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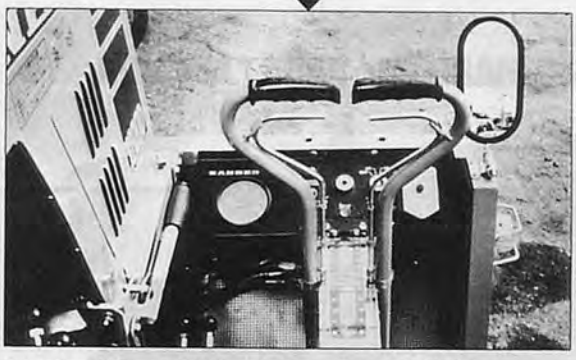
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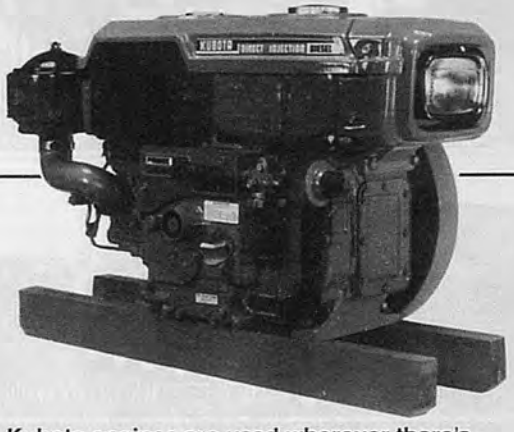
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Editorial

Research and Its Use

The topic or issue is not entirely new. As a matter of fact, it is as old as research itself – be it in agricultural mechanization or other disciplines. It is not uncommon for the rank and file of researchers to do research for research's sake. Even some scientists fall easy prey to the temptation of undertaking research only as a means of "inflating" their *curriculum vitae* with little or no regard as to whether the results of their research efforts filter down to or have any sue and meaning for the end-user farmers or just gather dust in a display shelf.

What is new in this editorial, however, is a renewed call or challenge to agricultural mechanization researchers, especially AMA's contributors and readers who are mostly on the staff of universities or research institutions to underscore the urgent need for farm-oriented research that is not only squarely addressed to the farmers' needs and problems but are also made available to the latter. And, of course, making the research available to the farmers necessarily means "watering down" the research language and its implications to a version that is understood by the farmers. This also means that researchers should work more closely with such allies as communication specialists and the agricultural extension service in treating the research results and bringing these to the farmers' level. This process is otherwise known as technology transfer: from the laboratory to the farmer.

The AMA receives annually more than a hundred articles for publication from all over the world. The editorial staff notes every now and then that the use of those articles could be enhanced if they are prepared in such a manner that they have meaning and use for farmers. Put in another way, most of the unpublished articles could have found themselves into print have they been prepared with the objective of filling in felt needs of the farmers.

The AMA editorial staff, henceforth, will make every effort to publicize as many articles in an issue – much more than it has done in the past – if only to promote the conduct of useful research among our contributors and readers. This means that AMA pledges to popularize more and more deserving articles in the interest of continued cooperation in the furtherance of agricultural mechanization.

Yoshisuke Kishida
Chief Editor

April, 1984
Tokyo

Reorientation of Agricultural Mechanization for Developing Countries

Part 2. Result Demonstration—An Effective Teaching Tool

by
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Abstract

A Result demonstration is our most effective tool for teaching the advantages and disadvantages of improved equipment compared with the conventional. The comparison is side-by-side in a farmer's field. Field practices are conducted by the farmer. Details of how to do it, data to be taken, and analysis are presented.

Introduction

There are mainly two kinds of demonstrations, "Result" and "Method." This paper covers the "Result" type. It is intended primarily for the extension specialists but can also be used with few modifications by researchers.

The result demonstration is one of the oldest forms of teaching (1). However, it has not been widely used by Agricultural Engineers and those concerned with advancing mechanization, particularly in the developing countries. On the other hand, our colleagues have. For example, the agronomists demonstrate the value of a new wheat variety against the native. Why not machines?

Simply stated, a result demonstration proves that a new machine is practical when used by a farmer on his farm. The authors proved this type of demonstration to be effective in India in the 1960's, using a seed drill. One result was that administrators and others realized the value of a machine in increasing yields and production. Is there a better teaching technique?

Ten Basic Requirements

Ten basic requirements are necessary in conducting a true result demonstration. They are as follows:

(1) Two plots of farming land side by side (usually a field is divided in half), each identical as possible in size, shape, soil type, drainage, natural fertility and physical situations around their boundaries, as, for example, no trees.

(2) One plot (control) is farmed by using the farmer's existing practices, and the other the "improved" practice(s). In mechanization the new machine and method of operation is the improved practice to be demonstrated.

(3) The two adjacent plots must be on a privately owned farm. Any comparison of selected operations on an experimental farm must be considered as being in the research phase and conducted under distinctly different circumstances and purposes.

(4) The farmer and/or his laborers must perform all of the field operations on both plots and must participate in the taking and

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Note: Part 1 of this paper appeared in AMA, Vol. 6, No. 2, Autumn, 1975 of which an Update was prepared by Prof. Giles and accompanies this report.

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Neil A. Dimick, Agricultural Engineering Advisor, U. S. AID, Egypt, previously in Pakistan. Prime Architect of precision land leveling program in Pakistan.

Dr. B. A. Krantz, Soil Specialist Emeritus, University of California, Davis, USA, previously Principal Agronomist and Leader, Farming Systems Research Program, ICRISAT, India. One of the pioneers to the systems approach.

recording of data.

(5) All operations on both plots must be carried through the final yield stage, including the harvesting, weighing and recording the yields.

(6) The Result Demonstration can consist of one machine variable, say the use of a modern grain drill, or more than one, involved in one crop or a multiple crop system.

(7) All similar operations on both plots must be carried out the same day. For example, both plots must be harvested and the product weighed separately the same day.

(8) A demonstration involving two adjacent plots for comparison must be repeated on four or five farms in the same general farming area. This replication is a requirement for making a statistical analysis.

(9) A statistical analysis of the data would be desirable, especially on the yield data, to determine its validity. One can then say with confidence how the machine will affect yields and other measurable values.

(10) If the statistical analysis reveals significant results, then a cost-benefit analysis should be made.

An Effective Teaching Tool

Why is the Result Demonstration such a good teaching tool?

It convincingly reveals all of the benefits and disadvantages of the improved mechanical operations on the farm. The results are comprehensive, comparative, on-the-farm, carried through the final yield stage, and provide valid data plus an economic analysis and farmer appraisal. Since the farmer operated the machine(s) on his farm, he can see, accept and have confidence in the results. As is frequently said, "seeing is believing." Neighboring farmers and visitors can also all witness the results.

Secondly, it teaches the designer, developer, dealer, extension specialists, etc., the subjective and the objective advantages and disadvantages of the machine (s) and its performance. All of these specialists should be involved in some aspect(s) of the demonstration.

Not for All Machines

Some machines are well adapted to a result demonstration while others are not. In Fig. 1, a newly-developed "ICRISAT" machine can be compared successfully, side by side, with traditional equipment for handling the crop residue and forming a bed (2). On the other hand, in Fig. 2, a cultivator is shown working one crop among many being grown in a cropping system that involves an entire natural drainage basin or catchment area (2). All of the surface water in this area drains to one point to be retained and utilized. The size of the area may be 10 ha or more. It is almost impossible to conduct a valid side by side comparison of the main system. Even if possible, a side by side comparison would reveal only the composite results of the entire system. Initially, ICRISAT evaluated segments of the system to obtain preliminary information. These small replicated experiments showed that higher yields could be achieved with improved soil and water management practices (3). However, no mention is made of such experiments involving a machine as the variable.

Where entire fields and areas are not and cannot be side by side, there are other ways of getting valid results. An example is a case study by Johnson III et al. in Pakistan (4). Twenty-four pre-



Fig. 1 The machine in the picture *is adapted* to a result demonstration. It reforms a broad bed immediately after harvesting pigeon-pea, in multi-cropping, and concentrates organic residues in the root zone of the next crop. Traditional equipment would uproot stubble. (From ICRISAT Annual Report 1977-78).



Fig. 2 The machine system involing an entire water catchment basin *is not adapted* to a result demonstration. Side-by-side comparisons of the total system on a basin area of 10 ha or more are almost impossible.

cision-leveled fields were studied against 26 traditionally-leveled fields. The results were secured by using regression analysis. They showed significant increase in yields for the precision-leveled fields.

The above case is cited because precision land leveling can only be accomplished on a practical basis by machines with long wheel bases, and, of course, operated in rather large fields. Nevertheless, land leveling offers one of our great opportunities for advancing mechanization.

Dimick (5) says that "land leveling is a foundation upon chich advanced mechanization must be built." Keep in mind that this includes yield intensive machines along with labor intensive crop production systems. Dimick is, of course, thinking of leveling to a precise grade for

row irrigation and surface drainage, combining fields, etc., as well as flood irrigation.

Two Examples

Two examples of a true result demonstration are summarized below.

Example No. 1

The authors in the early 1960s in India undertook a result demonstration on a machine (6) to show "how to do it," and prove how much the use of a machine affects yields and economic benefits. In this sense the demonstration is worth redescribing, however, old.

A seed-fertilizer drill for wheat was selected as the machine. Why? The popularly called "Package Program," involving major agricultural specialists, was having trouble achieving good wheat stands and yields in the demonstration districts. The machine's contributions were as follows:

(1) Uniform seeding and fertilizing rates that could be varied easily;

(2) Simultaneous and precision side placement of the seed and fertilizer;

(3) Uniform and precise placement of the depth of the semidwarf Mexican wheat seed, about 3.75 cm;

(4) Minimize loss of soil moisture in the seeding and fertilizing operations (only one operation);

(5) Pressing of the soil around the seed when planting under non-irrigated conditions;

(6) Provide immediate and correct dosage of phosphate for early root growth. No burning due to the nitrogen being included in the fertilizer mixture; and

(7) Increase the utilization efficiency of the fertilizer by its precision placement in the root zone.

The machine principles to accomplish the above were well known. These principles were combined into one, three-row machine within the draft power capability of a pair of bullocks. The machine was evaluated particularly in terms of yields changes compared with the traditional country plow method.

Some 60 result demonstrations gave an average of 12.5% increase in wheat yield (6). **Fig. 3** illustrates the visual difference in yields. Such a sight is quite convincing—an excellent teaching technique. At the prevailing prices a farmer who used his drill on 6 to 8 ha earned the cost of the drill. Successful with animal power, these same machine principles were subsequently adapted to the tractor.

Today there are more than 10 manufacturers of seed and fertilizer drills in India (includes both animal and tractor units) (8). Each manufacturer's model undoubtedly has unique features in conformation: metering device, soil opener, adjusting mechanism, etc. And that is the way it should be.



Fig. 3 An early field trial of a three row modern drill (center 6 rows) in Aligarh District, India, dramatically shows the improvement of the wheat crop. Traditional seeding and fertilizing methods were carried out on both sides.

Example No. 2

This involves a modern one-row precision planter with fertilizer placement (**Fig. 4A**). It was selected because (1) the visual effects are striking, (2) the performance are included herein as examples, and (3) it teaches what to do when the controls fail.



Fig. 4A A modern one-row seedplanter with side-placement of fertilizer used to plant maize in a result demonstration.



Fig. 4B The control, a country plow with a seed tube and funnel. Fertilizer was broadcast by hand.



Fig. 4C The visual side-by-side comparison of one replication, taken prior to maturity. Right is the result using the new planter (A). Left is the control (B). Aligarh Distirct, India. (1965).

The "control" for this 1965 result demonstration was the same as for the drill (**Fig. 4B**). Fertilizer was hand broadcast conventionally.

Eighteen replications on planting maize in Aligarh District gave an average increase of 40% (7). However, the yield data was not statistically significant.

Nevertheless, this precision planter offers without question a great opportunity to increase yields. So what should one do when the

results are not statistically significant? Repeat the result demonstration next season, and the next, if necessary. Isn't that the recommended procedure when learning a new skill or trade?

Yield and Labor Intensive Data Vital

There are many useful values that can be measured or calculated in conducting a demonstration. These are listed in **Table 1.** The first two are vital.

Since increased food production is the number one problem, it follows that yield per hectare is the most important measurement in determining the performance of a machine. And the resulting yield may not be necessarily increased. It could remain unchanged or even decreased. But, we have to know for a reliable performance evaluation.

Some say increased yields are not the result of the machine. For example, in the case of the drill, it was the fertilizer side placement. True, the latter affects yields, but no human being could place the seed and fertilizer so precisely by hand. Further, what farmer will take the time to do it? Take land leveling and grading. It is impossible to do a precise job with a plank. The base must be long.

Fig. 5 is presented to press the point that the tool itself may affect the performance of the biological plant. In the case selected, it was the type of soil openers for placing wheat seed. It is obvious that Opener No. 3 was far superior to either No. 1 or No. 2.

All yield-increasing machines are not necessarily confined to the field. One example is the use of more modern drying and processing equipment for paddy. The percentage of unbroken and unwasted kernels is increased with the finer equipment. And in that sense a higher yield is achieved.



Fig. 5 Each of the two photographs above (Left: Early seedling growth and Right: At maturity) are of one replication out of 4 of an experiment performed by Dr. B. A. Krantz on ICAR's Research Farm, New Delhi, India. The experiment was designed to determine the performance of three types of soil openers for placing wheat seed. Opener number 3 was obviously superior and was used on the newly designed wheat drill. (Photo courtesy of Dr. B. A. Krantz).

Labor utilization is a second priority need. There is some evidence, but not enough, that selective mechanization in combination with multiple cropping, will not only increase yields and production but also labor utilization (9).

The labor input as influenced by a machine has always been a popular measurement, usually with an eye to its decrease. Little has been done to achieve an increase. It is little wonder, therefore, that mechanization has been sometimes looked upon with skepticism. "Mechanization will throw people out of work" is one negative comment. We, Agricultural Engineers, simply have not been aggressive in developing farming systems that use wise combinations of machines and multiple cropping-selective mechanization. And to use our greatest tool, the Result Demonstration, to teach its merits.

Cost-Benefit Data

In order to make valid judgements on machines, operations and systems, one needs to have economic data and analyses on the conventional farming practice as well as the new. Further, to be as close to reality as possible, the data must be of machine operations performed by the farmer and/or his workers on his farm.

The analysis is valid only under the situation existing at the time the data were taken. There are simply too many variables that may change during its development and prior to its wide farm usage. Some of these variables are improved designs, labor costs, skills and the development of improved related agricultural specifications. An example of the latter is pelletized fertilizer rather than a variegated powder. What change this may make in the accuracy of metering, and costs. Also, we are all familiar with the history of how the cost of a machine is reduced through mass production and improved manufacturing techniques. The message herein is, yes, the cost-benefit analysis is one of the rerults, but use it wisely. It can be misleading.

Four Compelling Requisites

Manageable Simplicity Comes First

Agricultural Engineering specialists must first learn to master the operations of a one crop system in which the simplest, single new machine-method is used. Secondly, the crop used should hold the greatest potential for the area and the nation. Thirdly, the crop yields, plus or minus, must be statistically significant over the conventional. In later years, one may enlarge the demonstration so that all pertinent performance values are adequately measured and/or computed and assessed.

In Examples No. 1 and 2, one machine and one method of operation compared with the existing country plow method on the basis of yields is about as simple as possible. Even so, such will require dedication, diligence, work ethic, preciseness and time. It is not unusual to take three years in completing one simple demonstration. This latter is evident from the results of Example No. 2.

A Team Effort

The biological plant for producing food is perhaps one of, if not the world's, most complex "factory." There are so many inputs and factors that are influentially intertwined in making this biological "factory" productive and efficient. Also, there are such unpredicatable variables as weather and diseases. This simply means that if progress is to be maximized in food production, many specialists must become involved in the result demonstration – all the way from planning to analyses and publication, the farmer, too, for he is in reality a manager-operator of the total system.

If the result demonstration is to be a team effort, then that team must have a leader. He should be the most able and impartial of all the specialists involved. To select otherwise is to accept a lower level of human performance and results. However, it must be stated forthrightly that since the kind of demonstration proposed herein centers on one or more improved machine-method operations, the Agricultural Engineer should be the logical leader. If the demonstration is centered on, say, a new variety, then perhaps an Agronomist would be the logical leader.

Although the work of conducting a result demonstration is viewed as an Extension Education activity, there is no reason research scientists should not participate, actively as a part of the team, if they are interested and dedicated. Agricultural Engineers should be dedicated to this team approach.

Master Each Operation by Doing It Oneself

All specialists involved in planning and execution must master every detailed action and operation of the demonstration. One must not regress into the easier path of watching others do it. One can only become an expert by doing it oneself. For example, one must weigh the seed for each plot and see that it is applied equally.

One simply cannot teach the farmer-operator, or anyone else, well if one has not mastered each and every task. Some farmers and demonstrators in the Example No. 1 cited previously, who mastered and managed well the new drill and the bullocks that pulled it, got up to 70% increase in wheat yields. Others who were somewhat sloppy and careless got little or no increase. Remember that timely and precise operations are the key to high production farming.

Multiple Cropping Is Complicated

After the most elementary result demonstration has been mastered, the team of specialists should be ready to tackle a result demonstration in a multiple cropping system.

Why multiple cropping? Because it offers, where applicable, the best hope of not only increasing the total production per hectare per year but the labor utilization as well.

Based upon a preliminary study in India (9), a partially mechanized wheat-maize yearly rotation resulted in some worth-while revelations. They are itemized below. They have not been proven, but the probability of success is high.

(1) Total available horsepower per cultivated hectare and per ton of harvested crops can be minimized. In the study human, animal and mechanical sources are well balanced and constitute the total available horsepower.

(2) Labor demand peaks are reduced and yearly distribution is improved. The jobs relegated to human power are more pleasant and less drudgerous.

(3) The total amount of labor utilized per hectare per year is increased.

(4) Higher degree of mechanization – a contribution to the nation's industrial sector and to satisfy the farmer's hunger for tractors.

(5) Some of the machines in the cropping system can be used more hours per year than normal.

(6) Higher yields and production.

(7) Cost-benefits should improve.

A word of caution: It would be wise to master one aspect of the total multiple cropping system first and then gradually expand. For example, one aspect might be planting maize on top of a bed. The bed is prepared to a precise grade so that the furrow between beds will form a drain for excess water, or serve as an irrigation channel. So, the first year the

team can master the forming of the beds and the planting of the maize seed. In later years improved cultivation practices, harvesting techniques, the growing of the second crop can be added. It will take time, about 5 years, to proceed in this manner.

Planning and Execution

It must be clearly understood that research and development, if needed, on one or more aspects of the system, must precede the result demonstration. The result demonstration is one of those machine-methods that have convincing data to justify their acceptance by the farmer. It does not mean that the machine(s) is perfect. However, at some point in the process of developmental mechanization one must find out – take a calculated risk if necessary.

Improvement is an on-going activity and should be pursued vigorously. The result demonstration can point up such opportunities – another important result of good teaching.

On the other hand, the result demonstration should not be conducted prematurely, because excessive negative results and lack of knowledge about the operations will cause the farmer to lose confidence. Be sure the new machine method is well proven on the research farm first.

The most pertinent steps in planning and execution are itemized below:

(1) Research and development, and applicable technologies from around the world, suggest that a certain machine-method system be moved into the demonstration phase. In other words, the time has arrived to let selected farmers try it on their farm under carefully controlled conditions so as to insure significant factual results. Most importantly, the chance of increasing the production and/or the labor utilization per hectare per year – a net increase in income should be good.

(2) Make sure that machines and services for what is to be demonstrated will be available in advance of anticipated demands, if the demonstration is successful. Why demonstrate a machine that the farmer cannot purchase, or service is unavailable?

(3) Solicit the assistance of other concerned specialists. The single discipline approach in today's society is a "has-been," and in the end will probably fail.

(4) Conduct an intensive training course for all specialists who are to actively teach and/or participate in conducting the demonstration. They must be taught how to adjust and operate the machine(s), collect and report data, etc. All involved specialists must master all of the skills and techniques involved. Only then will farmers and other trainees have their complete confidence.

(5) Select farmer-cooperators and fields. Two adjacent plots are essential. Select a farmer's field that is reasonably uniform. Divide the field exactly in half – one for the control and the other for the new machine(s)-method(s) system. A field of 0.5 to 1 ha is usually suitable for a simple demonstration involving one machine.

The farmer-cooperator should be an individual that is basically an innovator and a good farmer. He should be enthusiastic regarding the new system, willing to cooperate, and dependable. Nothing is more discouraging and disastrous than to arrive at the farm on an appointed day and find that the farmer thought one plot was getting too weedy and proceeded to cultivate it several days in advance. If such happens, the entire demonstration must be scrapped.

The selection of the field and the farmer are exceedingly important for acquiring qualitative data and a fair comparison. The comparison should be repeated on four or five farms in the general area.

(6) Decide on the kind of data to be measured and/or calculated from **Table 1**.

There are, of course, other performance values. For example, data on water conservation and utilization would be vital if the machine-method under demonstration changed these environmental factors in a normal moisture stress area, such as in semi-arid land. In planning one must decide what kinds of data are vital to arrive at the desired performance values. Do not measure any more or any fewer values than are necessary for a comprehensive and accurate assessment.

Energy input for the human, animal and machine operations is very important and urgent in today's situation. However, these kinds of data are more difficult to get accurately. Machine draft and rate of travel could be measured periodically while conducting the demonstration. Average field efficiency could be measured, or calculated using educated assumptions.

Labor utilization data comes under the same general classification as draft and rate of travel. However, labor data in man hours is quite measurable.

The "farmer's appraisal" value is subjective. Nevertheless it is important information and should be included in each and every demonstration.

(7) Formulate and print proforma. The simplest of demonstrations require two proforma. The No. 1 proforma is to record the data for the early work, say, up through the first germination count. Proforma No. 2 is to be completed at the termination of the demonstration after the yield values and the farmer's appraisal de-

termined. Obviously, if the demonstration is more complex, more proforma and details may be necessary.

The content of each proforma will vary depending upon the extensiveness of the demonstration, data to be collected, type of machine(s), soil, etc. The details should be formulated to suit local situations. All proformas are to be returned to the leader for analysis.

As examples only, two sample proforma appear as **Tables 2 and 3**. They both pertain to a demonstration involving a one-row bullock-pulled, large-seed planter with side-placement of fertilizer versus the country plow method.

It is emphasized that a proforma must be customized for each type of result demonstration. A proforma is satisfactory only for the machine-method(s) for which it is devised.

(8) A visit should be made to each demonstration plot by at least one of the central or state office specialists in the accompaniment of the demonstrator during the course of the production season. The demonstrator is the one who supervised the layout and conduct of the demonstration. The purpose of such a visit is to help local officials and farmers evaluate the quality of the demonstration and to reject those having obvious errors that would prevent valid comparisons. For example, on the new-machine plot the seed dispensing tube clogged and remained so for several trips across the plot. The evidence was that there were no seed and no seedling emerging on these rows. Obviously in this case an accurate comparison cannot be made and that replication must be deleted.

(9) Data, especially yields, are analyzed statistically by a specialist.

(10)If the data is complete and valid, a cost-benefit analysis should be made preferably by a specialist.

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TABLE 1. DATA REQUIRED ON PERFORMANCE OF OPERATIONS

PERFORMANCE VALUE	UNITS	MEASURED	CALCULATED
I. YIELD			
a. Per ha.	kgs	X	
II. LABOR			
a. Per operation	No. of workers & man hours	X	
b. Per ha./week for season	man hours		X
c. Per ha. per year	man hours		X
d. Uniformity	Difference – highest & lowest man hours/ week for crop(s) season		X
e. Productivity	Production in tons per worker for year		
III. CAPACITY			
a. Time	hours per ha.	X	
b. Width of cut.	cm	X	
c. Speed of travel	M. per minute	X	
d. Field efficiency[1]	percent		X
IV. ENERGY			
a. Draft[2]	kgs	X	
b. Fuel consumption[2]	liters	X	
c. Per ha. or per kg of grain	hp hours		X
V. ECONOMIC			
a. Value of product			X
b. Costs	Local currency per ha		X
supplies (oil, repairs, etc.)			X
depreciation			X
operational			X
c. Input/output			X
VI. SOIL & STRUCTURE MAINTENANCE – losses and analysis made by a Soil Scientist			
VII. FARMER-OPERATOR APPRAISAL – appears on proforma only			

1. The filed efficiency is the ratio of *effective* field capacity to the *theoretical* field capacity expressed as percent. The *theoretical* field capacity is the rate of field coverage that would be obtained if the machine was operating continuously in a straight line without interruptions (turning at the ends, filling hopper, etc.) in hectares per hour. The *effective* field capacity is the actual average rate of coverage in hectare per hour. It includes the time lost in filling the hoppers, turning at the end of the row, unclogging openers, making adjustments, etc.

2. A few draft measurements using a simple spring type of dynamometer, or measuring the fuel consumption in the case of the tractor is recommended.

TABLE 2. EVALUATION REPORT ON SEED PLANTER – PROFORMA NO. 1*

District _____ Demonstration No. _____ Date _____

Note: Return one copy after germination count to _____

1. GENERAL

Demonstrator _____ Farmer _____ Crop _____

Date of Planting _____ Season _____

Soil (Circle one): Sand Sandy Loam Clay Clay Loam

II. SEEDBED PREPARATION

(a) Prepare the entire field at the same time using the same implements.

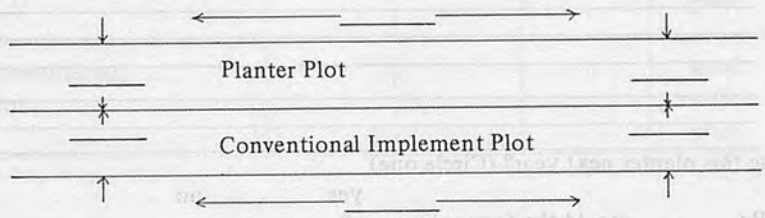
Date	Implements Used	Time Over the Field

(b) Condition of final seedbed (Circle one in each group)

Soil	Trash	Moisture
Coarse & cloddy	Very trashy	High
Medium clods	Light trash	Medium
Fine tilth	No trash	Low

(c) Average depth of seedbed in centimeters (Circle one) 15 3 10
(Measure at several locations).

(d) Divide the field in half: approximately one half for planter and one half for the conventional implement. Record the dimensions indicated.



Calculated Hectares _____

III. SEEDING AND FERTILIZING

The whole field *must* be planted using the same variety of seed and the same fertilizer dose, the only differences being the machine method of seeding and applying fertilizer.

(a) Hybrid seed used (Circle one) Yes No

(b) Variety _____

(c) Fertilizer (kind) _____
Composition if a mixture _____ N _____ P _____ K
Condition (circle one) Fine Medium Lumpy Granular
Moisture content (circle one) dry medium wet

(d) Implements or method used on conventional plot
Planting _____ Fertilizing _____

(e) Planter equipment used
Name of seed plate _____
Holes in speed plate _____ Holes _____ Holes
Sprockets-seed hopper _____ Teeth _____ Teeth
Drive wheel _____ Teeth _____ Teeth
Press wheel _____ Yes _____ No

*Adapted in part from proforma developed and used by the Intensive Agricultural District Program, and by the Agricultural Implements and Power Development Center, India.

IV. OPERATIONAL DATA	Planter Plot	Conventional Plot
1. Date of planting	_____	_____
2. Total seed used	_____ Grams	_____ Grams
3. Seeding depth	_____ cms	_____ cms
4. Total fertilizer used	_____ Grams	_____ Grams
5. Distance – fertilizer from seed		
Vertically under seed	_____ cms	_____ cms
Horizontally under seed	_____ cms	_____ cms
6. Total hours to plant and fertilizer each plot	_____ hr	_____ hr
7. Hours per acre	_____	_____
8. Number of times	_____	_____
Opener clogged	(Circle one)	(Circle one)
seed	1 2 3 4 5	1 2 3 4 5
fertilizer	1 2 3 4 5	1 2 3 4 5
9. Number of times trash had to be removed from openers	1 2 3 4 5	1 2 3 4 5
10. Load on bullocks (Circle one)	Heavy, medium or light	Heavy, medium or light

V GENERAL OBSERVATIONS

1. Ease of handling planter (circle one)

On the straight way:	easy	fair	difficult
At end of row	easy	fair	difficult
Transporting	easy	fair	difficult

2. Breakdown _____

3. What did the farmer like and dislike about the planter

Liked most _____

Disliked most _____

4. Does the farmer want to use this planter next year? (Circle one)

yes no

5. Assuming the planter cost Rs._____ would the farmer buy one?

yes no

6. If the farmer bought a planter
   (a) Would he do work for neighbors? yes no
   (b) On hire yes no
   (c) Does he want to buy the accessories
   i) seed press wheel yes no
   ii) transport wheels yes no
   iii) row marker yes no

7. Additional comments _____

VI. FIELD OBSERVATIONS

(a) General appearance of stand at 3 weeks. Planter plot compared, with conventional (circle) greener, same color, less green, more uniform, same uniformity, not as uniform.

(b) General comparison of two plots _____

(c) Plant population in plants per hectare before thinning

Conventional _____ Planter _____

Plant population/ha =

$$\frac{\text{Total number of plants in four 8 metre lengths x (5225)}}{\text{(Row spacing in inches)}}$$

Note: Lay off 8 metres at 4 different locations in each plot and count the number of plants.

TABLE 3. EVALUATION REPORT ON SEED PLANTER – PROFORMA NO. 2

Demonstration No. _____ Distict _____ Date _____
(same as on Form 1)

Demonstrator _____ Farmer _____

Note: One copy is to be filled in by the Demonstrator after the harvest season and sent to _____

I. YIELD SUMMARY

	Yield			
	Grain		Hey or Fodder	
	kg	kg/ha	kg	kg/ha
Planter Plot				
Conventional Plot				

II. CULTURAL PRACTICES

	Fertilizer applied after planting				Weeds Degree of weed control (circle)	Crop thinning	Plant population after thinning plants/ha	Average row spacing in cms
	Amount applied	Date of applying	Type of fertilizer	Mode of placement				
Planter Plot					good medium poor	yes no		
Conventional Plot					good medium poor	yes no		

III. GENERAL

1. Rains during growing season (circle one): heavy medium light
2. Assuming the planter costs Rs. _____ would the farmer now buy it:
   yes no
3. Does the farmer want to use the planter free of cost next year?
   yes no
4. Would the farmer hire the planter from his neighbor next year?
   yes no
5. If yes what ate per hectare would he be willing to pay? _____

Part 1. Policies and Attitudes for Action Programs

by
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1. The most pressing problems of the developing nations have not changed and should be restated emphatically; "too many persons, particularly under- and unemployed, and too little food."
2. Machines do alter crop yields. It has been proved that some machines will in fact help to increase yields. In addition some machines are necessary for successful multiple cropping and land forming, and in that respect contribute to increased yields. They also contribute to the increased utilization of labor and the sun's energy per hectare per year. Given this fact our profession should concentrate on the kinds of machine-systems that will accomplish this. It is termed selective mechanization applied to yearly production systems.
3. Reduced energy consumption of the machine is not the main problem, and by itself is not a valid criterion of progress. Specific problems like energy shortage will continue to emerge from time to time. For instance world wide availability of fresh water is incredibly small, and may be a very serious problem in the future. Or, perhaps solar power by satellite may be made practical (2). It is abundantly clear, however, that efficient food production and labor utilization remain valid mechanization goals in the foreseeable future.
4. There has been some misunderstanding and misinterpretation in our profession about Fig. 1– Chart of Agricultural Mechanization. Hopefully the following will add clarity.

   There is in fact a correlation between the *power* (hp/ha on the horizontal axis), and the *yield* (average aggregate yield in t/ha on the vertical axis). However, one cannot say that one causes the other.

   Some professional statisticians use a story to illustrate the latter. It goes somewhat as follows (3). Starling birds in one of the Scandinavian countries build their nests stop chimneys of a home wherein lives a baby. There is a correlation between the location of nests and babies in a home. That is, whenever one finds a nest on a chimney one will usually find a baby in the house. The reverse is true. However, this does not mean that starling nests cause babies or the reverse. Starlings build nests on those chimneys that are kept warmer in winter and that is usually the homes that have a baby living in them.

   The same philosophy applies to mechanization. In our case we are not sure what causes the correlation. The data simply shows that it exists. That is, whenever one finds high crop yields one usually finds a high degree of mechanization, or the reverse. The why is pure speculation.

   Admittedly when the study was first started in 1967, it was to prove that mechanization will in fact result in increased yields. The proof is still elusive. I personally think that in the broad sense a farmer who derives higher yields, and thus income, invests the extra money in labor and drudgery saving machines. He strives for a higher standard of living, as you and I would probably do. The above case does not detract from the established fact that some machines are yield-increasing.
5. A more meaningful index to progress in selective mechanization is badly needed. Effective horsepower was suggested as a starting point. This does not mean more power, necessarily. For example, compare Taiwan with the USA on page 5 of Part 1. Tons of production per hp, and effective hp/ha were correlated. An index of yields, production and labor utilization should be more meaningful. The point is that more factural information about a machine's performance is badly needed. Also, each nation must develop its own index for charting its progress in mechanization. One thing is clear: yields, production and labor utilization must be parts of that index of progress.
6. The problems cited herein must be attacked by a multiple disci-

*This is a companion article of the preceding report on same title prepared by Prof. Giles.

pline approach—the development of total farming systems of which the machine(s) is only one of the essential inputs. This is our only hope of achieving real progress quickly.

7. The need of what was termed "Operational Systems Institutes" was cited to satisfy No. 6 above. It is gratifying to note that a "Farming Systems Program" of ICRISAT (4) in India, although research orientated, has the philosophy envisioned. They are experimenting with a total system approach for a rainfed situation using the latest technology in such things as water conservation and new varieties. They are working on ways to maximize the use of rainfall (semi-arid conditions), improved cultivation methods and intercropping techniques, and minimal use of mechanical power equipment and chemical fertilizers. Bullock power along with simple, but efficient implements within the financial reach of the small farmers of the semi-arid tropics commands high priority. They have also started on-farm research as a means of transferring advanced technology to farmers.

   Their 1978-80 Annual Report lists 13 Agricultural Engineers (Implements and Soils & Water), 6 Agronomists, 4 Agroclimatologists, 4 Soil Physicists, 3 Soil Scientists and Chemists, 1 Entomologist, and 1 Senior Research Technician (Agronomy) on the staff of this farming systems program (3). This research and development project appears to be a system's development dream. It behooves all of us to intently watch and study their methods and results.

   Kampen (5) presented an excellent organizational chart of the Farming Systems Research Program at ICRISAT. They have molded the essential disciplines into 7 major definable problem areas common to the semi-arid tropics (SAT); Agroclimatology, Environmental Physics, Soil Fertility and Chemistry, Farm Power and Equipment, Land and Water Hydrology, Cropping Systems, and Production Agronomy and Weed Science. From this basic problem foundation, team work is expanded into 4 more advanced studies and experimentation; Operational Research on Natural Watersheds (Catchment Areas), Systems Analysis, On-Farm Studies and Benchmark Studies. All of this is under the direction of a coordinating unit. This interdisciplinary approach is impressive.

8. On page 11, Dr. Bradfield used a single-axle Landmaster and attachments, rather than a rototiller for his intensive cropping system experiment (6). Nevertheless the necessity of selective mechanization to make practical multiple cropping and higher production remains. Also, other measurable performance factors such as labor utilization and farmer appraisal are needed.

9. Two important definitions to reemphasize are:
   (a) Effective horsepower is what the power source is able to exert continuously during a normal work day, day after day, without abnormal deterioration. In the case of animals and humans, this means without losing body weight and vigor. In the case of new tractors it is the measured rated drawbar horsepower (not engine hp or advertised claims). Available, means able-bodied working people and animals, and that the tractors are in good repair capable of working satisfactorily.
   (b) Utilization of labor is an index involving man hours used per cultivated hectare per year, uniformity of man hours per week throughout the year, and total production per worker per year. Such an index has yet to be refined. Man hours is not, by itself, meaningful.

We must keep the above in the forefront if we are to evolve an index that has meaning to everyone, including Administrators.

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Suitability of Small Tractors in Pakistan: Technical Considerations



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According to the present policy of the Government, five makes of tractors; Massey Ferguson, Fiat, Ford, Belarus and ITM are being imported and assembled in the country. All these tractors fall within the range of 45 to 65 hp. It is generally felt by engineers and scientists that this range is too restrictive and there is a need to allow the import and manufacture of tractors with a wider range of horsepower, particularly, of smaller tractors in the range of 25 to 35 hp. The reasons for making this recommendation are complex and at times controversial. Perhaps the only way to find out if such tractors are, in fact, needed in the country is to introduce them in the market and draw appropriate conclusions from the farmers' response.

The picture in neighbouring India, especially in East Punjab, where agro-climatic conditions are very similar to those in Pakistan, at least Punjab province, shows that the small horsepower tractors have a definite place in farming system. **Table 1** gives the comparative tractor markets of India and Pakistan with reference to the tractor size and shows that over 77% of the tractors in India are in the range of 20-39, there are none in Pakistan in that range.

A study conducted in India in 1975 entitled "Level of Tractor Power Utilization – Different Operations" indicates that large horsepower tractors are utilized more for ploughing and land development operations, whereas, the small horsepower tractors are used more for transportation and light tillage operations. Thus, the smaller tractors are well suited for puddling operations in rice areas as well as for tillage operations for vegetable and orchard farming.

The drawbar pull available with a tractor is directly proportional to the weight of the tractor. Tractors in the range of 25-35 hp generally weigh about 2/3 to 3/4 the weight of 45 hp tractors. For example the weight ratio of MF 210 (25 hp) and MF 240 (45 hp) is 0.74. **Table 2** gives the power requirements for various tractor-operated farm machines. It can be concluded that the ability of a smaller tractor to carry out tillage operations with proportionally scaled down implements is lower than that of a bigger tractor by about the same proportion as its weight. However, the often repeated contention that the small tractor is incapable of carrying out certain tillage operations does not seem to be supported by this data. This table also indicates the size of tillage implements, both for clayey and loamy soils. These soils constitute 60.6 and 29.8%, respectively, of canal irrigated land in Pakistan.

Table 2 also shows an analysis of draft power requirements for various tillage implements on two most commonly found soil types in Pakistan, i e, loamy and clayey soils. These requirements are compared with the actual power available from 25 and 45 hp tractors.

The draft values for these implements have been taken as maximum for clayey soils and average of clayey and sandy types for loamy soils in the calculations. The maximum drawbar pulls of the tractors have been taken from Nebraska Tractor Test Data (Agricultural Engineers Year Book 1981) which are 4 280 Lbs for 45 and 25 hp tractors, respectively. Similarly, the maximum PTO horsepower are 41 and 22 for 45 hp and 25 hp tractors, respectively. In calculating the sizes and working depths of the implements, 80% of both the maximum drawbar pull and the PTO hp are used.

Table 1 Sale of Various Size Tractors in India and Pakistan.

Tractor Size (hp)	Unit: %	
	India*	Pakistan**
20-29	27.1	–
30-39	50.4	–
40-49	17.3	67.3
50 and above	5.2	32.7
Total	100	100

* Based on average production figures, 1975-79.
** Based on 1978 import figures.

Table 2 Power Requirements and Implement Size

Implement/ Machines	Power Requirement		Size of Implement				Remarks
	Clayel Soil	Loamy Soil	Clayey Soil		Loamy Soil		
			25 hp	45 hp	25 hp	45 hp	
Land preparation & sowing equipment:							
M.B. Plough	12 psi	8 psi	Single bottom, 14" size & 9" deep	2 bottom, 14" size & 9" deep	2 bottom, 14" size & 9" deep	3 bottom, 14" size & 9" deep	
Sub-Soiler	120 lb/in. deep	80 lb/in. deep	17" deep, Single tine	28" deep, Single tine	26" deep, single tine	42" deep, single tine	
Tandem disc harrow	120 lb/ft	80 lb/ft	–	–	–	–	Any suitable size
Rotary cultivator	40 psi	27 psi	30 in. size & 2 in. deep	40 in. size & 2 in. deep	30 in. size & 3 in. deep	40 in. size & 3 in. deep	
Cultivator	95 lb/ shovel/in.	60 lb/ shovel/in.	7 tine & 3" deep	11 tine & 3" deep	7 tine & 5" deep	11 tine & 5" deep	
Seed drill	100 lb/ft	65 lb/ft	–	–	–	–	Any suitable size
Other equipment:			25 hp.	45 hp			
Reaper	1 hp/ft cutter bar		–	–			Any suitable size
Thresher	0.8-1.2 hp/in. of cylinder width		1.5 ft cylinder width	3 ft cylinder width			
Combine harvester	2-4.5 hp/ft of cutter bar		4-10 ft	8-18 ft			
Trailer			6 000 kg	8 000 kg			

The table clearly indicates that medium-size tractors (25 to 35 hp) are capable of operating the existing disc harrows, seed drills and reaper-windrowers as efficiently as the 45 hp tractors. They can also work with the same size sub-soiler with adjusted depth of operation. In the case of moldboard plough, the number of furrows must be adjusted to suit the available power from the smaller tractors, down to one and two furrows in clayey and loamy soils, respectively.

It is also evident from the table that the medium-sized tractors can be operated with scaled down rotary cultivators, threshers, combine harvesters. Of these, cultivators, threshers and trailers are being produced entirely in the country. Sizing down cultivators and trailers will be very simple and no serious problem is foreseen in developing a cultivator and thresher of suitable size. The remaining two machines, rotary cultivators and harvesters, can be imported in appropriate sizes, until they are produced locally.

Table 3 Effective Field Capacities of Implements in Acres per Hour

Implement/Machine	Clayey soils		Loamy soils		Remarks
	25 hp tractor	45 hp tractor	25 hp tractor	45 hp tractor	
Moldboard plough	0.25	0.50	0.50	0.75	75% field efficiency
Sub-soiler	0.43	0.50	0.43	0.50	75% field efficiency and 2 ft apart rows
Rotary cultivator	0.53	0.82	0.53	0.82	75% field efficiency
Cultivator	1.12	2.00	1.12	2.00	75% field efficiency and 9" distance between consecutive tines

Effective field capacity C = (SW/8.25) x (EF/100), Where S = speed in mph, W = rated width of implements in ft. and EF = filed efficiency in percentage.
The rated widths of the four tillage implements are calculated from Table 2.
Moldboard plough = 14" and 28" for clayey and loamy soils, respectively, with 25 hp tractor and 28" and 42" for clayey and loamy soils, respectively with 45 hp tractor.
Rotary cultivator = 30" for 25 hp tractor, 40" for 45 hp tractor
Cultivator = 63" for 25 hp tractor, 99" for 45 hp tractor
The maximum pull speeds used in computing the effective field capacities are 2.71 mph and 2.35 mph for 25 hp tractor and 45 hp tractor, respectively.

In fact, it may be mentioned here that for some operations requiring low power like reaping, seed drilling and pulling a trolley on metalled roads, these medium-sized tractors consume less fuel and are more economical to operate compared to 45 hp or larger tractors.

It is also evident from **Table 2** that the machines of appropriate size will have to be marketed for smaller tractors. These implements are already available in the world markets and there will be a need to import some prototypes for multiplication. **Table 3** gives the field capacities of a few tillage implements for both types of tractors.

In general, the smaller horsepower tractors do not last as long as the larger ones. It is estimated that

Table 4 Comparison of Cost of Operation of 45 hp and 25 hp Tractors Using Cultivator

Item	45 hp tractor	25 hp tractor
Tractor:		
Price	Rs. 86 000	Rs. 57 000
Life	10 000 h (10 years)	8 000 h (8 years)
Yearly use (Average)	1 000 h	1 000 h
Salvage value (10%)	Rs. 8 600	Rs. 5 700
Insurance/year	Rs. 664	Rs. 498
Interest rate (yearly)	11%	11%
Fixed cost/h:		
Depreciation	Rs. 7.74	Rs. 6.4
Interest	Rs. 5.20	Rs. 3.45
Insurance	Rs. 0.66	Rs. 0.50
Total	Rs. 13.60/h	Rs. 10.75/h
Operating cost/h:		
Cost of diesel @ 4.7 ℓ average of 45 hp & 2.5 ℓ average of 25 hp at Rs.4/ℓ	Rs. 18.80	Rs. 10.00
Engine oil – sump capacity of 45 hp & 25 hp is 6.8 and 4 ℓ, respectively, prevailing rate Rs.12/ℓ	Rs. 0.54	Rs. 0.32
Transmission oil – capacity of 45 hp & 25 hp is 25 and 21 ℓ, respectively, change after every 500 h, prevailing rate Rs.12/ℓ	Rs. 0.60	Rs. 0.05
Air cleaner oil, 0.5 ℓ for each change after 10 h, rate Rs.12/ℓ	Rs. 0.60	Rs. 0.60
Cost of grease and lubricants for topping up at 10% cost of lubricants.	Rs. 0.17	Rs. 0.14
Wages of the operator @ Rs.7 200 per year.	Rs. 7.20	Rs. 7.20
Cost of spares and repairs (3.5% of original cost)	Rs. 3.01	Rs. 2.00
Total	Rs. 30.99/h	Rs. 20.76/h
Total (fixed & operating cost of tractor)	Rs. 46.51/hr	Rs. 31.11/h
Cultivator:	11 Tines	7 Tines
Price	Rs. 6 000	Rs. 3 000
Life	3 000 h	3 000 h
Annual use	400 h	400 h
Operating cost per hour:		
Depreciation	Rs. 2.00	Rs. 1.00
Interest	Rs. 0.82	Rs. 0.41
Repai/spares at 0.048% of original price.	Rs. 2.88	Rs. 1.44
Total	Rs. 5.70/h	Rs. 2.85/h
Tractor & Cultivator:		
Cost of operation with cultivator/h	Rs. 52.22	Rs. 33.96
Area covered/h	2.0 acres	1.12 acres
Cost/acre with cultivator	Rs. 26.11	Rs. 30.32

the life of 25-35 hp tractors will be about 75 to 80% of that of 45 hp tractors.

The most vulnerable component in the smaller tractor is its smaller engine, which is subject to higher vibrations and greater wear and tear. However, the price differential between the two sizes offsets this disadvantage. The operating cost of cultivation per acre (tine type cultivators) for the 45 and 25 hp tractors has been calculated and is shown in **Table 4.** Although the operating cost for a 25 hp tractor is slightly higher than that for a 45 hp tractor, the initial cost of the smaller tractor is almost 66% of the larger ones.

A study made at the University of Agriculture, Faisalabad "An Evaluation of the Farmer's Decision-Making for Investment in Farm Machinery, with Special Reference to the Tractor" indicates that the average use of a tractor per year is 1 109 h, 50% of which is utilized for ploughing. Assuming 1 000 as the national yearly average, approximately 500 h per year are utilized for ploughing. Thus, the existing population of 100 000 tractors is capable of cultivating only 16.67 million acres (six cultivations requiring 3 h of operation). To cultivate the remaining 30.33 million acres would, therefore, require almost thrice the existing tractor horsepower. Thus, there is need for a substantial increase in the population of tractors, small medium and large.

During a recent survey, conducted by the Farm Machinery Institute, it was found that about 14% of the total farmers in Pakistan would like to buy small tractors in the range of 25-35 hp. The survey also indicated that the interest in small tractors increases as the size of operational holding gets higher, which is contrary to the presently held belief that the small tractor is only meant for the small farmers. There is, however, ample evidence that significant need for small tractors exists in the country. It is also projected that as the small tractors are introduced in the market, and more farmers become familiar with them a larger number of smaller farmers will begin to buy them.

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Rational Use of a General-Purpose Farm Tractor in India



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Abstract

This paper discusses the utility index and the reliability index of a general-purpose tractor (26.1 kW). It also analyses the rational yearly and monthly use of a tractor having an insight of the general pattern of the breakdown. On the average, a 26.1 kW (35 hp) tractor has 600 operational hours per year of which about 50% is used in tillage operation. The major breakdown occurs after 5 to 7 years of use. Under normal working conditions and with reasonable maintenance, the tractor could be used for 15 years.

Introduction

The manufacture of tractors from the licenced unit increased consistently from 1414 units in 1962-63 to 113 000 units (sanctioned) in 1978-79. The nature of farm mechanisation in a developing country like India demands more tractors than the licenced one. These tractors range from 7.46 kW (10 hp) to 74.6 kW (100 hp) in size. However, a 26.1 kW (35 hp) tractor is normally considered as a general-purpose tractor and represents approximately 50% of the total tractor population in the country.

A large number of tractors are bought by farmers for farm purposes. These tractors ought to be used judiciously and efficiently. It has been observed that some farmers buy a tractor and keep it idle most of the time due to their limited amount of work. They do not have sufficient work for the tractor. They make prestige issue for not renting it to other farmers. This increases the non-utility index of a tractor as a whole. On the other hand, the tractors bought by many other farmers or agencies fail to utilize them efficiently for many reasons. The breakdown time of such tractors is considerably high, as well as the non-operational hours.

This study was thus envisaged to investigate the rational use of a general-purpose tractor, especially in the context of its utility index and reliability index. The utility index is affected by the nature and amount of work, tractor maintenance, managerial and planning skill. The reliability index, on the other hand, is dependent only on the availability of spare parts and the workshop facilities. Storage of spare parts of any tractor blocks the money, thus forcing the planner to consider the economics or the profit and loss criterion of the purchase of spare parts. In order to collect detailed information about various tractors in use, various organisations, agencies and individual owners were contacted. Entries on log books were tabulated in a standardized proforma. Among many power group of tractors, the most common 26.1 kW (35 hp) was selected.

Results and Analysis

Utility Index

Utility index is a direct indication of work machine contact hours. With an increase in the utility index the cost of operation and the non-operating hours decrease. This in turn, results into a net increase in the total power available for farm work.

The index is calculated along with the cost of operation calculation of a machine. Assume that i) a normal tractor wears out in 10 years with a trade in or a salvage value equal to 10% of the new cost. ii) hours per year for wear-out life equal to obsolescence life is 1000; iii) the repair cost per year is 1.0% of new cost; iv) the interest rate, taxes, insurance and shelter charges per year are 6% of the new cost. v) the operating cost per year is 5%

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of the new cost.

Thus the total cost of operation of a tractor is 0.25 X per year which includes fixed cost (0.16 X), operating cost (0.05 X) and the incidental surcharge for major breakdown (0.04 X). It boils down to:

$C = 0.25 \times 10^{-3}(X/K)$

where, C = Cost of operation per hour; X = new cost of the tractor; K = Utility index = (Number of working hours per year)/1,000

Reliability Index

This index measures the percentage of assurance of proper working of a tractor and is determinated as follows:

$$RI = \frac{A_1}{P_1} \times \frac{P_2}{A_2}$$

$$= \frac{0.04\ nX}{0.25 \times 10^{-3} BX} \times \frac{P_2}{A_2}$$

$$= \frac{0.04\ n}{0.25 \times 10^{-3} BX} \times \frac{P_2}{A_2}$$

$$= \frac{160\ n\ P_2}{BA_2}$$

Where, RI = reliability index; A_1 = breakdown charges available = 0.04 nX; n = number of years of breakdown occurence since purchase; X = new cost of the tractor; P_1 = penalty for breakdown = $0.025 \times 10^{-3} BX$; B = number of breakdown hours; P_2 = money blocked in storing the requisite spare parts; A_2 = breakdown charges-actual incurred.

The optimum reliability index is determined by equating the denominator to the numerator in the above equation and by assuming that $P_2/A_2 = 1$. Although P_2/A_2 is not exactly equal to 1 and it keeps on fluctuating but in an Indian condition through previous experience it has been observed that on an average P_2 is more or less equal to A_2. Thus the above equation is equal to :

B = 160 n = 1 600 hours (by assuming n = 10 years life span)

This indicates that in order to maintain an optimum reliability index, the total number of breakdown hours in the life time of a tractor must not exceed 1 600.

Farm Operational Hours

An average year-wise breakdown of operational and idle hours of a general purpose tractors is given in **Table 1** and in **Fig. 1**. With an average value of 600 h the total number of working hours ranges from 265 to 1273. This large fluctuation is due to an increase in non-operating hours. Tractors may not be in use due to many factors such as breakdown, no work to be done, or any other unavoidable circumstances such as when the driver is absent. The variation in the fuel consumption is directly attributed to the number of operational hours. However, there is a differnce in fuel consumption in various farm operations. Harrowing, ploughing, puddling, or any other tillage operation consumes more fuel than the transportation, levelling, threshing, cane crushing or other miscellaneous work. Although for a particular set of conditions, the specific fuel consumption is constant for a tractor, say, 275 g/kW/h (220 g/hp/h) for a 26.1 kW (35 hp) tractor (an

Table 1 Annual Breakdown of Operational and Idle Hours of a 26.1 kW (35 hp) Tractor

Unit: h

Year	No. of idle hours	Ploughing or Harrowing	Levelling	Puddling	Sowing	Threshing	Trans-porting	Miscella-neous	Total (ℓ)*
1.	400		N. A.						414 (1 230)
2.	1 200		N. A.						1 242 (3 700)
3.	1 488	688.0	9.0	–	–	242.0	14.5	25.5	979 (3 182)
4.	1 704	353.5	15.5	38.5	36.5	15.5	19.0	32.5	521 (2 095)
5.	944	398.5	40.0	56.0	44.5	8.0	111.5	63.0	713 (2 432)
6.	368	147.5	64.5	–	–	–	32.5	20.5	265 (949)
7.	1 056	444.5	147.5	71.0	35.0	28.5	–	60.0	786.5 (2 378)
8.	1 440	560.0	99.0	–	58.5	–	56.5	65.0	839.0 (2 711)
9.	760	170.5	46.0	37.5	19.5	6.5	63.5	33.0	376.5 (1 172)
10.	1 544	221.5	25.0	–	19.5	–	33.0	80.0	379 (1 273)
11.	1 288	51.0	26.0	–	–	2.0	44.0	26.5	149.5 (515)
12.	808	452.0	19.5	–	9.0	38.0	123.5	63.0	705 (2 011)
13.	816	101.0	45.5	153.5	22.5	–	160.0	164.5	647 (1 775)
14.	1 080	237.0	61.5	143.5	9.0	39.0	166.0	224.5	880.5 (2 021)

*Fuel (H.S.D.) consumption, ℓ

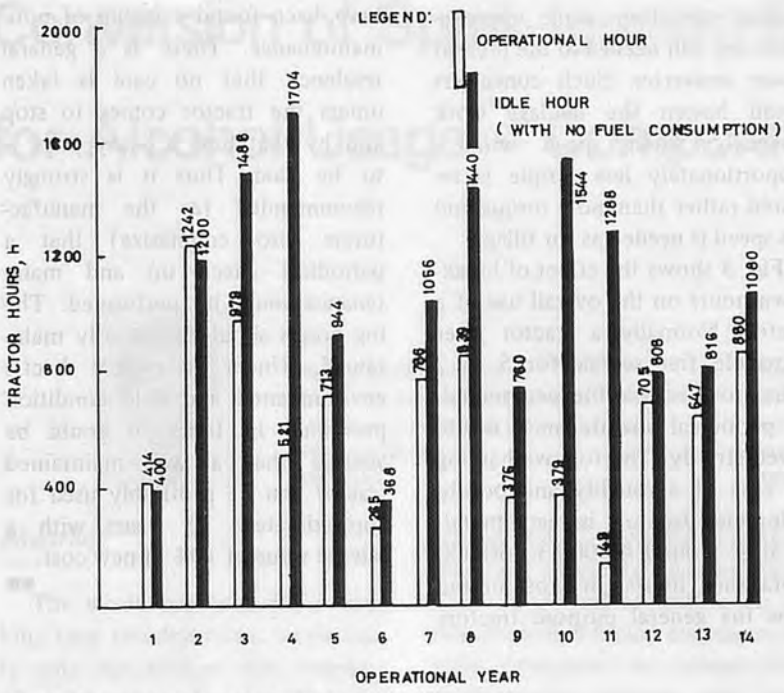


Fig. 1 Yearly operational and idle hours of a tractor.

average value), the consumption for the same operation may vary from one set of working condition to another. An example is the fuel consumption for harrowing operation which varies from 4 ℓ/h (for 26.1 kW tractor) to 3.5 ℓ/h which is due to a change in draft requirement which again is affected by soil conditions, machine adjustment and implement condition.

Table 1 also reveals that the tractor is mostly used for tillage operation (53% of the time). Transportation is the second important use (11.3%) for most of the tractors. This fact compells the planners and the engineers to reconsider the operational planning of a tractor. It is a fact that farm operations having their own peak demands for energy during an specific period of time, the planning is to be foreseen and a uniform distribution of monthly use of a tractor is to be scheduled. The working hours under miscellaneous use have to be increased. Unmechanised farm operations are to be mechanised, say, interculturing, harvesting, transplanting have a peak labour requirement which should be handled by using some equipment. Most of the idle hours could be turned into operational hours doing custom service. It is estimated that only by increasing the number of working hours of the present available tractors in use (say 50% increase) the total requirement of the tractor power in India may be met by the existing sanctioned licence. Besides, there will be an increase in the cropped area and miscellaneous side projects will also get a boost in this energy crisis.

A sample model of the monthly breakdown of operational hours of a tractor is shown in Fig. 2 along with fuel consumption. The peak utilization of the tractor was

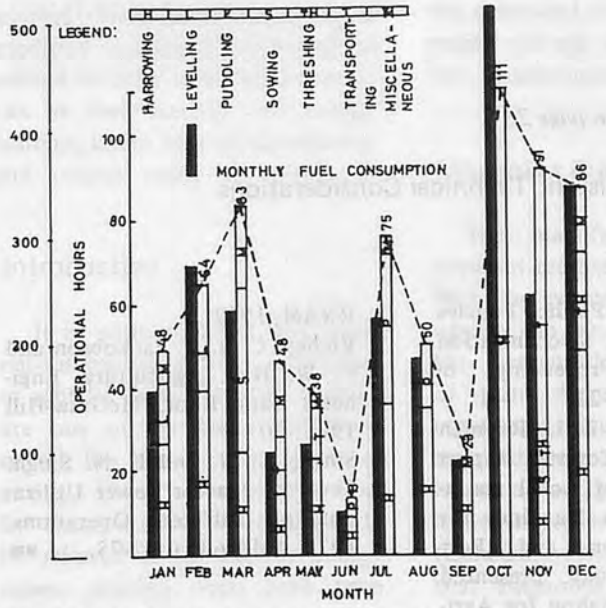


Fig. 2 Sample model of monthly operational hours and fuel comsumption of a tractor

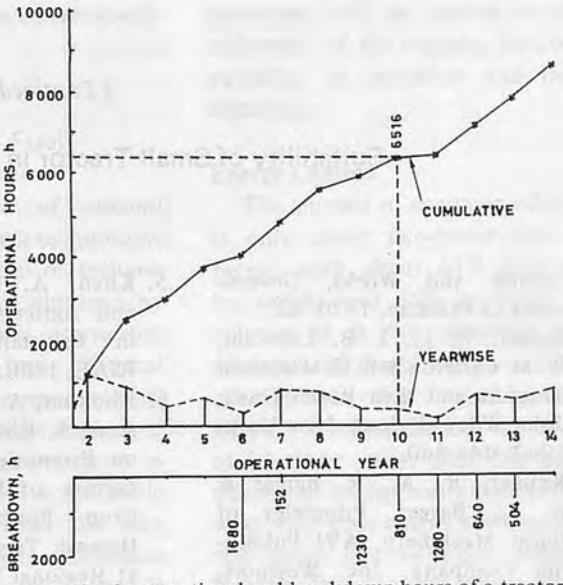


Fig. 3 Yearly operational and breakdown hours of a tractor.

observed in the month of October followed by December, March and July. Obviously, this increase is attributed to tillage operation which is performed during this period of time. The increase in November is due to transportation use. The lowest utilization in the month of July was a result of a breakdown. As a matter of fact, the curve shown in dotted line should have less fluctuations. This condition could only be achieved by increasing the operational hours of the tractor. In slack season (when farm operations are over) these tractors may be rented for haulage purposes. Although the present transmission system is satisfactory for tillage and partially for haulage operation, some improvements are still needed in the present power converter. Such converters would hasten the haulage work especially when speed with a proportionately less torque is required rather than more torque and less speed is needed as for tillage.

Fig. 3 shows the effect of breakdown hours on the overall use of a tractor. Normally a tractor gives a trouble free service for 5 to 7 years provided that the recommended periodical maintenance is observed strictly. The top overhauling (in case of a roughly and poorly maintained tractor) is recommended after around 45 000 to 60 000 operational hours. In most of the cases the general purpose tractors have been found a victim of poor maintenance. There is a general tendency that no care is taken unless the tractor comes to stop and by that time a heavy price is to be paid. Thus it is strongly recommended (as the manufacturers also emphasize) that a periodical check up and maintenance must be performed. The log books should be strictly maintained. Under a typical hectic environmental and field condition prevailing in India, it could be assured that a well maintained tractor can be profitably used for approximately 15 years with a salvage value of 10% of new cost. ■■

(*Contined from page 26*)

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Conversion of Spark-Ignition Engine for Alcohol Usage — Comparative Performance



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Abstract

The world has been for a very long time too dependent on virtually only one kind of fuel, namely; oil, as its source of energy. With the current high price of oil, steps are being taken to diversify the energy sources. Alcohol, namely methanol and ethanol, has a potential to be a substitute for oil as our energy source. It could be used in internal combustion engine as substitute or at least in complement with petrol. This paper discusses the suitability, efficiency and possible problems that might arise following their use as fuel. Their performances on a modified spark-ignition engine as related to their three basic properties as fuel, namely; the energy content, latent heat of vaporization and octane rating are discussed.

Introduction

It is, without doubt, that internal-combustion engines, either used in vehicles or as stationary engines, are one of the major consumers of oil, the world's main source of energy. Given an alternative fuel for them, the world would greatly be relieved of its current energy crises. Alcohol fuels have been favoured by many researchers as the potential oil substitute, with ethanol being the best prospect. However, many technical problems need to be solved before an efficient alcohol-fueled engine can be fully developed. At present only spark-ignition engines are commercially suitable for alcohol use. The switch to this fuel can only be done with relatively pure alcohol. Even that does not give a very satisfactory performance, characterised by high fuel consumption and lower power output. An attempt to study the comparative performance of a spark-ignition engine converted for alcohol usage was carried out. The performance was compared to the case when the engine was run on its conventional fuel, namely; petrol.

Ethanol as Engine Fuel

The manufacture of ethanol does not require a high technology. With the present level of technology it can be easily obtained by the fermentation and conversion of plant biomass into chemical compound. Since the raw materials required are green plant matters, it has an advantage over petroleum as a fuel source in that it is renewable (Zohadie, 1981). Also the fact that ethanol is liquid at standard temperature and pressure makes it all the more attractive to be the successor of petroleum. Storage, transportation and distribution of the fuel would not be of any problem. In fact, since its physical properties are almost similar to that of petrol, the existing structures and equipment used for the storage, transportation and distribution of petrol can be used with minimal modification should ethanol successfully emerge as a feasible fuel for internal-combustion engines.

The three general properties of ethanol, namely; energy content, latent heat of vaporization, and octane rating are associated with the modifications of spark-ignition engines for ethanol usage. These properties will be related to the efficiency of the engines, the compatibility of materials and their suitability.

Energy Content

The amount of energy in ethanol is only about two-thirds that of petrol, with about 61% as much by weight and 65% as much by volume. It is this property that hindered the direct switch to 100% ethanol-fuel for spark-ignition engine. The fuel-air ratio has to be enriched in order that the same amount of energy is supplied. Otherwise, very poor engine performance will result due to acute mixture leaning. This problem can be overcome by enlarging the fuel jet dia-

meter in the carburetor.

Latent Heat of Vaporization

The latent heat of vapourization of ethanol is 840 kJ/kg. This is about 2.5 times as much as that of petrol whose value is only 330 kJ/kg. In spark-ignition engine this is a very important quantity as, together with the volatility of the fuel, it determines the charge density in the cylinder. Due to its high latent heat of vapourization, ethanol can act as a coolant and reduces the intake temperature thereby improving the volumetric efficiency. Compression work is reduced through lower temperature and pressure and this further increase the performance of the engine.

Mixture distribution problem is a disadvantage following the high latent heat of vaporization and low volatility of ethanol. Cylinder-to cylinder variation in fuel mixture results in misfiring in the ones with leaner mixtures causing knocking to occur with a subsequent reduction in power output. Additional intake manifold heating, fuel injection to individual ports or a more careful manifold flow design to intensify higher mixture velocity and turbulence are suggested to tackle the mixture distribution problem. The first and third suggestions seem to be more practical since the introduction of fuel injectors would require drilling of the engine block. This will affect the design strength of the engine. Futhermore, since ethanol lacks lubricating action, wearing-off of the injector parts and injector pump can be expected.

Late vapourizing fuels can usually cause poor warm-up and acceleration. Even with petrol, the fuel could be seen to collect or even flow along the manifold walls during periods of acceleration. Poor warm-up can cause cold starting problem. Saturated vapours of ethanol was shown to be too lean to ingnite below 10°C and the problem becomes significant below 5°C. This cold starting problem is claimed to be the most noticeable effect of the low volatility of ethanol. Starting aids such as heaters and additives like petrol, ether and acetone have been suggested and tried. Although the temperatures never drop to 10°C in tropical countries like Malaysia, the problem can still be expected considering that even a petrol engine is sometimes difficult to start in the early morning.

Octane Rating

Because of its high octane rating, ethanol is capable of being compressed more with lesser possibility of self-ignition, hence increasing the spark-knock limit. Ethanol, therefore, enables an engine to operate at higher compression ratio with increased thermal efficiency. It was suggested that with ethanol a compression ratio of about 12:1 is possible. With agricultural equipment, a practical value of about 12:1 might have to be imposed due to the relatively low speeds and high loads necessary. Although various studies have shown that efficiency is increased at higher compression ratios for ethanol, practical constraints such as engine strength, durability and fuel behaviour tend to impose limits on the development of this factor.

Suitability of Alcohol to Engine Components

A number of reports have mentioned the problems of corrosion resulting from the use of alcohol fuels in internal combution engines. Generally, methanol creates more corrosion problems than does ethanol (DOE, 1980). Hirao (1979) reports that ethanol is less sensitive than methanol as to the property of corrosion. Holligan (1980) suggests that rubber and plastic components of the fuel system be replaced for alcohol-petrol blend. Buckingham (1981) reported that ethanol deteriorates plastics and engine modification must include replacing plastic and elastomer fuel system parts (gaskets, hoses, bushings, floats, filters, pump diaphragm, etc.) with non-plastic parts.

Excessive cylinder wear can also occur when straight ethanol is used at low temperature conditions. A test conducted was reported showing an increase in iron wear, viscosity of oil and acid content resulting from the use of straight ethanol during winter (DOE, 1980).

Engine Conversion

The engine modified and tested was the International Harvester UC-60 tractor engine. It is a four-stroke-cycle four cylinder engine mounted on a stand (**Fig. 1**). Its specifications are as follows:



Fig. 1 The modified International Harvester UC-60 tractor engine and the M&W hydraulic absorption dynamometer.

Cylinders	4
Bore	6.67 cm
Stoke	6.98 cm
Firing order	1-3-4-2
Valve clearance	0.038 cm
Spark plug gap	0.058 – 0.071 cm
Magneto point gap	0.033 cm
Standard fuel	petrol
Coolant	water
Max. idle speed	2 750 ± 25 rpm
Min. idle speed	475 ± 25 rpm
Max. loaded speed	2 500 ± 25 rpm

The Carburetor

For the carburetor, the metering orifice was modified for higher fuel flow so as to produce the equi-

valent energy as provided by petrol. The test fuel was to be 190 proof ethanol. The modification will, therefore, be made to suit the use of this fuel.

According to Rogowski (1953), the fuel flow rate in the carburetor can be represented as follows.

$$w_f = A_f k_f (2g\gamma_f \Delta P_f)^{1/2}$$

where, w_f = fuel flow rate; A_f = cross-sectional area of fuel metering orifice; k_f = fuel flow coefficient; g = gravitational acceleration; γ_f = specific weight of fuel; ΔP_f = pressure drop between orifice inlet and orifice outlet

Since the same carburetor was used and that k_f and ΔP_f are affected by the difference in the physical properties of petrol and ethanol which are negligible, they can and were, therefore, assumed to have equal values for both fuels.

Assuming uniform fuel distribution between the four cylinders of the test engine, the chemically correct (stoichiometric) fuel-air ratio for petrol will be 0.067 (Barger, et.al., 1967), that is:

$$F_p = W_p/W_a = 0.067 \text{ kg petrol/kg air}$$

where, F_p = fuel-air ratio for petrol; w_p = petrol flow rate; w_a = air flow rate

With the heating value of petrol taken as 43 961 kJ/kg. then 0.067 kg petrol produces 2 949.4 kJ of energy.

The heating value of ethanol is taken to be 26 496 kJ/kg. Thus, 2 945.4 kJ of energy is equivalent to 0.110 kg of ethanol. Therefore, the required fuel-air ratio for ethanol is 0.110.

With the assumptions made that $k_e = k_p$ and $\Delta Pe = \Delta Pp$ (where e denotes ethanol and p denotes petrol), the ratio of w_e and w_p becomes as follows:

$$\frac{w_e}{w_p} = \frac{A_e \sqrt{\gamma_e}}{A_p \sqrt{\gamma_p}} = \frac{0.110}{0.067} = 1.642$$

Therefore, $A_e = 1.642\ A_p \left(\frac{\gamma_p}{\gamma_e}\right)^{1/2}$

With the specific weight of petrol taken as 0.739 g/cm^3, and that of ethanol taken as 0.794 g/cm3, the value of A_e becomes as follows:

$$A_e = 1.584\ A_p$$

The original orifice diameter is 1.191 mm, letting the new orifice diameter be d_e, then the following equation can be used to obtain d_e.

$$A_e = \frac{\pi d_e^2}{4} = 1.584 \left(\frac{\pi(1.191)^2}{4}\right)$$

From the above equation, the required orifice diameter for ethanol (d_e) is 1.499 mm, an increase of 25.86% over the original value.

The Dynamometer Test

A dynamometer was connected directly to the flywheel of the engine. The dynamometer used was the M & W hydraulic absorption type, model P-400B (**Fig. 1**). This dynamometer gave direct readings of speeds and pressures. The resulting horsepower was computed using the calculator dial provided.

Since the dynamometer is driven directly by the crankshaft, the horsepower obtained is the brake horsepower. Fuel consumption tests were also carried out by noting the time required to consume 100 mm height of fuel in a specially fabricated cylinder tube.

Engine Performance

In the tests, both forms of alcohol, namely; ethanol and methanol, were used. Their performances, with regards to brake horsepower and fuel consumption, are compared with that of petrol.

Brake Horsepower

Fig. 2 shows the relationships between the brake horsepower and the crankshaft speed for the three fuels. Petrol produced the best engine performance in terms of brake horsepower. At low speeds all three fuels gave about equal power output with ethanol giving the lowest value. However, the rate at which the horsepower increases as the speed increases, is faster for ethanol than for methanol. This is shown in the figure, whereby at a speed of 860 rpm, the brake horsepower curve of ethanol eventually crosses that of methanol. At higher speeds, ethanol is evidently higher

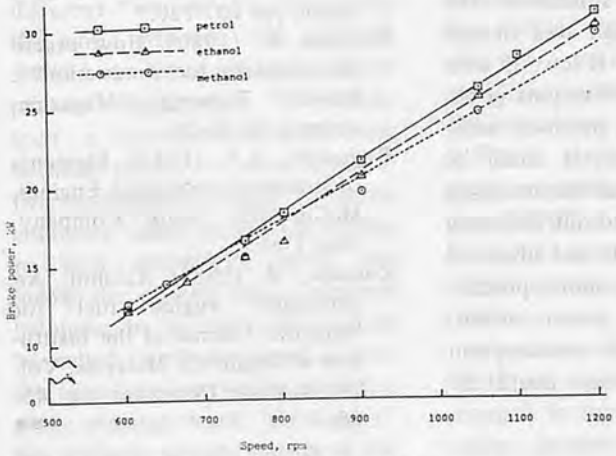


Fig. 2 Engine brake power and the revolution.

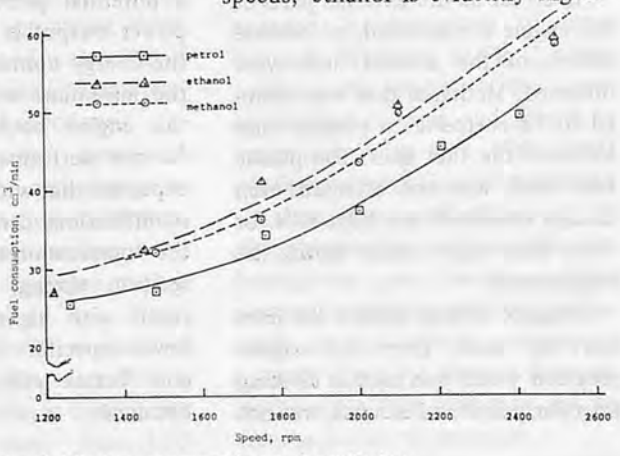


Fig. 3 Idle fuel consumption and revolution.

in power output than methanol.

The results also verify that the energy content of alcohol is no indication of the power output. In the case of ethanol, although its energy content is only two-thirds that of petrol, its power output does not indicate this ratio. In fact, its power output ranges from 92% as much at 650 rpm to 97% at 1 200 rpm. For methanol, the power output ratio ranges from 94 to 96%.

Fuel Consumption

Consumption-wise, both alcohol fuels give about equal rate, particularly at high speeds. This can be seen from **Fig. 3** which gives the fuel consumption rate at various crankshaft speed for the three fuels being tested. The consumption rate for alcohols are generally about 1.2 times higher than that of petrol. This is indeed quite surprising for the case of methanol whose energy content is only about 46% that of petrol, as compared to ethanol's 66.7%. However, it should be noted that these consumption curves were obtained during idling, that is, with the dynamometer disengaged from the flywheel shaft. Thus, a correlation between the brake horsepower and the consumption curves could not be justifiably made.

Effects on Engine Parts

In so far as the external parts of the engine a concerned, no adverse effects of the alcohol fuels were observed. Methanol that was claimed to be corrosive to plastics only softened the fuel lines. The plastic fuel tank was not affected even though methanol was kept in it for more than eight weeks during the experiment.

Ethanol affects neither the lines nor the tank. Even the copper junction which was used as dividing inlet for petrol and alcohol, was not affected. The use of plastic lines and tank, apart from avoiding corrosion, also served in eliminating the occurence of rusts due to the presence of water in the alcohols. In the cylinders, rusting was quite unlikely to occur because the fuels were always on the move. With the high temperatures and pressures created, the water might have just evaporated off.

The only operational problem faced by the engine was cold starting. Direct starting with alcohol was quite difficult and took such a long time that it was almost impossible. This was especially so when the engine had not been running for a long time and in the early morning. The introduction of the Y-junction through which petrol was initially used to start and warm the engine greatly helped in solving the problem. A three-minute run was sufficient for smooth alcohol transition. Unless and until a more suitable cure in terms of cost, convenience and performance for the cold starting problem, the method discussed above seems to be a practical approach.

Conclusion

Results obtained from the experiment have been very encouraging, showing that ethanol is indeed a potential petrol substitute. The power output is high even though the energy content is low. If with the minimum modifications given, the engine could produce satisfactory performance, it could be expected that with all the necessary modifications carried out including the compression ratio and advanced ignition timing, a more positive result with higher power output, lower specific fuel consumption and better efficiency could be obtained.

The effects of alcohol fuels on engine parts can be expected but is not too serious. Even the brass metering orifice equipment and the carburetor itself were spared by both methanol and ethanol. In fact, the problems of material incompatibility reported previously are mostly due to the use of ethanol blends. Thus, it can be seen that ethanol has a very bright prospect as the world's future renewable fuel. Energy crises would one day become a thing of the past through more itensified research and development into ethanol production and usage.

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Some Thoughts on Agricultural Mechanization



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Abstract

A theory has been developed to classify the world into different groups based on the state of agricultural mechanization. A strong element of relationship exists between the agricultural advancement and industrial potential of a country under a very secure social and political climate. There has been inadequate response from advanced countries to help developing nations boost their agricultural production. Poor planning, political instability, low literacy level and brain-drain, and elite hierarchy are some of the factors responsible for such global classification.

Introduction

World leaders, planning strategists, and international organizations generally refer to the so-called different "worlds", i.e., classifying the world into 1st, 2nd, and 3rd world but without any clear criteria of the classification. Of course, such a classification does exist because people in some contries live comfortably while in some countries, some people are unable to feed themselves, hence live below the poverty line. Countries belonging to the 3rd world used to be called "underdeveloped". Now the term has been replaced with a more pleasing word "developing" but without any real change in the socio-economic status of these countries.

A theory has been developed to classify the world into the aforementioned groups, based on well-defined parameters, particularly from the agricultural mechanization view point. Nine countries selected to formulate the bases for the theory are Egypt, India, Japan, Libya, Pakistan, Saudi Arabia, United Kingdom, USA, and USSR. The differences among these countries are many, including economic, industrial and agricultural sector development, labor utilization and availability, political and social system, and natural resources. **Table 1** shows different agricultural mechanization related factors which have been used to establish the theory.

World Classification

Two separate hypotheses to classify the world were considered and verified by comparing them with one another and with some of the already established parameters. The hypotheses are as follows:

1. World classification based on total economically active population (TEAP) and per capita income.
2. World classification based on TEAP percentage enganged in agriculture.

Countries with 40% or more of TEAP of which less than 20% is engaged in agriculture having per capita income more than US$ 3 000 fall in 1st world – agriculturally and industrially advanced countries in which the labor force has been exploited and utilized up to its maximum extent. Low percentage of TEAP involved in agricultural sector is an indication of high level of mechanized farming being practiced in a country. Countries with TEAP 20-40% of which more than 50% is engaged in agriculture and per capita income falls within the range of the 1st world, are grouped in 2nd world – countries having potential for advancement; but countries with per capita income less than US$ 3 000 are categorized in 3rd world – countries with zero potential for advancement, unfortunately is a large segment of today's world. This criterion of world classification is given in **Fig. 1** where demarcation of different worlds is clearly identified. Several countries have been included in the figure to clarify the concept.

A plot of TEAP versus TEAP engaged in agriculture of these countries is shown in **Fig. 2** which confirms the validity of the above established concept and also is in agreement with the UN's FAO continental classification standards.

Also, these world classes can be distinguished by plotting effective horsepower per hectare against average aggregate yield of major crops per ha of each country on a yearly basis for about a five-year period (2). This plot may not be clear as the above approach.

Japan, UK, USA, and USSR

Table 1 General Information of Selected Countries

Item	EGYPT	INDIA	PAKISTAN	LIBYA	SAUDI ARABIA	JAPAN	U.K	U.S.A.	USSR
(1) Population density (per km²)	42.42	210.78	93.84	1.68	3.75	318.10	231.25	24.0	12.0
(2) Literacy level (%)	44	36	23	40	15	99	99	99	99
(3) GNP growth rate (%)	5.8	1.1	0.8	4.5	13.0	3.6	1.6	?	4.4
(4) Per capita income (US $)	280	150	200	6260	6089	6010	4360	8773	3990
(5) Government stability factor (%)	0.73	0.91	0.26	0.5	1.00	0.95	1.00	1.00	1.00
(6) Economically active population — Total (%)	28.15	38.33	27.10	25.13	25.82	51.41	46.29	45.53	50.40
(7) Economically active population — TEAP in Agric. (%)	50.4	63.2	53.9	15.7	15.0	11.0	2.0	2.2	16.3
(8) Land used in agriculture (%)	2.86	57.03	25.91	1.31	0.52	13.23	28.60	20.63	10.31
(9) Per capita land (ha)	0.08	0.24	0.24	0.89	0.12	0.04	0.12	0.85	0.85
(10) Arable land per farm-worker (ha)	0.48	1.00	1.69	21.88	0.85	0.75	13.31	85.71	10.73
(11) Cultivated land / farm worker (ha)	0.46	0.98	1.66	?	?	0.64	12.50	84.00	10.00
(12) Irrigated land (%)	100	24	66	6	36	50	2	10	5
(13) Farm population/ tractor	242.0	525.0	249.0	9.0	1183.0	5.0	1.2	0.5	8.2
(14) Available mech. farm power (HP/ha)	0.41	0.10	0.12	0.25	0.05	13.30	3.27	1.17	0.57

Sources: Item 1–4 & 9: Information Please Almanac 1981 and 1981 World Almanac.
Item 5: (Life of Prevailing Constitution/Life of the country)....based on country history.
Item 8–13: Calculated from 1980 FAO Production Yearbook Vol. 34.
Item 14: (50/Col.10/Col.13)———50 HP of a farm Tractor assumed.
? Data not available

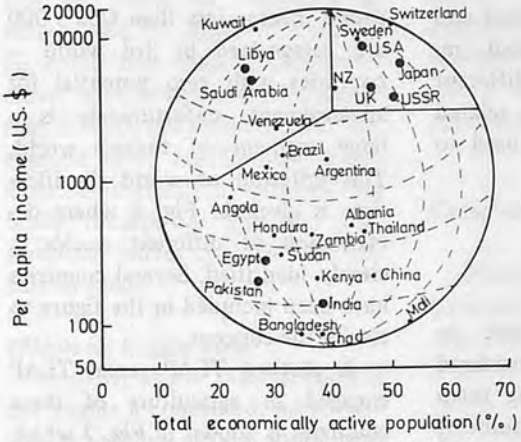


Fig. 1 World classification based on TEAP and per capita income. Source: FAO Production Yearbooks.

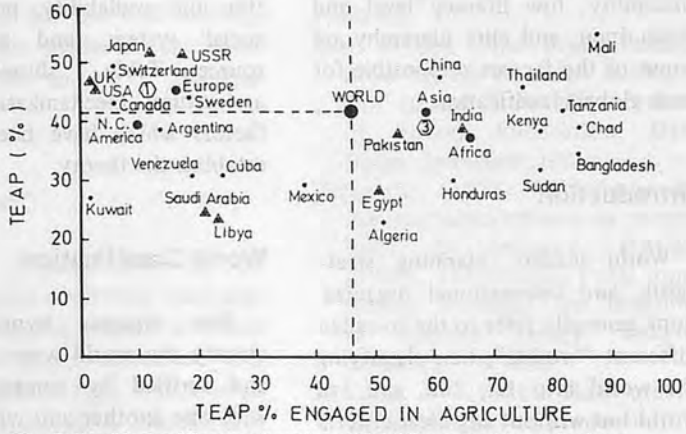


Fig. 2 World classification based on TEAP% engaged in agriculture. (1) – Developed countries and (3) – Developing countries (FAO classification). Source: FAO Production Yearbooks.

are among the 1st where the TEAP% engaged in agriculture is between 2 (UK) and 11 (Japan) and the arable land per farm worker ranges from 0.75 ha in Japan to 85.71 ha in the USA.

Libya and Saudi Arabia are among the 2nd world group. The labor force in these countries is limited (average TEAP <25%) and average arable land per farm worker is about 12 ha, with very low population densities. The most serious problems are those of salinity, water loss, lack of land leveling, and antiquated irrigation methods. But these countries are spending 60-65% of their yearly oil revenues on developmental projects of which 25-30% is always allocated for the enhancement of agriculture sector to diversify the economy base. Of course, with the prevailing oil gluts and disarray of OPEC members and the allocations of agricultural funds could be expected to decline considerably.

Egypt, India, and Pakistan clearly fall in the 3rd world where inadequate infrastructure, limited

arable land, inefficient use of irrigation water, low percentage of TEAP (Average for these three countries is 31) of which more than 50% is engaged in agriculture, lack of capital, high population density (India 211/km^2), and low literacy level are the limiting factors for advancement. Agriculture is the main source of gross national product (GNP) in these countries where the labor force is not properly exploited and is underutilized.

In **Figs. 1 and 2**, it is indicated that some of the 3rd world country exploit their labor force even higher than the 1st world countries but they still cannot raise themselves from the poverty line (e.g., Mali with per capita income US$95). This is due to poor management of agricultural resources and improper use of TEAP. These countries possess very limited natural resources, and besides being confronted with high population desities and extremely low literacy levels, they follow traditions blindly and generally live under unpredictable political atmosphere.

Among the 1st world countries falling in 2nd world group indicates high output of TEAP. Literacy level among these nations is almost 100% and people are innovative and progressive. Countries facing high population densities, like, Japan (318/km^2) have utilized their TEAP in sectors other than agriculture and have emerged as world's top industrial states. Japan is selfsufficient in most food stuffs and manages to export fish and fruit.

In the 2nd world, the obvious resource for high per capita income is either oil or some other mineral reserves for which these countries are less dependent on agriculture, at least for the time being. These countries have very limited skilled manpower but this is compensated by expatriates. A survey made by an Arab Labor Organization indicates that Saudi Arabia has the least population percentage of expatriates among the Gulf states. Four million foreigners were involved in the economic immigration to Gulf states by the middle of 1980, half of whom were in Saudi Arabia. The total population of the Gulf countries, excluding Iraq is around 11.5 million, with Saudi Arabia's population the largest at 7.5 million. According to this estimate, 60% of the Saudi Arabian labor force in 1980 was made up with expatriates. And, US$ 300 billion allocated for the Third Five Year Developmental Plan (1981-85), by now, may have just doubled the number of expatriates in the Kingdom of Saudi Arabia.

Tractorization.

The ratio of farm population to the number of tractors in a country is an indication of the level of mechanical power available to a farmer in that country. **Fig. 3** shows this ratio trends for the selected countries over the past two decades. The number of tractors available in a country does not represent an absolute available mechanical power per ha in that country but still it is an important parameter to explain agricultural mechanization status of the country. Among the 1st world countries, the figure indicates that a US farmer possessed about one tractor (approximately 40 HP) in 1960, while at present one farmer possesses roughly two tractors (**Table 1**). UK and Japan can reach one to one ratio of farm population and number of farm tractors sometimes during the last decade of this century if the prevailing trend is maintained, lagging behind the USA about four decades. Such classification further helps subclassify each world group. The figure also shows that Japan's position was not different from India

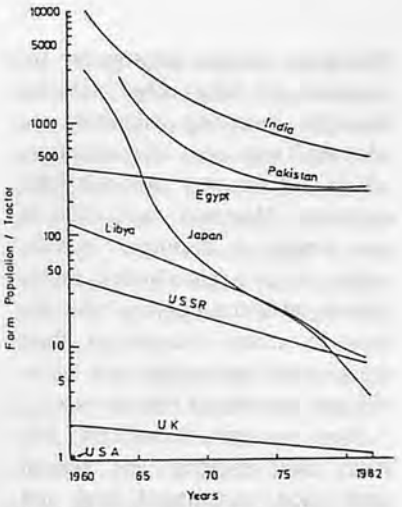


Fig. 3 Farm tractorization trends.
Source: FAO Production Yearbooks.

and Pakistan before 1960 and was actually lagging behind Egypt. But the government sponsored postwar agricultural mechanization policies helped Japan reach the level of having the world's highest mechanical power per ha (**Table 1**).

Factors Responsible for World Division

Government Stability.

Looking through the history and political background of these selected countries, it is seen that the nations with stable governmental systems, any type of government, have high per capita income, total economically active population (TEAP), and literacy level and generally fall in the 1st world, while countries with unstable governments fall in the 3rd world. The government stability factor for each country given in **Table 1** has been calculated dividing the life of the prevailing constitution by the life of the country.

Major development schemes generally require more than a decade from the time they are decided on until full production is achieved. But unfortunately, in the 3rd world countries, in many instances, the governments change several times within a decade.

Therefore, foreign investments are stopped, no long range national strategies, including agriculture are adopted, and even the resources within the country are not fully exploited. Moreover, agriculture is not simply a technical matter, rather it is a biocomplex multi-system involving humans who are slow to accept changes in their practices or technology and adopt efficient patterns of resource use.

For example, countries like India and Pakistan are blessed with good agricultural land and excellent network of canals and rivers, the resources not depletable like oil wells, if used properly. Pakistan's stability factor is the lowest (Table 1) because the prevailing constitution is the third since her independence about 35 years ago. On the other hand, India became independent on the same day as Pakistan's but due to relatively stable governmental setup she made tremendous progress in science and technology despite her problem of high population.

Agricultural mechanization reorganizes the relationship between land, labor, and capital. Therefore, the question of output versus reorganization has been a policy matter among the agriculturally advanced nations. Government policies are used to change the cropping patterns to distort the pricing system. Also, the farmers are powerful enough to make their demands heard. The last factor is particularly in sharp contrast to the situation in almost all the 3rd world countries where decisions are made by the urban elites. Policy makers in these countries have to deal with political instabilities and they are well aware of the fact that riots occur in cities rather than in rural sectors. This very fact explains the limited governmental subsidies for agriculture and the chunk of funds going to the urban areas.

Literacy Level and Brain-Drain

Literacy level is another important parameter beside per capita income, GNP growth rate, and total labor force to assess an overall potential of a country for advancement. Provision of adequate educational facilities, including qualified instructors is a pre-requisit for mechanized agriculture. In most of the 3rd world countries, such facilities are woefully inadequate or non-existent. Equally important is the education of farmers to help facilitate the agricultural extension work. Some of the 3rd world countries possess good agricultural extension programs but lack of agricultural education acts as a barrier to explain the benefits of modern farming practices. Uneducated people are hard to be detracked from their fore-fathers' traditions.

A worse dilemma is the migration of already scarce intellectuals from the 3rd world to advanced countries. For example, high percentage of 3rd world professionals going abroad for higher education never return to their native countries, partly due to high remunerations and better opportunities. Also, political instability in their home countries is another reason for such intellectual drifts. Some, who return, generally are not equipped with proper education, as most of the education programs in the host countries are not oriented towards the fulfilment of the developing nations' needs.

Poor Planning.

Agricultural mechanization is a complex subject requiring the expertise of many skilled individuals. It involves several components. such as design, development, testing, manufacturing, finance, operation, repair, and maintenance. If any component is missing, weak, or poorly-coordinated, the entire system can fail. Therefore, careful planning is essential in ensuring that every requirement of planning is thoroughly met.

The progress of agriculture in the 3rd world directly depends upon mechnization and its success can, in turn, be measured by the wisdom and efficiency of the planners and the individuals responsible for the program implementation, the judgement of the people, and adaptability of the farmers. Failure of agricultural mechanization in some of the 3rd world countries has resulted mainly due to poor planning and improper selection of the type of mechanization (selective mechanization) suitable to those countries.

Little planning has been done to upgrade and rationalize research on mechanization strategy. The result has been an ad hoc approach, the direction of which is determined largely by the political considerations and the available donor funding. Neither, unfortunately, reflects a sound and balanced understanding of the economic and technological needs of small farmers.

An agricultural mechanization program can easily run into a multi-billion dollar project and its failure can bring catastrophic results for a poor country. Therefore, extreme care must be taken during planning and implementing the program taking into account all the limiting factors. The agricultural mechanization program should be provided with feedback, essentially at the initial implementation stage and be reviewed periodically for making some adjustments and corrections in the program and modifying certain program objectives, if needed.

Urbanization

The urbanization trend for the quest of better standard of living and better opportunities is affecting the nations of the 3rd world

because the migrants are not being accommodated in cities due to lack of industry, thus causing an overall drop in total economically active population (TEAP) whereas, the reverse is true in the 1st world nations (Fig. 4).

Motives of migration (rural to urban) are a complex mixture of urban "pull" – the attraction of higher wages, social, cultural, and educational activities, and glamor of towns, and rural "push" – the desire to escape from stagnation, that offer only heavy unrewarding jobs in the atmosphere of little hope (6). Selective mechaniztion has been suggested to counter urbanization (8) – used under selected conditions mechanization can provide a "counter pull" to resist the attraction of the city – a "pull" for agriculture rather than the traditional "push" if selected considering the cultural, economic, employment, and production needs of the country concerned.

Selective mechanization for the 3rd world countries is any form of mechanization which does not decrease the demand for labor per unit of land (10), increases the production (including worker), and is cost reducing (8). The definition has been broadened on the ground that it is not realistic to put much emphasis on employment in agriculture per unit of land. Development is for people and the only means of improving the welfare of people is through an increase in labor productivity (real income). An increase in production per unit of land may be development but not for the laborer (8).

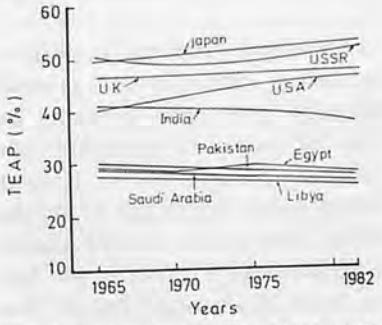


Fig. 4 Total economically active population (TEAP) trends. Source: FAO Production Yearbooks.

Role of Advanced Countries

It is an accepted fact that the condition of people does not change unless they try to change it. Obviously, if the developing nations do not strive to solve their problems themselves, the developed nations should not be blamed and held responsible for their plight. But, in this interdependent world with limited resources, a joint effort is always appropriate in helping solve the world hunger problem.

It cannot be denied that the advanced countries are extending some assistance to the poor nations but they are not shouldering the responsibility adequately. It is common practice that the donor countries decide on the type of aid to be given to a poor country and not what is essential for the country. Further, the degree of control retained over the donation use prohibits its proper utilization and effectiveness. Based on the donation limitations, the recipient countries become locked into development strategies which might not be appropriate at all to their circumstances. The aid programs designed for agriculture mainly consist of heavy machinery and equipment which are not suitable to the farming conditions of the poor countries. Personnel provided with these aids as an integral part of the aid packages are always well-qualified but their unfamiliarity with the socio-economic setup of a poor country negates the program effectiveness.

These aid programs can only materialize if the advanced countries do not impose completely their capital-intensive technologies on these poor nations. Rather, they should use their experience to help set up local manufacturing and secure an appropriate technology even if it is to be imported from some non-donor country. Once the USAID realized that the past donor aid efforts to developing countries had too often concentrated upon introduction of their own capital-intensive equipment to meet the local needs (9).

An appropriate approach is to support local small-scale manufacturing and procure in less-developed nations where some suitable technology may be available. The emphasis should be given to programs and policies which help apply labor-intensive technologies in industry where feasible and encourage small-scale firms in particular. (There are hundreds of small-scale manufacturing firms in the US. Some farmers' workshops are also manufacturing specialized equipment.)

Third world nations must take note of the long-term perspectives of the industrially advanced countries in the sphere of both oil and food. The importance they attach to greater production of food within their own countries is indicated by the high level of protectionism practiced by them. They develop their agriculture through protectionism and their industrial and energy sectors through competition.

Educational Institutions

Educational programs in the 3rd world institutions are not tailored towards the need of these countries. These programs are very similar to the ones in the advanced countries rather focusing on the appropriate technology needed by the developing nations. This similarity is partially due to the involvement of academicians from advanced countries in setting up these institutes as well as the curricula. An appropriate agricultural and engineering curricula can prove

a backbone of agricultural development for a poor country, but unfortunately, these curricula lack national spirit and system approach and are never coordinated with the national development strategies. In most cases, once the curricula are established, they remain unchanged for decades and no appropriate modifications or new inputs are added. For a developing nation, it is essential to inter-relate the diverse parameters of today's world of limited resources, population explosion, and economic crises with the related social and humanistic issues (1). (In the US, curricula are reviewed and modified each time the school is up for accreditation which happens after every four or five years. Also, individual faculty members are given considerable freedom in what they teach.)

For example, in the developing countries, the engineering curricula generally emphasizes design and manufacture, just like in the advanced countries, while the graduates in their practical life get little opportunity to do design work. Rather they engage themselves in activities according to the local needs for which, as a matter of fact, they are not adequately trained in the educational institutions. More than 80% of the machinery and equipment being used in the 3rd world are imported and mostly in the assembled form. Thus, the graduate engineers are involved in the following activities instead of design and manufacturing:

1. Project initial designing, feasibility analysis, cost and benefit analysis, and actual installation.
2. Decision making, planning, scheduling, and coordination.
3. Evaluation of design specifications of proposed projects and consulting.
4. Administration, public dealing, and manpower planning and training.
5. Machinery and spare parts indenting, purchasing, procurement, ledger keeping, and verification.
6. Field work, inspection, and machinery repair and maintenance.

Developing nations should rise from the level of followers and develop their own educational programs according to their needs and priorities. Of course, basic engineering courses are essential to understanding and carrying out the above mentioned tasks effectively. But the advanced engineering courses consituting a bulk of the undergraguate curricula must be replaced with appropriate subjects according to the aforementioned practical diversification. An immediate need is to change the curricula to incorporate the national priorities. The curricula should be reviewed periodically on a regular basis to include or exclude courses or course contents based on the experience of field engineers. For a developing nation, a mix of traditionally trained and new more appropriately trained engineers with a ratio of one to five can be adopted depending on the needs and future plans of the nation (4).

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Mechanized Cultivation of Taro *(Colocasia Esculenta)* in Fiji



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Abstract

Taro is an important food crop in Fiji. Presently taro production is mainly confined to manual- and animal-based systems of production which require very high levels of labour input. A study was conducted to evaluate a tractor based system of production relative to animal based system. It was found that the operational costs of production were much lower in the tractor-based technology. Much higher gross margins per hectare and per man-day could be expected in the tractor-based production system. This finding will be particularly useful to commercial growers of taro in Fiji. Overall, it is concluded that considerable mechanization possibilities exist for taro cultivation in Fiji.

Introduction

Taro (*Colocasia esculenta* L. Schott), known locally as dalo, is an important staple food crop of the indigenous societies of the tropical world. Throughout the islands of the Pacific, Asian archipelago, Central Africa, West Indies and the islands of the Caribbean and Central America taro forms an important part of the people's diet. However, it is only in the last 20 years that serious research has been carried out in taro. Many governments of the developing world are now making considerable investment into taro research in an effort to increase food supply availability both for rural and urban communities. Payoffs from research into the tropical root crops have always been high and taro is no exception (Chandra, 1980). The annual world production of taro is about 4.4 million t and most of it is produced by Nigeria, Ghana and Japan.

Present Production Systems

Much of the taro produced in Fiji at present is grown in dryland culture (Chandra, 1979 a,b). However, in some areas where suitable conditions prevail, wetland production of taro is an important cultural practice. Some of the areas where wetland cultivation of taro is presently carried out are in the upper Sigatoka Valley, next to Namoli village, small and remote river valleys in Vanua Levu, Taveuni and Kadavu and on other smaller islands. In terms of total annual production of taro in Fiji it is estimated that dryland production of taro would account for over 90% of the production.

In Fiji taro is an 8 to 12-month crop and is planted and harvested throughout the year although the main planting season is during the early part of the rainy season from September to December. The main varieties grown in Fiji are Toakula, Tausala-ni-Samoa, Samoa and Vaivai Dina although up to 70 varieties have been recorded and maintained in the germplasm collection at the Koronivia Research Station (KRS).

The present production system is heavily dependent on manual labour. There are two ways of land preparation. In a small plot subsistence situation all land preparation



Fig. 1 A typical Fijian village (Koro).



Fig. 2 Extension agricultural engineer and farmers discussing taro mechanization problems in the field.

is done manually using forks or spades. In other areas where the plots are larger draught animals such as horses and bullocks and sometimes tractors are used for land preparation. In subsistence situations once a suitable tilth has been achieved about 30 cm deep holes are made at planting distances of 1 m using a thick wooden stick called *doku* or *naisau*. The planting material, which is the taro top or sucker, is placed in the hole and the base covered by soil. Taro requires a considerable amount of hand weeding, this being repeated four to five times during crop growth, especially during the rainy season when the weeds predominate. In other areas, taro is planted in furrows made by draught animals. Here weeds are controlled manually and by inter-row cultivation. At about 3 to 4 month age the crop is ridged, again using draught animals.

Harvesting in both situations is similar. The crop is lifted manually either by pulling or by using forks. For marketing, about 30 cm of petioles are left on the corms, tied and sold in bundles of 3 to 6.

The recent Fiji Census of Agriculture (1978) indicates that the average yield of taro in pure stands is 13.4 t/ha. The corm yield was estimated as 76% of the whole plant yield and, therefore, the average yield of taro corms only was 9.2 t/ha. The Census data shows that taro was grown in pure stands on 1 535 ha and in mixed stands on 1 340 ha. Altogether about 23 000 farmers grow taro in Fiji of which 75% cent are indigenous Fijian *matagali* (land holding clan) farmers cultivating 82% of the total area under taro. The average plot size of pure stand taro per farm was 0.08 ha. Annual production of taro in Fiji is estimated at 34 700 t.

Most of the taro produced in Fiji is used as subsistence products on the farm. Both the young leaves and the corms are consumed. Less than 50% of the total taro production in Fiji probably enters the urban markets. Some of the marketed fraction is exported overseas in New Zealand, New Caledonia, Australia, USA and Canada.

Experimental Procedure

Taro production systems studies enable a more optimum use of farm resources towards some stated objective (Chandra and Sivan, 1981). A farmer may have one or several objectives in farming. These could be to: (a) maximize yields, (b) minimize costs and (c) maximize profits. Obviously, different production technologies may suit different objectives of the farmer. It was the purpose of this study to evaluate the animal- and tractor-based systems of taro production in terms of gross margins analysis per ha and per man-day.

Field experiments for this research were carried out between 1978 and 1980 on a farmer's field in southeast Viti Levu. The farm was located about 10 km and within easy road access to KRS, the base of this research programme. An agreement was made with the farmer to lease the land for the duration of the experiment. As a compensation to the farmer all taro produced in the experiment was to be retained by the farmer. All inputs for the experiment were to be supplied by the project and hence there were no direct costs to the farmer.

Average annual rainfall in the study area is 3 120 mm which is well distributed throughout the year although 63.5% of the rainfall is obtained in wet summer months from November to April. Bright sunshine totals 1680 h per annum. The mean temperature is 28.3°C; the mean maximum temperature is 29.5°C; the mean minimum temperature is 24.9°C. The soil is alluvial in origin, silty clay in texture and had a pH of 5.30 in water solution.

An area of 0.4 ha was used for the tractor-based system and 0.2 ha for the animal-based system. The variety used was Toakula which is one of the high yielding varieties of taro in Fiji. The animal-based system used a pair of bullocks. The animal drawn implements used were the common plough and harrow used in Fiji. For the tractor system a medium-sized tractor was used. All operations in the tractor system were mechanized, including the planting task, except for harvesting which was done manually as in the case of animal systems. The tractor system utilized two disc ploughings and three disc harrowings. Planting was done by a tractor drawn planter which was developed earlier in Fiji (Sharma. 1978). The herbicide and fertilizer applications were done manually in both systems. Throughout the experiments the material and labour costs were recorded at the site. The data was then converted to per ha basis and the main results are reported below.

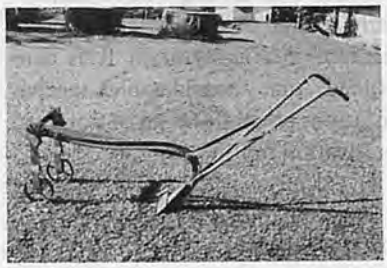


Fig. 3 Animal-drawn improved hoe for weed control developed by the author in Fiji.



Fig. 4 Tractor-drawn taro planter developed by the author in Fiji.

Results and Discussion

The results of the study are summarized in **Tables 1 and 2. Table 1** shows that the animal production system incurs much higher cost than the tractor system. There are three operations which are responsible for this. Firstly, the taro planter used in the tractor system reduces the labour requirements for this task considerably. Secondly, hand weeding requires much more labour than if the weeds were controlled by inter-row cultivation using tractor. Thirdly, labour requirement for the harvesting task in the animal system is much higher than in the tractor system because of poor weed control, even when the crop is ready for harvest. Overall the animal system incurs about 35% more operational cost than the tractor system. However, it should be noted that if the depreciation on tractor and bullocks, together with the appropriate implements, were taken into consideration then the overall differences in the costs of production could very much have been in favour of the animal system.

Table 2 shows the results of the gross margins analysis. The tractor production system gave slightly higher yield and the number of man-days required was about half that in the animal production system. A farmgate price of $130/t was used to calculate the value of crop. The gross margins/ha of taro produced in the animal production system was only about 25% of that generated in the tractor system. In terms of gross margin/man-day the animal system accounts for only 12% of that in the tractor system. Hence, the tractor production technology is extremely efficient relative to the animal production technology in terms of gross margins/ha and gross margins/man-day.

Table 1 Cost of Operations Unit: $/ha

Item	Animal	Tractor
Land Preparation		
Ploughing (2)	40	40
Harrowing (3)	45	45
Planting		
Planting materials	450	413
Labour	116	38
Weed Control		
Hand weeding inter-row cultivation	96	25
Herbicides	60	60
Labour for herbicide application	15	10
Fertilization		
Fertilizer	111	111
Labour	25	15
Harvesting		
Labour	281	164
Total	1 239	921

Table 2 Gross Margins Analysis

Item	Animal	Tractor
Yield (t/ha)	11	13
Man-days	162	79
Value of crop ($)	1 430	1 690
Production costs ($)	1 239	921
Gross margins/ha ($)	191	769
Gross margins/man-day($)	1.18	9.73

Conclusion

This study has shown that considerable mechanization possibilities exist for taro cultivation in Fuji. Much higher returns can be expected by tractorization if the initial cost of tractors are not taken into account in the analysis. Commercial growers of taro would particularly find the tractor production technology suitable. This is because tractors enable considerable savings in labour through a much greater rate of work. Overall, considerable scope exists for improving taro cultivation technology in Fuji.



Fig. 5 Taro being planted by a tractor-drawn taro planter.



Fig. 6 Mechanized cultivation of taro is picking up in Fiji.

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Mechanization of Peanut Harvesting in Malaysia



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Abstract

This paper discusses the research needs in peanut harvesting which is facing labour shortage due to industrialization process. Research areas are suggested and the approach adopted in the development of machines should consider designs that are complementary with on-farm resources and are capable of being produced, utilised and maintained using local skills. Various parameters that affect machine performance are also described based on available data.

Introduction

Malaysia is a developing country whose future economic development rests largely on the progress made and the goals achieved in the agriculture sector.

Malaysia's agricultural population consists primarily of smallholders. In 1980, agriculture contributed about 23% of the Gross Domestic Product and on it depended 48% of the population for their livelihood. Agricultural technology has been applied in almost every sector of agriculture and for various agricultural activities from land preparation to processing of agricultural products. The development of this technology, in a way, has been spurred by the shortage of labour due to industrialization process. A recent survey indicates that the estate sector alone suffers a shortage of 11 000 workers (Anon, 1982). With acute shortage of labour, especially during peak periods such as transplanting and harvesting, it is no longer feasible not to resort to mechanical power. Though satisfactory progress has been achieved, Malaysia still lags behind other developed nations in the mechanization of the agriculture sector.

Peanut has been described as a promising diversification crop in Malaysian agriculture because of its agronomic and economic potential. The peanut grows best in soil which is well drained, light-textured and with a pH of 6-6.5. In recent years acreages planted to peanut have expanded. In fact in certain rice growing areas where double cropping is not practised peanut is the most popular off-season crop. In 1972 about 4 578 ha were planted to peanut in Peninsular Malaysia and increased to 6 000 ha by 1978. This resulted in a marked increase in export and, consequently, a reduction in import of peanut and peanut-based products. In 1978 the import of peanut and peanut-based product was about 9 000 t compared to the export of 4 000 t. In 1979 the import of peanut and peanut-based product was only 7 000 t while the export of such products increased to 15 000 t **(Table 1 and 2)**.

Studies have shown that the potential profitability of peanuts is high and has been recommended as an attractive short-term cash crop for estates or smallholding farms for intercropping with perennials (RRIM, 1974). However, the cost of production is also high. A large labour force has to be employed, especially during harvest which is done on contract basis. In 1978 the harvesting cost was M$100/acre which increased to M$250/acre in 1980 and accounted for about half of the total production cost (Zohadie and Wan Ishak, 1981).

From a study on the manual harvesting process for peanut production, stripping the nuts from the plant is the most critical operation as it utilizes most of the labour input. At present the pulling and stripping process require 84 man-hours per ha (Zohadie and Wan Ishak, 1981).

Mechanization in the production of peanuts in western countries has reached a very high level. Modern harvesting and handling practices result from research in the mechanisation of this crop. A factor that has been considered of great importance is the

Table 1 Import of Peanut and Peanut Based Product to Malaysia

Item	1978		1979	
	Quantity (t)	Value (M $ 000)	Quantity (t)	Value (M $ 000)
Peanut oil for domestic and other uses	1 767	3 425	2 065	3 978.0
Hydrogenated peanut oil	0.005	–	5	11.1
Peanut in shell	1 668	1 193.5	1 404	994.1
Shelled peanut	5 512	4 681.2	4 032	3 588.9
Total	8 947	9 299.8	7 506	8 587

(Adapted from Ahmad Puzi Abu Bakar, 1982)

Table 2 Export of Peanut and Peanut Based Product from Malaysia

Item	1978		1979	
	Quantity (t)	Value (M $ 100)	Quantity (t)	Value (M $ 000)
Peanut oil domestic and other uses	3 574	11 594.5	14 422	27 265
Hydrogenated peanut oil	12.32	53.7	0.133	0.3
Peanut in shell	330	876.8	412	1 057.4
Shelled peanut	52	100.8	53	63.7
Total	3 968.3	12 625.8	14 887.1	28 386.4

(Adapted from Ahmad Puzi Abu Bakar, 1982)

quality of agricultural products. Thus farmers are equipped with the latest techniques and operating methods to bring about high and economical production.

Progress in this regard is still slow. In contrast to the farmers in the developed countries, peanut growers in Malaysia still practice the traditional methods of planting, harvesting and shelling which are inefficient and labour intensive. As a result, most farmers grow peanut for domestic consumption rather than for commercial purposes. Factors that hinder the application of modern technology are many. Apart from the socio-economic constraints, there is a lack of suitable mechanical system for local conditions. Besides it is too expensive to import machines from overseas which need modifications. Also, the small, fragmented plots are uneconomic for full scale mechanization.

Current Status of Mechanization

Land Preparation

Land preparation is about the only operation that is fully mechanized in the entire peanut production in the country. For this purpose, it has become a standard practice to use 4-wheel tractors or 2-wheel (pedestrian) tractors especially in areas where double cropping is not practised in the off-season.

Harvesting and Threshing

This is the most labour intensive operation in peanut production. At present manual labour is still being used in pulling the plants off the ground which requires less effort. Fig. 1 shows how the plants are pulled off the ground and stacked before the nuts are stripped (Fig. 2). Stripping the nuts is the most time-consuming operation. At present pulling and stripping would take 84 man-hours per ha or 6.4 man-hours per 100 kg. In certain areas where stationary threshers are available, plants are first pulled off the ground and stacked near the machine to save time for threshing. With this operation, the total production in one hour could reach as high as 50 kg for a double cylinder thresher (Ahmad Puzi, 1982) and 45 kg for a single cylinder thresher (Zohadie and Wan Ishak, 1982).

The introduction of stationary threshers and shellers in peanut production is not new as it started nearly two decades ago in the country with the work of Ramly (1966) who conducted a trial on a simple peanut stripper which made use of a rotating cylinder formed of 5 round bars fixed between end plates. Further work was later carried out by some notable researchers, namely; Rivera, E.S. and Medd, M. W. (1968); Rivera E. S. et al (1969); Choa Swee Lin (1976), Sharan Che Man (1979); Fazli (1980); Razali Razak (1980); Zohadie and Wan Ishak (1981); Ahmad Puzi Bakar (1982) and most recently by SIRIM (Anon, 1982). These designs were aimed at helping farmers on smallholdings with simple but cheap threshers and shellers that not only remove drudgery from the process but also save time. Quite a number of those designs are engine-driven.



Fig. 1 Pulling of peanut stalks.



Fig. 2 Stripping the pods from the plant.



Fig. 3 Locally fabricated machine being tested at Kuala Brang, Trengganu.

Some improvements and modification can be made on these designs in order to make them more efficient and suitable for small farm use. Research is currently being undertaken by several bodies like UPM, MARDI and SIRIM towards better performance of the designs. Fig. 3 shows one of the machines fabricated locally being tested at Kuala Brang, Trengganu. As yet there is no machine that has ever been designed locally that could dig, clean vine, thresh and shell the pods in single operation. This could be due to the fact that most of the area covered with peanuts are small plots which are unsuitable for the use of such machine. However, the introduction of a small multi-row harvester may be a practical solution though the initial cost of the machine is perhaps beyond the reach of most small farmers.

Potential Research Areas

Two factors which were mainly responsible for increased interest in the development of mechanical peanut harvester are: i) the increase in harvesting costs; and ii) the problems involved in the procurement of manual labour.

As far as mechanization is concerned, mechanical handling and harvesting of peanuts offer the best possible solution for reducing the cost of production of this cash crop. Farmers with small acreages of peanuts have not been able to mechanize because of the high cost involved. Therefore, the trend should be to stress peanut production into larger farm units which can justify mechanization. The best way to reduce the cost of production is to use mechanical equipment wherever possible.

With the exception of mechanical harvesters, much of the machinery developed for the other crops could be adapted to peanut production and since harvesting requires more man-hours of labour than all other operations, development design and research should be directed toward a suitable machine for harvesting peanuts. Experience overseas reveals that tractor-operated harvesting equipment could reduce the labour requirement from 1/12 to 1/30 compared with traditional practices. The typical working speed of existing equipment for harvesting is about 2.5 km/h (Kalkat, H. S. et al 1978). Areas of study that could be considered in the design of machineries for smallholdings include a peanut lifter or digger and a peanut thresher.

The lifting mechanism for the harvester should consist of something sharp that can penetrate the soil at the required depth and loosen the ground. One of the most economical and satisfactory implements for lifting the plants is the angle drag with a cutter blade mounted under the drag. This tool can be animal-driven or tractor-mounted. When using the animal drawn cutter, the operator could ride the drag whereby he can control the depth of cutting blade by shifting his weight. For the tractor mounted drag, the depth of cut is controlled by the hyraulic lift system. In this manner a fine degree of control as to depth of digging could be maintained.

Recently the Magoye Regional Research Station in Zambia designed peanut lifters suitable for a pair of animals. One of the designs was made from a plough from which mouldboard, landslide share and frog were removed. The blade was attached to the lower end of the beam and wheels were mounted at the front to guide the unit between ridges. The second design consisted of a rectangular frame fitted with handles. Its blade was slightly curved and supported between two back legs. At the front there was a towing ring and two steadying legs fitted with skids, serving the purpose as the wheels. The ring, legs, handles and blade could all be adjusted for height and angle of cut, respectively. From tests carried out in dry and moist conditions, the rectangular lifter was better although a lot of pressure was needed to keep the blade at the required depth in moist condition. It was also noticed that mechanical lifting is only practical if planting is done on the ridges that are well formed. If the ridges have been flattened for any reason, the blade will not penetrate below the pods. It will just cut its way through the root system leaving some pods still in the ground or badly damaged.

Basically, peanut threshing involves the detachment of pods from the panicles and this process may either be done manually or by means of a mechanical thresher. In Malaysia areas where stationary mechnical threshers are unavailable stripping the pods is still done by hand. At present there are quite a number of stationary mechanical threshers designed and fabricated locally for use by farmers in Kuala Brang, Trengganu (Desa and Zohadie, 1982). However, further investigation should be carried out to improve the performance of the existing machines.

In designing the machine, Singal et al (1979) pointed out that a good thresher should satisfy the following requirements: the efficiency of threshing should be above 95%; minimum separation losses; and clean pod output.

Other factors which determine the effectiveness of such operation include the following: a) the type of thresher used; b) methods of harvesting; c) the peripheral speed of the threshing element; d) cylinder concave clearance; e) the type and variety of crop; and f) the conditions of crop in terms of moisture content and maturity stage.

Type of Thresher

Review of past investigations reveal that a mechanical harvester was first tested in the USA in the early 50's. Stokes et al (1950) reported studies on three types of experimental combines using a conventional cylinder arrangement, on overshot cylinder and the combing principle for removing the pods from the vines. The cylinder type unit tended to get more nuts under adverse conditions but all types were effective under favourable conditions. A rather remarkable machine that could dig, clean vine, stem and bag an acre of peanuts in 1 h has also been designed as reported by Baker et al (1951). The machine lifted the plants from the soil by the tops, shook out loose soil, raised and dropped them on top of the first cylinder. A second cylinder consisted of picking teeth would deposit the vines on the vine track which shook the peanuts from the vines as they moved upward to the rear of the machine. Further work was later suggested by Sorenson (1952) on the use of spring tooth cylinder for the complete separation of pods from panicles. In 1980, Fazli tested a stationary drum thresher fitted with wire loops but the results showed significant number of pods remaining in the stalks. He, however, suggested the incorporation of other peg shape and a suitable concave to help the stripping process.

Method of Harvesting

Stokes et al (1950) reported that it took 30.5 man-hours per acre to dig, windrow, pile and thresh manually and 9.5 man-hours per acre to dig, windrow, pile and thresh with a thresher towed through the field. When crops were dug, windrowed and threshed using combine, the time taken was 4.1 man-hours. However, combining caused considerable loss of peanuts. This could be due to effect of other factors since the process involves the interaction of machine and crop parameters which together influence the level and rates of performance of the thresher and the quality of the threshed pods. It clearly indicates that further work is necessary to avoid such losses.

Speed of Threshing

The speed of rotation of the threshing drum plays an important role on the efficiency and damage to pods. A study carried out by Wesley Chaffin as reported by Ahmad Puzi (1982) showed that cracking and breaking of pods could be avoided by proper spacing of the thresher teeth and the cylinder speed maintained below 400 rpm. This is supported by a test carried out by Rivera, E. S. and Medd, M. W. (1968), Rivera et al (1969), Fazli (1980) and Ahmad Fuzi (1982) on single and double cylinder type threshers.

Clearance

The selection of clearance is determined by the speed and type of cylinder used. It has been found that, generally, there is an increase in efficiency as the clearance between 300 and 400 m/min, the board decreases. For a single cylinder with a peripheral speed between 300 to 400 m/min, the recommended clearance is between 30-38 mm (Rivera, E. S. and Medd M. W., 1968) whereas for double cylinders at a speed of 232 m/min the optimum clearance setting is 45 mm (Ahmad Puzi 1982). Ahmad Puzi reported that the above setting resulted in a threshing efficiency of 75.5% with a minimum pod damage of 8.9%. The output capacity was 50 kg/h and the mean force required to detach each panicle was found to be in the range of 1-2.2 kg. A similar design using double cylinders, but with a tapered clearance, resulted in a threshing efficiency of 95.8%.

Crop Moisture Content

Moisture content is perhaps the most critical factor affecting the harvesting of peanuts. Woodroff (1966) reported that peanuts are usually threshed at an average kernel moisture content of 18-25% (wb). However, Singal et al (1979) stated that the optimum moisture content for peanut harvesting is between 35% and 40%. Threshing at site was also found to reduce pods with panicles (Fazli, 1980). Delay in threshing would certainly damage the pods in the form of partial splitting and this would be most crucial when the nuts reach germination stage. However, if nuts are dry, damage could be minimised by decreasing the drum speed and increasing the clearance between the drum and the threshing surface.

Conclusion

Mechanisation in the harvesting of peanuts certainly offers many advantages. Other areas that would need further research include better seed production and preservation, better shelling, grading, storing and marketing. In the development of machines for peanut production, it is essential that the following factors are considered: i) The machine should be i) low in capital costs; ii) use local materials whenever possible; iii) should not displace labour; iv) should have low operating costs; v) acceptable to farmers; vi) small enough in scale to be affordable by small groups of farmers; vii) can be understood, controlled and maintained by farmers without a high level of technical know how; and viii) flexible so that it can continue to be

used or adapted to fit changing circumstances.

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Sprinkler Distribution Patterns as Affected by Pressure and Wind



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Abstract

Using a 7° Trajectory Full Circle Sprinkler with a 4.8 mm diameter nozzle and more than hundreds of samples of water distributed from each of a series of 6 tests, each repeated thrice, the effect of pressure and wind on the shape of sprinkler patterns, which dictates sprinkler uniformity, was studied. Three dimensional computer graphics, developed to visualize the effect, showed that under low wind, the shape is donut type at low operating pressure; as the pressure increased, the uniformity of shape extended inward and the pattern became larger providing more irrigation coverage. When the wind was high, a reduced donut effect was observed at low pressure; as the pressure increased, some distortion and elongation of the pattern-shape, shifting of the pattern in the direction of wind, and slight improvement in irrigation coverage were observed. With further increase in pressure the above characteristics of wind (other than improving the irrigation coverage) became pronounced. From examinations of all the 18 patterns it was concluded that under low wind, a high operating pressure (414 kPa) is preferable while under high wind, a medium pressure (276 kPa) would yield the best patterns.

Introduction

The shape of the sprinkler distribution pattern plays a dominant role in the effectiveness of water distribution from a sprinkler. Although an absolute uniform application of water is not possible, higher uniformities would result from fairly uniform-shaped distribution patterns; a distorted pattern would yield poor distribution—the more the distortion, the poorer the distribution.

Sprinkler operating pressure and the prevalent wind conditions are thought to influence the distribution patterns most. Pair *et al* (1975) observed that a pressure that is too low would result in a donut-shaped distribution pattern and a pressure that is too high in an approximately bell-shaped, pattern. None of these shapes would help achieve acceptable uniformities which is regarded as 80% or above by the irrigation farmers.

Wind is probably the principal factor which causes undesirable water distributions. Seginer and Kostrinsky (1975) studied the effect of wind on sprinkler patterns and reported that the only effect of wind was distorting the distribution patterns. Shull and Dylla (1976) investigated the effect of wind on distribution patterns from a large, single nozzle sprinkler. They used a 2.51 cm diameter ring nozzle for sprinkling and 9.8 cm diameter cans to catch the spray. Placing these sampling cans 6.1 m apart on a square grid network and running 15 field tests under windy conditions, they observed that application pattern distortion was primarily a function of the wind velocity and pressure.

The shape of the application pattern and its distortion is judged by examining visually the contours of equal water depths in a two dimensional plane. The method requires a good understanding of technical drawing and a sound imaginative skill, since, in reality, a three-dimensional phenomenon in space has to be imagined from a two-dimensional graph in a plane. A two-dimensional graph would not give a picture as clear as a three-dimensional graph would do. Clear

visualization of the shape of the sprinkler pattern is necessary to be able to estimate the application uniformity. If the shape of the pattern is clearly conceivable, it would require no expertise and technical background to estimate the uniformity resulting from the pattern.

Catch-can method of sampling the sprinkler spray has been used by many. In this method, empty cans, called catch-cans, are placed on some selected points on the ground, water is allowed to sprinkle through the sprinkler and is collected in the empty catch-cans. Volumes of water has collected in the sampling cans (can-volumes) constitute the data indicative of the water distribution norm on the ground. Although no standardized procedure is available for placing these catch-cans on the ground it is suspected that a 6.1 m spacing between sampling cans, as used by Shull and Dylla (1976), would not adequately represent the true distribution of water.

This study was, therefore, undertaken to use a smaller spacing between sampling cans and visualize the shape of the sprinkler distribution pattern using three dimensional graphs in space, and to see how the shape is affected by pressure and wind.

Experimental Investigation

Field tests each of 150 min duration were conducted with a 7° Trajectory Full Circle Sprinker head fitted with a nozzle of 4.8 mm diameter. The tests were carried out with three levels of pressures of 138 (low), 276 (medium), and 414 kPa (high), and two levels of wind speeds of less than 9.6 (low) and between 9.6 and 20 km/h (high). These 6 tests, each with three repetitions, were conducted between wind speeds of 0 and 21 km/h resulting in a total of 18 tests. Spray during all these tests was sampled on the ground using empty catch-cans. Before each test, cans of 10.6 cm of internal diameters and 8.5 cm of heights were placed on each grid point, one meter apart, on a 41 m by 41 m square grid network. This one meter distance between catch-cans was well within the spacings proposed by Davis (1966), who reported that sampling cans should be placed on the ground such that each of them represent from 2.0 to 2.5% of the pattern wetted area to give good representation of the distribution.

Sprinkler operating pressure, wind speed and flow of water to the experimental system were recorded during every test. At the end of each test, the can-volumes were recorded immediately.

The operating pressure was recorded using a calibrated pressure gauge installed near the sprinkler nozzle. Wind speed and direction were recorded by means of an automatic recording windvane installed 30 m away from the sprinkler head; and the flow of water to the sprinkler was measured using a totalling flow meter. Spray volumes (can-volumes) obtained in the catch-cans on the entire grid were measured using three graduated glass cylinders—a small one graduated from 0 to 25 ml for measuring very small amounts of water, a medium one from 0 to 100 ml for little larger amounts, and a large cylinder graduated from 0 to 500 ml for larger volumes.

Results and Discussion

Can-volumes obtained from the 18 field tests constituted the basic data to develop the distribution pattern to be utilized to observe the effects of pressure and wind on the shape, and consequently on the uniformity, of these distribution in patterns. The can-volumes for each test were first converted depths of water by dividing these by the internal diameter of the catch-can. Distribution pattern termed in this study refers to a distribution of these water depths.

Distribution patterns have been described using two-dimensional graphical procedure (Christiansen, 1942) to show the effects of pressure and wind on water distribution. The present study took a different approach. Using the water depths caught in the sampling cans, and with the help of computer graphics, three-dimensional distribution patterns were drawn by the CALOM Plotter to help easy visualization of the pattern shape as well as to help examine visually the effects of the above factors. While developing these patterns, the vertical scale to indicate the depths of water within the pattern was kept constant for all the 18 tests so that visual comparison between patterns can easily be made. Six of these patterns representing distributions from a 1.52 m low riser sprinkler are presented in **Figs. 1 - 6** which would allow clear visual examinations. The magnitudes and directions of wind during the tests have been shown by arrows in these figures. Since exact unidirectional flow of wind does not occur in nature, the predominant directions of wind during the tests were considered as the directions of wind. The other test conditions for these patterns are shown in the titles of the respective figures.

Figs. 1 - 3 demonstrate that under low wind speeds, the pattern shape approaches uniform as the operating pressure is increased. At low pressure the shape is of donut type where most of the water is distributed toward the outermost periphery of the pattern **(Fig. 1)**. As the pressure is increased to medium and high, the uniformity of shape extends inward and the pattern becomes larger indicating higher uniformity and better irrigation coverage, respectively **(Figs. 2**

and 3).

Figs. 4, 5 and 6 show similar patterns but at high winds. When the pressure is low (Fig. 4) at this condition, a reduced donut effect and shifting of pattern in the direction of wind are noted as compared to Fig. 1. As the pressure is increased to medium, some direction and elongation of the pattern shape, shifting of the pattern in the direction of wind, and slight enlargement in the pattern coverage are observed (Fig. 5). As the pressure is further increased to high, the pattern coverage remains about the same but the distortion of the shape, shifting of pattern, and the pattern elongation characteristics of wind become pronounced (Fig. 6).

Figures obtained from other tests exhibit similar characteristics of pressure and wind. From visual examinations of the figures obtained from all the 18 tests it was concluded that good uninformities cannot be expected from sprinkers

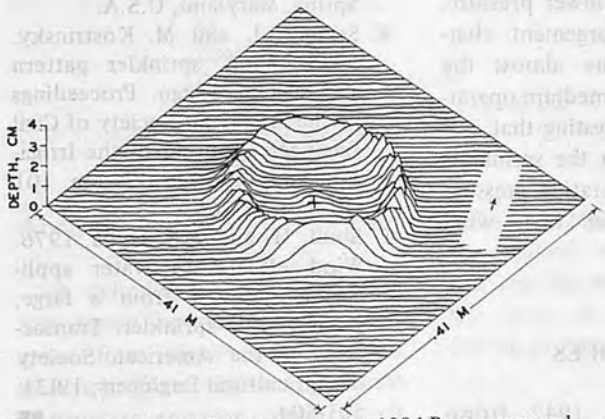


Fig. 1 Sprinkler distribution pattern at 138 kPa pressure and 1.4 km/h wind speed.

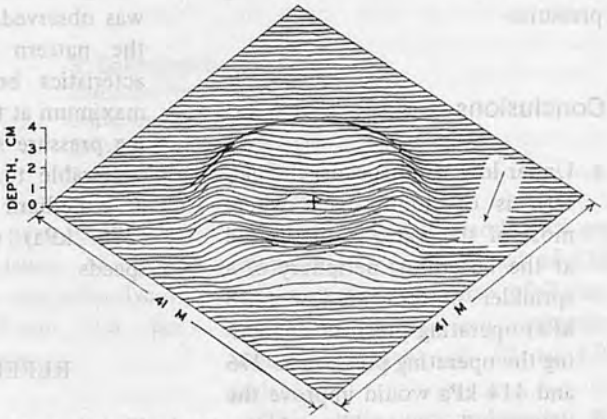


Fig. 2 Ditto at 276 kPa and 3.7 km/h.

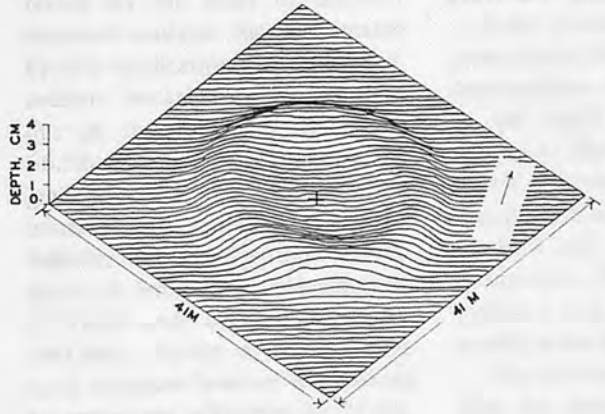


Fig. 3 Ditto at 414 kPa and 2.0 km/h.

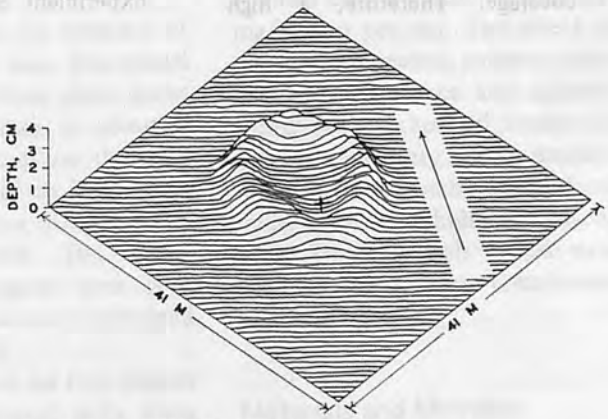


Fig. 4 Ditto at 138 kPa and 16.5 km/h.

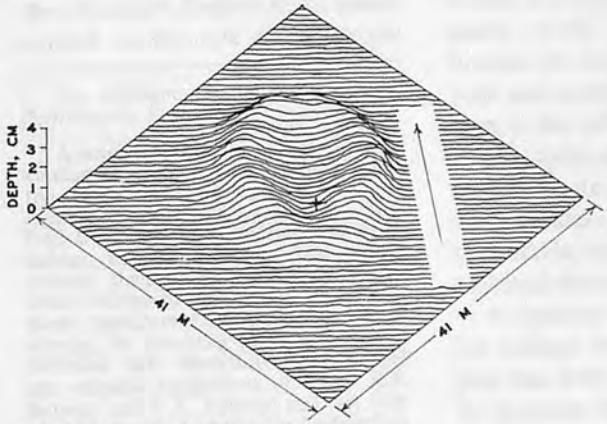


Fig. 5 Ditto at 276 kPa and 14.5 km/h.

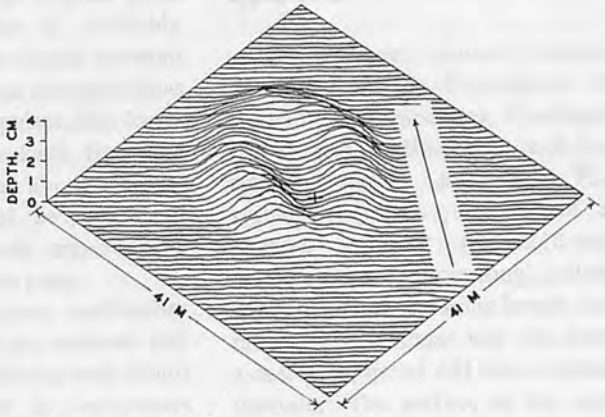


Fig. 6 Ditto at 414 kPa and 15.2 km/h.

operated at low pressure under low wind conditions; rather, high operating pressure is preferable in such a situation. But if the wind speed is high, a high operating pressure would not yield good uniformity and irrigation coverage; under such a condition, if irrigation is unavoidable, it is better to run the sprinklers at a medium operating pressure.

Conclusions

1. Under low wind speeds, the pattern is of donut shape where most of the water is distributed at the outermost periphery of a sprinkler pattern at low (138 kPa) operating pressure. Increasing the operating pressure to 276 and 414 kPa would improve the pattern shape yielding better water distribution and irrigation coverage. Therefore, a high operating pressure (414 kPa) is preferable under such conditions.
2. Higher wind results in distorted, elongated, slightly enlarged and shifted patterns. These effects (other than enlargement of the pattern area) are pronounced at higher operating pressure. Although a reduced donut effect was observed at lower pressure, the pattern enlargement characteristics become almost the maximum at the medium operating pressure suggesting that it is preferable to run the sprinklers at a medium operating pressure (276 kPa) under high wind speeds.

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Cylinder Concave Mechanism and Chemical Treatment for Dehulling Pigeon Peas

by

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Abstract

A cylinder concave mechanism was tested for making dal or split pulse from pigeon peas (*Cajanus indicus*). Three different machine parameters: entrance clearance, exit clearance and cylinder speed were tested on the grain of different moisture contents that was treated by the application of acetic acid, sodium bi-carbonate or mustard oil. A dehulling efficiency* of 66.5% was obtained with untreated graded grain at 11% moisture content and dehulled with the dehuller set at an entrance clearance of 5 mm, exit clearance of 1.75 mm and cylinder speed of 300 rpm. Drying of pigeon peas to a moisture level of 8.9 %(d.b.) increased the efficiency to 71.2%. All chemical treatments increased the efficiency. Sodium bi-carbonate applied at the rate of 33.6 g per 100 kg of pigeon peas resulted in the highest efficiency of 76.2% and was the most cost effective at the cost of 1.5 cent U.S. per 100 kg of pigeon peas.

* The efficiency is defined in section *Performance Evaluation*

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Introduction

India produces 12 million t of pulse grains every year. The annual consumption of these pulse grains as dal (split pulse) is about 9 million t. The pulses are the main source of protein of the Indian diet. The protein content of pigeon peas is 14.0 to 28.9%. The annual production of pigeon peas is 6 million t and is mostly consumed as split pulse (1,2).

The recovery of dal from pigeon peas by conventional mills using twin rollers is 54.3% which is lowest in comparison to other pulse grains (3,4). This is probably because of stronger bond between husk and cotyledons in pigeon peas than in the other pulses. The losses in the form of brokens, fines and mealy waste are about 23.9%. These losses could be minimized if suitable methods are adopted to dehull the pigeon peas.

A cylinder concave mechanism for making dal from soybean and peas has been evaluated and found to perform better in comparison with the conventional mills (5,6). Efficiencies of 78% and 79% are reported at cylinder speed of 325 rpm, entrance clearance of 7 mm, exit clearance of 3 mm and grain moisture content of 10 to 15% (d.b.).

This study was undertaken to evaluate the performance of the cylinder concave dehuller for making pigeon pea dal. The effect of machine parameters; entrance clearance, exit clearance and cylinder speed and of chemical treatments on dal recovery was studied. Mustard oil is used by conventional millers to ease dehulling of pigeon peas. The chemicals tested were acetic acid, sodium bi-carbonate and mustard oil.

Materials and Methods

Equipment

The cylinder concave system developed in the Department of Agricultural Engineering, Pantnagar (India) was modified and used for splitting pigeon peas (7). The system (**Fig. 1**) consisted of a serrated cylinder (A) 218 mm diameter and 375 mm long, a plain concave (B) of the same length and radius. The cylinder was cut from a cast iron pipe of 221 mm external diameter. The surface of the pipe was knurled for better hulling. A

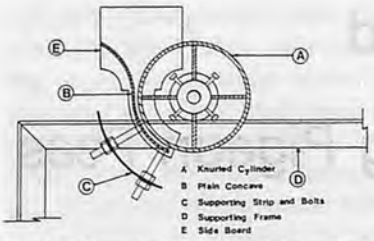


Fig. 1 Schematic diagram of the cylinder concave dehuller.

4 mm thick mild steel sheet was used for making the concave. The concave was supported on two mild steel plates through a pair of bolts at either end of the concave (C). Various entrance and exit clearances of hulling zone were set by adjusting the pair of bolts at different effective lengths in the supporting strips. The supporting frame (D) was fabricated from 50x40x5 mm angle iron. It had the overall dimensions of 1050x500x500 mm. The mild steel plates of sizes 50x6 mm were curved with a radius of curvature 180 mm and were welded to the frame. Two slots were cut in each plate to allow the bolts supports the concave to pass through them. Side boards (E) were welded to the frame at both sides. The cylinder was rotated with a 3.75 kW, 3-phase, 1440 rpm motor coupled through a gear reduction unit which allowed the variation in the cylinder speed.

Procedures

The pigeon pea grains of mixed varieties obtained from the Crop Research Centre, Pantnagar, was used in the study. The mixed variety grain was selected over a particular variety because of similar practice in the dehulling industry. The grains passed through 480 mesh but retained on 400 mesh sieve were used for experiments. One hundred grains were randomly picked and the average grain diameter perpendicular to cotyledons was determined by using a micrometer to a 0.01 mm accuracy. Machine parameters (entrance clearance and exit clearance) were decided on the basis of this average grain diameter. Machine parameters giving highest efficiencies were used for further tests which were conducted to determine the effect of grain moisture content and chemical treatments on the dehulling efficiency.

The graded grains were conditioned to higher moisture levels, by mixing the grains with predetermined quantities of water in an air tight revolving cylinder for 1 h and leaving for 24 h at room temperature for uniform penetration of moisture into the grain kernels. The moisture content of samples was lowered to a desired value by drying the samples in a convection air oven at 65°C. The moisture content and chemical treatments mined by oven drying. Samples weighing 10 to 15 g were dried at 100°C for 24 h in a convective air oven.

The chemicals at various levels were also mixed with grain in the same revolving mill cylinder. The treated samples were left for 24 h at room temperature before dehulling.

Grain samples, 100 g each were fed manually to the hopper of the huller. The milled product was collected just below the huller in a polyethelene sheet and was divided into three parts: (1) whole cotyledons, (2) unhulled grains, and (3) broken kernels including husk, mealy waste and fines. The whole cotyledons were separated by passing the milled product from the 280 mesh sieve and retained on 200 mesh sieve. The whole cotyledons called dal included cotyledons of two-thirds or more cotyledon length. The unhulled grains were picked manually from the overflow of 280 mesh sieve. Brokens and mealy wastes were underflow of 200 mesh sieve. The hulls were blown out with help of a hand held electric blower. The unhulled grains and dal were weighed separately for each sample and used for further analysis. The percentage of husk of a representative sample was determined by manual dehusking of pigeon pea grains and was found to be 15.3%

Parameter Selection

For conducting various tests of dal making process, the following variables were selected for the study.

1. Machine parameters:
   Cylinder speed R, rpm: 100, 200, 300, 400 and 500.
   Entrance clearance d_i, mm: 4.0, 4.5 and 5.0.
   Exit clearance d_o, mm: 1.50, 1.75, 2.00, 2.25 and 2.50.
2. Grain parameters:
   Grain moisture content m, percent (d.b.): 6.7, 8.9, 10.8, 13.5 and 16.4.
3. Chemicals:
   Percent purity of the acetic acid solution applied at the rate of 1 litre per 100 kg of grain: 20, 40, 60, 80 and 100.
   Normality of the sodium bi-carbonate solution applied at the rate of 1 litre per 100 kg of grain: 0.2, 0.4, 0.6, 0.8 and 1.0.
   Percent of mustard oil applied on the grain mass basis: 0.2, 0.4, 0.6, 0.8 and 1.0.

The levels of the above machine parameters and moisture content were chosen on the basis of measured average orthogonal grain diameter and on the basis of previous study (5-7).

The levels of acetic acid and sodium bi-carbonate were chosen randomly because not much background information about them was available and of the oil were chosen on the basis of a survey made to dal mills at Hathras, India and nearby rural areas. The mills reported the quantity of mustard oil ranging from 200 to 600 g per 100 kg of pigeon peas whereas rural housewives reported the quantity of 1.0 kg per

100 kg of pigeon peas.

The chemicals selected are not harmful to human beings. The sodium bi-carbonate is frequently used to improve the cooking quality of the split pulse. Acetic acid is consumed as vinegar and the mustard oil is commonly used in frying.

The control sample dehulled at the similar machine parameters without any chemical treatments was used to compare the effects of chemical treatment on the hulling efficiency.

Performance Evaluation

To evaluate the performance of the cylinder concave dehuller the hulling efficiency was determined according to Kuprit (8):

$$C_h = (1 - M_{uh}/M_t) \quad \ldots\ldots (1)$$

$$C_{wk} = K/(K + b) \quad \ldots\ldots (2)$$

$$E = C_h \cdot C_{wk} \times 100 \quad \ldots\ldots (3)$$

where: C_h = coefficient of hulling that defines quantity of dal recovered; C_{wk} = coefficient of wholeness of kernel that defines the quality of dal recovered; E = efficiency of hulling, %; M_{uh} = mass of unhulled grains in final product, g; M_t = mass of sample before dehulling, g; K = mass of whole kernels in the final product, g; b = mass of brokens in the final product, g.

The samples before dehulling did not contain any hulled grain and brokens.

Results and Discussions

Effect of Machine Parameters

The hulling efficiency of the pigeon peas is governed by the machine parameters and the rheological properties of the material. Both the coefficients of hulling and of wholeness of kernel are the function of moisture content of the grain, cylinder speed, entrance and exit clearance

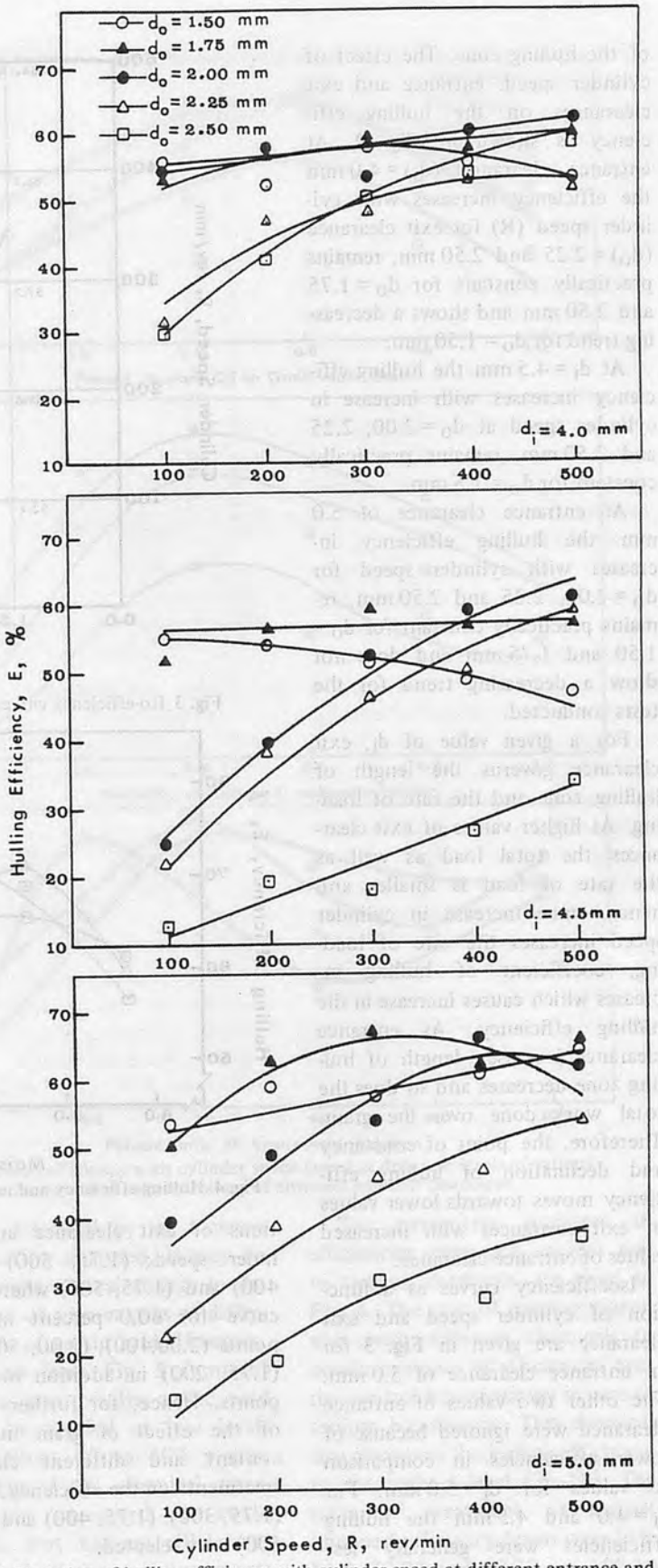


Fig. 2 Variation of hulling efficiency with cylinder speed at different entrance and exit clearances.

of the hulling zone. The effect of cylinder speed, entrance and exit clearances on the hulling efficiency is shown in **Fig. 2**. At entrance clearance (d_i) = 4.0 mm the efficiency increases with cylinder speed (R) for exit clearance (d_o) = 2.25 and 2.50 mm, remains practically constant for d_o = 1.75 and 2.50 mm and shows a decreasing trend for d_o = 1.50 mm.

At d_i = 4.5 mm the hulling efficiency increases with increase in cylinder speed at d_o = 2.00, 2.25 and 2.50 mm, remains practically constant for d_o = 1.5 mm.

At entrance clearance of 5.0 mm the hulling efficiency increases with cylinder speed for d_o = 2.00, 2.25 and 2.50 mm, remains practically constant for d_o = 1.50 and 1.75 mm and does not show a decreasing trend for the tests conducted.

For a given value of d_i, exit clearance governs the length of hulling zone and the rate of loading. At higher values of exit clearances the total load as well as the rate of load is smaller and hence, since increase in cylinder speed increases the rate of loading, coefficient of hulling increases which causes increase in the hulling efficiency. As entrance clearance increases, length of hulling zone decreases and so does the total work done over the grain. Therefore, the point of constancy and declination of hulling efficiency moves towards lower values of exit clearances with increased values of entrance clearance.

Isoefficiency curves as a function of cylinder speed and exit clearance are given in **Fig. 3** for an entrance clearance of 5.0 mm. The other two values of entrance clearance were ignored because of lower efficiencies in comparison to values for d_i = 5.0 mm. For d_i = 4.0 and 4.5 mm the hulling efficiencies were generally less than 60.0%. Isoefficiency curve for 64.0% included the combinations of exit clearance and cylinder speed; (1.75, 300) (1.75, 400) and (1.75, 500) whereas the curve for 60.0 percent included points (2.00,400); (2.00, 500) and (1.75, 200) in addition to above points. Hence, for further testing of the effect of grain moisture content and different chemical treatments on the efficiency, points (1.75, 300); (1.75, 400) and (1.75, 500) were selected.

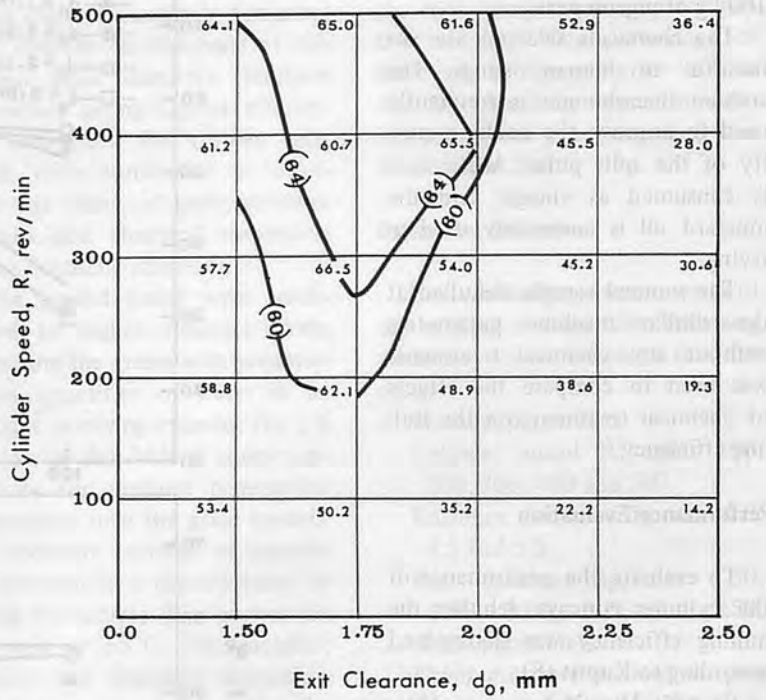


Fig. 3 Iso-efficiency curves as a function of cylinder speed and exit clearance.

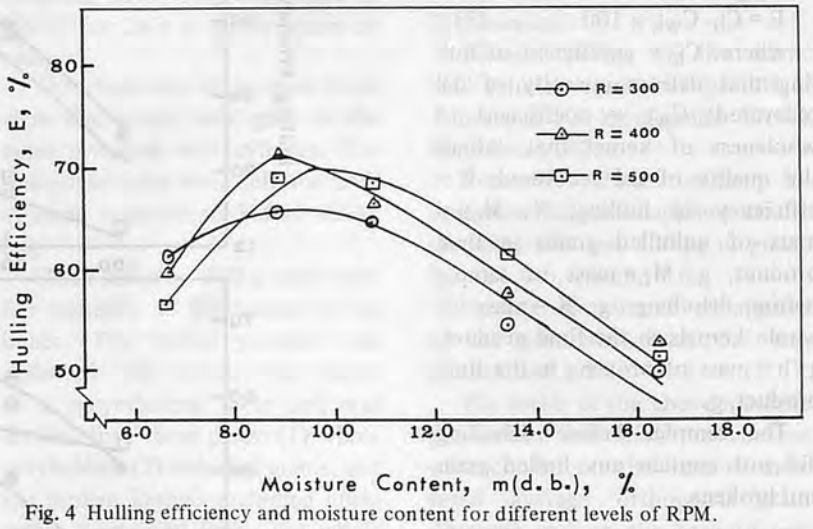


Fig. 4 Hulling efficiency and moisture content for different levels of RPM.

Effect of Grain Moisture

The effect of variation in moisture content of grain (6.7 to 16.4%) is shown in **Fig. 4**. The higher efficiencies at all cylinder speeds were obtained at moisture content of 8.9%. The efficiency decreased above and below this moisture content of pigeon peas. At lower values of moisture contents the reduction in the hulling efficiency was due to increased brittleness of

the dried grains. At higher moisture contents the grain passed either unhulled or compressed with intact husk. For a better hulling, the grain should be hulled at moisture content of about 9.0% (d.b.).

Effect of Mustard Oil Treatments

Maximum efficiencies were obtained at 0.6 percent oil level for all values of cylinder speeds. The efficiency curve for cylinder speed of 400 rpm showed the higher efficiencies in comparison to 300 and 500 rpm (**Fig. 5**. top). The reason for this is higher breakage at cylinder speed of 500 rpm and less hulling at 300 rpm for similar values of d_i and d_o due to increased and reduced rate of load, respectively.

Effect of Sodium Bi-carbonate Treatments

Fig. 5 (centre) shows the effect of different treatment levels of sodium bi-carbonate on hulling efficiency. Efficiency was maximum at 0.4 N solution of sodium bi-carbonate for all cylinder speeds. Here also the hulling efficiencies were higher at cylinder speed of 400 rpm for similar reasons.

Effect of Acetic Acid Treatments

The effect on hulling efficiency at different cylinder speeds and acetic acid treatment levels is shown in **Fig. 5** (bottom). It was observed that maximum efficiency for all values of cylinder speeds was nearly the same: around 74.5%. At 300 rpm this was obtained at 20% acetic acid purity level whereas for the other two speeds this was obtained at 40% purity level. Thereafter, the hulling efficiency in all the cases decreased slightly and then again increased. This increase was mainly due to decreased breakage at higher levels of acetic acid treatments. The reason for the

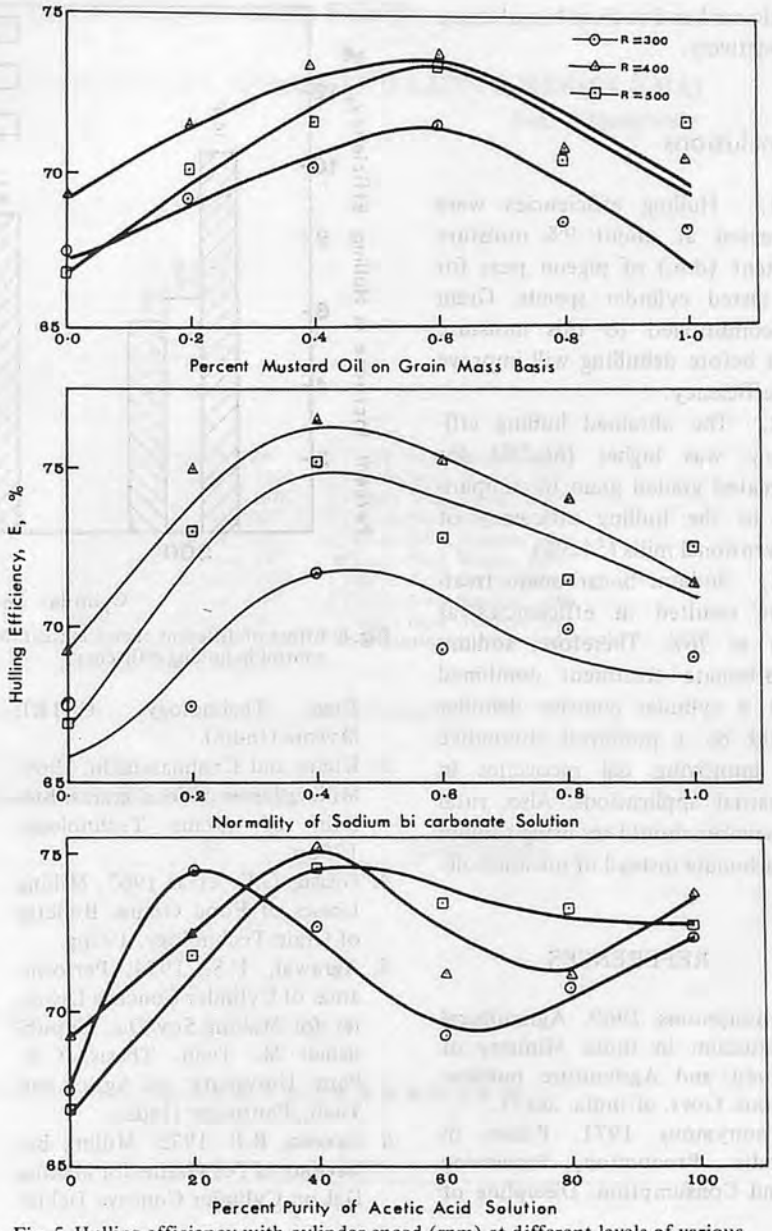


Fig. 5 Hulling efficiency with cylinder speed (rpm) at different levels of various chemicals and at selected values of entrance and exit clearances.

decrease followed by an increase could not be analysed. It may be due to some typical change in the behaviour of pigeon peas at different levels of acetic acid. However, it is clear from **Fig. 5** (bottom) that for best results acetic acid should be applied at low levels ranging from 20 to 40% purity.

In **Fig. 5** all chemical treatments are compared. It could be seen that highest efficiencies in case of all chemical treatments lie in the range of 73.0 to 75.0%.

The percentage increases in efficiencies over the control due to treated chemicals are given in **Fig. 6**. The cost of treating pigeon peas with different chemicals to obtain increases of efficiencies over the control was minimum in case of sodium bicarbonate. This chemical also improved the hulling efficiency to the highest level (76.2%). The costs of treatment at highest obtained efficiency levels were U.S. $1.0, $0.23 and $0.02 per 100 kg of pigeon peas for mustard oil,

acetic acid and sodium bi-carbonate respectively.

Conclusions

1. Hulling efficiencies were increased at about 9% moisture content (d.b.) of pigeon peas for all tested cylinder speeds. Grain pre-conditioned to this moisture level before dehulling will improve the efficiency.

2. The obtained hulling efficiency was higher (66.5%) for untreated graded grain in comparison to the hulling efficiency of conventional mills (54.3%).

3. Sodium bi-carbonate treatment resulted in efficiencies as high as 76%. Therefore, sodium bi-carbonate treatment combined with a cylinder concave dehuller would be a preferred alternative for improving dal recoveries in industrial applications. Also, rural housewives should try using sodium bi-carbonate instead of mustard oil.

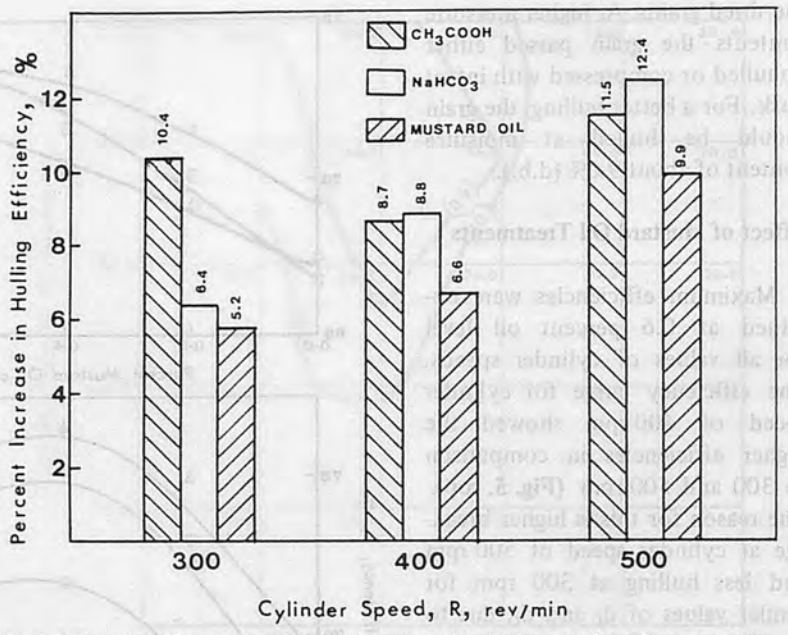


Fig. 6 Effect of different chemical treatments and cylinder speeds on increase over control in hulling efficiency.

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Design and Development of Solar Copla Dryers



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Abstract

Dried coconut meat is known as copra. Wet meat (45 to 50% moisture content, wet basis) has to be dried to 6% moisture content for storage and for oil extraction. Drying of copra is commonly practised in open on mud or cement floor requiring about 9 days. A low cost solar dryer using black painted palmyra mat as drying floor and double layered polythelene sheet as transparent cover was found to reduce drying time to 5.5 to 6 days. The solar cabinet dryer with drying surface inclined at an angle equal to latitude, provided with reflectors from 3 sides of the dryer and also having a provision for manual suntracking was developed. The drying time required was 3.5 to 4 days at double the spreading density compared to open sundrying.

Introduction

Copra is the dried meat obtained from the coconut (*Cocos nucifera.* Lin.). Fresh coconut meat contains about 45 to 50% moisture content (wet basis) and it has to be dried to 6% moisture content for safe storage and for oil extraction. Annual production of the coconut in India is about 5 800 million nuts from 1.1 million ha area (1). Forty percent of the total production is converted into copra upon drying (2). The coconuts are harvested every month except during monsoon when the trunk becomes slippery. About 68% of the total production has been harvested and processed during October to May (**Table 1**) (3).

India, a tropical country, is blessed with plentiful supply of bright sunshine. On the west coast the average intensity of solar radiation is in the order of 440 cal/cm^2/day. The average sunshine hours are about 8.5 during October to May (4). The availability of this free energy for copra drying during this period is most economical.

The average land holding of coconut growers in India is only 0.2 ha and about 90% of total land holdings are below 1 ha (5). These small farmers dry their copra on the mud floor in the yard of the house. Copra is a high moisture and slow drying product. Unlike other agricultural products, the endosperm is exposed for drying which makes it more vulnerable to deterioration due to dirt, dust and microorganisms. The substitution of drying floor with black painted palmyra mat reduces drying time by 21% (6).

Two types of small capacity solar copra dryers have been developed with the following objectives: 1) To improve the copra quality by avoiding a direct atmospheric exposure during the process of drying and 2) To conserve and effectively utilise the convective heating of the air due to solar energy received by the black surface.

Table 1 Annual Coconut Production Pattern

Month	Production
October	5.6
November	6.5
December	6.0
January	6.4
February	7.7
March	9.8
April	14.1
May	11.7
June	9.8
July	8.2
August	7.7
September	6.5
Total	100.0

Description of Dryer

Low-Cost Poly-Solar Dryer

The drying surface was a black painted palmyra mat. The frame was made up of 10 mm diameter MS bars. The transparent cover was of double layered 200 gauge polythelene sheet. The frame was such that the top cover was inclined at 27°, that was angle of latitude + average angle of solar declination over the rain free days in order to get maximum penetration of solar radiation. For air circulation at inlet and exhaust, 0.75 cm diameter

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Fig. 1 Low cost poly solar dryer.

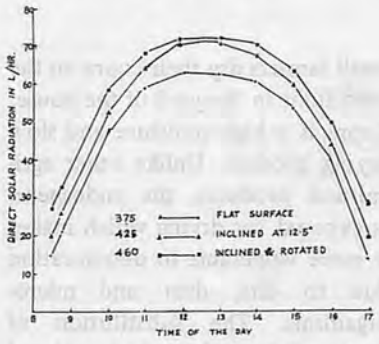


Fig. 2 Variation of solar radiation in a day.

Table 2 Materials for Low Cost Poly-Solar Dryer

Material	Quantity
MS bar, 10 mm dia	8.0 m
GI wire	20.0 m
Polythelen sheet (200 gauge)	8.0 m
Black painted palmyra mat	one

holes were provided at front and rear top of the poly dryer. The bottom of the poly cover was tied to the frame by wire rings. The position of the structure was kept stationary facing south. The area of the drying surface was about 1.17 m (**Fig. 1**). The transparency of the new double layered polythelene sheet was 80%. The bills of materials is given in **Table 2.**

The direct solar radiation at Kasaragod (12.5°N, 75°E and 10.7 MSL) on the flat surface in the month of January was 374 langleys/day (0830 to 1700). The solar radiation on the inclined surface (12.5°) facing south was 425 langleys/day and the inclined surface at 12.5° continuously facing sun received 460 langleys/day (**Fig. 2**).

Solar Cabinet Dryer

To achieve maximum reception of solar radiation, a solar cabinet dryer as shown in **Fig. 3** was developed. The frame of the dryer was made of locally available jackwood. The drying surface 1.06 m^2 area was of 22 gauge corrugated GI sheet to get absorber area of 1.19 m^2. The drying surface was inclined at an angle of 12.5° and fitted on 3 cm thick jackwood plank board with 2 g coir fibre insulation in between. The drying chamber was made of 3 mm window glass on sides and 3 mm acrylic plastic sheet on the top to avoid the risk of breakage during handling. The height of the drying chamber was kept at 40 cm uniformly from inlet to exhaust end. Inlet and exhaust of 0.35 m^2 area covered with wiremesh were provided for air circulation. Commercial grade aluminium foil mounted on the hard board was used for the reflectors on the three sides. The reflectivity of such reflectors has been 74 to 85% (7). The total area of the reflectors was 1.5 m^2. The inlet opening was covered by black painted GI sheet hood inclined at 45°. The area of the hood was 0.36 m^2 and was provided to have pre-heating of the incoming air and to avoid the effect of direct air drought. Caster wheels were provided for changing the direction and movement to short distances. The GI rod on the top cover guided the position of the dryer which was changed at 1100 and 1400. The bill of material is given in **Table 3.**



Fig. 3 Solar cabinet dryer.

Materials and Method

The tests of drying were conducted in a body dryer and in solar cabinet dryer in comparison to the open drying on the black painted palmyra mat. The spreading densities were 40 nuts/m^2, 60 nuts/m^2 and 80 nuts/m^2 on outside in poly dryer and in the cabinet dryer, respectively. The initial moisture content and the moisture content at the end of every day were determined for a composite sample by oven drying method (105°±1°C for 8 h). The temperature inside the dryer and outside were measured by mercury thermometers. The relative humidity of the air inside the cabinet and outside was measured by Assman's psychrometer. The solar radiation on the flat and inclined surface was measured by direct solar radiation meter (Surya Mapi) in langleys per h. The air velocity in the cabinet was measured with the vane anemometer. The drying of copra was conducted up to 6% moisture content, wet basis.

Table 3 Materials for Solar Cabinet Dryer

Material	Quantity
Jack wood	0.075 m^3
Coir fibre (insulation)	2.0 kg
Corrugated GI sheet (22 gauge)	1.25 m^2
GI sheet (22 gauge)	0.35 m^2
3 mm window glass	1.40 m^2
3 mm acrylic plastic sheet	1.25 m^2
Aluminium foil (24 gauge)	1.65 m^2
Hard board	1.65 m^2
Wooden reapers	11.00 m
Caster wheels	4 pcs.

Results and Discussion

The initial moisture content of copra was 46±2%, wet basis. The average drying conditions in the day during the experimentation were 60% relative humidity, 30.4°C temperature and 49% (r.h.), 46.1°C temperature on the outside and in the cabinet dryer, respectively. The difference in the air temperature in the dryer and outside was minimum at 7°C and maximum at 20°C. The average solar radiation on the inclined surface and flat surface was 67 and 55 langleys per h, respectively (**Fig. 4**). The average temperature of the air in the poly dryer was 36.2°C compared to 30.4°C of the ambient air (**Fig. 5**). The average solar energy per hour and variation in the air temperature in the cabinet in comparison to outside over total drying period showed that (**Fig. 6**) even at constant variation of solar radiation the temperature difference was less on the first day compared to the other three days. This may be mainly due to the higher moisture content of the copra on the first day. The average temperature differences over the period of drying between ambient and drying cabinet was 17°C. The average air velocity in the cabinet measured during drying was 5m/min. The variation in the moisture content of copra with respect to drying time in days for open, poly dryer and cabinet dryer was plotted on the ordinary graph (**Fig. 7**). The drying time required was 7 days, 5.5 to 6 days and 4 days in case of open, poly dryer and cabinet dryer, respectively. The drying test results as presented in **Table 4** showed that the drying capacities were 0.91 g/m²/day, 1.74 g/m²/day and 3.6 g/m²/day in

Table 4 Drying of Copra by Different Methods

Drying method	Drying time (days)	Spreading density (nuts/m²)	Copra production (kg/m²/day)
Open drying on black painted palmyra mat	7.0	40	0.91
Poly solar dryer	5.5	60	1.74
Solar cabinet dryer	4.0	80	3.60

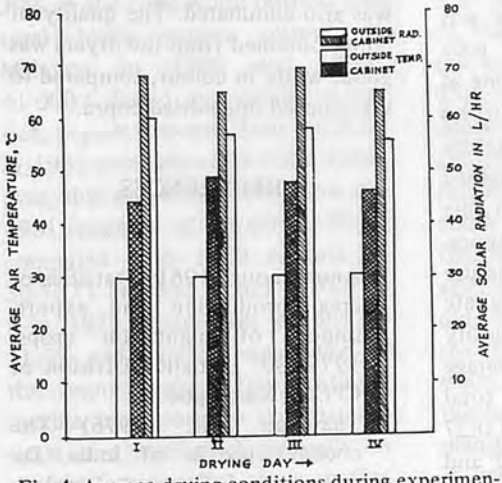


Fig. 4 Average drying conditions during experimentation.

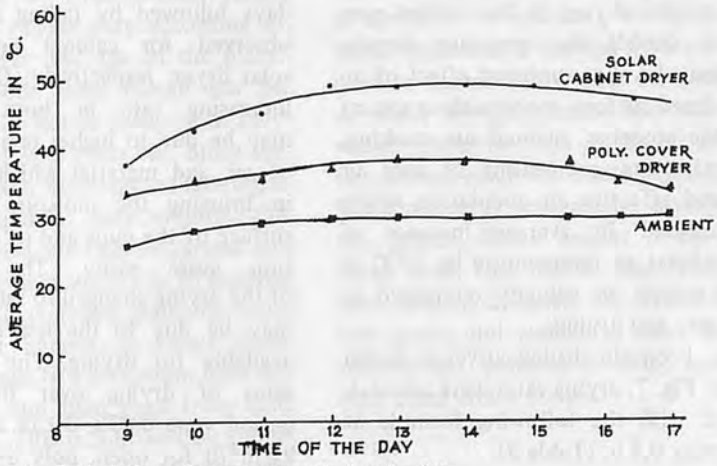


Fig. 5 Variation of temperature during the day.

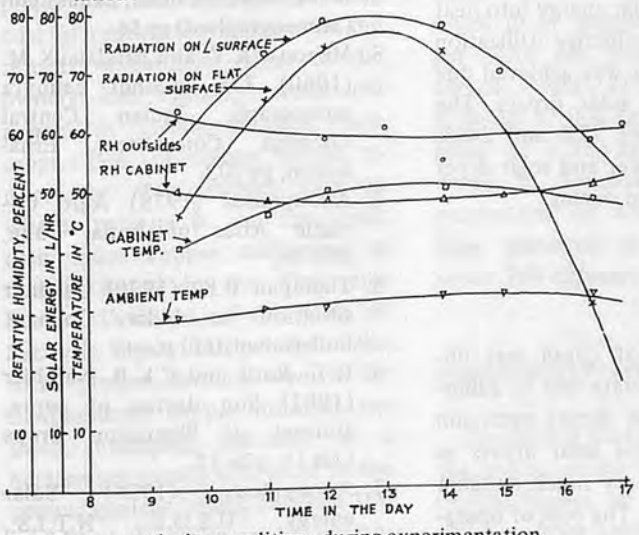


Fig. 6 Average drying conditions during experimentation.

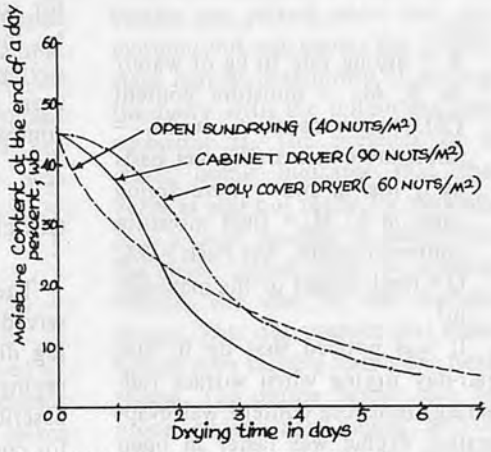


Fig. 7 Moisture content and drying time.

Table 5 Copra Drying Rate and Drying Time

Method of drying	Rate of drying in kg of water /m²/h on the day													
	0.5h	1h	1.5h	2h	2.5h	3h	3.5h	4h	4.5h	5h	5.5h	6h	6.5h	7h	Average
Open	.44	.17	.107	.073	.071	.048	.051	.036	.027	.025	.017	.014	.016	.007	.078
Poly dryer	.148	.15	.258	.269	.343	.197	.117	.055	.038	.037	.036	.011	–	–	.138
Solar cabinet dryer	.356	.424	.448	.506	.198	.107	.08	.047	–	–	–	–	–	–	.270

open, poly dryer and cabinet dryer, respectively. The saving of time in comparison to open in the order of 21.4% and 42.8% was found by poly dryer and cabinet dryer, whereas per day capacity of drying/ m^2 could be increased by 91% and 296% by the use of poly dryer and cabinet dryer, respectively. The less drying time required in the poly dryer might be the effect of conservation of heat energy produced by black painted palmyra mat due to the absorption of solar energy, which resulted in increasing in drying air temperature by 6°C. The quicker drying in the cabinet even at double the spreading density may be the combined effect of inclined surface, more surface area of the absorber, manual sun tracking, reflectors, pre-heating of inlet air and effective air circulation which resulted in average increase of cabinet air temperature by 17°C at 5 m/min air velocity compared to open sun drying.

From the drying curves as shown in **Fig. 7**, drying rates were calculated with the following formula at every 0.5 h, **(Table 5)**.

$$R = \frac{(M_0-M_1)(100-M_f)\,Q}{(100-M_0)(100-M_1)(t_0-t_1)\,100}$$

where,

R = drying rate in kg of water/ m^2/h; M_0 = moisture content (%), wet basis at t_0 h; M_1 = moisture content (%), wet basis at t_1 hrs. t_0 and t_1 were drying time in h; M_f = final moisture content percent, wet basis = 6%; Q = final weight of the material/ m^2

It was noticed that up to first half-day drying when surface (adhering) moisture content was evaporated, drying was faster in open compared to both dryers, i e, 0.44 kg/m^2/h, 0.358 kg/m^2/h and 0.148 kg/m^2/h in open, cabinet and poly dryer, respectively. This may be due to the fact that ample air movement was an important factor during this stage of drying as reported in earlier experiments (6). In the later stages drying in both dryers was faster compared to open drying which may be the effect of higher temperature due to effective utilization of incident solar radiation. Drying in the open, occured mostly at falling rate period except for first half-day. But drying at increasing rate up to first 2 and 2.5 days followed by falling rate was observed for cabinet and poly solar dryer, respectively. Drying at increasing rate in both dryers may be due to higher temperature of air and material which helped in bringing the moisture to the surface of the cups and its evaporation more easily. The nature of the drying changed to falling rate may be due to the less quantity available for drying. The average rates of drying over the total period were 0.078, 0.138 and 0.27 kg/m^2/h for open, poly dryer and cabinet, respectively. The efficient conversion of solar energy into heat energy and its effective utilization for copra drying was achieved due to the use of solar dryers. The drying rates were 77% and 246% more in poly dryer and solar dryer compared to open drying.

Conclusion

The quality of copra was observed to deteriorate due to adhering dirt and dust during open sun drying. Hence the solar dryers as described were very much suitable for copra drying. The cost of operation was very low as no external source of energy was required. The drying time required could be considerably reduced due to effective utilization of solar radiation even at higher spreading densities thereby avoiding microbial infestation as has been reported while prolonged open-sun drying. The cost of the dryers were Rs.50 and Rs.900 for poly dryer and cabinet dryer, respectively. These dryers could also suitably be used for drying pepper, cocoa, etc which are grown as intercrops with coconuts. The labour requirement in avoiding birds' menace during copra drying was also eliminated. The quality of copra obtained from the dryers was good, white in colour, compared to discoloured open-dried copra.

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Studies of a Simple, Locally Designed Pepper Thresher for Sarawak



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Introduction

Malaysia, the largest producer of black pepper, contributes about 33% of the total world output. The total black pepper output of Malaysia in 1980 was about 41 000 t. Based on available statistics, pepper exports from Sarawak in 1982 were about 24 050 t. However, this was about 16% below the 1981 exports of 28 606 t. When compared with 1980 exports of 30 707 t and the record of 36 118 t in 1979, there was decline of 21.7% and 33.4%, respectively, of the export value. The continual decline in exports in the past 2-3 years was attributed primarily to the depressed prices. Low market prices and the continually rising cost of production had eroded the returns of farmers. Some of the owners had virtually abandoned pepper in favour of other cash crops. This, of course, would reduce the state export earnings where pepper is an important cash crop. Pepper cultivation is mainly found in the First and Second Divisions of the State of Sarawak. Eighty-four percent of the total pepper area is owned by smallholders. Pepper holdings are small, averaging one-fifth of a hectare per family with most of the pepper gardens having between 100 to 250 vines. Using approximately 2.5m square planting, the average vines per ha was calculated to be 1680. Planting densities varied ranging from as low as 1 167 vines to as high as 1724 vines per ha. Yields of black pepper vary according to the cultivar and age of the plant. The pepper vines should not be allowed to flower freely until they are about two years old. Since the period from flowering to fruiting is about eight to nine months, the first harvest can only be carried out after the vines are 30 to 36 months old. Yield increases gradually from the first harvest at about three years of age to a maximum between the fifth and eight years from field planting. This is followed by gradual yeield decline. An average production of black papper was surveyed to be approximately 495 kg per farm per year. The average annual yield of green berries is about 15 000 kg/ha with sample mean of 1 538 kg per farm surveyed in Sarawak. The average production of white pepper per farm surveyed in Sarawak was about 350 kg/year.

Production Process

Harvesting time is determined by the colour of the fruit. The colour of the berries on the fruit spikes changes from green to yellow and then to red when ripe. As a guide, the fruit spike is picked as soon as one berry on the spike turns red. The pepper vines are picked at least once a week. Currently, pepper is harvested by plucking the fruit bunch by hand. A wooden ladder is used to harvest fruits that are out of reach by the picker. The harvested fruits are then marketed in two forms: black and white pepper. Black pepper is prepared by drying the berries. White pepper is prepared from ripe berries that have been soaked in water for at least two weeks and washed in order to remove the pericarp or skin, and then dried under the sun.

Production of Black Pepper

If black pepper is prepared, the berries are picked when they are matured but still green. The correct stage may be determined by cutting the berry with the thumb nail and squeezing it. The presence of a white liquid indicates that the berry is still not ready for picking. It is a good practice to remove all the fruit spikes (ripe or unripe) toward the end of the harvest season. This step ensures that there will be even fruiting during the next season. The unripe berries may be processed into black pepper. Red or yellow berries should be avoided

when black pepper is to be produced because these ripe berries when processed will cause uneven coloration. Prior to drying, the harvested spikes are kept in the shade for at least 24 h so as to facilitate easy separation of berries from the spike. The berries are easily separated from the stalks by rubbing the harvested spikes against a horizontal wire mesh with holes big enough to allow the detached berries to pass through. These berries are collected on a mat underneath and then dried under the sun. After thorough drying, the stalks and other trash are picked out or removed by winnowing and the pepper is ready for sale.

Production of White Pepper

White pepper can only be prepared from ripe berries. The berries of the first, second and last pickings in a season are usually unsuitable. There are three stages in the preparation of the white pepper, namely soaking, washing and drying.

Harvested pepper berries are placed in sacks and soaked in a pond or stream for about 10-14 days. Clean running water is prefered to stagnant, muddy water as the finished product will be cleaner and whiter in colour. Stagnant and muddy water gives a brownish color to the berries. This operation allows the pericarp to soften and later to rot, hence easy to remove. The berries are emptied into a tub where they are trampled on by foot. This is followed by washing so as to remove the stalks and the decayed pericarp. The berries which are resoaked for one to two days are rewashed to ensure a good quality product. After the second soaking and washing, the pepper corns are dried under the sun immediately. A delay may result in berries acquiring a dark colour. It is advisable for the berries to be kept under water if the weather is unfavourable for drying. Damp corns will easily turn mouldy. The pepper corns should be thoroughly dried because under-drying causes loss of the desirable white colour and the spicy flavour. In good weather the pepper corns are dried for at least 3 days. Loss in weight when the corns are dried correctly is about 30%. The finished product should not have a moisture content higher than 10%.

Mechanization

Agricultural mechanization can play a vital role in helping small farmers to increase the productivity of an agricultural worker and making farm work less arduous. But farm mechanization has not made any significant impact on agriculture in the State of Sarawak. At the present moment, to the best knowledge of the authors, there is no machine in the market for the purpose of pepper production. Most of the farm operations are done manually which require considerable amount of labour, especially the harvesting operation. The high labour requirement, increasing labour cost and high production cost are beginning to cause a strain on the production process. This has prompted the mechanization group at the University of Agriculture Malaysia, Sarawak to consider mechanization, fully or partially, in order to improve the efficiency of pepper harvesting.

Mechanical Thresher

After a careful analysis of the production process, it was determined that stripping the berries at the initial stage might help the farmers in reducing the production cost in terms of labour and time requirements. The fruit spikes (ripe or unripe) can be picked and threshed immediately. The green and matured berries can be prepared for black pepper and the red or yellow berries which are ripe and fully developed can be prepared for white pepper. Picking the fruit spikes, ripe and unripe at the same time ensures that there will be even fruiting the following season. In the producion of black pepper, much time for detaching berries from the spikes can be saved using a mechanical thresher which can also accomplish cleaning prior to drying. For white pepper production, the mechanical thresher can thresh and clean the berries at the initial stage before soaking is done. We foresee that there is a possibility of removing the pericarp during the threshing process. If it is successful, then a lot of time and labour can be saved. This method will eliminate cleaning the decayed pericarp and stalks and the pepper berries can be soaked until it is ready to be dried. In order to achieve this, some modifications need to be done to the machine being evaluated.

A study conducted by the principal author revealed that there was a significant difference in the force of detachment of berries from the stalk depending on the colours of the berries. The mean force of detachment for the green and yellow fruits were 220.5 g and 158.0 g, respectively. The maximum force of detachment of the berries recorded was 270 g. It was also found that the minimum rupture force was 509 g and the mean rupture force was about 560 g. These analysis are important in designing a thresher that uses impact and stripping forces and also in determining the rpm of the threshing cylinder. The rpm of the threshing cylinder will determine whether the pericarp can be removed or not from the berries.

A locally designed thresher was fabricated, tested and evaluated for



Fig. 1 Outside view of the thresher

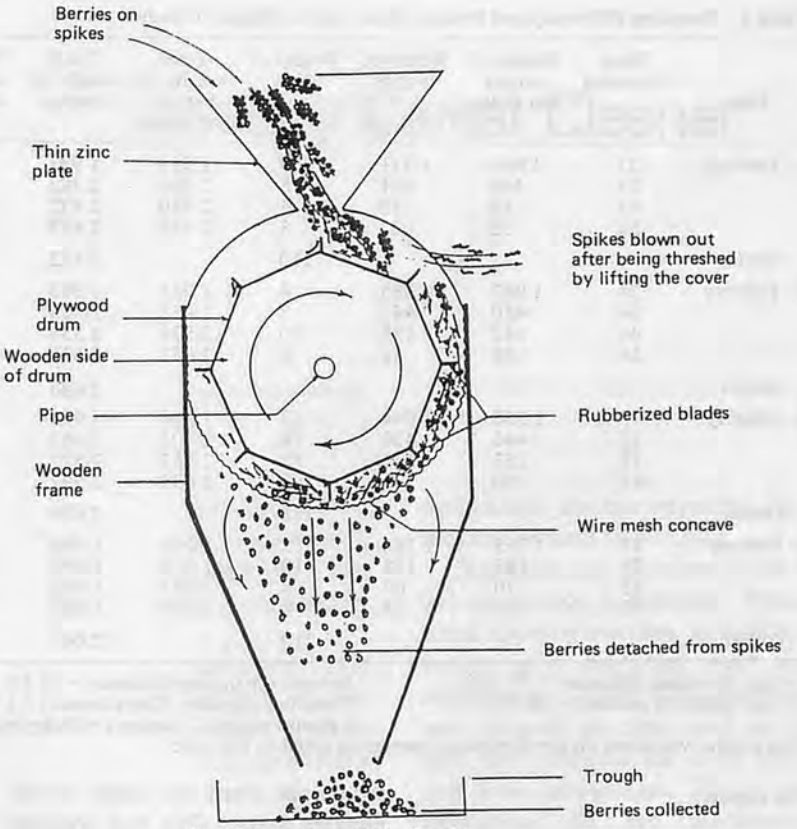


Fig. 2 Operation of the thresher.

the threshing of pepper. The thresher was designed to be used by either manual or engine power source. Figs. 1 and 2 illustrate a three-dimensional view, front and side views and mode of operation of the thresher, respectively. Threshing is accomplished by the blades lined with rubberized material to soften the whipping and beating action on the berries. The threshing surfaces are made of corrugated wire mesh to facilitate better threshing action. Separation occurs at the concave made of wire mesh large enough to allow the berries to drop through by gravitational force. The stalks are retained on the concave and thus carried along by the rotating drum and thus blown out. Cleaning is accomplished by the action of the rotating drum which creates centrifugal forces on the materials. The rubber blades also act as a blower to assist cleaning. A slanting wire mesh was placed on the delivery trough to catch the broken stalks due to overthreshing.

Methodology

The thresher functioned satisfactorily in detaching berries from the stalk. The maximum efficiency can be achieved if the time of threshing were increased. Overthreshing only occurs at higher rpm and not due to prolonged time. The concave, made of wire mesh, allows the threshed berries to pass through immediately after it has been threshed. Thus, there was no undue retention of the threshed berries in the drum. A 100% purity of the product was obtained by separation with the use of the wire mesh at the delivery trough. The capacity of the thresher varies depending upon the operator's judgement and power source. If the operator is satisfied with the completeness of threshing, he opens the thresher cover to allow the trash and bigger materials to be blown out. The operation will then proceed with another feeding to the machine. The average feeding was 3 kg.

A few tests were carried out by manual power at the University farm, in order to determine the performance characteristics in terms of threshing efficiency and purity of the product. For each test run, about 3 kg of berries were threshed. Threshing efficiency was calculated by taking the total weight of clean berries and the weight of the berries still attached to the stalk. The number of berries attached to the berries were counted. The purity of the product was calculated by the weight of the clean berries and stalks at the delivery trough. Machine capacity was determined by the weight of stalks at the delivery spout. For the purpose of evaluation, a slanting wire mash at the delivery trough was used. All the berries and broken stalks collected at the delivery trough were analysed. The berries still attached to the stalk at the outlet spout and delivery spout were counted and weighed to determine the threshing efficiency. The purity of the product was analysed immediately after the last feeding and at 10 sec consecutively. The threshing efficiency was analysed after each test. When the drum was rotated by the engine, it was noted that the revolutions using the lowest engine speed (rpm) was fast enough not only to detach the berries from the stalk but it also caused "skinning" or depericarping of the berries a turning point in the discovery of a technique to mechanize white pepper production. More modifications would be required. Hence, the machine operation of the mechanical thresher is not discussed in

Table 1 Threshing Efficiency and Product Purity for the Pepper Thresher

Item	Time (Seconds)	Weight of berries and stalks	Weight of berries	Weight of stalk	Total weight of berries and stalks	Total weight of berries	Weight* of berries attached	Total* weight of berries attached	Threshing efficiency (%)	Purity of product (%)
1. Delivery	21	1 940	1 931	9	1 940	1 931	1.8	1.8		99.5
	31	456	451	5	2 396	2 382	1.4	3.2		99.4
	41	54	50	4	2 450	2 432	1.0	4.2		99.3
	51	32	27	5	2 482	2 459	1.1	5.3	99.8	99.1
Outlet				210		2 512	53	58.3	97.7	
2. Delivery	24	1 987	1 983	4	1 987	1 983	0.3	0.3		99.8
	34	450	443	7	2 437	2 426	0.7	1.0		99.5
	44	142	132	10	2 579	2 558	0.8	1.8		99.2
	54	58	52	6	2 637	2 610	0.9	2.7	99.9	98.9
Outlet						2 680	70	72.7	97.3	
3. Delivery	17	1 956	1 944	12	1 956	1 944	1.7	1.7		99.4
	27	446	436	10	2 402	2 380	2.2	3.9		99.1
	37	153	141	12	2 555	2 521	2.2	6.1		98.7
	47	80	71	9	2 635	2 592	2.0	8.1	99.7	98.4
Outlet				178		2 656	64	72.1	97.3	
4. Delivery	15	1 765	1 760	5	1 765	1 760	0.3	0.3		99.7
	25	148	138	10	1 913	1 896	2.2	2.5		99.1
	25	70	62	8	1 983	1 960	0.2	2.7		98.8
	45	31	23	8	2 014	1 983	1.2	3.9	99.8	98.5
Outlet				210		2 047	64	67.9	96.7	

Average threshing efficiency = 97.25%
Average purity of product = 98.7%
Average separating efficiency = 86.8%
Threshing capacity (Clean berries) = 176 kg/h
Labour cpacity (2 persons) = 88 kg/man-h

*The weight was based on the number of berries attached to the stalk

this paper.

Result and Discussion

The performance characteristics in terms of threshing efficiency and quality of the recovered berries are influenced by both machines and crop variables. The performance of the thresher depended upon the speed of the threshing drum; length of time and amount of pepper berries allowed to be threshed at one time; and crop variables, including the cultivar of pepper and their stages of maturity. **Table 1** shows the data collected when the thresher was operated manually. The average threshing efficiency was calculated to be 92.25%. Threshing efficiency can further be increased if the time of threshing were increased as evidenced by the total weight of berries attached to the stalk collected at the outlet spout. Further increased threshing time will increase threshing efficiency to an average of 99.8%. The thresher functioned satisfactorily in separating the berries and the stalks. Separating efficiency was at an average of 86.8%. As such, only 13.2% of the separation must be done at the delivery spout. This was achieved by placing a slanted wire mesh to catch the stalks but allow the berries to pass through. Cleaning efficiency was considered to be perfect as the trash left in the machine was negligible. Cleaning was accomplished by opening the cover of the thresher. The average purity of the product was 98.7%. It will be shown in **Table 1** that purity of the product decreased with the time of threshing. The total amount of time to thresh about 11 kg of raw product was 197 S. Thus, an average thresher capacity for these tests was 201 kg/h for the raw products and 176 kg/h for clean berries. The labour output was 88 kg/man-h with two persons operating the thresher.

Conclusion

The potential use of the locally designed thresher for the farmers of Sarawak is very great. The machine can also be adapted for paddy threshing due to similarity in crop variables. Therefore, the thresher can be adapted to at least these two crops and is yet to be evaluated for other grain crops. This mechanical thresher was made out of wood because of its availabilty at the farm, light, cheap and easy to fabricate. The authors feel that the thresher will be popularly used because it is cheap and can be adapted to various grain crops. The farmers of Sarawak produce paddy and pepper and also other crops for their additional source of income.

The introduction of this level of mechanization to the framers of Sarawak will definitely reduce the labour requirement as well as increase productivity and income. In addition, the production process will be less arduous and more attractive for the younger people to work on farm. Agriculture in Malaysia has always been a labour-intensive operation. With the present trend towards industrialization, most of the workers prefer the glamour of living and working in factories and firms in urban areas. Labour shortage at the farm can be alleviated by increasing the productivity of labour in the agricultural sector through mechanization. ■■

An Appropriate-Technology Cereal Cleaner



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Abstract

An appropriate-technology cereal cleaner was designed, fabricated and tested. Cleaning was done by the use of combined air blast and sieve arrangements. Test results showed that the optimum angle of tilt of the sieves was 4° to 5° and the recommended speed was between 300 and 350 rpm. The machine was found, through opinion surveys, to be acceptable to the farmers. The selling price, when mass-produced was estimated to be below US$ 300.

Introduction

The principal food grain crops grown in Nigeria include maize, rice, wheat, sorghum, millet and beans. The estimated percent increase in production of food grain in Nigeria from 1976-1980 has been tremendous: 36% for maize, millet and sorghum and 59% for rice and wheat, (Olyide 1972).

There are three categories of farmers in Nigeria (Igbeka, 1978): the rich and enlightened few (10%), the intermediate, half-educated plenty (70%) and the dwindling old, illiterate and poor group which form 20% of the farming population. The majority of farmers called intermediate, because of their educational and financial status produce more than 50% of the food crops in Nigeria. In recent times, many of them have been drifting away from the farm to the cities to take up jobs as messengers, drivers, and nightwatchmen. This has made food prices in the country very costly.

In order to reverse this trend, the agricultural engineers in the country have been called upon to develop appropriate-technology machines and implements for these intermediate farmers that should be relatively cheap, easy to operate and would need minimum technical skill to maintain. Considering the large quantity of food grain crops expected when production inputs are increased, it is necessary to improve the traditional ways of cleaning these grains. Cleaning is an extremely important step in the production of high-quality seed crops and grain. The quality of flour, bread or beans is affected by the purity and the cleanliness of the seeds which go into the products (Hall, 1972). Seed which is to be planted should be free of other crop seeds, straw and chaff, sand, dust, smut kernels and diseased or damaged seeds.

Many types of processing equipment have been developed to clean small seeds, seed grain and beans which are produced on the farm. Most of these machines require electric power to operate. Unfortunately, most rural areas of the developing countries do not have electric power extended to them, the farmers do not benefit from the use of electric power for most of their farm operations. Also, these equipments are too expensive for the rural farmers to purchase.

This work was, therefore, carried out to develop a relatively cheap cereal cleaning machine, a modified version of a prototype built by Adegboyega (1980). The machine was designed to clean and grade with the combined aid of air blast and sieve arrangement. This is an adaptation of the traditional methods of seed cleaning in which the sieve is hand-vibrated and air blast is generated by blowing with the mouth or atmospheric wind.

Theoretical Design Analysis

The basic concept in the design boarders mainly on separating and cleaning the seeds, by size and specific weight. Therefore, the physical and aerodynamic properties of he components to be separated will come into play. The chaff is blown off by the air blast and the good, whole seeds are separated from the small broken ones by the sieve.

The Sieve Mechanism

The basic requirement of the shaking and vibrating sieves is that they have a horizontal oscilating motion and a small vertical motion. This combined motion ensures that the seeds move or slide down the screen and at the same time are tossed to give the whole bulk of seed a stir. **Fig. 1** shows the movement of a seed on an inclined

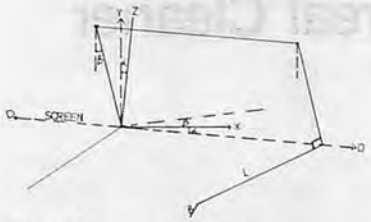


Fig. 1 Movement of screen.

screen. The angle of movement is the same as the angle of suspension, β .

The distance moved, S, is given as

$S = R(1-\cos wt) \pm (R/4L)\cdot \cos^2 wt$ . . . . . (1)

where R = radius of eccentricity; L = length of connecting rod; t = time

Where R is very small compared to L, the last term is discarded. The equation is correct if the connecting rod is perpendicular to the suspending rod. The velocity, V, and acceleration, a, are given as

$V = \dot{S} = Rw\sin wt$ . . . . . (2)

$a = \ddot{S} = Rw^2 \cos wt$ . . . . . (3)

Taking it along it along the direction of the screen, D, we have:

$\dot{D} = Rw\sin wt \cos\beta\cos\alpha$ . . (4)

where α = angle of tilt of screen

$\ddot{D} = Rw^2 \cos wt \cos\beta\cos\alpha$. (5)

In the direction perpendicular to the screen, Z, we have:

$\dot{Z} = Rw\sin wt \sin\beta\cos\alpha$ . . . (6)

$\ddot{Z} = Rw^2 \cos wt \sin\beta\cos\alpha$ . . . (7)

A particle will move or slide on the screen if:

$M\ddot{D} > \mu M(g - \ddot{Z})$ . . . . . (8)

where M = mass of particle; μ = coefficient of friction between screen and particle; g = gravitational acceleration.

The acceleration determines the sliding; therefore it will just start to slide in one direction if:

$\ddot{D} \geqslant \mu(g - \ddot{Z})$ . . . . . (9)

$Rw^2 \cos wt \cos\beta\cos\alpha \geqslant \mu(g - Rw^2 \cos wt \sin\beta\cos\alpha)$. (10)

Re-arranging equation (10) we have:

$Rw^2 \cos wt \cos\alpha(\cos\beta/\mu + \sin\beta) \geqslant g$ . . . . . (11)

With the same reasoning, the particle will move in the opposite direction if:

$Rw^2 \cos wt \cos\alpha(\cos\beta/\mu - \sin\beta) \geqslant g$ . . . . . (12)

The particle will loose contact with the screen and jump up when:

$\ddot{Z} \geqslant g$ . . . . . (13)

Substituting we have:

$Rw^2 \cos wt \sin\beta\cos\alpha \geqslant g$. (14)

Equations 11, 12 and 14 are the basic design equations. During construction, R and β were chosen within the limiting and recommended range and kept fixed. The other two parameters, w and α, were adjustable and could be changed to meet the requirements of the three design equations. The effect of these two parameters on the screening efficiency of the machine were also tested.

Basic Features of the Seed Cleaner

The cleaner is basically comprised of the frame, hopper with a metering device at the base, fan, sieves and collector (**Fig. 2**). The equipment is operated by a diesel engine or electric motor and is made mainly of iron and metal sheet. It was an adaptation and modification of the prototype constructed by Adegboyega (1980), which was made basically of wood and operated by hand (**Fig. 3**). It derives its motion from an eccentric drive. The various parts are described as follows:

Frame and Hopper – These are made from metal angles and plates. The frame supports the hopper, fan, sieving case and feed to be bonded. Mortice and tension joints with screw nails were adopted for rigidity.

The hopper has a capacity of 0.102 m^3 and is made of metal. It is made of gauge 8 sheet metal and shaped like a rectangular prism tapering down the base. The top measures 90 cm x 54 cm while the base measures 80 cm x 48 cm. The height is 36 cm and the angle of slant of the sides is 35°.



Fig. 2 The cereal cleaner – final stage.



Fig. 3 First prototype cereal cleaner.

The metering device, situated at the base of the hopper, meters out a predetermined quantity of seeds per revolution. It is made of two cast iron pipes and a 5 mm metal plate, forming a fluted wheel. The quantity metered per revolution is given as:

$Q_I = 4S_A L$ . . . . . (15)

where S_A = Area between the metal strips; L = length of metal strip.

From the dimensions of the design, Q_I was calculated to be 192 cm^3. The quantity discharged per minute, Q_T, is given as $Q_T = 4S_A LN$ . . (16) where N = rpm

The Cleaning Unit – The mixture of seeds and chaff (uncleaned seeds) is metered into the cleaning chamber. The chamber contains two sieves of different sizes of openings and a fan. The sieves are given vibrating motion through an eccentric drive. They were made from punched metal sheets and

attached to wooden frames. Provision was made to vary the angle of tilt of the sieves.

The fan (low-speed centrifugal fan) was made from locally available materials. The blades were made of plywood measuring 400 mm x 155 mm x 12.5 mm. Eight blades supported with 5 mm thick flat mild steel of 25 x 535 mm were used. Bolts and nuts were used to fasten the blades to the supports. The housing was made from plywood cut into two scroll-like shapes and a galvanized iron sheet folded round the cut plywood frame and held in place with screws. The fan housing opens into the sieving chamber through a rectangular duct.

Collecting Units – Collection is made at three points. The feed is cleaned and seperated into good product, stones or small seeds and chaff. These products empty into three different ports of wooden plates fixed at an angle of 10° to the horizontal.

Performance Tests and Evaluation

The machine was tested in the laboratory for its ability to separate small seeds and stones from good big seeds and chaff from seeds. The effects of angle of tilt of the screen and speed (rpm) on the machine performance were also investigated. The tests were conducted using an electric motor but a diesel engine attached to the machine was used during field demonstrations. Rice and cow peas at 10.2% and 11% moisture content, respectively, were used as test materials.

Test Procedure

Two separate sets of tests were conducted with two types of food grains – rice and beans. The first set was to test the ability of the machine to separate the light chaff from the seeds by means of air blast while the second set was to test its ability to separate small broken seeds or stones from good whole seeds by means of the screen.

In both cases mixtures of known weights of clean whole seeds and chaff or husk or clean whole seeds and broken seeds were fed into the machine. The machine was operated until the whole mixture completely went through the machine. The recovered contents in the trays were weighed and the efficiency or degree of cleaning was calculated. The amount of air blast was varied in the first set of test while the angle of tilt of screen and speed were varied in the used second sets of tests. Each test was repeated three times and the average taken. Circular hole screens were used for beans while oblong hole screens were used for rice.

Test Results and Evaluation

For purposes of these tests the following terms and nomenclature were adopted (Fig. 4)

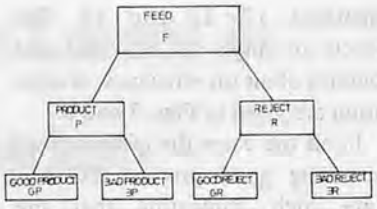


Fig. 4 Flow of material in the machine.

1. Efficiency of separating good products GP/(GP +GR) . . (17)
2. Efficiency of separating bad rejects EB = BR/(BR + BP) . . . . . (18)
3. Total efficiency ET
   ET = EG x EB . . . . . (19)

   where GP = Good product, GR = Good reject, BR = Bad reject and BP = Bad product

Therefore, in the tests, only two categories of products were supposed to be recovered: the "Product" and the "Reject". When some rejects found their way into the product tray, they were called the "Good reject".

Tables 1 and 2 give the weights of the different grades of product collected. From these weights, the efficiencies were calculated using

Table 1 Summary of Weights Collected at the Product and Reject Trays at 250 RPM (Unit: kg)

	Rice					Beans				
Angle of tilt	GP	BP	GR	BR	EG %	GP	BP	GR	BR	EG %
1.7°	308	82	42	68	88	301	72	49	78	86
3.4°	315	65	35	85	90	308	58	42	92	88
4.0°	318	59	32	91	91	308	53	42	97	88
5.0°	322	51	28	99	92	315	54	35	96	90
6.7°	308	63	42	87	88	297	53	53	97	85
7.5°	311	56	39	94	89	301	58	49	92	86
8.5°	304	60	46	90	87	294	61	56	89	84

Table 2 Summary of Weights Collected at the Product and Reject Trays at Angle of Tilt of 4°

(Unit: kg)

	Rice					Beans				
RPM	GP	BP	GR	BR	EG %	GP	BP	GR	BR	EG %
50	210	85	140	65	60	196	97	154	53	56
100	238	84	112	66	68	227	90	123	60	65
150	248	72	102	78	71	262	82	88	68	75
200	297	74	53	76	85	280	56	70	94	80
230	315	57	35	93	90	311	52	39	98	89
270	308	51	42	99	88	301	46	49	104	86
310	287	46	63	104	82	294	45	56	105	84
350	262	50	88	100	75	245	30	105	120	70
400	231	66	119	84	66	217	44	133	106	62
450	213	101	137	49	61	224	77	126	73	64

equations 17, 18 and 19. The effects of angle of tilt, rpm and volumes of air on efficiency of separation are given in **Figs. 5 and 6.**

In all the cases the efficiency of separating good product EG was quite high, indicating that the design of the machine has met the engineering requirements. Also, the total efficiency E_T in all the cases was reasonably high, the highest being 61% and lowest 20%.

Fig. 5 shows that the total efficiency increases with the angle of tilt up to a maxium at about 4.5° and start decreasing. It means that the optimum angle of tilt is 4°, beyond which the efficiency decreases and can go down as low as zero; in which case, the screen will be so steep that no separation is expected. The whole mixture would slide down into the product tray immediately they emptied into the screen from the hopper.

The efficiency increases with the rpm in a non-linear manner **(Fig. 6)**, like in the angle of tilt. It levels off and then starts decreasing. Therefore the efficiency is low at too low speeds and at very high speeds. The optimum speed of operation is between 300 to 350 rpm. A similar trend is observed in the effect of air volume on the performance of the machine. The efficiency is low at low air volumes and at very high air volume. At low air volumes the force is not enough to carry off all the chaff and light materials; while at very high volumes, the force is so much that both the light and good heavy seeds are carried off, thus reducing efficiency. The volume of air is a product of the duct cross-sectional area and air velocity given as

$$Q = AV$$

where Q = volume of air, m^3/h; A = duct cross-sectional area, m^2; V = air velocity, m/h.

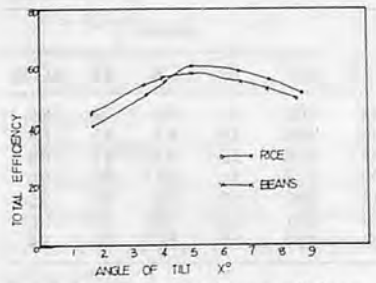


Fig. 5 Screening efficiency and sieve tilt angle.

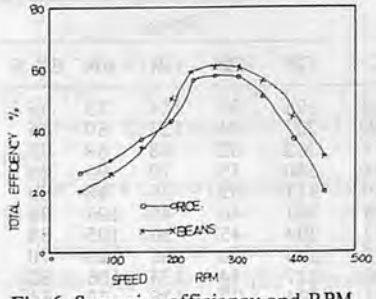


Fig. 6 Screening efficiency and RPM.

Table 3 Result of Acceptability Survey

Question	Yes	No
1. Do you think the machine has performed successfully the work you want it to perform?	100%	–
2. Do you think the machine will save you time and induce you to produce more?	100%	–
3. Would you accept the machine for your cleaning?	100%	–
4. Would buy the machine if sold between ₦200 and ₦250	88%	12%
5. If No, choose a second alternative:		
a) ₦150	10%	2%
b) ₦100	–	–
c) Can't afford	2%	

Cost of Production

Frame and body	₦60
Hopper metering device	30
Drive mechanism	50
Sieves and collectors	54
Fan unit	38
Total	₦232

(₦1.00 = US$1.54)

The above cost will drastically reduce when mass-produced under a good engineering management. The cost of the materials will be reduced when bought in large quantities. When massproduced, the cost of producton will be ₦140, so the machine could be sold between ₦ 180 and ₦ 200 apiece. At this price, 80-88% of the medium-income farmers can afford it.

Acceptability of Machine – The machine was demonstrated in many agricultural shows to rural farmers and to many cooperative society farmers. After each demonstration, their opinions about the machine were surveyed by distributing questionnaires to them. Also, many of them asked questions and, in fact made some recommendations for ease of operation.

The result of the opinion survey showed that 88% of the farmers would buy the machine at a moderate price between ₦200 and ₦250 (US$300 and $375), while 10% would buy the machine only if it is sold at ₦50 (US$225) and 2% said they could not afford it at all. All the farmers surveyed said that they liked the machine and believed that it would save them time and induce them to increase production. **Table 5** shows the result of the acceptability survey.

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Quantitative and Qualitative Losses in Paddy and Wheat in Bangladesh



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Abstract

This paper estimates that the probable qualitative and quantitative losses in paddy and wheat in Bangladesh during harvest, hauling, threshing, drying and storing amount to as high as 25% of the total production.

These losses can be considerably reducecd by applying modern post-harvest technology like mechanical threshing, drying and storing. In addition, farmers should be trained by extension workers in preventing such losses.

Introduction

Bangladesh is an agro-based country and produces two to three rice crops on the same land. Even then the government has to import a considerable quantity of food grain from other countries. **Table 1** shows the trend of food grain procurement and storage in the country.

Rice is the staple food of the people of Bangladesh and wheat is the second most important crop.

Some study show that the quantitative loss of paddy in the country may be more than 25% of the total production (Nazrul, 1977). **Table 2** shows the percentage losses of paddy and their causes.

The losses vary by crop, variety, harvesting period, handling, method of threshing, drying, processing, type of storage, duration of storage, transportation and distributon. Other variables are, climate and culture in which the food grain is produced and consumed. The sources of losses in the food grain system are shown in **Fig. 1**.

Three periods of time may be indentified during which food grain may be lost. Each period has its characteristic problems and these are:

(a) Preharvest loss: This loss occurs before harvest begins.

(b) Harvest loss: This loss occurs between the onset and completion of harvesting.

Table 1 Import and Procurement of Food Grains, Distribution Through Rationing and Government Stocks.

Unit: 100t

Year/Month	Import		Internal precurement		Distribution		Stock	
	Rice	Wheat	Rice	Wheat	Rice	Wheat	Rice	Wheat
1980-81								
July	–	304	51	18	40	64	317	462
August	–	228	68	6	39	66	311	715
September	–	126	88	4	47	86	360	865
October	10	82	71	–	45	98	388	881
November	10	46	43	–	37	86	414	860
December	10	–	128	–	36	53	422	814
January	15	–	169	–	30	78	575	769
February	–	–	113	–	38	102	702	686
March	18	–	53	5	55	109	734	590
April	–	77	19	76	51	106	760	495
May	–	–	6	47	49	52	710	542
June	–	115	41	21	40	79	776	492

Source: Monthly Statistical Bulletin of Bangladesh Vol. No. 6, June, 1981.

Table 2 Losses of Paddy-Rice Produced in the Farm and Cycled Through Commercial Process and their Causes.

Causes of loss	Loss out of Total Production
Delay in harvesting (shattering, birds, rodents, cutting and transportation)	25-17%
Threshing, cleaning and drying	4-6%
Farm storage	5-8%
Commercial storage	20% of the paddy cycled through commercial process

Source: Md. Nazrul Islam, 1977.

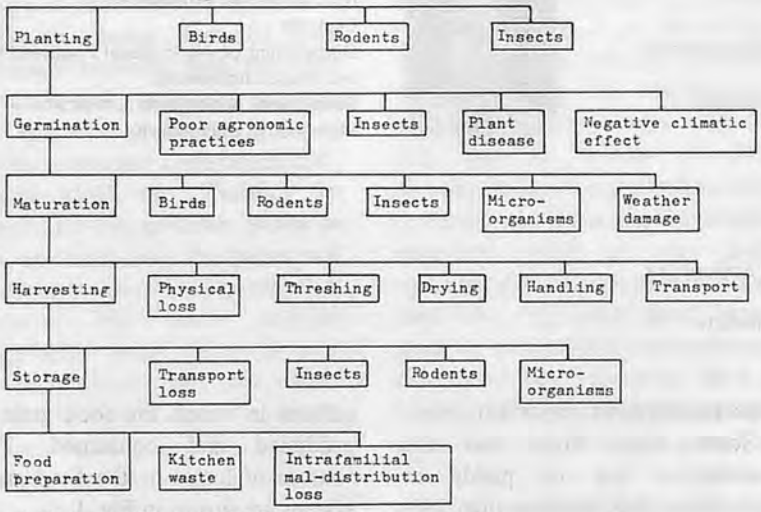


Fig. 1 Sources of losses in food grain system.

(c) Post-harvest loss: The loss that occurs between the completion of harvest and the point of human consumption.

The loss of food grain in Bangladesh involves a series of well defined stages in harvesting through threshing, winnowing, parboiling, drying, milling and storing. Food losses occur at each of these stages, but it is difficult to measure them with precision, because of enormous variability that exists in the techniques adopted, the timing of operation and their sequences.

Types of Losses

(A) Harvesting and transportation loss: Harvesting is done with sickles and the harvesting time is determined by the experience of the farmers. Paddy moisture content at harvest varies with practices and it ranges from 20-25%. Before harvesting, when the grain is mature rodents, insects, and birds start spoiling the grains by eating or cutting the panicles. Rodents make underground holes in the field (**Fig. 2**) and preserve paddy in them for their consumption.

Due to over-drying of paddy stalks in the field, the panicles become brittle and cracking develops in the grains and fall in the field. On the other hand, if the paddy or wheat is immature when harvested, it results in higher amount of breakage during hulling. Bala *et al* (1980) investigated the quantitative and qualitative losses of wheat in relation to moisture content and suggested that major losses of wheat occur during harvesting and threshing. Grain losses also occur at the time of transporting paddy panicles from field to the farmer's house. Bundles of paddy or wheat stalks are carried to the farmer's house on head loading or by bullock carts. If the paddy stalks are overdried, a considerable amount of grain is lost during this operation.



Fig. 2 Underground rat holes in the paddy field.



Fig. 3 Manual threshing of paddy.

(B) Threshing: In Bangladesh paddy and other food grains are sometimes threshed manually (**Fig. 3**). In some districts like Dhaka, Mymensigh, etc the bundles of panicles are placed in heaps on platform or on the ground before threshing. Such arrangements with high moisture content lead to the development of high temperature in heaps and serious deterioration of the quality of grains occurs in the form of discolouration, moulding, attack of mites and other micro-organisms.

Threshing is mostly done by treading the paddy stalks with bullocks on clay floor in the winter and on woven bamboo mats in the rainy season. Although mechanical threshing is very rare, yet some pedal threshers (**Fig. 4**) are used in the districts of Comilla, Noakhali, Dhaka, etc. **Table 3** shows the harvesting and threshing losses of wheat.



Fig. 4 Pedal thresher in operation.



Fig. 5 "Kula" used by farmers.



Fig. 6 Sundrying of paddy in the rural areas.

(C) Winnowing, parboiling and drying: In the rural areas of Bangladesh winnowing and drying of food grains are done manually. Wind cleaning is the only process adopted with "kula" (Fig. 5) when grains are tossed into the natural wind. The chaff, straw, leaves, empty grains and dusts are carried away by wind, whereas the heavy grains fall on the ground.

Table 3 Wheat Harvesting and Threshing Losses

Date of Harvest	Moisture Content (%)	Harvest and threshing losses (%)	
		Traditional (Manual)	Mechanical (Pedal thresher)
Feb. 27, 1979	50.05	27.33	17.19
March 2, 1979	46.43	18.03	12.48
March 5, 1979	30.46	12.18	7.72
March 8, 1979	17.49	10.77	6.22
March 11, 1979	17.98	9.13	9.75
March 14, 1979	15.47	4.09	7.25

Source: B.K. Bala *et al*, AMA, Spring, 1980.

Parboiling has been widely practiced in Bangladesh as far back as pre-historic time. This process, after years of practice by the wives of farmers, is a matter of experience. In some urban and sub-urban areas parboiling is done mechanically.

Sun-drying is widely practiced by the farmers and also by rice millers. Sun-drying is very helpful for drying 'Aman' paddy, as it is harvested in the winter season. After parboiling the grain is spread in front of the dwellings of farmers to a thickness of 2-3 cm on the drying floor as shown in Fig. 6 and stir them from time to time systematically. This process is repeated until the paddy is evenly dried to a moisture content of 14-16%. The moisture content of grains is determined by the experience of the housewives by crushing the rice grain with their teeth. During drying some quantity of grain is consumed by birds, chickens, ducks, etc. According to Wimberly (1972), in the field, harvesting, drying and threshing losses account for 21.6% of the total production.

(D) Storage: Paddy is stored after drying as dry paddy and after parboiling followed by drying and milling as parboiled husked rice. Optimum storage conditions should protect paddy and wheat from unfavourable weather conditions, insects, rodents, birds, etc, both from qualitative and quantitative points of view.

The storage structures of Bangladesh can be divided into three categories.

i) Farmer level storage – Farmers store paddy and husked rice for their own consumption, generally in conventional storage structure. Some of their structures like woven bamboo dole, "gola" etc. are susceptible to rodent attack. The average percentage of loss in some of these rural storage structures for a period of 16 months is 0.11% (Samajpati et al, 1978).

ii) Commercial level storage – Businessmen store food grains, generally, in gunny bags in their own godowns. They are very much aware of grain losses for less-profit in business and, hence, preserve the grains carefully.

iii) Government level storage – The Food Department, Government of Bangladesh, has its own central supply depots and local supply depots in different districts. In addition, the Government also has five food silos in different places of the country, where huge quantities of grains are stored.

The different pre-storage practices employed in the processing of paddy and wheat have an important bearing on the subsequent keeping quality. The climatic conditions prevailing during harvesting will affect the moisture

content of the grain, which is an important determinant of the level of infestation by fungi and insect pests. Drying techniques also have a prefound effect on storage and milling of grains. Inadequate drying may lead to severe insect infestation and mould growth in store.

Losses during storage may be qualitative or quantitative. Quantitative loss is defined by the physical weight loss and is regarded as the most significant type of storage loss. According to Huq (1980), the average food loss of paddy and parboiled rice, in a variety of different storage structures in Bangladesh is 2.43%, as shown in **Table 4.**

Mandal *et al* (1978), investigated the quantitative storage losses of paddy and wheat in the District of Mymensingh and found them to be 1.5% for Government level storage and 2.8% for farmer level storage.

The principal agents which are responsible for storage losses are:

Fungi – Fungi as associated with stored cereal grains may cause the following types of losses to the grains.

(a) Decrease the germinability;
(b) Discolouration of the seed;
(c) Heating and mustiness;
(d) Biochemical changes;
(e) Possible production of toxins; and

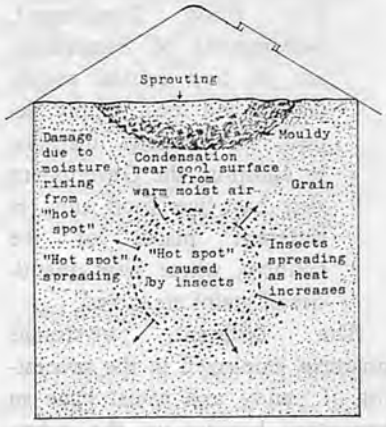


Fig. 7 Spoilage of grain due to temperature gradients, movement of moisture and localized development of fungi and insects (Hall, D.W., 1970).

Table 4 Average Losses for Paddy Rice and Parboiled Rice

Commodity	No. of stores sampled	Average storage period (month)	Average quantity stored (kg)	Loss by weight (%)			
				Insect loss	Rodent loss	Total loss	Food loss
Paddy rice	63	4.36	67.30	1.06	1.29	2.35	2.94
Parboiled rice	34	2.71	96.90	0.32	1.16	1.48	1.48
Overall weighted average	97	3.78	77.60	0.80	1.24	2.04	2.43

Source: Fazlul Huq A.K, Tropical Stored Product Information, 1980(39).

(f) Loss in dry matter.

At a relative humidity below 70%, most storage fungi do not grow. It is anticipated that the quantification of weight loss, when the loss is due to fungal damage, will depend on local practices in the use of the damaged materials.

Weather Conditions – The temperature of the grains with high moisture content at the centre of the stored bulk may rise due to the presence of insects resulting in hot spot as shown in **Fig. 7.** If uniformly dried grains are put into the store at a constant temperature, the damages due to condensation and translocation of moisture will be minimum.

Insect – Insects are major causes of post harvest grain losses. By boring into the kernel and feeding on the surfaces, they consume food, selective nutrients, encourage higher moisture in the grain and promote the development of microorganism. As reported by Hall (1970), there are three primary pests of paddy and these are angomois moth, weevils and lesser grain borer.

In the tropics, particularly in Bangladesh, insects multiply very rapidly during the monsoon, if the infested paddy is kept in store. The lower the moisture content of the grain (below 14%), the safer it is from insect infestation.

Mites – Mites require a higher grain moisture content than insects and they can withstand relatively low temperature (around 40°F). Losses in stored grain due to mite infestation can be kept to a minimum by storing the grain at low moisture content and low temperature.

Rodents – Rats and mice can cause considerable loss in stored grains and damage may be of threefold nature:

(a) Consumption of certain quantity;
(b) Fouling a much larger quantity with their excretions; and
(c) Making holes in the containers

Rodents and insects are responsible for maximum amount of loss of food grain. The rodent loss may be as high as 40% of the total loss. Rats are not only destructive because of the amount of grain they consume but also because they transmit disease. Most often serious rodent losses occur in relatively long term storage or in a long established marketing or warehousing situation, where grain is present under a stabilized pattern.

Respiration – A mass of grain can be considered as a living organism that feeds on itself. It is made of individual seeds which are hosts to many microorganisms. It is the nature of mold, yeasts and bacteria to reduce organic materials to simpler organic compounds or even to its inorganic form. Weight losses due to respiration of the grain itself are unimportant until the moisture is so high that serious deterioration by micro-organisms occur. Long before the grain is completely destroyed, it is made useless as food because of the musty odour, discolouration and possible formation of toxic substances. In fact, this will occur by the time when 1 or 2% of the

dry weight has been lost.

Conclusion

Post-harvest food grain system in Bangladesh is still mostly primitive and as such food losses occur at each of these stages. Although there is no systematic survey of actual losses of grains at different levels, estimates as high as 25% of the total production are made. Progress in reducing post-harvest food losses requires the identification and elimination of the constraints to the application of existing technology. The major constraint may be lack of finances, but it is equally possible that lack of knowledge and the trained personnel as well as political and cultural constraints exist.

Mechanized cultivation and other modern inputs together with the replacement of traditional low yielding varieties, might increase the present crop intensity. Paddy and wheat should be harvested in time because around 15% of the produce, including bird and insect losses in the field, is lost due to untimely harvesting. A considerable amount of food grain is lost, specially in Aus and Boro paddy, for want of mechanical drier.

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Effects of Pineapple Waste Storage Conditions on the Chemical Composition of Bran



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Abstract

During the times of financial crisis in the livestock industry in South East Asia, pineapple solid waste offers a vast and cheap source of animal feed. The conversion of pineapple waste into animal feed requires a number of machine operations. A temporary storage of the raw waste forms an important part of these operations, during which nutritional losses are inevitable. A study was conducted to evaluate the effects of storage conditions on the chemical composition of the bran produced from the stored waste. The results show that the raw pineapple waste should not be stored for more than 3 days in either open or closed system in the temperature range of 20 – 40°C.

Introduction

The growth of the food processing industry has brought forth the problem of efficient disposal of waste in terms of environmental pollution. This is forcing technologists to find ways for the effective utilization of wastes and by-products. At present when dairy and meat industries are facing economical ploblems due to continuous increase in animal feed prices, the utilization of wastes from food processing industry looks promising from both environmental pollution and economic points of view. Hutagalung (1977) reported that the utilization of various wastes as animal feed reduced the traditional feed costs of about 60 – 80% to 30 – 50% of the total livestock production cost.

pineapple is one of the major crops grown in the tropical belt of the world. The major portion of the produced pineapple is canned for human consumption in many parts of the world. The canning process of pineapple leaves behind a large quantity of solid waste which includes over-ripe pieces, end portions, the central core, the skin and trimmings immediately beneath the skin, and comprises 50 – 60% of the inintial mass (Pal, 1980) .

Pineapple waste, solid as well as liquid, has been used to produce different by-products such as vinegar, syrup, acetic acid, ethyl-alcohol and stockfeed. Most of these methods offer the possibility of waste utilization but rarely solve the entire problem of its disposal, since only a small portion of the waste is utilized. The conversion of waste into bran (dried solids) after extraction of juice and dehydration offers a solution to this problem. Both the syrup produced from the concentration of juice and the bran can be utilized in livestock feeding ration.

The production of bran from the pineapple waste involves several operations starting with extraction of juice to the packing of bran. In case of any mechanical break down, it is necessary to store the incoming raw waste temporarily. This paper describes the effects of pineapple waste storage conditions on the chemical composition of the bran produced from the stored waste. The study was conducted at the Asian Institute of Technology, Bangkok, Thailand.

Material and Methods

The pineapple waste was collected from the Siam Food Products Co. Ltd., which is one of the seven major canneries in Thailand. The waste was first reduced to a size less than of 25mm (average) and properly mixed. Samples of 2 kg each were then stored in plastic bags at temperatures of 20, 30 and 40°C for 1, 3, 5 and 8 days before preparing the bran. In some of the bags the waste was kept air tight by closing them properly; others were kept open, to study the effect of air on the changes in chemical composition. A

hydraulic pressure of 3.43 MPa was applied to extract juice from the stored waste and the residue was dried overnight in hot air oven at 70 °C. The dried waste was ground in laboratory size hammer mill using 100 mesh grate.

A chemical analysis was carried out to determine dry matter, ash, minerals, ether extract, crude fiber, crude protein and total sugar contents of the bran using procedures specified by A. O. A. C. (1975). The results were expressed on the dry basis. Carbohydrates and gross energy values were calculated using the results of chemical analysis. The calorific value of the bran was termed as gross energy and it was calculated using the following relationship.

Gross energy (cal/g) = 95 x (ether extract, %db) + 56.5 x (crude protein, %db) + 41.5 x (carbohydrates, %db) (1)

The data obtained for the chemical composition of bran samples was statistically analysed using the Statistical Analysis System (SAS) (Barr, *et al*, 1979). Regressional analysis was carried out for the compositional parameters as a function of storage time and temperature to obtain regression equations and correlation coefficients (**Table 1**). The significance of correlation was tested at 95 % confidence level.

Results and Discussion

The pineapple bran composition determined in this investigation, and the statistics derived from the data given by Henke (1931), Senik and ldrus (1977), Muller (1978), David (1980) and Pal (1980) (**Table 2**) indicates a wide variation. This shows that the chemical composition of bran produced from the fresh waste would vary considerably with the variety of pineapple, its ripeness, season of year, geographical location and the percentage of various portions of fruit in the waste. It also points out that the amount of juice extracted from the waste will also affect the composition of the bran because of extraction of certain soluble components into the juice.

Table 1 Pineapple Bran Composition from Different Sources.

Components	Pal (1980)	From the data of Henke (1931), Senik and Idrus (1977), Muller (1978), David (1980) and Pal (1980)			
		Minimum	Maximum	Mean	Standard deviation
Ash	4.2	3.0	6.6	4.1	1.1
Ether extract	1.2	0.8	1.6	1.2	0.3
Crude protein	5.4	3.5	9.3	5.4	1.9
Crude fibre	17.6	15.4	24.4	18.3	3.0
Nitrogen free extract	65.0	47.2	70.4	62.0	7.7
Carbohydrates	82.6	71.6	85.6	79.9	5.2
Calcium	0.32	0.13	0.39	0.23	0.1
Phosphorus	0.29	0.11	0.91	0.30	0.31
Total sugar	13.6	1.5	23.3	11.8	7.2

Talbe 2 Correlation Coefficients for Composition Parameters of Pineapple Bran as a Function of Storage Time and Temperature.

Independent	System	Total dry matter	Ash	Ether extract	Crude protein	Total sugar	Carbo-hydrates	Gross energy
Time	Open	−0.85	−0.62	0.31	0.82	−0.85	−0.78	0.38
	Closed	−0.45	−0.28	−0.019	0.43	−0.73	−0.13	−0.08
Temperature	Open	−0.22	0.23	−0.50	−0.21	−0.10	0.20	−0.63
	Closed	0.24	0.14	−0.005	−0.31	−0.29	0.14	−0.07

The dry matter recovered from the stored samples was reduced by 15% during storage which can be attributed to its decomposition by the fermentation process. The amount of calcium, phosphorus, ash and crude fibre did not show any significant change during storage.

Storage temperature did not show any influence on ether extract in the closed system. A correlation coefficient of −0.50 was observed in the open system indicating the decrease in ether extract percentage with increase in temperature in the presence of air. A regression model relating ether extract with storage time in the closed system could be obtained as

$ETH2 = 1.29 + 0.87t - 0.096t^2$; $r^2 = 0.90$ (2)

Where,

ETH2 = ether extract, % db;

t = time in days; r^2 = coefficient of determination

The crude protein was positively correlated with storage time, giving a correlation coefficient of 0.82 in the open system which could be attributed to increased microbial population. The crude protein was negatively correlated with storage temperature, however, the correlation was not significant at 95% confidence level. The following regression model related the crude protein percentage in the open system with the time and temperature.

$CP1 = 6.27 + 1.13 \times 10^{-2}\ t - 0.26\ \ln(T)$; $r^2 = 0.79$ (3)

Where,

CP1 = crude protein, % db;

T = storage temperature, °C

Total sugar content was the only nutritional parameter of the bran which showed sharp decrease and a clear trend of change with storage time. Results are given in **Fig. 1 and 2.** Correlation coefficients were −0.85 and −0.73 for open and closed systems, respectively. The decrease in the total sugar content could be attributed to the fermentation process. The higher correlation coefficient for the open system indicated an increase in the rate of biochemical reaction in the presence of air. Muller (1978)

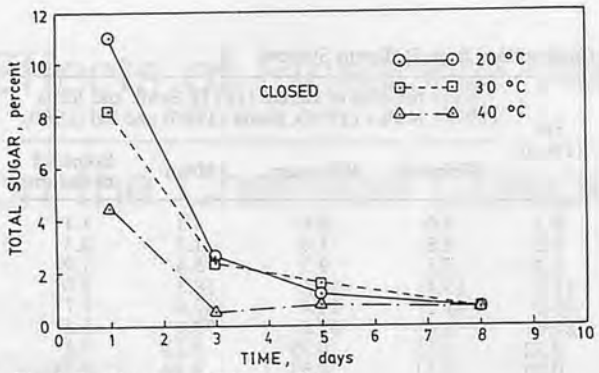


Fig. 1 Total sugar and storage time.

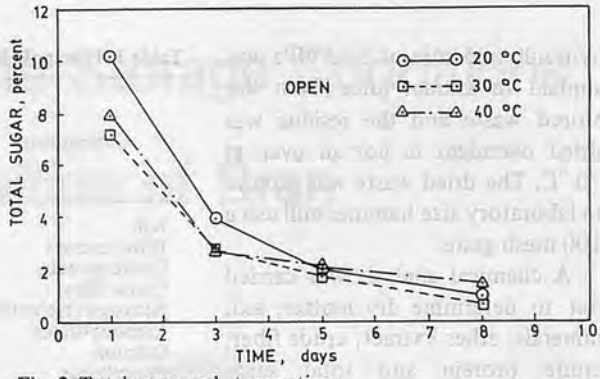


Fig. 2 Total sugar and storage time.

reported that the fermentation of lactic acid took place from monosaccharides when waste was left in open air. The sugar content was not significantly affected by the storage temperature. The following regression models related the percentage of sugar content with storage time and temperature.

$$TSUG1 = 11.08 - 3.11t + 0.234t^2 ; r^2 = 0.91 \quad (4)$$

and,

$$TSUG2 = 12.17 - 3.51t + 0.280t^2 - 4.11 \times 10^{-5} T^3 ; r^2 = 0.84 \quad (5)$$

Where TSUG1 and TSUG2 are total sugar contents for the open and closed systems respectively.

The storage time did not exhibit any significant change in the carbohydrate content in the closed system. In the open system a significant negative correlation was observed between the carbohydrate content and storage time with a correlation coefficient of -0.78. However, a regression model could not be obtained.

There was 2.4 % increase in the gross energy content of bran after 5 days of storage. This was not a marked change and could be attributed to errors associated with the chemical analysis. The gross energy had marginal correlation with storage time in both systems, while it had significant correlation with the temperature of storage in the open system. The gross energy could be related with storage time in the closed system by the following regression equation.

$$GRE2 = 4093 + 58t - 65t^2 \quad r^2 = 0.82 \quad (6)$$

Where GRE2 is the gross energy in cal/g.

Conclusion and Recommendations

It can be concluded from this study that pineapple waste storage up to 8 days and a maximum storage temperature of 40 °C has insignificant influence on the nutritional parameters except the total sugar value of the bran in either closed or open system. However, visual assessments reveal that the storage of waste after 5 days, either in open or closed system, led to the reduced acceptability of bran due to unpleasent smell and fungal growth. The juice extracted from the samples stored for more than 3 days was also not suitable to produce any other by-products due to low sugar contents (less than 3 %). Hence, it is recommended that the raw pineapple waste should not be stored for more than 3 days under storage conditions tested in this study. Because of the variations in chemical composition of bran from various sources, analysis of the pineapple bran should be carried out for each lot to recommend its proper portion in the animal feed.

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Development of Ostwald Chart for Paddy-Straw Combustion



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Abstract

Combustion of hydrocarbons for the production of energy requires a controlled air-fuel ratio for maximizing energy output from the reaction. The analysis of resultant flue gases of the combustion reaction indicates deficiency or excess of air in the combustion reaction. The Ostwald chart for any fuel combuston helps in determining the percentage of excess or deficiency of air and thus in determining the optimum combustion conditions for the fuel. This investigation was undertaken to construct an Ostwald chart for paddy straw based on its composition and to show the use of developed chart in actual practice.

Introduction

Since long, wood and fossil fuel have been the prime source of energy in the world. The store of the fossil fuel is disappearing very fast. The search for an alternate energy source is now a deep concern everywhere.

India's energy problem should be studied in the context of 75% of its people living in half million villages. The rural population in India is expected to grow up to 800 million by 2 001 (4). Moreover, for the next 20 to 30 years, the bulk of this population will be engaged in agricultural activities. Therefore, we shall have to concentrate our attention largely on meeting the energy needs of the rural and agricultural sectors. Ultimately the organic matters, particularly the agricultural residues attract the attention of technologists and engineers as a renewable energy source for harvest and post-harvest operations.

The excess or deficiency of air during combustion may be computed from the flue gas analysis. To avoid long computations, Ostwald invented graphical charts for different fuels. The charts were made on the assumption that all hydrogen is burnt and carbon monxide is the only combustible gas in the flue gases. The charts were modified by Keller (1) to take account of the experimentally determined fact that when CO appears, an equal volume of H_2 is usually present. Thus, the modified Ostwald charts are made for paddy straw for the use on furnace test. This chart (**Fig. 1**) allows a very close estimate of the excess air from a flue gas analysis.

Methodology

Paddy straw contains 35.6% carbon, 27.7% oxygen and 4.5% hydrogen by weight. Part of the hydrogen is already combined with the oxygen in the form of water. The remainder, which is available for combustion is

$$(0.04585 - \frac{0.27724}{8}) = 0.0112 \text{ kg}$$

of hydrogen per kg of straw.

The equivalent volume of carbon, considered as a gas is found. This equivalent volume is found by diving the percent weight by the molecular weight; 12 for carbon and 2 for hydrogen.

$$C = \frac{0.35656}{12} = 0.029713$$

$$H_2 = \frac{0.0112}{2} = 0.0056$$

$$\text{Sum} = 0.035313$$

or

$$C = \frac{0.029713}{0.035313} \times 100 = 84\%$$

$$H_2 = \frac{0.0056}{0.035313} \times 100 = 16\%$$

It means that, from the chemical reaction stand point, the straw is equivalent to a gas containing 84% carbon and 16% hydrogen by volume.

The reaction equations for complete combustion are –

$C + O_2 = CO_2$; $2H_2 + O_2 = 2H_2O$

Hence, 1 equivalent volume of carbon requires 1 volume O_2 and forms 1 volume CO_2; 1 volume H_2 requires 1/2 volume O_2 and

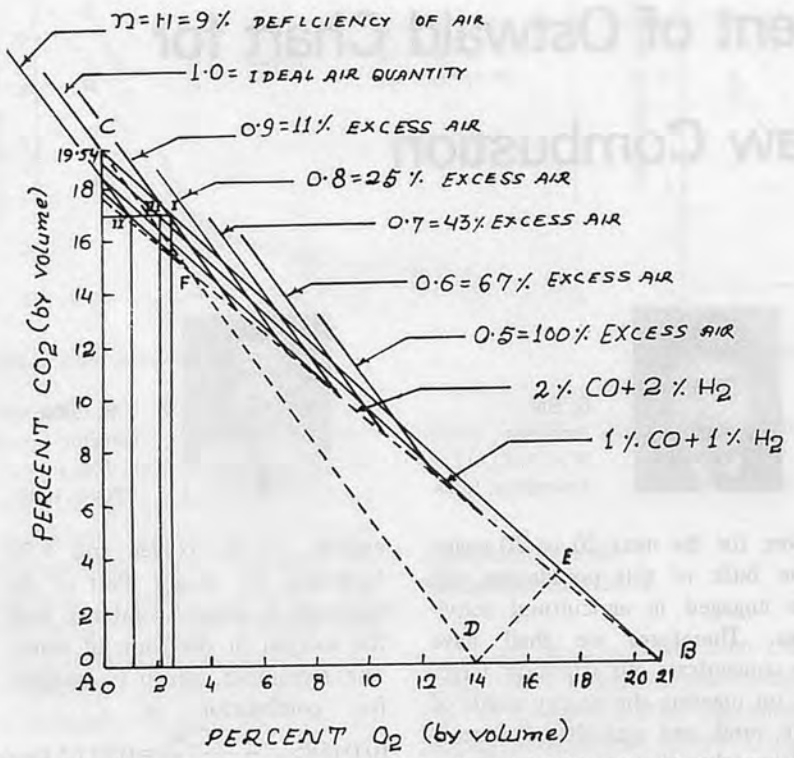


Fig. 1 Ostwald chart for paddy straw containing (in weight) 35.6% C, 4.58% H_2, 27.7% O_2, 0.77% N_2, 0.12% S.

Table 1 Oxygen and Carbon Dioxide Content in Dry Products of Perfect Combustion

Air ratio n	1	0.9	0.8	0.7	0.6	0.5	1.1	1.2	1.3
Excess air %	0.0	11.0	25.0	43.0	67.7	100.0	−9.0	−16.7	−23.0
O_2 %	0.0	2.14	4.26	6.38	8.50	10.60	−2.14	−4.3	−6.45
CO_2 %	19.54	17.55	15.57	13.60	11.63	9.68	21.54	23.53	25.53

forms 1 volume H_2O which disappears by condensation. For incomplete combustion of carbon the reaction is:

$$2C + O_2 = 2CO$$

in which 1 equivalent volume of carbon takes 1/2 volume O_2 and forms 1 volume CO.

The ideal quantity of oxygen required for complete combustion, per equivalent cubic meter of fuel considered as a gas, is

$0.84 \times 1 + 0.16 \times 1/2 = 0.92\ m^3$

The actual volume of oxygen is 0.92/n. where n is the ratio of ideal air to actual air.

Complete combustion means no CO or H_2 is formed.

$CO_2 = 0.84\ m^3$

$$O_2 = \frac{0.92}{n} - 0.84 - \frac{0.16}{2}$$

$$= 0.92\left(\frac{1}{n} - 1\right)$$

= [O_2 originally present
− O_2 absorbed by C
− O_2 absorbed by H_2]

$$N_2 = \frac{79}{21} \times \frac{0.92}{n} = \frac{3.46}{n}$$

Thus, the total volume of dry products:

[O_2 originally present
+ N_2 − O_2 absorbed by H_2]

$$= \frac{0.92}{n} + \frac{3.46}{n} - 0.08$$

$$= \frac{4.38}{n} - 0.08$$

Then, percent O_2

$$= \frac{100 \times 0.92\left(\frac{1}{n} - 1\right)}{\left(\frac{4.38}{n} - 0.08\right)} \quad (1)$$

$$\text{percent } CO_2 = \frac{100 \times 0.84}{\left(\frac{4.38}{n} - 0.08\right)} \quad (2)$$

When n = 1, O_2 = 0, and CO_2 = 19.535% which is maximum CO_2 content that can be obtained by combustion of the straw; it represents the peak of the chart on the left hand side (point-C). When n = 0, then CO_2 = O and O_2 = 21.0% corresponding to the extreme right hand corner of the chart (point B, **Fig. 1**). Intermediate point on the combustion line (BC on the chart) are determined by using definite values of n as parameter and calculating the corresponding percentage of CO_2 and O_2 from the above mentioned expressions and are listed in **Table 1**.

Incomplete combusition:

All carbon burnt to CO, no CO_2 present,

and $H_2 = CO$

$CO = 0.84\ m^3$

$$N_2 = \frac{79}{21} \times \frac{0.92}{n}\ m^3$$

$$= \frac{3.461}{n}\ m^3$$

$H_2 = CO = 0.84\ m^3$

This is according to the assumption that CO and hydrogen appear in equal volumes. But actually, hydrogen cannot exceed $0.16\ m^3$ because that is all the hydrogen initially present in the fuel. Hence the 0.84 must be considered merely a mathematical fiction, like the negative oxygen in the **Table 1** useful for the purpose of constructing the chart but not in itself corresponding to any real quantity.

The oxygen initially present is $0.92/n\ m^3$ of this, 0.84/2 is taken by the CO. The hydrogen burnt is (0.16 - 0.84), negative quantity, hence the oxygen 'absorbed' by it is (0.16 - 0.84)/2, again a math-

ematical fiction. The oxygen remaining in the product is:

$$O_2 = \frac{0.92}{n} - \frac{0.84}{2} - \left(\frac{0.16 - 0.84}{2}\right)$$

or $$O_2 = \frac{0.92}{n} = 0.08$$

Total dry products ($CO + H_2 + N_2 + O_2$)

$$= \left(0.84 + 0.84 + \frac{3.461}{n} + \frac{0.92}{n} - 0.08\right)$$

$$\text{Total dry product} = \frac{4.38}{n} + 1.6$$

Hence, the CO content is

$$\%\,CO = \frac{100 \times 0.84}{1.6 + \frac{4.38}{n}}$$

The oxygen content is

$$\%\,O_2 = \frac{100 \times \frac{0.92}{n} - 0.08}{1.6 + \frac{4.38}{n}}$$

When n = 1, CO = 14.0 and O_2 = 14.0

This determines point D on the chart. The distance DE then corresponds to 14.0% CO, and by dividing this length proportionally and drawing lines through the division points parallel to BC, the constant CO lines are obtained.

By calculating the percent O_2 for given value of n, the end points on line AB of the constant air ratio lines are obtained and listed in **Table 2.**

Not all the charts thus constructed can be used, however, on account of the fact mentioned above that not enough hydrogen is present in the fuel to fulfill the assumption that the volume of hydrogen in the products equals the volume of CO. The boundary line between the upper usable part of the chart and the lower unusable part can be determined thus:

For n = 1, is all of the H_2 present in the fuel appeared unburnt in the products, the latter would contain

Table 2 Percent Oxygen and Percent Carbon Monoxide in Incomplete Combustion

Air ratio n	1.0	0.9	0.8	0.7	0.7	0.5	1.1	1.2	1.3
Excess air %	0.0	11.0	25.0	43.0	67.7	100.0	−9.0	−16.7	−23.0
CO_2 %	14.0	13.0	11.87	10.69	9.44	8.11	15.05	−16.15	16.90
O_2 %	14.0	14.57	15.12	15.70	16.33	17.0	13.55	13.08	12.63

$H_2 = 0.16\ m^3$

$CO = H_2 = 0.16\ m^3$

$CO_2 = 0.84 - 0.16 = 0.68\ m^3$

$O_2 = 0.92 - 0.68 - \frac{0.16}{2}$

$= 0.16\ m^3$

$N_2 = \frac{79}{21} \times 0.92 = 3.46\ m^3$

$\therefore$

Total = $N_2 + H_2 + CO_2 + CO + O_2$

$= 3.46 + 0.16 + 0.68 + 0.16 + 0.16$

$= 4.62\ m^3$

Then, $CO_2 = \frac{0.68 \times 100}{4.62} = 14.72\%$

$CO = \frac{0.16 \times 100}{4.62} = 3.46\%$

$O_2 = \frac{0.16 \times 100}{4.62} = 3.46\%$

This determines point F. The boundary line is then the line drawn through points B. and F. (shown as a broken line in **Fig. 1**)

The Ostwald chart for other agricultural residues may be constructed by following the aforesaid procedure.

Use of the Chart

Let a flue gas analysis show CO_2 = 17% and O_2 = 2.6%. By following horizontal and vertical lines denoting these two quantities to their intersection at point I of **Fig. 1**, it is found that the representative point on the chart lies on the line of perfect combustion, so that there is no CO in the products of combustion. Air ratio, as found from the slightly inclined lines, equals 0.9; its reciprocal equals 1.11, which means that combustion was carried on with 11% excess air.

If the gas analysis had shown 17% CO_2, as before, but only 1.1% O_2, then point II of **Fig. 1** would have been reached. This point lies three inclined spaces away from the perfect combustion line, CB, which means that the gases contain 3% CO and 3% H_2. The air ratio is 1.1; its reciprocal is 0.91, which means that combustion took place with 9% air deficiency.

If, finally, the stack gas analysis has shown 17% CO_2 and 2.18% O_2, then point III would be reached on the chart. It is located 1 CO space distant from the line of perfect combustion, accordingly, the stack gases must contain 1% CO and 1% H_2. The air ratio is 0.96; its reciprocal is 1.04; which means that combustion took place with 4% excess air.

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NEWS

DLG-Ausstellung '84: 58th International Agricultural Show

May 30-June 5, 1984, Frankfurt am Main/West Germany

The "DLG-Ausstellung '84" will show again a comprehensive survey of the worldwide offer of machines and equipment, as well as operating materials and livestocks for the agricultural enterprise. The exhibition program is classified into the following topics:

- Agricultural tractors, machinery and equipment for agriculture
- International and national livestock show
- Seeds and plant materials, fertilizers and feedstuffs
- Energy and environment technologies
- Design and construction in agriculture
- Forest technology
- Community technology
- Technologies in raising vegetable, fruits, and in horticulture.

Based on the present state of the registrations, 1163 outright exhibitors, as well as 309 additional firms through representations, will show their products. Of this total, 312 of the exhibitors and 229 of the represented firms come from abroad, i.e. from 28 countries. As a total, 541 foreign firms present themselves, from all important European countries, from the U.S.A., Canada, Japan and New Zealand. Thus, approximately 37 percent of the exhibiting enterprises come from foreign countries.

For further information inquire at Deutsche Landwirtschafts-Gesellschaft, Zimmerweg 16, D-6000 Frankfurt am Main 1, (Phone 0611/71680, Telex 413185 dlg d).

Landbouw LAI 84

January 23-28, 1984
Amsterdam, The Netherlanes



The 1984 Landbouw RAI, the international agricultural machinery show established a new record in attracting 132 462 visitors. When it was last held two years ago, the show attracted 127 689 visitors.

For the exhibitors the commercial results were extremely good, in both the livestock and the arable sectors. A striking amount of interest was shown in the uses to which computers can be put in farming. For the most part, they are used to reduce costs and improve quality.

For the first time there was an export pavilion at the Landbouw RAI. 63 firms took part in it and various export orders were concluded.

SIMA

March 4-11, 1984, Paris/France

The 55th International Exhibition of Farm Machinery (SIMA) was held in Paris at the Place de la Porte de Versailles.

This year is especially named as "Spraying Year", and the various solutions proposed throughout the world for plant protection (correctness of the doses delivered, homogeneity, rapidity of the operations, reduction of quantities, etc) will be dealt with.

As usual medal-winning ma-



chines (five gold, four silver and nine noteworthy) were selected by the Committee to Encourage Technical Research in November, 1983.

The Gold Medal Winning Machines are introduced in the following "New Products" column.

50th Anniversary Celebration and International Conference on Soil Dynamics

June 17-19, 1985, Auburn, Alabama, U. S. A.

An International Conference on Soil Dynamics is being sponsored by the National Tillage Machinery Laboratory, USDA, ARS, and the Agricultural Engineering Department, Agricultural Experiment Station, Auburn University at Auburn, Alabama on June 17-19, 1985.

The conference is part of a celebration of the 50th Anniversary of the National Tillage Machinery Laboratory. The first call for papers for the conference was announced on December 1, 1983.

Those wishing to prepare a paper to the conference should submit a 200 word abstract to the conference coordinator by May 1, 1984. Final papers will be due on March 15, 1985. Persons interested in further details should contact, William R. Gill, Conference Coordinator National Tillage Machinery Laboratory, P.O. Box 792, Auburn, Alabama, 36831-0792 or call (205) 887-8596. ■■

NEW PRODUCTS

A New Cultivator from Agron Equipment (S) Pte, Ltd. Singapore





The Agron cultivator (top) has simple, trouble free double reduction chain and sprocket drives in an enclosed chaincase with tough ball bearings on the input and output shafts and needle bearings on the layshaft. It is the ideal machine for small farmers, gardeners, nurseries, etc. Either as conventional cultivator or with optional furrower or 300 kg tip trailer, it's the perfect all-round machine. Available less engine, or with Newton 3½ HP engines Shibaura 3½ or 5 HP engines.

Transport wheels which are quickly moved up to the work position, control tine and shields are standard equipment. Optional furrower attachment has a depth wheel incorporated to ensure even uniform furrows. Optional tip trailer includes trailer hitch, clip on wheels to replace cultivator rotors, seat and drum brake on the cross axle.

Other Agron products include: Tine Tillers (bottom), Slashers and Fertilizer Spreaders.

For further information contact:

Agron Equipment (S) Pte, Ltd.
GPO Box 511, Singapore 9010,
Singapore

Improved MDH Bean Harvester and Corn Picking Head from Chisholm-Ryder Co, Inc.



Features:

* New tandem fan system assures positive cleaning action
* Independently controlled reel, conveyors, fans adjust for all conditions
* More sensitive header flotation improves picking accuracy
* Full 114" harvesting width gives greater adaptability
* Flexibility of movement eliminates need for headlands
* New bin features prevent overloading, simplify dumping

The Model MDH now comes with an air-conditioned cab as standard equipment. The unit is powered by a turbocharged 6-cylinder diesel engine with 150 bhp at 2 200 rpm. A true, positive hydrostatic 4-wheel drive with no transmission provides infinitely variable ground speeds. The MDH harvests in any direction without need to follow the row and, thus, eliminates the need for wide headlands.



Features:

* Dependable hydraulic motors replace hard-to-maintain drive chains and sprockets.
* Gentle auger feed system precludes cob and kernel damage associated with gathering chains.
* Independent speed control of each function assure maximum yield under all field conditions.
* Geometrically-shaped snouts pick up downed stalks more efficiently.
* Parallel stalk rolls reduce spare part requirements.
* Rear wheel power assist for 4-wheel drive available.

HYDRA-IV, a high efficiency corn picking head developed by Chisholm-Ryder, introduces an entirely new concept in sweet corn and field corn harvesting. The new 4-row picker has no drive chains or sprockets to repair or replace, no gathering chains to break cobs or damage kernels. Instead, it employs reliable, variable-speed hydraulic motors to power all picker functions. A smooth-acting, auger drive and transport system moves corn ears gently but surely from stalk rolls to conveyor. Drive auger, cross-auger, and stalk roll speeds are individually controlled. These can be varied independently of ground speed and of each other for maximum yield under all field conditions.

For futher information cotact:

Chisholm-Ryder Co., Inc.
Niagara Falls, NY 14305
U.S.A.

High Speed Thresher VOTEX Twinfan 500

The Votex "Twinfan 500" is a complete threshing machine intended for smaller sized farms and able to thresh nearly any crop. The thresher is placed on a two-wheel



chassis, which can be towed from field to field or heap to heap by a tractor, another suitable vehicle or animal.

Apart from the simplicity, the main feature is that it is the only thresher in the world that is independent for a non-horizontal position.

The threshing system of the "Twinfan 500" is basically a further development of the one so succesfully used in the already famous "Ricefan". Actually, it is a combination of two Ricefan units with an extra cleaning and bagging device. The essence again is the use of a threshing drum incorporating a cross-flow fan, together forming a simple combined threshing/cleaning unit.

Weight and dimensions:

– Weight	490 kg
– Drum width	500 mm
– Drum diameter	400 mm
– Concave coverage	165°
– Nett. concave openings	72%
– Power requirement	7,4 kW
– Tyre size	600x9"
– Wheel thread	125 cm

For further information contact:

Vogelenzang Andelst b.v.
Postbus 1, 6673 ZG Andelst
The Netherlands

Zero's Beta 150 PC Dairy Farm Computer

Singer Products Company, Inc. introduces the Zero Beta 150 PC computer, a total dairy farm management system. This system



not only provides critical herd management information, but also optimizes feed dispensing. It was developed specifically for maximizing milk production.

The Beta 150 PC records totals of individual cow feed consumption in the herd on a daily or monthly basis. Each cow is fitted with a tough polyurethane sealed responder which contains no batteries or moving parts. This transmits a digital code to the interrogator allowing positive cow identification ensuring a programmed optimum feed for each cow is automatically dispensed. Reprogramming can be done in seconds.

Feed consumption can be called up from the system instantaneously providing direct feed control. Any variations in feeding consumption will immediately alert the farmer of illness, pregnance, calving or other conditions. Underfeeding reports are generated automatically.

The Beta 150 PC features a simple sealed "keypad", enabling reliable operation in the humid, corrosive atmospheres often encountered on farms. Reports are called up immediately on a clear LED display and permanent hard copy reports are generated on the built-in thermal printer. Power is safe 24 VAC and the Beta 150 PC features a 2 month memory saving integral battery back-up. In more than a year of field tests the Beta 150 PC has typically increased average herd production up to 25% and has paid for itself in production increases of milk and butterfat, combined with a reduction of feed expenditure.

Exclusive export distributors:

Singer Products Company Inc.
875 Merrick Avenue
Westbury, N.Y. 11590

Gold Medal Winning Machines at 55th SIMA

No.1 Rotary Subsoil Plough by Sté Eurodrain S.A.R.L.



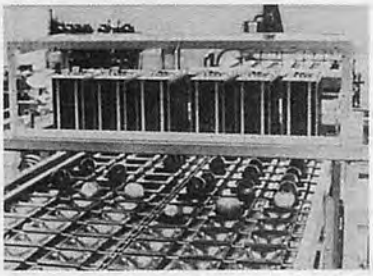
This rotary plough has a 2.40 m wide drum, fitted with 12 to 18 tines, working at depths of 35 - 70 cm; this inplement considerably destroys the ploughing pan. Fixed scrapers help to roughly remove the clods of the arable layer.

The tines attack the soil to the rear, thus eliminating any traction effort. A hydrostatic pump maximum power of 120 HP is sufficient to rotate the drum.

This equipment is particularly well adapted to clayey subsoils, and for all works associated with drainage.

No.2 Electronic Grader for Fruit and Vegetables by M.A.F.

Electronic diameter grading and contact-free grading are now largely possible thanks to a sensor used for the first time on this type of equipment. A linear network placed behind a lens makes it possible to recreate, line for line in a memory, a digital image of the fruit moving



at constant speed along the conveyor. A computer system integrated with the sensor then determines the contour of the fruit. The processing unit gathering the data then controls the components allowing fruit and vegetables to leave the machine as required.

Not touching the fruit or vegetables and yet assessing their shape (diameter for pears, peaches or tomatoes, and length for endives), improving rapidity and accuracy together with flexibility in programming the various grades, thus simplifying the packaging operation.

No.3 Moist Weed-Killer Applicator with Mobile Cords by Ets Matrot



An endless cord impregnated with systemic weed-killer moves crosswise, carried by rollers at the rear of the tractor. It applies this week-killer on the casual plants exceeding the height of the cultivated plants.

At every passage, this cord is soaked in a tank with a constant level. Rollers with adjustable pressure make sure impregnation is regular so that the drops of weed-killer do not fall on the crops.

This implement can thus apply the necessary quantities of weed-killer whatever the density of the casual plants or the viscosity of the solutions.

No.4 Semi-automatic Pruning Machine for Trained Vines by Sté Pellenc & Motte



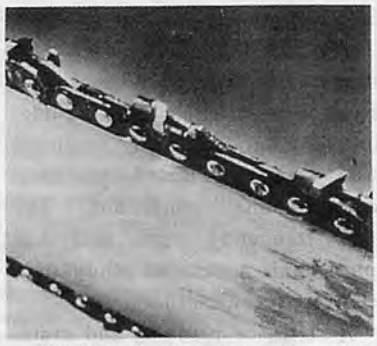
On either side of the training system, two vertical drums absorb the shoots and cut them into short twigs. These drums move apart by themselves when passing pickets. The wires may enter them without damage. Any pulling on the wood is therefore eliminated.

The horizontal rotary disks, stacks of which make up the drums, ensure clean cuts similar to those made by secateurs. Their position in relation to the stocks can be easily adjusted vertically and laterally by a single lever, since the machine is carried on the side of the tractor, well in sight of the driver. Pruning may therefore be carried out for a certain number of shoots to the number of buds desired, without renewing the cutting operation.

During this work there is no danger for the operator because the drums rotate very slowly (around 60 rpm).

The time devoted to pruning is therefore considerably reduced in particular for Rpyat rows or those with alternating intervals, as well as for other vine configurations.

No.5 Tungsten Carbide Chain-Saw Chain by Carbichain France



Thanks to the tungsten carbide inserts fitted to the steel lonks by an original crimping process, this chain offers the considerable advantage of eliminating sharpening. It opens up new possibilities for use, for instance cutting at ground level.

Also allowing high cutting speeds (over 22 m/sec.), it increases production at felling sites (a saving in maintenance time) and reafforestation sites (with considerable savings on stumps clearing). ■■

BOOK REVIEW

Consequences of Small-Farm Mechanization

(Philippines)

Mechanization of Small Farms in South and Southeast Asia affects all production stages from land preparation through crop production, harvesting, and postharvest processing. Because adoption of agricultural machinery increases capital input, it is expected that either the level of output should increase or the level of other inputs decrease. Such changes are likely to have an impact on employment, income and income distribution, and social welfare.

Evaluation of the consequences of mechanization as well as formulation of appropriate policy guidelines is a predominantly empirical issue strongly related to local socioeconomic conditions. The most frequently used analytical approach is a detailed study of a relatively specific situation.

A series of planning and monitoring workshops was held at IRRI to review project progress. The fourth workshop, in which study results from both ADC and IRRI were presented, was held 14-18 September 1981. A summary report of the papers and discussion is available upon request from the IRRI Agricultural Engineering Department.

A committee reviewed the papers presented and selected those for inclusion in this book. The committee recommended that three papers on farm mechanization in Pakistan be consolidated into a single paper (second chapter). It also recommended that 12 papers for the Philippines, West Java, and South Sulawesi studies be summarized in the final three chapters.

Size: 23 x 15cm, 184p, paper cover.

Published 1983 by International Rice Research Institute
P.O. Box 933, Manila, Philippines

Proceedings of the Conference on Weed Control in Rice

(Philippines)

The Conference on Weed Control in Rice, at Los Baños, Philippines, 31 August to 4 September 1981; was held under the joint sponsorship of the International Rice Research Institute (IRRI) and the International Weed Science Society (IWSS).

Over the years IRRI conferences have gained the reputation of being working conferences and this one was no exception. Workshops on research and collaboration opportunities and on training opportunities and needs developed realistic and implementable recommendations. The workshop moderators can take a great deal of credit for the success of the workshops: L.J. Matthews and L.C. Burrill on training and D.L. Plucknett, M.W. Schreiber, and Roy Smith, Jr. on research.

Throughout the Conference – in the papers presented and the discussions that followed – the need for maintaining an ecological balance between weeds and crops was stressed. Participants and observers alike were keenly aware that weeds – those plants that compete for light, water, and nutrients with our cultivated crops – are an inescapable, perhaps even a necessary part of the world's flora.

Size: 23 x 15cm, 422p, paper cover.

Published 1983 by IRRI.

Trickle Irrigation in Humid Regions – Puerto Rico (Annual Report: Oct. 1, 81–Sept. 30, '82)

(Puerto Rico)

By Megh R. Goyal

Drip irrigation system for fruits and vegetables was installed at Fortuna Agricultural Research and Development Center, Juana Diaz during summer, 1981 and winter 1980, respectively. Bibliography-Drip/Trickle Irrigation was compiled and has been published as technical bulletin No. 3 by National Agricultural Plastics Association. Solute movement study at ISPRAC Farm indicated little movement of K and much higher mobility of P than expected. Pepper yield did not differ significantly in all treatments of Orthene 75S via drip irrigation. Growth parameters versus days after transplanting curves showed exponential relationships in drip irrigated summer peppers. Coefficient of correlation among the growth parameters, and N-P-K-Ca-Mg uptake varied from 0.85 - 0.99. Statistical analysis indicated that plant height data in different plastic-mulch types can be used to predict fresh total plant weight and fresh fruit weight with a coefficient of determination of 0.9 - 0.97. Summer pepper yields were lower at 5% level compared to winter pepper in all the treatments. Fruit performance parameters and plant height exhibited lower values during summer compared to winter peppers.

Size: 28 x 21.5cm, 129p.

Published 1982 by Agricultural Experiment Station, University of Puerto Rico, Mayaguez Campus, College of Agricultural Sciences, Rio Piedras, Puerto Rico 00927. ■■

A NOTE TO AMA CONTRIBUTORS

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

Criteria for Article Selection

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

a. are written in the English language ;
b. are relevant to the promotion of agricultural mechanization, particularly for the developing countries ;
c. have not been previously published elsewhere, or, if previously published are supported by a copyright permission ;
d. deal with practical and adoptable innovations by small farmers with a minimum of complicated formulas, theories and schematic diagrams ;
e. have a 50 to 100-word abstract, preferably preceding the main body of the article ;
f. are typewritten, double-spaced, about 4,000 words (approximately equivalent to 8 pages of AMA-size paper) ; and those that
g. are supported by authentic sources, reference or bibliography.

Rejected/Accepted Articles

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

Procedure

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b. Contributors of articles for the AMA for the first time are required to attach a passport-size ID photograph (black and white print preferred) to the article. The same applies to those who have contributed articles three years earlier. In either case, ID photographs taken within the last 6 months are preferred.
c. The article must bear the writer(s) name, title/designation, office/organization, nationality and complete mailing address.

Format/Style Guidance

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

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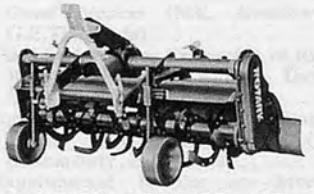
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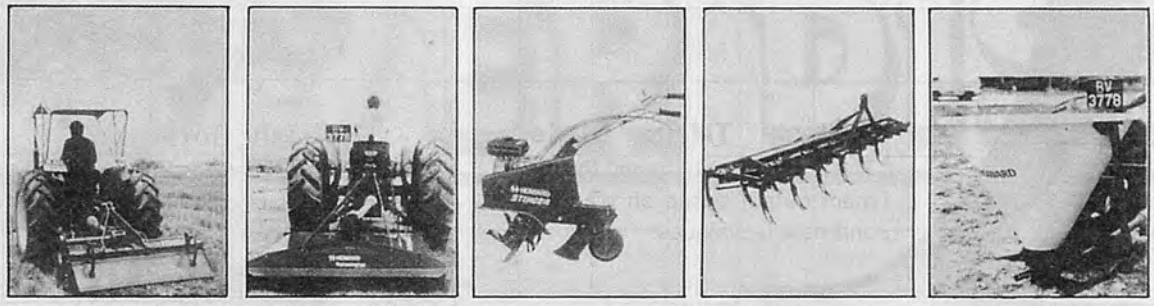

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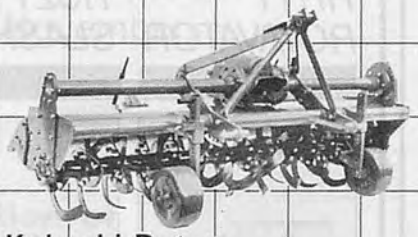
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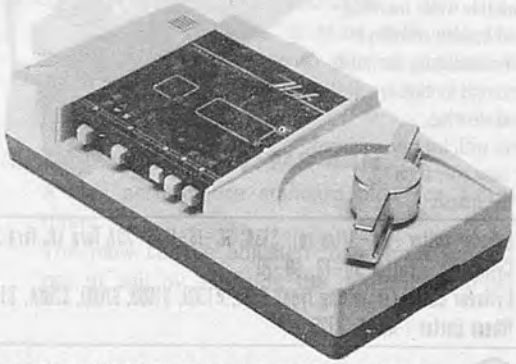
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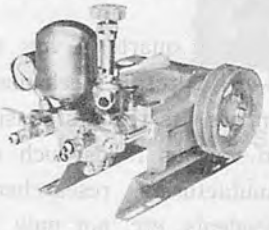
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