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AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

VOL.XIII, NO.1, WINTER 1982

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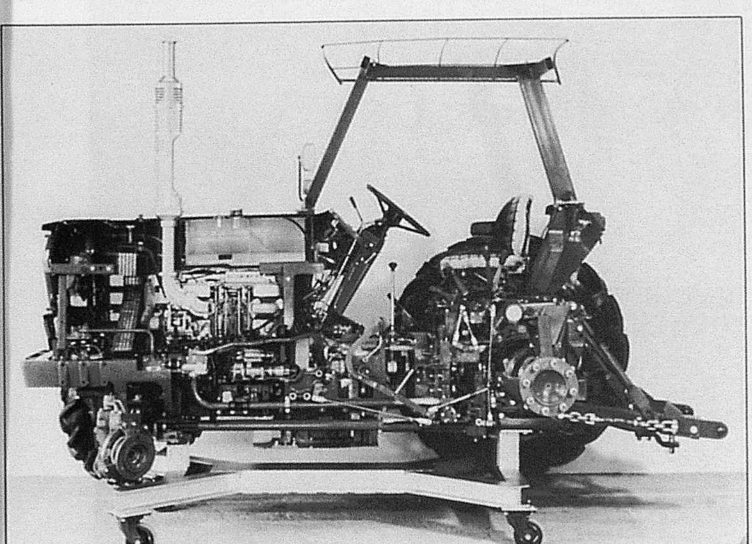

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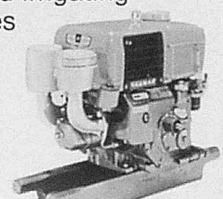

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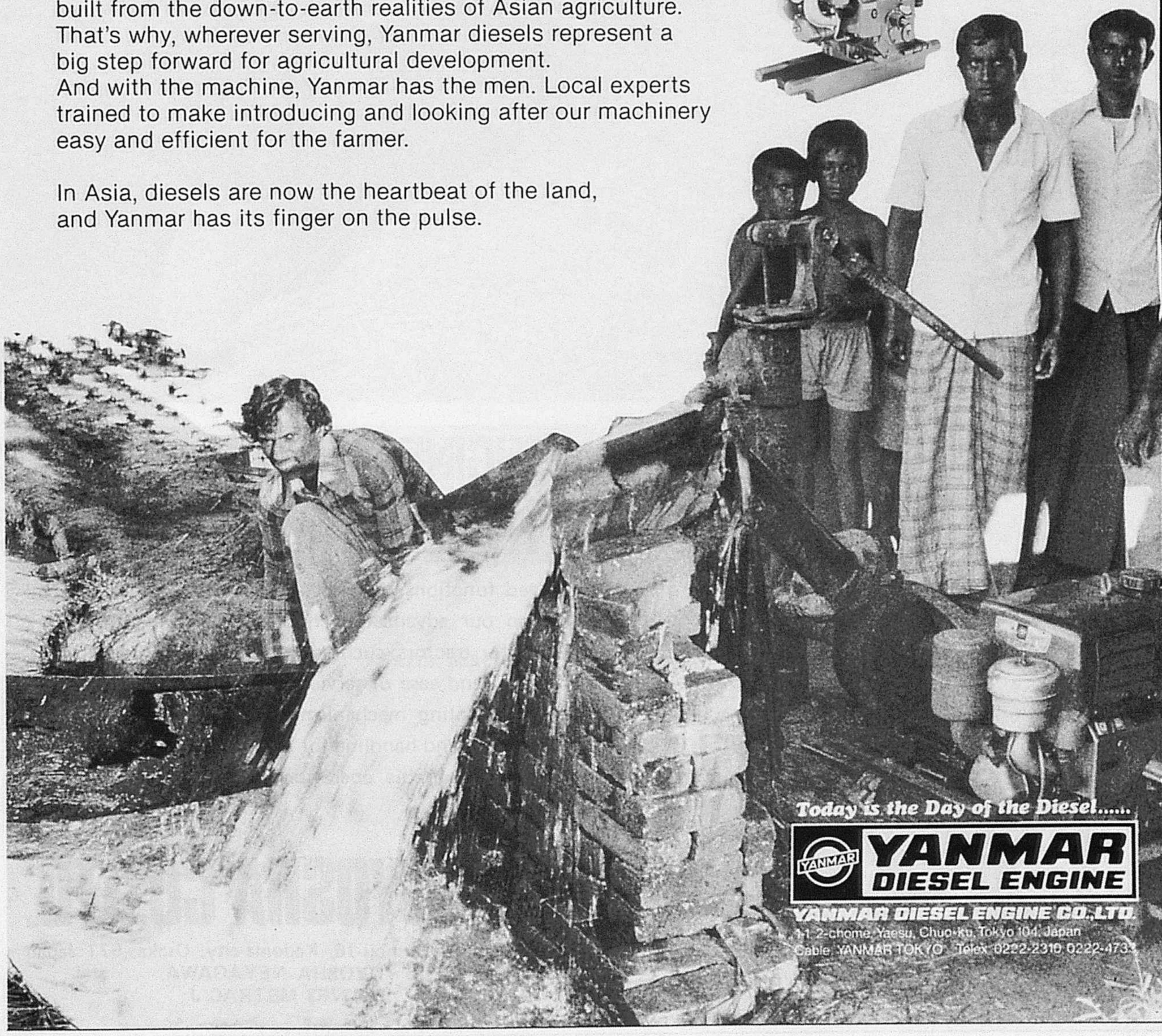

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EDITORIAL

Bridging the Technology Gap

A Happy New Year to all AMA readers!

As we wish all AMA readers and supporters a more hopeful and productive year, some notable happenings over the past year prompt us to look back awhile and relate them to what is in store for all us in the days ahead. Overall, these happenings tell us in no uncertain terms that the need to bridge the technology gap, particularly in food production, yet continues to be of primary importance.

In Japan and the Republic of Korea, for example, last year's winter was unusually warm when the crops required a normally cool temperature. The result was a bad crop that set back some headways gained in agricultural and other technologies. In contrast, the United States and Canada sustained a higher growth rate in agricultural productivity in the past year. But Brazil, for another example, suffered also a bad crop that necessitated the country to import huge quantities of food grains. Clearly, the aberations of the weather stand large in these happenings. But equally clear, also, is the need to improve the technology, in this case that of weather forecasting, to enable the farmers to prepare their crop production plans ahead of time.

While it is true that developed countries have accumulated a wealth of various agricultural technologies to tide them over somehow during years of bad weather, it is the underdeveloped and developing countries that suffer the most – a situation that calls for more effective technology transfer from the "haves" to the "have nots", especially along the lines of agricultural mechanization which the AMA has since considered to be the key to producing more food.

Seen in the light of the world burgeoning population, notably in the Third World countries, teeming millions, and particularly children, continue to go to bed hungry. It is this glaring disparity between the rich and poor countries where the crucial need to bridge the gap is greatest.

The AMA advocates that in order to narrow, let alone bridge the gap, the rich countries must increase their allocation of investment funds to hasten development in the poor countries. Such increase is still a minute sum compared with allocation for arms among the superpowers of the world.

The AMA, therefore, maintains that bridging the technology gap is everybody's concern. And for this reason, we address a clarion call to all AMA readers, writers and co-editors not falter, but keep to going, in the common crusade to help overcome recurrent food shortages in the poor countries.

Chief Editor
Yoshisuke Kishida

January, 1982
Tokyo

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AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

Vol. XIII, No.1, Winter, 1982

Agricultural Engineering Technology for Developing Country Students

by
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Introduction

The Agricultural Engineering Technology graduate program at the Michigan State University has been developed with focus on the appropriateness of technology for the world's limited supply of natural resources. A systems analysis provides the central theme for the curriculum. Simulation modeling provides a means of determining the relative effect of the numerous parameters in the consideration of alternative technologies.

Engineering Curricula

Karcher of the World Bank (1980) reported that the Indian government five-year development plan anticipated a doubling in the number of unemployed university graduates and engineering diploma holders from about 700 000 in 1977-78 to over 1.4 million in 1982-83. That's development? Dr. Malik of the Arab Development Institute stated in an ASEE article (1979) that engineering graduates in developing countries have little opportunity to do design work. Is then the traditional engineering training, with emphasis on design and manufacturing, appropriate for all developing countries? This paper discusses an Agricultural Engineering Technology program, and the role it can play in fulfilling the training needs for developing countries.

Malik (1979) argues that most engineers in developed countries are engaged in design and manufacturing, but in developing countries they have little opportunity for design since much of the machinery imported is already designed and manufactured. According to Malik a study of Pakastani engineers showed graduates performing the following tasks:

- Feasibility studies for installing new projects;
- Engineering and economic evaluation of designs and specifications of proposals submitted by consultants;
- Manpower planning and training;
- Equipment installation, network planning and industrial coordination;
- Production planning and scheduling;
- Machinery maintenance and replacement, and;
- Management.

Basic engineering design knowledge and training are certainly necessary to effectively carry out some of these tasks. Also, most developing countries should be looking forward to and at the appropriate time, planning for local manufacturing of machinery and equipment. The local manufacturing will, however, be on a smaller scale than in developed countries and present special engineering problems.

Should not the engineering curricula then be formulated to reflect the needs of the country and provide technical training accordingly? Just as the technology from developed countries is not always directly applicable and appropriate for developing countries, neither is the traditional engineering curriculum of developed countries necessarily oriented to the design and manufacturing that is applicable and/or appropriate. There seems little reason, for example, to continue the same traditional training of more engineers in India than will be employed; and at the same time disregard training needs to better carry out many of the tasks in which it has been indicated that Pakistani and other developing country engineers are engaged. A mix of traditionally trained engineers and new more appropriately trained engineers could be adopted depending on the needs and future plans of a country. For Pakistan, Malik (1979) suggested that 20 percent of the engineers be trained with the traditional curriculum. The other 80 percent would take a new curriculum altered by dropping advanced thermodynamics, heat transfer, stress analysis, advanced levels of mechanics of machines, advanced hydraulics and design of electrical machine, and add probability and statistics, work measurement and methods engineering, operations research, computer programming, operations and production management engineering economic analysis and case studies in manpower management and maintenance scheduling. It will be noted that the basic design and analysis courses have been retained and only the advanced courses eliminated. Some might describe this curriculum as industrial engineering. If one needs to put a traditional name on it, that may be the closest.

Curricula evaluation should be an on-going exercise in all countries. There is a broadly held philosophy in developed countries that the more successful engineers will move out of traditional engineering tasks into supervision, management and administration. However, most engineering curricula have not been modified to reflect this movement so that graduate engineers can be better prepared for these future responsibilities. For the most part undergraduate curricula have been focused on training the graduate for his or her first job. If that's all that can be expected of undergraduate curricula, then certainly graduate programs should be focused beyond that first job.

Systems Approach

Along with, or as a partial substitute for the courses suggested by Malik, the systems approach should be more directly integrated into engineering programs both at the undergraduate and graduate level. The systems approach has the capability of inter-relating the diverse parameters of today's world of limited resources, population explosion, and economic crises with the related social and humanistic issues.

The systems approach on systems engineering means different things to different people. Kahne (1980) defines it thus:

Systems engineering is the analysis and design of a collection of objects, phenomena and/or policies for the purpose of integrating and controlling their contribution to an overall goal. Control is the central theme of systems engineering. Computers are often used to implement control strategies. Foundations of control and systems theory are developed and tested. Modeling and simulation techniques are developed for analysing and designing large scale systems. Particular emphasis is placed on the development and effective application of analysis and design principles to technology-oriented and policy-oriented systems problems.

Kahne points out in an ASEE Journal article (1980) that systems modeling is necessary to best utilize the digital computer in providing input on today's diverse societal problems. The computer is readily adaptable for solving differential equations for examination and analysis of physical systems. However, the present-day problems of society have many parameters some of which are difficult to quantify, thus estimates are necessary. An exact solution to an approximation of a problem may be of little value. For example, the solution to an energy resource problem determined in the absence of a global resource allocation policy may well be meaningless.

Macro-models of large scale systems will have significant impact on the future planning and decision making by world leaders. While economists and systems analysts may play the dominant role in macro-modeling, engineers must play a critical role in micro-model development and a verification for technological performance and efficiency at the operational level. Technology-oriented, macro-models are meaningless unless aggregated from realistic and representative sub-or local models.

For a specific example agricultural engineers and agricultural engineering technologists understand and can best measure and determine the performance characteristics of rice production and post-production operations. Seedbeds must be prepared, seeds planted or seedlings transplanted, the growing plants nurtured to maturity and then the rice grain harvested, handled, threshed, dried, transported, stored, milled and marketed. Losses, labor utilization, machine performance efficiencies, and cost and returns must all be accounted for accurately. Only micro models that truly represent the real world at strategic locations – specific sites can be successfully aggregated to broad country, regional or global macro models.

Agricultural Engineering Technology

Material to fill this systems science void has been incorporated into the new Agricultural Engineering Technology (AET) Ph.D. program at Michigan State University. This doctoral level program is proving to be a natural extension of the BS and MS curricula in Agricultural Engineering Technology (some departments call it Agricultural Mechanization or Mechanized Agriculture) offered by many Agricultural Engineering departments in colleges/universities in America. These departments have for years now recognized the need for graduates trained to carry through with the application of mechanical equipment and machines. The graduates carry the engineers' design and manufacturers' product through the phases of feasibility analysis, planning, marketing, management service, maintenance and repair. The first two years of the BS in AET curriculum provides a strong core of courses in elementary economics, business communications, accounting, human relations and managerial principles in lieu of the design and analysis courses in the Agricultural Engineering curricula. The third year AET courses focus on systems and analysis of agricultural production systems, mechanical systems in agriculture, and processing systems for biological products. The fourth year AET courses pertain to the application of technology to agricultural production and its post-production systems.

This particular doctoral program was started at Michigan State in 1972. Since its' creation, two advanced systems science courses have been a unique requirement of this program and additional systems courses are encouraged. A number of the AET Ph.D. candidates chose systems science for their secondary field of endeavor while others select agricultural economics, management, education, or production agriculture.

The growth of the AET Ph.D. program at MSU was quite modest during the first five years. At that time there were eight active candidates pursuing the doctoral degree, only one of which was a foreign student. The program's growth during the last three years has been quite phenomenal. During the fall term 1980 there were 22 active AET Ph.D. candidates of which 10 were foreign students.

There is the continuing concern by some that the doctoral AET program might infringe upon the Agricultural Engineering Ph.D. program. It was envisioned at the time of introduction that the AET

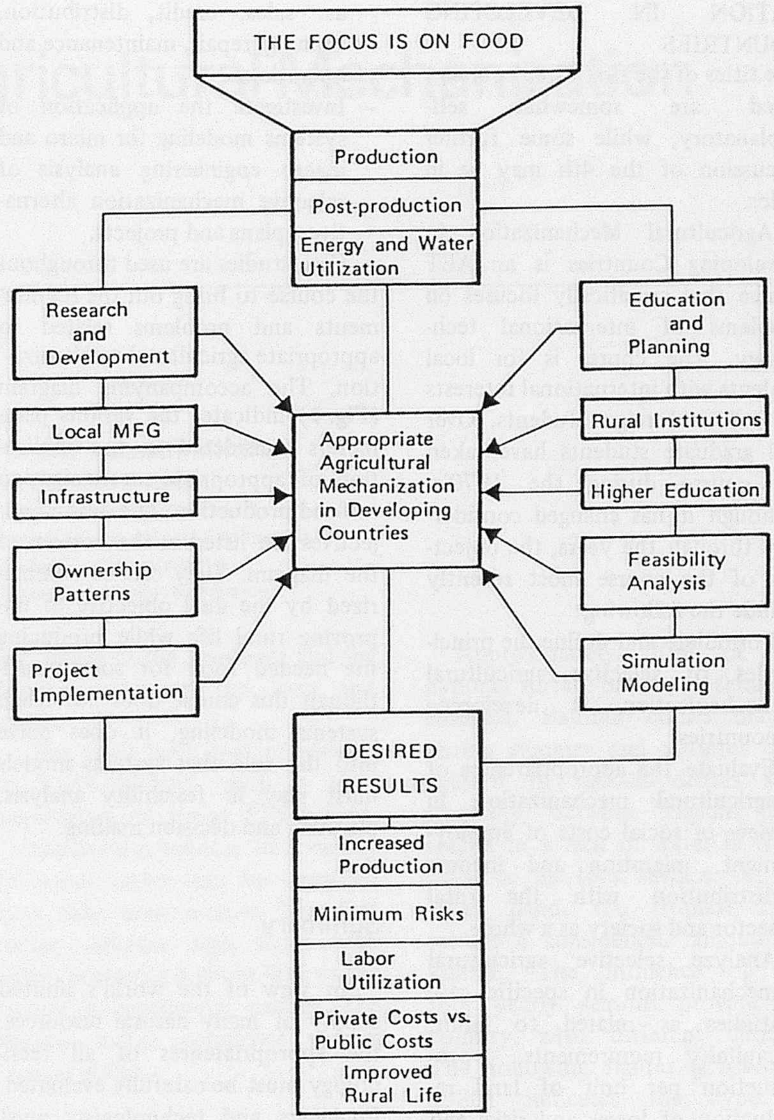

Fig. 1 Agricultural mechanization in developing countries

program would be complimentary to the AE program. It has been observed, however, that more of the AE Ph.D. programs are including some advanced systems science courses. This may be a matter of normal evolution and development rather than because of the AET program.

Foreign students were initially somewhat hesitant to enter the AET Ph.D. program. After five years only one had entered, although by 1980 10 of 22 were from foreign countries. (The MSU AE department maintains its' foreign student enrollment at not more than 50 percent of all graduate students in the department.) Foreign students may be confronted with more rigid job classifications and pressures in their home countries that cause a greater focus towards the traditional, recognized, and more prestigious engineering degrees.

The graduate level courses that have been developed at MSU for the AET Ph.D. degree are:

ANALYSIS OF AGRICULTURAL SYSTEMS
ENVIRONMENT MEASUREMENTS
MAN-MACHINE RELATIONSHIPS
AGRICULTURAL MECHANI-

ZATION IN DEVELOPING COUNTRIES

The titles of the first three courses listed are somewhat self-explanatory, while some further discussion of the 4th may be in order.

Agricultural Mechanization in Developing Countries is an AET course that specifically focuses on problems of international technology. The course is for local students with international interests as well as foreign students. Over 100 graduate students have taken the course during the 1970's. Although it has changed considerably through the years, the objectives of the course most recently include the following:

- Formulate and define the principles of selective agricultural mechanization in developing countries.
- Evaluate the appropriateness of agricultural mechanization in view of social costs of employment, migration and income distribution with the rural sector and society as a whole.
- Analyze selective agricultural mechanization in specific case studies as related to labor, capital requirements, protuction per unit of land reduction of losses and risks and returns to farmers.
- Develop guidelines for the necessary supporting programs for successful mechanization such as: sales, credit, distribution, training, repair, maintenance and operations.
- Investigate the application of systems modeling for micro and macro engineering analysis of selective mechanization alternatives, plans and projects.

Case studies are used throughout the course to bring out the requirements and problems related to appropriate agricultural mechanization. The accompanying diagram (Fig. 1) indicates the various parameters considered in the application of appropriate mechanization to food production. The desired objectives are listed at the bottom of the diagram. They can be summarized by the dual objective of improving rural life while producing the needed food for society. Although this course does not teach systems modeling, it does delve into the role that systems models must play in feasibility analysis, planning and decision making.

Summary

In view of the world's limited supply of many natural resources, the appropriateness of all technology must be carefully evaluated. Engineers and technologists must be trained to participate in this process as they should be best able to understand, develop and manipulate the physical mechanisms to provide the most good for society. Systems analysis and modeling provide a means of determining the relative effect of the numerous parameters in the consideration of alternative technologies.

The AET doctoral program incorporates systems analysis as a central theme. Simulation models, if properly designed and verified to truly represent the real world, provide a means of analyzing the application of technology to food production and post-production operations. The pragmatic test of the success of this educational program can best be based upon where the graduates are and what they have accomplished 10 years after graduation.

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Status of Agricultural Mechanization in Mexico

by
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Abstract

Mexico is one of the fastest developing countries of the world. Its population density is 37.5 persons/km^2 which is low in comparison to other developing countries. This country has abundant natural resources. Although the soil conditions, climate, topography, water and other related factors are not very favourable for agricultural production, the country as a whole has achieved considerable progress in achieving high yield through the implementation of mechanization in agriculture which began in 1918. The present Government has also given great deal of emphasis to mechanization in agriculture, which is very necessary for Mexico.

Introduction

Mexico is situated in the American Continent within the northern hemisphere which borders with the United States of America in the north, the Gulf of Mexico and the Antilles Sea in the east, Guatemala and Belice in the southeast and the Pacific Ocean in the west and south.

The total land area of Mexico is 1 958 201 km^2 with a total population of about 73.5 million.

Mexico is a country of a variety of zones which can be classified into two main sectors. The first sector includes high lands with slopes comprising about 40% of the country's continental surface. The second sector comprises various coastal plains.

Climatic Conditions

The topography, geographic location and vast littoral extension have great influence over the climatic conditions of the country. Its climate divides the country into three main zones; 1) tropical lands with altitudes below 900 m above sea level and an average temperature of 28°C; 2) moderate lands in the mountain ridge and plateau having a range of temperature which vary from 20° to 25°C; and 3) highlands at 2 600 m above the sea level and over.

Approximately 70% of the national surface has dry or semi-dry climates. Rainfall comes mainly during summer and autumn. The amount of rainfall differs substantially between regions and results in a lack of water in four-fifths of the total surface. On the other hand, the tropical areas receive a considerable amount of rainfall. The influence of the four yearly seasons provide the country with different climate. The following figures (CANACO, 1980) indicates the type of climatic conditions prevailing in the country as a whole: tropical rains, 13%; temperate rains, 26%; and dry areas, 41%.

Soil Conditions

Land and water exist in disequilibrium condition in Mexico. There is very crucial water scarcity in the immense plains which are located in the north. As a result, most of these areas are deserts. Fortunately the mountainous areas of the south and southeast have water. Almost 30% of the territory is mountainous with declivities of more than 25° whereas hardly 35% of the territory is flat with declivities below 10° (CANACO, 1980).

The soils of the country belong to the orders of : 1) aridisols; 2) mollisols; 3) ultisols; 4) alfisols; 5) inceptisols; and 6) vertisols. Most soils contain a pH more than neutral which hampers the production of agricultural crops. Moreover, the soils contain a huge amount of pebbles and stones which also impair agricultural production.

Type of Land Ownership and Use

In Mexico agricultural lands are divided into two types of ownerships: 1) private; and 2) ejidal.

Private lands belong to particular persons or private organizations whose ownership rights can be sold or transferred.

Ejidal lands are distributed by the Government to landless persons. They can cultivate these lands and can use all the benefits out of the lands but cannot sell or transfer the right to any other person or organization.

Table 1 shows the percentage distribution of landholdings by the private and ejidal sectors (Barchfield, 1980).

The country's specific climate and soil characteristics reduce the tillable agricultural surface to 23 million ha or 12% of the total area. **Table 2** indicates the soil use comparison structure in percentage (CANACO, 1980).

Population in Mexico is very unevenly distributed. Approximately 27% is concentrated in three urban areas: Monterrey, Guadalajara and the Valley of Mexico. Only 35.1% of total population live in rural areas and this

Table 1 Percentage Distribution of Landholdings

Types of exploited lands	Sectors	
	Private	Ejidal
Total area exploited	50.2	49.8
Total cultivated area	44.9	55.1
Total area irrigated	50.9	49.1

percentage is decreasing due to the industrialization as well as expansion of cities.

As a consequence it is found that the agricultural sector provides only 9.3% of the total gross national income which is very little in comparison to other sectors.

Mechanization of Agriculture

The official interest in mechanization of agriculture was manifested in 1918 by the Government's importation of 112 tractors for distribution to the private farmers at cost price (Alcantara, 1978). Mechanization in agriculture increased gradually until 1930 at which time there were 3875 tractors in the country. During the following 10 years the actual value of the agricultural machinery increased by only 1%.

According to the decision of the President in 1941 a new system was established by which farmers who had 10 ha of land or less and were interested, could obtain one iron plough to replace his obsolete wooden plough at half the price and the Federal Government would pay for the rest.

The credit policy of the government also facilitated the aquisition of imported machines at a lower price at the end of the 1940s and the beginning of the 1950s. The National Bank of Agricultural Credit also gave long-term low interest loans to the private sector. This program promoted the large scale orientation of mechanization of agriculture.

With the advent of the "green

Table 2 Percentages of Soil Use Structure

Types of soil use	Percentage
Tillable lands	12
Prairies and grazing lands	37
Forests	27
Others	24

revolution" the importation of high yield seeds, fertilizers and agricultural machinery was accelerated. However, not until the mid-1950s and early 1960s did the green revolution make a direct impact to the continuation of mechanization of agriculture in the country. Between 1962 and 1969, the number of tractors in the irrigated area increased 40%, combines, 58%; and harvesters, 129%; which indicates the increased interest in purchasing modern agricultural machinery (Alcantara, 1978). In the distribution system, one distributor or agency charged 25% of the price of the machine as commission. As a result, mechanization of agriculture involved a transfer from the base of agriculture to the interest of regional commerce and manufacturing of tractors and implements to compensate the exploitation by the middleman.

Considering this factor the economic policy of the Government restricted the importation of agricultural machines so as to encourage national fabrication or assembling of tractors and implements. After 1966 no tractors with a capacity of less than 62.53 kW (85 HP) was imported. During the following five years about 5 000 tractors within that power range or lower were fabricated annually. The total number of tractors rose to 150 000 by 1977 (CANACO, 1980). In the ensuing years the number has increased and according to the planning of the Government in 1981 the total number is proposed to reach 219 020 units (Reig, 1975).

Irrigation and Yield

Two principal types of Mexican farmers may be identified: 1) those having small area of non-irrigated lands (both private and ejidal); and 2) those having large areas of irrigated lands.

The cultivators belonging to the first category do not have sufficient capital to buy agricultural machinery, fertilizers, no favourable scope to use water and modern technology and, consequently, most of them use traditional farming practices and, in turn, get low yields.

On the other hand, farmers belonging to second category have capital, water, fertilizers, modern technology and other related necessary materials, hence obtain higher yield. Even then the yield is different for different zones depending the conditions of soils, slope, rainfall, and temperature.

The total area so far irrigated by power-pump and gravitational forces comprise 3 504 000 ha (CANACO, 1980).

Table 3 Average Yield of Principal Crops, 1976

Crop	Average yield, ton/ha
Maize	1.1
Wheat	1.0
Paddy	2.7
Sorghum	3.3
Oats	0.7
Barley	1.5

Table 3 shows the average yield of principal crops (Barkin and Suarez, 1980).

Figs. 1 to 4 represent traditional system of cultivation with primitive tools and animals in non-irrigated lands. **Figs.** 5 to 9 represent the

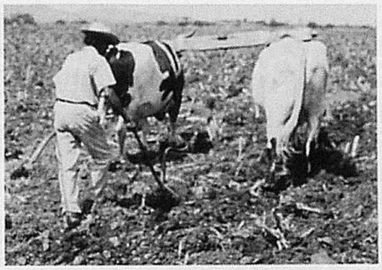

Fig. 1 Ploughing with animal draft

Fig. 2 Levelling by an wooden bar with animal draft

Fig. 3 Manual harvesting of peas

Fig. 4 Manual threshing of peas

Fig. 5 Ploughing with a tractor

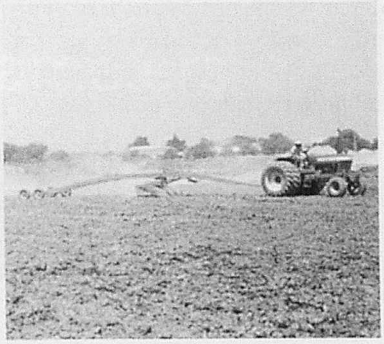

Fig. 6 Levelling of soil by tractor with grader

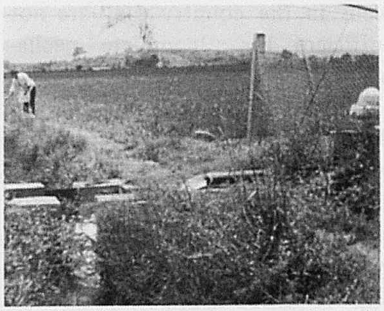

Fig. 7 Deep tube well to supply water for irrigation

Fig. 8 Distribution of water in the field

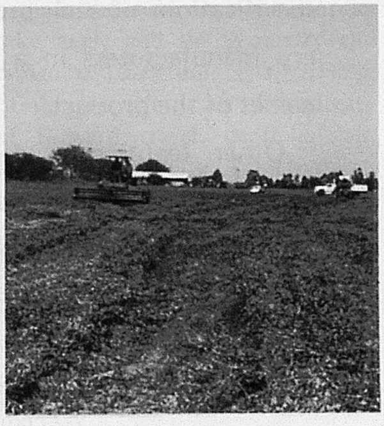

Fig. 9 Harvesting of peas with a harvestor

present mechanized system of cultivation with different types of agricultural tractors, implements and harvesters in irrigated lands.

Conclusions

Although there are presently hundreds of thousands of tractors, implements, seeders, harvesters, combines and other agricultural machines, power-pumps, deep tube wells in the country they are not sufficient for a complete mechanization of agriculture.

The majority of the farmers do not have their own tractors and other agricultural machinery so as to cultivate their lands properly and in time to meet agro-technological requirements which is one of the main factors for attaining high yield.

Compounding the problems of mechanization is the lack of agricultural engineers specialized in mechanization.

There exist economic, social, scientific and technological problems which sometimes act as barriers to the progress of mechanization of agriculture.

There is, therefore, need to conduct vast investigations in these fields.

Even though there are many problems, including proper planning, Mexico is in a much more advanced position than many countries with respect to the mechanization of agriculture.

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Influence of Soil-Tool Parameters on Unit Draft

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Abstract

Puddling of rice fields is an important operation before transplanting. Its importance has greatly been increased due to the cultivation of high yielding varieties which require a good degree of puddling and timely transplanting. There are mainly two types of puddlers used in India namely; bullock-driven and power-driven. The bullock-driven puddlers include traditional country plough, mould board plough and other rotary puddlers. The power-driven puddlers include plough, harrow, cultivator, and rotary tiller in combination with cage wheels. In the present study soil-tool parameters have been studied in order to obtain technical information which may help in designing a puddler for low unit draft and better puddling operation.

Introduction

There are different types of bullock drawn puddlers available in India. The unit draft requirement of each of these puddlers is high and hence the efficiency of the animal-machine system is quite low. In the absence of technical data on puddled soil, it can be fairly concluded that much effort has not been put to designing a puddler for lower unit draft and efficient puddling.

In this context an effort has been made to study the various soil-tool parameters simulating the actual field conditions in the laboratory. A soil-engaging tool with adjustments to vary the parameters and rotating about a horizontal axis has been used for the experiment.

Theoretical Considerations

The analysis of forces acting on tillage tools is a complicated problem because of the unpredicability and complexity of the nature of soil-tool system and wide fluctuations in operating conditions. However, these factors can be effectively correlated for minimum energy consumption resulting in maximum efficiency. The puddling index of the soil is a measure of the effectiveness of puddling and, in turn, the measure of efficiency of a puddler. The lower unit draft at different operating conditions should be the important criterion of efficiency in designing a puddler.

The variables that come into consideration in designing a puddler can be broadly grouped into i) soil variables, ii) tool variables; and iii) variables due to operating conditions. The soil veriables include the velocity of propagation of compression and shear waves, co-efficient of soil-tool friction and adhesive forces. The velocity of propagation of compression and shear waves depends on the moisture content, nature and texture of the soil. The tool variables include the nose angle, tool angle, rake angle and the geometry and design of the tool. The variables of the last group are the velocity of forward travel, depth of cut and angular velocity of the tool.

The variables considered for the present study are i) tool angle; ii) nose angle; and iii) depth of cut.

Experimental Set-Up

An experimental set-up, including the soil bin, was designed for

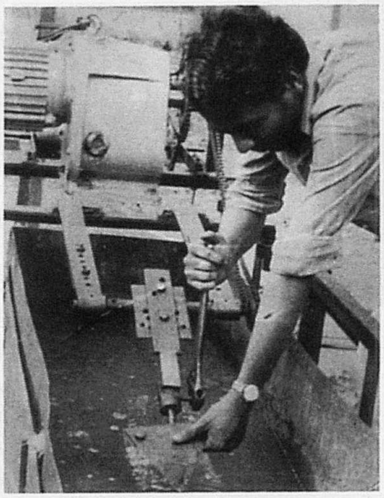

Fig. 1 Adjustment of the triangular tool on the experimental set-up

the purpose. The soil bin was made of mild steel sheet with rails rigidly fixed over the bin for movement of the tool carrier. The rotational and translatory motion of the tool were obtained from a three-phase, 2-hp electric motor with gear reductions running at 25 rpm. The operating speed of the tool was maintained at 1.5 km/h.

A triangular tool was selected for the present study. The nose angles were changed from 35° to 75° at an interval of 5° and the tool angles were varied from 0° to 80° at an interval of 10°. The tool was operated at 4 cm of standing water and the respective draft forces were measured by a spring dynamometer.

Results and Discussion

The effect of the nose angle on the unit draft at different operating depths and for sandy loam and clay soils are shown in Fig. 2. The unit draft decreases as the nose angle increases and this continues up to 60° nose angle. Beyond 60°, the unit draft increases with increase in nose angle. This holds true for both types of soil.

The unit draft is least at 60° nose angle which is twice the shear failure angle of the soil. The shear failure path changes to the path other than the least force path as the nose angle increases beyond 60° and thereby increases the unit draft. increases the unit draft.

The effect of tool angle on unit draft at different nose angles, depth of operation and type of soil are shown in Figs. 3, 4 and 5. The unit draft decreases, attains minimum value at 30°, and increases with an increase in the tool angle beyond 30° up to 80°. It is also shown that the unit draft decreases for higher depth of operation for a given nose and tool angle for both sandy loam and clay soils.

The minimum unit draft at 30° tool angle and 55°, 60°, and 65° nose angle are 0.36 kg/cm^2, 0.15 kg/cm^2 and 0.35 kg/cm^2 in sandy loam soil, respectively. The unit drafts at 30° tool angle and

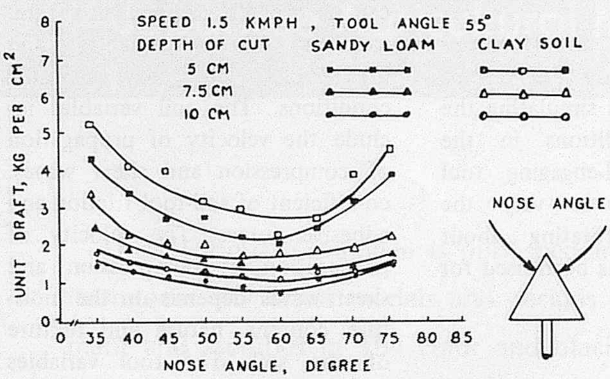

Fig. 2 Relationship between nose angle and unit draft

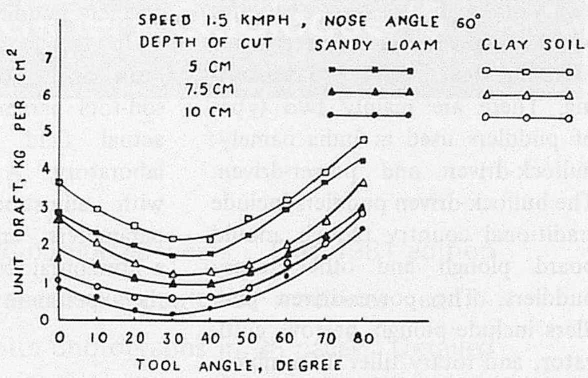

Fig. 4 Effect of tool angle on unit draft

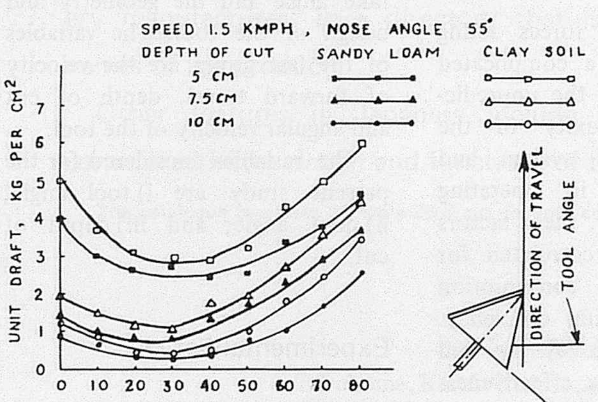

Fig.3 Effect of tool angle on unit draft

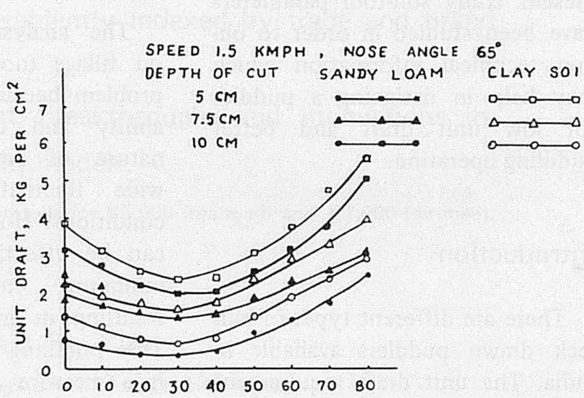

Fig. 5 Effect of tool angle on unit draft

55°, 60° and 65° nose angle are 0.47 kg/cm^2, 0.19 kg/cm^2 and 0.55 kg/cm^2, respectively, in clay soil. The minimum unit draft for both types of soils are at 10 cm operating depth. The unit draft of the triangular tool for a given tool and operating parameters indicates a higher value in clay soil than that in sandy loam.

The decrease in unit draft at higher depth of operation may be due to the fact that the rate of increase in contact area of the triangular tool is greater than the rate of increase in draft. The total draft shows an increasing trend with the increase in the depth of operation.

Conclusion

It is concluded from the above study that the unit draft of a triangular tool:

a) Is minimum at 60° nose angle and 30° tool angle;

b) Decreases with increases in operating depth;

c) Indicates a reduction in value when the depth of operation is increased from 5 to 10 cm in both sandy loam and clay soils; and

d) Is higher for clay soils than that of sandy loam soils.

Suggestions

The unit draft in relation to different forward and rotational speeds of the tool in different types of soils, and stress distribution over the tool surface are some of the aspects to be studied as a continuation of the present study in order to obtain sufficient information for design of a puddler.

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Economic Efficiency of Tractors on Punjab Farms

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Introduction

Compulsions of current agricultural situation and requirements are such that there cannot be a straight answer to the question on whether India should go ahead with mechanization of its agriculture. We want our agriculture to be labour-intensive and, hence, labour-saving devices should be avoided/discouraged. While we have abundant labour to be provided with employment, labour shortage is felt at the time of certain farm operations, particularly at the time of harvest when any delay might be damaging to the crop through insects, grain shedding or rain. The policy of the Government is to encourage small farmers and the intensive agriculture and hence equipment which places premium on large farms and extensive cultivation should be discouraged. At the same time, the policy-makers want higher productivity per unit of land and labour employed in agriculture and, hence, encourage those equipments which help in saving land and increasing labour productivity without displacing it. It is also desired by the planners to save bullock labour to the extent possible because bullocks are a drag on the economy and they compete with man for land in raising fodder for their feed.

Thus, while there is need and justification for the mechanization of Indian agriculture, we cannot afford to encourage it indiscriminately. A choice based on immediate implication and long-term perspective has to be made which also means that the choice may differ from region to region and/or from one farm size to another, depending on compulsions of economic conditions. A large number of studies exist to show whether it is economical to have mechanization [3,4,9,12,14]. But, very few studies have been undertaken to find out the changes in efficiency due to the mechanization of farm operations. Practically there is no study so far which might shed light on whether the tractor is used optimally or whether it is used more than or less than its economic requirement. In other words, literature is silent on whether the tractor is surplus on farms. Such a study would, it is hoped, shed light for the policy makers to make a rational choice between tractorized and non-tractorized farming technology.

The present study was undertaken with the following objectives in view:

1. What are the sources of inefficiency and what is their relative contribution to the aggregate economic inefficiency when the farmers adopted only bullock-operated (non-tractor) farm technology. Call this Situation I.
2. How has the efficiency changed when tractor-technology was introduced along with bullock operations. Call this Situation II.
3. How many tractor hours are needed by different farm sizes in order to attain an optimum level of revenue.

Methodology and Locale

The present inquiry is based on data taken from the 'Cost of Cultivation" project being conducted by the Punjab Agricultural University, Ludhiana. The data taken for this study pertains to the year 1976-77. Based on the soil-climate-crop complex, the Punjab state was divided into three distinct types of farming zones. A three-stage stratified random sampling design was adopted with *tehsil* (village) within each zone as the first unit, a cluster of three villages within each *tehsil* as the second unit and the holdings within each cluster of villages as the third unit of sampling. Out of these zones, Zone- I (Wheat-Paddy- Maize area)*[1] was selected, again, purposively, because the scope of the present inquiry

*1.This zone covered 41.85% of the total area of the State, where wheat in *rabi* and paddy and maize in *Kharif* occupied 38.30 and 10.85% of the total cropped area, respectively, during the year 1974-75.

did not allow us to consider all the zones.

The operational holdings of all the sample farmers were pooled and arranged in ascending order of size of cultivated area. The farms were divided into three categories.*2

1. Small. . . .Below 2.60 ha
2. Medium. .2.61 to 7.60 ha
3. Large . . .Above 7.61 ha

The average farm size was 1.35, 5.26, and 7.78 ha, respectively, under small, medium and large farm categories. The division of farmers into different size groups was done because the nature of farming decisions of these groups differ substantially from one another in terms of types of technology used, nature of cropping patterns followed, and various binding constraints. Representative farm approach was used based on averaging all the farm situations under a given farm size, with the assumption that the farms of given size have similar technological and economic characteristics and problems.

The Model – The following hypotheses about farm decision-making will have to be kept in perspective in developing the model, especially when studying the farms of the developing economies.

1. Farmers first determine subsistence needs.

2. Farmers try to achieve a crop mix and crop rotation which try to balance full utilization of resources, with a desire to maximize production and revenue.

3. Farmers attempt to distribute marketing risks by choosing a 'portfolio' of crops. Changes in the portfolio are limited by rules-of-thumb or flexibility constraints.

4. Farmers' decisions are based on short-run horizons and they limit new activities in any one year to reduce risks of investing too much on the basis of short-run information.

5. Within the constraints outlined above, the farmers allocate their remaining resources so as to maximize anticipated net cash returns from farming.

The linear programming approach was adopted to multi-output and multi-technologies problem, which a farmer is facing.

The general form of the model is:

$$\text{Maximize } CX$$

$$\text{Subject to } AX \leqslant B,\ X \geqslant 0$$

where,

C = Vector of net income per hectare from activities followed on the farm,

X = Vector of levels of activities,

A = Input-output coefficients matrix, and

B = Input availability vector.

The following steps were involved in understanding the behaviour of the farmers under both Situation I and Situation II conditions separately.

Step I – Activity analysis was carried out taking into account the availability of the farm resources such as fertilizers, labour, machine(tractor) hours, etc. That is, it was assumed that the farmer has access to only those physical resources which were reported in farm accounts for a given year. This represented 0_2 situation of the model, that is, when both resources and preferences (upper or lower bound on acreage) are constrained.

Step II – Activity analysis was re-run by removing the preferences constraints and keeping resources restrictions. This gave 0_3 situation of the model.

Step III – The activity analysis was again run by removing all the restrictions. That is, under the situation the farm was allowed to hire, purchase or transfer one activity for another. This represented 0_4 situation of the model.

For the purpose of measuring economic efficiency, let us define the following quantities:

0_1 = Actual net income which the farmers received from their business during the year.

0_2 = Net income (value of the objective function) when both resources and preferences (upper and lower bounds on acreage) are constrained.

0_3 = Net income when there are resource restrictions but preferences are not restricted.

0_4 = Net income when there are neither resources nor preference restrictions.

The existing level of economic efficiency is $E = 0_1/0_4$, which lies between 0 and 1, i.e.; $0 \leqslant E \leqslant 1$.

Let us designate the quantity $0_4 - 0_1$ as the aggregate economic inefficiency. This is a result of various factors at work. We can attempt to reduce the aggregate inefficiency into components in the following manner:

$0_4 - 0_1 = (0_4 - 0_3) + (0_3 - 0_2) + (0_2 - 0_1)$, and observe that

$0_4 - 0_3$ = loss of net income due to resource constraints (system inefficiency);

$0_3 - 0_2$ = loss of net income due to preference constraints (risk aversion),

$0_2 - 0_1$ = loss of net income due to erroneous expectations about returns and/ or unexpected changes in the market (individual inertia)*3.

The available literature is full of arguments for and against the profitability of tractor farming [2,3,4, 5,8], with the ultimate support for

*2. For details on Methodology see Mehta (1978).

*3. The *ex ante* income may not have been realized because the farmer is unable to forecast accurately the likely constraint and net returns, the reduction in the *ex post* income from the expected levels may also be due to the unexpected changes in the market. That is, the farmer may not be able to realize his *ex ante* net income because of market conditions. But, we have termed this inefficiency as individual inefficiency. Accurate information gathering or lack of it is attributed to the individual.

Table 1 Basic Tableau for Modified Simplex Method

	C_j	C_1 C_2 . . . . C_n	C_{n+1} . . . . C_j	
Resource Constraint	Rsource Availability	Real Activities	Disposal Activities	R
	B	P_1 P_2 . . . . P_n	P_{n+1} . . . . . P_j	
Land				
Rabi	$\geqslant$			
Kharif	$\geqslant$			
Labour				
L-1	$\geqslant$			
L-2	$\geqslant$			
L-3	$\geqslant$			
Fertilizer				
N	$\geqslant$			
P	$\geqslant$			
K	$\geqslant$			
Tractor				
T-1	O =			
T-2	O =			
T-3	O =			
Working Capital				
Rabi	$\geqslant$			
Kharif	$\geqslant$			
$Z_j - C_j$				
M				

Note: 1) For i=1, 2, . ., n, Pi are real activities being followed by the farmers, and for i=n+1 , . . . , j, P_i are disposal activities
2) C_1 , . . . , C_n are the prices which the farmers expect for P_i real activities, and C_{n+1}, . . . , C_j are the prices attached to disposal activities.

the adoption of technology. Almost all the studies have shown that it is profitable for the medium and large farms to adopt tractors; also, as the volume of business is below the break-even point, the small farms were not encouraged to adopt this technology. Data taken from the evaluation study of the H Y V Programme carried out by the Programme Evaluation Organization, during 1968-69, revealed that farmers operating below 5 acres (2 ha) did not have any tractor, in the package as well as in the non- package study area of Punjab. The literature is not complete, however, from the point that it does not show what minimum hours of this machine (tractor) are required for attaining the optimum revenue. The present inquiry tried to study the tractor hours needed to achieve optimum revenue under other given constraints, that is, under 0_1, 0_2, 0_3 and 0_4 constraint situations. For this, the modified simplex method as illustrated by Heavy and Candler (1973) was adopted.

The data are shown in **Table 1**. Under column B, the zero in the tractor- row merely recorded that the first plan considered was the limiting case where the farmer has zero tractor-hour availability. Here, it is necessary to define a new criterion row designed as M. The elements of the M- row are obtained by dividing the individual negative coefficients in the Z–C row by the appropriate a_{ij} for tractor hours. The coefficients in the M row are computed only for activities with negative figures in the Z–C row, since only these activities will increase income.

Dividing Z–C row by the tractor hour coefficient transforms the marginal revenue quantities (Z–C) from a per unit of activity to per tractor hour basis. That is M, the new decision row, indicates the marginal revenue per tractor hour for each activity. The activity with the highest marginal revenue per tractor hour is indicated by the activity with the most negative figure in the M row. It should be clear that the M row is used only to select the outgoing column and has to be recomputed in each new tableau from the Z–C and tractor hour rows. This means that the M row should not be carried down from initial tableau to intermediate tableau. Once we select the outgoing column, the input coefficients and Z–C row of the next tableau are computed in the usual way.

Similarly, a ratio column (R) is computed for all rows, except tractor hour row, i.e., this row is never selected to be the outgoing row. The result is that in the succeeding interactions the 'availability' of tractor hours becomes successively more negative. This negative quantity may be interpreted as: If the original supply of tractor hours had been equal to the absolute value, then the plan being considered would be feasible. For example, for medium farms under Situation II, the tractor hour supply was 731.69; 1 012.75; 1 374.34 and 1 968.46 under 0_1, 0_2, 0_3 and 0_4 respectively, in the final tableau showing that the plans would just exactly consume the above given tractor hours service to give optimum cropping plan. **Table 2** summarizes the programmed tractor hours for all the farm sizes under all constrained conditions of Situation II.

It is shown in **Table 2**, that the optimum tractor hours needed per hectare are greater on large farm sizes, except under 0_3 situation. It can be concluded that as the restrictions are removed within one farm size, that is, moving from 0_1 to 0_4, the utilization of tractor hours goes on increasing. This shows that the most efficient use of tractor (and for that matter any other piece of machinery)*4 is made only when the owner of tractor is free on all internal and external (system) restriction. It was assumed that the tractor was available for 20 days (a day of 8 h) in a month during lean periods and 20 days (of 12 h) a month during peak period. The availability of

*4.This point is emphasized here only on the basis of empirical evidence gathered in the study area.

Table 2 Optimum Tractor Hours Required For Attaining Rational Cropping Pattern For Optimum Revenue, by Farm Size, Situation II.

Item	Small	Medium	Large
0_1	–	731.69 (139.10)	1 163.92 (148.27)
0_2	–	1 012.75 (192.54)	1 717.74 (218.82)
0_3	–	1 374.34 (261.28)	2 016.92 (256.93)
0_4	–	1 968.46 (374.23)	2 948.46 (375.60)
Average farm size	1.35 ha	5.26 ha	7.85 ha

Note: Figures in parentheses show tractor hours required per ha.

tractor hours, thus, was 1 950 h for a year. This means that 0_3 and 0_4 situations under large and only 0_4 situation under medium farm sizes were most efficient. All other situations did not allow the tractor operation as economic venture. This is why the tractor owners undertake contract work on those farms where there are no tractors*5. Also, they undertake transporting jobs as well. Another technique of utilizing the tractor economically is using it as stationary farm power for lifting underground irrigation water and threshing operations, etc.

For quantifying the surplus use of tractor, a second degree equation was adopted to study the relationship between the size of holding and tractor hours required per unit of land. The general form of the equation is

$$X = a + bY + cY^2$$

where X is the number of tractor hours per hectare and Y is the average size of farm (in hectares). The coefficients worked out for the sample are given in the following regression equation:

$$(1)\quad X = 288.5278 - \underset{(0.1109)}{0.2260}\,Y + \underset{(0.0043)}{0.0082}\,Y^2$$

(Figures in parentheses are standard errors).

$R^{-2} = 0.8538$

The coefficient of multiple determination R^{-2}, was quite high and significant at 5% level. This shows that the farm size accounted for 85.38% of the total variation in the number of tractor hours required per hactare.

*5. It was observed that only those tractor owners who are unable to use tractors economically and efficiently on their farms are undertaking off-farm tractor jobs.

The estimation of the gross surplus is based on the fact that at a certain point, as the farm size is increased, the number of tractor hours used per unit of area stops decreasing and begins rising thereafter. Thus, by equating dX/dY with zero, the optimum farm size (Y*) has been found out at that point. Corresponding to this Y*, the optimum tractor hours requirement per hectare (X*) has been calculated. The number of tractor hours used which exceeded the optimum is termed as the surplus.

$dX/dY = -0.2260 + 0.0164\,Y = 0$

$Y^* = 13.7805$ ha

Putting this value of Y* in (1), we get

$X^* = 286.9706$ tractor hours.

In terms of integral calculus this surplus could be expressed as:

The proportion of surplus

$$= \frac{\int_m^n f(Y)dY - X^*(Y^* - m)}{\int_m^n f(Y)\,dY}$$

$$= \frac{\int_m^n (a + bY + cY^2)dY - X^*(Y^* - m)}{\int_m^n (a + bY + cY^2)dY}$$

Where m is the smallest farm size holding, which was 0.53 hectare, and n was the optimum farm size (=Y*), in the present study.

The area (between m and n) of the curve, thus, turned out to be 3 811.3925; and proportion of surplus tractor hours was 0.0023.

Under optimum farm size and optimum tractor use, the proportion of surplus is 0.23% which is negligible. But, under a situation obtained under normal circumstances, it was determined if the use of tractor was optimum or not.

For purposes of this paper, the weighted average of the proportion of surplus tractor hours was calculated by multiplying the surplus tractor hours per hectare in each size group with the total area under each group, summing them up and dividing by the total tractor hours actually used.

I. Minimum tractor hours required = (Total cropped area on all holdings) x (optimum number of tractor hours per hectare)

A) Minimum requirement on all farms = 958.69 x 286.9706 = 275 115.84 hr

B) Minimum requirement on medium farms = 657.86 x 286.9706 = 188 786.48 hr

C) Minimum requirement on large farms = 300.83 x 286.9706 = 86 329.36 hr

II. Tractor hours actually employed by

A′) All farms = 327 661.68 hr

B′) medium farms = 221 572.23 hr

C′) large farms = 106 089.45 hr

III. Surplus tractor-use = Actual tractor hours used (–) Minimum requirement.

A″) On all farms = 52 546.84 hr

B″) On medium farms = 32 785.75 hr

C″) On large farms = 19 760.09 hr

IV. Proportion of Surplus = Surplus hours/Actual hours

A‴) On all farms = 0.160369

B‴) On medium farms = 0.147969

C‴) On large farms = 0.186259

This means that 16.04, 14.80 and 18.63% of the total tractor hours employed in crop production is surplus on all farms, medium and large holding groups, respectively, under existing technological adoption.

Conclusion

The proportion of surplus gradually increased with an increase in the farm size. The small farmers were not keeping any tractor on their farms because it was not economical. Even at existing levels of constraints the tractor operations are not economical on medium and large sizes under Situation I; whereas, under Situation II, the tractors might be economical under situations of 'no preference restriction' to 'no restriction'. The number of tractors was increasing in the study area even when it is not economical because of the opportunities on off-farm tractor employment, e.g., transportation of farm produce from village to market, ploughing fields of other farmers, threshing, etc. Another reason may also be the economic ignorance and false social image building habit of the farmers. Possession of tractors is considered to be a status symbol among the rural community of the study area.

Table 3 shows that the total economic inefficiency increases with an increase in farm size under Situation I and Situation II from 69.59 to 82.58 and 75.13 to 83.21%, respectively. Although the economic inefficiency increased less (8.08%) in the case of the large holdings as compared to the medium holdings (in which case it increased by 13.99 percentage points), the magnitude is more for large holdings.

Table 3 also shows that, in general, the "System Inefficiency" was much higher under large holdings under both Situations than under medium holdings. When technological shift was affected the system inefficiency increased by 27.15 percentage points in medium farms and 1.40 percentage points in large holdings. Thus, the medium farms are unable to cope with the restrictions imposed by system. But, the risk inefficiency and individual inertia has decreased to a large extent on medium farms. This shows that if the 'system' is improved the plight of medium farms could be improved to a greater extent.

The implication of this inquiry might be summarized as: The political decision of advocating the smaller farm sizes is judicious and most rational from a longer perspective. If India is to turn its agriculture to modern one for increasing production and productivity, the planners should stick to the policy, which will in turn discourage tractor owning tendency (because of its uneconomic employment) but may encourage tractor hiring which will be advantageous to both parties: the owner and the user.

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(Continued on page 36)

Table 3 Computation of Measures of Economic Inefficiency, Small, Medium and Large Synthetic Situations, Punjab 1976-77

Net Income	Small (1) Situation I	Small (2) Situation II	Small (3) (2) – (1)	Medium (4) Situation I	Medium (5) Situation II	Medium (6) (5) – (4)	Large (7) Situation I	Large (8) Situation II	Large (9) (8) – (7)
0_1	3 590.80	–	–	9 298.75	14 564.08	5 265.33	9 695.88	10 145.68	449.80
0_2	4 058.44	–	–	11 211.98	15 231.21	4 019.23	10 545.87	10 945.87	400.00
0_3	4 942.45	–	–	19 269.20	16 307.51	2 961.69	13 083.46	13 363.93	280.47
0_4	23 065.62	–	–	30 587.62	45 488.18	14 900.56	55 651.13	60 432.76	4 781.63

Inefficiency Measures	Small Situation I A*	Small Situation I B*	Small Situation II A	Small Situation II A	Medium Situation I A	Medium Situation I B	Medium Situation II A	Medium Situation II B	Large Situation I A	Large Situation I B	Large Situation II A	Large Situation II B
0_4-0_3	18 123.17	78.57	–	–	11 318.42	37.00	29 180.67	64.15	42 567.67	76.49	47 068.83	77.89
0_3-0_2	884.07	3.83	–	–	8 057.22	26.34	1 076.30	6.60	2 437.59	4.38	2 418.06	4.00
0_2-0_1	107.64	0.47	–	–	1 913.23	6.25	667.13	4.38	949.99	1.71	800.19	1.32
0_4-0_1	19 114.82	82.87	–	–	21 268.87	69.59	10 941.99	75.13	45 955.25	82.58	50 287.08	83.21

Remark: *A=Loss in Net Income, **B=Loss in Net Income as percentage of 0_4.

Effect of Lug Angle of Cage Wheels on Tractive Performance of Dual Wheels under Submerged Soil Conditions

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Abstract

The field performance of cage wheels fitted in conjunction with the rear pneumatic wheels of a tractor was studied under submerged field soil conditions. These cage wheels had lug angles of 0, 22, 27, 33 and 42 degrees. Cage wheels with zero degree lug angle gave maximum tractive efficiency of 33.4% and lowest range of slip variation from 30.2 to 37.2% at different stages of drawbar loading. The wheel sinkage was minimum for cage wheels with lug angles in the range of 22 to 27 degrees.

Introduction

Agricultural tractors are normally operated under difficult soil conditions, especially in rice fields. The efficiency of field operations is limited due to very adverse traction performance of pneumatic wheels under wet soil conditions. This, in fact, has necessitated the development of various types of traction aids such as strakes, girdles, half tracks, chains and cage wheels which can increase the tractive performance of pneumatic wheels to a certain extent. Different types of cage wheel designs have been evolved by manufacturers claiming superiority of their design over the others. Almost all of these designs are built on a cut and try method and their better design may reduce slippage and sinkage of wheels when operated under submerged soil conditions.

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Objective

This study was undertaken to measure the effect of lug angle of cage wheels, when used as dual wheels in conjuction with the pneumatic wheels of a tractor, for their optimum performance under submerged field soil conditions. The performance of the wheels was studied by evaluating the wheel slippage, wheel sinkage, rolling resistance, power requirement and tractive efficiency.

Review of Literature

Most of the earlier research investigations on traction have been done to improve the tractive performance of pneumatic tires in deformable soils other than saturated and submerged soils. Studies have also been conducted on a limited scale to evaluate the performance of rigid lugged traction wheels under wet soil conditions in laboratory soil bins and soil vehicle mechanics has been developed to predict the vehicle performance in field soils (2, 3, 8, 10).

The International Rice Research Institute, Philippines[12] reported several multiple regression equations on traction studies for pneumatic tires with cage wheels mounted on front or rear wheels of tractor in tandem position showing that self-propelled axle torque (rolling resistance), maximum (full slip) axle torque, maximum net tractive effort (measured) and maximum tractive effort (computed) were increased with axle load or weight and that weight may be important in obtaining traction in flooded soil. This contradicts with the earlier beliefs that in flooded soils with deep mud, adding weight to the tractor would not increase net traction. It was further reported that self-propelled axle torque and maximum axle torque were inversely related to the cone index and the net tractive effort increased with the cone index. At low cone index, greater sinkage was encountered resulting in increased compaction and bull-dozing resistance.

Pandey and Ojha[7] studied the effect of lug angle on tractive performance of rigid wheels in puddled soils by choosing three steel wheels of power tiller having 685 mm diameter and 152 mm rim width. The lug angles were varied between 15 and 30 degrees. They compared the performance of the wheels on the basis of curves between pull and slip, slip and coefficient of traction, pull and tractive efficiency, and reported that tractive performance of the wheels with 20 degree lug angle was better than the other two wheels. The better performance was reported to be due to optimum soil contact area of wheels with 20 degree lug angle resulting in reduced rolling resistance and increased tractive effort.

Gee Clough and Chancellor[5] conducted studies on pull and lift characteristics of single lugs on rigid wheels in flooded soils and reported that as the lug angle was increased from 15 to 35 degrees the lug surface became more nearly parallel to the soil surface at the entry and thus both lift and pull per unit contact area of the lug were increased.

Bangali Baboo[1] studied the effect of lug angle on the cage wheel performance by taking a conventional diesel tractor as test tractor and mounting the cage wheels on its rear wheels. Drawbar loads were applied by pulling another tractor behind the test tractor. He reported that cage wheels with zero degree lug angle showed the best performance in respect of drawbar load, wheel slippage and wheel sinkage. This, however, contradicts with the results of earlier studies on some similar work done by other workers. Therefore, it was felt necessary to conduct the experiments under more controlled conditions and to study in detail the effect of lug angle of cage wheels on traction performance of dual wheels in submerged soils.

Materials and Methods

The experimental set-up and instrumentation devised for the studies on cage wheels consisted of the following:

a) Ten rectangular outdoor soil bins;

b) A set of five pairs of cage wheels with varying lug angle;

c) One electric tractor as test tractor;

d) Ten variable loading drum dynamometers with wire rope and hook;

e) One proving ring drawbar dynamometer;

f) Cone penetrometer;

g) Soil core sampler with rammer; and

h) Steel scales with flat base plate to measure wheel sinkage.

Details of the set-up are as follows:

Outdoor Soil Bin – Ten rectangular soil bins each of 60 m x 3 m size, were prepared in a selected field. Each soil bin was divided into three test plots measuring 10 m x 3 m and leaving 15 m length on the head side for bringing the tractor to uniform speed at load. A distance of 5 m was left between the test plots. The field had silty clay loam soil with 36.6% sand, 43.6% silt and 19.8% clay. A field slope of 0.1% was maintained in each soil bin to facilitate proper flooding and drainage of water simultaneously. The layout of the experimental plots is shown in Fig. 1.

Cage Wheels – Five pairs of cage wheels with lug angles of 0, 22, 27, 33 and 42 degrees (Fig. 2) were fabricated from mild steel angle iron (40 x 40 x 5.0 mm). The diameter of each wheel was 1 070 mm. Each wheel had 12 lugs of 50 mm height which were equally spaced over the wheel periphery. The construction details of a cage wheel with 22 degree lug angle is shown in Fig. 3.

Test Tractor – An electric-motor-driven tractor was used as the test tractor in the experiment. This tractor was developed by replacing the engine and its accessories from an Escort-37 tractor with a 15 hp induction motor. It facilitated measuring of the energy input to the drive wheels directly with the help of an energy meter. The power to the motor was supplied through a 4-core cable which was carried with the help of steel rings along a G.I. wire drawn in between two I-section mild steel poles.

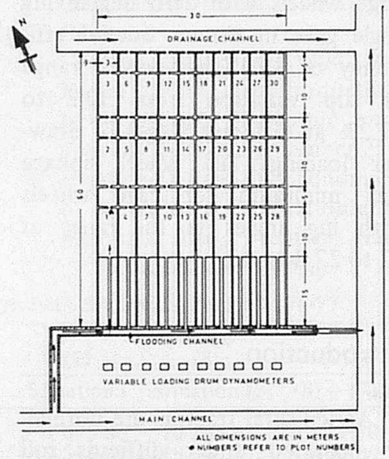

Fig. 1 Layout of the experimental plots

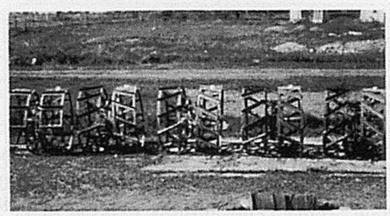

Fig. 2 Five pairs of cage wheels with 0, 22, 27, 33 nd 42 degree lug angles

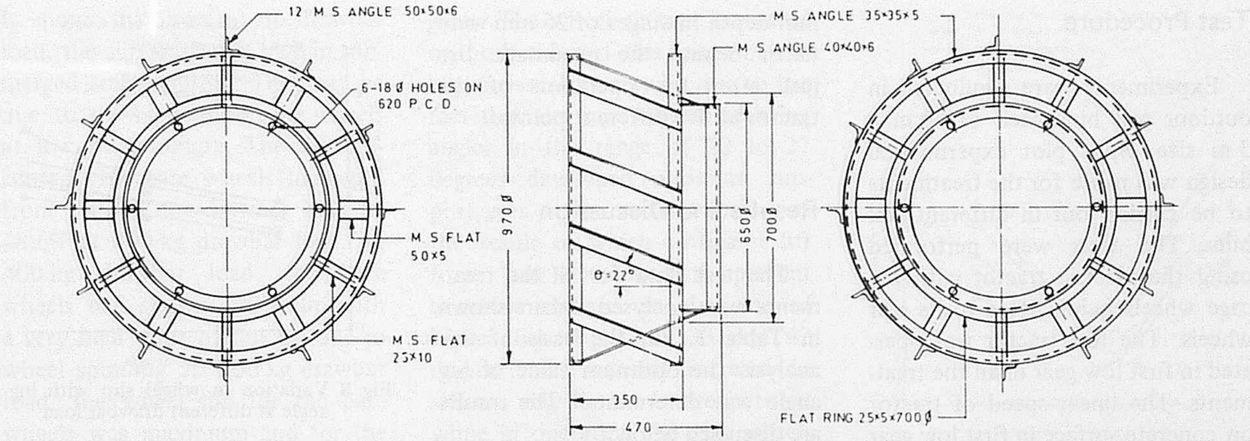

Fig. 3 Cage wheel with 22° lug angle, unit: mm

The tractor body was insulated with wood having two coatings of insulating paint. The test tractor with the cage wheels fitted to its rear wheels is shown in Fig. 4.

Variable Loading Drum Dynamometer – Ten variable loading drum dynamometers were fabricated and were installed at one end of each soil bin. Two control panels: one above and one below the rotating drum, regulated the load to be imposed on the drawbar of the test tractor. A wire rope of 50 m long was wrapped over the loading drum. One end of the wire rope was connected to the proving ring drawbar dynamometer to measure the pull. The variation of load to be imposed on the tractor drawbar was attained by loosening or tightening the nuts. This unit is shown in Fig. 5.

Proving Ring Drawbar Dynamometer – A proving ring of 1 000 kg capacity was used as dynamometer for measuring the drawbar load. The ring was mounted within a rectangular sliding mild steel frame (Fig. 6). When the frame was pulled from both ends the proving ring was deformed in proportion to the force applied. The proving ring was calibrated by varying the load from zero to 400 kg against the deflection of the micrometer dial.

Cone Penetrometer – The cone penetrometer was provided with a proving ring which was used to determine the penetration resistance of soil (Fig. 7). The proving ring capacity was 11.6 kg and a dial indicator with a least count of 0.01 mm indicated the penetration load applied with a sensitivity of 0.45 kg per division. The detachable, 30-degree penetration cone had 645 mm^2 cross sectional area at its larger end. The proving ring of the penetrometer was calibrated and checked in accordance with the data supplied by the manufacturer.

Fig. 4 Electric tractor with cage wheels

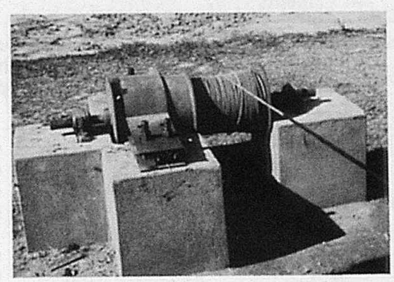

Fig. 5 Variable loading drum dynamometers

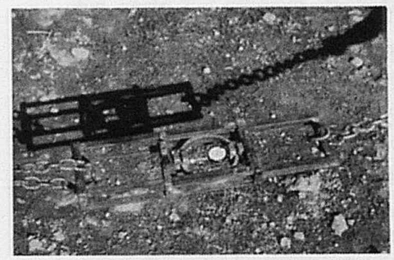

Fig. 6 Proving ring drawbar dynamometer with frame

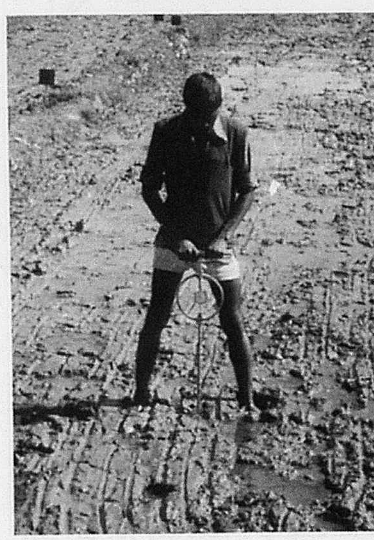

Fig. 7 Cone index observation by cone penetrometer

Soil Preparation – In order to maintain almost similar soil conditions in all the treatments, soil preparation was done in the soil bin before each test. The top layer of 10 to 15 cm of soil was thoroughly mixed with water with the help of a bullock drawn mould board plough followed by two planking operations. The field was allowed to dry for about 72 h after which the moisture content, bulk density and cone index values were taken to confirm the uniformity of soil conditions. Then the soil bins were flooded with water for about 4 h to ensure complete saturation of top layer of 10 to 15 cm of soil.

Test Procedure

Experiments were conducted in outdoor soil bins each of 60 m x 3 m size. Split plot experimental design was made for the treatments to be carried out in different soil bins. The tests were performed using the electric tractor with the cage wheels being fitted to its rear wheels. The test tractor was operated in first low gear in all the treatments. The linear speed of tractor on concrete surface in first low gear was 1.53 km/h. Drawbar load of 100, 200, 300 and 400 kg were applied on the test tractor with the help of variable loading drum dynamometer. The load variation was measured with the help of a proving ring drawbar dynamometer. A no load stage of operation was also carried out. Test length of 10 m was kept fixed for all the treatments. At each stage of drawbar loading the following observations were recorded.

1) Wheel Revolution – The left and right rear wheel revolutions were recorded with the help of revolution counters mounted on the final drive of the test tractor.

2) Wheel Sinkage – The depth of wheel sinkage was measured with the help of two steel scales. The scale with a base plate was placed vertically into the rut formed behind the pneumatic tire. Another scale kept parallel to the top soil surface was held along the face of the vertical scale. The depth of rut was measured separately for the left and right wheels at six different points within the test length.

3) Power Input – The power input to the rear axle was measured with the help of an energy meter connected in the circuit.

4) Time of Travel – The time taken by the tractor to move the test length was noted by a stop watch to determine the speed of travel.

5) Cone Index Value – Cone penetrometer readings up to 150 mm depth in stages of 25 mm were taken behind the pneumatic tire just after the operation of the tractor at five different points.

Results and Discussion

The test data for all the treatments were analysed and are shown in **Table 1**. On the basis of this analysis the optimum value of lug angle was determined. The results are discussed below.

Effect of Lug Angle on Wheel Slippage – A zero degree lug angle cage wheel gave minimum slip variation from 30.2% at no-drawbar load to 37.2% at 400 kg drawbar load whereas a 42-degree lug angle cage wheel gave maximum slip variation from 38% at no-drawbar load to 52.3% at 400 kg drawbar load (**Fig. 8**). All other cage wheels had slip variation between these two ranges. The general tendency of all the curves is an increase in slip percentage with increase in lug angle of the cage wheels at all four stages of drawbar loading. All the wheels had slip variation from 30.2% to 38.4% at no drawbar load.

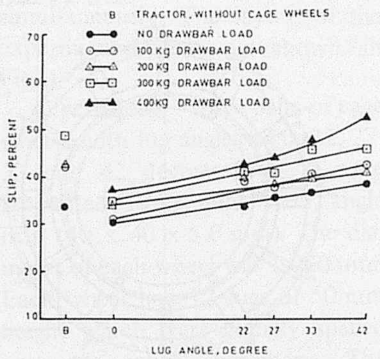

Fig. 8 Variation in wheel slip with lug angle at different drawbar load

Table 1 Measured and calculated values of field test data under different test treatments

Treatment No.	Wheel slippage (%)	Wheel sinkage (cm)	Drawbar horse-power (ps)	Axle horse-power (ps)	Tractive efficiency (%)	Rolling resis-tance (kg/ gross t)
A_0L_1	33.7	8.6	0	1.99	0	154.7
A_0L_2	42.3	12.7	0.32	3.26	9.9	
A_0L_3	42.4	14.7	0.56	3.06	18.5	
A_0L_4	48.7	13.8	0.77	3.64	21.2	
A_1L_1	30.1	9.6	0	1.13	0	18.0
A_1L_2	30.9	10.8	0.40	1.95	20.6	
A_1L_3	34.0	11.4	0.74	2.29	32.3	
A_1L_4	34.0	12.7	1.12	3.38	33.3	
A_1L_5	37.1	13.6	1.40	4.20	33.4	
A_2L_1	33.6	6.6	0	1.70	0	113.2
A_2L_2	39.0	7.3	0.35	2.61	13.4	
A_2L_3	39.9	8.1	0.68	2.49	27.5	
A_2L_4	41.1	8.8	0.98	3.68	26.8	
A_2L_5	42.8	8.6	1.31	4.66	28.1	
A_3L_1	35.5	7.9	0	2.05	0	177.2
A_3L_2	37.6	7.5	0.35	2.54	14.0	
A_3L_3	38.3	8.3	0.66	2.85	23.4	
A_3L_4	40.5	6.8	1.01	3.30	30.8	
A_3L_5	44.1	8.2	1.21	4.77	25.4	
A_4L_1	36.6	11.3	0	2.07	0	183.9
A_4L_2	40.6	11.4	0.33	2.90	11.5	
A_4L_3	39.6	10.0	0.67	3.48	19.4	
A_4L_4	45.9	11.3	0.91	4.04	22.5	
A_4L_5	47.8	12.8	1.17	4.40	26.8	
A_5L_1	38.1	12.2	0	3.31	0	428.7
A_5L_2	42.2	11.1	0.32	3.40	9.4	
A_5L_3	40.7	11.0	0.73	3.99	18.3	
A_5L_4	45.4	12.2	0.91	3.76	24.4	
A_5L_5	52.3	16.0	1.08	4.47	24.2	

A_0 refers to pneumatic wheel alone; A_1, A_2, A_3, A_4 and A_5 refer to cage wheels with lug angles of 0, 22, 27, 33 and 42 degree respectively. L_1, L_2, L_3, L_4 and L_5 refer to 0, 100, 200, 300 and 400 kg drawbar loads respectively.

It shows that even at no drawbar load, the slip was quite high in submerged soil conditon. This may be due to the high sinkage of wheels at low soil strength. The slip percentage for bare wheels increased from 34% at no-drawbar load to 48.6% at 300 kg drawbar load. At 400 kg drawbar load, the bare wheels had shown 100% slip with a very high value of sinkage due to wheel spinning. At 300 kg drawbar load, the wheel slip for the bare wheels was maximum and for the dual wheels with zero degree lug angle, it was minimum. At 400 kg drawbar load, the dual wheels with lug angles of cage wheels as 0, 22, 27, 33 and 42 degrees showed a slip value of 32.2, 42.8, 44.2, 47.6 and 52.3% respectively. This means that higher pull with less slippage was achieved with zero-degree lug angle cage wheel.

At no-drawbar load, the slip percentage of the bare wheels was higher than that for the zero-and 22-degree lug angle cage wheels whereas the 27, 33 and 42 degrees lug angle cage wheels showed higher slip percentage than the bare wheels. This may be due to the variation in rolling resistance value. The rolling resistance for the bare wheels was 154.7 kg per gross tonne whereas the dual wheels had 18.0, 113.2, 177.2, 183.9 and 428.7 kg per gross tonne of rolling resistance for lug angles of 0, 22, 27, 33 and 42 degrees, respectively.

Effect of Lug Angle on Wheel Sinkage – The wheel sinkage increased with an increase in drawbar loading (Fig. 9) due to the fact that the weight transfer to the rear wheels from front wheels of the tractor increased with an increase in drawbar loading. This increase in load on the rear axle resulted into higher load per unit contact area of the wheel surface and, consequently, in higher sinkage of the wheel. The sinkage was minimum for the cage wheels with lug angles in the range of 22 to 27 degrees. The wheel sinkage increased on both sides of this range of the lug angles. This may be due to the fact that the cage wheels with lug angles in the range of 22 to 27 degrees developed optimum support area at the contact surface as the result of which sufficient lift force had developed to prevent excessive sinkage. In the case of higher lug angles of 33 and 42 degrees, the general increase in sinkage may be due to the fact that while in operation the cage wheels with these higher lug angles are supported only on two opposite corners of two consecutive lugs at times during the course of rotation of the wheel. At this point, the total support area becomes too small which might be resulting in higher momentary penetration of the wheels. Wheel sinkage for tractor wheels without any cage wheels was higher as compared to those for dual wheels for all the loads. This indicates that cage wheels when used as dual wheels provide more floation due to the increased surface of contact between the wheel and soil.

Effect of Lug Angle on Tractive Efficiency – For all the lug angle cage wheels, the tractive efficiency increased with increased drawbar load (Fig. 10). At 400 kg drawbar load, the zero degree lug angle cage wheel showed the highest value of 33.4% tractive efficiency whereas the 42 degree lug angle cage wheels showed the minimum value of 24.3%. The high power output with zero-degree lug angle may be due to low-slip percentage of the wheels at all stages of drawbar loading ensuring comparatively higher speed of operation. The tractor with pneumatic wheel alone showed the lowest value of 21% tractive efficiency as compared to all the dual wheels under test. The tractive efficiency increased rapidly with an increase in drawbar load up to 250 kg beyond which the rate of increase was low. The better traction performance of the zero-degree lug angle cage wheels might be due to the fact that, while in operation, there was a total engagement of a lug with the soil and shear resistance of soil over the lug was in the direction perpendicular to the lug surface. When the angle of the lug was increased, the contact between the lug and soil was gradual and the soil in front of the lug had more of sliding tendency as compared to that in case of the zero-degree lugs. Due to this sliding tendency, the shear strength of the soil in front of an angled lug was reduced resulting into lower value of tractive force and higher value of wheel slippage.

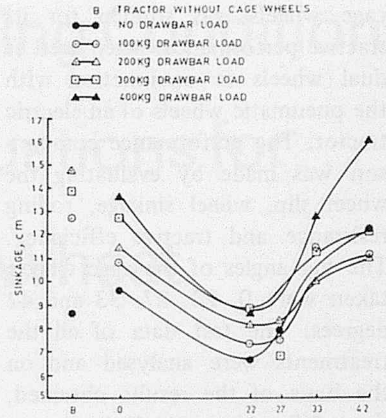

Fig. 9 Variation in wheel sinkage with lug angle for different drawbar load

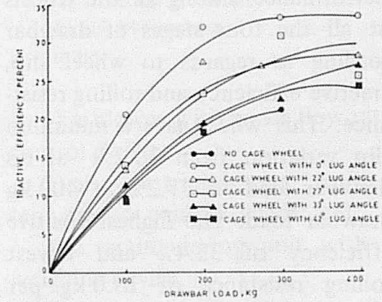

Fig. 10 Variation in tractive efficiency with drawbar load at different lug angles of cage wheels

Conclusion

The effect of the lug angle of

cage wheels was studied for its tractive performance, when used as dual wheels in conjunction with the pneumatic wheels of an electric tractor. The performance comparison was made by evaluating the wheel slip, wheel sinkage, rolling resistance and tractive efficiency. The lug angles of the cage wheels taken were 0, 22, 27, 33 and 42 degrees. The test data of all the treatments were analysed and on the basis of the results obtained, the following conclusions are drawn:

1) The dual wheels with zero degree lug angles showed the best performance among all the wheels at all the four stages of drawbar loading as regards to wheel slip, tractive efficiency and rolling resistance. This wheel gave a minimum slip variation from 30.2% at no drawbar load to 37.2% at 400 kg drawbar load. The highest tractive efficiency of 33.4% and lowest rolling resistance of 18.0 kg per gross tonne were also achieved with the zero-degree lug angle cage wheels. However, all the wheels had slip in the range of 30.2% at no-drawbar load to 52.3% at 400 kg drawbar load.

2) The wheel sinkage was minimum for the cage wheels with lug angles in the range of 22 to 27 degrees. A maximum sinkage of 16.1 cm was observed for the 42-degree lug angle at 400 kg draw bar load.

3) For traction purposes, a cage wheel with zero degree lug angle gave the best performance and this parameter may be selected for the design of traction wheels.

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Determination of Optimum Drying Conditions and Development of Drying Equations for Thin-Layer Drying of Parboiled Wheat

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Introduction

Wheat bulgur is one of the special products of wheat. The process of wheat bulgur production consists of parboiling, drying, debranning and splitting. The debranned split wheat bulgur can be used as a substitute for rice. It takes about 25 to 30 min to cook it fully (1).

Thin-layer drying refers to the grain drying process in which all grains are fully exposed to the drying air under constant drying conditions. All commercial flow dryers like the Columnar dryers, baffle dryers and Luisiana State University dryers are designed on the basis of thin-layer drying principles.

Practically no information pertaining to the thin-layer drying characteristics of Indian varieties of parboiled wheat is available. Therefore, the major objectives of this study were to investigate into the following:

1) Effects of soaking temperature and time and steaming temperature and time on the quality of the gelatinised wheat kernel; 2) Effects of each of the air temperatures of 65°, 75° and 85°C on drying characteristics of parboiled wheat; 3) Effects of different air velocities such as 5.4, 12.5 and 30.7 m/min on drying characteristics of parboiled wheat; 4) Effects of the above drying conditions on the cracking of dried parboiled wheat; and 5) Derivation of drying equations for the above drying conditions.

Materials and Methods

The laboratory batch dryer used for the drying studies is shown in Fig. 1. The set up consists of the following units:

1) a blower with an air flow rate control device;

2) an electric heater with a temperature control device; and

3) a grain drying unit with a weighing device.

The temperature was controlled within ±2°C with the use of a thermostat and a variac. The air velocity was measured at different points over the cross-section of the drying chamber by an anemometer. A small variation in air velocity was observed at the sides of the drying chamber. However, a minimum air velocity necessary for the drying study was maintained. The humidity of the drying

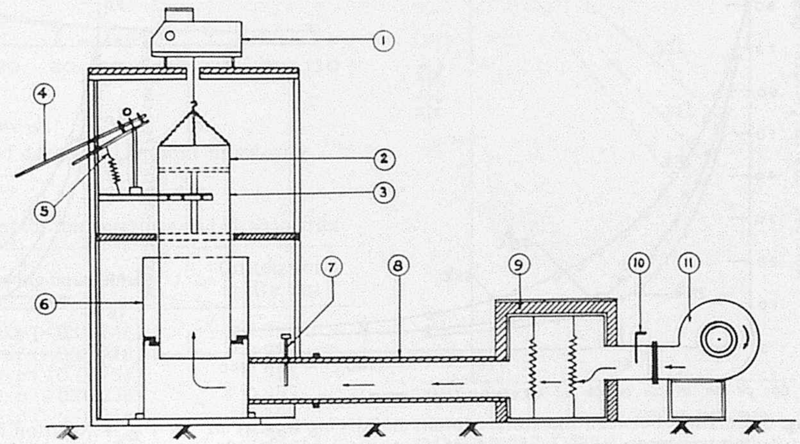

Fig. 1 Schematic diagram of experimental set-up

air was not controlled. The variation in ambient relative humidity in the closed room where the experiments were conducted was within ±6% only in January, 1979 and its effect was neglected. The average humidity of the ambient air was 0.0118.

The moisture contents of the samples were determined by the use of a standard air oven drying method (150°C ±2°C). All data presented in different figures are the average of three replications.

The average initial moisture content of the raw wheat sample was 11% (d.b.). The sample was cleaned and mixed throughly. Then the raw wheat was soaked in hot water at a constant temperature of 75°C for 2.5 h in a hot water bath to raise its moisture content to 80-83% (d.b.). The optimum soaking temperature and time were determined by studying the hydration characteristics of the wheat (Fig. 2). Then the soaked wheat was steamed in an autoclave for 15 min at an atmospheric pressure for complete gelatinisation. After that the parboiled wheat samples of 250 g were kept in polyethylene bags and stored in a refrigerator at about 5°C until used.

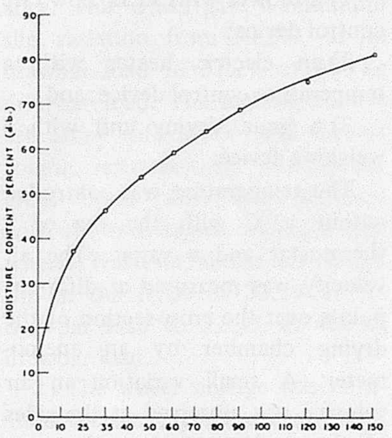

Fig. 2 Hydration characteristics of wheat (Temperature of water: 75°C)

When a stable temperature condition was reached, a 200 g representative sample was uniformly spread in single grain layer over the supporting wire mesh of the drying pan and balanced quickly. The drying was continued at certain temperatures until the sample was dried to the desired moisture level. The sample was weighed periodically to determine the moisture loss at certain intervals. The moisture contents of the samples were determined before and after each drying experiment. The samples were dried from 83% to 10% (d.b.) at each of the air temperatures of 65°, 75° and 85°C. After each drying experiment the samples were tempered for about 12 h in polyethylene bags and were allowed to attain room temperature gradually.

Results and Discussion

Equilibrium moisture content – The equilibrium moisture contents of parboiled wheat were 5.2, 4.5 and 4.31% (d.b.) at 65°, 75° and 85°C, respectively. Therefore, the equilibrium moisture content of parboiled wheat decreased with the increase of air temperature. It is well known that the relative humidity of the drying air decreases as its temperature increases. This decrease in relative humidity causes the grain to reach equilibrium moisture content at lower levels. The variation in air velocity from 5.4 m/min to 30.7 m/min had no effect on the equilibrium moisture content of parboiled wheat.

Effects of air temperature – The relationship between moisture content and drying time for each of the air temperatures 65°, 75° and 85°C and air velocities 12 m/min and 30.7 m/min are shown in Figs. 3 and 4, respectively. The above figures indicate that the moisture contents of parboiled wheat were decreased exponentially with the progress of drying time at all temperatures. The above drying curves are asymptotic to the limiting values, equilibrium moisture contents. It is also apparent that the

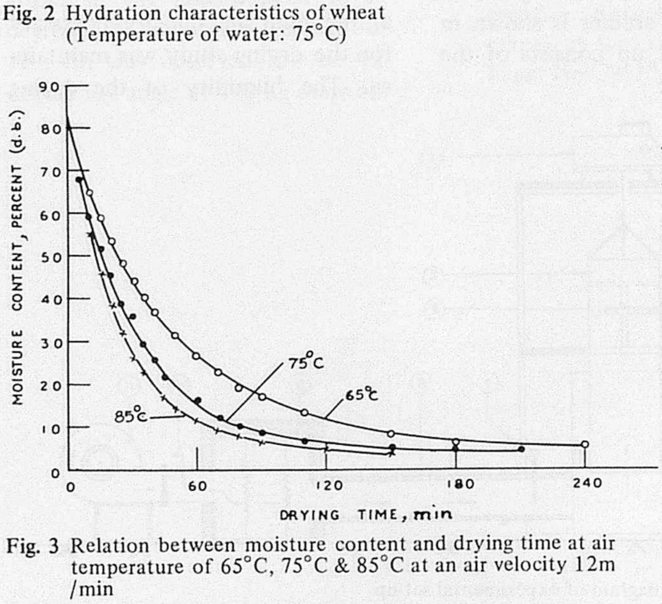

Fig. 3 Relation between moisture content and drying time at air temperature of 65°C, 75°C & 85°C at an air velocity 12m /min

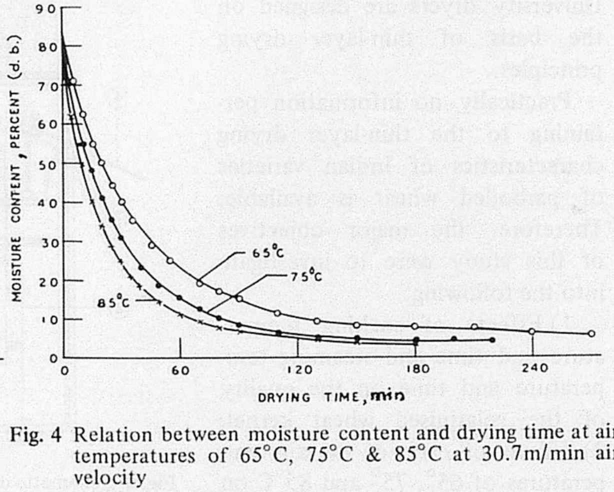

Fig. 4 Relation between moisture content and drying time at air temperatures of 65°C, 75°C & 85°C at 30.7m/min air velocity

rate of drying increased as the drying air temperature increased. The drying times required for drying of parboiled wheat from 83% (d.b.) to 10% (d.b.) for different drying conditions are shown in Figs. 3 and 4.

The drying rates versus drying times for different air temperatures are plotted in Fig. 5 indicating that parboiled wheat containing as high as 83% (d.b.) moisture was dried under constant-rate period for a short time. Subsequently, it was dried under a falling-rate period. It may also be seen that the rate of drying was unusually high at the very beginning of drying. This may be due to the initial adjustment caused by the evaporation of moisture from the outer surface of kernel and husk.

Effects of air velocity – Fig. 6 shows that the variation in air velocity from 5.4 to 12 m/min had no effect on the rate of drying. But the drying rate was slightly increased at an air velocity of 30.7 m/min.

Drying constant and drying equations – The logarithm of moisture ratio, MR vs drying time, θ are plotted in Figs. 7 and 8 which show that except for an initial period of drying, the relationship between Log MR and θ are linear and that the slope of the straight line is the drying constant, K. The drying equations (derived by least square method) for different drying air temperatures and air velocities for drying of parboiled wheat are shown in Table 1.

It may be seen from the above table that the correlation coefficients vary from 0.992 to 0.998 which indicate the goodness of fit of all drying equations. Therefore, the drying equations developed for parboiled wheat can be used with accuracy for the above drying conditions.

Effects of drying conditions on product quality – In order to evaluate the effects of drying air temperature on the quality of the dried parboiled wheat, the percentage of cracked grains in the dried product was measured. For convenience, cracks in parboiled wheat were

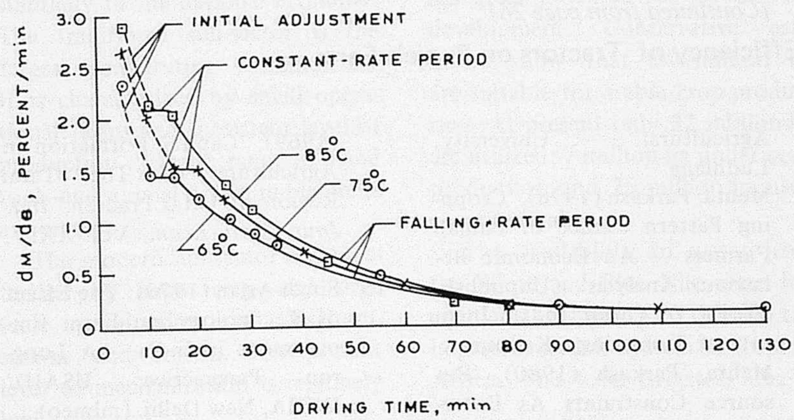

Fig. 5 Effect of drying air temperatures on rate of drying at 12m/min air velocity

Table 1 Empirical drying equations for different air temperatures and air velocities

Air temp. °C	Air velocity m/min	Empirical drying equations	Correlation coefficient
65	5.4 to 12	MR = 0.99 exp (−0.0224θ)	0.998
75	5.4 to 12	MR = 0.96 exp (−0.0341θ)	0.994
85	5.4 to 12	MR = 0.90 exp (−0.0375θ)	0.996
65	30.7	MR = 0.90 exp (−0.0223θ)	0.997
75	30.7	MR = 0.92 exp (−0.0325θ)	0.998
85	30.7	MR = 0.826 exp (−0.035θ)	0.992

MR: Moisture ratio, M-Me/Mo-Me and θ: = drying time, min.

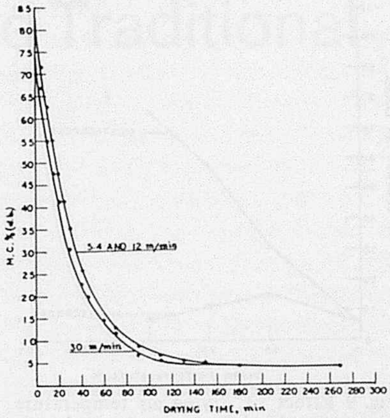

Fig. 6 Moisture content vs drying time for 75°C air temperature

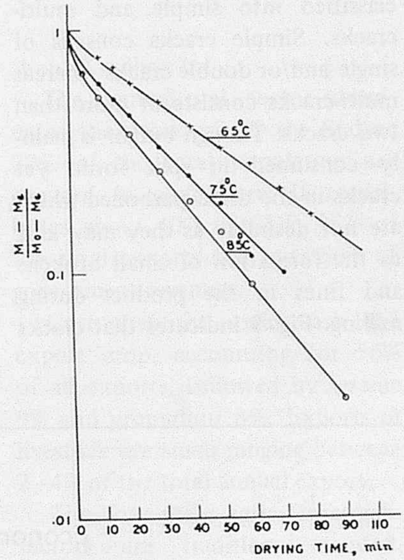

Fig. 7 Moisture ratio vs drying time for 12m/min air velocity

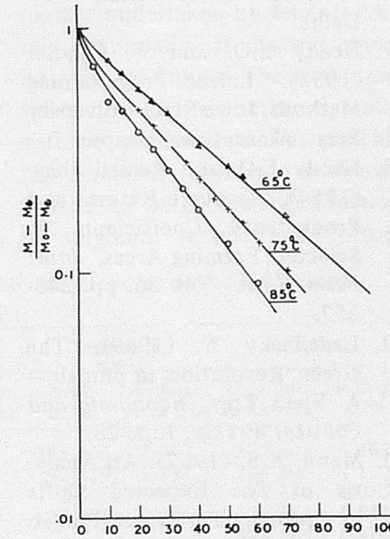

Fig. 8 Moisture ratio vs drying time for 30.7m/min air velocity

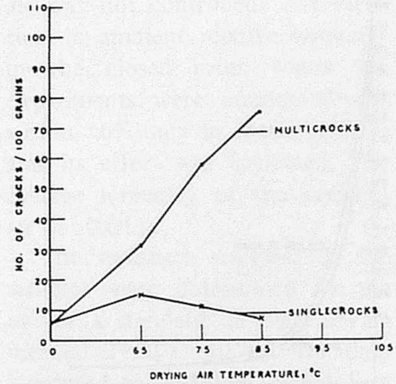

Fig. 9 Effect of drying air temperature on development of cracks in wheat bulgar

classified into simple and multi-cracks. Simple cracks consists of single and/or double cracks whereas multi-cracks consists of more than two cracks. Though bulgur is mainly consumed in split form, yet cracks in the dried parboiled wheat are not desirable as they may lead to the formation of small brokens and fines in the product during milling. Fig. 9 indicates that cracks in the dried parboiled wheat increases as the temperature of the drying air was increased. At temperatures 65° and above multi-cracks were mainly formed. At temperatures above 75°C the percentage of cracked grain in the dried product increased sharply.

Optimum drying conditions – From the standpoint of total drying time and cracks develped in dried parboiled wheat, drying air temperature of 75°C can be taken as optimum for drying of parboiled wheat.

Summary

Results of the studies of the effects of drying air temperatures of 55°, 65°, 75°, and 85°C and air velocities of 5.4, 12 and 30.7 m/min on thin layer drying characteristics of paboiled Kalyan Sona variety of wheat show that the rate of drying always increased as the drying air temperature increased. But the equilibrium moisture content decreased with the increase of air temperature. The variation in air velocity from 5.4 to 12 m/min had no effect on the rate of drying. Empirical drying equations relating moisture ratio, MR to drying constant, K and drying time, θ developed for the above drying conditions can be used with accuracy. The percentage of cracked grains in the dried product increased sharply at temperatures above 75°C. The drying air temperature of 75°C may be taken as optimum for thin layer drying of parboiled wheat.

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(*Continued from page 26*)

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Mechanization for Modern and Traditional Agriculture in Sudan

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Abstract

Sudan is a large sparsely populated country with a high potential for agricultural development. The agricultural sector dominates the economy of the Sudan; 72% of the population are engaged in agriculture. It contributes 40% of GDP, 95% of the total exports and over 50% of government revenue.

The two sub-sectors, the traditional and modern, contribute substantially to the national economy. The traditional sub-sector is the largest constituting 4 million ha. It is characterized by small operational farms and subsistent level of production. A wide range of hand tools and animal drawn implements are used.

The modern sub-sector is characterized by large farms and large scale production of sorghum, sesame and cotton. The present level of mechanization is relatively low.

Improvements in the traditional agriculture can be achieved by improving the existing farming practices; improving the hand tools and animal drawn implements, local development and adaptation of equipment, and introduction of a selective form of mechanization. In the modern sub-sector, complete mechanization of field operations for the main crops is needed.

Introduction

Sudan, the largest country in Africa, covers about 2.5 million km^2. The population is estimated at about 16.3 million persons and growing at a rate of 2.2% year. Much of the country is sparsely populated and there is no population pressure on presently developed land. Although a large part of the country consists of desert or semi-desert, the Sudan nevertheless has great potential for agricultural development. Conservative estimates show that 84 million ha are suitable for arable crop production. At present only 32 million ha are utilized; 7 million ha under crop production and 25 million ha used as range land.

The availability of water from the White and Blue Nile rivers has enabled the country to develop the largest irrigation system in tropical Africa. The total irrigated area is about 2 million ha.

The agricultural sector dominates the economy of the Sudan; 72% of the total population are engaged in agriculture. It contributes about 40% of GDP, 95% of the total exports and over 50% of government revenues.

Cotton is the main cash and export crop, accounting for 56% of all exports, followed by sesame 9% and groundnut 8%. Exports of livestock are small ranging between 2–4% of the total annual export.

The four main agricultural subsectors are traditional rainfed, mechanized rainfed, irrigated and livestock. Irrigated agriculture is mostly undertaken by tenants who rely, especially at harvest time, on seasonal labour. The traditional sub-sector is predominantly subsistence production. The mechanized rainfed sub-sector is characterized by large scale production of sorghum, sesame and cotton.

Table 1 Total areas and average yields of the main crops for rainfed and irrigated agriculture (1974/75)

Crop	Rainfed		Irrigated		National	
	Area in ha	Average yield t/ha	Area in ha	Average yield t/ha	Total production in t	Average t/ha
Long staple cotton	–	–	355 965	1.467	522 201	1 467
Medium staple cotton	–	–	92 219	1.131	104 299	1.131
Short staple cotton	67 419	0.262	–	–	17 664	0.262
Sorghum	2 297 723	0.788	165 472	0.986	1 973 761	0.801
Millet	1 111 457	0.400	–	–	444 583	0.400
Groundnut	674 570	0.743	160 957	1.881	803 966	0.962
Sesame	923 622	0.305	–	–	281 705	0.305
Wheat	–	–	251 284	0.979	246 007	0.979

The first two sub-sectors are dealt with in this paper. **Table 1** shows the areas and production of the main crops for the rainfed and irrigated agriculture in 1974/75.

Out of the 7 million under cultivation, 5 million ha are under rainfed agriculture in the two sub-sectors – traditional and mechanized. The rainfed agriculture is concentrated mainly in the central rainlands extending from east to west within the savannah belt and with rainfall ranging between 400-800 mm annually.

Traditional Sub-Sector

It is the largest agricultural sub-sector of 4 million scattering over the vast area of the Sudan. It is characterized by:

1. Small operational farms of sizes ranging between 1-2 ha.

2. Traditional primitive methods of farming using locally made hand tools and animal drawn implements for cultivation and harvesting of crops. Shifting cultivation is also practiced.

3. Subsistence level of production – Because of limited inputs in terms of physical energy, capital and technical know-how, farmers cultivate small areas to produce food for their families and a little extra to exchange for other family needs.

4. Lack of capital – As production is of subsistent level, farmers do not have enough capital to purchase good quality seeds, fertilizers and machinery.

5. Lack of technical know-how – For many years farmers in rural areas used to the traditional methods of farming inherited from their fathers and grandfathers. They have not been exposed to modern technology and power machinery.

6. Inefficient utilization of natural resources – With existing practices and methods of production, farmers cannot cope with jobs requiring high physical energy input such as clearance of bushes and forest, deep ploughing and other cultivation operations.

7. Complex social and political problems – As subsistent farming is not rewarding, there is a growing discontent among young people in rural areas. As a result, farmers are faced with a serious problem of labour migration from rural to urban areas where high wages can easily be earned. The situation is made worse by the attitude of farmers' young members of the family towards field work as they look down to it.

Due to the wide variation in climatic conditions, there are many crops grown (cotton, sorghum, sesame, groundnut, millet, wheat, horse beans etc.) and different methods are employed to produce them. In many parts of the Sudan, particularly in the western and southern regions, all cultural operations are undertaken by manual labour with the help of hand tools. In other areas such as the northern regions, animal drawn implements are used. The current agricultural practices in these regions will be described briefly.

Hand tools – There is a wide variety of hand tools consisting mainly of axes, hoes, shovels, sickles and knives. Each of these tools is usually used in connection with a certain operation in the sequence of agricultural operations. For example, in land clearance an axe 'Fas' is used for cutting down shrubs; the digging hoe 'Toria' is used for land preparation and sowing. Another method of sowing is by means of a sowing stick known as 'Saluka' which is forced into the soil and rotated to produce a hole for seed to be deposited. Weeding operation is carried out with a weeding hoe 'Hashasha'. Harvesting is usually done with the help of a sickle or knife which is used for cutting grains (sorghum, millet) sesame, grasses and other forage crops.

Animal drawn implements – These include the plough, 'Kamara' for crushing clods and levelling, harrows and rollers; levelling board 'Qussabia' for levelling and raising of irrigation banks and ridgers. Harvesting of crops is done manually. The animals used to operate these implements are oxen, horses, camels and donkeys.

Animal drawn implements are very popular in the northern provinces. The animal power is used for land preparation, harvesting of some crops and transport of farm products. Since the average farm size in these areas is usually very small, less than 2 ha, the immediate introduction of powered machinery will lead to inefficient utilization of such machinery. It is, therefore, not to be used until such time that the size of farm holdings is increased to allow efficient use of powered machinery.

Mechanized Sub-Sector

Mechanized farming in the Sudan started in 1946 for large scale production of sorghum to meet the grain shortage after the second world war. It was reasonably a successful trail which encouraged the government to increase the area devoted to mechanized agriculture. The crops grown are sorghum, sesame and short staple cotton. **Table 2** shows the areas and production of these crops under the two sub-sectors, traditional and mechanized. The production of sorghum, groundnut and cotton in the mechanized sub-sector outyielded the traditional by 47.7%, 186.4% and 38% respectively. However, the small decrease (10.5%) in yield of sesame may be attributed to losses in the harvest operation. The size of farm holdings ranges between 420-630 ha. Mehcanized farming in these areas has been justified

Table 2 Total areas and average yield of main crops in traditional and mechanized sub-sectors (1974/75)

Crop	Traditional		Mechanized	
	Area in ha	Average yield t/ha	Area in ha	Average yield t/ha
Sorghum	1 129 149	0.595	1 141 224	0.879
Groundnut	631 134	0.690	160 159	1.976
Sesame	219 450	0.324	94 710	0.290
Cotton (short staple)	46 919	0.267	20 500	0.371

for several reasons:

1. The semi-arid and arid rainfed areas are characterized by a relatively short rainy season (July-September) and therefore farm operations have to be carried out within very short periods of time.

2. Many of the soils of the central clay plains have high clay content and are difficult to cultivate with traditional means.

3. Labour is in short supply in certain areas during the time of planting and harvesting.

4. The productivity of the underutilized land can be increased considerably by extensive means of powered machinery.

The development of mechanized farming has undergone three phases. The first phase 1945-53 was completely under the government control and the total area cropped was 13 020 ha. The second phase 1953; in this phase the private sector was allowed to invest and the government role was to provide necessary infrastructure including roads, domestic water supply, pest control, extension services etc. and to run pilot farms to solve mechanized production problems. The third phase started 1968 with the establishment of the Mechanized Farming Corporation (MFC) which has undertaken several major schemes. In this phase, the government has made an agreement with the World Bank to finance the bush clearance operations, supply domestic water, roads and machinery procurement for some projects which were planned on sound land use principles. During the last seven years, mechanized farming has developed at a fast rate reaching about one million ha.

From 1970 to date, importation of tractors and machinery has been increasing steadily with few fluctuations as shown in **Table 3**. These fluctuations do not reflect the demand for tractors and machinery which has always been greater than the supply, but due to availability of foreign exchange and finance.

Importation of farm machinery as indicated in **Table 3** reflects the nature of tractor utilization and trends in mechanization. Ridgers and wide level disc with a seed box are imported in the largest numbers. The former is used extensively in the irrigated areas while the latter in the rainfed agriculture. In the mechanized subsector, land preparation and sowing are mechanically done. Weed control and harvesting of cotton and sesame is manual, sorghum is mechanically harvested by the combine harvester.

This trend of mechanization is likely to continue for the next few years until new methods and techniques are developed. However in the last five years, mechanized farming in Damazein area has witnessed the introduction of large tractors (more than 150 h.p.) and heavy machinery e.g. heavy off-set discs and large seed drills. This followed the allotment of large areas to private companies like Sudanese-Egyptian Agricultural Integration Co. and Damazein Agricultural and Animal Production Co.

Problems of Mechanization

The main problems of mechanized rainfed agriculture in the Sudan can be summarized into:

1. In the rainfed modern subsector it is planned that all farm operations have to be completely mechanized. To achieve this objective an experimental station and a few pilot farms were set up in the early fifties. The work in the experimental station has continued in the agronomic and breeding aspects while the mechanization aspect was not carried out seriously. The pilot farms have been used for commercial production rather than application of new techniques and practices. This incomplete mechanized crop production system creates a bottleneck in the supply of labour for certain critical operations such as weeding, cotton picking and

Table 3 Number of agricultural tractors and machinery imported in Sudan, 1970-80

Type of machinery	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	Total
Tractor (wheel)	1 271	800	130	1 940	2 047	662	1 722	792	711	545	532	11 152
Disc plough	193	187	550	100	510	1 206	292	–	416	–	–	3 454
Ridger	385	425	–	–	400	29	500	90	100	–	–	1 929
Wide level disc with seedbox	1 130	520	500	500	147	65	97	75	132	–	–	3 166
Off-set disc harrow	35	70	20	64	213	32	132	56	–	–	–	622
Multi-purpose blade	25	19	8	–	–	–	32	–	–	–	–	84
Planter	–	120	–	3	76	206	12	–	13	–	–	430
Fertilizer distributor	10	2	–	10	10	–	1	–	–	–	–	33
Groundnut digger	–	–	–	–	70	131	121	120	–	–	–	442
Grain combine	118	135	50	20	220	387	187	106	30	–	–	1 253
Pick-up baler	20	35	10	–	5	–	–	–	–	–	–	70

sesame harvesting.

2. Land preparation is carried out by means of the wide level disc. There are doubts as to the effectiveness of the wide level disc as a cultivation implement specially for weed control, moisture and soil conservation purposes. Thus, the question of land preparation needs to be further investigated and appropriate methods of seedbed preparation to various crops under different localities have to be developed.

3. Interrow weeding is carried out manually. Labour becomes scarce, more expensive and not available at critical times. Therefore, interrow cultivation or other methods of weed control have to be introduced as an important factor in saving labour and reducing the cost of production.

4. Harvesting is the major problem. For sorghum the machinery is available, but the problem lies in breeding combinable varieties. Breeding programs are in progress and a variety has been released which was suitable for direct combining.

Sesame harvest is the main problem, it is harvested manually and the cost of harvest is 65% of the total cost of production. Sesame varieties grown in the Sudan are shattering varieties which are superior to non-shattering varieties in yield and oil content. A research program investigating the possibility of partial and complete mechanization of sesame harvest is being conducted with the support of the Mechanized Farming Corporation and the World Bank. Preliminary results showed that the use of binder is not feasible. Combine harvesting with some modifications in the header of the combine has been tried and found to be technically possible, but with high losses in the order of 23%. More work with combines is in progress with the hope of minimizing harvest losses. If the combine harvester can be used successfully in sesame harvesting, this would make operating combines in rainfed areas highly economical.

Cotton harvesting is not a serious problem at present since the area under cultivation is small. Trails in mechanical picking under Sudan conditions have shown that the operation is technically possible. However, the cost of a cotton picker is considerably high and perhaps yields have to be increased to make investment in cotton pickers economically justifiable.

Conclusions and Recommendations

1. Sudan is a large sparsely populated country with great potential for agricultural development.

2. Traditional and modern agriculture co-exist and contribute substantially to the national economy of the country.

3. The national policy is aiming at increasing agricultural production by horizontal expansion and intensification. Mechanization has to be used as an essential tool in production.

4. To improve productivity (i.e. labour, animal and land) in the traditional sub-sector the following requirements have to be met: 1) Local development and adaptation of hand tools and animal drawn implements. 2) Improvement in the existing traditional farming practices to a higher level of efficiency through crop rotations, shifting and burning cultivation that increases the fertility of soil. 3) Introduction of a selective form of farm mechanization with some emphasis on operations where human and animal power is inadequate for acceptable level of production. This can be achieved by introducing small tractors with matching equipment and small stationary threshers. 4) Provision of credit facilities to small farmers to enable them to obtain good quality seeds, fertilizers, improved production tools and powered machinery.

5. In the modern sub-sector the policy is towards increasing the production of sorghum, short staple cotton and sesame. In order to achieve this objective, two major problems have to be solved: 1) Interrow weeding – as labour is scarce, expensive and not available at critical times, the possibility of mechanical and/or chemical control of weeds must be investigated. 2) Harvesting – technical and economical problems in the harvest of sesame and cotton have to be overcome.

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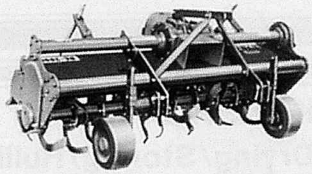

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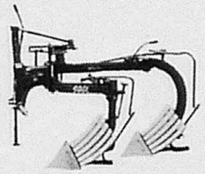

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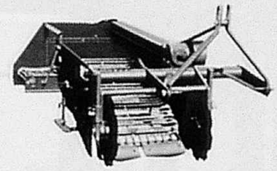

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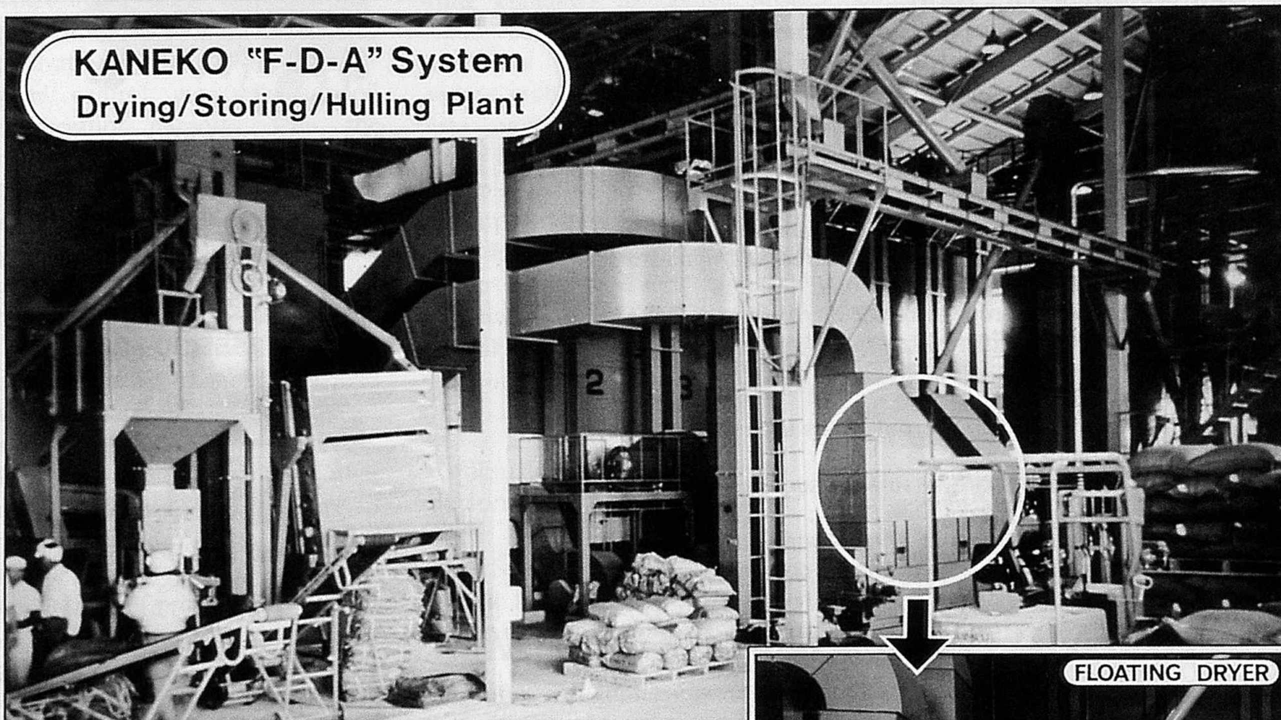

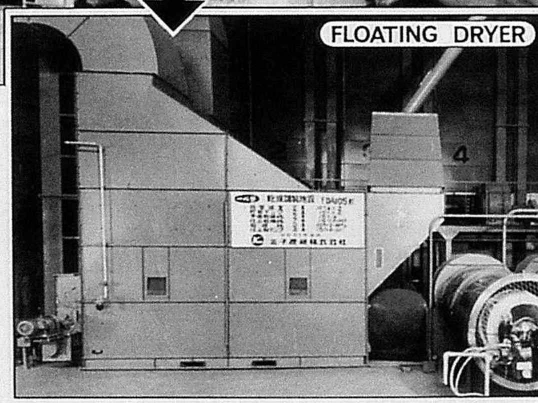

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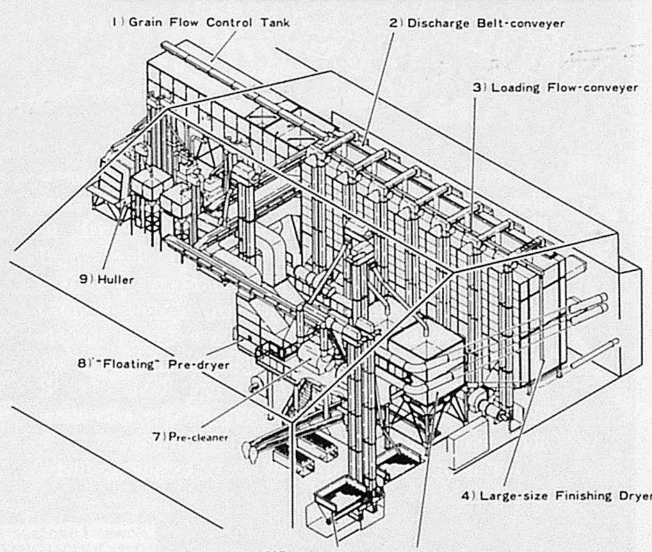

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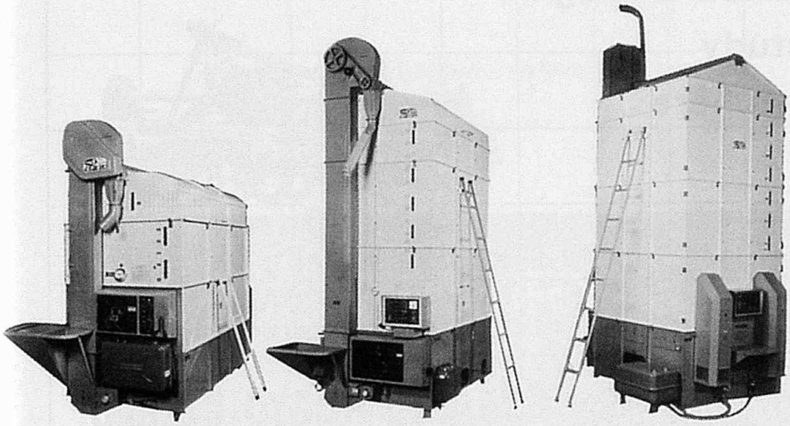

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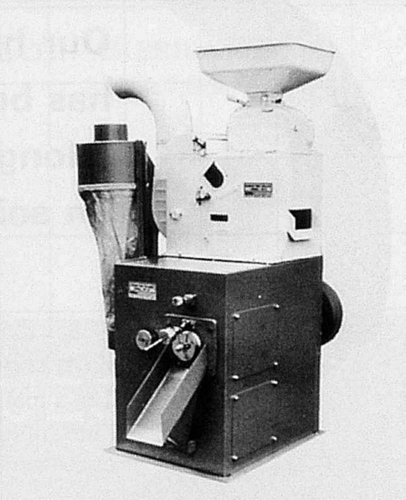

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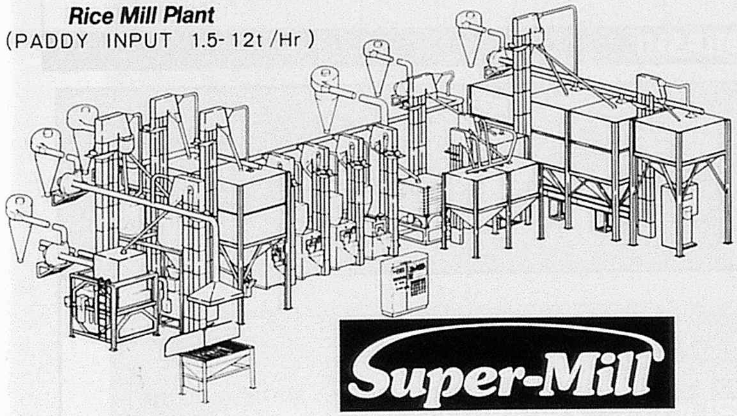

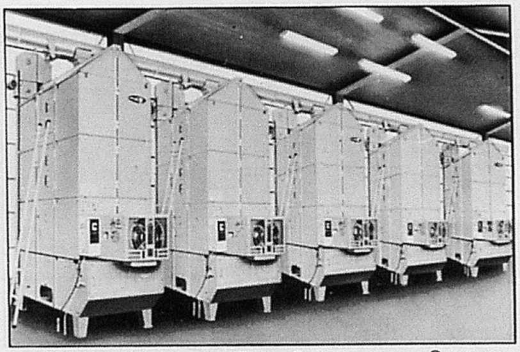

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Evaluation of Farmer's Competence to Maintain Farm Tractors

by
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Introduction

The life expectancy of farm tractors profoundly depends on maintenance and repair, the most important aspects of tractor management. The value of a farm tractor depends upon its unfailing and efficient operation. Thousands of hours of serviceable life have been built into the engine of the tractors by the manufacturer. These many hours of operation can be realized only by observing a systematic maintenance programme and by supplying it with clean high quality fuel, clean air and high quality lubricants in the proper amounts.

Maintenance and repair costs are approximately proportional to the amount of use per year and cease when the tractor stops operating. With good maintenance, the cost of repairs and wear can be reduced. But, more important, a tractor properly maintained or tuned up will enable to get work done in time. If the tractor is not maintained properly the farmer will loose money or the cost of production will go up. Tractors kept in good condition do better work.

Timeliness of performing field operations is a major concern of regular tractor maintenance. Therefore, it is becoming increasingly important to farmers as they identify the penalties of late operations. Wheat has been reported to suffer 4 to 6% reduction in yield for each week of delay in planting. In the northern corn belt of Pakistan, it is estimated that each day of delay in planting after May 15 can decrease yields 60 kg/ha. (Hunt 1974).

Many tractors operate longer than the wear out life but with increased average repair and maintenance costs per hour. Good tractor maintenance begins upon purchase of the tractor. The dealer will go over the tractor pointing out special features and also explains what an owner must do properly for the care of the tractor.

Maintenance is simplified to the extent that it is possible to keep the tractor in better mechanical condition. A small but adequate stock of wearing replacement parts can be kept with minimum trouble and outlay. With regular oil changing, intelligent use and maintenance, the modern tractor will assuredly give reliable service. Alongwith the poorly developed service sector, the competence of the farmers is considered lowest to maintain the tractors. The main objective of this study was to evaluate the farmers' competence to maintain the tractors. The repair and maintenance cost per hour as affected by annual use in hours was determined. Repair and maintenance cost as affected by age of the tractors was also determined. Difference of repair and maintenance cost per hour among various makes of the tractors was ascertained.

From this study, the farmers will have a guideline regarding the optimum use of tractors for minimizing repair and maintenance cost per hour. The effect of age on maintenance cost will be helpful in making decisions for replacing an old tractor with a new one at a certain age of the tractor. The study will be helpful to government and other agencies for future planning of providing tractor services to farmers through custom hire systems.

Method of Study

The study was conducted within a radius of 100 km of Tandojam during 1980, in an area of 31416 km^2. The area selected was fertile, a favourable climate prevailed and the farmers were quite progressive. Almost the entire cultivated area was irrigated by canals or canals and tubewells. Wheat was the main rabi crop and cotton kharif crop of the area. Sugarcane has become an important crop particularly close to the Tando Allahyar and Mirpurkhas Sugar Mills.

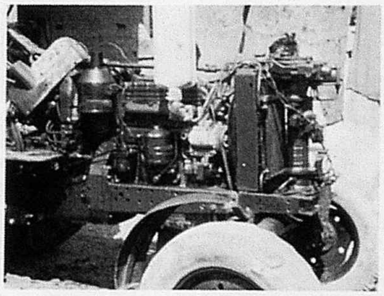

Fig. 1 Belarus tractor under repair on the farm

Table 1 Number of Tractors, Area and Horsepower per Hectare

Tractor Brand	Tractors Nos.	Total Area (ha)	Area per Tractor (ha)	Tractor HP per ha	Total Cropped Area (ha)	Tractor HP per Cropped Area (ha)
Belarus	33	3612	109.45	0.50	2501	0.73
Fiat	20	2688	134.40	0.46	2204	0.57
Ford	19	3490	183.58	0.34	2761	0.42
Massey Ferguson	17	2130	125.29	0.40	1878	0.45
Deutz	11	728	66.18	0.92	676	0.99
Total	100	12648	619.00	2.62	10020	3.16
Average	–	126.48	123.80	0.524	100.20	0.632

The sampling procedure was stratified, proportionate, cluster and randomized according to the requirements so that it may represent the whole area. Instead of randomizing the tractors from the study area, the cluster sampling method was adopted to avoid greater travel expenses and nonproductive time. A large sample of 100 tractors was selected for detailed study. The tractors included in the sample were used for at least once a year. The tractor owners or managers and operators were interviewed and data were collected from records and through verbal information on pre-tested questionnaire with respect to tractor expenditure incurred on repair and maintenance, fuel, oil and labour. The information given by the tractor owners or managers and operators was relied upon in the absence of any records. Out of 100 diesel tractors selected for the study, 33 were Belarus, 20 Fiat, 19 Ford, 17 Massey Ferguson and 11 Deutz. In most of the new tractors the annual use was confirmed and recorded from their hour meters. The number of tractors surveyed and the area operated by these tractors is given in **Table 1**.

The repair and maintenance cost per hour was calculated for the different types of tractors according to annual use, age, and make.

The repair and maintenance costs include all repairs and maintenance work, spare parts, oils, lubricants and labour charges. The repair and maintenance cost per hour was calculated by dividing the annual cost by annual use.

Results and Discussion

The farms and barren lands require tractors for sustained cropping and to bring idle lands under cultivation. There has been a rapid increase in the number of tractors. Farmers are interested in intensifying crop areas by extending the use of the tractors. The main objective of this study was to evaluate the ability of the farmers to maintain the tractors. The results are discussed under the headings: 1) Repair and maintenance costs affected by age of tractors; 2) Repair and maintenance costs affected by annual use; 3) Repair and maintenance costs for various makes of tractors.

Repair and Maintenance Costs as Affected by Age of Tractors

The age of the tractors and repair and maintenance cost per hour is shown in **Table 2**. The older tractors had higher repair and maintenance cost per hour. This was due to the fact that older tractors had frequent breakdowns which are blamed on poor workmanship. The hydraulic problems of tractors plagued the owners. The repair and maintenance cost of tractors was high during the age of 4 to 6 years. The hourly high cost has occurred due to engine overhauls, tires and batteries replacement, fuel injection pump repairs, hydraulic system service, etc. The repair and maintenance cost increased as age increase beyond 8 years. This shows that the repair cost is directly related with the age of tractors.

After 1975, a sudden rise in the prices of spare parts, lubricants and materials took place due to high inflation rate and exorbitant rise in petroleum prices. The prices of spare parts and lubricants were more than four times in 1979-80 than 1974-75. Non-availability of genuine spares had been a major cause of frequent breakdowns, which required repairs and replacements within a short period. It was found that majority of the tractors beyond the age of 3 years required engine overhauls after one or two years. The repair charges by service shops had also substantially increased and varied from one shop to another. These factors had added to a high percentage of repair and

Table 2 Age of Tractors and Repair and Maintenance Cost per Hour

Age Since New (Years)	No. of Tractors	Annual use (h)	Repair and maintenance cost: Rs / h	Percent of Total cost (Owning + operating)	Percent of Purchase Price (Average / 100 h)
Upto 2	47	1123	1.21	3.47	0.16
2 – 4	22	1381	3.86	12.39	0.59
4 – 6	15	1264	5.54	16.16	0.91
6 – 8	3	644	7.54	18.99	2.22
Above 8	13	856	8.52	23.52	3.38

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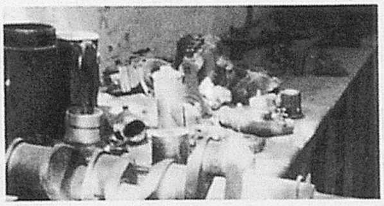

Fig. 2 Broken tractor parts

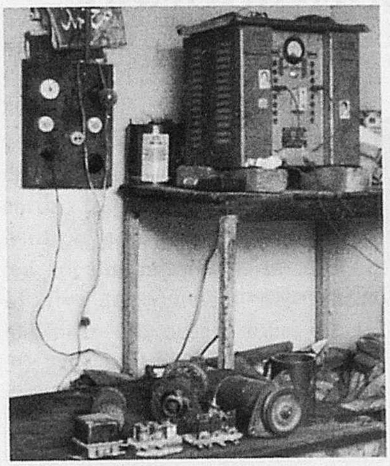

Fig. 3 Generator, self starter repair and battery charging

Table 3 Annual Use and Repair and Maintenance Cost per Hour

Annual use (h)	No. of Tractors	Annual use (h)	Repair and maintenance cost		
			Rs / h	Percent of Total cost (Owning + operating)	Percent of Purchase Price (Average / 100 h)
Upto 500	10	359	13.14	18.49	3.29
501 – 1000	38	735	5.64	12.42	0.96
1001 – 1200	11	1088	3.96	10.91	0.55
1201 – 1400	8	1311	1.69	5.58	0.23
1401 – 1600	8	1488	3.34	10.35	0.43
Above 1600	25	1972	1.72	6.88	0.26

Table 4 Tractor Makes and Repair and Maintenance Cost per Hour

Tractor make	No. of Tractors	Average Annual use (h)	Repair and maintenance cost		
			Rs / h	Percent of Total cost (Owning + operating)	Percent of Purchase Price (Average / 100 h)
Ford	19	1277	2.16	7.02	0.26
Belarus	33	1096	2.91	7.34	0.54
Fiast	20	1376	3.45	11.57	0.45
Massey Ferguson	17	1254	3.46	11.69	0.52
Deutz	11	545	11.44	25.30	5.52

maintenance cost per hour. Untrained tractor operators and mechanics were also major causes of high repair and maintenance costs. The findings of Esmay and Faidley (1973) that the life expectency of tractors was 25% less and repair costs were 100% more than in the United States. Lonnemark (1967) quoted repair and maintenance costs from the year book of the American Society of Agricultural Engineers 1965 as an expressed percentage of the purchase price. In developing countries the cost of repairs is 150% as compared to 120% in United States due mainly to higher prices of spares and sometimes to a lack of knowledge of proper operation and maintenance.

Repair and Maintenance Costs Affected by Use

Table 3 shows the repair and maintenance costs for various ranges of annual use. The cost of repairs and maintenance is closely related to the amount of annual use. The repair and maintenance cost may not have been significantly affected by annual use due to the fact that the old tractors requiring more annual repair and maintenance costs have fallen in the group of tractors having low annual use. The repair and maintenance cost per hour was lower for the tractors used for long periods each year. However, the high rate of annual use had resulted in more breakdowns and increase in the annual repair and maintenance cost. The repair costs decreased when annual use was increased beyond 1 000 h. The costs per hour may not have been increased by increased annual use of more than 1 400 h due to the fact that few tractors required repairs in this group of tractors having high annual use. The related reduction in repair and maintenance cost per hour with increased annual use agrees with the view of Lonnemark (1967).

Repair and Maintenance Costs for Various Makes of Tractors

Repair and maintenance cost per hour and percent of purchase price is given in **Table 4**. The majority of the Deutz tractors and a few other tractors were beyond 8 years of age, which needed more repairs. These tractors incurred in higher rate of repairs and maintenance cost per hour. This is in agreement with the findings of Lonnemark (1967). The repair and maintenance cost for the Belarus and Ford tractors was lower as compared to other makes due to less repairs during the early life and high rate of annual use. As reported by the farmers, all the makes except Deutz tractors were successful in the area. The number of Belarus tractors was high as this make was comparatively cheap and the spare parts were easily available at lower rate.

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Measurement of Hydraulic Properties of a Brown Flood-Plain Soil of Bangladesh

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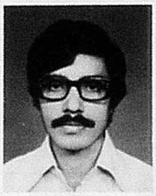

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Abstract

The instantaneous profile method based on simultaneous monitoring of the changes in water content and the soil water pressure head was used to determine the hydraulic properties of a brown flood-plain soil of Bangladesh. It was observed that the functional dependence of the hydraulic conductivity on the soil-water content obeyed a straight line relationship on semi-log plot. Greater soil-water content was required for the same hydraulic conductivity in the sub-soil than the surface soil. The hydraulic conductivity determined by this method can be applied to the analyses of drainage and evapotranspiration components of the water-balance equation in further studies of field-water management.

Introduction

A reliable estimate of soil hydraulic characteristics for effective prediction and control of the dynamics of water in a field soil is a prerequisite for soil water management. Knowledge of these hydraulic properties is essential for a better understanding of soil-water behaviour including the irrigation scheduling, drainage, water conservation, solute transport, run-off control etc. Two of the most important physical properties that influence water movement are the ability of the soil to transmit water (hydraulic conductivity) and the capacity of soil to retain water under pressure (drying curve). In measuring these parameters for a field situation, a number of methods are now available. This paper describes the determination of hydraulic conductivity characteristics of a soil profile of calcaric fluvisol following the method of Rose *et al* (1965). The method is based upon monitoring the transient state internal drainage and when carried out in the field eliminates any possible alteration of soil hydraulic properties due to disturbance of soil structure during sampling as well as any doubts about the applicability of steady state methods to transient state process. The application of tensiometry and the use of neutron moisture gauge in this method make possible the rapid monitoring of soil water pressure and soil water content data respectively (Watson 1968, Hillel *et al*, 1972).

The objectives of the present study was to determine the *in situ* hydraulic conductivity and other related properties of a Bangladesh flood-plain soil using the instantaneous profile method.

Experiment

The experimental plot area was bare and uncultivated for the preceding one year period, located in the Regional Agricultural Research Station, Ishurdi, Pabna. The soil – a calcareous brown flood-plain loam developed from the Ganges river alluvium – is classified as a calcaric fluvisol. A description of some physico-chemical properties of the soil profile upto 75 cm is presented in **Table 1**.

Measurements were made on a

Table 1 Some physico-chemical properties of calcareous brown flood-plain soil (Ishurdi, Pabna)

Depth cm	Sand %	Silt %	Clay %	pH	CEC me/100g	Organic matter %	$CaCO_3$ %	Field Capacity vol.%	Bulk density $g.cm^{-3}$
0-15	45.6	32.9	21.5	8.3	27.4	1.30	4.3	29.6	1.16
15-30	40.9	35.5	23.6	8.2	21.3	0.69	7.9	39.9	1.37
30-45	46.6	31.4	22.0	8.4	21.7	0.49	9.8	40.6	1.17
45-60	42.7	34.3	23.0	8.5	17.8	0.36	9.2	40.7	1.16
60-75	45.8	30.8	23.4	8.3	12.5	0.23	9.3	41.6	1.12

8x8 m level fallow plot enclosed with wooden planks sunk at 30 cm depth and also covered above by earth ridges upto 30 cm. Two neutron access tubes were installed to a depth of 1.5 m. A series of five tensiometers were installed near the access tubes at 15, 30, 60, 90 and 120 cm depth to measure the soil-water pressure head from mercury manometer readings. Water was ponded on the surface and the plot was irrigated with sufficient water for three consecutive days in order to wet the whole profile. The plot was then covered by a sheet of plastic and then with a layer of loose soil to prevent any water flux across the surface.

Soil-water content was measured during the internal drainage process to a 120 cm depth on eight occasions over a 43 days period, the first being 24 h after the disappearance of surface water from the soil. The measurements were carried out in aluminium access tubes with a troxler neutron moisture gauge having 100 mci-Am-Be fast neutron source. Tensiometer data were also recorded simultaneously along with the neutron readings. Gravimetric soil sampling around the access tubes were also made to check neutron moisture data.

The procedure of Hillel, et al (1972) were followed in full in the handling and calculation of the experimental data.

Results and Discussion

The results of the experiment are summarised in **Figs. 1-3**. Calculations of soil moisture flux and hydraulic conductivity are shown in **Tables 2 and 3**.

Soil water storage – **Fig. 1** shows the amount of water stored in the soil profile as a function of time after steady state infiltration has ceased. The term storage is used to describe the amount of water temporarily retained in the soil profile above a particular depth at any particular time. The amount of water in the profile decreased monotonically with time. Within the 105 cm profile 38.71 cm of water stored after 24 h had

Table 2 Calculation of soil moisture flux

t (days)	z (cm)	$\partial\theta/\partial t$ ($days^{-1}$)	$dz(\partial\theta/\partial t)$ (cm/day)	$q = \Sigma dz(\partial\theta/\partial t)$ (cm/day)
1	0-15	0.0102	0.153	0.153
	15-45	0.0075	0.225	0.378
	45-75	0.0049	0.147	0.525
	75-105	0.0024	0.072	0.597
2	0-15	0.0074	0.111	0.111
	15-45	0.0069	0.207	0.318
	45-75	0.0041	0.123	0.441
	75-105	0.0025	0.075	0.516
4	0-15	0.0057	0.0855	0.0855
	15-45	0.0053	0.159	0.2445
	45-75	0.0034	0.102	0.3465
	75-105	0.0024	0.072	0.4185
6	0-15	0.0049	0.0735	0.0735
	15-45	0.0041	0.123	0.1965
	45-75	0.0027	0.081	0.2775
	75-105	0.0021	0.063	0.3405
8.5	0-15	0.0039	0.0585	0.0585
	15-45	0.0032	0.096	0.1545
	45-75	0.0021	0.063	0.2175
	75-105	0.0017	0.051	0.2685
17	0-15	0.0027	0.0405	0.0405
	15-45	0.0019	0.057	0.0975
	45-75	0.0013	0.039	0.1365
	75-105	0.0012	0.036	0.1725
28	0-15	0.0017	0.0255	0.0255
	15-45	0.0012	0.036	0.0615
	45-75	0.0010	0.030	0.0915
	75-105	0.0008	0.024	0.1155
43	0-15	0.0012	0.018	0.018
	15-45	0.0007	0.021	0.039
	45-75	0.0008	0.024	0.063
	75-105	0.0003	0.009	0.072

Table 3 Calculation of hydraulic conductivity

z (cm)	time (days)	q (cm/day)	$\partial H/\partial z$ (cm/cm)	k (cm/day)	$\bar{\theta}$ ($cm^3.cm^{-3}$)
15	1	0.153	0.877	0.1745	0.3281
	2	0.111	1.000	0.1110	0.3049
	4	0.0855	0.933	0.0914	0.2965
	6	0.0735	0.933	0.0788	0.2858
	8.5	0.0585	1.07	0.0547	0.2801
	17	0.0405	1.33	0.0305	0.2754
	28	0.0255	1.67	0.0153	0.2387
	43	0.0180	2.00	0.0090	0.2140
45	1	0.378	1.83	0.2066	0.4090
	2	0.318	1.83	0.1738	0.4021
	4	0.2445	1.83	0.1336	0.3982
	6	0.1965	1.83	0.1074	0.3962
	8.5	0.1545	1.80	0.0858	0.3859
	17	0.0975	1.73	0.0564	0.3835
	28	0.0615	1.67	0.0368	0.3754
	43	0.039	1.60	0.0244	0.3650
75	1	0.525	1.67	0.3144	0.3898
	2	0.441	1.73	0.2549	0.3878
	4	0.3465	1.87	0.1853	0.3854
	6	0.2775	1.80	0.1542	0.3821
	8.5	0.2175	1.80	0.1208	0.3790
	17	0.1365	1.73	0.0789	0.3709
	28	0.0915	1.50	0.0610	0.3651
	43	0.0630	1.33	0.0474	0.3601
105	1	0.597	1.80	0.3317	0.3687
	2	0.516	1.67	0.3090	0.3634
	4	0.4185	1.40	0.2989	0.3622
	6	0.3405	1.37	0.2485	0.3601
	8.5	0.2685	1.27	0.2114	0.3578
	17	0.1725	1.07	0.1612	0.3522
	28	0.1155	0.967	0.1194	0.3505
	43	0.072	0.667	0.1079	0.3485

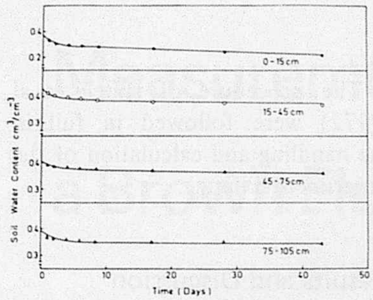

Fig. 1 Soil-water content as a function of time obtained from neutron moisture meter data

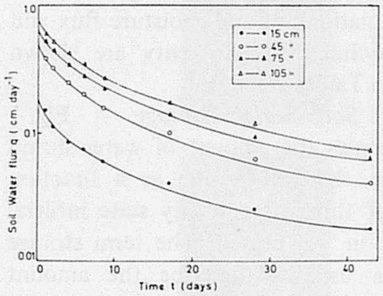

Fig. 2 Soil-water fluxes as a function of time and depth of soil-profile during internal drainage period

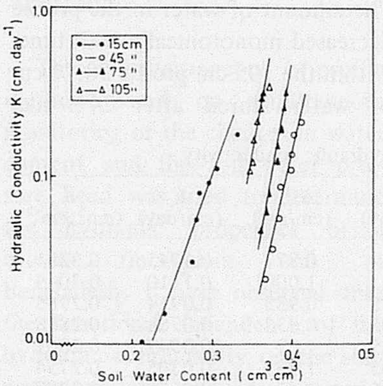

Fig. 3 Relationship between hydraulic conductivity and volumetric soil-water content at different depth of the soil profile

diminished to 36.59 cm following 43 days of drainage and redistribution, whereas at the shallow depth of 15 cm, 4.92 cm of water had reduced to 3.21 cm for equivalent times.

Soil water flux – Corresponding to the above changes in soil water storage, the soil water flux increased in general with depth and decreased with time. Soil water flux is the quantity of water leaving the profile per unit time accross a specific depth. **Fig. 2** is a plot of the flux for the four depths. Although the flux decreased rapidly during the first few days following the cessation of infiltration, water never stopped moving out of the profile during the whole experimental period. After 43 days drainage, the flux at 15, 45, 75 and 105 cm depth was 0.018, 0.039, 0.063 and 0.072 cm per day respectively.

Hydraulic conductivity – A measure of the rate that a particular soil would conduct water at a given water content is known as the hydraulic conductivity. As mentioned earlier the theory described by Hillel et al (1971) was followed in the experiment and hydraulic conductivity was calculated from the equation, $k(\theta)=q/(\partial H/\partial Z)$. The profiles of soil water pressure head was obtained by hand fitting curves to measurements at five depths described previously. Graphical differentiation of the h profiles (graphs not shown) yielded values of $\partial H/\partial Z$ at appropriate depths.

The calculated values of hydraulic conductivity "K" were plotted against mean θ in **Fig. 3** for four profile depths. It was observed that the functional dependence of soil hydraulic conductivity on the soil-water content obeyed a straight line relationship on a semi-log plot. This indicated that the function is an exponential one and can be described by an empirical equation, $K=ae^{b\theta}$, where K is the hydraulic conductivity, θ is the volumetric water content and a, b are the characteristic constants of the soil. It is also observed from **Fig. 3** that K varies from depth to depth along with water content and greater water contents are required for the same hydraulic conductivity at different soil layers. These differences in the hydraulic conductivity characteristics would be expected, because the soil profile depicts differences in its physical properties. Similar observations were also made by Olsson and Rose (1978), Nielsen *et al.* (1973)

The internal drainage method or the instantaneous profile method can readily be applied to the measurement of the unsaturated hydraulic conductivity of soils *in situ.* It is observed from the study that greater soil water contents are required for the same hydraulic conductivity in the subsoil than the surface soil. Once the hydraulic conductivity in relation to soil wetness is known for the soil profile, it would become easier to interpret soil water content and soil suction values from a cultivated field to calculate the drainage component of the field water balance. The actual rate of evapo-transpiration can also then be obtained using empirical equations.

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Alternative Gas-Fuel Producer for Driving Gasoline Engine (Part 1)—

Charcoal Gas Producer

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Introduction

Introduced here is the newest model, designed for education and training purposes in universities and institutes, together with drawings, engineering know-hows, operation instruction, and development story.

The model in the report is not a mass-production model. These models were developed in the conditon that they can be made up of materials and supplies easily available anywhere. They can also be manufactured without the aids of skilled hands, without compromising the integrity of proven structural performance and serviceability for practical use. The models introduced here is applicable to drive gasoline engines and kerosene engines of 4 to 6 PS in nominal capacity.

Acknowledgements: The authors would like to express many thanks to those who have extended cooperation for the development and designing of the models. They are Dr. Sakuzo Takeda, Dr. B.A. Stout, Prof. C.M. Hansen, Mr. Tomizo Kato.

Note: This article was translated into English and developed with additional technical data from Sakai's paper, a charcoal gas-fuel producer for driving gasoline engine (in Japanese), published by Engineering Consulting Firms Association, Tokyo, Japan in 1979.

Applications and Features

During the 1920's to 1940's when wars after wars ran havoc with the world, many advanced countries felt it necessary to develop alternative engine-fuels because of fuel shortage.

In Germany, for example, the government ordered that all vehicles but military ones had to be operated with alternative fuels. As the result, strenuous efforts were made to develop viable fuel gas generators fed with wood-chips, charcoal or coal etc.[1)2)] In Japan, about 40% of all the private vehicles were converted to alternative fuel cars. Other European nations were no exceptions. It was reported that in Sweden, about 60,000 vehicles, or about 90% of the total, had to be mounted with gas generators.[3)] The technology on the gas generator was naturally applied to the agricultural machinery such as tractors and engines, to save stringent energy situation during and after the war. From the latter half of the 1940's, however, inexpensive oil fuel glutted the world markets, totally replacing the alternative fuel producers.

This history shows that one of the most practical ways to run internal combustion engines on non-fossil fuel without major modification is to use a gas-fuel composed of mainly carbon monoxide (CO), generated by wood-chips, charcoal or coal materials.

Nuclear energy, solar energy, and other various forms of natural energy have been under study and are already utilized in our daily life to some extent. It is, however, difficult to use them directly for current agricultural and industrial engines in our daily use with no or minimum modification of the engine structure. Alcohol from sugarcane and other plants, oil from red gum and other oil plants, coal liquefaction technology, biogas, and hydrogen which is expected to become our ultimate fuel, have also been studied, but none of them are immediate answers to local energy needs for driving existing engines without any modification of their main structures. A system in which the engine is run on CO gas generated from wood-chips, coal or chacoal is quite simple compared with the future-oriented ones mentioned above, and be manufactured easily by a blacksmith in rural area and anyone who has welding skill.

The gas producer introduced herein may be felt too simple or rather primitive, but it can compare favorably with the future-oriented energy system in terms of energy efficiency (calorific value available/calorific value input).[4] In addition, the CO gas burns in the engine and turns into clean, innocuous CO_2 gas.

The first model of author's gas producers was developed in 1973, the first year of the Oil Shock, in order to give a practice to the university students majoring in agricultural machinery. In 1974, Sakai designed and exhibited the prototype of a charcoal gas-fuel generator for running stationary gasoline engines at the Energy Symposium sponsored by the Japanese Society of Agricultural Machinery. Later it was modified and the performance characteristics were studied.[5]

It happened that the foreign trainees at Uchihara International Agricultural Training Center, most of whom were university graduates from the developing countries and came to learn about Japanese agricultural machinery, visited Sakai's laboratory. They were so interested in the models that Mr. Kato, Course Head of the Center, decided to put the model on the regular workshop training curriculum. According to this decision, efforts were made to improve the models with emphasis on the following points.

1) The gas generator system should be simple enough to be manufactured easily by students who may have no particular skill.

2) All the materials for the gas generator system should be available easily in developing countries.

3) The gas generator system should be composed of as small number of parts as possible, and should be simple in shape.

4) The gas generator system should be realized with minimum welding and machining skills.

5) The gas generator system should have practically perfect performance and function when applied to engines.

6) The gas generator system should be easy to be inspected and maintained, and have a practical durability.

7) The gas generator system should be made as compact as possible, and should be intended for engines of 4 to 6 PS which are most popular in Asian farming area.

With these design conditions charcoal gas generator was chosen instead of wood-chip gas generator which is liable to discharge much tar and coal gas generator which is requested to be manufactured with cast iron against high temparature burning. This model was improved after that and the same models were manufactured in Agricultural Engineering Department of Central Luzon State University, Philippines in 1977, of Michigan State University, U.S.A. in 1978, and also in Agricultural Engineering Division, Department of Agriculture, Thailand in 1980. These models offered many technical know-hows to the authors. So that the model performance was gradually promoted. For example, it became clear that the diameter of bottom hole in the furnace was very important to have stable and continuous driving.

Charcoal is produced everywhere in the world. Charcoal is popular in rural area in developing countries as fuel for ironing and cooking etc., and charcoal price there is often much cheaper than in Japan. It might be not so simple to draw a conclusion on the economy of CO gas generator that account much on social structure and wood resources, because the commodity prices vary depending on demand and other various marketing factors.

The model shown here is not a wood-chip gas generator. However, the model can be converted into a wood-chip gas generator with reasonable modifications. In addition, it can operate the diesel engine which is added reasonable modification and adjustment. Their upgrade one is also applicable to vehicles. The auther expects to discuss these technical know-hows in other opportunity, following this paper.

As illustrated in **Fig. 1**, the gas generator is composed of a generator, 1st cleaner, second cooling cleaner, mixer etc.

Operation Principles and Structural Concepts (Refer to drawings)

Furnace

When charcoal is burned, it is converted usually into carbon dioxide gas as a result of chemical reaction between carbon, one of the main ingredients in it, and oxygen in the air.

$$C + O_2 = CO_2 \quad \ldots\ldots\ldots (1)$$

If there is no sufficient oxygen, carbon monoxide gas (CO gas) is generated, as the following equation.

$$2C + O_2 = 2CO \quad \ldots\ldots\ldots (2)$$

As carbon monoxide gas is highly toxic especially because of the strong bondage with hemoglobin in the blood, and if it is inhaled by a person, it may cause even his death. Therefore, much attention has to be paid not to breath incomplete burning gas from charcoal.

When the carbon monoxide gas is mixed with sufficient air, it is turned into harmless carbon dioxide gas (CO_2) as follows:

$$2CO + O_2 = 2CO_2 \quad \ldots\ldots (3)$$

The charcoal gas generator is a device in which the chemical reaction are described by the formulas (2) and (3).

It seems, however, the processes of generating gas in the furnace are complicated, and various explanations on the processes have been made by scientists. This is because the burning characteristics of charcoal change largely depending upon the characteristics of charcoal used,

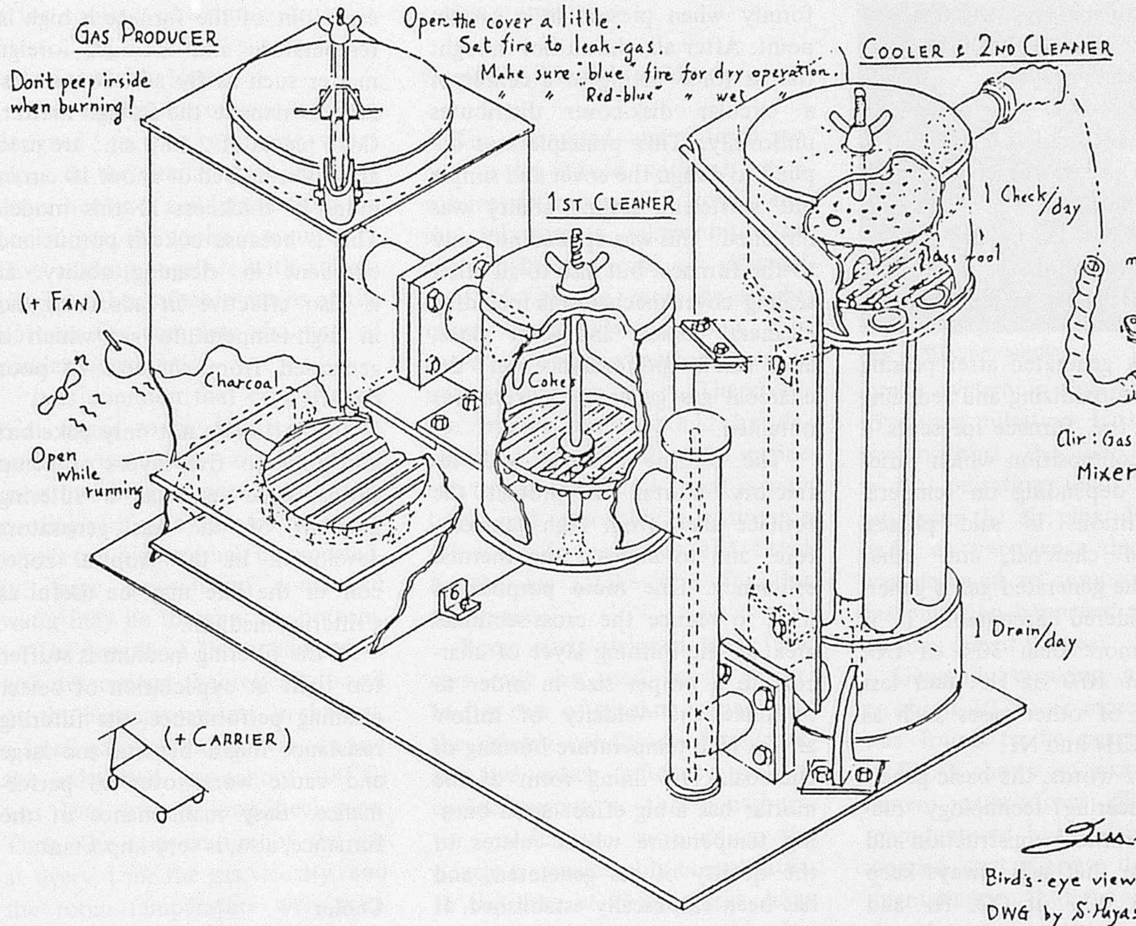

Fig. 1 Schematics

furnace structure, state of supply air, the volume and velocity of the generated gas, and so on.

The most widely accepted processes of the burning in Japan might be as shown in the following formulas.[6)]

(See Fig. 2) The temperature in the furnace is above 1 000°C in the highest part, and the burning processes may be classified into following temperature layers.

1) Oxidizing phase (burning phase) from 1 000°C to 1 300°C:

$C + O_2 = CO_2 +$
97 200 kcal/mol . . . . (1)

(In case sufficient oxygen is available for burning)

$C + O = CO +$ 29 200 kcal/mol
. . . . (2)

(In case sufficient oxygen is not available for burning)

$CO + O = CO_2 +$
68 000 kcal/mol . . . . (3)

(In case CO generated in the process given by the formula (2))

$H_2O + C = CO + H_2 -$
28 400 kcal/mol . . . . (4)

(In case the moisture in the fuel or in the air is heated to 990°C or higher)

$2H_2O + C = CO_2 + 2H_2 -$
18 000 kcal/mol . . . . (5)

(In case the steam is below 680°C)

As stated above, when the temperature in the furnance become over 1 000°C inevitably oxygen becomes deficient. As a result, the burning in the furnace becomes to generate carbon monoxide gas and at the same time to decompose moisture in the fuel or in the combustion air into hydrogen gas (H_2).

Since these two gases are useful for combustion in a engine, it becomes a basic technical know-how on a charcoal gas generator how to manufacture the furnance which

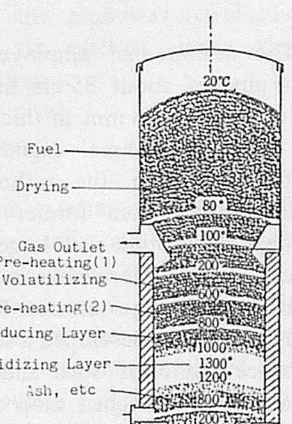

Fig. 2 Physical and chemical principle

can keep the furnace temperature high enough.

2) As is clear from the formulas (3) and (5), carbon dioxide gas (CO_2) is already useless as a fuel, but is subjected to the following process

in the reducing layer of temperature about 800 to 1 000°C, lying over the burning layer;

$CO_2 + C = 2CO -$

38 800 kcal/mol . . . . (6)

(Where CO_2 gas is in contact with red-hot carbon)

$H_2O + CO = H_2 + CO_2 -$

10 400 kcal/mol . . . . (7)

(Where CO gas is in contact with steam)

The gas generated after passing through the oxidizing and reducing layers in the furnace presents a chemical composition which varies delicately depending on temperature conditions in said phases, quality of charcoal, and other factors. The generated gas is generally considered acceptable if it contains more than 30% of CO, more than 10% of H_2, and less than 60% of other gases such as CO_2, O_2, CH_4 and N_2.[7)]

In other words, the basic generator engineering technology dictates such furnace construction and furnace use that will always keep more than 40% of CO, H_2 and other combustible gases in volumetric ratio in the generator output gas.

The author had employed an iron pipe of about 35 cm in diameter and 4 to 6 mm in thickness for the first three engineering prototypes. Then, the author received letters from former JICA trainees saying that such large iron pipes are hardly available in rural area in developing countries. Therefore, the author developed a square furnance made of steel sheet as shown in the attached shop drawings, and learned that we can design anything even though the designing conditions seem very restrictive.

To tell the truth, the author had difficult time to design the cover. Leakage of gas or air from this kind of gas generator brings poor performance. If the furnance cover is square, it is rather difficult to attain perfect gas-tightness because the square cover is not deformed uniformly when pressed at a certain point. After all, the author thought that a force acting at a center of a circular disk-cover distributes uniformly. This principle was applied to design the cover and simple but sufficient sealing ability was obtained. This was applied not only to the furnace, but also to all other sealing cover mechanisms including cleaners, cooler, and joint pipes, and stable performance of the charcoal gas generator system was obtained.

The furnace is lined with refractory mortar to protect the furnace shell from high temperature, and to increase the thermal efficiency. One more purpose of it is to reduce the cross-sectional area of the burning layer of charcoal to a proper size in order to optimize the velocity of inflow air for high-temperature burning of charcoal. The lining form of the mortar has a big effect upon burning temperature which relates to the quality of gas generated, and has been empirically established. It is very important that the diameter of the bottom hold of the mortar is 12 cm for 3 to 4 PS engine, 13 to 14 cm for 4 to 6 PS one and 15 to 17 cm for 7 to 10 PS one. These diameters can be formed by the mortar. Size of charcoal pieces should be about 3 to 4 cm^3 under the condition mentioned above.

If all the inside wall of the furnace is covered by 3 to 5 cm thick mortar, thermal efficiency of the generater can promote.

If refractory mortar is unavailable, it may be substituted by pulverized brick, clay and water.

The grating at the bottom of the furnace is properly sized and designed shakeably to dislodge ash in an efficient way, and an ash pit be provided thereunder.

First Cleaner

The generated gas which just came out of the furnace is high in temperature and includes foreign matter such as fly ash. It is necessary to remove the foreign matter. Coke pieces of 2 to 3 cm^3 are used as a filtering bed of about 10 cm or more in thickness in this model. This is because coke is porous and excellent in cleaning ability. It is also effective in adsorbing tar in high-temperature gas which is generated from charcoal of poor quality.

In the 1940's not only coke but also four to five layers of hemp cloths were used as a filtering medium of the gas generators developed. In the tropical zone, coir or the like may be useful as a filtering medium.

If the filtering medium is stuffed too tight in expectation of better cleaning performance, the filtering resistance might become too large and cause worse over all performance. Easy maintenance of the furnance, also, is very important.

Cooler

The gas from which larger dust particles are removed in the first cleaner should be cooled down to normal temperature before being supplied to the engine, in order to increase the charging efficiency of the fuel gas into the engine.

(Assume that gas has a volume, V, at an absolute temperature of $(273 + T_1)$°K. Then, its volume will be reduced by $V/(273 + T_1)$ if its temperature is lowered by 1°C.)

The authors found through calculation that if we choose the cooling device of automobile radiators which seem the best heat exchangers easily available on the market, the one of about 20 cm^2 x 5 cm is enough for the 4 PS engine.

The cooler can be made considerably small if its radiator pipe is made of a material of high thermal conductivity (usually nonferrous metal) and has fins for wider heat transfer area. However, if the cooler is of a simple structure of steel pipes or steel sheets, it has to be inevitably larger.

The models introduced here are designed to use ordinary water pipes or the similar steel pipes. As water becomes condensed from the cooled gas, the cooler is required to have a sump together with a drain plug or other suitable means at the bottom for complete draining of condensed water.

It is common that even if charcoal seems to be dry, it includes several per cent or more of moisture in gravimetric ratio. Accordingly if the furnace temperature is not high enough unexpectedly, large amount of condensed water may be found at the bottom.

The length of the cooling pipes was determined theoretically based on the preparatory test. In the test, a small gasoline engine was run and the exhausted gas (about 400°C) was lead into a long steel pipe. Then, the temperature of the gas at every 1 m, the gas velocity, and the room temperature were measured[8].

Second Cleaner

This is the second and final cleaner for the cooled gas. The filter element is glass wool of 5 cm in thickness. It was necessary to hold this element with the cleaner body because it is liable to be sucked into the engine.

In addition, the element and the cleaner should be designed in order that easy inspection and replacement of the element are able to be secured and the cross-section area of the cleaner may be large enough to prevent excessive filtering resistance.

Recently, oil-bath type air cleaner has become popular. It should be kept in mind that this type is not suitable for the charcoal gas generator system, as the oil volume increase with condensed water from gas, resulting engine stopping.

Operating Principle of Mixer

The generated and filtered gas has to be mixed with air at a volumetric ratio of 3 to 5, and the mixture is taken into the engine. In the case of charcoal gas, this mixing ratio should be taken as a reference only, because the engine performance is not so sensitive to it. Therefore, the mixing ratio should be determined in order that the engine can run at the fastest speed powerfully and smoothly. A suitable value should be made and fitted to the air intake pipe for this purpose.

Some parts stripped from junk cars may be used for a mixer. In the case of gasoline engine fuel, the mixing condition of fuel and air give much influence on the engine output, so that a carburator mechanism surrounding the nozzle is considerably complicated. In the case of charcoal gas, however, research report said that there were no significant differences in engine output between various types of mixers. The author had the same result in his study. The design of the mixer, particularly of its pipe leading to the engine, is required to fit the shape of engine carburetor air inlet pipe. Therefore it is not shown on the shop drawings. The authors expect the reader to make one on his own diea after due study of Fig. 1 and overall plan drawing. Important functions of the mixer are as follows:

A Lightweight – Usually, this mixer has to be installed instead of the engine air cleaner. If the mixer is heavier than the original engine air cleaner, excessive stress might happen and cause some trouble on it and engine.

B The overall length of air pipe should not be too short – The gas passing through the engine

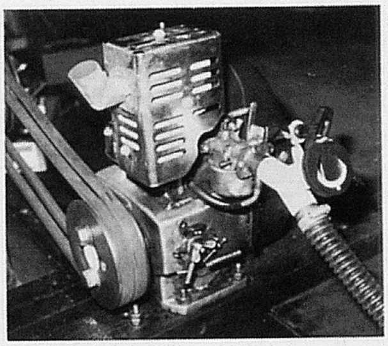

Fig. 3 Mixer example

intake system is always subjected to violent pulsation. If the air pipe is too short, the fuel gas which is also pulsating, tend to pushing out from the air pipe. The author had an experience that a mixer was designed so compact that the gas pulsation happened and caused pushing out of the gas.

Generally speaking, an air pipe of about 10 cm or more in length was found to be practical good.

Fig. 3 shows an example of a mixer made from plastics and manufactured by students. It was worried that thermal deformation might happen, but the mixer functioned well for three years as a subject for graduation thesis. Only once, the pipe was rewelded because it cracked under violent vibration.

Engine

The gasoline engine for agricultural or industrial use has a governor relating to the carburetor. On the other hand, the one for automobile use has none. This means that the carburetor should not be dismantled, if loading condition is all the time variable. When uniform load is expected like water pump, the carburetor with a governor mechanism can be removed from the engine.

Fig. 4 shows concept of the horsepower produced by an gasoline engine which run on charcoal gas without any modification. Generally speaking, engine horsepower based on charcoal gas is

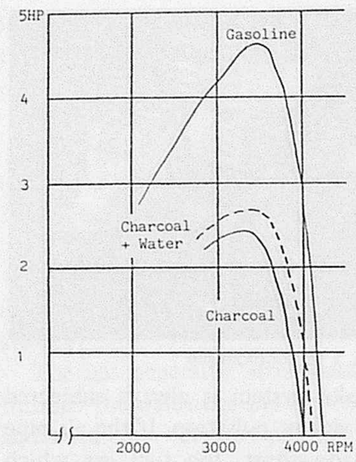

Fig. 4 Performance curve (without modification of the engine)

about half or a little more than a half of that based on gasoline. Attension has to be paid on engine adjustment to maximize the engine power. It is known that the flame velocity of CO gas mixture is slower than that of gasoline. Accordingly, engine adjustment in order to increase the engine output is as follows:

Advance the ignition timing – The ignition timing varies depending upon the type of engines, and it is difficult to state the best recommended timing like so and so degrees ahead of the upper dead center. The author's experience shows that in the case of gasoline engine, an advancement of ignition timing by 10° to 15° led to an increase of output by a little more than 10%.[8] The ignition timing should preferably be advanced as much as possible in general.

B Increase the compression ratio – It is difficult for an ordinary farmer to change the compression ratio of a engine. Even if a farmer has a lathe and can turn the cylinder head, he will not be able to make it without measuring technique of the compression ratio precisely.
(According to the tests a compression ratio change from 6 to 6.5 increased the output by a little less than 5%, but that the change from 6 to 7 increased only 3%.)[8]

Other Technical Know-Hows

A Air leak problem – The whole device must not have any gas or air leaking phenomena. Air leaking-in causes to produce poor gas or operation. When the producer set finished to be made, smoky materials such as newspaper, only cloth or wood-chip could be burned in the furnace, and give breath pressure from any inlet hole to the whole inside space of the device. Then, pin hole or clearance shows smoke leakage. Any pin-hole or clearance of the device has to be found and rewelded or repaired.

B Dry gas and wet gas – Charcoal gas which is generated without adding water is called the dry gas. On the other hand, the charcoal gas which is generated by injecting water into the generator to develop hydrogen gas (H_2) is called the wet gas. The model in the drawings are dry gas model. It is observed that, addition of water from a water tank into the air inlet for the grating at a rate of one to three droplets a second, increased the engine speed by 5 to 10%, and also increased the output by 5 to 10%. According to the past reports, it was said that many charcoal gas generators manufactured at the end of world war II were equipped with a water drip-feed device. It was common that the drip rate was adjustable for a driver observing the conditions of engine and furnace. In those days, the standard drip rate was one to two drops a second.

In order to generate hydrogen gas (H_2) by decomposing water, energy is required as shown in the foregoing formulas (4) and (5). In other wards, adding water to the generator reduces the burning temperature of charcoal. This means that the water drip rate should be determined in a manner that will not reduce the temperature of oxidizing phase (burning layer) in the furnace below the degree necessary for the generation of CO gas (1,000°C to 1,300°C).

The author found that the acceptable drip rate was 2 to 3 drops a second for the hard charcoal (e.c. for rotisserie) which is easy in rising temperature and also easy to keep temperature high. For the soft charcoal, however, which is not easy in rising temperature, the rate was less than 1 drops a second. As explained above, generation of hydrogen gas from water by making use of heat of burning charcoal increase not only the flame velocity, but the energy efficiency. It is advised to try a water drip-feed system to meet individual engine, charcoal gas generator and charcoal available.

C Start – The model have a big hole for removing ash at the bottom of the furnace. Bottom space has also a welded air inlet pipe which feeds air into the furnace even when the big hole is closed. When the start is not so urgent, ignite the charcoal with a spill under the furnace, and feed air from a big hole with a manual fan or by an domestic electric fan. The charcoal gas generator will be ready to run a engine within about 20 min.

If quick start is needed, mount a manual or industrial electric fan at the outer end of the air inlet pipe and operate it. The engine will be able to start within about 10 min. The fan need to have such a function that nothing wrong will happen concerning air intake through the air inlet pipe even after the fan stops running.

D Calorific value of charcoal and fuel cost – Charcoal is generally classified into soft type and hard type. Its quality varies widely depending on the kinds of wood from which the charcoal is made. In general, charcoal has a calorific value of 6,500 to 8,000 kcal/kg. The specific charcoal consumption G (i.e., consumption of charcoal/h/PS) is dependent largely on the quality of furnace and matching to an engine used. Specific charcoal consumption G, was in the range from 0.6 to 1.1 kg.[7)]

On the other hand, gasoline has a calorific value of about 10 500 kcal/kg. It could be said that the special charcoal consumption corresponding to 1 ℓ of gasoline will be 1 to 2 kg or about 1.5 kg on the average.[7)3)]

The capacity of the fuel tank for a gasoline engine is usually determined in such a manner that the engine can run for about a half day at a maximum rated load without refueling. It is interesting to know that the normal horsepower rating of a engine is roughly equal to the capacity of the fuel tank given in terms of liters. In the case of charcoal gas generator, the output is usually in the range of 50 to 70% of gasoline. It may be said that the charcoal gas generator will be satisfactory if hopper capacity is enough to hold charcoal whose weight in kilograms is at least three times the nominal output rating in horsepower of a given engine. However, the charcoal gas generator takes about 30 minutes to attain a thermal equilibrium after start. When charcoal left in the furnace becomes too small in quantity, the temperatures condition in the furnace deteriorates. It is also required to provide some free space above the hopper. Thus, the capacity could preferably be the value in kilograms as reduced from several times the nominal engine horsepower rating.

From the discussion above, the required volume V (ℓ) of the furnace is derived as follows;

$$V = \frac{PS \times G \times H}{Wc} + a$$

where, PS: engine horsepower rating, G: specific charcoal consumption, 0.6 to 1.1 kg/ps/h, H: continuous running time in hours, Wc: mean density of charcoal, 0.6 to 0.4 kg/ℓ.
a: freespace in the top of furnace (3 to 5 ℓ), and minimum volume for oxidizing and reducing layers.

The model is capable of running an engine of 4.5 to 5 PS in nominal rating for at least 3 h.

Tooling, Materials and Supplies, and Production Cost

The devices and tools necessary for the manufacturing of the models introduced here are a set of gas welding and cutting tool, drilling machine or hand drill, blackmith tools, and threading tools and jigs. If there is available a lathe for machining packing seats, the work will become easier. Without lathe, the packing seat can be grounded to shape.

As shown in the parts list, the materials required are mostly standard SS steel (in JIS). Bolts, nuts, and steel pipes are also available easily in the market.

There are a few items which may be a little bit difficult to get. They include flexible pipe, mortar and asbestos gasket. In Japan, the materials necessary for one set of charcoal gas generator costed about $100 in 1979.

It took about a month for two undergraduate students who have no experience in welding and spared 2 h on the average every weekday to make a gas producer set. The author helped them a little for educational purposes for welding of important parts. Another case was a team of 2 expert welding workers and about 12 unskilled students, led by the author at the Uchihara International Agricultural Training Center. The team worked 8 h a day according to a program, and could complete a gas generator within 3 days. In the fourth day, the trial driving was ready. In Michigan State University, two part-time students engaged in manufacturing a charcoal gas generator.. They worked 8 h a day at a well-equipped shop. They could complete it in a week, except for a minor mistake which was negligiable concerning the performance of the generator.

In any cases referred to above, all the necessary preparations for materials and tooling were made in advance according to the drawings and parts lists. The materials cost plus labor cost actually required makes the production cost.

In case a charcoal gas generator is manufactured in a hurry, fuel burning temperature is liable to become lowered, as its mortar is not dried and baked well. It is, therefore, recommended to dry up the mortar for more than 24 h and fill the charcoal into the generator, and then carry out baking process thoroughly. The trial run should be carried out after such preparation.

Operation Instructions

When everything is ready for starting a engine, the first thing to do is to put charcoal into the furnace. If a quick way of making a fire is needed, it may be recommendable to put a little amount of used charcoal or soft one under the charcoal.

For a stationary charcoal gas generator of small horsepower less than 10 PS the recommended average size of charcoal pieces was reported to be about 3 cm^3 according to many Japanese research papers, although considerably bigger size of it was recommended in some European papers. This may be for bigger horsepower driving device.

In Southeast Asia, charcoal is generally made from natural wood, so normal kinds of charcoal available on the market can be used for the charcoal gas generator without any trouble.

However, there is not applicable charcoal which is made from coconut shell and is used as activated carbon material. As this is too hard, it is slow in burning which means slow in producing gas and to produce weak engine power, unless special engineering ideas are added.

In the United States, it is hard to find natural charcoal. The charcoal available at supermarkets in the U.S. usually refers to briquette for barbecue. The briquette, which is called "mametan" in Japan, is press-formed from charcoal powder with additives, the briquette generates tar-laden gas, which tends to cause valve stick, and produce to plenty ashes which are not easy sometimes to be broken into free as pieces. Therefore, this is not suitable for the charcoal gas generator. To sum up, except for special charcoals of slow burning, all the charcoals are acceptable if they are proper in size.

After charging charcoal, open the top cover, and ignite the charcoal from below the grate. If an air blower is operated, the generator will start to produce combustible gas within about 10 to 15 min. This can be checked as follows. Open the top cover, and ignite the gas from the top. If the gas is nice, it will burn very well.

When the cover is closed, the combustible gas is delivered to the engine and flow out from the mixer air inlet pipe. Bring a fire near the air inlet pipe. Then the pipe will generate a jet stream of flams. If not, repeat all the process to blow up the charcoal and check at the air inlet pipe again. When nice gas from the air inlet pipe is recognized, close the air valve to turn off the flame. Stop the air blower, and proceed to the start of the engine. With the mixer air inlet of about half open and the throttle valve of fully open, run the starter. The engine will make a good start.

When the engine gets started adjust the air inlet valve to a position at where the engine runs best. If the charcoal gas generator is equipped with a water drip-feed device to produce wet gas, adjust the water feed to a rate of 1 to 2 drops a second while taking care not to reduce the furnace temperature.

In about 30 min after engine start, the entire generator will attain a thermal equilibrium state. If a engine gets started at the time when the generator is almost full with charcoal, it may run in a best condition for 1 to 2 h after start. It is important that the charcoal pieces have to move down in the furnace depending on burning process at the bottom space of the furnace. However, it happens sometimes that the charcoals pieces cannot move down because of bridging phenomena hooked by side walls. Vacant space in the furnace will become the most critical reason to produce poor gas.

When engine running becomes suddenly irregular, don't hesitate to open the top cover of the furnace, and put a stick into the charcoal, and shake the stick. The engine can start and live again sometimes.

When the charcoal left in the furnace becomes small in amount and the top layer of it becomes dull-red, it is the time when charcoal should be recharged.

In order to stop the operation, fully open or close the mixer air inlet valve of the engine.

When the operator carelessly open the generator cover during engine running or immediately after engine stopping, the combustible gas will make an explosive gas with air, and may burst into flame to burn his hair.

It is generally said that the charcoal gas generator should be cleaned once every week if it is run continually. It is recommended to inspect carefully every day.

Reference Shop Drawings, and Parts List

Model S5-3 is the fifth and latest one designed by the authors, and can be manufactured by making use of steel materials specified in JIS.

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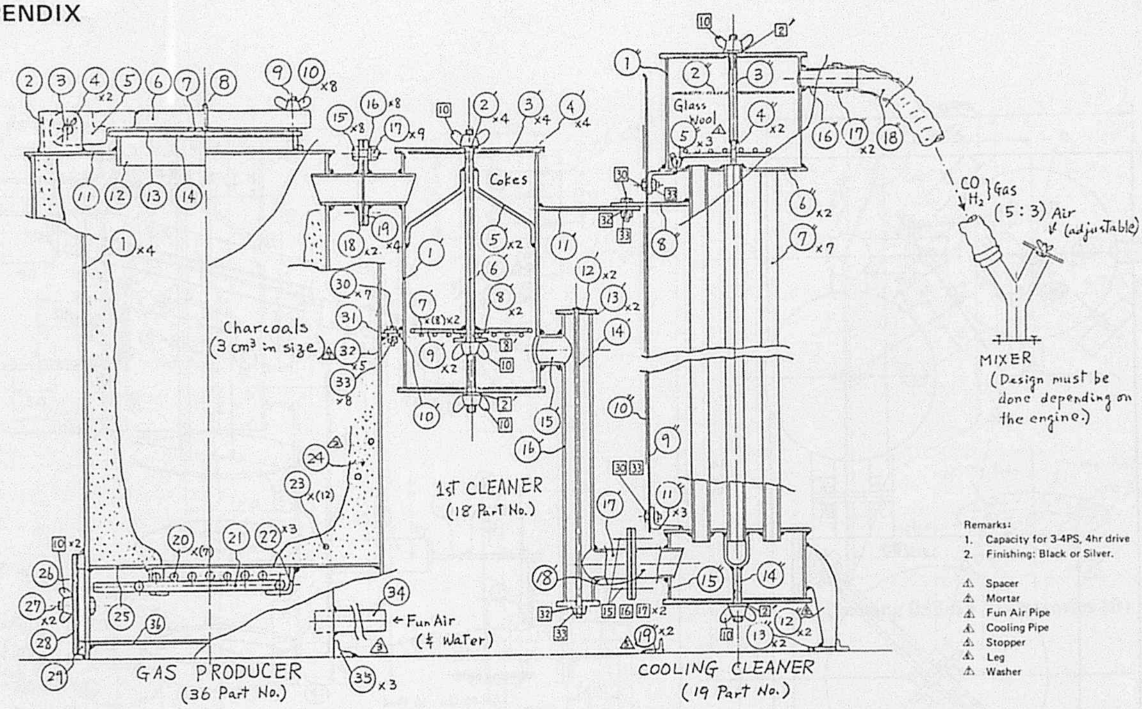


Drawing 005-1 Layout of Charcoal Gas-fuel Producer (A)

Parts List (No./Name/Quantity/Material Size & JIS)

A. Gas Producer

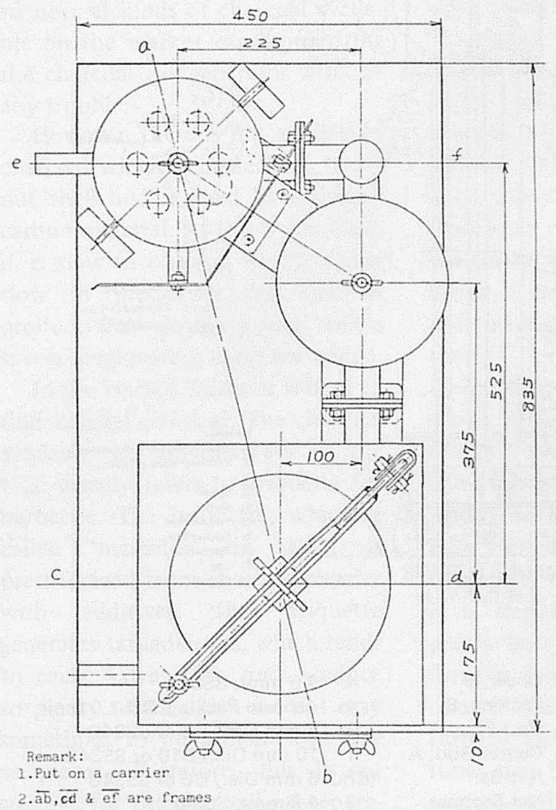
No.	Name	Quantity	Material Size & JIS
①	Side Plate	(4)	4-5 mmt, SS34P
②	Support Flange	(1)	4-5 mmt, SS34P
③	Bearing Bar	(1)	10 mm Dia. D10
④	Pin	(2)	For 10 mm Dia. Bar
⑤	Arm Plate	(1)	4-5 mmt, SS34P
⑥	Arm	(1)	4-5 mmt, SS34P
⑦	Push Plate	(1)	4-5 mmt, SS34P
⑧	Hanger	(1)	6 mm Dia., SS34B or D6
⑨	Bolt, Cover	(1)	M10x80–90 mm
⑩	Butterfly Nut	(8)	3 for 1st Cleaner, 2 pcs for Cool-Cleaner
⑪	Top Plate	(1)	4-5 mmt, SS34P
⑫	Inlet Guide	(1)	4-5 mmt, SS34P
⑬	Cover, A	(1)	4-5 mmt, SS34P
⑭	Packing, A	(1)	Asbestos Packing, 0.4-1 mmt
⑮	Bolt, A	(8)	M10
⑯	Spring Washer, A	(8)	M10
⑰	Nut, A	(9)	M10
⑱	Packing, D	(2)	Asbestos Packing, 0.4-1 mmt
⑲	Coupling Flange	(4)	4-5 mmt, SS34P
⑳	Grate Bar	(7)	10 mm Dia., D10 or SS34B
㉑	Grate Frame	(1)	10 mm Dia., D10 or SS34B
㉒	Grate Guide	(3)	4-5 mmt, SS34P
㉓	Anchor	(12)	6-10 mm Dia., D6-10
㉔	Mortar	(1)	Heat Resistant to 1 200°C
㉕	Base Plate	(1)	4-5 mmt, SS34P
㉖	Cover Plate	(1)	4-5 mmt, SS34P
㉗	Bolt, C	(2)	M10x50–60 mm
㉘	Packing, C	(1)	Asbestos Packing, 0.4-1.0 t
㉙	Frange	(1)	4-10 mmt, SS34P
㉚	Bolt, B	(7)	M6x30
㉛	Support Plate, A	(1)	4-5 mmt, SS34P
㉜	Spring Washer	(4)	M6, 2 pcs for Cleaners
㉝	Nut, B	(8)	M6, 6 pcs for Cleaners
㉞	Air Pipe	(1)	SGP20(SGP3/4"), 27.4 Dia, 2.8t
㉟	Stopper, A	(3)	4-5 mmt, SS34P

B. First Cleaner

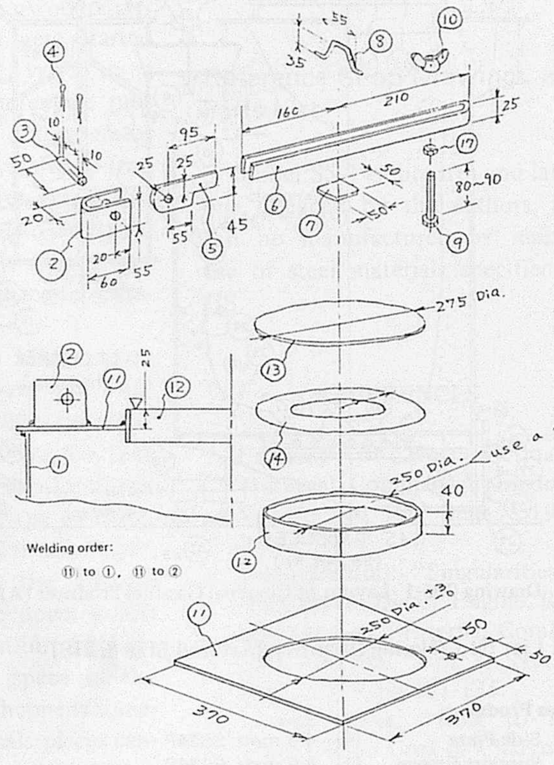
No.	Name	Quantity	Material Size & JIS
①'	Body, First Cleaner	(1)	SGP175(SGP 7"), 190.7 mm Dia. 5.3 mmt
②'	Washer, A	4	M10
③'	Cover, B	4	4-5 mmt, SS34P
④'	Packing, B	4	Asbestos Packing, 0.4-1.0 mmt
⑤'	Rod Frame	2	6 mm Dia., D6 or SS34B
⑥'	Center Rod, A	1	10 mm Dia., D10 or SS34B
⑦'	Net Bar	(8)x2	6 mm Dia., D6 or SS34B
⑧'	Net Stopper	2	4-5 mmt, SS34P
⑨'	Net Frame	2	6 Dia, D6 or SS34B
⑩'	Support Plate, B	1	4-5 mmt, SS34P
⑪'	Support Plate, C	1	4-5 mmt, SS34P
⑫'	Pipe Cover	2	4-5 mmt, SS34P
⑬'	Packing, D	2	Asbestos Packing, 0.4-1.0 mmt
⑭'	Tension Rod	1	a0 mm Dia., D10 or SS34B
⑮'	Pipe, B	1	SGP32(SGP1-1/4") 42.7 mm Dia. 3.5 mmt
⑯'	Pipe, C	1	SGP32(SGP1-1/4") 42.7 mm Dia. 3.5 mmt
⑰'	Pipe, D	1	SGP32(SGP1-1/4") 42.7 mm Dia., 3.5 mmt
⑱'	Pipe, A	3	

C. Cooling Cleaner

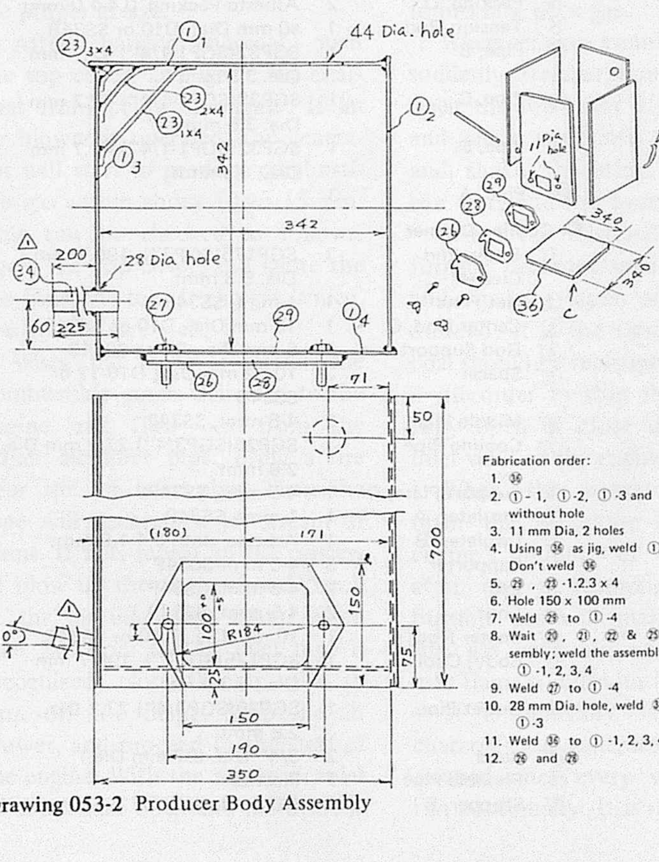
No.	Name	Quantity	Material Size & JIS
①"	Body, 2nd Cleaner	1	SGP175(SGP7"), 190.7 mm Dia. 5.3 mmt
②"	Net Plate	1	1 mmt, SS34P
③"	Center Rod, C	1	10 mm Dia., D10 or SS34B
④"	Rod Support	2	6 mm Dia., D6 or SS34B
⑤"	Spacer	3	10-12 mm Dia., D10-12 or SS34B
⑥"	Middle Plate	2	4-5 mmt, SS34P
⑦"	Cooling Pipe	7	SGP20(SGP3/4") 27.2 mm Dia., 2.8 mmt
⑧"	Support Plate, D	1	4-5 mmt, SS34P
⑨"	Insulater, A	1	1 mmt, SS34P
⑩"	Insulater, B	1	Asbestos cloth 0.4-1.0 mmt
⑪"	Supporter	3	4-5 mmt SS34P
⑫"	Leg	2	4-5 mmt, SS34P
⑬"	Foot	2	4-5 mmt, SS34P
⑭"	Center Rod, B	1	10 mm Dia., D10 or SS34B
⑮"	Body, Cooler	1	SGP175(SGP7"), 190.7 mm Dia., 5.3 mmt
⑯"	Outlet Pipe	1	SGP20(SGP3/4") 27.2 Dia., 2.8 mmt
⑰"	Band	2	3/4" Dia. (27 mm Dia.)
⑱"	Flexible Pipe	1	Plastics
⑲"	Stopper, B	3	4-5 mmt, SS34P



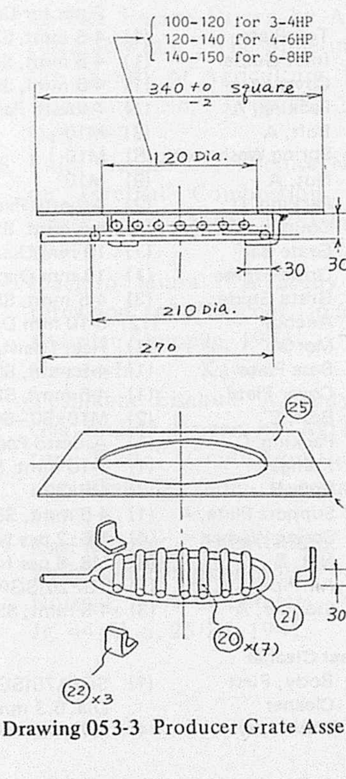
Drawing 005-2 Layout of Charcoal Gas-fuel Producer (B)



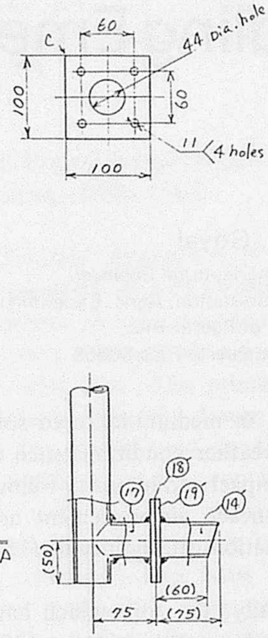
Drawing 053-1 Producer Cover Assembly

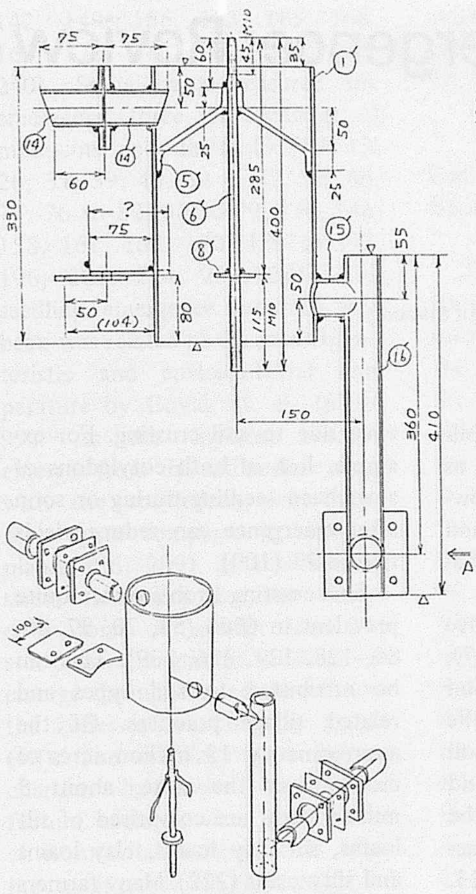


Drawing 053-2 Producer Body Assembly

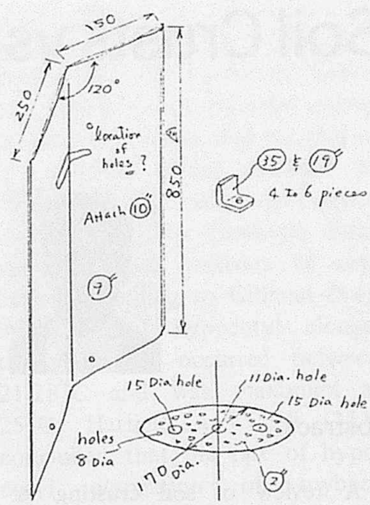


Drawing 053-3 Producer Grate Assembly

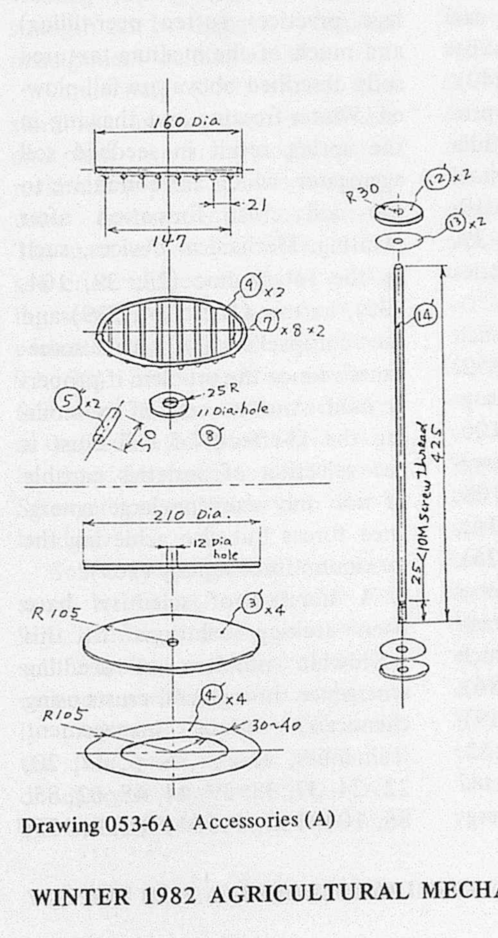




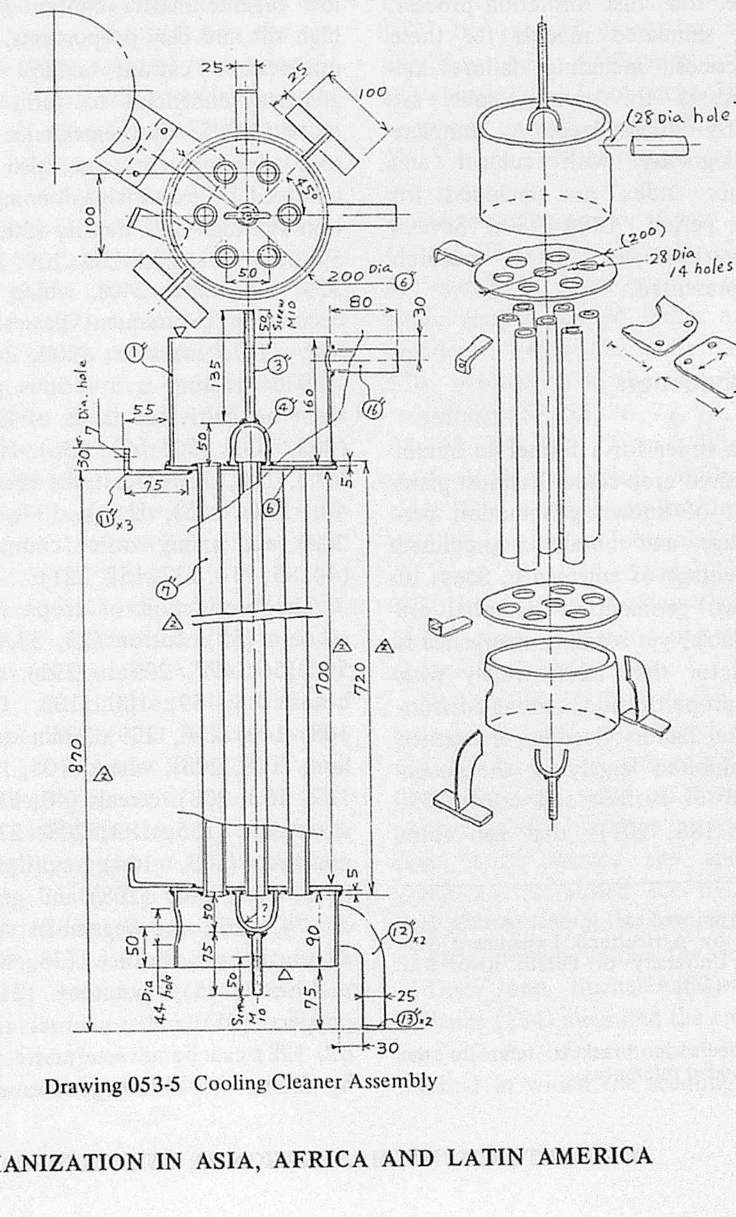
Drawing 053-4 First Cleaner Assembly



Drawing 053-6B Accessories (B)



Drawing 053-6A Accessories (A)



Drawing 053-5 Cooling Cleaner Assembly

Soil Crusts vs Seedling Emergence: Review

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Abstract

A review of soil crusting vs. seedling emergence research and related work is presented. The seedling emergence process, seedling emergence forces relative to time, soil crust formation process, and simulated models for these processes, including failure mechanisms for crusted soils, are briefly summarized. A complete bibliography with subject and author index are included for the period 1880-1980. Several suggestions for further research are presented.

Introduction

In order for a farmer to obtain a desired crop stand, he must plant seeds of known germination percentage and obtain a predicted percentage of emergence. Seeds of known germination potential are available, yet seedling emergence is a factor that varies widely with soil properties and seedling environmental factors. Seedling emergence is inhibited largely by the occurrence of surface soil crusts (39, 153, 188, 209)* that can form naturally in medium-textured soils due to weather conditions such as rainfall impact and intensity followed by surface air movement and solar radiation causing drying (153, 154).

Generally, the soils which have low organic matter content (87), high silt and clay proportions, and monovalent cations exhibit the greatest tendencies to form soil crusts (39). Seedling emergence and root development can also be hindered by excessive soil compaction and high bulk density (20, 23, 59, 101, 171, 202, 203, 209, 210, 229, 230, 231, 240), which can occur due to frequent passes by heavy field machines (209, 240).

Soil crusting is a serious problem on cultivated lands of India (103, 104, 156, 169, 236), Israel (117, 118, 120), Australia (9, 10, 40, 154, 155), U.S.A. (37, 39, 209) and many other countries (44, 85, 114, 132, 157, 221).

The production of crops such as corn (52), cotton (23, 37, 52, 59, 156, 177, 229 to 231), soybeans (88, 89, 100, 102, 106, 108, 148, 156, 239), grain sorghum (108, 208), wheat (105, 108, 137, 153, 208), cereals (40, 114), sugarbeets (135, 183, 203, 226), mustard (103, 104), sunflower (103, 104), guar (208) and grasses (74, 126), and vegetables such as cucumbers, lettuce (38, 86), radishes (115), potatoes (219), peppers (45) and tomatoes (53, 62, 128) can be adversely affected by failures to obtain good emergence due to soil crusting. For example, loss of both cotyledons of a soybean seedling during or soon after emergence can reduce yields from 8-9% (109).

Soil crusting problems are quite prevalent in Ohio (53, 70, 87, 88, 89, 128, 129, 226, 239). This can be attributed to soil types and related tillage practices. Of the approximately 12 million acres of cropland in the state, about 5 million acres are comprised of silt loams, silt clay loams, clay loams and silty clays (222). Many farmers are still following conventional tillage practices (often over-tilling) and much of the medium-textured soils described above are fall-plowed. Winter-freezing and thawing in the spring result in seedbed soil aggregates, which are conducive to the soil crust formation after planting. Mechanical devices, such as the rotary hoe (23, 39, 104, 239), harrow (103, 104, 239) and the cultipacker (39), can sometimes reduce the problem if properly used. Another way of overcoming the ill-effects of soil crust is the selection of varieties capable of not only exerting large emergence forces but also achieving the maximum force rapidly (169).

A number of scientists have been seeking solutions to this worldwide problem of seedling emergence through soil crusts using chemicals, various management techniques, etc. (4, 5, 6, 17, 20, 22, 24, 37, 38, 39, 44, 45, 62, 85, 86, 104, 114, 115, 117, 132, 135,

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*Numbers in brackets refer to the appended references.

142, 149, 156, 163, 165, 168, 169, 176, 182, 209, 226, 239, 240). Some have measured the emergence force of seedlings of monocots and dicots (9, 10, 13, 26, 31, 39, 40, 49 to 52, 58, 66, 71, 76 to 82, 87 to 99, 134, 141, 158, 161, 162, 170, 190 to 193, 196, 209, 214, 233, 234). The seedling emergence force of soybean was related to the seed characteristic and environmental temperature by Goyal, et. al., (87 to 99). As the soybean seedling emerges from the soil surface along with the cotyledons, it requires more force compared to hypogeal plants (26, 209). If the bending stress developed by the emergence force is greater than the soil crust strength the seedling will emerge through the crust or follow the zones of weakness or cracks (40). The seedling force can be changed by seed characteristic factors such as size, variety and environmental factors, thus helping to increase the percentage of seedling emergence. Soil crust strength can be changed by various management techniques (39).

Vandenberg (225) stated that simultaneous consideration of soil and plant mechanics would permit maximizing plant growth for particular environmental conditions. The state of bending stress on the soil crust surface due to an emerging seedling has been defined and evaluated by Goyal, et. al., (90 to 92, 98). The punching mode of failure of soil crusts by seedlings, as defined by Taylor, 1971, may be true for weaker crusts only. Stronger crusts appear to fail by bending.

Soil crust properties were measured by Goyal, et. al., (90, 95, 96). Bending stresses generated in soil crust by emerging dicot and monocot seedlings were analytically predicted (90, 91, 97) using the thin plate theory (220) and dimensional analysis (164). Thermal stresses which cause shrinkage cracks were not included in the analytically predicted stresses (90, 92, 98).

Soil Crust Versus Seedling Studies, 1880-1980

Seedling Emergence Process – Germination of a dicot seed is the initiation of a marked swelling of the seed followed by rupturing of the seed coat. The primary root develops from the lower end of the hypocotyl and is the first structure to make contact with the soil. As the primary root grows downward in the soil, lateral roots and root hairs develop. The hypocotyl then elongates rapidly, pushing the cotyledons upward out of the soil into the air where these separate into approximately horizontal positions on both sides of the plumule. The plumule then begins active growth, giving rise to the stem and foliage leaves. Cotyledons act as food storage factories until the leaves develop. Emergence is complete at this stage (109). Lateral anchorage is extremely important for the shoot to exert its potentially available force (51). If a zone of low soil strength is present immediately below a high strength layer, the shoot will tend to grow horizontally rather than vertically (9, 10, 40).

The effect of temperature on seedling emergence has been studied by many authors. Martin (150) while working on the Calland, Wayne, Wells and Williams varieties of soybean found that the number of hours to reach 50 percent emergence tended to decrease as the temperature increased from 10 to 35°C. The same results are reported by Overholt (167) for Amsoy 71, Chippewa 64, and Wayne cultivars of soybeans at a temperature range of 10 to 30°C. The optimum temperature for the root and hypocotyl elongation of cotton during the first four days is reported to be 27° and 33°, respectively, by Arndt (8). Grabe and Metzer (110) reported strong inhibition of hypocotyl elongation of soybeans (Ford cultivar) at 25°C and the same emergence rate at 20°C for Hawkeye, Ford and Chippewa cultivars of soybean. According to Gillman (84), inhibition of hypocotyl elongation (Amsoy) occurred between 21-28°C and was maximum at 25°C. Hatfield and Egli (111) concluded that the rate of hypocotyl elongation of soybean (Cutler, Lee 68) increased rapidly as temperature increased from 10° to 25°C and then rapidly decreased when the temperature was allowed to vary from 30° to 40°C. At 10°C the rate of elongation was very slow and at 40°C germination and elongation did not occur. They suggested a soil temperature of 25-35°C in order to get rapid emergence.

Seedling Emergence Force and Critical Time – Workers involved in emergence force studies used strain gauges bonded either on a cantilever beam (13, 161, 162, 170, 193) or on an aluminum ring transducer (52, 53, 76, 77, 78, 80, 87, 93, 94, 95, 99) in a Wheatstone bridge electrical configuration. The findings on maximum seedling emergence force and critical time obtained during 1950-1980 by different workers for different types of seeds are summarized in **Table 1**.

Williams (233, 234) found the emergence force and initial seed mass to be closely related (R^2 = 0.99). He also indicated that 70 percent of the variation in emergence force among the species could be accounted for by the amount of hydrolyzable carbohydrate reserve within the seeds.

Drew and Buchele (50) and Williams (234) measured the emergence force of monocots by a method in which the seedling was

Table 1 Results on Maximum Seedling Emergence Force, 1950-80

Crop	Force, (Newtons)	Critical time, (h)	Investigators (Year)	Remarks
Alfalfa	0.15	–	Williams (1956)	
Alfalfa	0.18	–	Williams (1963)	Var. Caliverde
	0.19	–	Williams (1963)	Var. Ranger
Alfalfa	0.14	48	Jensen et al., (1972)	Var. Ranger
Alsike Clover	0.09		Jensen et al., (1972)	
Corn	2.67	–	Drew et al., (1962)	
Corn (Var. Dixie)	2.93	–	Drew et al., (1965)	Seed size, 0.32 gm/seed
	2.37	–	Drew et al., (1965)	Seed size, 0.23 gm/seed
Corn	4.63	130	Miles et al., (1969)	
Corn	2.40	–	Gifford et al., (1969)	
Corn	0.74	–	Parihar et al., (1975)	Planting depth Bulk Density 2 cm 1.40 gm/cm^3
	0.96	–	Parihar et al., (1975)	2 1.55
	1.19	–	Parihar et al., (1975)	2 1.70
	0.65	–	Parihar et al., (1975)	4 1.40
	0.98	–	Parihar et al., (1975)	4 1.55
	1.18	–	Parihar et al., (1975)	4 1.70
Corn	0.28	40	Badhoria et al., (1977)	Var. Vijay Composite
	0.25	36	Badhoria et al., (1977)	Var. VL 54
	0.26	51	Badhoria et al., (1977)	Var. Local
Cotton	2.22	–	Drew et al., (1965)	Var. Auburn – 56
Cotton	1.99	70	Garner, Bowen (1966)	32°C, Soil moisture: 7.8%
	2.07	50	Garner, Bowen (1966)	32°C, Soil moisture: 8.5%
Cotton	3.50	–	Edwards (1966)	One seed
	5.80	–	Edwards (1966)	Two seeds
	8.50	–	Edwards (1966)	Three seeds
Cotton	2.59	–	Gifford, Thran (1969)	
Cotton (Calculated)	1.82	–	Drew et al., (1971)	Stem Dia. Axial Pressure 1.75 mm 756 kPa
	3.02	–	Drew et al., (1971)	1.75 mm 1267 kPa
	4.63	–	Drew et al., (1971)	1.75 mm 1925 kPa
Cotton	2.70	133	Drew et al., (1971)	Temperature: 23.9°C
	2.45	115	Drew et al., (1971)	Temperature: 29.4°C
	2.58	98	Drew et al., (1971)	Temperature: 32.2°C
	2.22	120	Drew et al., (1971)	Temperature: 26.7°C
Crimson Clover	0.23		Williams (1956)	
Crimson Clover	0.22	–	Williams (1963)	Var. Auburn
	0.24	–	Williams (1963)	Var. Talladege
	0.29	–	Williams (1963)	Var. Dixie
	0.29	–	Williams (1963)	Var. Common
	0.37	–	Williams (1963)	Var. Kentucky, sol.
	0.51	–	Williams (1963)	Var. Antauga
	0.62	–	Williams (1963)	Var. Mississippi, sol.
Cucumber	1.57	–	Gifford, Thran (1969)	
Lima Beans	3.04	–	Gifford, Thran (1969)	
Mechanical Seedling	3.60	–	Buchele et al., (1967)	Predicted
	3.11	–	Buchele et al., (1967)	Measured
				Tip Dia. Surface Compaction
Mechanical Seedling	0.62	–	Morton, Buchele (1960)	.269 cm 3.5 kPa
	2.49	–	Morton, Buchele (1960)	.269 cm 17.3 kPa
	4.18	–	Morton, Buchele (1960)	.269 cm 34.6 kPa
Narrowleaf-birdsfoot trefoil	0.05	144	Jensen et al., (1972)	
Radish	0.42	–	Gifford, Thran (1969)	
Red Clover	0.12	48	Jensen et al., (1972)	Var. Kenland
Red Clover	0.16	–	Williams (1963)	Var. Kenland
Rose Clover	0.24	–	Williams (1956)	
Soybean (Williams Var.)	2.64	107	Goyal (1977)	Temp. 26°C Soil Compac. 220 kPa
Strawberry Clover	0.11	30	Jensen et al., (1972)	Var. Salina
Subterranean Clover	0.59	–	Williams (1956)	
Tall Wheat-grass	0.06	–	Gifford, Thran (1969)	
Tall Wheat-grass	0.12	144	Jensen et al., (1972)	

allowed to grow in vermiculate and to develop its force against a glass rod in a vertical glass tube. Gifford and Thran (80) found positive correlation between seed size and emergence force. Miles and Matthes (158) used a linearly variable differential transformer to measure the deflection of cantilever beam due to force exerted by corn seedling. Esashi and Leopold (66) measured the physical forces in the germination of Xanthium seeds by a U-tube device which had a rubber stopper at one end to hold the seed and a strength meter at the other hand.

Jensen, Frelich and Gifford (134) concluded that seedling force differed significantly for various forage species and was positively correlated with seed mass (r = 0.91). They also indicated that the seedling vigor is determined by how fast a seedling is able to exert its force. Parihar and Aggarwal (170) found that corn seed size and depth of planting had no effect on the corn seedling force.

Badhoria, Aggarwal and Tripathi (13) observed no significant differences in the emergence force of three corn varieties, i.e., Vijay Composite, VL54 and Local. They also indicated that the probability of emergence was high if the seedling was able to exert its force earlier. The Vijay Composite Variety has a higher probability of emerging through soil crust than other corn varieties.

Taylor and Ratliff (214) measured the root growth force using a strain gauge force transducer. The root growth force was in the range of 0.2 to 2.0N, 0.5 to 3.4N, 1.6 to 5.1N for cotton, peas and peanuts, respectively. The average critical time was 14, 17 and 19 hours for cotton, peas and peanuts, respectively. Stolzy and Barley (200) found root growth pressure for peanuts as 610 kPa.

Goyal, et. al., (87, 90, 93, 94, 95, 98) experimentally evaluated

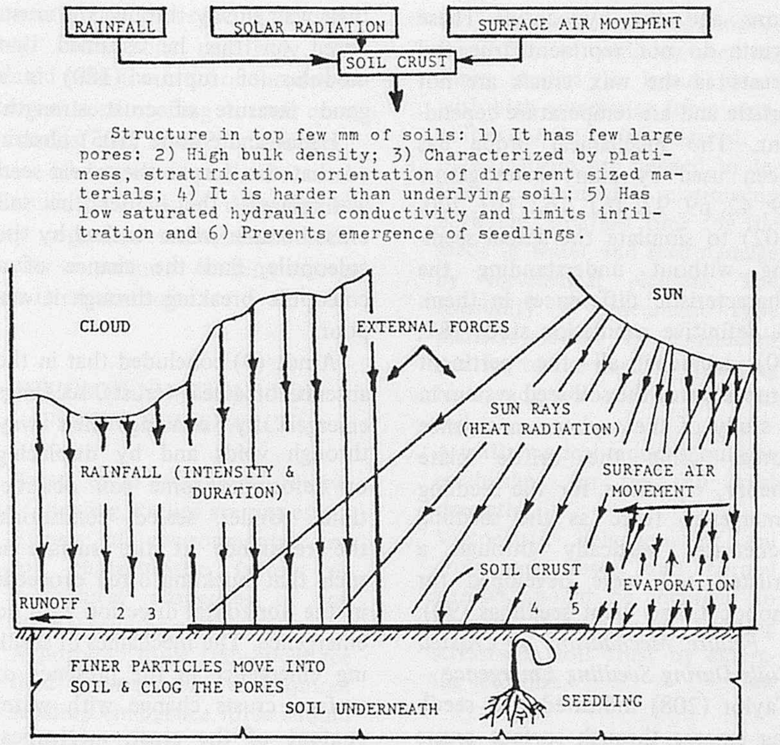

Fig. 1 Process of Crust Formation (90, 95): 1 Instantaneous slaking of soil aggregates; 2 Dispersion and orientation of finer particles; 3 Results in zone of higher bulk density at surface; 4 Soil dries and; 5 Surface tension forces cause particle interaction and orientation as shrinkage takes place and hard layer is formed.

the effects of environmental factors and other physical parameters on soybean seedling emergence force and the critical time. They found that the seedling force number vs. time index curves were similar to the sigmoid growth curve up to the critical time. The mean maximum values of soybean emergence force were 2.9, 3.5, 3.9, 3.7N at ambient temperatures of 15, 20, 26 and 32° respectively and at soil cone index of 660 kPa.

Soil Crust Formation and Its Effects – Crusts are those hard layers that develop at the soil surface due to the action of raindrop or irrigation water and subsequent drying. The structure of this layer is markedly different from that of the soil mass below (141). McIntyre (155) reported that the soil crusts formed by rainfall impact consisted of a 0.1 mm skin and 1 1.5 mm thick washed-in region. Thin structures from uncrusted soil showed an open structure with a large volume of pores. On crusting, the particles became densely packed with negligible air spaces (39). In short, the crust has higher bulk density (20, 21, 22, 23, 39, 64, 97, 106, 120, 123, 129, 144, 145, 236), lower macro-porosity and higher mechanical strength than the underlying soil (39, 129, 146, 148, 206).

The soil crust is formed (Fig. 1) as a result of: i) mechanical destruction of aggregates and simultaneous compaction by raindrop impact, ii) washing of fine particles into the inter-aggregate spaces and iii) rupture of soil aggregates by air entrapped in the previously dry soil particles (155, 206). Tackett and Pearson (206) presented a clear evidence of particle segregation under simulated rainfall and of a marked increase in density of a very thin surface layer. This densification is attributed to two factors (118): the tendency of platy particles in a state of semi-suspension to settle with their long axis horizontally, and possible attraction between adjoining particles.

The strength of the crust on any particular soil is a result of the complex physical and physio-chemical processes or reactions which are controlled by the proportion and nature of the soil components and by external conditions. Different soils respond differently to the environmental conditions to which they are subjected (39).

Probably the most important direct effect of soil crusts is on seedling emergence and early development of seedlings. Their influence in decreasing or preventing emergence has been illustrated many times. Also, seedlings may be injured by the movement of soil during cultivation of a crusted soil (39). The energy of the seedlings and soil crust impedance decide the fate of a seedling. If the energy in the seedling falls short of soil crust impedance, the seedling cannot push through the crust and the result is a poor crop stand.

Other important effects of soil crusts include reduction in water infiltration, increased runoff and erosion, reduced water-use efficiency, restriction of air capacity and internal aeration, decreased microbial activity and increased surface soil impedance (39).

Simulated Models for Soil Crusts and Seedling Emergence – Taylor (208) evaluated the emergence of wheat, grain sorghum and guar through nonporous wax surface crusts (211, 212) with wax penetration numbers (12) ranging from 15 to 20 and with thicknesses of 0.625, 1.25, 2.5 cm. He found that emergence was affected by the hardness and thickness of the crusts. Ten to 20% of the cotyledon leaves and growing tips were sheared from the guar seedlings by harder wax crusts. The hypocotyl broke at the juncture of the cotyledons and the hypocotyl. These crusts do not represent true soil crusts as the wax crusts are not brittle and are temperature dependent. The mechanical probe has been used by many investigators (9, 42, 69, 97, 161, 162, 191, 200, 202) to simulate the actual seedling without understanding the characteristic differences in them. A definitive simulation study (87, 90) included all the pertinent properties of the soil-seed system in a study of the soybean emergence force. Using the brittle plate theory, equations for the seedling emergence force as the seedling penetrates vertically through a crusted soil were developed for monocot and dicot seedlings (90).

Failure Mechanisms of Crusted Soils During Seedling Emergence – Taylor (208) indicated that seedling emerge through surface crusts by at least four mechanisms: (a) The seedlings often can exert sufficient pressure to displace soil material and create a path for a individual seedling. The hardness of crust determines the percentage of seedlings which can emerge by this mechanism. (b) A group of seedlings may exert sufficient total force to rupture and lift a portion of the crust. Through this mechanism, a group of seedlings exerting force on a small area of surface crust may have the ability to emerge through a crust which would prevent emergence of an individual plant. (c) Individual seedlings may emerge through cracks or ruptures which have developed as a result of internal stresses in the crusts (40). (d) Some of the individual seedlings, such as wheat and grain sorghum, transfer water from roots to the shoot tip entrapped in the crust. This accumulation of guttated water can change the shear strength of a soil crust.

Hanks (106) mentioned that what seedlings do not press on the crust until broken but rather worm their way slowly through the crust. Based on this he assumed that modulus of rupture (180) is a good measure of crust strength.

Hadas and Stibbe (105) observed that the deeper the wheat seed was placed, the harder the soil crust became when reached by the coleoptile, and the chance of a coleoptile breaking through it was poor.

Arndt (9) concluded that in the absence of a seal (crust), seedlings emerged by weaving their way through voids and by displacing or deforming some soil obstructions. Under sealed conditions, the resistance at the surface is such that buckling often proceeds in the horizontal direction with no emergence. The mechanics of seedling emergence in the presence of surface crusts change with water content of the crust, mechanical composition of the soil, frequency of cracking, size of the seedling, location of the seedling in the vertical plane and location of the seedling in the horizontal plane particularly w.r.t. positions of the natural cracks in the seal. He presented 6 broad classifications of impedance mechanisms (**Fig. 2**) based on crust cracking characteristics and seedling size: (a) Adequate cracking for fine seedlings which are flexible with relatively ineffective lifting force. Here the cracks are sufficiently frequent and wide to permit free emergence of most of the seedlings either directly or by reasonable detours, (b) Adequate cracking for coarse seedlings which are rigid with relatively effective lifting force. Here the strength of small plates in immaterial, (c) Inadequate cracking for fine seedlings causes delayed and partial emergence of sown crops by detouring. In the case of self-sown annuals, the plates are lifted bodily without tilting and jamming on neighboring plates since the combined effort is sufficient to overcome the gravitational force of the plate. (d) Inadequate cracking for free emergence of coarse seedlings. Here a jamming situation arises which the seedling may or may not overcome. (e) Absence of cracks for fine seedlings. Since the individual seedlings have little lifting power, they cannot emerge unless the seal is very wet, or the stand is dense enough for the combined effort to produce shear failure of the seal. (f) Absence of cracks for coarse seedlings. The seal is held rigid over the seedling by its wide extent. The displaced cone may be small and remain intact, or it may be large with secondary ruptures which are probably caused by tension in the upper surface due to the weight of cone the point of lift. This secondary failure was similar to the condition of loading in the Richards' apparatus (180). In general, for fine seedlings the frequency of cracking was most effective whereas both size and frequency of cracking were significant for caorse seedlings.

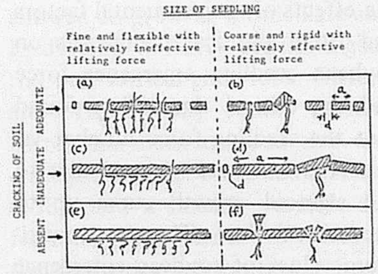

Fig. 2 The main combinations of seedling size and crust cracking characteristics used in the identification of failure mechanisms (Arndt, 1965a).

Assur (11) mentioned punching of crusted sheets (salt ice) due to highly concentrated loads.

Taylor (209), while reviewing the work of others, mentioned that emerging seedlings, with a shoot about 1 mm or less in diameter (grasses and cereals), usually displace soil particles by compression and shear until the tip is near the soil surface. At that time, if the force transmitted by the tip is sufficient to overcome the tensile strength of the soil crust, an inverted cone of soil is ruptured out of the crust. Seedlings of dicotyledonous crops emerge by rupturing the soil crust in a dome or cone large enough to accommodate the cotyledons.

The failure mechanisms mentioned above may be true for the weaker crusts and not for the stronger ones. It was hypothesized by Goyal, et. al., (97, 98) that stronger crusts appear to fail in bending during seedling emergence. They developed an analysis to predict the state of soil crust surface bending stresses generated by emerging dicot seedlings using the thin plate theory (220) and dimensional analysis (164). The concluding results were as follows: The bending stress number was positively correlated with the ratio of down-the-row seed spacing to hypocotyl radius but negatively correlated with the ratio of the down-the-row seed spacing to soil crust thickness and with the index of ratio of uncrusted soil and crust modulii. Based upon these results they suggested management techniques to promote seedling emergence in crusted soils.

RECOMMENDATIONS FOR FURTHER RESEARCH

Based upon the above review, the following studies are suggested:

1. Effects of environmental and soil characteristic factors on mechanical properties of soil crust should be evaluated.
2. A portable force transducer for field measurement of required seedling emergence force should be designed and developed.
3. Possibility of utilizing seedling force studies to breed plants with high emergence force capabilities should be investigated.
4. Investigations are needed to determine any possible relationship between retention time for the seeds in water and seed damage by mechanical planters. The feasibility of pneumatic type planters should be considered relative to the need for planting high moisture seed in crusted soil.
5. A mathematical model should be established for the soil crust strength.
6. Viscoelastic behaviour of soil crust and subsoil, and thermal stresses should be included to predict the surface bending stresses in soil crust by emerging seedlings. ■■

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Announcement

Amendment of AMA's Editorial Policy and Guideline

In view of the rising costs of printing, mailing and other charges, the AMA management regrets that the standing editorial policy and guideline pertaining to *A Note to AMA Contributors,* will have to be amended as of the Winter issue, Vol. 13. No. 1, 1982 as follows:

Item c of the policy on *Rejected/Accepted Articles* should now read: "The AMA does not pay for articles published. However, the writers of accepted articles are given 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)"

The AMA management is confident that the contributors will appreciate the problem behind this amendment and that, as usual, they will continue to extend their cooperation.

Food Production and Rural Development in Commonwealth Countries

by
Nurul Islam
Minister of Agriculture
Bangladesh

On summerizing the working papers of the Commonwealth Secretariat on Food Production and Rural Development, we find some areas where current initiative could be expanded or intensified and where new initiative could be launched. These include:

a) Increasing food production in small island states;

b) Intensification and development of programme for small and medium farmers on post-harvest technology, with special emphasis on the reduction of post-harvest losses;

c) Further attention to livestock production, particularly the smallholders;

d) Assisting member countries with project identification and preparation;

e) Agricultural and rural development management training;

f) Management of fisheries in EEZ;

g) Initiation of poverty-oriented rural development programme;

h) Development of epiculture and sericulture programmes; and

i) Exploration of areas of further regional collaboration in agriculture and rural development.

One would readily agree that the areas enumerated are important and deserve support. What I would like to do is to emphasise some priority areas and delineate certain activities that I consider essential for accelerating agricultural production. In doing so I would draw on our own experience.

Water Management

Water is the life-blood of agriculture. The security needed by farmers for investing in the known seed-fertilizer technology can only be provided through expansion of the irrigated acreage plus drainage and flood control. Two-thirds of the envisaged incremental production in the five-year food production programme of Bangladesh will come from irrigation alone. To achieve this target, new irrigation facilities need to be developed. What is equally important is to expand the irrigation coverage through better management and institutional infrastructure. I, therefore, strongly suggest that greater efforts be made for the development of water management programmes, through exchange of experiences among the various countries of the Commonwealth. The Secretariat can be a catalyst in such regional or pan-Commonwealth wide exchange of experience.

Soil Depletion and Corrective Measures

Soil depletion is a major problem facing the world today, particularly the less developed countries many of which are in the Commonwealth. According to FAO estimates, of the total 1-5 billion hectres of arable land under cultivation 5-7 million hectres are being completely lost to agricultural production every year through 'soil depletion. Unfortunately not much has been done to arrest the trend of such depletion. Recent FAO initiatives are also inadequate. We would, therefore, urge the Commonwealth Secretariat to initiate special programmes for in-depth investigation into problems connected with soil erosion, salinization, pollution, desertification and forestry operations.

Technology Transfer and Agro-support and Agro-Based Industry

In recent times there has been a lot of talk about transfer of technology, but very little about building up local manufacturing capability. The result, for example, has been uncertain availability of agricultural equipment and in some cases 'stop and go' financing. I agree that it is important to carry out experiments on the improvement of indigenous equipments. It should, however, be borne in mind that appropriate technology does not necessarily mean obsolete technology. Selective mechanisation might be the only way out for realising the growth potential of countries like Bangladesh so that the turn-around time between two crops and post-harvest loss can be minimised.

The case for mechanization of agricultural operations in a labour-abundant, developing country, appears at first-sight rather ill conceived. However, on closer examination it is revealed that introduction of HYV technology and intensive multiple cropping system impose severe limitation on available turn around time for ploughing, sowing, weeding, harvesting, threshing, etc. Selective mechanization becomes inevitable for an increase in the productivity of agricultural labour.

In a country like Bangladesh where farming has always been a part of living rather than an economic or business proposition, the production plan worked out by the farmers is in general linked to their immediate needs. What is available in excess of farmers needs depends largely on the weather. Local and potential surpluses have not yet been tied with the forward linkages which could provide price incentives for sustained growth in farm surplus areas.

The forward linkages imply agro-based industries which could add value to the surplus farm produce. Surplus farm products are preceded by the introduction of modern seed-based technology, HYVs, increased fertilizer use, multiple cropping systems and improved cultural practices which require backward linkages of agri-support industry.

During the last few years, as a result of the introduction of modern technology, there has been a significant increase in production in some Commonwealth countries. But in order for the products to have value added they have to be processed. In order to develop production and sustain growth, storage, marketing and processing activities will have to be geared and post-harvest losses minimised. The introduction of agro-based industries is thus so very important that involves the generation of appropriate technology packages.

In this field, there is a need to share the experience of countries in the region and the Commonwealth which have successfully transferred technology to the user and to establish a transfer chain of research, development, engineering design, fabrication, installation, commissioning and production.

Small Farmer Credit Programme

In Bangladesh about 50 percent of the population is landless. The problems of the small and marginal farmers are of special significance not only from the equity point of view but also from the perspective of effective demand. How do they get access to credit or to employment opportunity? In spite of the rhetoric, we are yet to evolve an effective credit delivery system for the small and marginal farmers. The Secretariats' initiative in this complex field will be quite challenging, although difficult.

Agrarian Reform

Coming to question of institutions, there has been a lot of talk about agrarian reform in international and national fora. The share-croppers in many countries still do not have any tenurial right, while legislative land-reform has often been an excuse for perpetuating the existing power-structure. Even if the political will is there, administrative and procedural problems are yet to be overcome and land-records are to be set right. A proper cadastral survey requires investment. Post-reform credit and technological package are to be provided to the beneficiaries. The beneficiaries are to be organised.

The need for such reform is well enunciated and exhaustively documented. What is important is how to go about it. If the Secretariat could initiate actions on implementation of various ways and degrees of land-reforms, I shall personally welcome the same.

Development of Information Network for Co-operation Among Commonwealth Countries

In order to make technical co-operation among Commonwealth countries meaningful and effective, there is an urgent need for the establishment of a communication training and research network. The member countries should be able to know, as quickly as possible, developments in the field of research, extension and technology among the community of Commonwealth. Clearly, the Commonwealth Secretariat has a major role to play in this regard. There are a number of areas in which we have complementary capacities to tackle priority problems of common concern. It is unfortunate that the Commonwealth assets of know-how, places of advanced learning technical manpower and consultancy potential are not effectively utilised. A mechanism need to be developed so that these resources can be pooled and shared by the member countries for their common benefit.

The areas of activities I have mentioned are by no means exhaustive. I am sure that my distinguished colleagues with their vast experience and wisdom will be able to suggest other areas of activity to be undertaken by the Food Production and Rural Development Division. ■■

International Conference on Agricultural Engineering and Agro-Industries in Asia

Nov. 10 - 17, 1981 Bangkok, Thailand

This conference organized and financed by the Asian Institute of Technology, Bangkok and collaborated with ASAE and UNIDO, aims at bringing together agricultural engineers and other professionals in related fields from the Asia-Pacific region in particular, but also from other parts of the world, to discuss the state-of-the-art, to define research needs, and to exchange ideas and experiences on the contribution of agricultural engineering to the development of agriculture and associated industries. This first international Conference in the Asian region is a significant step towards achieving these goals. The main objectives of this Conference are: 1. to identify areas requiring research and development work to help agricultural industries to increase food supplies; 2. to stimulate basic and applied research in the fields of agricultural engineering and agro-industries; and 3. to promote the exchange of ideas and experiences pertaining to present and future developments in agricultural engineering and agro-industries.

The conference was attended by 300 participants from 21 countries and more than 70 papers were read in the respective sessions.

APO Symposium on Farm Mechanization

November 24 - 30, 1981, Tokyo/ Japan

The government of Japan hosted the APO Symposium on Farm Mechanization in Tokyo on 24-30 November, last, which was implemented by the Agriculture, Forestry and Fisheries Productivity Conference (APC) in cooperation with the Ministry of Agriculture, Forestry and Fisheries. Fourteen participants from 10 member countries and 2 non-member countries, 9 resource speakers (from the International Rice Research Institute, ESCAP and the University of California at Davis and local institutions), and 10 observers from both local government and private sources attended the Symposium. The participants also took time out to observe the operations of the Rice Center at Konan-mura and the Institute of Agricultural Machinery at Omiya, both on the outskirts of Tokyo.

Five major topics were the central focus of discussion, namely; i) Trends in Farm Mechanization and Farm Machinery Supply in the Region; ii) Technological Aspects/Problems of Farm Mechanization; iii) Socio-Economic Aspects/ Problems of Farm Mechanization; iv) Government Policies for Farm Mechanization; and v) Main Issues and Future Prospects of Farm Mechanization in the Region.

Among other major considerations, the Symposium noted that:

i) In most of South and Southeast Asia, only partial agricultural mechanization has taken place. On the other hand, mechanical power has completely replaced draft animals as source of farm power in Japan; almost completely in the Republic of China, and to a considerable extent in the Republic of Korea; farm machines are important for land preparation and transport in the Philippines, Thailand and Sri Lanka wherein draft animals remain equally important sources of farm power; in India and Pakistan where draft animals are also important, the use of farm machinery has gained headway, particularly in wheat production; and Indonesia and Nepal depend mainly on human and animal power for agricultural production.

ii) The current pattern of mechanization adoption found in labour-abundant areas of Asia is not expected to create rural employment problems because reduced labour needs per unit of production are, in part, offset by increases in the economic intensity of production.

iii) Agronomic changes and farm mechanization complement each other for greater crop yields and productivity, particularly in member countries where farm mechanization has advanced considerably. The attainment of higher crop yields and use of multiple cropping practice through selective mechanization should be the main goal.

iv) The development of the farm machinery industry is still in its infancy stage amidst abundant farm labour in most of Asia. The industry, in general, is small in scale and is faced by the lack of adequate financial means and research capability.

v) Increasing fuel prices can only have a negative impact on the costs of field machinery operations but greater adverse effect on the costs of pumped irrigation water and nitrogen fertilizer which consume more energy.

(Courtesy of the APO News, Vol. 12, No. 1, January, 1982)

International Congress of the 12th Agricultural Machinery Exhibition "Landbouw RAI 82"

January 19-20, 1982, Amsterdam/ Netherlands

An international symposium will be organized on Agricultural

NEWS

Mechanization in Tropical and Developing Countries. The following themes will be dealt with:
- the mechanization of rice production
- the mechanization of potato production
- the mechanization of soil tillage
- the drying, processing and storage of tropical crops.

Special exhibition

The implements being used in mechanized farming in tropical countries will be on show at a special exhibition in the RAI building.

Information on agricultural mechanization in the tropical and developing countries will further be given by experts from the Agricultural College, the Institute for Mechanization, Labour and Buildings, and other agricultural institutions in Wageningen.

Landbouw RAI 82

The congress and the special exhibition will be organized during the International Exhibition for Agricultural Mechanization, Landbouw RAI 82, which is to be held from 18th to 23rd January, 1982, at RAI, Amsterdam, the Netherlands.

The exhibition programme includes: new implements and machinery for agricultural and horticultural purposes, including tractors, machines and other mechanical aids for arable and grassland farming, animal husbandry, fruit growing, field vegetable production and forestry.

Furthermore farm buildings and equipment and other products for use in farming and field vegetable production, such as feedstuff, seeds, fertilizers, crop protection chemicals, tools, engines, fuels and lubricants.

In 1982, there will be more than 250 exhibitors at Landbouw RAI.

In 1980, the exhibition attracted 113,814 visitors - a new record.

SIMA — The 53rd International Exhibition of Farm Machinery

March 7-14, 1982, Paris/France

No show in the world presents such a wide choice of equipment: under 2 300 trademarks originating from 30 countries, almost 20 000 machines and items of equipment are exhibited covering all types of use, all requirements for all countries.

Farmers, technicians, dealers, industrialists, teachers and researchers thus form a universal symposium where the latest evolutions in technique, the latest progress in agronomy, the latest requirements of users are all discussed.

The 14th international exhibition of mechanised gardening equipment: In 1982 there will be many novelties amongst the 3 000 items of equipment for activities ranging from gardening and horticulture to the creation of green spaces and the maintenance of the landscape.

The international club: This is the meeting place where visitors from five continents cand find the atmosphere and the conveniences conducive to the comfortable prolongation of their contacts: a reception and rest center, a bar, a fast-service restaurant, hostess and interpreting services.

SaudiAgriculture 82

April 25-29, 1982, Riyadh/Saudi Arabia

SaudiAgriculture 82 will take place at the newly constructed, purpose-built al-Dhiafa Exhibition Centre in the Olaya district of Riyadh. The Exhibition Centre, which is fully air-conditioned, has all the facilities expected of a major exhibition complex. The Centre has 6,000m^2 of inside space and 4,000m^2 of outside space.

EXHIBIT PROFILE:

Farm Buildings and Equipment

Machinery and Equipment
- Agricultural tractors (current annual imports in excess of 2,500 units).
- Agricultural implements including ploughs, cultivators, drills, harrows, balers, combine harvesters, spraying and dusting equipment, fertilizer distributors, mowers, hand implements.
- Engines and pumps
- Irrigation equipment
- Horticultural systems and equipment
- Handling equipment
- Food processing machinery and equipment

Animals and Livestock Production Equipment and Systems

Crop Cultivation
- Seed.
- Fertilizers.
- Chemicals.
- Insecticides and pest control equipment.

Auxiliary Products and Services

Elmia Landbruk 82
International Trade Fair

June 10-15, 1982, Elmia, Jönköping/Sweden

The international trade fair that has become the traditional meeting point for agriculture and horticulture in the Scandinavian market. A comprehensive presentation of current ideas and the latest developments in agricultural technology.

Agricultural machinery exhibition

In the Elmia exhibition grounds:

NEWS

The big exhibition of agricultural machinery and equipment, the core of the trade fair, is arranged, as usual, in close cooperation with LELA (the Swedish Association of Suppliers of Agricultural Machinery). It includes:

- Agricultural buildings: materials and construction, equipment and technical fittings
- Tractors and tractor equipment
- Machinery for soil preparation, manure and fertilizer distribution, and for sowing
- Machinery for harvesting
- Machinery for beet and potato growing
- Equipment for drying, storing and other handling of grain and strong feeds
- Equipment for mechanization of animal husbandry
- Sprayers, pumps and chemical preparations

In exhibition halls 2 and 3: Here will be shown, to mention only the largest product groups: equipment for indoor mechanization, stable fittings, poultry farming equipment, pumps, motors, spare parts, technical components, communication radio equipment, personal safety equipment. Information stands, arranged by authorities and organizations, will also be found here.

Horticultural machinery exhibition

In the Elmia exhibition grounds: machinery and equipment for gardens of different sizes and for different uses.

Livestock section

In the exhibition grounds, the show rings and the stables: a large number of animals of Sweden's foremost breeds of horses and cattle will be shown in cooperation with the breeders' associations.

Who attends the trade fair?

Elmia Lantbruk 82 is one of the most important international trade fairs on agriculture and horticulture in Europe. Its target group is made up of top experts on agriculture and horticulture in Sweden and the rest of Europe; representatives of industry, authorities and research bodies; and, of course, farmers.

Elmia Lantbruk 80, the previous farming trade fair, attracted 99,320 visitors, about 7,000 of whom came from abroad. (Source: Advertising Statistics Ltd.) This means that most Swedish farmers visited the trade fair which has become a must for all those planning to invest in new machinery.

For information contact:

Elmia Lantbruk 82, Elmia AB, Box 6066, S-550 06 JÖNKÖPING, Sweden

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Drip Irrigation Committee was established in the College of Agricultural Sciences University of Puerto Rico

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The committee was established in March, 1981 with the objectives to promote the science and art of various disciplines in drip irrigation research; to stimulate efforts towards productive research and intension to extend and increase the association of allied scientists and technologists; to encourage professional improvement; and to broaden the usefulness of drip irrigation discipline in cooperation with other groups.

Active members of this committee are scientists assigned to the regional project S-143 (H-326) entitled "Trickle Irrigation in Humid Regions", other collaborators in the college and representatives from state/federal agencies working for agriculture.

Responsibilities of said committee include

(1) Review - existing drip inrrigation projects, work plan for new proposal, work plan for coming year, manuscripts for publication;
(2) Meet as scheduled
(3) Arrange at least one seminar on "Drip Irrigation Developments in Puerto Rico" during the year;
(4) Coordinate and plan research and extension programs relating to drip irrigation. ■■

BOOK REVIEW

RNAM-Digest 2
Power Tiller — Design, Development, Manufacture and Marketing
(Philippines)

The foreword states: RNAM has been able to organize itself to address so fundamental and pervasive a problem as changing the technical and economic equilibrium faced by small farmers (characterized by static technical, social and economic conditions and low productivity and slow growth) through introduction of superior working devices. It is definitely poised for a greater pay-off, when it embarks upon its second phase next year. One of the important activities of RNAM is to function as a clearing-house of information on farm mechanization programmes and relevant technological developments in the field of farm machinery, implements and tools and to strengthen documentation and reference materials and services at the participating national institutions. Notable progress has been made in this activity. Nine newsletters, a Digest on Rice Transplanters, a Regional Catalogue of Agricultural Implements giving details and drawings of 156 implements from developing countries, four consultants' reports and 26 technical circulars have been released. This work is to be continued in future.

The next in the line is this Power Tiller Digest. RNAM collected technical material from different institutions, countries and publications and after compiling all the useful information, prepared a tentative draft which was then circulated to experts in FAO, UNIDO, IRRI, participating countries and to the technical Advisory Committee for eliciting their views and comments. This publication has taken benefit of the valuable comments received. It is hoped that the information contained herein will prove useful to planners, administrators and professional engineers in the developing countries of Asia and the Pacific.

Size: 22.5cm x 15cm, 76p.

Published by Regional Network for Agricultural Machinery (RNAM) Los Banos, Laguna, Philippines

Design and Operation of Farm Irrigation Systems
American Society of Agricultural Engineers
(U.S.A.)

ASAE has published a new monograph edited by M.E. Jensen, USDA-SEA/AR, Beltsville, MD. The purpose was to both collect the many facets of the state-of-the-art and to try to improve the state-of-the-art where significant advances had been made.

The monograph goes beyond the typical indepth review of subject literature by providing guidance to practicing engineers and engineering students who use the material presented for designing irrigation systems. For this reason sample calculations are included.

The book fills a need for a major reference in systems management research while attempting to assemble in one place recent advancements in irrigation theory and science as a basis upon which to build future technology.

Size: 23.5cm x 15cm, 829p.

Binding: Hardcover, Price: $44.95

Textbook discounts allowed.

Published by American Society of Agricultural Engineers, P.O. Box 410, St. Joseph, MI 49085

Forest Regeneration
American Society of Agricultural Engineers
(U.S.A.)

This book covers the Proceedings of the Symposium on Engineering Systems for Forest Regeneration, March 2-6, 1981, Raleigh, NC.

There are many facets of the forest cycle from seed to harvest to use. However, this Symposium was generally limited to those operations normally referred to as regeneration, which include areas such as seedling production, seed orchard operations, site preparation, timber stand improvement operations, and protection. In years past, all of these operations have been labor intensive and costly. In many cases the survival rate of trees has been low due to poor quality manual work. Rising costs, increased acreages being worked, need for higher quality results, and decreasing manpower availability all dictated the urgency of mechanization. Here, then, was the challenge for agricultural engineers, and most especially for those in the new discipline called Forest Engineering.

In order to take advantage of the broadest expertise possible, it was decided to make this Symposium international in coverage. This would provide the greatest opportunity to present the state-of-the-art concepts and an open forum for information exchange among leaders in research and development.

Size: 23cm x 15cm, 376p

Binding: Softcover, Price: $24.50

Published by American Society of Agricultural Engineers, P.O. Box 410, St. Joseph, Michigan 49085 ■■

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

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

Format/Style Guidance

a. 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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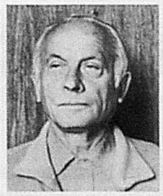




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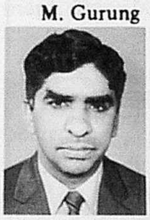




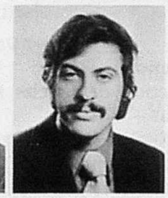

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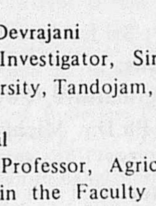
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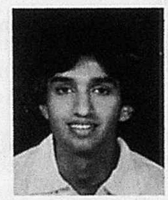

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M.Sc., Ph.D. Michigan State Univ., 1978

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Use of Alternate Energy Systems for Agriculture in Developing Nations.

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BACK ISSUES

(Vol. 12 No. 1, Winter 1981 ~)

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INDEX TO ADVERTISERS

CONTRIBUTORS WANTED

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

FARM MACHINERY INDUSTRIAL RESEARCH CORP.

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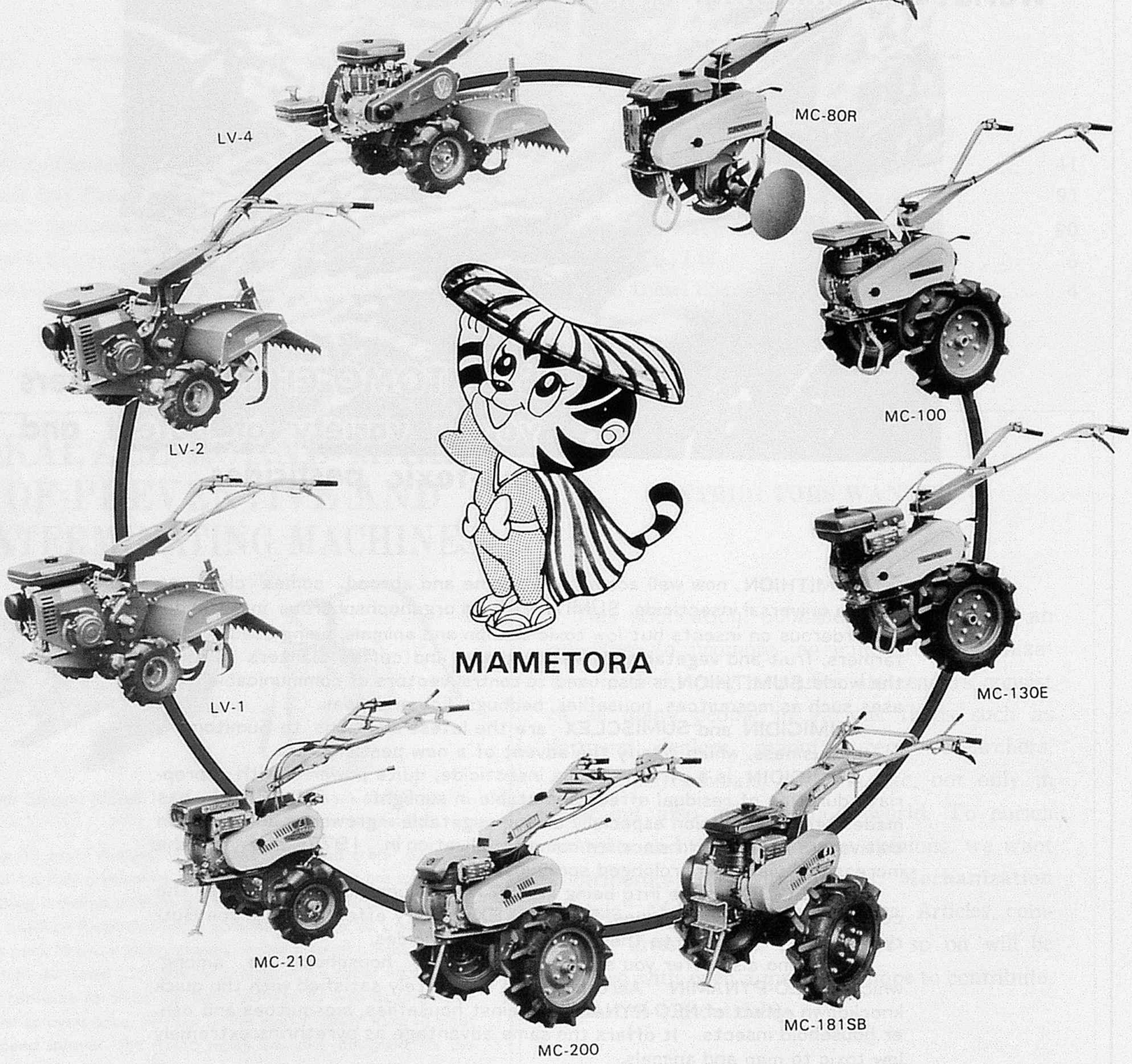

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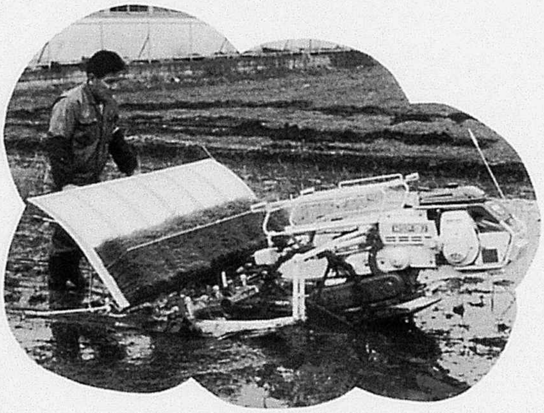
This is cassette type transplanter only to put in seedling boxes. Suitable for Chinese cabbage, lettcue, cabbage and cauliflower.

Tobacco transplanter that is mostly used for trans planting tobacco in Japan.

Plowing operation by Mametora Tiller.



Oil pressure is largely introduced to this planter, and so this Mametora Planter is easy to use. This can be used for planting all Kinds of seed-lings from small to large.

Operation in a greenhouse by Return Cultivator SR Type. This has wide application for seedbed, ridge and cultivation in orchards.