
C1	0.47	1.23	0.79	98.2	99.21	2.12
C2	0.67	1.86	0.68	98.6	99.31	2.55
C3	0.90	2.98	0.34	98.9	99.66	3.32
F1	0.93	2.03	0.43	98.7	99.46	2.45
F2	0.57	2.02	0.62	98.6	99.21	2.67
F3	0.53	2.03	0.76	98.4	99.11	2.80

not statistically significant. Increase in cylinder speed increased the impact force exerted by the wire loop to detach the paddy grains from the earheads which is reflected in the increase of breakage percentage at higher speed. But at higher feed rates, breakage percentage was lower. This is due to passing of thick layer of material between wire loop and concave and hence lower impact forced exerted on the grains.

Higher cylinder speed or the higher peripheral velocity causes higher blower grain losses. At 450 rpm blower grain percentage was 1.23 and at 500 and 550 rpm it increased linearly with an increase in speed to 1.86 and 2.98%, respectively. This linear trend was not observed while increasing the feed rate.

The percentage of unthreshed grain decreased with the increase of cylinder speeds but increased with the increase of feed rates **(Figs. 7 and 8)**. The decrease in unthreshed grain was due to higher impact level imparted to the crop during threshing process at higher cylinder speed. Higher feed rate or through-put provide less chance to the panicles to hit against an individual wire loop to be threshed which eventually also get less time and leave some of the unthreshed and thus increases the unthresh percentage.

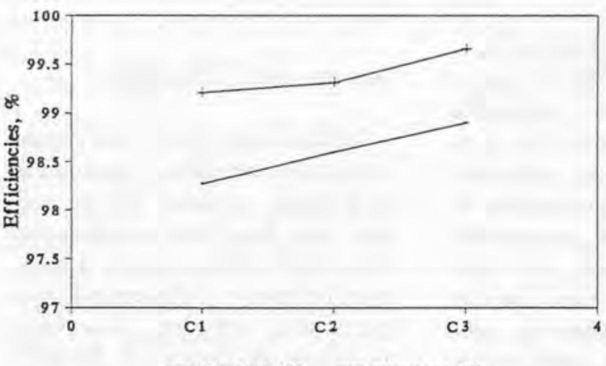

Fig. 5 Machine efficiencies at three different cylinder speeds.

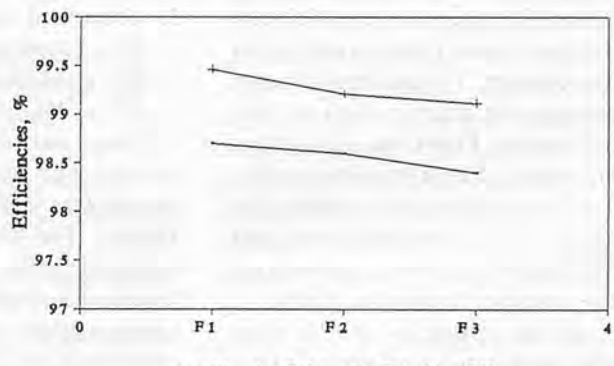

Fig. 6 Machine efficiencies at three different feed rates.

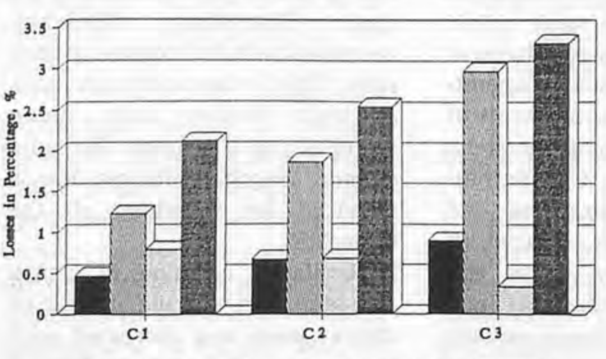

Fig. 7 Machine losses at different cylinder speeds.

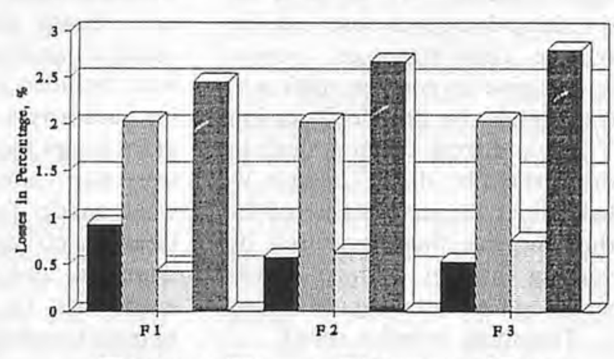

Fig. 8 Machine losses at different feed rates.

Table 4. Operating Cost per Ton of Paddy for Hold-on Type Paddy Thresher

Items	Cost (Rs/t)
Labour cost	
a) unskilled (@Rs.4.4/h)	16.25
b) skilled (@Rs.5.0/h)	9.25
Fuel cost (@Rs.5/lit)	12.50
Lubricating cost (20% of fuel cost)	2.50
Grain losses (@Rs.3.25/kg)	85.80
Variable Cost:	
Excluding grain losses	40.50
Including grain losses	126.30
Fixed cost (depreciation, interest, repair and maintenance)	70.00
Operating Cost (variable costs + fixed costs):	
Excluding grain losses	112.00
Including grain losses	196.00

Total machine loss, including breakage, blown and unthreshed grain ranged from 1.78 to 3.54%. The percentage of total machine losses increaed with the increase of cylinder speed, and a similar trend was true for feed rates. The total manual threshing losses with hold-on rice thresher on the same variety was 7.93%, which was 3 times more than the total machine losses.

The cost of operation of the hold-on type paddy thresher was divided into two categories, fixed and variable costs (**Table 4**). It was assumed that total yearly use would be 500 h for 5 years. Initial cost was Rs. 40 000. On these basis, depreciation, interest, taxes and repair, and maintenance cost Rs. 70/t. Operating costs were determined at its optimum operating conditions, i.e., output capacity (537 kg/h) and grain losses (2.64%). The operating costs of the thresher excluding and including grain losses, were Rs. 112 and Rs. 196/t, respectively. **Table 5** shows the cost of manual threshing. The cost of manual threshing, excluding and including grain losses, were Rs. 92 and Rs. 350/t, respectively.

Table 5. Cost of Manual Threshing

Items	Cost (Rs/t)
Manual operatin cost	
a) for threshing (@Rs.4.4/man-h)	74.80
b) for winnowing and bagging (@Rs.4.4/man-h)	17.60
Grain losses (@Rs.3.25/kg)	257.72
Total cost:	
a. Excluding grain losses	92.00
b. Including grain losses	350.00
Assumptions:	
a) Grain losses	7.93%
b) Labour requirement	
i) for threshing	17 man-h/7
ii) for winnowing & bagging	4 man-h/t

Conclusions

The results obtained from the study are summarized and concluded as follows:

1. The grain damage (breakage) was in the range of 0.4 to 1.20%. The percentage of grain damage increased with the increase in cylinder speed for all feed rates. Grain damage was 0.4% for optimum operating condition.
2. The total machine loss was in the range of 1.78 to 3.54%. The percentage of total machine loss increased with the increase of cylinder speed for all feed rates. Total machine loss was 2.64% for optimum operating condition.
3. Threshing efficiency was in the range of 99.02 to 99.85%. The threshing efficiency increased with increasing cylinder speed and decreased with increasing feed rate. Threshing efficiency was 99.2% for optimum operating condition.
4. On the basis of comparison of mechanical threshing with manual threshing in terms of total grain losses, it can be said that the thresher has satisfactory performance. There was 2.64% total loss using the thresher as compared to 7.93% for manual threshing.
5. The labour requirement to thresh one t of grain using the thresher averaged 5.55 man-h when operating the machine with three persons, as compared to manual threshing which require 21 man-h to thresh one t of grain.
6. The total cost for threshing using the thresher was Rs. 196 as compared to Rs. 350 for manual threshing.

REFERENCES

1. Anon, (1982). Ten Years of Pakistan In Statistics 1972-82. Federal Bureau of Statistics, Statistics Div., Govt. of Pakistan.
2. Anon, (1985). Agricultural Statistics of Pakistan, Govt. of Pakistan, Ministry of Food, Agriculture and Co-operative, Food and Agriculture Division (Planning Unit), Islamabad.
3. Tanveer, T., Saeed, M. A., and Khan A. S. (1991). Hold-on Type Rice Thresher, FMI Test report No. HT/FMI/91, PARC, Islamabad.
4. Khan A. U., Zaidi, S. H. and J. Akhtar, (1979). Development of Multicrop Axial Flow Thresher, report by IRRI-PAK Agricultural Machinery Programme, Islamabad.
5. Anon, (1981). IRRI-PAK Progress Report July 1976 - June 1981 by IRRI-PAK Agrickultural Machinery Programme, Islamabad.
6. Anon, (1983). Buk Sung Power Grain Thresher, FMI Test Report No. FMI/T&E-10/83 PARC, Islamabad.
7. Sagar, M.A., Ali, A.C. and Ashraf, M. (1991). Present harvesting and threshing practices of Paddy. Progressive Farming 11(6): 19-21.

Utilization of Date Palm Leaves and Fibres as Wetted Pads in Evaporative Coolers

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Abstract

The evaporative cooling most commonly used in agricultural applications is the fan-and-pad system in which corrugated cellulose pads (Cel-dek) are the most widely used. These pads are imported at a relatively high cost.

Date palm leaves and fibres pruned-off trees annually are available in huge quantities in the Kingdom of Saudi Arabia. In this investigation, cooling pads developed from palm leaves and fibres were mounted and tested in an evaporative cooler. The performance of pads was evaluated in terms of saturation efficiency and degree of cooling. Results were evaluated and compared to those obtained when using a Cel-dek pad. Favourable agreement was obtained, especially when using the palm fibre pad.

This investigation shows that there is a great potential for utilizing date palm leaves and fibres in fabricating wetted pads for evaporative coolers used widely in cooling most agricultural structures during the summer in hot and arid regions of the world.

Introduction

The total number of date palms in the Arab world is estimated to be 62 million trees, out of which an estimate of 13 million trees are found in the Kingdom of Saudi Arabia (Ministry of Agriculture, 1992) producing an average of 234 000 t of leaves and fibres annually (estimated at 18 kg/tree) as a result of cleaning and pruning operations. This huge quantity of discarded leaves and fibres represents a challenge to researchers to find ways and means of exploring its potentials in future industries.

However, since early times a number of handicrafts depending on dates leaves and fibres are known to exist. But only a small quantity is being consumed in such traditional crafts. The present work aims at locating one area in which such huge quantities of leaves and fibres could be exploited in the future.

The objective of the present study is to fabricate cooling pads assembled into different configurations of date leaves and fibres. These pads are mounted and tested in an evaporative cooler set-up and their performance is evaluated and compared to that of a commercially known Cel-dek pad in so far as saturation efficiency and degree of cooling are concerned.

Evaporative Cooling

Evaporative cooling is generally accepted to be an adiabatic humidification process (Mannix et al., 1982). This process takes place when unsaturated air is brought into contact with a free water surface in the absence of other sources of heat. Water evaporates in the air stream resulting in a drop in the air dry bulb temperature due to sensible heat removal while the humidity and latent heat content of the air increases. It is obvious that more cooling would be witnessed when the air to be cooled is less humid. Evaporative cooling, therefore, has much greater potentials in hot and arid regions of the world.

In practice evaporative cooling process usually ends before the air is fully saturated. The efficiency of an evaporative cooler depends on the extent to which complete saturation is approached. Mathematically the saturation efficiency is expressed by the following relationship:

$$\eta = \frac{T - T^1}{T - Tw}$$

where

T = Ambient air dry bulb temperature

Tw = Ambient air wet bulb temperature

T^1 = Cooled air dry bulb temperature

The evaporative cooling system most commonly used in agriculture is the wetted pad system (Wiersma and Scott (1966). The pad most widely used consists of a 5-10 cm thick porous screen made of plastic impregnated flutted sheets of paper glued together to form what is commercially known as (Cel-dek). The cooling performance of such pads had been extensively investigated and documented in the literature (Wiersma (1974), Buffington et al., (1978), Mannix et al., (1982), Abdalla et al., (1990). The results of these investigations show that wetted pad evaporative cooling efficiency depends on many factors, such as air velocity through pad (face velocity), pad thickness, and pad wetting rate. The American Society of Agricultural Engineers — ASAE (1982) recommended an air velocity of 1.25 m/s for the standard 100 mm thick Cel-dek pad widely used in agricultural applications. An optimum water circulation rate of 2.4 ℓ/min-m^2 of pad surface has been recommended by Wiersma and Benham (1974) for efficient cooling and effective pad cleaning action under most practical conditions.

Potential of Evaporative Cooling in Saudi Arabia

The inlands of the Kingdom of Saudi Arabia are characterized by hot and dry climatic conditions throughout most of the summer months of May to October. The mean maximum monthly temperatures vary between 35°C and 42°C with the absolute daily maximum temperatures soaring as high as 47°C (Abdalla et al., 1991). The mean monthly relative humidity, which is usually associated with maximum temperatures, varies between 16% and 22%. These conditions are ideal for evaporative cooling systems.

Materials and Methods

Two identical wooden boxes 1.15 m × 1.15 m × 1.3 m were fabricated in the workshop. In the front side of each box an opening 0.3 m × 0.3 m was left to accomodate an exhaust fan which was used to create an air stream through the wetted pad. The back of each box was left open where a metallic frame holding the pad material was fixed. A 100 mm-thick Cel-dek pad was mounted in the frame of one of the boxes. The frame mounted at the other box was used for testing the performance of different configurations of pads composed of date leaves and fibres. The pads were maintained uniformly wet by water being properly distributed along the upper edge of the pad as shown schematically in **Fig. 1**. Excess water from the pad was drained into a water reservoir from which it was pumped for recirculation.

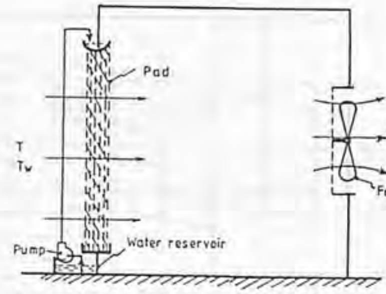

Fig. 1 Sketch of evaporative cooler.

Temperatures in the system were measured by two methods. The entering (T) and exiting (T^1) dry bulb temperatures of the air were sensed with a digital thermometer. The wet bulb temperature of the entering air (Tw) was measured with an aspirating psychrometer placed in the air stream. Measurements were taken weekly at 13:00 hours each time throughout the experimental period, May to July 1992.

Results and Discussions

Table 1 shows the experimental data, namely; dry and wet bulb temperatures obtained during the experimental period. The dry bulb temperatures of the outside (entering) air and the dry bulb temperatures of the air exiting the coolers recorded for the defferent wetted pads are shown graphically in **Fig. 2**.

The relative cooling efficiency for the three wetted pads is indicated by the saturation efficiency

Table 1. Conditions of Entering and Exiting Air from Coolers During the Experimental Period, May to July 1992

Date (1992)	Entering air conditions		Exiting air conditions					
			Cel - Dek		Date Leaves		Date Fibres	
	T°C	Tw°C	T^1°C	Saturation Efficiency	T^1°C	Saturation Efficiency	T^1°C	Saturation Efficiency
6/5	35.2	19.0	23	75.3	26.5	54	23.9	69.7
13/5	38	19.5	23	81	27.5	57	23.6	78.0
20/5	36	17.2	21.2	78.7	24.5	61	21.8	75.5
27/5	42	18.6	22.4	83.4	26.6	66	23	80.4
3/6	41	20	23	85.7	27.5	63	24.2	77.5
10/6	42	18.7	22.5	84	26.8	65	23	81.3
17/6	42.5	18.5	22	85.4	26.7	66	23.5	79.2
24/6	43.8	18	21.3	87.2	27.9	61.6	23.5	78.7
1/7	44	18.2	21.3	88	26.5	68	23	81.4
8/7	43	19.6	21.8	90.5	27	68.3	23.5	83.3
15/7	44.5	18.8	21.5	89.4	26.8	69	23.5	81.7

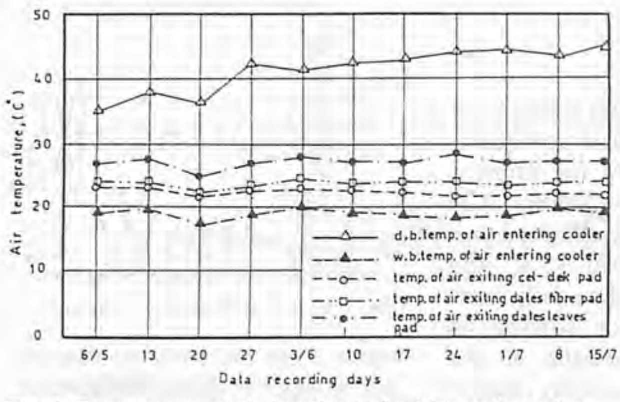

Fig. 2 Temperatures of air entering and exiting coolers using different wetted pads recorded at 1 p.m. daily.

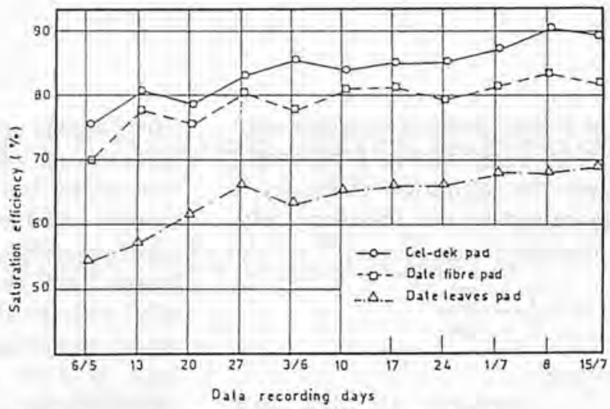

Fig. 3 Saturation efficiency of different wetted pads.

which was calculated for each type of pad and the values obtained are shown graphically in **Fig. 3** for the whole period.

As can be shown from **Table 1** and **Fig. 2**, the outside air dry bulb temperatures varied between 35°C and 45°C while the wet bulb temperatures varied between 17°C-20°C throughout the period of the experiment. The best cooling level, which is indicated by the highest saturation efficiency and the lowest dry bulb temperature of the air exiting from the coolers, is obtained when using the Cel-dek pad. The date leaves pad gave the least cooling i.e., the lowest saturation efficiencies and the highest exiting air dry bulb temperatures, though a temperature drop between 9-18°C was noticed. Meanwhile, the pad composed of the date fibres gave favourably good results of saturation efficiencies and exiting dry bulb temperatures as compared to results obtained when using the Cel-dek pad shown in **Figs. 2** and **3**.

During the course of the experimental work, it was observed that some foam accumulated on the upper side of the Cel-dek pad which slightly restricted water flow down the pad while this phenomena did not occur while using the experimental pads. No biological deterioration or fungi formation were detected in any of the three wetted pads during the experimental period which extended from May to July, 1992 with reservoir water only being topped-up.

Conclusions and Recommendations

The levels of cooling reached in the present investigation when using the date fibre pad, compared favourably well with values of saturation efficiency and exiting air dry bulb temperature obtained using the commercially known Cel-dek pad. The date leaves pad gave a reasonable degree of cooling with air dry bulb temperatures dropping between 9-18°C.

These results show that there is a great potential for utilizing date palm leaves and fibres in fabricating wetted pads for evaporative coolers which are used widely in cooling most agricultural structures throughout the summer in the Kingdom of Saudi Arabia.

At this stage it is recommended that extensive experimental work is to be conducted on different pad configurations in order to reach a better design of a self-supporting cooling pad that will render the best cooling performance.

The industry anticipated to arise based on the results of this study in utilizing data palm residues for the fabrication of cooling pads is expected to contribute to the individual farmer income and hence to the national economy.

REFERENCES

1. Abdalla, A.M., and Narendran, R. (1990). Utilization of wind power and wetted pads to evaporatively Utilization of wind power and wetted pads to evaporativekly cool cow sheds under hot and arid climatic conditions. AMA, Vol. 21, No. 4, pp. 33-37.
2. Abdalla, A.M. and Al-Eknah (1991). Development and evaluation of wind powered evaporative cooling system for dairy cow sheds in Saudi Arabia. Arab Gulf J. Scient. Res., 9(3), pp. 41-53.
3. Buffington, D.E., Skinner, T.C. Collette, B. and Borer, D. (1978). Evaporative cooling for hot humid climates. Paper presented at the Southwest Southcoast Regional Meeting, American Society of Agricultural Engineers, Houston, Tx.
4. Mannix, J.G., Koon, J.L. and Flood, C.A. (1982). Heat transfer in evaporative cooling pad, ASAE paper No. 82-4062, St. Joseph MI.
5. Ministry of Agriculture and Water (1992). Agricultural Statistical Yearbook, Vol. 7, 1992 (1412H).
6. Wiersma, F. and Benham, D.S. (1974) Design criteria for evaporative cooling. ASAE Paper No. 74-4527, St. Joseph MI.
7. Wiersma, F. and Scott, G.H. (1966). Microclimate modification for hot weather-stress relief of dairy cattle. Trans. of ASAE 9(3): pp. 309-311. ■■

Farm Mechanization in Nepal

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Abstract

This study highlights the trend, current status, policy implications, development constraints and the issues related with the farm mechanization in Nepal. The low level of mechanization is one of the factors responsible for the low productivity in agriculture. The country could achieve the objectives of higher production and increased employment through selective mechanization. The improved manual tools and animal-drawn implements for the hilly areas and the terai plains, and mechanically-powered pumps and threshers for the terai plains will be important inputs to increase the output with the existing cultivable land. In view of the diminishing feed resources and low productivity of the draught animals, the agricultural sector may face severe energy constraints in the future. The energy constraints in the terai plains may be overcome by adequately supplementing draught animals with the inanimate sources of power. However, in view of the lack of factual information, a comprehensive research is needed to determine the appropriate levels of mechanization for different farm conditions.

Introduction

Nepal is a land-locked country situated between China in the north and India in the south, east and west. Located between 80°15' to 88°10' east longitudes and 26°20' to 30°10' north latitudes, the country spans an area of 147 000 sq. km.; and is roughly rectangular in shape with a width ranging from 130 to 240 km and a length of approximately 800 km. The country is divided into three well defined ecological zones, viz. the Terai, the Hills and the Greater Himalayas. The terai is the flat land on the southernmost part comprising both the low fertile strip and the inner terai containing the forested Churia hills. Parts of this area are only 75 m above mean sea level. The hills which consist of the Mahabharat range and the lower Himalayan foothills range in elevation from 750 m to roughly 4 000 m where most of the population lives. The Greater Himalayas are located on the far north, above 4 000 m that rise to heights of over 8 000 m and which present unending folds of snow-covered, inaccessible terrain of little agricultural significance.

Like many developing countries, Nepal's economy is heavily dependent on agriculture. In 1990, the GNP per capita was US$ 170; and the agricultural sector absorbed about 92% of the total labor force, generated about 60% of the national GDP and accounted for almost 75% of the total merchandise exports (RAPA, 1992). As the supplier of raw materials and the consumer of various inputs and services, this sector has a pronounced effect on other sectors of the economy as well. Food grains constitute almost 80% of the country's agricultural GDP. Crop production is the dominant agricultural activity. The cropping practices vary considerably depending on location, soil, climate and availability of inputs. There are two major cropping patterns, viz. paddy-based and maize-based. In the terai plains, the cropping pattern is paddy-based; while in the hills, it is maize-based on hill slopes and paddy-based in the valleys. The main cereal crops are paddy, maize, wheat, millet and barley; while potato, sugarcane, oil seeds and tobacco are the main cash crops. The area, production and yield of major crops are given in **Table 1**.

The agricultural resource base of the country is severely limited by topography. About 52% of the cultivated land is in the terai and the rest is in the hills and mountains. Farming is carried out in small units, the average size being 1.12 ha. With few growth options available and in view of the heavy dependence on agriculture, the economic development of the country depends on agriculture. Realizing the vital role of the agricultural sector, the government has been allocating more than 25% of the capital outlay for the development of agriculture. But in spite of all the efforts,

Table 1. Area (in '000 ha), Production (in '000 t) and Yield (in kg/ha) of Major Crops in Nepal in 1988/89

Crops	Terai			Hills			Mountains			Total		
	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield
Paddy	1066.3	2444.6	2292.6	345.8	764.6	2211.1	38.2	73.9	1934.6	1450.3	3283.1	2263.7
Maize	147.6	249.0	1687.0	522.0	749.1	1435.1	52.1	73.4	1408.8	721.7	1071.5	1484.7
Millet	11.7	11.9	1017.1	148.5	149.5	1006.7	22.3	21.6	968.6	182.5	183.0	1002.7
Wheat	314.2	493.8	1571.6	243.0	293.0	1205.8	42.0	43.1	1026.2	599.2	829.9	1385.0
Barley	3.3	3.1	939.4	15.2	13.7	901.3	10.8	10.0	925.9	29.3	26.8	914.7
Oilseeds	122.9	79.6	647.7	29.3	18.0	614.3	2.6	1.5	576.9	154.8	99.1	640.2
Potato	18.8	197.3	10494.7	43.6	314.7	7217.9	19.1	128.7	6738.2	81.5	640.7	7861.3
Tobacco	7.1	5.3	746.5	0.1	0.1	1000.0	—	—	—	7.2	5.4	750.0
Sugarcane	27.2	861.0	31654.4	2.2	40.0	18181.8	0.1	1.7	17000.0	29.5	902.7	30600.0

Source: DFAMS (1990).

agricultural productivity has remained low. During the last two decades, the average annual growth rate of food grain production was 2.6% per annum, while the population increased at the rate of 2.3% per annum. The increase in production was achieved largely through an increase in cultivated land; the yields of major cereal crops either increased just marginally or declined. The yields of paddy and wheat increased from 1.88 t/ha 1.14 t/ha to 1.99 t/ha and 1.30 t/ha, respectively; while the yield of maize declined from 1.69 t/ha to 1.64 t/ha (ADB, 1982; CBS, 1991). With no land frontier available for the expansion of arable land, the country is facing a challenge greater than ever before to meet the food grain requirements of its rapidly increasing population. The future increases in agricultural production can only come from an increase in the output of the existing cultivable area.

Trends in Farm Mechanization

Hand tools and animal-drawn implements, traditionally, have been the mainstay of agriculture in Nepal. The use of mechanical power began in mid-sixties with the introduction of 64 tractors and 30 pumpsets (Pudasaini, 1980). By 1970, the number of tractors increased to 794, following the importation by the National Trading Limited (NTL), the former Land Reform Saving Corporation (LRSC) and the private dealers. Provision of credit facilities for purchase through the Agricultural Development Bank (ADB/N) and the LRSC was the major factor contributing to the promotion of tractor use during this period. The population of tractors increased rapidly during 1970s when ADB/N, under the Agricultural Credit Projects financed by the Asian Development Bank (ADB), started importing tractors and distributing these to farmers on medium-term credit. However, because of the government's apprehension about the adverse effects of tractorization on rural employment and income, the ADB/N discontinued financing for 4-wheel tractors during the Sixth Plan Period (1980-1985). The government's attitude during the Seventh Plan and till date has remained neutral on the issue. The ADB/N has resumed financing for tractors, because of which the tractor population in the last five years has more than doubled.

Similarly, during 1966-1975, the number of pumpsets continued to increase. The ADB/N imported 1 160 pumpsets in 1976 and 1 400 pumpsets in 1978 as a part of the second and third Agricultural Credit Projects funded by ADB. The Agricultural Inputs Corporation (AIC) also imported 898 pumpsets in 1976 besides the regular imports by private dealers (Khoju, 1982). Power tillers first appeared on Nepal's farming scene in the early seventies following the import of power tillers from China by NTL. Power wheat threshers were introduced around late sixties simultaneously with the popularization of high yielding varieties of seeds; but the threshers started gaining popularity only after mid-seventies. Pedal threshers are becoming popular in Kathmandu valley for threshing paddy. About 1700 pedal threshers were in use in 1991.

The establishment of Agricultural Tools Factory (ATF) in 1968 marked the beginning of local production of improved manual tools, animal-drawn implements

Table 2. Population of Selected Power-operated Farm Machinery in Nepal during 1965 to 1989.

Particulars	1965	1970	1975	1980	1985	1988	1989
4-wheel tractor	64	794	1 925	2 514	2 789	4 018	6 060
Power tiller	—	—	100	424	994	1 050	1 100
Pumpsets	30	1 130	3 312	9 886	17 225	22 637	23 000
Wheat threshers	NA	NA	80	2 412	3 861	5 056	7 650

Source: Pariyar (1991a) and Karki (1989).

Table 3. Farm Power Availability in Nepal

Source of Power	Available Units, number	Power Rating kW/unit	Available Power in kW
Human labor	7 234 000	0.07	506 380
Draught animals			
Cattle	2 325 080	0.30	697 524
He-buffalo	180 120	0.44	82 054
	2 505 200		778 578
Mechanical power			
4 Wheel tractors	6 060	22.38	135 622
Power tillers	1 000	7.46	7 460
Stationary engines	23 000	3.73	85 790
	30 060		228 872
Total			1 513 830

and power-operated machines. The indigenous production of improved farm equipment by ATF has facilitated the pace of mechanization development in the country. The trends in mechanization during the period 1965 to 1989 can be seen from **Table 2.** It was estimated in 1989 that about 12 500 units of power wheat thresher and 48 000 units of mechanically-powered pumpsets will be required by the end of the century (Karki, 1989). Not much information is available on the extent of the market potential for other farm machineries.

An estimate of the current extent of farm power availability is presented in **Table 3**. The farm power available per ha for cultivated land of 2.65 million ha is 0.57 kW; and for cropped area of 3.92 million ha representing cropping intensity of 1.47, it is 0.39 kW. This power availability is extremely low for productivity increases in the agricultural sector. Agriculture in Nepal is heavily dependent on human and animal power, which constitute 34% and 51% of total farm power, while the mechanical sources contribute the rest, 15%.

Table 4. Equipment Used in Farm Operations in Nepal Terai

Farm Operation	Hand Tool	Animal-drawn Implement	Power-operated Machinery
Tillage	Spade	Wooden plough, Ridger, Mouldboard plough, Wooden plank	Tractor - Cultivator, Disc harrow, Leveller, Power tiller - Cultivator
Sowing / Planting / Interculture	Hoe, Spade	Plough, Corn seeder	
Plant protection	Sprayer, Duster		
Irrigation	Hand pumps, Rower pumps		Diesel pumpsets
Harvesting	Sickle		
Threshing	Maize sheller		Wheat & Multi-crop thresher, Corn sheller
Winnowing and grading	Winnower		
Transportation		Tire-cart	Tractor with trailer

Source: APROSC (1991).

Table: 5. Human Labor and Animal Power Use Per Hectare in Various Farm Operations in Nepal Terai

Farm Operation	Paddy		Wheat		Maize		Sugarcane		Oilseeds	
	Man - days	Animal / pair days	Man - days	Animal / pair days	Man - days	Animal / pair days	Man - days	Animal / pair days	Man - days	Animal / pair days
Tillage										
i) ploughing	8	18	14	19	7	21	39	22	19	14
ii) puddling	21	21								
Sowing (broadcasting / planting / transplanting)	13		11	10	11	12	58	19	2	4
Weeding	33	—	—	—	36	—	46	—	—	—
Harvesting	39	—	37	—	37	—	49	—	20	—
Threshing (others)	19	6	23	4	23	—			28	21
Total	133	45	85	33	114	33	192	41	69	38.5

Source: APROSC (1991).

Mechanization in Terai Plains

The mechanization technologies used in the terai plains can be grouped into manual tools, animal-drawn implements and power-operated machines. The power required for various farm operations is mostly derived from draught animals-predominantly bullock power; and hence, the trend is towards the development and use of improved bullock-drawn implements. Pneumatic-tired animal-drawn carts of 0.5 t capacity and other animal-drawn implements such as mould-board plough, 3-tine cultivators, 4-disc and 6-disc harrows are gaining popularity. Mechanically-powered pumpsets are becoming popular, since the availability of irrigation water has enabled farmers to grow up to three crops a year with two successive paddy crops followed by a wheat crop. **Table 4** shows the equipment used in various farm operations.

The draught animals are the main source of power for tillage operations. Power-operated machines are used to a limited extent for tillage operations; while the use of manual tools is negligible. Farm operations such as sowing, transplanting, weeding and interculture, plant-protection, fertilizer/manure application and harvesting are performed using manual tools. Sowing behind the plough is practiced to a limited extent. Mechanically-powered pumpsets and manual water pumps are used for lift irrigation. Threshing is mostly done manually; with limited use of animals and mechanical power.

Table 5 shows the per hectare use of human and animal power in various farm operations of five major crops (APROSC, 1991). It is obvious that among the cereal crops, paddy is the most labor-intensive crop requiring 133 man-days. Similarly, the animal pair days required is 45 in paddy indicating that the draught animals are used most in paddy cultivation. Operation-wise, transplanting and weeding of paddy and weeding of maize are highly labor intensive. The sugarcane cultivation requires the highest man-days per hectare, i.e. 192 man-days.

It is estimated that with the current level of energy use and availability of mechanical power, the draught animals which are about 0.9 million in population, require seven weeks to complete the tillage operation in the terai region. Although a detailed research is needed on energy use patterns and their effects on crop production, it is observed that there exists an acute energy shortage in tillage operation. An optimum time period for tillage ranges from three to four weeks. The delayed transplanting and the low cropping intensity resulting from energy constraints, could be responsible for the low agricultural production. In order to enhance the productivity, this energy shortage should be overcome by adequately supplementing the draught animals with the use of inanimate energy resources.

Mechanization in the Hills

The mechanization technologies used in the hills can be grouped into manual tools and animal-drawn implements. Most of these tools and implements have limitations which result in excessive drudgery and low productivity of land and labor associated with various environmental problems (Pariyar, 1991b). There has been little change in their design and performance capabilities over time. **Table 6** shows the type of farm tools and implements used in various farm operations in hill agriculture.

Table 6. Types of Farm Tools and Implements Used in Farming Operations in the Hills

Farm Operation	Manual Tools	Animal-drawn Implements
Land Preparation		
(i) Ploughing	Spades of different shapes	Wooden Plough
(ii) Harrowing	Clod crusher	Wooden harrow/puddler
(iii) Puddling		
Sowing / Planting	Garden hoe	Wooden plough
Weeding / Interculture	Garden hoe, Wooden rake	None
Manure Application	Spade	None
Harvesting	Sickles	None
Threshing	Wooden sticks, Pedal threshers	None
Winnowing / Cleaning	Bamboo-mat	None
Transportation	Bamboo-mat basket	None

Source: Pariyar (1991b).

Tillage is performed by animal-drawn traditional plough, harrow and puddler. The plough in remote hills is completely made of wood. In areas which are near to motorable roads, the plough share is a small metallic bar, while the rest of the plough components are made of wood. The harrow and the puddler are completely wooden. In steep slopes, narrow terraces, newly reclaimed areas and in major part of Kathmandu valley, even animal-drawn implements are not used for land preparation. Manual spades are used for tilling the land. Sowing behind the plough is practised in some part of the hills for planting maize. Weeding, interculture, manure application and harvesting are completely manual operation. Threshing of the crops is also done manually. paddy is usually threshed by beating the plants against stone or log or mud-packed threshing floor. Wheat, barley, millet and oilseeds are threshed by beating with different types of threshing sticks. Threshing by bullock trampling over the crops on the threshing floor is also practised in some areas. The use of pedal threshers is gaining popularity in Kathmandu valley. Maize cobs are unhusked by hand, or by beating the cobs with sticks or by rubbing the cob against one another. The grains are winnowed and cleaned by means of a manual winnower made of bamboo-mat.

Animal Draught Power and Fodder Availability

Available statistics indicate that the population of draught animals in the country is increasing at the rate of 0.5% per year (DFAMS, 1990; ADB, 1982; Rajbhandary and Shah, 1981); while the cultivated land during the past two decades increased at the rate of 2.6% per year (DFAMS, 1990; APROSC,1985). This way, the density of draught animals and hence, the effective power availability per hectare of cultivated land has declined in the real sense.

The animal feed situation is most precarious, with 57% of the areas in the country calculated to have overall feed deficits (Shah et. al., 1991). A study conducted in 1982 (ADB, 1982) reported that the overall level of feeding was no more than 50% of the requirement; and it was decreasing because there was a continuous increase in livestock population; while the main off-farm fodder base, i.e., forest and range land which contributed as high as 72% of the total feed, was declining both in area and productivity. The study also pointed out that about 90% of the available feed was being used only for maintenance, i.e., for keeping animals alive; while less than 10% was being utilized for productive purposes such as draught power, milk and meat production. It is felt that the feed supply situation in the country has worsened during the past decade.

In view of the diminishing feed resources and low productive capacity of the livestock, in general, it is obvious that adequate measures will have to be undertaken to improve fodder availability and/or reduce the livestock population. Rajbhandary and Shah (1981) stressed that the livestock population, and especially the number of cattle should be drastically reduced. Such measures may discourage an increase in the population of draught animals; and conversely, livestock for milk and meat production may be preferred and maintained. As such, unless the draught animals are adequately supplemented with alternative power sources, i.e., mechanical power and/or are more fully and efficiently utilized, the energy constraint in agriculture in the future will be much more severe; and this may have a serious impact on the country's entire agricultural production system which is so heavily reliant on livestock for draught power.

Mechanization and Energy Related Studies

Pudasaini (1980), on the basis of a field survey which involved 102 farmers from Bara district in the central terai, reported that the cropping intensity, yields, income and employment were higher on mechanized (pumpset owner, tractor owner, tractor hirer, tractor and pumpset owner) than on traditional bullock-operated farms.

Thapa and Roumasset (1980), in a study conducted in the terai region of the country, indicated significant association of a high level of mechanization with high cropping intensity, high yields per hectare, high labour use except in land preparation, a high percent of hired labour.

Khoju (1982) studied the economics of pump irrigation in the eastern terai plains, and concluded that the pump irrigated farms had higher cropping intensities, higher levels of resource use, including manpower and higher crop yields than rainfed farms.

Shrestha (1988) studied the flow of energy in the production of selected crops in two agro-ecologically different districts, one in terai and one in hills. The information was collected on the physical energy and other material inputs and outputs by interviewing 104 farmers about the crop production activities for the last calendar year. The findings were the following:

i) The total energy inputs in terai plains ranged from 4 417 to 6 472 kWh/ha for paddy, from 4 639 to 7 222 kWh/ha for wheat, and from 4 722 to 6 833 kWh/ha for sugarcane. Similarly, in the hills, the total energy input ranged from 2 444 to 3 806 kWh/ha for paddy, from 3 611 to 4 667 kWh/ha for wheat, and from 3 500 to 4 417 kWh/ha for maize.
ii) The energy ratio for paddy varied from 6 to 8 in terai plains, while it varied from 16 to 22 in hills. The energy ratio for wheat was about 6 for terai as well as the hills. Similarly, energy ratio for sugarcane and maize was 16 and 7.5, respectively.
iii) In tractor farms, the bullock power was significantly substituted by tractor power, and the total physical energy input was high.

Rijal et. al., (1991) reported the total animate energy requirements for paddy, wheat, oil seeds and potato were 711, 754, 287, and 486 kWh/ha, respectively, in the terai. The animate energy requirements for paddy, maize, wheat, barley, oil seeds and potato were 1 198, 799, 1 140, 658, 538 and 1 090 kWh/ha, respectively, in the hills.

Local Manufacture of Farm Equipment

The Agricultural Tools Factory Limited (ATF) is the largest manufacturer and supplier of agricultural equipment in the country. The factory is located at Birganj (Parsa district), about 250 km south east of Kathmandu. The major equipment produced by ATF during the period 1985/86 to 1989/90 are presented in **Table 7**.

Other than ATF, there are altogether 12 small and medium scale agricultural machinery manufacturers in the organized sector. Their basic products are turbines, trailers, threshers and corn shellers. These manufacturers are listed below:

- Balaju Yantra Shala, Kathmandu
- Gobar Gas & Krishi Yantra Vikas Limited, Butwal
- Butwal Engineering Works Pvt Ltd, Butwal
- Nepal Hydro & Electric Pvt Ltd, Nepalganj
- Development and Consulting Services, Butwal
- National Structures & Engineering Pvt Ltd, Patan
- Junkiri Industries Pvt Ltd, Butwal
- Inter Tech Pvt Ltd, Butwal
- Nakarmi Engineering Works, Kathmandu
- Krishi Aujar Yantra Udyog Pvt Ltd, Birganj
- Nepal Kishan Works, Jitpur
- Agro-Engineering Works Pvt Ltd, Butwal

Table 7. Details of Equipment Produced at ATF, Birganj

Name of Equipment	Quantity produced				
	1985/86	1986/87	1987/88	1988/89	1989/90
Tractor trailers	96	23	40	27	36
Power threshers	97	211	84	96	233
Tractor disc harrow	1	5	2	3	—
Tractor cultivators	41	20	41	9	5
Power corn shellers	—	—	—	12	—
Diesel pumpsets	—	—	—	715	1 267
Pedal threshers	167	281	160	83	149
ADV wheel axle sets	605	521	499	426	407
Animal-drawn disc harrow and cultivators	240	176	94	46	28
Animal-drawn plough	2 127	1 975	3 247	3 066	1 659
Hand maize sheller	432	860	1 226	633	578
Hand tools	3 972	13 398	13 450	13 411	5 449

Source: APROSC (1991).

Some workshops provide repair and maintenance services on farm machineries, and produce agricultural machineries on job order basis only. Village-level artisans are the main suppliers and repairers of simple tools and implements in the countryside. Their major products are sickles, spade, hoe, plough share and axes. The local capabilities for research, development and manufacture of farm equipment require strengthening in view of the future mechanization needs.

Mechanization Policies and Strategies

The agricultural sector has been accorded top priority by the government in terms of development plans and annual budgets. However, since no budget breakdown on farm mechanization is available, it is difficult to identify priorities in farm mechanization. Nevertheless, the government's attitude towards farm mechanization based on plan documents and policy pronouncements can be summarized as the selective mechanization of farming with labour-intensive technology. Emphasis is placed on the modernization of agriculture through the use of high yielding seed varieties, fertilizer, pesticide and irrigation. In so far as farm machinery is concerned, there seems to be no contradiction in government objectives to introduce those machinery which increase production without displacing labour (NPC, 1991). Irrigation equipment and grain storage bins have been encouraged through liberal credit and subsidy schemes. With regard to tractor and power tillers, the government has sometimes discouraged their use, and sometimes kept silent, in view of their potential effect on labour displacement (Karki and Chapagain, 1989).

Development Constraints and Opportunities

The rugged terrain, steep slopes, narrow terraces and lack of access roads impose severe limitations to the use of mobile machines in the hills and mountains. It is for this reason that many of the available power-operated machineries are concentrated in the terai and the mid-hill valleys. Even in terai, small and fragmented holdings, high capital investment required for machineries, abundance of cheap labor, low purchasing power of farmers and traditional methods of farming are the factors hindering the growth of mechanization.

Legislation regarding land ownership has placed a ceiling of 17 ha that an individual can own in the terai region. This has caused the individual farms to become smaller. Add to this the fact that the inheritance laws of the country lead to progressive fragmentation of holdings. Lack of alternative employment opportunity due to the slow development of non-agricultural sectors has placed a heavy burden on the agricultural sector alone in so far as labor absorption is concerned. There is hardly any migration of labor force from the agricultural sector to other sectors.

The objective of development in the country is growth with equity. The government programmes are focussed on meeting the minimum basic needs of all the people. In this regard, provision of employment is considered to be one important basic need. Past trends show that agriculture has to provide employment to most of the labour force. Another important objective in agricultural development is to achieve maximum possible production. So, in essence, the desired course of development in agriculture would be higher production with increased employment. In the context of mechanization, it is therefore, clear that any type of mechanization which augments both production and employment would be appropriate. Farm mechanization in Nepal will, therefore, have to be guided in such a way that its overall effect will be to increase production and to further the absorption of labor rather than cause its displacement. Since human and animal power will remain the major source of farm power in foreseeable future, farm mechanization will have to emphasize mainly on the extension of improved manual tools and animal-drawn implements. In view of the expanding wheat cultivation and need for supplemental irrigation, the use of mechanically-powered irrigation pumps and wheat threshers should be promoted in the terai region.

There are evidences from other countries that the selective use of inanimate power and equipment into systems of agricultural production has enhanced food production through increased cropping intensity and improved timeliness (Khaskeli et. all., 1991; Ahmad, 1983), and assisted in increasing employment opportunities (Patil, 1987; Chaudhary, 1984). However, due to lack of factual data, it is very difficult to assess the potential role of mechanically powered technology in agricultural development of Nepal. The studies conducted so far in Nepal have dealt on some specific aspects only; and hence, are unable to furnish major conclusions about farm mechanization in totality. There is, therefore, a need to examine carefully the impact of different levels of mechanization for different farming conditions. This area requires further investigation.

Conclusion and Recommendations

Traditional manual tools and animal-drawn implements constitute the mainstay of the Nepalese agriculture. The future increases in agricultural production in the country have to come from mainly the existing cultivable land. There is a lack of a clear-cut government policy on farm mechanization. Suitable farm equipment would be an important input to enhance agricultural productivity. Mechanization will have to be guided towards the extension of improved tools and implements. The energy shortage must be overcome by supplementing the draught animals with the use of mechanical power. The use of mechanical power remains very low. Energy shortage may be one of the reasons for low yields in the terai. Mechanically-powered irrigation pumps and wheat threshers have good prospects in the terai. The local capabilities for research, development, testing and manufacture of farm equipment need strengthening.

Experiences of other developing countries indicate that Nepal could achieve the dual objectives of higher production and increased employment through selective mechanization. However, in order to decide on suitable strategy for mechanization, it is necessary to know the effects of different mechanized techniques on the output and employment.

REFERENCES

1. ADB (1982). Nepal Agriculture Sector Strategy Study, ADB /HMGN, Kathmandu, Nepal
2. Ahmad, B. (1983). Implications of Farm Mechanization for Employment, Productivity and Income. AMA, 14(2).
3. APROSC (1985). Nepal Perspective Plan for Agriculture: 1985-2000 - Main Text, APROSC, Kathmandu, Nepal.
4. APROSC (1991). Assessment of Farmers' Needs for Farm Tools, Implements and Machineries in Bara and Chitwan Districts. Agricultural Projects Services Centre. Kathmandu, Nepal.
5. CBS (1991). Statistical Yearbook of Nepal 1991, Central Bureau of Statistics, Kathmandu, Nepal.
6. Chaudhary, M. A. (1984). Agricultural Mechanization and Labor Employment: A Case Study of Punjab Pakistan. AMA, 15(4).
7. DFAMS (1990). Agricultural Statistics of Nepal 1990. Department of Food and Marketing Services, Ministry of Agriculture. Kathmandu, Nepal.
8. Karki, A. B. (1989). Demand Study of Selected Agricultural Machinery in Nepal. RNAM. Los Banos, Philippines.
9. Karki, A. B. and D. P. Chapagain (1989). Review of the Existing National Policies and Strategies for Agricultural Mechanization in Nepal, RNAM, Los Banos, Philippines.
10. Khaskeli, M. U.; Jamali, L. A.; Rattar, F. M. and K. A. Ibupoto (1991). Mechanized vs Traditional Cultivation of Sugarcane Crop in Pakistan. AMA, 22(2).
11. Khoju, M. R. (1982), The Economics of Pump Irrigation in Eastern Nepal. Research Paper No. 14, ADC/APROSC. Kathmandu.
12. NPC (1991). Approach to the Eighth Plan: 1992-1997, Natioanal Planning Commission, Kathmandu, Nepal.
13. Patil, A. S. (1987). Implications of Tractorization on Employment, Productivity and Income in an Irrigated Area of Ahmednagar District, India. AMA, 18 (3).
14. Pariyar M. P. (1991a). Country Report on Nepal. Utilization of Farm Machinery in Asia, APO, Tokyo, Japan.
15. Pariyar M. P. (1991b). Mechanical Technologies for Hill Agriculture: An Inventory of Existing Options and Alternatives, ICIMOD, Kathmandu, Nepal.
16. Pudasaini, S. P. (1980). Farm Mechanization, Employment and Income in Nepal: Traditional and Mechanized Farming in Bara District. Research Paper Series No. 3, ADC/APROSC. Kathmandu.
17. Rajbhandary, H.B. and S. G. Shah (1981). Trends and Projections of livestock population in the Hills - in Nepal's Experience in Hill Agricultural Development, Ministry of Agriculture, HMG /N, Kathmandu, Nepal.
18. RAPA (1992). Selected Indicators of Food and Agriculture Development in Asia Pacific Region, 1981-91, RAPA Publication 1992/15, Regional office of Asia and the Pacific, FAO, Bangkok, Thailand.
19. Rijal, K., Bansal, N. K. and P. D. Grover (1991). Energy in subsistence agriculture: a case study of Nepal. Int. Jour. of Energy Research, 15(2).
20. Shah, P. B., Schreir, H., Kennedy, G. and S. J. Brown (1991). Overview of the national food, feed and fuelwood resources of Nepal: a GIS based model - in Soil Fertility and Erosion Issues in the Middle Mountains of Nepal: Workshop Proceedings, Topographical Survey Branch, Kathmandu, Nepal.
21. Shrestha, B.L. (1988). Energy Analysis of Selected Crops in Nepal. Master's Thesis No. AE 88-15. AIT. Bangkok, Thailand.
22. Thapa, G. B. & J. A. Roumasset (1980). The Economics of Tractor Ownership and Use in Nepal Terai. Research Paper Series No. 8, HMG/USAID/ADC. Kathmandu, Nepal. ■■

Effect of Different Tillage Operations on Emergence and Yield of Wheat

by

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Abstract

A spring-tine cultivator was compared with moldboard plow plus disc harrow, and rotary tiller in order to test the emergence and yield of wheat. No discernable differences in emergence were observed but the moldboard plow plus disc harrow showed the highest grain yield (447 g/m^2) as compared to the other tillage equipment used in the experiment. The tillage operation effects on yield may be ranked in descending order as moldboard plow plus disc harrow > rotary tiller > cultivator 2 passes > cultivator 1 pass, with moldboard plow out yielded by 6% to 42%, respectively.

Introduction

The goal of proper tillage is to provide a suitable environment for seed germination, root growth, weed control, soil erosion and moisture control. The common tillage implement used in Pakistan is spring-tine cultivator for all types of tillage operations (Sheikh et al., 1983). This cultivator does not satisfy the proper tillage requirement. It is so constructed that it skips untilled soil between the tools and, consequently, farmers over-till soil to achieve a suitable seedbed. The number of passes averages 7.5 in Punjab *barani* area (Khan et al., 1986, Hobbs, et al., 1985 , Hussain et al., 1985). The over-use of cultivator rather compacts the soil restricting the root growth and infiltration, disturbing soil structure and increasing expenditure on fuel cost estimated at US$6 million (Hussain and Munir, 1986). Besides, it also increases soil erosion due to run off and wind.

No tillage can be justified on the basis of tradition and habit. Any tillage practice which merely changes soil condition and does not produce required results should be eliminated or changed. About 86% of the total hours were spent on tillage in Sind and different combinations of tillage implement have varying effect on soil preparation (Afzal et al., 1983). The soil needs to be prepared only enough to ensure optimum crop production and weed control. Any tillage activity beyond this is questionable (Bukhari et al., 1981). As such there is potential benefit in reducing energy cost, soil and water conservation and timeliness associated with minimum or no tillage (Sharma et al., 1984).

Karim et al., (1983) compared the effects of three tillage treatments: minimum, conventional and deep tillage relative to yield of wheat on a grey terrace soil in Bangladesh under rainfed and irrigated conditions. In the irrigated area a maximum yield of 2.25 t/ha, and 36% increase in yield over the conventional tillage was obtained from deep tillage. Khan et al (1990) conducted an experiment on primary deep tillage with moldboard and traditional cultivator under rainfed conditions in Rawalpindi areas from 1983-84 to 1986-87. Deep primary tillage with moldboard plow gave 16% more grain yield than the conventional cultivator in Islamabad during 1982-83. In 1983-84 from three experiments on farmers' fields the difference between moldboard and cultivator plow was more than 52%. The average increase in wheat grain yield due to moldboard plow over cultivator was 36%, 24%, 15% during 1984-85, 1985-86, 1986-87, respectively.

The primary objective of any cropping program is continued profitable production. Most farmers prefer to follow proven practices with readily available equipment. Various tillage operation offer varying results under different conditions. This study was undertaken to evaluate the difference among tillage operations.

The specific objectives of the study were:

1. To determine if there is difference in emergence and yield of wheat using different tillage operations; and
2. To determine the significant difference between the following tillage treatments on yield of wheat
   a. One pass of cultivator with moldboard plow;
   b. One pass of cultivator with rotary tiller (rotavator).
   c. One pass of cultivator with two passes of cultivator.
   d. Two passes of cultivator with moldboard plow.

Materials and Method

The initial tillage experiments was performed in the autumn 1989 at the NWFP Agricultural University farm. The second experiment was moved to a newly-formed field in 1991. Four tillage treatments were replicated three times on plots of 4 m × 90 m.

In October 1989 a randomized complete block design was used, while in the second experiment, conducted in 1991 a completely randomized design was used. The tillage treatments for these experiments were as follows:

First experiment (1989)
- Rotary tiller one pass
- Three bottom moldboard plow + Disk harrow
- Two pass 11 tine cultivator
- One pass 11 tine cultivator

Second experiment (1991)
- Rotary tiller, one pass
- Three bottom moldboard plow
- Two passes 11 tines cultivator
- One pass, 11 tines cultivator

A wooden plank was used in both experiments to level the field. A seed drill of 11 × 9 was used at a planting rate of 99 kg/ha. Fertilizer rate was 124 kg/ha (45% Nitrogen urea). Three normal irrigations were applied to each plot. Four random samples were collected from each plot at the time of emergence after two weeks in both experiments. Yield data were collected at the time of harvest. These samples were threshed and the grain weight was then recorded of each sample separately.

Results and Discussion

Analysis of variance showed that different tillage treatments had no significant effect on the emergence of wheat during the initial test. However, a significant effect ($P < 0.0032$) on grain yield of wheat was observed (**Table 1**). During the second test, the tillage treatments showed significant difference on emergence of wheat seed (**Table 2**) but no significant grain effect was observed on yield. Data on the emergence and yield for both the tests are summarized in **Table 3**.

Wheat Yield (Grain)

The moldboard plow showed the highest yield mean over other three treatments in 1989. The mean yield for the moldboard plow was significantly higher than the rotary tiller, two passes and one pass cultivator, respectively. As such they could be ranked as the best for wheat production. Although the cultivator 2-pass versus 1-pass showed no statistical difference in yield, the former cultivator outyielded the latter by 16.8%. In 1991, the moldboard plow plus disc harrow produced the highest grain yield of 288 g/m^2 and the 2-pass cultivator had the lowest yield of 239 g/m^2. The

Table 1. Analysis of Variance on Wheat Yield, Initial Tillage Experiment, 1989

Source	DF	Sum of Squares	Mean Square	F Value	Pr>F
Block	2	43 407.3	21 703.6	2.9	0.0678
Treatment	3	121 802.1	40 600.7	5.4	0.0032
Error	42	317 538.5	7 560.4		
Corrected Total	47	482 747.9			

Table 2. Analysis of Variance on Emergence of Wheat, Second Tillage Experiment, 1991

Source	DF	Sum of Squares	Mean Square	F Value	Pr>F
Rep	2	3 209.7	1 604.9	2.8	0.0811
Sample	2	262.9	131.4	0.2	0.7996
Treatment	3	6 391.0	2 130.3	3.7	0.0243
Error	28	16 329.4	583.2		
Corrected Total	35	26 193.0			

Table 3. Effect of Different Types of Tillage Operation on Emergence and Yield of Wheat

Tillage operation	Emergence, 1989 (plants/m^2)	Emergence, 1991 (plants/m^2)	Yield, 1989 (g/m^2)	Yield, 1991 (g/m^2)
Moldboard + disc harrow	123.3	86.9	447	288
Rotary tiller	130.2	121.8	418	263
Cultivator 2 passes	96.0	116.7	368	239
Cultivator 1 pass	123.3	108.8	315	263
LSD (0.05)	53.6	17.4	57.5	115.8

moldboard plow plus disc harrow outyielded the rotary tiller by 9.5%; the 2-pass cultivator, by 10%; and the 1-pass cultivator, by 20%.

In 1989 the yield were 20% to 58% higher than in 1991 for all types of tillage implements. The low yield for 1991 and partial inconsistency was observed among the tillage operations, which may be due to the spatial variability inherent in the field.

Emergence of Wheat Seed

The tillage treatments showed insignificant variations in mean values for emergence in the 1989 tests but significant differences were noted for the 1991 tests. The results of emergence for the two experiments which were conducted on different locations were inconsistent within the type of tillage as well as with the yield data.

The location for the 1991 tests might have affected the yield and seed emergence. For example, the field was subjected to leveling and the top soil might have been either replaced or moved to a new location and did not have much time for proper development. Similarly, variability in soil fertility might have been induced. These factors eventually caused inconsistent results between the two location with respect to response to tillage practices.

In conclusion, it is suggested that extreme care should be e xercised in selecting field site for experiments related to tillage operation. Sites with maximum uniformity in physical and chemical conditions will help in evaluating the effect of tillage practices on crop production.

REFERENCES

Afzal, M., U. Mustafa, and T. Ahmad. 1983. Status of Selected Tillage Implement on Progressive Farm in Pakistan. AMA Japan, Vol. 14, No. 2.

Bukhari, S.B., S. Pal, L. Laszlo, B.T. Devrajani. 1981. Performance of Tillage Implement Combination. Summer AMA Japan.

Hussain, K.A, H.M. Munir. 1986. Factors Affecting Choice and Use of Tillage Implement: Pakistan Setting. AMA Japan, Vol.17, No.4.

Hobbs, P.R, et al. 1985. Yield Assessment of Wheat in Rainfed Area of Northern Punjab: Wheat Programme, National Agriculture Research Center. Islamabad.

Karim, Z., A.J. M.S. Karim, A.A. Pahiwan. 1983. Tillage and Irrigation on Water Use by Wheat in Grey Soil o Bangladesh. Vol.14, No.2 AMA.

Khan, B.M., A.R., B.R. Khan, K. Saeed, P.R. Hobbs and N.I. Hashmi. 1990. Effect of Deep Tillage on Grain Yield of Wheat under Rainfed Conditions. Pakistan J. Agriculture Research Vol.11, No.2.

Khan, B.R, Khan, A. Razzaq, M. Munir, M. Aslam, S. Ahmad, N.I. hashmi and P.R. Hobbs. 1986. Effect of Diffeernt Tillage Implements on the Yield of Wheat. Pakistan J. Agriculture Research Vol.7, No.3.

Sharma, D.N., M.L. J.S. Sharma. 1984. Evaluation of No-Tillage and Conventional Tillage Systems. AMA Japan Vol.15, No.3.

Sheikh, G.S. et al., 1983. A Progressive Approach to Minimum Tillage. AMA Japan. Vol.14, No.3.

Some Research Results on Mechanization of Wet-rice Cultivation in Vietnam

by
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The agriculture of Vietnam is considered as basis of the national economy. To develop the agricultural production is one of key programs of the Vietnamese Government. Agricultural mechanization is an important measure, among others, in the modernization of agricultural development. In Vietnam, the agricultural mechanization process has been experienced nearly 30 years and, as a consequence, farmers, contracting services workers as well as various diverse farms has been furnished by millions of horsepowers (from various sources of engines and tractors). Land under mechanized per annum reaches 30% of the total cultivated area; 40% of total cultivated area in fully irrigated and drained. A great part of this energy source has been also spent on processing of agro-products for food and feed, contributing to the change of the social and economical life area.

Climate and land specifications — Vietnam lies in between 8° to 22° latitute and has a humid tropical climate with an annual average temperature of 18°-20°C, the shiny hours of 1 400-1 500 and the relative humidity of 70-80%; the rainy days of 150-160 are distributed irregularly among months **(Fig. 1)**.

Due to complicated topography of the land, and the traditional cultivation technology, it's possible to classify the agricultural zones following different sizes of field plots and different topographical conditions.

The variation of the field plots is Vietnam could be classified into 12 levels **(Fig. 2)**.

The graphs from **Fig. 3** indicate an approximation of a standard distribution. The average length of the field plot in Mekong River delta is 175 m, in the Northern delta: 130 m, and in the coastal area of the Central, 100 m.

In addition, land for cultivation having a slope lower than 12° is concentrated in the mountainous regions of the North, the Western plateau and in the Eastern part of the South. These are the regions under industrial crops (coffee, tea, and rubber tree...).

Particularly, since several recent years, after the implementation of the policy in agricultural management in which farm household is considered as a basic unit, land in agriculture has been shared out into small narrow plots that cause problems in the use of big farm machinery (particularly of the size over 30 kw).

Owing to a controllable system of irrigation the physico - mechanical properties of soils have gradually improved, creating favourable

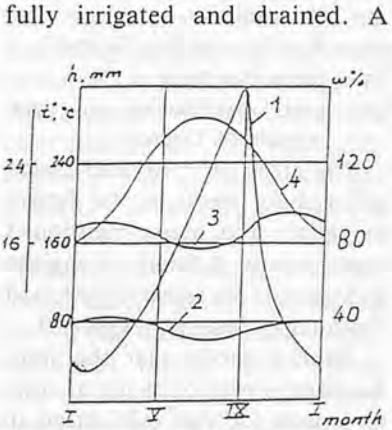

Fig. 1 Variation in rain precipitation (1), moisture evaporation (2), air humidity (3) and air temperature by month in the year.

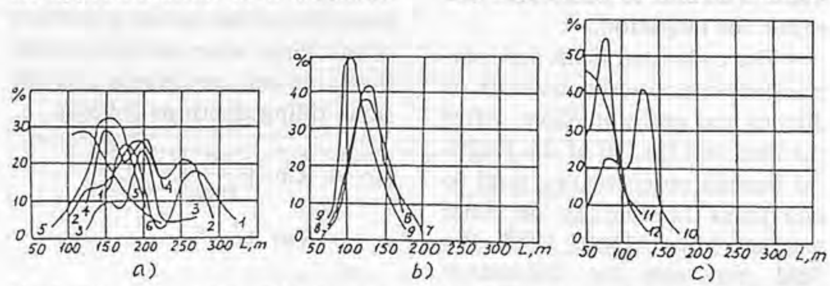

Fig. 2 Distribution of the field plot lengths (a) - Mekong River delta, b) - Red River delta, c) - Coastal area of Central).

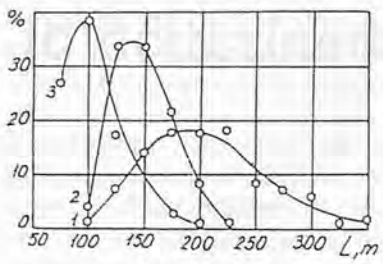

Fig. 3 Distribution of field plot lengths (1 - Mekong River delta, 2 - Red River delta, 3 - Central region).

conditions for aggregates mobilization.

Some studies on soil properties of wet rice fields in Vietnam have shown that soils textures are of multilayer characterized by uneveness of its structure in relation to working depth. The shearing stress and bearing capacity of wet soils are smaller than that of dried soils.

In some areas, soil is swampy with deep mud layer and is under saturated condition. In general, the shearing and bearing resistance of that kind of soil are small, affecting mobilization of tractors and agricultural machines. The stickiness of the soil to working surface of the implements and machines varies with the moisture content and percent of free water in the soil.

The climatic and soil properties of Vietnam require the following conditions for better use of agricultural machinery in rice production:

- The field surface should be level, the gradient should be as small as possible to prevent uneven water level and to make the field easier for irrigation.

- The cultivated fields are complicated with cris-cross network of ditches and paths at edges. After the Decision No. 10 of the Political Bureau on entrusting land to individual households on final product since March 1988, the field plot size for cultivation general, is less than 500 m^2.

- Wet rice requires good seedbed preparation and an eveness of soil surface, therefore it's important to select system of tractors and agricultural machines appropriate for that purpose.

Table 1.

Shape of measurement head	Value of parameters A, m, n in different tilling depths h, m.								
	0,05			0,10			0,15		
	A	m	n	A	m	n	A	m	n
Cone-head with diameter d				34.75	0.045	0.90	2.041	0.346	0.351
Flat wege-shape with working width L	29.82	0.65	0.79	1.136	0.419	0.466	1.367	0.235	11.65

Table 2.

No	Soil hard pan	System of mobilization	a	δ	δ_0
1	Muddy soil with moisture content W = 50 ÷ 50%	- Tractor MTZ-50 + steel cage wheels	0,18	4,10	0,06
		- Tractor MTZ-50 + additional wheels	0,40	5,40	0,09
2	Soil with high moisture content of W = 40% without free water	- MTZ-50 + half caterpillar	0,16	16,00	0,30
		- MTZ-50 + lugcaterpillar	0,26	2,80	0,05
3	Clay soil with moisture content of W = 25 ÷ 35%	MTZ-50 + rubber wheel			
		- dry field after harvesting	0,37	0,85	-
		- dry field after plowing and harrrowing	0,17	3,00	0,04

The above mentioned conditions cause certain difficulties for tractor to maintain its proper operation. The slip of drive wheels increases, adhesion of drive wheels decreases. Sometimes the tractor is sunk too deep causing the lifting of front wheels.

One of the factors relating to the selection of tractors and other power sources is the ditermination of the size of working machines, and the types of lugs of drive wheels. In order to define it, it's necessary to determine the resistance of machines' motion. The researches on the basis of theory of modelling and similitude have defined the motion resistance of machines when working under the same soil conditions and the same tilling depth as follows:

$$Ro = Rm. [\frac{bo}{bm}]^{i+m}$$

$$= Rm.\lambda^{1+m}$$

where:

ho, hm are tilling depths of real machine and of the model, respectively;

Ro, Rm - the resistances of real machine and model, respectively;

λ = bo/bm - similitude ratio.

The experimental measurements of horizontal soil resistance by measured cones of different sizes are given in **Table 1**.

The slip of tractors wheel on wet soil always exist, in order to determine the slip of wheels in relation to the draw-bar pull we extend the use of formular by a "$\delta = (a \cdot \varphi)/(1 - b.\varphi_T^3) + \delta o$": properties of soils **(Table 2)**.

δo - Tractor's slip without draw-bar pull;

$\varphi_T = R_T/G_3$ - pulling factor;

R_T - draw bar pull;

G_3 - load distributing on rear wheels of tractor.

The sizes of cultivated fields still remain small in the future to satisfy the above-mentioned requirements. A family of engines and tractors for rice cultivation in Vietnam is designed **(Table 3)**.

Table 3 shows that the standardized power capacity of tractors used for rice cultivation in Vietnam ranges from 8 to 36 kW. In addition, owing to the policy of entrusting land to individual

Table 3.

Rice cultivation zones of Vietnam	Some characteristics and properties of soils for rice production							
	Length of the field L, m	Specific soils resistance Ko, kN/m^2	Tilling depth a, m	Specific soils resistance over 1m of working width kN/m	Tractive efficiency	Specific working capacity, m^2	Power required, kW	Rated power, kW
Mountains areas	30 ÷ 50	0.35×10^5	0.12 ÷ 0.14	4000 ÷ 6000	0.70	1.24	7.10 ÷ 10.06	8.30 ÷ 12.50
Central-coastal areas	50 ÷ 100	$(0.45 \div 0.50) \times 10^5$	0.12 ÷ 0.14	4800 ÷ 7600	0.70	2.03	15.60 ÷ 22.30	18.40 ÷ 26.30
The Red river delta	100 ÷ 200	$(0.50 \div 0.60) \times 10^5$	0.12 ÷ 0.14	5650 ÷ 8000	0.80	2.91	20.50 ÷ 29.00	24 ÷ 31
The Mekong river delta	150 ÷ 250	$(0.40 \div 0.50) \times 10^5$	0.12 ÷ 0.13	4800 ÷ 6500	0.75	3.50	24.00 ÷ 29.80	27.70 ÷ 35.60

household on final product it is necessary to equip household with simple agricultural machines. Therefore, it is necessary to include small-size engines with power from 4 to 6 kW into the available engine family (both gasoline and diesel).

At present, small sizes engines attached to tractors are popularly used in Vietnam. Tractor such as Lotus - 12, Yz - 12, Zetor - 3011, Yanmar - 220/330, Someca - 215, MTZ50/80 are in operation. Besides, a family of gasoline engines with power capacity from 4 to 6 kW attached to simple multipurpose frame is also in use to serve a large number of households.

Mechanization of land preparation for rice cultivation in Vietnam has begun since 1960. In the beginning years, it was only some technical measures aiming at increasing of wheeled tractor's mobilization on wet rice land. Depending on soil properties the adhesion principle of motion system is classified as follows: "Sinking and floating". In the former case, lugs of wheels acting on soil may be from iron wheels, additional wheels, steel wheels with rubber lugs etc... The latter case is based on the support of additional devices such as floating boat, sliding sheet etc... which can help limit the sinkage of tractors.

One of technical progresses that has successfully been popularized in the past 20 years in Vietnam in rice cultivation is the introduction of tractor MTZ with cage and additional wheels as well as floating boat (**Fig. 4**).

On the basis of theory of modelling and similitude the relation between power consumption and variable parameters (e.g. size of floating boat) is defined by the following equation:

$$Y = -1.193 - 5.63\pi_1 + 3.27\pi_2 - 52.98\pi_3 - 1.19\pi_1.\pi_2 + 11.20\pi_2.\pi_3 + 10.22\pi_1^2 - 0.68\pi_2^2 - 219.80\pi_3^2.$$

Where:

$$r_p = \frac{P}{P.v.B.L} = Y,$$

$$\pi_1 = \frac{G}{P.B.L};$$

$$\pi_2 = \frac{g.B}{v^2}; \quad \pi_3 = \frac{h}{B}$$

P : power necessary for tractor equipped with cage wheels and floating boat;
G - weight acting on boat KN;
B - working width of boat m;
L - length of boat m;
v - linear velocity m/s;
p - soil hardness KN/m^2
g - gravitational acceleration m/s^2

Based on the results gained, a family of floating boats for swampy land has been introduced (**Table 4**).

Depending on particular soil condition, a family of floating boats, cage wheels attached to different sizes of tractors has been introduced contributing considerably to wet rice production in Vietnam. Its scope of application is illustrated in **Table 5**. Besides, a family of small size power tillers has also occupied an important position in agricultural production of Vietnam (approximately 20% of power supplied).

The upgrading of machine's ef-

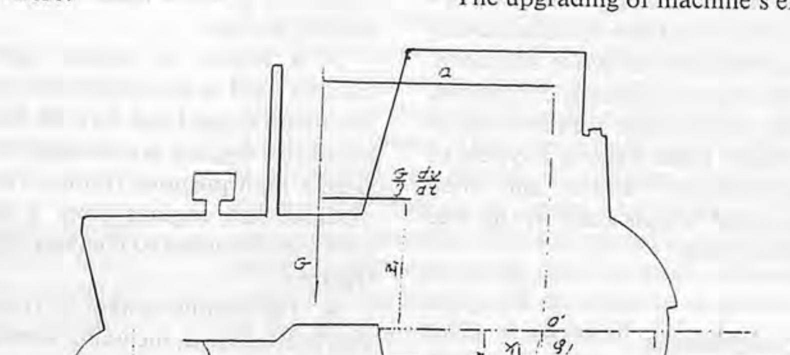

Fig. 4 Tractor MTZ with cage and additional wheels as well as floating boat.

Table 4.

Parameters		Unit	Family of Floating Boats		
			P-0.45	P-0.55 model	P-0.77
Power required,	N	kW	9	14	22.5
Tractor aggregated			YANMAR -220	YANMAR -330	MTZ-50
Tractor draw bar pull		kN	6	9	14
Boat working width,	B	m	0.45	0.55	0.70
Working width of cage wheel,	Bp	m	0.80	0.95	1.10
Distance from the lowest point of drive wheel to bottom of boat,	h	m	0.13	0.16	0.20
Linear velocity,	v	m/s	1.40	1.50	1.65
Load acting on boat,	Q	kN	997	1 510	2 380
Volume of soil done per unit of time,	Q_1	kg/s	349	547	871
Working capacity per hour,	W	ha/h	0.80	1.02	1.31
Specific power consumption					
Over an unit of soil cultivated,	N/Qn	kW.h/t	92	92	92
Over an unit of area,	N/W	kW.h/ha	11.25	13.72	17.55
Pressure on boat					
Over an unit of area,	Q/(B.L)	kN/m^2	850	850	850
Over an unit of working width,	Q/B	kN/m	2 215	2 745	3 400

Table 5. Scope of Utilizing Agricultural Tractors and Their Attached Mobile Wheels in Rice Land Preparation

Soil features	Type of mobile wheels					
	Rubber wheel	Half-caterpillar	Additional wheel	Iron wheel	Cage wheel	Floating boat
Kind of soil	Light sand	Medium clay	Medium clay	Medium clay	Heavy clay	Heavy clay
Mud depth layer, m	—	—	0.20 ÷ 0.30	0.30 ÷ 0.40	0.30 ÷ 0.40	0.40 ÷ 0.60
Water level, m	Dry soil	Moist soil	0.20	0.20	0.40	0.40
Soil compactness at the layer, kN/m^2	(8 ÷ 9).10^4	5.10^4	5.10^4	5.10^4	5.10^4	(2 ÷ 4).10^4

ficiency has been solved in accordance with geographical and soil conditions as well as operational technologies. The criteria for selecting a system of agricultural machines appropriate for each operation of rice intensive farming is the minimum standardized expenditure. Solving these two objectives functions simultaneously can help find effective solutions. Depending on specific conditions, the most suitable solution will be chosen. **Table 5** shows a system of agricultural tractors and their attached wheels used in the Red River delta.

Conclusions

1. In order to increase labour productivity and income of farmers involved in rice production in Vietnam, it is important to carry out an integrated mechanization of all operations of rice cultivation following seeding and transplanting practices.

2. To implement the above stated approach the decisive matter is to carry out a comprehensive research on physico-mechanical properties of soils for rice cultivation in order to help design and manufacture a suitable system of attached machines and mobile devices.

3. A family of engines and tractors used in rice cultivation in Vietnam ranges from 4 to 36 kg. Small size engines are attached to simple multipurpose frames, the medium size engines from 9 to 14 kw are attached to medium size tractors.

4. The mobile system of tractors is diversified, including wheels of high rubber lugs, steel wheels, additional wheels and floating boats that help increase adhesion performance of tractor's wheels and prevent sinkage of agricultural machines.

5. When choosing the structure of machine-aggregates for rice cultivation, it is necessary to take into account the climatic and socio-economic conditions of the developing countries. On the basis of an economic mathematical model using minimum standardized expenditure function and minimum power consumption function, a system of operational machines has been chosen to satisfy the needs of cultivation technology and soil properties. The system of machines is not only suitable for the current needs but also can satisfy to some extent the needs in the next 10-15 years.

REFERENCES

1. Trepenicov I.I. Operational performance of agricultural tractors, M., "Masgiz", 1963.
2. Zanghiev A.A. On the optimization of the working width of machines in combined with various tractors. Messx 7, 1985.
3. Pham Van Lang. Study on the tractor - machine aggregate working in the field of Vietnam. Doctor of science Dissertation.
4. Trinh Ngoc Vinh, Pham Van Lang etc. Research results on the small floating tiller in submerged field with deep hardpan in Vietnam. Scientific report, presented at the meeting held by Science Committee of Agricultural Engineering and Food Industry, Committee of sciences and technologies, Ministry of Agriculture and Food Industry. Hanoi, Aug., 1989. ■■

ABSTRACTS

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

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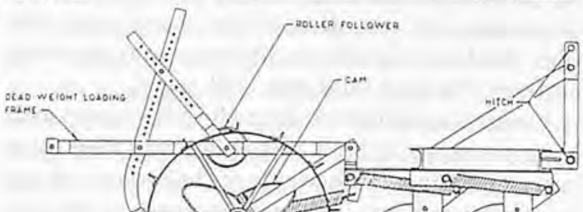
Basin Lister as an Attachment to Tractor Drawn Cultivator: Asokan, D., Assit. Professor; Balasubramanian, M., Prof. and Head; Swaminathan, K.R., Dean, respectively, College of Agric. Engg., Tamil Nadu Agric. University, Coimbatore 641003, India.

A tractor-drawn basin lister **(Figures)** as an attachment to standard nine tyne cultivator was developed and evaluated in the field. The unit was capable of forming basins of size 240 × 30 × 20 cm in three rows. By using the tractor-drawn basin lister 5-6% more moisture could be saved in the clay loam soil in comparing with tilling the soil with cultivator. The effective field capacity of the basin lister was 0.48 ha/h and the operational cost of farming basins was Rs. 130/ha.



SIDE ELEVATION

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Physical Characteristics of Plantain Fruits (Musa AAB cv Agbagba): Nwandikom, G.I.; Asoegwu, S.N., Dept. of Agric. Eng. Federal University of Technology, P.M.B. 1526, Owerri, Nigeria, respectively.

Plantain production is on the increase in Nigeria. Domestic food production statistics of 1985 showed that it ranked third among other major food crops cultivated in the country (Ojo. 1991). But, according to FAO (1981) report, it suffers the highest post-harvest loss due to poor handling and storage condition it is subjected to after harvest. This problem could be solved if there is enough information about its engineering properties.

Again, with the increase in production, it is a potential foreign exchange earner for the country. In this circumstance, the export promotion council should have features, mainly physical or pomological characteristics for standardizing the quantity and quality of the products that should be exported.

The investigation reported in this paper is on the physical characteristics of the bunches and fingers of plantains fruits (cv agbagba). The characters investigated were the weight, axial dimensions, fullness index, fruit curvature, volume, uniformity index and density. Rules of thumb for estimating bunch mean values of some of the characters were established. Also emperical equations relating some of the easily measurable physical characteristics to the more difficult measurable ones were also developed.

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Comparative Economics of Wheat Harvesting and Threshing by Various Means: Ahmad, Ch. Bashir, Senior Subject Matter Specialist; Yamin, Muhammad, Asst. Research Officer, respectively, Farm Management and Farm Economics, Adaptive Research Farm, Sheikhupura, Pakistan.

The present study was aimed determining the comparative economic benefits of various methods of harvesting and threshing of wheat as practiced in Pakistan. Manual harvesting plus mechancial threshing was compared with reaper harvesting plus mechanical thresher drawn by tractor and self-propelled combines deployed for harvesting and threshing of wheat. There was a significant increase in wheat yield by the use of combine instead of manual harvesting or reaper harvesting plus mechanical threshing. The self-propelled combines proved more economical and the most efficient method of harvesting and threshing as compared to the other partially mechanized techniques in vouge in the country at present.

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A Computer Model for Life Cycle Cost Analysis of Biomass Energy System: Ahmad, Munir; Chaudhary, A.P., Senior Engineer, Farm Machinery Institute, NARC, Islamabad, Pakistan; Marley, S.J., Professor; Greiner, T.H., Assoc.

Professor, Agric. Eng. Dept., Iowa State University, Ames, IA, 50011, USA, respectively.

To assist potential users of biomass energy to make wise decisions concerning energy sources, a computer model for life cycle cost analysis (CYCLE) of biomass energy system was developed. The model is also a useful tool for performing parametric analysis of biomass energy systems.

CYCLE was used to perform the life cycle cost analysis of a biomass energy system in use at the Iowa State University McNAY Memorial Research Centre. The effects of various uncertain input variables were also studied.

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Tractive Performance Prediction Using Soil Properties: Guruswamy, T., Head, Dept. of Farm Machinery; Verma, S.R., Professor, Dept. of Farm Power and Machinery, respectively, College of Agric. Engineering, Ludhiana - 141 001 India.

Field investigations were undertaken to evaluate the tractive performance of 35 hp agricultural tractor rear tyre of size 12.4-28.00, 6 ply rating in silty clay loam soils. Tractive properties viz., shear strengh parameters, sinkage co-efficients, cone index, bulk density and soil moisture were measured in a test field with wheat stubbles, ploughed and prepared seed bed conditions in soil moisture range of 13, 16 and 19%. Tractive performance parameters viz., rolling resistance, coefficient of traction and tractive efficiency were predicted using four methods., Bekker's method, Wismer and Luth's method, Brixius's method and NIAE (Mobility number) method and compared with the observed values in the field. The predicted tractive performance parameters by Bekker's method were fairly accurate and agreed with the observed values under field conditions.

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Effect of Various Operational Parameters on the Performance of Hydrostatic Steering System for a Diesel Tractor: Dash, R.C., Lecturer, Das, D.K., Professor and Head, respectively, College of Agric. Eng. and Tech., O.U.A.T., Bhubaneswar - 751003, India; Pandey, K.P., Professor, I.I.T., Dept. of Agric. Eng., Kharagpur - 721302, India.

A hydrostatic steering system (**Figure**) for diesel tractor was designed and developed at I.I.T., Kharagpur in 1986-87. The same unit was taken and mounted on an International B-275 tractor and tested on a hard surface covered with mild grass. The steering efforts were recorded at five levels of front wheel inflation pressure (2.04, 1.90, 1.70, 1.36, 1.02 bar), four levels of forward speed (2.74, 4.32, 6.2, 7.36 kmph), three levels of front axle load (6 036.8, 5 664.4 and 5 292 N) and two levels of toe-in (9.53, 6.35 mm). A single arm steering wheel with two strain gauges mounted on it was used to measure the steering effort. The steering effort of conventional mechanical steering system was also evaluated under similar test conditions. It was found that the steering effort for traditional mechanical steering system was 7 to 12 times higher than that of hydrostatic steering system.

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Study of the Burr Mills in Wheat Grinding: Islam, Md. Nurul, Lecturer, School of Mech. Eng., University Science Malaysia, 31750 Tronoh, Perak, Malaysia.

The performance of stone and steel plate burr mills were experimentally studied and experimental results were compared. Plate clearance was a significant factor for size distribution. In the case of the stone mill, mill speed was found to be a factor of product size variation at low speed up to 700 rpm, but the insignificant difference was observed between 700 and 1500 rpm mill speed.

Fineness modulus was found linearly related with plate clearance of both stone plate and steel plate burr mills. Fineness modulus of the product of the stone plate mill was much less compared to that of steel plate mill product which indicates that the steel plate mill is suitable for coarser product while the stone plate mill is suitable for finer product.

Since the size of the product increased with the increasing plate clearance, the specific energy requirement decreased with the increase of plate clearance. Energy requirement by steel plate mill was significantly less than that of stone plate mill. Of course, the size of the stone plate mill product was comparatively larger.

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Some Physical Properties of Melon (colocynthis citrullus L.): Fashina, A.B., Head of Agric. Eng.College of Agriculture, Ahmadu Bello University, P.M.B., 1058, Zaria, Nigeria; Aboaba, Professor and Head, Dept. of Agric. Eng., Faculty of Technology, University of Ibadan, Ibadan, Nigeria.

The physical properties of three varieties of melon (*colocynthis citrullus* L.), were determined by physical measurements. The parameters investigated were size and shape, surface area, bulk and solid densities of the whole seed, shelled seed and seed shell, respectively.

The length of the three varieties varied between 13.9 and 15.9 mm, the width between 8.3 and 10.4 mm and the thickness between 1.7 and 2.5 mm. The length, widths and thicknesses were significantly different for all the varieties.

The bulk and solid densities of the three varieties at five levels of moisture content were determined. For both density determinations and for all the varieties, the shelled seed had the highest densities, followed by whole seeds, while the seed shells had the least.

284

Energy Forecasting in the Agricultural Sector (A Case Study of developing countries: Indian Union): Panesar, Balwinder S., Graduate Student; Fluck, Richard C., Professor, respectively, Agric. Engineering Dept., University of Florida, Gainesville, FL, 32611 U.S.A.

Energy policy and forecast for agriculture has greater relevance for developing countries as these have predominantly agriculture-based economies and the impact of worldwide energy crisis could be devastating. A model, comprising of time series, unit energy consumption and econometric submodels in a structural framework, have been formulated to help in the selection of proper functional form of these submodels and to forecast energy requirements of agricultural sector. Diesel fuel and electricity forecast for Indian agriculture is 12.66×10^6 t and 86×10^9 kWh, respectively, for the year 2000.

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Water Consumption by Selected Crops and Climatology in Trinidad: Goyal, Megh R.,Professor in Agric. Engineering, University of Puerto Rico, Box 5984, Mayagüez, PR 00681-5984, U.S.A.; Brathwaite, Oscar, Country Extension Agent, Government of West Indies, Trinidad, West Indies.

This paper discusses the climatic data of five weather stations in Trinidad and the potential evapotranspiration with Hargreaves-Samani and modified Blaney-Criddle methods. It presents the estimates of total water consumption by selected crops at five locations in Trinidad. Evapotranspiration range (mm/day) was 3.6 to 4.6 at the University of West Indies, 3.6 to 4.8 at Piarco, 3.6 to 4.7 at Hollis, 3.6 to 4.8 at Navet, 4.1 to 5.3 at Penal.

319

Parameters to Establish Degree of Polish in Punjab Rice Varieties: Thapar, V.K.; Seghal, V.K.; Paul, Shashi, respectively, Dept. of Processing and Agric. Structures, College of Agric. Eng., Punjab Agricultural University, Ludhiana 141004, India.

Brown rice is polished to partially remove the bran so as to improve the whiteness and palatability of the rice with a minimum loss of nutrients. White rice is generally preferred by the consumers. This motivates some of the rice millers to overpolish the coarser varieties resulting in the loss of nutrients, so as to mix it with the fine varieties. Therefore, in order to maintain the quality of the rice, it is very important to polish the brown rice to the required optimum level.

Several methods have been proposed to check the over polishing of the rice grains. These methods can be classified into two main groups. In the first group, the methods estimate objectively or subjectively the amount of outer layer remaining on the starchy endosperm and in the second group, the methods express the chemical or optical character of the milled product. In the present study, an attempt was made to validate some of such methods for selected punjab rice varieties and compare with the established quick and reliable methods which can measure the degree of polish in the available commercial samples.

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Comparative Assessment of Grain Storage Structures in Nigeria and Some Countries in Africa and Asia: Adesuyi, S.A., B.Sc. (Hons.), Ph.D (Agric.) Dip. Agric. Engin. (Silsoe), Fellow, Food Science and Tech., Nigeria Institute, Ibadan, Nigeria. Post-harvest Technology Programme, School of Agriculture and Agricultural Technology, Federal University of Technology, Akure, Ondo, Nigeria.

Grains comprising maize, rice, millet and sorghum are very important agricultural products in the economy of Nigeria. Their roles as food for the citizens, raw materials for agro-allied industries and livestock feed are highlighted. The extent of losses occuring during storage and their causes are dealt with. The types of storage structures available for grain storage are discussed. The traditional storage structures include the native underground storage pits in places such as Bornu and Kano, plinths in the open; the rumbus as the commonest method by which farmers store grains in Northern

Nigeria; and the crib that is extensively used for grain, especially maize storage in Southern Nigeria. The deficiencies of these traditional storage structures and efforts made to solve the problems associated with them leading to the evolution of improved traditional structures are discussed. The use of 200-litre drums for hermetic storage of grains is mentioned. The modern storage structures used in Nigeria and their effectiveness in enhancing the quality of the agricultural products stored in them are critically examined. Such modern storage structures include well-built standard warehouses or stores on medium-to large-scale levels, metal silos both in public and private sectors, concrete and timber silos including the newly designed multi-produce silo by the Post-Harvest Technology Programme in the Federal University of Technology, Akure.

Rubber silos, particularly Butyl rubber, had been tested in Nigeria with unfavourable results, so also are air-houses.

Recommendations for improving food storage in developing countries with particular reference to grain storage structures are made.

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Energy Expenditure of Rural Women for Paddy Cultivation: Parvathi, S., Assist. Professor, Dept. of Bio. Energy; Chandrakandan, K., Professor, Dept. of Agricultural Extension and Rural Sociology; Kumar; V.J.F., Assoc. Professor, Dept. of Farm Machinery, respectively, Tamil Nadu Agricultural University, Coimbatore-641003 India.

A study was undertaken in Thondamuthur block of Coimbatore district in Tamil Nadu to determine the energy expenditure of the rural farm women for different paddy cultivation activities and to suggest suitable measure to reduce their drudgery. It was concluded that the energy expenditure for pulling seedlings, trampling, transplanting, weeding, harvesting and threshing are 2 065, 2 245, 2 500, 2 250, 2 440 and 2 350 K cal/day, respectively. The endurance limit of the subjects for pulling seedlings, weeding and threshing operations was 30 to 35 min. with 50% restpause. Endurance limit for trampling, transplanting and harvesting operations was 15 to 20 min. with rest-pause of 60%. ■■

Royal International Agricultural Exhibition

July 3-6, 1995
Stoneleigh Park, Warwickshire, U.K.

The Royal International Agricultural Exhibition, Europe's premier exhibition of farming, food and the countryside, has been extensively restructured for 1995 in one of the most significant and far-reaching developments in the Exhibition's 155-year history.

Fundamental to the change is the concept of a series of specialist exhibitions - shows within a show - based on the Royal Agricultural Society of England's proven, highly successful technical events formula. By working in close consulation with exhibitors, visitors and relevant organizations, the RASE has developed a series of themed, specialist areas, each supported by technical demonstrations, exhibits, trade stands and displays from key organizations.

The new structure of the Royal International Agricultural Exhibition will ensure that exhibitors and the audience they wish to meet are brought together. Separate marketing plans have been developed for each area to ensure that visitors can quickly and easily target their area of particular interest; innovative new features will be used to draw in new customers; and new rest, information and refreshment areas have been developed to ensure visitors can use their time most efficiently.

Saudi Agriculture 95 14th Agriculture Water & Agri-Industry Show

October 8-12, 1995
Saudi Arabia

The show will take place 8/12 October, 1995 at the Riyadh Exhibition Centre.

Saudi Arabia's commitment to further agricultural development, upgrading and expansion of its existing infrastructure and new project investment continues to provide a dynamic market for international manufacturers and suppliers of agriculture technology.

Fresh opportunities are also being created by new government policies aimed at encouraging diversification from wheat to barley, increasing productivity of high value crops, expanding meat and vegetable production and improving quality of output.

In line with new priorities **Saudi-Agriculture 95** will also highlight water technology with the introduction of SaudiWater-Tech. Skilled water management is vital to Saudi Arabia's agricultural future and plans are being introduced to conserve supplies at the same time ensuring theat food production targets are met. Food processing will also be highlighted with the introduction of SaudiPro-Pak. This is in answer to Saudi Arabia's growing output of agricultural produce which farmers are marketing increasingly to the food trade network both at home and overseas.

Contact: Overseas Exhibition Services Ltd., 11 Manchester Square, London W1M 5AB UK. Tel: +44-1714861951, Fax: +44-1719358625.

"AGRITECHNICA '95"

International DLG Exhibition for Agricultural Machinery
Nov. 14-18, 1995
Hanover, German

Shortly after the closing date for stand applications it is already clear that there will be a high level of participation by agricultural machinery manufacturers from Germany and other countries in the International DLG Exhibition for Agricultural Machinery "AGRITECHNICA '95", to be held from 14 to 18 November 1995. According to the information supplied by the organizer, the German Agricultural Society (DLG), the world's leading companies in the trade - including all the multinational manufacturers of tractors and agricultural machinery - will be represented at the exhibition. Some 1 000 firms, including about 35 percent from abroad, are expected to share the gross exhibition floor space of 130 000 m^2. In addition to the large joint community participations already registered from France, Italy and the Netherlands, joint community participation by firms from the USA is planned for the first time. "AGRITECHNICA '95" thus impressively emphasises its leading position in Europe as world market for agricultural machinery.

"AGRITECHNICA" has been held five times in Frankfurt am Main since 1985. On the grounds of the far-reaching changes in the agricultural sector in west Germany, the reunification of Germany and the changes in central and eastern Europe, the 1995 exhibition will be held for the first time at the Fairgrounds in Hanover. Hanover is located at the heart of important European arable farming areas with a large number of key investment regions.

Further information about "AGRITECHNICA '95" is available from the German Agricultural Society (DLG), Eschborner Landstrasse 122, D-60489 Frankfurt am Main, telephone + +49/69/24788-0 or telefax + +49/69/24788-110.

4th Asia-Pacific Resional Conference

Nov. 20-22, 1995
Ginowan, Okinawa, Japan

The 4th Asia-Pacific Conference of

the International Society for Terrain Vehicle Systems is to be held from 20-22 November, 1995 at the Okinawa Heights, Ginowan, Okinawa, Japan.

This conference is sponsored by the Japanese Society for Terramechanics, etc.

The primary objectives of the conference are to provide opportunities for engineers active in terramechanics to exchange their experiences, ideas, to stimulate discussions and also to promote advancement on all aspects of the research, design, development and operation of vehicles and machinery for use in agriculture, earthmoving, construction and transportation.

International Conference on Rational Use of Renewable Energy Sources in Agriculture, in Connection with the Environmental Control

June 2-7, 1996
Budapest, Hungary

Contact: Conference Secretariat, Hungarian Society of Agricultural Sciences (MAE) H-1055 Budapest, V., Kossuth L.tér6-8, Hungary

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Fifth International Congress on Leaf Protein Research

June 17-21, 1996
Rostov-on-Don, Russia

The Fifth International Congress LEAFPRO-96 on Leaf Protein organized by the Russian Federation State Committee on Higher Education, Ministry of Science and Technical Politics of the Russian Federation, Russia's Academy of Sciences, Russia's Academy of Agricultural Sciences, Russia's Academy of Technological Sciences (the South Russia's Branch), the North Caucasian Scientific Centre of Higher School, the Don State Technical University and the International Society for Green Vegetation Research (SGVR, Australia).

Prior four international forums on leaf protein were held in India (1981), Japan (1985), Italy (1989), New Zealand (1993).

LEAFPRO-96 will be held at the Don State Technical University from June 17 to 21, 1996. The town of Rostov-on-Don is the largest industrial, scientific and cultural centre in the South Russia with the population exceeding 1.2 million.

The programme will focus on the opening and closing ceremonies, working sessions, poster sessions, a video session, technical tours to the out-of-town experimental complex of the Don State Technical University and also to the leaf protein production facilities.

Contact: Mr. N. Proydak, President of SGVR LEAFPRO-96 Organizing Committee, The Don State Technical University, 1, Gagarin Square, Rostov-on-Don 344010, Russia, Telephon: 7 863 2 32 03 17; 7 863 2 38 15 87 Fax: 7 863 2 32 03 17; 7 863 2 32 79 53; 7 863 2 34 53 55.

International Conference on Agricultural Engineering

September 23-26 1996
Polythecnic University, Madrid, Espain

The EURAGENG Conference AgEng'96 in Madrid is organised by the CEIR and the Polythecnic University of Madrid. Its aim is to present the latest developments and future directions in agricultural engineering research in Europe and in the rest of the world.

Contact: Prof. Jaime Ortiz-Canavate, E.T.S. Ingenieros Agronomos, Ciudad Universitaria. 28040 Madrid-Espain Tel: 34-1-336 5852, Fax: 34-1-336 5854.

Short Courses at Silsoe College

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9 April - 5 May 95 — Agriculture & Food Development through Enterprise - Joint programme with School of Management

October 95 — Postharvest Technology of Grains, 10 week continuing professional development programme

27 Nov. - 1 Dec. 95 — "Postharvest Technology and Commodity Marketing" - Conference in Accra, Ghana with Exhibition of Agriculture, Irrigation, Forestry and Food-Processing Equipment

January 96 — Postharvest Technology of Fruit, Vegetables and Root Crops, 10 week continuing professional development programme.

Contact: Mrs Gill Burrows, Continuing Professional Development, Cranfield University, Silsoe, Badfordshire MK45 4DT, England Tel: 0525 863349 Fax: 0525 863344.

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The IAMFE/CHINA '94 Conference and Exhibition

October 17-20, 1994
Beijing, China

The Ninth International Conference on Mechanization of Field Experiments was successfully arranged and carried out at Beijing Agricultural Engineering University (BAEU) on Oct. 17-20, 1994. This was the first time an international conference on mechanization of field experiments has been held in the P.R. of China. The conference has very successfully contributed to the exchange and discussion of new academic ideas by means of displaying materials and graphs, machinery demonstrations and consultative technology cooperation. The event was well received by the agricultural authorities of China.

Plant breeding in China. IAMFE was established 30 years ago. Since 1964, LAMFE has been successful in it's aim to improve the mechanization level in plant breeding and to promote the contacts between engineers and breeders all over the world. However, in Asia the progress has gone slower. Not until 1978, China introduced foreign equipment and started to manufacture a few self-designed machines. Since then the plant breeding efficiency has been greatly improved.

To little attention was paid to spread this achievements through out the country. The LAMFE/CHINA '94 conference, the first international conference of its kind in Asia, is an important milestone in the development of plant breeding and industrial processing within China. Two big companies, Hege and Wintersteiger, have signed intentional contracts with Chinese manufacturers. Technical and commercial contacts with other manufacturers will follow.

The Conference attracted 130 participants. 30 of these came from 16 countries outside China, namely Austria, Denmark, France, Germany, Hungary, Japan, Lithuania, The Netherlands, New Zealand, Norway, The Philippines, Sweden, United Kingdom, Uruguay, USA and Yugoslavia. It was sponsored by the International Association on Mechanization of Field Experiments, General National Seed Station of Ministry of Agriculture, P.R. of China, Beijing Agricultural Engineering University, Chinese Society of Agricultural Engineering, etc..

Presentation of papers took place during 3 days, Monday-Wednesday Oct. 17-19. 34 papers were presented and discussed. During the presentations, the Chinese speeches were translated to English and vice versa. The participants exchanged their ideas and views both on conference and free times. The need for mechanization of field plot operations was highly recognized.

The Proceedings consists of 432 pages and includes 68 of the more than 70 papers in a wide range of topics that were submitted to the Conference. It consists of seven sections: 1) Basic and Methodical Questions, 2) Theoretical Questions, 3) Plot Drills and Planters, 4) Harvesting of Cereals and Other Crops, 5) Seed Processing, 6) Instrumentation, Computer Technology and Simulation and 7) Plot Preparation and Other Technology. All participants of the conference received a copy upon registration. The Proceedings has also been mailed to all members of IAMFE.

The Machinery Exhibition and Demonstration was visited by several hundreds of persons besides the participants of the conference. The Exhibition was open from Monday to Wednesday. On Tuesday a demonstration in the field was organized. The German manufacturer Hans-Ulrich Hege and the Austrian manufacturer Wintersteiger showed parts of their range of seeding and harvesting machinery. The English manufacturer Massey Ferguson, the Dutch manufacturer Selecta and the Finnish factory Wilson were also represented. The Chinese Kelian Agricultural Machinery Factory demonstrated their five kinds of machinery and tools for use in field plot operations. Also Shanxi Hydro-Machinery factory, Beijing Changyang Agricultural Machinery Factory, BAEU, Hebei Agricultural University, etc., displayed seed processing equipment and field plot machinery.

Monday, Oct. 17. Opening of the Conference and Exhibition. This was a ceremony of very high standard. Two former Deputy Ministers of Agriculture of China, Mr. Liu Peizhi and Prof. Wang Lianzheng honored this occasion with speeches. The other speakers were: Mr. Wang Keping, Chairman of the Organizing Committee for IAMFE/CHINA '94, Prof. Weng Zhixin, President of Beijing Agricultural Engineering University and Mr. Egil Øyjord, President of IAMFE. The Embassy of Israel was represented. After a busy day with keynote speeches, a welcome dinner for the participants was organized.

Tuesday, October 18, was great day with demonstrations of plot research equipment. After lunch the Conference continued with keynote speeches. At night the Organizers arranged a friendship party with excellent entertainment by the students of the University, good music and dance.

Wednesday, Oct. 19. Closing of the Conference. Establishment of the IAMFE Chinese Branch. After another busy day loaded with keynote speeches, it was time for the evening banquet for celebration of the 30th Anniversary of IAMFE and the closing of IAMFE/CHINA '94. The President of Beijing Agricultural Engineering University, Prof. Weng Zhixin, announced that an IAMFE Chinese Branch will be established. A Preparatory Committee with Prof. Guo Peiyu, Vice President of Beijing Agricultural Engineering University as Chairman, was established during the Conference. The IAMFE Chinese Branch will follow the aims of IAMFE and work hard to develop high-yield, high-quality and efficient agriculture in the P.R. of China.

The Deputy Minister of Agriculture of the People's Republic of China, Mr. Liu Cheng Guo, presented to the founder and President of IAMFE, Mr. Egil Øyjord, a meaningful plaque with inscription and thanks from the Organizing Committee of IAMFE/CHINA '94 for his outstanding contributions for mechanization of field experiments during 30 years, and especially to China. Representatives of the Norwegian and the French Embassy in China conveyed their congratulations to Mr. Øyjord. The Representative of The French Embassy invited the participants to the IAMFE/FRANCE '96 Conference and Exhibition at the INRA Centre in Versailles. The President of IAMFE, Egil Øyjord thanked for the great honor shown to him. He thanked all who had worked for the success of IAMFE/CHINA '94 and expressed his wish to continue his co-operation with China.

Thursday, Oct. 20 — Sunday, Oct. 23. The conference participants visited the Agricultural Museum in Beijing. Post conference visits were arranged to The Forbidden City, Temple of Heaven, The Great Wall and The Summer Palace. Saturday night, a banquet for the Organizing Committee and the helpers of IAMFE/CHINA '94 was given by the President of IAMFE.

[Authors: Prof. Guo Peiyu, Vice Chairman of LAMFE/CHINA '94 and T. Leuchovius, Executive Secretary of IAMFE]

UNACOMA Press Conference on Italian Agricultural Mechanization in 1994

"We can consider 1994 a satisfactory year as far as tractors and agricultural machinery is concerned, quite a good year for gardening equipment, and not entirely negative for earth-moving machinery." Alfredo Celli, president of UNACOMA, summed up the year this way during the press conference held for journalists at the Economic Documentation Centre, illustrating a variety of data concerning production, the national market and imports and exports in the field, wrapping up the past year.

Production of tractors, agricultural and gardening machinery in 1994 is estimated at 690 000 tons, for a value of 7 890 billion Italian liras, for an increase in weight of 9% and in value of 14.5% compared to 1993. Breaking down the equipment into principle types, 59 500 tractors were produced (up 8%), 95 800 self-propelled agricultural implements and machines (up 12%), 113 900 engines (up 9%). Agricultural implements showed an average increase of 10% with respect to 1993 results. As far as gardening machines are concerned, an overall production worth 900 to 1 000 billion Italian liras has been calculated, with an increase of 15% over the past year.

Within the sectors represented by UNACOMA, earth-moving machinery is also included; overall production was 310 400 tons in 1994 (up 3.5%), for a value of 2 760 billion Italian liras (up 8%).

The national market, according to UNACOMA statistics calculated on the basis of information provided by manufacturers, counted 26 000 new tractors (25 610 in 1993), with a slight increase (of 2/3%), a result which must be seen in perspective of the considerable slump which has lasted for several years; consider, for instance that 40 000 new tractors were registered in 1989. The total fleet of tractors in use as of Dec. 31, 1994 is estimated at 1 486 000 units.

On the other hand, according to Ministry of Agriculture, Food and Forestry Resources data - which refers to the total registration of vehicles for which a request for detaxed fuel has been filed - the number of tractors registered in 1994 was 27 700 (27 370 in 1993), the number of combined harvesters was 453 (against 439 in 1993), the number of transporters and other multi-purpose farm vehicles was 3 049 (down from 3 176 in 1993).

As far as the remaining categories of machines (walking tractors, motor mowers, motor hoes and other machines and engines) are concerned, Ministry of Agriculture, Food and Forestry Resources data cannot be directly compared to previous years, since price facilitations for petrol were suspended in 1994, eliminating registration of a number of these machines.

We may opportunely consult UNACOMA data for this field; it indicates an increase of 12-13% for transporters and other multi-purpose farm vehicles and motor hoes, and a drop of around 10% for walking tractors and motor mowers. Engine production was also on an upswing (11%), while other farm machinery held steady or showed a slight increase.

Data on exports was very positive: ISTAT (the Italian Central Statistics Institute) reports an average increase of 22% over the first nine months of 1994 (tractors up 17% and agricultural machinery up 25%), for a total of 2 197 billion Italian liras, and a profit on the balance of trade for this category of 1 714 billion Italian liras (up 26%). We must point out that ISTAT export data is underrated by at least 100 billion liras, since many types of agricultural equipment are classified under customs categories which include other industrial machinery (like the pumps, for instance), and cannot be examined separately.

Expectations for 1995 - Celli affirmed - should be in line with 1994 performance, not only as an effect of the devaluation of the Italian lira - which has increased the competitiveness of Italian products - but above all thanks to the flexibility of Italian production, the technological validity, compliance with safety standards, and guarantee of reliability for the machine operator.

Computerized Finder System Available for Articles on Engineering in Agriculture

A computerized index of technical articles in agricultural engineering periodicals — along with searching software — is available without charge from W.J. Chancellor (BIOAGENG @UCDAVIS.EDU).

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Insect Pests of Rice

(Philippines)

edited by M.D. Pathak and Z.R. Khan

Rice is attacked by more than 100 species of insects, 20 of which can cause significant economic damage. Average yield loss due to various insect pests in Asia—where over 90% of the world's rice is grown—is about 20%. Any decrease in pest damage means a corresponding increase in much-needed rice production.

Any reduction in insect pest damage must come from incorporating genetic resistance into new genotypes, and from the development of suitable cultural and biological control methods.

1994. 89 pages. 21.59 × 27.94 cm. Paperback. HDC US$30.00, LDC US$8.00 plus airmail (US$6.00) or surface (US$1.50) postage.

This book is available from Communication and Publications Services, IRRI, P.O. Box 933, Manila 1099, Philippines.

Neem Pesticides in Rice: Potential and Limitations

(Philippines)

edited by Lim Guan Soon and Dale G. Bottrell

IRRI started research on botanical pest control in rice and rice-based cropping systems in the late 1970s. The research focused mainly on neem tree products, and involved close collaboration with national institutions in many Asian countries, and with the International Centre of Insect Physiology and Ecology, Nairobi, Kenya.

This book reviews the status and prospects of pest control using neem in rice-based cropping systems in developing countries, with special emphasis on its potential and limitations in IPM programs. Results reported in this book show that neem adversely affects some nontarget organisms but does not affect others.

1994. 69 pages. 15.24 × 22.86 cm. Paperback. HDC US$10.00, LDC US$3.00 plus airmail (US$3.50) or surface (US$1.50) postage.

Rice Roots: Nutrient and water use

(Philippines)

edited by G.J.D. Kirk

The rice plant invests up to 60% of its energy as carbon in its root system. Our understanding of the rice roots and their function in the capture of nutrients and water lags well behind our understanding of the rest of the plant.

This is particularly so for rice, compared with other cereals, because the rice plant's ability to grow under waterlogged conditions arises from morphological and physiological adaptations in its roots.

As part of the last International Rice Research Conference, a symposium on rice roots and the uptake of nutrients and water was held to review present knowledge and to make recommendations for future research.

This publication contains selected papers from that symposium.

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Proceedings of the International Agricultural Engineering Conference

(Thailand)

edited by V.M. Salokhe and G. Singh

The International Agricultural Engineering Conference was organized at the Asian Institute of Technology, Bangkok, Thailand from 6-9 December 1994. The objective of this conference was to bring together scientists, engineers, researchers and experts in various disciplines of agricultural engineering for formal presentation and discussion on topics of relevance in the coming years.

The proceedings of this conference contain one hundred and three technical papers contributed by scientists from over twenty three countries. The proceedings contain over 900 pages and are divided in two different volumes.

Vol. I: Farm Power and Machinery, Post Harvest and Biotechnology

Vol. II: Soil and Water Engineering, Agricultural Systems, Agricultural Waste Management, Electronics and Computers in Agriculture, Ergonomics, Energy in Agriculture, Structures and Environment

The proceedings are available for sale. The cost of one set of proceedings (2 volumes) is US$200 (inclusive of air mailing charges). The orders can be placed, with a payment by bank draft or cheque payable to "Asian Institute of Technology", with:

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Growth and Mineral Nutrition of Field Crops

(USA)

edited by N.K. Fageria, V.C.Baligar and Charles Allan Jones

Emphasizing soil as the substrate

for plant growth, this volume examines climate-soil-plant relationships governing growth and mineral nutrition of most vital temperate and tropical field crops around the world-including cereal, legume, and pasture crops. This work also reveals the practical applications of new concepts and principles via discussions on modern agricultural practice and presentations of experimental evidence.

Showing how a simulation model of crop growth and soil fertility elucidates the overall requirements of a given plant species, this guide covers recent knowledge of genetic, physiological, and agronomic bases of crop growth, nutrient uptake, and use efficiency... plant and soil processes and socioeconomic factors that constrain or enhance crop production... conservation tillage and organic farming useful for Low Input System Agriculture and similar systems... and more.

Published by Marcel Dekker, Inc., 270 Modison Avenue, New York, New York 10016 U.S.A.

Stored-Grain Ecosystems

(U.S.A.)

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edited by Digvir S. Jayas, Noel D.G. White and William E. Muir

Providing a complete overview, of grain storage systems, this comprehensive reference takes a multidisciplinary approach to grain storage research—applying knowledge from the fields of biology, cereal chemistry, economics, engineering, mathematical modeling, and toxicology to the study of the complex interactions among physical and biological variables in stored-grain bulks that cause the deterioration of stored grain.

Covering grain storage practices in subtropical, tropical, and temperate climate regions, **Stored-Grain Ecosystems** details the prevention and control of pests and contaminants, including live insects and mites, insect fragments, microflora, mycotoxins, and pesticides... discusses how expert systems can use models to predict when insects or molds will become a problem in stored grain... outlines postharvest loss reduction activities for several developing countries... evaluates physical methods for the control of insect populations in stored-grain ecosystems... summarizes the geometrical, thermal, hygroscopic, and mechanical properties of both bulk grain and single grain kernels... reviews mathematical models of heat, moisture, and gas transfer in stored-grain ecosystems... examines the various species of insects that infest stored rice and the damage they cause... and more.

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Proceedings of the FPAC III Conference

(USA)

This proceedings, sponsored by the Food and Process Engineering Institute, a unit of ASAE, examines the changing technologies of food processing, food equipment manufacturing, food handling and university/government programs.

Experts from around the world and from many various backgrounds will deliver the practical, technical knowledge you can use in your work. Learn the latest global trends in food process automation in areas such as sensor technologies, automated inspection systems and computer-operated controls. Investigate ways to improve information transfer between food processors, food equipment manufacturers, food handlers and university/government personnel.

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j. Convert national currencies in US dollars and use the later consistently.
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