International specialized medium for agricultural mechanization in developing countries

ISSN 0084-5841

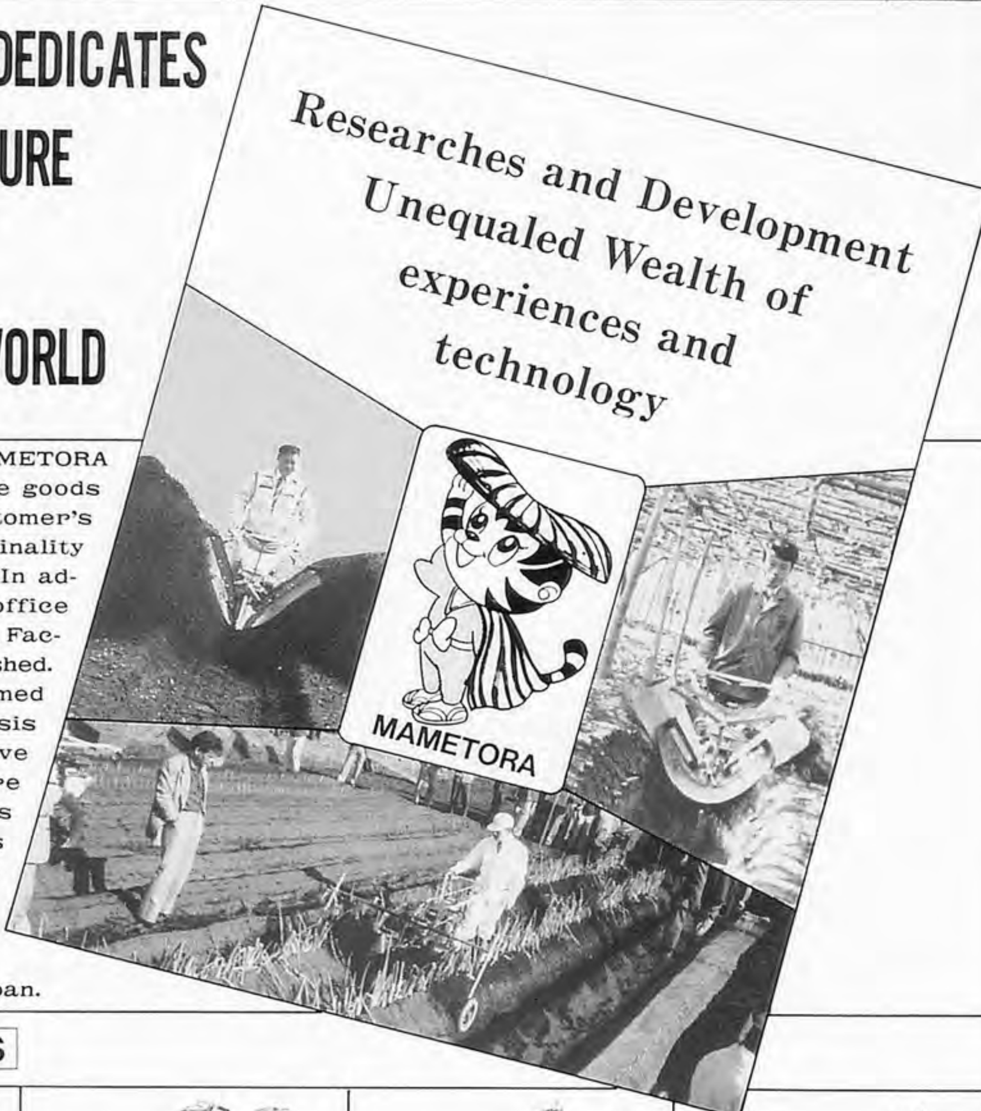
AMA

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

VOL.25, NO.2, SPRING 1994

FARM MACHINERY INDUSTRIAL RESEARCH CORP.

MAMETORA DEDICATES TO AGRICULTURE ALL OVER THE WORLD



It is the motto of MAMETORA that we manufacture goods in order to meet customer's benefits with originality trusty and hearty. In addition to the head office in Okegawa Kisakata Factory has been established. Now that we have formed the much steadier basis as a comprehensive manufacturer. We are always making efforts to manufacture goods of high quality and are pleased to devote ourselves to the food industry in the world as well as that in Japan.

EXPORT SERIES

MC-8C
MINI POWER TILLER MULTING ROTOR SET (1.7ps)

MC-AⅡ
ONE WHEEL POWER TILLER (4.0ps)

DMC-700V
POWER TILLER (7.0ps)

HMD-V-RB
POWER TILLER(8.0ps)

SRV-4V
POWER CULTIVATOR (7.0ps)

TP-3V
VEGETABLE TRANSPLANTER

MH-750
HAMMER KNIFE MOWER

SC-10
CRAWLER CART

MAMETORA AGRIC. MACHINERY CO., LTD.

HEAD OFFICE ADD: 9-37, NISHI-2 CHOME, OKEGAWA-SHI, SAITAMA-KEN, JAPAN.
TELEPHONE: 0487-71-1181 FAX: 0487-71-1529

KIORITZ technology brings you a range of U.L.V. Sprayers for abundant harvests and a safe, comfortable environment.

By combining its long accumulation of chemical spraying technology with the latest concepts field, KIORITZ has developed a revolutionay U.L.V. (Ultra Low Volume) spraying system which is incorporated in its new line of U.L.V. Sprayers. Designed for both insect pest control and generl agricultural spraying applications, these multipurpose machines offer unmatched versatility and safety for a wide range of spraying needs.

HIGH-SPEED U.L.V. SPRAYER (TRUCK-MOUNTED TYPE) KM-500/KM-1000

This is a multipurpose sprayer ideal for general applications such as exterminating desert locusts and other insect pests, prevention of malaria, etc. The KM-500 is designed to be mounted on a pickup truck of 1-ton or larger capacity (1-ton class or higher in the case of a 4WD vehicle), while the KM-1000 can be mounted on a 2-ton or larger pickup truck (4-ton class or higher for a 4WD vehicle).

U.L.V. NOZZLE DMULV-1 (Attachment for ECHO Duster/Mist Blowers & Power Blowers)

This high-perfom×

This high-performance U.L.V. nozzle can be attached to the ECHO range of Duster/Mist Blowers (DM-9, DM-3500, DM-4500, DM-5500, PB-4500) for environmental hygiene control such as malaria prevention, etc. as well as general-purpose applications.

PNEUMATIC U.L.V. SPRAYER (BACKPACK TYPE) KP-140A

This compact and lightweight high-performance U.L.V. Sprayer can be employed for both environmental hygiene control such as malaria prevention, etc. and for general-purpose use.

KIORITZ CORPORATION has been strongly and actively engaged in O.D.A (official development assistance) projects supported and aided by the Japanese goverment.

You can never go wrong by using KIORITZ PRODUCTS.

KIORITZ CORPORATION

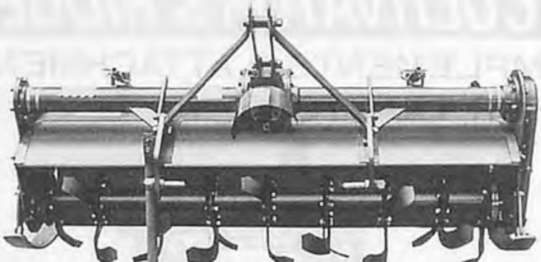
7-2, SUEHIROCHO 1-CHOME, OHME, TOKYO, 198 JAPAN
PHONE:0428-32-6118 FAX:0428-32-6145 TELEX:2852070 KIORITZ-J

Niplo AGRICULTURAL MACHINERY

We Look Forward To

Extend Agribusiness

With Global-Minded People.



Model: SX-1600NA(25~40HP)

Main Niplo Products

ROTARY TILLER
DRIVE HARROW
FLAIL MOWER
DEEP ROTARY TILLER
DIGGER
SEEDER

MATSUYAMA PLOW MFG. CO.,LTD.

Head Office & Factory

Head Office & Factory: 5155, Shiokawa, Maruko-machi, Nagano-ken, 386-04, JAPAN
Telephone: Ueda (0268) 42-7500 Fax: (0268) 42-7528

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.

7-2 Kanda Nishikicho, Chiyoda-ku, Tokyo, Japan (Tel. 03/291−5717∼8, 3671∼4)

International specialized medium for agricultural mechanization in developing countries

ISSN 0084-5841

AMA

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

VOL.25, NO.2, SPRING 1994

Edited by

YOSHISUKE KISHIDA

Published quarterly by

Farm Machinery Industrial Research Corp.

in cooperation with

The Shin-Norinsha Co., Ltd.

and

The International Farm Mechanization Research Service

TOKYO

Editorial, Advertising and Circulation Headquarters
7, 2-chome, Kanda Nishikicho, Chiyoda-ku, Tokyo, 101, Japan

FARM MACHINERY INDUSTRIAL RESEARCH CORP.
SHIN-NORIN Building
7, 2-chome, Kanda Nishikicho, Chiyoda-ku, Tokyo 101 Japan
Printed in Japan

This is the 83rd issue since its maiden issue in the Spring of 1971

EDITORIAL

The world seems to be thrown into further confusion these days. Various events and troubles burst on our ears and eyes from every corner of the world through TV or newspapers. There is very little good news. Regional wars and terrorism have been occuring frequently. No one knows exactly what has caused them. It seems even the world undergoes a change periodically. We are going into the period of chaos and fluidity toward the 21st century.

In the field of agriculture, an agreement in Uruguay Round will produce a large effect on the future world situation. Actually in Europe the closing and integration of farms is rapidly going on and large scale farms are given more and more weight. On the other hand there remain to be many small farms in most developing countries, where mechanization of agriculture hardly goes forward and the farmers depend on still man and animal power. Even under present condition, farmers are suffering from lower price of agricultural products compared with industrial products. It is obvious that agricultural products will further fall in price by the effect of Uruguay Round. To make a living only by farming will be more difficult and young people will flow out of rural area to cities. Many slums have being born in the big cities of developing countries. Yet the flow of young people to cities never stops, which directly shows that agriculture remains to be poorly paid work. This problem is basically arising from agricultural policy giving priority on the profit of city consumers. Among consumers there is a constant demand on cheaper agricultural products and to meet their demand is the main current of agricultural policy. We hardly find the nation that has the policy to raise the price of agricultural products to secure the livinghood of farmers. The only exception is Rice Control System of Japanese government. There is, however, large calls for the abolition of this system among consumers.

Under such a current stream of the world, what we can do for the growth and stability of agriculture in developing countries? Though the answer is difficult to find, it is important for us to promote effective means, especiallly, effective mechanization so that farmers can take a step toward raising their productivity.

Yoshisuke Kishida
Chief Editor

Tokyo, Japan
April, 1994

CONTENTS

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

Vol. 25, No. 2, Spring 1994

Appropriate Use of the Wheel in Sustainable Agriculture Developments

by
John E. Morrison, Jr.
Agric. Engineer
USDA-Agric. Res. Service
808 East Blackland Road
Temple, TX 76502
U.S.A.

Abstract

The basic mechanics and historical perspective on the use of wheels in agriculture is reviewed. An assay is made of the use of wheels in modern agricultural mechanization and, in particular, the characteristics of transport wheel interactions with soil. Criteria are advanced for the selection of appropriate technologies for mechanization in developing countries. All technologies beyond non-mechanized tools and implements use wheels and wheel-like forms and would not exist without this basic machine element.

Introduction

The wheel is symbolic of industrialized peoples. The use of wheels dates back to some distant time during early development of civilizations. We were interested in the inclusion of the wheel and wheel-like elements in tools and implements used for agriculture. It is easy to assume that the wheel was first used in agriculture on dollies and carts for haulage of supplies and produce. This is supported by the examination of centuries-old traditional agriculture in some current developing countries, where we will find the use of wheeled carts, but few or no other agricultural implements or tools which utilize the concept of the wheel. This situation is an abnormality, because wheeled, powered modern technology may pass nearby and jet aircraft may fly over these otherwise wheelless traditional farmsteads. The emphasis of this paper is to review the roles of wheel elements in modern agricultural cropping and then to visualize the appropriate use of wheels in cropping tools and implements for low-input farmers in developing countries.

Keywords: Wheels, agricultural mechanization, developing countries, implements, low-input systems, sustainable.

Basic Mechanics of Wheels

Wheels are solid disks or circular frames connected by spokes to a central hub and generally mounted on a central axis. Wheels can be anything like a wheel in shape, movement, or action.

Wheels have four basic mechanical properties: a) mechanical leverage; b) continuity of shape and motion when rotating; c) load-bearing support between two entities; and d) resistance to axial thrust, (**Fig. 1**). Without such a mechanical element, could modernization and industrialization have ever occurred? Probably not.

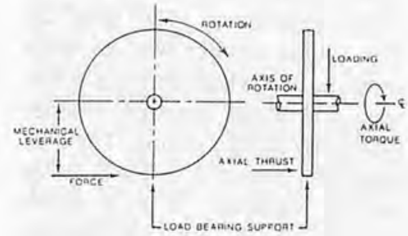


Fig. 1 Basic mechanics of a wheel.

Historical Perspective

It appears that Pliny, Roman historian, described the first field "machine"; that is, the first machine with moving parts, wheels. He wrote in 70 AD (translated), "On the vast estates in the provinces of Gual, large frames fitted with teeth at the edge and carried on two wheels were driven through the corn by a pack animals pushing from behind; the ears thus torn off fall into the frame," (Quick and Buchele, 1978). This was an animal-draft powered grain stripper. This is an example of the application of transport wheels as the first known form of mechanization of agricultural implements, but it disappeared.

Agricultural mechanization

innovation does not seem to have advanced beyond wheeled hauling carts, wagons, and carriages until the 1700's. Because plows and harrows were the earliest animal-draft tillage implements, it's reasonable to assume that the first wheels were added to these implements. Wooden beam traditional plows in Germany, before moldboard plows, had front depth gauging wheels (seen by the author in German museums). Such plows with depth wheels can be seen operating in India today. The rolling coulter was added to wooden beam moldboard plows in the 1800's (Mckinley, 1980) (**Fig. 2**). The rolling coulter was an early example of a wheel-form that was used for some function besides transport/depth gauging. The disk plow was patented in 1867. In its earliest versions, it had depth gauging wheels. By 1876 designs had transport wheels, depth adjustment levers, and operator's seats (Mills, 1986).

The disk harrow was introduced in the USA about 1870 and early illustrations show them equipped with a seat for the operator (Mills, 1986). Unlike the rolling coulter, harrow discs were concaved and orientated at an angle to the direction of travel to cut and throw soil. another tillage tool, the spring tooth harrow was introduced in 1869 and early illustrations show front and rear depth gauge/transport wheels, depth adjustment levers, and an operator's seat (Mills, 1986) (**Fig. 3**). Row crop cultivation was advanced from handtools to animal-draft cultivating implements. Mechanization started with the addition of depth control wheels, then transport wheels, depth adjustment, and operator's seat.

Rotary power transmission systems were added to agricultural machines following the adoption of transport wheels. This was a necessary progression of developments, because the rotary power was transmitted from the transport wheels to driven mechanisms. Early developments in wheel-driven mechanisms included: a) the 1787 machine for reaping corn by William Pit (Quick and Buchele, 1978); b) various later cutters, conveyors, and strippers for cutting cereal grain crops, including the Bell reaper in 1828 with cutters, reel, and lateral conveyor; c) potato diggers with elevating conveyors by 1900; d) seed metering boxes for row crop planters and for grain drills by the 1870's; and e) riding sickle-bar mowers for cutting hay (Mills, 1986). Power transmission systems were combinations of sprocket /chain and gear drives.

Animal-draft provided power for the above machines. The addition of wheel-driven powered mechanisms increased the draft requirements. Wheel traction limited the potential to transmit power. Machine sizes were limited by the number and strength of available draft animals. The substitution of engine-power for animal-draft removed some of these limitations, but did not drastically change the basic functions of cropping machines. Wheels and wheel forms continued to be used for transport and gauge wheels, gears, sprockets, sheaves, cutting discs, rolling coulters, etc., as they had been developed over 200 years.

Wheels in Agriculture

Wheel forms have provided elements of rotary power-transmission systems (Bainer et al., 1955). These are notably belt pulleys and sheaves, chain sprockets, various types of gears, rolling-contact bearings, clutches, and brakes. These elements apply equally to the transmission of

Fig. 2 Early moldboard animal-draft plows, some with depth gauging wheels and rolling coulter. (McKinley, 1980)

Fig. 3 Disk and spring tooth harrows, some with depth gauging wheels, transport wheels, wheels, an operator's seat. (Mills, 1986)

rotary power to machine components and to tractive force wheels.

Hand-pushed machines, such as planters and weeders, use wheels. Farm transportation of supplies and products with human-powered carts, and also manually-turned machines have long been a part of mechanizing agriculture. This has been done without animal-draft or the IC engine.

Several tillage machines use active wheel elements, including plowing disks, harrowing disks, rolling coulter discs, powered rotary tillers, rotary hoe pronged wheels, sectional roller and packer wheels, rolling stalk cutters, ridging or hilling discs, disc furrow openers, depth-control wheels, and furrow closing and packing wheels (Klenin et al., 1985).

Wheels have been used for miscellaneous functions on agricultural machinery (Bosoi et al., 1987;

Bainer et al, 1955). Included are disc distributors for manures and fertilizers, metering discs or wheels, rotary pump elements, irrigation pipe movers, cam followers, cutter blades, rotary brushes, raking wheels with prongs or spring fingers, and for steering and control handles and adjustment devices.

Crop harvesting/threshing machines have used many functional wheel-elements in addition to power transmission elements. Harvesters have used material-feeding rollers, grain threshing drums, blower wheels, digging disks, digging finger wheels, slicing and cutting disks, and residue spreading rotary discs (Quick and Buchele, 1978).

Farm transport wheels fall into two general categories, powered and non-powered. Modern agriculture rolls on wheels, or in some instances with low-pressure tracks over wheels. Transport wheels can be rigidly aligned, steerable, or castered. Transport may be for power units, for pushed or pulled implements or containers, or for self-propelled machines. For the transport functions, wheels are usually employed in pairs to balance loads, but three-wheeled power units and self-propelled machines are not uncommon. For maneuverability, steering or castered wheels are commonly combined with rigidly aligned wheels. Transport wheels may serve an additional function of gauging or controlling the height of a machine above the soil surface. Powered wheels are functionally linked with rotary power transmission systems.

Wheels and Tires and Soil

Transport wheels in modern agriculture are universally fitted with pressurized pneumatic tires, so that the functional performance of the two elements are as of one.

Support

Such wheel/tires must be of adequate size to support the specified load. The tire diameter may be increased, the tire width increased, and/or the air pressure increased to support additional loadings (ASAE Standard: ASAE S430, 1991). Soil sinkage will occur if the maximum pressure in the soil contact area under the tire exceeds the compressive soil strength. Sinkage is fairly linear with the maximum pressure (Ageikin, 1987). If soil sinkage is to be avoided, i.e., compressive soil strength is not exceeded, then the loading may be decreased, tire diameter increased, the tire width increased, and/or the air pressure reduced to enlarge the tire contact area (Soane, et al., 1981).

Traction

Powered wheel/tires must develop enough tractive effort against the soil to initiate and sustain machine motion. Tractive effort is the reaction to forces of tire rolling resistance, any draft forces, and any inertial loading (ASAE Standard: ASAE S296.3, 1991) (**Fig. 4**). The use of lugs or cleats on the outer surface of traction tires may increase maximum tractive effort with smooth tire surfaces (Taylor, 1973). Net traction can be increased, within limits, by increasing wheel/tire contact area, increasing dynamic loading, and/or decreasing inflation pressure (Burt and Bailey, 1982).

Soil Compaction

Soil compaction occurs when the specific volume of soil is reduced upon passage of a transport wheel/tire. If a wheel/tire surface contact pressure exceeds the soil elastic limit, then soil failure will occur under the tire resulting in compaction and a depression, "rut", in the soil surface. (Sommer et al., 1975) found that the most compaction occured at the highest load and highest tire slip for powered wheels. Soil compaction by transport wheels has been the cause of up to 40% of reduction in corn (*Zea mays* L.) yield for silage as compared to zero traffic yields (Negi et al., 1980). Fausey and Dylla (1984) demonstrated that wheel traffic compaction along one side of crop rows reduced both corn an soybean (*Glycine max* L.) rooting potential to extract nitrogen from the soil. Vermeulen and Arts (Personal communication, 1990) stated that crop yields can be maintained on a recovered-seabottom soil with unrestricted wheel trafficking if wheel unit loads are maintained at pressures less than values which would cause the formation of ruts. Their results imply that maximum machine axle loads are determined by the maximum size of tires and minimum inflation pressures which can be used for a given machine operation and soil condition. Conversely, deep subsoil compaction has been correlated with machine axle load, regardless of tire contact area. For instance, Kinney et al. (1991) found significant soil stresses at the 20-34 cm subsoil depth from equally weighted single tire,

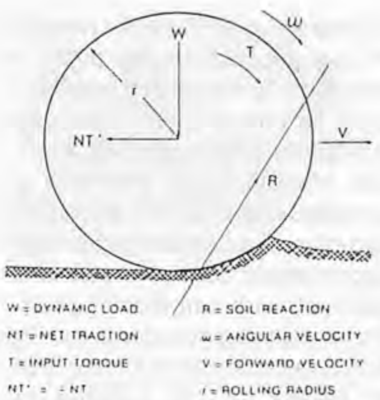


Fig. 4 Basic components of interactions between a powered wheel/tire and compressible soil. (ASAE S296.3, 1991)

dual tire, and steel track tractors.

The emphasis in this paper is placed on farmer-owned and operated mechanization for crop production and associated activities. We will see that the wheel as a machine element is a necessary part of each and every technology improvement beyond implements and tools with non-moving parts. Technology imporvements may be the simple addition of some type of wheels, or the addition of mechanisms which require or encompas wheel elements.

Appropriate Technology for Developing Countries

Dryland (non-irrigated) agriculture sections in many developing countries remain traditional and non-mechanized (IRRI, 1986). Traditional animal-drawn cropping implements have developed over the centuries, but have changed little from their earliest forms. In general, these implements, like the handtools which preceded them, have no moving parts. These implements are tools, but not machines.

The subsistence dryland farmer in any country has very limited potential to make substantial investments in machines for crop production, hauling, and farmstead operations (IRRI, 1986). Therefore, the challenge is to select appropriate technologies to be introduced into subsistence dryland cropping areas which will improve the reliability of individual farming operations to be sustainable.

Cropping, Farmstead and Hauling Activities

It is instructional to list operational activities which may occur on farms in the course of a cropping year:

1. Primary Tillage
2. Secondary Tillage
3. Fertilizer Application
4. Manure Application
5. Field/Seedbed Preparation Tillage
6. Seeding
7. Crop Thinning
8. Weeding
9. Intercultivation Tillage
10. Chemical Weed Control-Application
11. Chemical Insect Control-Application
12. Chemical Disease Control-Application
13. Selective Harvest
14. Broadcast Harvest
15. Bulk Crop Drying
16. Threshing/Separation
17. Final Cleaning and Bagging
18. Stubble/Residue Cutting and Gathering
19. Hauling:
    Workers to fields
    Supplies from city
    Supplies to fields
    Tools and implements to fields
    Produce to storage
    Produce to markets
    Manure to fields
    Forage to farmstead

Criteria for Appropriate Use of Wheels

If we address the non-mechanized situation of traditional agriculturists, and wish to introduce effective, affordable mechanization into their farming activities and rural societies, we need criteria for the most appropriate selection of mechanization technologies. I suggest the following six criteria for the selection of appropriate technologies:

1. Technologies that will support the production and marketing of the maximum cropping yields, specifically:
   a) Timely seeding;
   b) Adequate crop stand establishment;
   c) Non-limiting weed control;
   d) Timely harvesting;
   e) Timely crop processing for marketing.
2. Technology that will increase what one operator can do specifically:
   a) Lift or support;
   b) Carry or transport;
   c) Push/pull.
3. Technologies that will avoid untimely work stoppage by the operator or power unit/machine system, by providing:
   a) On-the-go lifting;
   b) On-the-go adjustments;
   c) On-the-go pickup or discharge;
   d) Avoidance of excessive rest and cooldown stoppages.
4. Technologies that will reduce time and human energy used in turning at the end or corner of the field, specifically:
   a) Tool lifts;
   b) Small turning radii;
   c) Eliminate manual implement carrying around turns;
5. Technologies that will reduce operator activities to those which are needed for successful operation/procedures, specifically:
   a) Eliminate walking unless he she does something productive by walking;
   b) Mechanize low-priority controls/adjustment to allow operator manipulation of higher-priority tasks;
   c) Make more labor time available for productive activities.
6. Technologies that will haul, specifically:
   a) Supplies;
   b) Tools/implements;
   c) Produce to storage/market.

Technologies selected may apply to several of the six criteria. It is important that selected technologies should not violate these or other legitimate criteria. Wheel elements will be necessary components of mechanization in most, if not all, of these technological developments. The use of wheel elements will be appropriate if one or more of the six criteria are met in a manner which is cost effective and/or affordably reduces the toil and burden of sustainable agricultural activities.

Introduced mechanization technology will have the greatest positive impact on a farming operation if it removes the most limiting constraint to increased production, market returns, or other basis of evaluation. All cropping, farmstead, and hauling activities may be evaluated in time-and-motion studies with consideration to the value of timeliness of activities relative to the end product of the farming operation. Results from such studies should identify obvious needs. If, for instance, the mechanical weeding of row crops during short dry periods between seasonal rains is limiting the manageable production acreage, then a higher level of intercultivation mechanization may be appropriate technology for sustainable production of larger acreage (Grenoble et al., 1990). In other cases, it may be timely tillage, seeding, harvesting, threshing, or any other of the 19 activities listed above which is appropriate for mechanization inputs.

Example of Appropriate Use of Wheels

An example will serve to demonstrate the appropriate use of wheels in the first step of moving from non-mechanization cropping tools/implements to agricultural machines. For example, the animal-drawn row crop intercultivation tillage tools in Asia consist of a long pole from the attachment to the animals, a crossbar, one or more intercultivation tools attached under the crossbar to till the soil and undercut weeds between crop rows, and a vertical operator's handle for tool guidance and lifting at turns (**Fig. 5**). This implement operates at a stabilized depth for the tillage tools and soil conditions. If conditions change across a field, then depth, draft energy, and effectiveness changes are mostly beyond the control of the operator.

Fig. 5 A traditional animal-drawn implement-tool for intercultivating row crops.

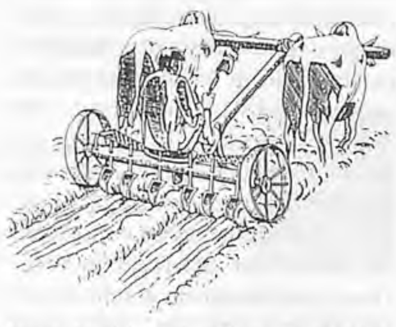


Fig. 6 Stage I depth control wheels added to the basic intercultivator transforming it from a tool into a machine with moving parts.

Fig. 7 Intercultivation machine with Stage II rigid transport wheels, tool depth adjustment and lift, and operator's seat.

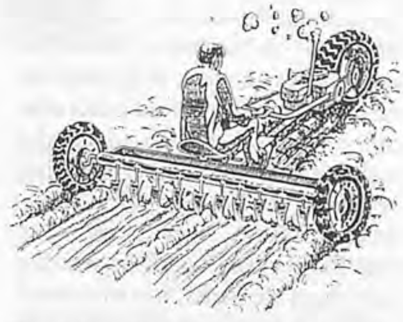


Fig. 8 Stage III mechanization of intercultivation machines with engine-powered draft, pneumatic transport wheels, and operator controls and seating commensurate with higher speed operation.

Stage I

If we "mechanize" the intercultivation operation by the addition of two simple depth gauging wheels (**Fig. 6**), we may provide the following improvements:

a) Increase the effectiveness of weed control by cutting weed roots at the appropriate depth;
b) Avoid excessive soil water loss from tilling at excessive depths;
c) Reduce the fatigue of the draft/animals by reducing draft oscillations;
d) Reduce the draft energy requirements by avoiding excessive tillage depths;
e) Reduce operator energy and toil by reduced implement oscillations.

The addition of the two simple gauge wheels met Criteria No. 1 (c), 2 (b), 3 (d). The implement may still need to be lifted and carried around turns, or it could be tilted up on one wheel and turned by the animals; in that case, it would also meet Criteria No. 4 (c).

Stage II

If we introduce transport wheel, tool lift, and an operator's seat to the intercultivation implement, **Fig. 7**, will provide in addition to the above improvements:

a) On-the-go tool depth adjustment with the tool life mechanism, for changing soil or weed conditions;
b) Implement transportation

between the farmstead and field;

c) Elimination of manual tool lifting/carrying around turns;

d) Reduced operator fatigue by no walking.

The substitution of two transport wheels for the simple gauge wheels and addition of a tool lift mechanism and operator's seat met Criteria No. 2 (a), 3 (a), 4 (a), 4 (b), 4 (c), 5 (a), and 6 (b). This second set of mechanization technologies may not have reduced implement draft or increased productivity but it may allow the intercultivation task to be done by an operator who would otherwise not be strong enough to do the walking and implement carrying required with the first-step-mechanization implement. The tool lift and the operator seat are not wheel elements, but the use of transport wheels required the tool lift and made possible the seating of the operator.

Stage III

If we continue to mechanize intercultivation tillage by substituting an IC-engine/traction power unit for the draft animals, **Fig. 8**, we may provide the additional improvements of:

a) Increasing field travel speed, approximately doubling work rate;

b) Increasing work rate by increasing implement working width to match engine power and potential draft;

d) Increasing available work time by increasing transport speed between farmstead and field;

e) Relinquish the costs and labor to purchase and maintain draft animals.

The substitution of engine-traction for animal-draft met Criteria No. 1 (c), 2 (c), 3 (d), and 5 (c) with the largest improvement being the several potential means to increase the implement work rate. The addition of an engine-traction unit uses wheel technology in the ground traction wheel/tire, and in the power transmission system elements. These mechanization improvements are only possible with the wheel.

Any one of the three stages of mechanization of intercultivation could be appropriate technology for the economic/cropping system of a certain farmer. If land area is limiting production, then Stage I mechanization will reduce operator and animal toil with some potential improvement in effectiveness and work rate. Stage II mechanization will further reduce operator toil, but may not improve work rate. State III mechanization will enable the cultivation of larger acreage, if available, either farmed or contracted by others for off-farm income. Over-mechanization would not be sustainable by an individual farmer. Likewise, the introduction of machines or power units with soil compacting levels of wheel/tire loads may not be long-term sustainable.

Conclusions

The wheel is a basic machine element which appears in almost all agricultural mechanization implements. Without the wheel, there would be no mechanization. Appropriate forms of the wheel may be chosen to advance to higher and higher levels of mechanization, as needed by an individual farming situation. The introduction of mechanization or advancement to higher levels is justified for removing a farm production "bottleneck" which is limiting the potential production or threatening long-term production sustainability.

REFERENCES

Ageikin, Ia s. 1987. Off-the-road wheeled and combined traction devices. (Trans. from Russian.) Amerind Pub. Co. Pvt. Ltd., New Delhi, India.

ASAE. 1991. ASAE S430, Agricultural equipment tire loading and inflation pressures. ASAE, St. Joseph, MI 49085.

ASAE. 1991. ASAE S296.3. Uniform terminology for traction of agricultural tractors, self-propelled implements, and other traction and transport devices. ASAE, ST. Joseph, MI 49085.

Bainer, R., R.A. Kepner, and E.L. Barger. 1955. Principles of farm machinery. John Wiley & Sons, Inc., New York, NY.

Bosoi, E.S., O.V. Verniaev, I.I. Smirnov, and E.G. Sultan-Shakh. 1987. Theory, construction and calculations of Agricultural Machines, Volume 1. (Trans. From Russian.) Amerind Pub. Co. Pvt. Ltd, E.C. and A.C. Bailey, 1982. Load and inflation pressure effects on tires. TRANSACTIONS of the ASAE 25 (4): 881-884.

Fausey, N.R. and A.S. Dylla. 1984. Effects of wheel traffic along one side of corn and soybean rows. Soil and Tillage Research 4:147-154.

Grenoble, D.W., D.R. Daum, and D.M. Gama. 1990. Mechanization in a developing country—Swaziland. applied Agr. Research 5 (3): 235-240.

IRRI, International Rice Research Institute. 1978. Proceedings of the international agricultural machinery workshop, Los Banos, Philippines. IRRI, P.O. Box 933, Manila, Philippines.

Kinney, G.R., D.C. Erbanch, and C.J. Bern. 1991*. Soil strain under three tractor configurations. (*In publication for Applied Engineering in Agriculture, ASAE, ST. Joseph, MI 49085).

Klenin, N.I., I.F. Popov, and V.A. Sakun. 1985. Agricultural Machines. (Trans. from Russian.)

(Continued on page 22)

Theoretical and Actual Field Capacity of Mouldboard Plow for Different Plowing Patterns

by

Rahmatullah J. Malik
Assoc. Prof.
Faculty of Agric. Eng.
Sindh Agric. Univ.
Tandojam, Sindh, Pakistan

Syed Sarwar Shah Bukhari
Student
Faculty of Agric. Eng.
Sindh Agric. Univ.
Tandojam, Sindh, Pakistan

Ali Akbar Channar
Asst. Prof.
Faculty of Agric. Eng.
Sindh Agric. Univ.
Tandojam, Sindh, Pakistan

Shamsuddin A. Maher
Assoc. Prof.
Faculty of Agric. Eng.
Sindh Agric. Univ.
Tandojam, Sindh, Pakistan

Khalid Ahmed Maher
Assoc. Prof.
Faculty of Agric. Social Sciences
Sindh, Agric. Univ.
Tandojam, Sindh, Pakistan

Abstract

In field research experiment, 3-40 cm tractor-mounted Mb-plow with depth control wheel was tested to determine and compare the theoretical and actual field capacity for three plowing patterns most commonly used and adopted to plow rectangular fields. The Mb-plow was tested for the following three plowing patterns:

Head-land pattern from boundaries of field.

Head-land pattern from back furrow.

Head-land pattern with 3 laid-out sub-fields.

The interaction and influence of soil factors, machine-system parameters and different time elements involved and affecting the field capacities of Mb-plow were incorporated, studied and evaluated.

The actual field capacity was found to be less than the theoretical field capacity. The decrease in actual field capacity was 48% for head-land pattern from boundaries, 46% for head-land pattern from back furrow and 45% for head-land pattern with 3-laid out sub-fields.

The actual field capacity for head-land pattern with 3-laid out sub-fields was highest than the other two plowing patterns.

Introduction

Farm machineries are recognized and accepted as reliable companions by the farming community. As a result their use for agricultural production has become an outstanding feature of modern farming. A progressive and successful farmer who opts for the use of machines as only tool of production, needs to operate the machinery effectively in a business like manner in order to obtain maximum overall profit. This means that the operation of individual machine must be evaluated, adjusted and combined in a manner that the overall performance fetches the greatest profit to the farm business.

The rate of performance of tillage machines should be evaluated and reported in terms of area covered per hour or properly called as machine capacity. Tillage machines capacities are expressed and quoted as theoretical field capacity and effective field capacity. Theoretical field capacity of any tillage machine is the rate of field coverage if the machine were performing the intended task for 100 percent of the available time at the rated speed and utilizing 100 percent of the rated width. In comparison, the effective field capacity is the actual rate of field coverage by the machine based upon the total field time committed to mechanize the intended operation.

It is usually impossible to operate the tillage machines such as the mouldboard plow at the rated width of cut and rated speed of operation. Therefore, effective field capacities are substantially less than the theoretical or potential field capacities. The main factors which effect and reduce the actual or effective field capacity of tillage machines from their theoretical capacity are: machine maneuverability, field shape, field size and plowing pattern. It is reported that long and regular shaped fields, quick and short turns by machine, and suitable plowing methods contribute to high machine capacity. On the contrary, if the field is short and narrow, the machine negotiates slow and long turns. If the field is of irregular shape, the choice of plowing method is not proper and correct. Therefore, the machine capacity will be reduced greatly because the machine will require more time to complete the same field. This is due to considerable time wasted in the field and during that time the machine is not actually processing the field but is spent on such events like idle travel in the field, turning time at field corners and time required for minor adjustment in the field.

Hunt (1983) has reported 10 elements of time waste for different machine operations. Further, he quoted specifically five major elements of time waste that are associated with tillage machines and those should be included and counted for the tillage operation. These elements are: turning time, time of crossing water-ways, idle travel time, machine field adjustments time, and minor repair and maintenance time. All the above mentioned elements of time waste affect and reduce the time efficiency which in turn affects the field efficiency of the machine. The field efficiencies are not constant values for specific tillage machines. Instead, they vary widely according to the field conditions, machines system characteristics and method of plowing. The field efficiencies, in turn, affect the effective field capacity or the field performance of the machine.

Tillage is a most important preliminary farming operation. For the tillage operation to be economical and profitable it requires that the performance of the individual tillage machine must be evaluated. Amongst the tillage machinery the mouldboard plow is the most important primary tillage tool as it is widely used on the farms world-wide. Evaluation of the field performance of the mouldboard plow is a most to ensure best and economical tillage operation and thereby make the whole farming enterprise economical and profitable. For this purpose the present research/study to investigate the effect of different variables which influence the field capacities of the mouldboard plow.

Methodology

The research work was intended to determine and compare the theoretical and actual field capacities of the mouldboard plow with a view to evaluating its field performance. For this purpose the following materials and the method were used and adopted.

Materials

Tractor mouldboard plow with 3-40 cm bottoms, fitted with depth control wheel was tested. The overall size of the plow was 120 cm (1.2 m), **Fig. 1**. The other materials and instruments used during the field work were: meter scale, tri-square, steel tape, ranging poles, wooden pegs and stop watch.

Land for Field Work

Prior to the conduct of the experiment of plowing operation with mouldboard plow, the land was visited and surveyed in order to study its topographical conditions. After the appraisal of the land contours and shape it was determined that the land was rectangular in shape, fairly levelled, covered with stubbles of previous paddy crop, and has large numbers of bunds available inside it. The bunds were about 5-6 m apart. The entire field was measured and divided into three equal-

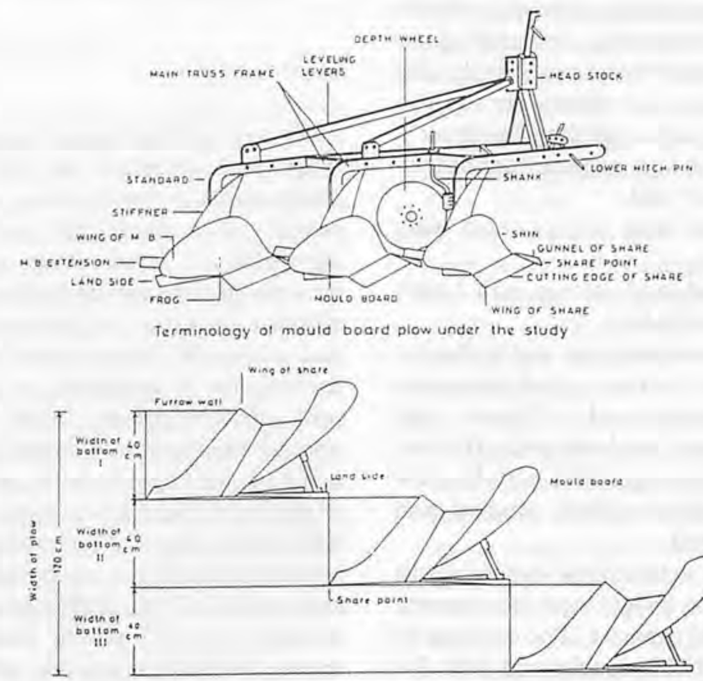


Fig. 1 Size of plow was determined by measuring the distance from wing of share to land side by holding the ruler perpendicular to the land side.

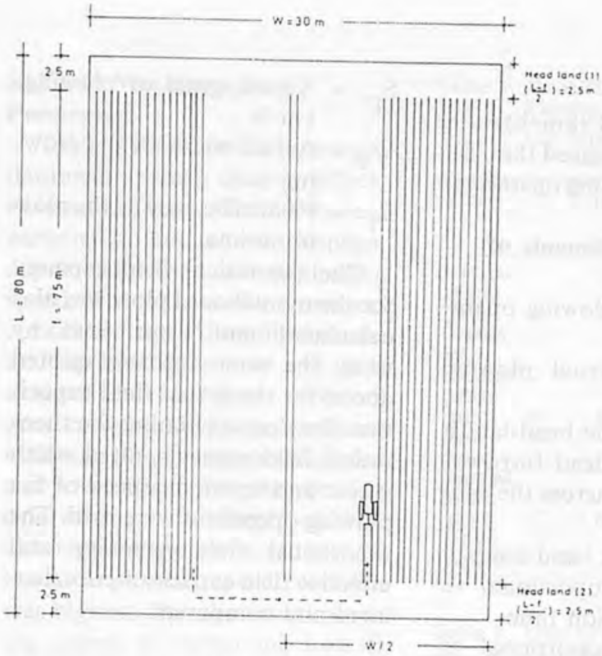


Fig. 2 Field layout of head-land pattern from boundaries of the field.

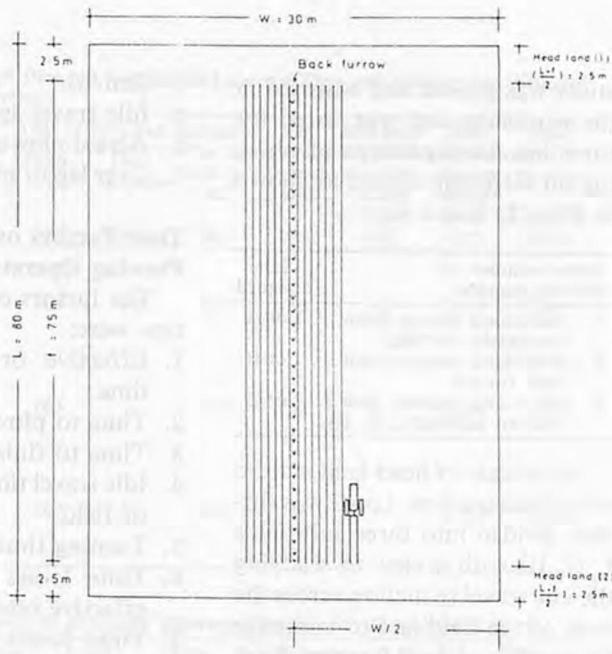


Fig. 3 Field layout of head-land pattern from back furrow in the centre of field.

sized lots with the following dimensions:

Item	Length (m)		Width (m)		Area (m^2)
Lot-A	80	×	30	=	2 400
Lot-B	80	×	30	=	2 400
Lot-C	80	×	30	=	2 400

The three lots designated and labelled above were used for three different patterns of plowing. Lot-C was further divided and laid out into three sub-fields I, II and III of equal size, i.e., 800 m^2

The head-lands measuring 2.5 m were demarcated and laid out at both ends of the individual fields for purposes of tractor turning while plowing. The pegs or poles were fixed at the extremities of the head-lands to guide the operator while making turns on plowing trips.

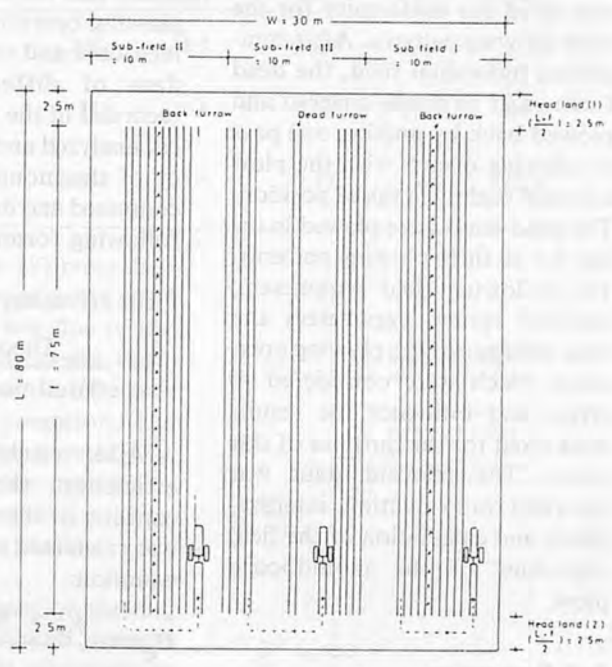


Fig. 4 Field layout of head-land pattern with 3-laidout sub-fields.

Choice of Plowing Patterns

Because the fields were rectangular in shape, the head-land pattern of plowing was adopted. Thus the following three most prevalent and common head-land patterns of plowing were chosen to study and evaluate the field capacities of the mouldboard plow. The three patterns of plowing so selected were: head-land pattern from boundaries of field; head-land pattern from back furrow; and head-land pattern with 3-laid out sub-fields I, II and III.

The field layout of the above three patterns of plowing were sketched as shown in Figs. 2, 3 and 4.

Experimental Procedure

In order to evalualte, assess and compare the theoretical and effective field capacities of the mouldboard plow, the following method for the experiment was adopted:

The mouldboard plow under

study was pre-set and adjusted in the workshop and was tested for three headland patterns of plowing on different alloted as shown in **Figs. 2, 3** and **4**.

Name number of plowing pattern	Lot assigned
1. Head-land pattern from boundaries of field.	Lot-A
2. Head-land pattern from back furrow.	Lot-B
3. Head-land pattern, with 3 laid out subfield I, II, III.	Lot-C

In the case of head-land pattern with 3 laid out lots, Lot-C was further divided into three sub-fields I, II, III with a view to studying the idle travel reduction across the ends of the field and to minimize the number of dead furrows. Each field was plowed completely, turn by turn, the direction of plowing was fixed for uniformity for the three plowing patterns. After completing individual field, the dead furrows (if any) was covered and plowed back by making one pass of plowing over it with the plow adjusted slightly in raised position. The head-lands were plowed in the end for all three plowing patterns. The following field parameters, machine system parameters and time elements of the plowing operation which were considered to affect and influence the results were fixed for the purpose of this study. The relevant data was recorded for evaluation, interpretation and calculation of the field capacities of the mouldboard plow.

Soil Parameters

The soil parameters were:

1. Moisture content of soil.
2. Bulk density.

Machine-system Parameters

The machine-system parameters were as follows:

1. Actual width of plow cut (cm).
2. Depth of cut (cm).
3. Wheel slippage (%).
4. Optimum speed of plowing (km/h).
5. Idle travel speed (km/h).
6. Actual plowing speed (km/h).
7. Over lap of plowing operation.

Time Factors or Elements of Plowing Operation

The factors of plowing operation were:

1. Effective or actual plowing time.
2. Time to plow the head-lands.
3. Time to finish dead furrows.
4. Idle travel time across the ends of field.
5. Turning time at head-lands.
6. Time losses proportional to effective operation time.
7. Time losses proportional to area.

The above mentioned time elements and factors involved in the plowing operations were actually measured and recorded. The field data of different parameters recorded in the field was tabulated, analyzed and the field efficiency of the mouldboard plow was computed and determined with the following formula:

Field efficiency E_f

$$= \frac{\text{Theoretical time}}{\text{Total time of operation}}$$

After establishing the field efficiency, the effective field capacity of the mouldboard plow was calculated using the following equation:

$$C_e = \frac{S_p \times W_e \times E_f}{C}$$

where,

C_e = Effective field capacity, ha/h

S_p = Actual speed of plowing, km/h

W_e = Actual width of the plowing (m)

E_f = Field efficiency of the plow in desimal

The theoretical field capacity for the mouldboard plow was also calculated and determined by using the same formula quoted above for the actual field capacities. But for calculating the theoretical field capacity, rated width of cut and optimum speed of the plowing operations were used. The theoretical field capacity and effective field capacity were calculated and compared.

Results and Discussions

To evaluate the field capacities of mouldboard plow; the effect of soil parameters, machine-system parameters, and time factors of plowing operation were combined and incorporated in the present study. The main soil parameters chosen were moisture content percentage and bulk density of the soil, whereas the machine-system parameters selected were the actual width of cut, overlap, wheel slippage, rated and actual speed of plowing, idle speeds and the time elements of plowing operation considered were productive and idle time.

The data regarding the above mentioned soil, parameters, machine-system parameters and time elements of plowing operation was recorded, tabulated and the results were analyzed and calculated.

Table 1. Effect of Soil Parameters on Machine-system Parameters

Sample Field	Soil Parameters		Machine-system parameters						
	Moisture (%)	Bulk density (g/cm³)	Actual width of cut (cm)	Depth of cut (cm)	Overlap (%)	Wheel slippage (%)	Optimum speed of plowing (km/h)	Idle travel speed (km/h)	Actual plowing speed (km/h)
Lot-A	17.84	1.35	115	22	6.4	11.95	5.00	4.79	4.00
Lot-B	18.99	1.37	117	25	4.3	13.71	5.00	4.60	3.95
Lot-C	17.90	1.36	117	23	4.2	12.55	5.00	4.04	3.96

Soil and Machine-system Parameters

Table 1 shows the different soil parameters which directly affected some of the machine-system parameters like wheel slippage, depth of cut and actual plowing speed. The main soil parameters considered were the soil moisture and the bulk density of soil. It is evident that for higher moisture content, wheel slippage increased while the plowing speed decreased and vise versa. For the plowing operation, in sample Lot-A although the moisture content was low, the plowing speed recorded was highest than the actual plowing speeds of remaining Lots B and C. This variation was due to the fact that the depth in the former case was less than the depth of operation in the latter cases. The bulk density of the soil also affected the actual plowing speed and it was noted that for less bulk density of sample fields, higher plowing speeds were obtained and vice versa.

Time Elements of Plowing Operation

Table 2 indicates the various time elements involved in the plowing operation in the case of three plowing patterns. These time elements were categorized as being the effective and idle time. The effective time comprised of the time required to plow the fields including the head-lands, while the time loss components were idle turning time at ends and corners, across the head-lands of field, time losses due to field clogging, field obstructions, minor field adjustments and checking of plow. The effective and idle times were recorded for the sample fields and the total time per hectare was calculated which were 2.48, 2.42 and 2.342 h/ha, respectively. The time per hectare for pattern 1 and 2 was about 6% and 3.5% more than pattern 3. The time per hectare for pattern 1 was about 2% more than pattern 2. This variation in total times per hectare was due to the difference in plowing speeds, overlap, width of cut and the time losses in the plowing operation. The time losses calculated were 12.3%, 11.5% and 7.9% for patterns 1, 2 and 3, respectively.

Table 2. Total Time of Plowing the Sample Lots and Time per Hectare for Different Plowing Patterns

Plowing pattern	Lot	Effective time to plow the field (sec)	Time of Finishing: Head-lands (sec)	Time of Finishing: Dead furrows (sec)	Idel travel time at ends of field (sec)	Idel Turning time at head-land (sec)	Time losses proportional to effective time (T_h) (sec)	Total time for plowing sample field (sec)	Total time of plowing (h/ha)
Head-land pattern from boundaries	A	1 670	169	69	187	56	0	2 151	2.48
Head-land pattern from back furrow	B	1 699	165	—	172	52	—	2 088	2.42
Head-land pattern with 3 laid out sub-fields	C	1 628	167	66	115	48	0	2 024	2.34

Table 3. Time Efficiency of Different Plowing Pattern with Mouldboard Plow

Plowing pattern	Effective plowing time per field (h) A	Total time per field B	Time efficiency per field (A/B) × 100 (%)	Effective time per hectare (h) A	Total time per hectare B	Time efficiency per hectare (A/B) × 100 (%)
Head-land pattern from boundaries	.53	.597	88.7	2.208	2.48	89.0
Head-land pattern from back furrow	.52	.58	89.6	2.17	2.42	89.6
Head-land pattern with 3-laid out sub-fields	.52	0.562	92.5	2.17	2.342	92.6

Time Efficiency

The time efficiency of plowing operation for different patterns was determined and calculated for sample Lots and also per hectare. The time efficiencies obtained for the sample lots were 88.7%, 89.6% and 92.5%, respectively, whereas the time efficiencies per hectare were found to be 89.0%, 89.6% and 92.6% (**Table 3**). The bar charts shown in **Fig. 5** were constructed for the time efficiencies per hectare. From the bar charts it is obvious that the time

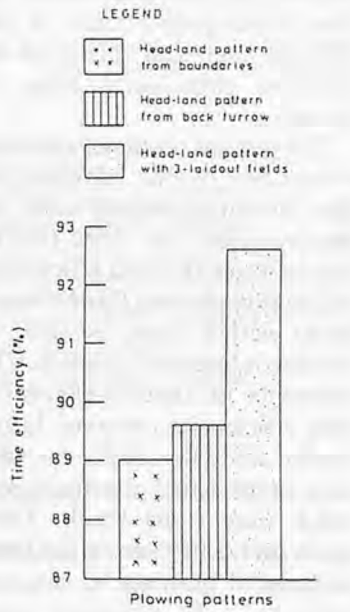


Fig. 5 Bar-chart showing the time efficiency per ha for different plowing patterns.

efficiency for the plowing pattern 3 was greater than the other two patterns. This was due to the fact that time losses for pattern 3 were less than the other two patterns of plowing.

Field Efficiency

The data for different variables used for determining the field efficiency of the mouldboard plow is given in **Tables 4** and **5**. Field efficiencies which were necessary for determining the actual field capacity were calculated and established on the basis of the theoretical and total time required per unit area (1 ha). The field efficiencies of the plow under study, calculated from the data shown in the above tables, were 68%, 69% and 72% for different plowing patterns. The histogram constructed for field efficiency and placed at **Fig. 6** shows that the field efficiency of pattern 3 was highest than the other two patterns. The variation in field efficiencies was due to the differences in the actual plowing speeds, time losses on the different events involved in plowing operation, the time losses proportional to the effective time and difference in effective time total time of operation.

The present results of the field efficiencies of the mouldboard plow are in agreement with the results quoted by Hunt (1983), who reported the field efficiencies of tillage implement (Mouldboard plow) varied from 74-88% at different speeds of 5-9 km/h. The difference of about 4-6% in the field efficiencies observed in the present study was due to the variation in the actual plowing speeds which were 4.005 km/h, 3.946 km/h and 3.959 km/h for three methods of plowing.

Actual or Effective Field Capacity

The data of different variables necessary for calculating the effective field capacity is shown in **Table 6**. The main parameters for determining the effective field capacity were actual speed of plowing, actual width of plow, and the efficiency of the plowing operation. The actual speed of plowing for three patterns of plowing was determined from the field data of plowing trips and time of each trip. The average actual plowing speeds so calculated were found to be 4.005 km/h, 3.946 km/h and 3.959 km/h for three patterns of plowing, respectively. The average width of cut was also calculated from the field data of width of cut and these values were 1.15 m, 1.17 m and 1.17 m for patterns 1, 2 and 3, respectively, also, in **Table 6**.

The field efficiency values used for calculating the effective field capacity were 68%, 69% and 72% for the three different plowing patterns. On the basis of the data of different variables given in the above table, the effective field capacity was calculated which were 0.310 ha/h (.825 ac/h), 0.32 ha/h (.79 ac/h) and 0.33 ha/h (0.83 ac/h), for pattern 1, 2 and 3, respectively. The bar charts were also constructed for the effective capacities which are attached to **Fig. 7**. The effective

Table 4. Theoretical Time to Plow Lots A, B and C and One-hectare Field

Plowing pattern	Sample field	Rated width of plow (m)	Optimum or rated speed of plowing S_R (km/h)	Theoretical time to plow the field $= (L \times W)/(C_1 \times S_R \times W_R)$ (h)	Theoretical time for one hectare $= 10\,000/(C_1 \times S_R \times W_R)$ (h/ha)
Head-land pattern from boundaries	Field-A 2 400m^2	120	5.00	0.40	1.67
Head-land pattern from furrow	Field-B 2 400m^2	120	5.00	0.40	1.67
Head-land pattern with 3-laid out sub-fields	Field-C 2 400m^2	120	5.00	0.40	1.67

C_1 = 1 000 m.

Table 5. Field Efficiency (E_f) of Mouldboard Plow for Different Plowing Patterns

Plowing pattern	Lots	Speed of plowing (Sp) km/h	Total time to plow the given field	Total time to plow one hectare field (h)	Theoretical time to plow one hectare field (h)	Theoretical time/ha E_f = /(Total time/ha)
Head-land pattern from boundaries	Lot-A 80 × 30 = 2 400 m^2	4.005	.597	2.48	1.67	68%
Head-land pattern from back furrow	Lot-B 80 × 30 = 2 400 m^2	3.946	.58	2.42	1.67	69%
Head-land pattern with 3-laid out sub-fields	Lot-C 80 × 30 = 2 400 m^2	3.959	.562	2.342	1.67	72%

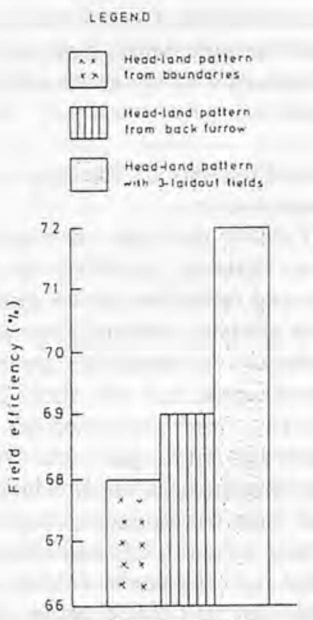


Fig. 6 Bar-chart showing the field efficiency per ha of different plowing patterns.

Table 6. Actual Field Capacity of Mouldboard Plow for Different Plowing Patterns

Plowing pattern	Actual speed of plowing (km/h)	Actual width of plow cut (m)	Efficiency of plowing (%)	$C_e = (S_p \times W_e \times E_f)/C$ ha/h, (ac/h)
Head-land pattern from boundaries	4.005	1.15	68.00	0.310 (0.78 ac/h)
Head-land pattern from back furrow	3.946	1.17	69.00	0.32 (0.79 ac/h)
Head-land pattern with 3-laid out sub-fields	3.959	1.17	72.00	0.33 (0.83 ac/h)

C_e = Effective Field Capacity ha/h.

Table 7. Theoretical Field Capacity of Mouldboard Plow for Different Plowing Pattern

Plowing pattern	Optimum speed of plowing (km/h)	Rated width of plow (m)	Efficiency of plowing (%)	$C_{Th} = (S_R \times W_R \times E_f)/C$ ha/h, (ac/h)
Head-land pattern from boundaries	5.00	1.2	100	0.60 (1.5 ac/h)
Head-land pattern from back furrow	5.00	1.2	100	0.60 (1.5 ac/h)
Head-land pattern with 3-laid out sub-fields	5.00	1.2	100	0.60 (1.5 ac/h)

C_{Th} = Theoretical field capacity, ha/h.

field capacity for plowing pattern No. 1 was slightly less than pattern No. 2 and about 7% less than pattern No. 3. This variation was due to the difference in width of cut, efficiency of plowing operation and effective and total time of plowing and overlap in the plowing operation. The overlap in plowing was found to be 6.4%, 4.3% and 4.2% for pattern No. 1, 2 and 3, respectively. The result of actual field capacities achieved during the present study are in close agreement with the result reported by Bukhari et al. (1990) who obtained the actual field capacities of 0.39 ha/h for the mouldboard plow operating at a speed of 4.60 km/h, the variation of 15% in the present results was due to the variation in the actual speed of plowing operation.

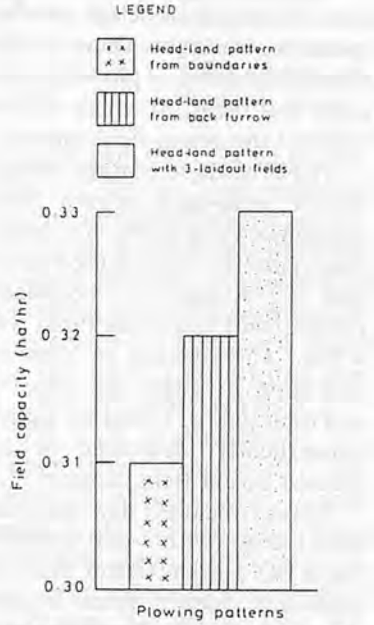


Fig. 7 Bar-chart showing the actual field capacity/ha for different plowing patterns.

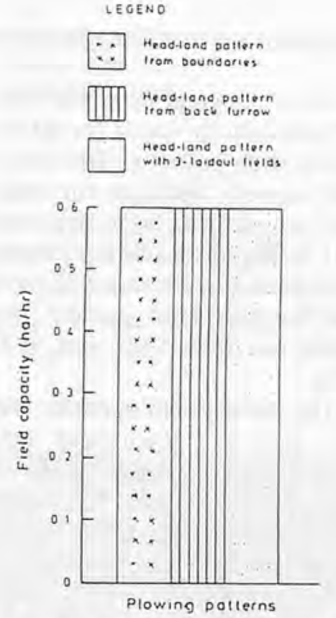


Fig. 8 Bar-chart showing the theoretical field capacity/ha for different plowing patterns.

Theoretical Field Capacity

Table 7 indicates the different variables affecting the theoretical field capacity. These were optimum speed of plowing and rated width of plow which were measured, recorded and calculated from field data. The optimum speed for three methods of plowing was 5.00 km/h while the rated width of plow was 1.2 m. The theoretical field capacity was calculated on the basis of these values mentioned in the **Table 7**. The theoretical field capacity for the different plowing patterns so calculated was found to be 0.60 ha/h for all three pattern of plowing. The histograms of theoretical field capacity was also constructed (**Fig. 8**).

Table 8. Comparison of Actual and Theoretical Field Capacity of Mouldboard Plow for Different Plowing Patterns

Plowing pattern	Theoretical field capacity (C_{Th}) (ha/h)	Actual field capacity C_2 (ha/h)	Difference (ha/h)	Decrease percent (%)
Head-land pattern from boundaries	0.60	0.31	0.29	48.00
Head-land pattern furrow	0.60	0.32	0.28	46.00
Head-land pattern with 3-laid out sub-fields	0.60	0.33	0.27	45.00

Comparison between Theoretical and Actual Field Capacities

Table 8 compares the theoretical and actual field capacities of the mouldboard plow for three patterns of plowing. The actual field capacities for all three methods of plowing are less than the theoretical field capacities. The actual field capacities were 48%, 46% and 45% less than the theoretical field capacities, respectively. The decrease in actual field capacity from the theoretical field capacity was due to the difference in optimum and actual plowing speeds, variation in the effective and total time committed to the machine to plow the same field, overlap in plowing operation, and efficiency of plowing operation.

Conclusions and Suggestions

For rectangular fields the actual field capacity varied for different plowing patterns. The actual field capacity obtained for head-land pattern from boundaries was 0.31 ha/h; for head-land pattern from back-furrow was 0.32 ha/h and for head-land pattern with 3-laid out sub-fields was 0.33 ha/h.

The actual field capacity was less than the theoretical field capacity. The decrease in actual field capacity from theoretical field capacity was 48%, 46 and 45% for the plowing patterns 1, 2 and 3, respectively.

The actual field capacity for head-land pattern with 3 laid out sub-fields was higher than the remaining two plowing patterns 1 and 2.

The moisture content of the soil influenced the tractor wheel slippage, for higher moisture content, wheel slippage increased which in turn affected the actual speeds of the plowing operation resulting in the decrease of the actual field capacity of the plow.

The bulk denisity of the soil also influenced the actual plowing speed, for the higher value of bulk density less speed of plowing operation was recorded which in turn affected the actual field capacity.

The overlap percentage recorded for head-land pattern from boundaries was 6.4%, for head-land pattern from back-furrow was 4.3% and for head-land pattern with 3 laid out fields was 4.2%. The overlap in plowing operation affected the effective and total time of operation which, consequently, decreased or increased actual field capacity.

It was concluded that the head-land pattern with 3-laid out sub-fields was more efficient than the head-land pattern from boundaries and head-land pattern from back-furrow.

REFERENCES

Barnes, K.K., T.W. Casselman and D.A. Link. Field efficiencies of 4-row and 6-row equipment. Agril. Engg. 40: 148-150, Mar., 1959.

Culpin, C. Farm Machinery, 11th Editions. Collins Professional and Technical Books, 8-Grafton Street, London W1 x 3LA.

Hunt, D. Farm Machinery Management, 8th Edition. The Iowa State University Press, Ames, Iowa, 1983.

Kepner, R.A., Bainer, R. and Barger, E.L. Principles of Farm Machinery, 3rd. Edition, 1982. AVI, Publishing Company, Inc. Westport Connecticut, U.S.A.

Renoll, E.S. Row-crop machinery capacity as influenced by field conditions. Auburn University Agricultural Experimental Station Bulletin 395, Auburn, Ala., 1969.

RNAM-Regional Network of Agricultural Machinery. Test Codes and Procedures for Farm Machinery, Technical series No. 12, 1983.

Smith, H.P. Farm Machinery and Equipment, 8th Edition, 1976. McGraw Hill Book Company, New York. ■■

(Continued from page 14)

Appropriate Use of the Wheel in Sustainable Agriculture Developments

Amerind Publishing Co. Pvt. Ltd., New Delhi, India.

Mckinley, M. 1980. Wheels of farm progress. ASAE, ST. Joseph, MI 49085.

Mills, R.E., ed. 1986. Implement and tractor, reflections on 100 years of farm equipment. Walsworth Press, Marceline, MO 64658.

Negi, S.C., E. McKyes, F. Taylor, E. Douglas, and G.S.V. Raghavan. 1980. Crop performance as affected by traffic and tillage in a clay soil. TRANSACTIONS of the ASAE 23 (6): 1364-1368.

Quick, G.R. and W.F. Buchele. 1978. The grain harvesters. ASAE, St. Joseph, MI, 49085.

Soane, B.D., P.S. Blackwell, J.W. Dickson, and D.J. Painter. 1981. Compaction by agricultural vehicles: a review. II. Compaction under tyres and other running gea. Soil and Tillage Research 1:373-400.

Sommer, C., H. Steinkampf, M. Zach, and W. Czerataki. 1975. Ein beitrag zum problem der bodennerdichtung beim einsatz leistungsstarker schlepper (A contribution to the problem of soil compaction resulting from the use of powerful tractors.) Landbauforsh. Völkenrode, 25: 69-74.

Taylor, J.H. 1973. Lug angle effect on traction performance of pneumatic tires. TRANSACTIONS of the ASAE 16 (1): 16-18.

Vermeulen, G.D. and W.B.M. Arts. 1990. (Personal communication reviewing current research.) Inst. of Agr. Engineering (IMAG), Wageningen, The Netherlands.■■

Experimental Study on the "Comet Type Passage-holes" Plow

by
Tan Lihong
Lecturer
Agric. Eng. Dept.
Zehjiang Agric. Univ.
Hangzhou, China

Zhu Hengfu
Asst. prof.
Agric. Eng. Dept.
Zhejiang Agric. Univ.
Hangzhou, China

Wu Sishi
Prof.
Agric. Eng. Dept.
Zhejian Agric. Univ.
Hangzhou, China

Abstract

This paper reports a study on the "comet type passage-holes" plow. With designed "comet type passage-holes" on moldboard and ploughshare, the new type plow can produce an air-liquid medium layer on friction surface of plow and soil in tilling which changes the fricative property and reduces plowing resistance. A series of field tests show that the 1LS-320F type plow (usually used in South China) with designed "comet type passage-holes" can reduce specific draft of plowing (SDP) by 8 ~ 12% in tillage with water and by 2.5 ~ 3.5% in dry field.

Introduction

Plowing is the most basic farming operation in land cultivation which requires vast energy. Much of the energy utilized in plowing is easing the friction between plow and soil besides and partly in soil cutting, deformation and overturning.

The soil makes relative motion on mouldboard in plowing with the new type plow. A lot of passage-holes that produce negative pressure with the motion of soil are made in suitable position of mouldboard. The water in field (in tillage with water) or air (in dry tillage) is drawn from passage-holes into touching surface of the soil with the mouldboard which an air-liquid medium reduces fricative resistance. To draw water or air conveniently and avoid plugging the holes, a tail trough was designed as shown in **Fig. 1**.

The main parameters of the "comet type passage-holes" are diameter D of holes, length L and depth H of tail trough. These parameters directly influence the sizes of the passage-holes" (D: 8 ~ 16 mm, L: 20 ~ 40 mm, H: 2.5 ~ 4 mm) and have remarkable effect of drawing water and air. The direction of tail trough is along the trace of moving soil.

In order to reduce fricative resistance, the position of the "comet type passage-holes" in the mouldboard and ploughshare is concentrated on an angle where pressure is in **(Fig. 2)**.

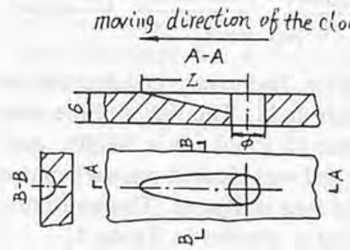


Fig. 1 Comet type passage holes.

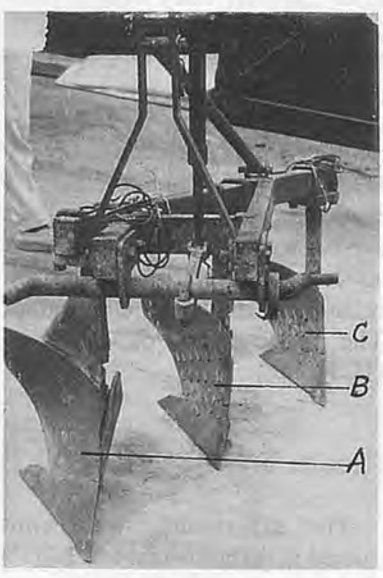


Fig. 2 1LS-320F type plough designed with "comet type passage-holes on mouldboard and ploughshare.

Test Instruments and Soil Condition

In order to collect electrical information, four strains were stiched on special ploughpost (elastic material like 45# steel) and linked in whole-bridge circuit, as shown in **Fig. 3a**. With a CX-1 type computer the electrical information of deformation can be translated into the information of plowing resistance and recorded automatically **(Fig. 3b)**.

Test Soil Condition

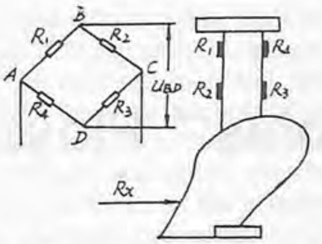


Fig. 3a The position and bridge circuit for the strain-gages.

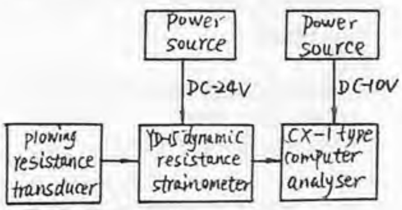


Fig. 3b Test circuit.

The test was conducted in paddy field. The rice stubble was about 15 to 20 cm in height, and the soil was plowed once when the field was irrigated. The soil condition is shown in **Table 1**.

Three plows were tested one after another. They were A plow (no "comet type passage-holes"), B) plow (with "comet type passage-holes" D: 8 mm, L: 30 mm, H: 3.5 mm), and C Plow (with "comet type passage-holes" D: 12 mm, L: 30 mm, H: 3.5 mm). The position of the plows can be interchanged during the test so that the effect of position on resistance may be eliminated. The plows were of the type (1LS-320F).

Results and Analysis

The experiments were conducted in orthonormal test L_9 (3^4) **(Table 2)**, L_4 (2^3) **(Table 3)**.

The SDP of the three plows differed from one another. The SDP of the plows designed with "comet type passage-holes" were less than those not designed with "comet type passage-holes."

The effect of reducing SDP on plows designed with "comet type passage-holes" was different in tillage with water and in dry soil. In the former tillage, the SDP was reduced 8~12%, but in the dry tillage the SDP was only about 2.5~3.5%.

The effect of reducing SDP was different when taking different sizes of "comet type passage-holes": i.e., the C plow reduced resistance more than the B plow.

Table 1. Test Soil Condition

Soil depth	Diameter of soil grains (mm)					Soil depth	Soil fastness
(mm)	0.25~0.05	~0.01	~0.005	~0.001	<0.001	(mm)	N/cm²
0~18	8.5	68.7	5.8	9.0	8.0	0~5	190.1
						5~10	195.0
18~84	8.5	68.5	5.5	7.8	9.7	10~15	208.7

Table 2. Orthonormal Tests L_9 (3^4) in Field

Test number	Water depth (H cm)	Tillage speed (V km/h)	Tillage depth (cm)	f_1* N/cm²	f_2* N/cm²	f_1*	f_3* N/cm²	f_2*
1	6	2	14	3.420	3.058	10.6	3.058	10.6
2	6	3.4	16	3.646	3.273	10.2	3.263	10.5
3	6	5.8	18	3.861	3.410	11.7	3.391	12.2
4	3	2	16	3.391	3.038	10.4	3.028	10.7
5	3	3.4	18	3.616	3.234	10.6	3.205	11.4
6	3	5.8	14	3.798	3.450	9.1	3.420	9.8
7	1.5	2	18	3.391	3.048	10.1	3.028	10.7
8	1.5	3.4	14	3.587	3.288	8.5	3.263	9.0
9	1.5	5.8	16	3.783	3.469	8.3	3.459	8.5

Table 3. Orthonormal Tests L_4 (2^3) in Field

Test number	Moisture content	Tillage speed (V km/h)	Tillage depth (cm)	f_1* N/cm²	f_2* N/cm²	f_1*	f_3* N/cm²	f_2*
1	25%	3.4	14	4.116	3.989	3.1	3.969	3.6
2	25%	5.8	18	4.322	4.224	2.3	4.214	2.5
3	25%	5.8	14	4.332	4.224	2.5	4.204	2.7
4	25%	3.4	18	4.126	3.998	3.1	3.989	3.3

*: f_1, f_2, f_3: presented SDP of A plow, B plow, C plow.
f_1, f_2: presented reducing SDP of B plow, C plow.

Effect of Water Depth on Field Surface on SDP Reduction

As shown in **Table 2** when the tillage depth was 18 cm and tillage speed was 2 km/h (or 5.8 km/h), the SDP was least (or resistance reduced was maximum). **Fig. 4** shows some curves tested on this condition.

The effect of reducing SDP was basically identical when the water depth was changed from 1.5 to 6 cm. So the tillage in low water depth is suitable for improving the working condition of tractors.

Effect of Tillage Speed on SDP Reduction

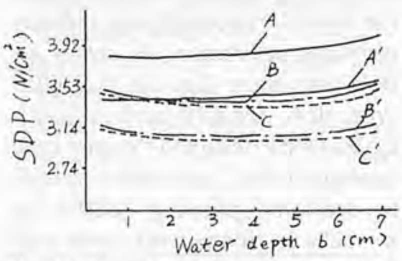


Fig. 4 Effect of the water depth on reducing SDP.
A: No hole, V=5.8km/h;
A':No hole, V=2km/h;
B: 8mm diam. holes, V=5.8km/h;
B':8mm diam. holes, V=2km/h;
C: 12mm diam. holes, V=5.8km/h;
C':12mm diam. holes, V=2km/h

Fig. 5 shows some curves obtained when tillage depth was 18 cm and water depth was 1.5 cm. It shows that the SDP increases gently for the plows designed with "comet type passage-holes."

Effect of Tillage Depth on SDP Reduction

Fig. 6 shows that the effect of tillage depth on reducing SPD was

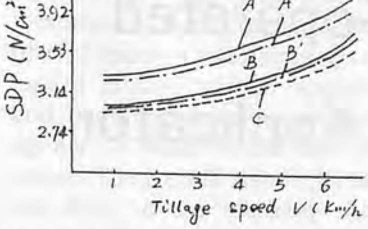


Fig. 5 Effect of tillage speed on reducing SDP.
A: No hole, water depth 1.5cm
A':No hole, water depth 3cm
B: 8mm diam. holes, water depth 1.5cm

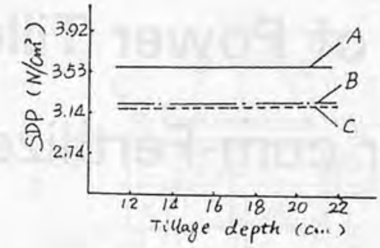


Fig. 6 Effect of tillage depth on reducing SDP
Water depth 8cm, V = 3.4km/h
A: No hole; B: 8mm diam. holes; 12mm diam. holes

identical basically when the tillage depth was changed from 12 cm to 22 cm.

Conclusion

By designing some "comet type passage-holes" in suitable position of mouldboard and ploughshare, the new type plow can produce an air-liquid medium layer on fricative surface between plow and soil in tilling, which changes fricative property, reducing plowing specific draft and saves energy. The 1LS-320F type plow designed with "comet type passage-holes" can reduce SPD by 8 ~ 12% in tillage with water and by 2.5 ~ 3.5 ~ in dry tillage. The effect of reducing SDP is remarkable.

REFERENCES

1. Willam R. Gill, Glen E. Vanden Berg, Soil Dynamics in Tillage and Traction, Agricultural Research Service, U.S.A., pp. 268 ~ 278.
2. Nanjing Research Institute of Agricultural Machinery, Several Experiment Study on Reducing Plowing Resistance, Transactions of The Chinese Society of Agricultural Machinery, Vol. 4, No. 2, pp. 134 ~ 148.

NOTIFICATION

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

Articles for publication must contain one printed copy along with one copy on 3.5 inch floppy disk and black & white photographs for the articles.

Format Guidance

The floppy disk copy must contain the following format.

a. are written in english language;
b. are written in any of these format like DOS, Word for Dos, Word Perfect, Word Star, Word for Windows, Word for Macintosh and which should be written on the surface of the disc;
c. whole article must written in same format and style;
d. the pages on floppy disk must not be numbered;
e. the tables and figures titles must be numbered;
f. the data for the graphs must also be included.

The remaining Instructions to AMA Contributors are shown in the back side of AMA.

The editorial staff of AMA realize that some contributors still have difficulty to support these changes. In this case, please contact us. Please remember the articles in the new format will be given priority for publication.

FARM MACHINERY INDUSTRIAL RESEARCH CORP.

7-2 Kanda Nishikicho, Chiyoda-ku, Tokyo, Japan (Tel. 03/3291-5718, 3671 ~ 4)

Development of Power Tiller-operated Potato Planter-cum-Fertilizer Applicator

by
M.L. Gupta
Lecturer
Agricultural Mechanization Section
Department of Plant Production
University of Queensland, Gatton College
Lawes Qld 4343, Australia

D.K. Vatsa
Asst. Agric. Engineer
Dept. of Agric. Eng.
H.P. Agric. Univ.
Palampur, H.P., India

M.K. Verma
Sr. Tech. Asst.
Dept. of Agric. Eng.
H.P. Agric. Univ.
Palampur, H.P., India

Abstract

A single-row power tiller-operated potato planter-cum-fertilizer applicator was developed. The planter consists mainly of seed and fertilizer metering mechanisms, two lugger ground wheels, sprocket and chain drive unit, a furrow opener and a bund former. It can perform three functions simultaneously, viz., sowing seeds, applying fertilizer and making ridges/bunds. The field trials were conducted to determine the performance of the planter at different forward speeds of the power tiller. The effective field capacity of the machine at optimum speed of 1.33 km/h was about 0.04 ha/h. The average field efficiency was about 60%. There was a net saving of 45% in the cost of planting potatoes and 90% reduction in labour requirement when compared with the traditional method.

Introduction

Potato plays an important role in the economy of Himachal Pradesh State, India. The cool temperate climate at the hills provide ideal conditions for the production of disease-free speed potatoes which are supplied to other parts of the country. At the present time, potato sowing is carried out manually which is not only time-consuming and labour intensive, but also costly. There is often an acute shortage of labour during the sowing season which causes delay in sowing operation. Thus, it is essential to introduce suitable machines for mechanizing the potato cultivation in the State.

Topography and size of land holdings are the two major constraints that restrict the introduction of tractors in Himachal Pradesh. Also, majority of the farmers cannot afford to own a tractor because of its high initial cost. Hence, the tractor-operated potato planters currently available in India cannot be adopted by the farmers of this hill State.

Power tiller is visualised as a suitable mechanical power source in the hill regions. When power tillers were introduced in 1960 in India, they were primarily used for cultivation of rice crop because the matching equipment to raise other crops were not available (Ojha, 1988). In the recent past, efforts have been made to develop power tiller-operated equipment for seedbed preparations for various crops (Pandey et al., 1983). However, no suitable power tiller-operated machine is available at present which can simultaneously sow the potatoes and apply the fertilizer. Therefore, an attempt was made to develop a light weight power tiller-operated potato planter-cum-fertilizer applicator suitable for the regions of India.

Methodology

Design Considerations

The basic design considerations in developing the planter were:

(i) The planter should be suitable for operation with power tiller in small terraces.
(ii) The planter should be able to maintain a minimum row spacing of 50 cm.
(iii) The planter should be able to perform three functions simultaneously, viz., sowing seeds, applying fertilizer and making ridges.
(iv) The planter should be simple in construction so that it could be easily fabricated by local manufacturers.
(v) The cost of the planter should be within reach of small and medium farmers.

Machine Description

Keeping in view the design considerations, a prototype single row, semi-automatic potato planter-cum-fertilizer applicator was fabricated. **Fig. 1** shows the assembly drawing of the planter. It consists of a seed hopper, a fertilizer hopper, a rotating ring, two lugged ground wheels, sprocket and chain drive unit, a furrow opener, a bund former and the frame. The ground wheels provide the drive to the metering shaft through the sprocket and chain drive arrangement. The rotating ring is driven through a set of bevel gears and revolves in a horizontal plane. A fluted roller mechanism was used to measure the required quantity of fertilizer. During the field operation, the power tiller driver operated the tiller while another person placed the potato tubers in the pockets provided in the rotating ring (**Fig. 2**). The potato tubers from the pockets fell through a seed tube into a furrow made by the furrow opener, the seed-to-seed spacing being 17.5 cm. Simultaneously, fertilizer at a desired rate was also applied at about 4 cm spacing to the side of potato seeds. The ridge was formed with the help of the bund former. There is also a provision to adjust the planting depth and ridge height in the machine. The weight of the planter is 48 kg and cost about Rs.2700 (US$ 108).

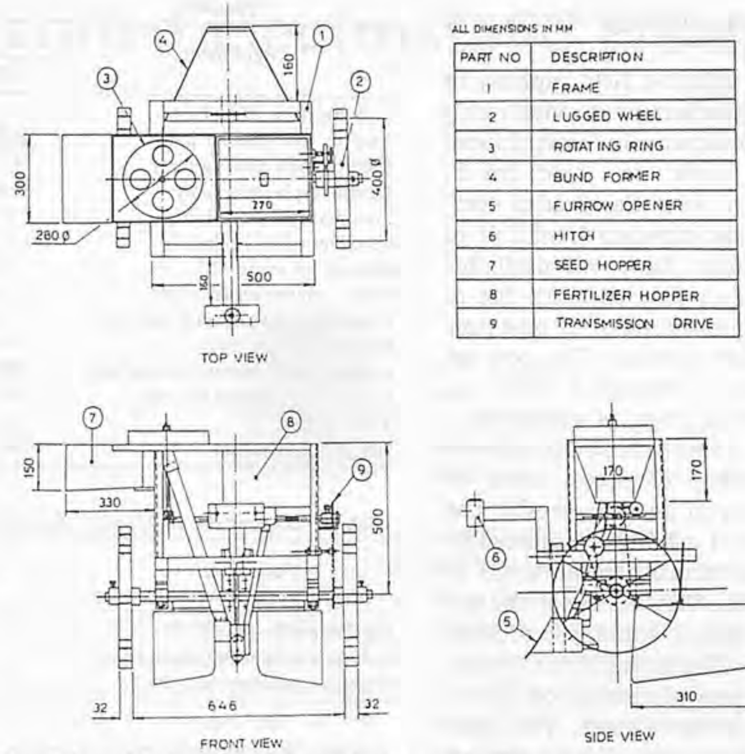


Fig. 1 Assembly drawing of potato planter-cum-fertilizer applicator.

Field Testing

Field tests were conducted to check the performance of the potato planter-cum-fertilizer applicator. The testing of the planter was done by attaching it to a 7.5 kW Mitsubishi power tiller being manufactured in India. The potato variety "Kufri Jyoti" (N = 12%, P = 32%, K = 16%) in the ratio of 1:3.85 were used for testing. This ratio was selected such that the recommended dose of N, P and K could be applied at sowing time (Sud, 1986). The planting depth was adjusted to 5 cm and fertilizer rate was set at 285 kg/ha.

The machine performance parameters like effective field capacity, row-to-row spacing, seed to seed spacing, depth of planting, acutal fertilizer rate, speed of operation, missing of seeds and fuel consumption were measured as per the procedures given in the IS Code (Anonymous, 1981). Field data were also collected to determine the labour requirement and cost of sowing potatoes by manual method.

Cost Analysis

Cost calculations were carried out based on the procedure given in the IS Code (Anonymous, 1979). The annual use of power tiller and planter was assumed to be 800 and 200 hours, respectively. The fixed and variable costs associated with the power tiller and planter were considered in the calculation of the cost of potato planting.

Fig. 2 Potato planter-cum-fertilizer applicator in operation.

Results and Discussion

The field performance data of power tiller operated potato planter-cum-fertilizer applicator are shown in **Table 1**. It was possible to maintain row-to-row spacing of about 50 cm. The average actual fertilizer rate was 271 kg/ha against the theoretical rate of 285 kg/ha, thereby indicating an accuracy of about 95%. The seed-to-seed spacing varied from 17.1 to 20.4 cm and increased with an increase in speed of operation, possibly due to vibration of the machine. The average planting depth was 4.8 cm.

The effective field capacity of the planter increased considerably with the increase in forward speed from 0.84 to 1.65 km/h. However, when the speed of operation was increased from 1.65 to 2.08 km/h, there was negligible increase in field capacity due to higher proportion of turning time in small terraces. The cost of operation decreased with an increase in speed of operation.

Fig. 3 shows the effect of speed on missing of seeds, yield of potato crop and net profit. The number of missing seeds increased with an increase in the speed of operation. This was due to the fact that at higher speed, the rotating ring revolves at faster rate resulting in non-placement of porato tubers in its pockets. The plant population decreased with an increase in speed resulting in lower potato yield at higher speed and vice versa. It can be ascertained from this figure that the net profit was maximum at a speed of 1.33 km/h which is the optimum speed of operation for this planter.

The comparison of manual and mechanical methods of planting potatoes is shown in **Table 2**. At optimum speed of operation, the cost of planting potatoes with the planter was Rs.510 man-h/ha with the traditional method, thereby indicating labour savings of 461 man-h/ha, i.e., 90%.

Table 1. Performance of Power Tiller Operated Potato Planter-cum-Fertiloizer Applicator

Parameter	Seed of Operation (km/h)			
	0.84	1.33	1.65	2.08
Soil moisture (%, db)	17.4	18.0	16.9	17.7
Row to row spacing (cm)	50.5	50.5	49.8	50.4
Seed to seed spacing (cm)	17.1	.18.5	19.0	20.4
Depth of planting (cm)	4.8	4.9	4.8	4.8
Fuel consumption (l/h)	0.635	0.557	0.533	0.518
Fertilizer rate (kg/ha)	272.7	269.2	276.7	265.6
Missing of seeds (%)	0.0	1.47	4.85	29.36
Plant population (No./m)	4.46	4.22	3.98	3.11
Effective field capacity (ha/h)	0.025	0.041	0.050	0.052
Field efficiency (%)	58.14	60.29	60.24	50.35
Labour requirement (man-h/ha)	80.0	48.8	40.0	38.5
Cost of operation (Rs./ha)	1175	705	575	552
Yield (t/ha)	13.57	13.36	12.40	8.96
Net profit (Rs./ha)	9180	9456	8425	5310

Table 2. Comparison of Manual and Mechanical Methods of Planting Potatoes

Parameter	Method of Planting	
	Manual	Planter
Field capacity (ha/h)	0.002	0.041
Labour requirement (man-h/ha)	510.000	49.000
Cost of operation (Rs./ha)	1275.000	705.000

Conclusions

The power tiller-operated potato planter-cum-fetilizer applicator can successfully plant potatoes as well as apply fertilizer at sowing time. Two persons are necessary to carry out the sowing operation, i.e., one for operating the power tiller and the other for feeding the potato tubers in the seed metering mechanisms. The planter is simple in construction and can be easily fabricated by the manufactures with basic workshop facilities. It is light in weight and works well in small terraces. The planter cost of Rs.2700 is within reach of small and medium-sized farmers. The cost of planting potatoes and labour requirement width this machine are much less than the manual planting method.

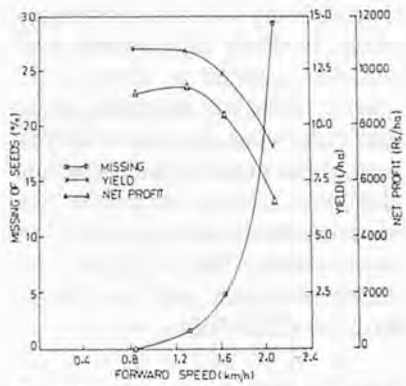


Fig. 3 Effect of forward speed on missing of seeds, yield of potato crop and net profit.

REFERENCES

Anonymous (1979). Guide for Estimating Cost of Farm Machinery Operation. IS: 9164-1979, Bureau of Indian Standards, New Delhi.

Anonymous (1981). Test Code for Potato Planter. IS: 9856-1981, Bureau of Indian Standards, New Delhi.

Ojha T.P. (1988). Success and Failures of Power Tillers in Indian Agriculture. Agricultural Engineering Today, 12 (2): 30-330.

Pandey, M.M., Bohra, C.P., Maheshwari, R.C. and S.S. Tomar (1983). Power Tiller and Matching Implements. Tech. Bul. No. CIAE/PTS/83/19, Central Institute of Agricultural Engineering, Bhopal.

Sud, V.K. (1986). Package of Practices for Rabi Crops in Himachal Pradesh. Directorate of Extension Education, Himachal Pradesh Krishi Vishvavidyalaya, Palampur.

■■

A Manually-operated Electrostatic Planter for Small Seeds

by
Sultan Ahmmed
Sci. Officer
Agric. Eng. Div.
Bangladesh Agric. Res. Institue
Joidebpur, Gazipur, Bangladesh

C.P. Gupta
Prof.
Div. of Agric. and Food Eng.
Asian Institute of Technology
G.P.O. Box 2754, Bangkok, Thailand

Abstract

Single-row, manually-operated electrostatic planter for small seeds[1] was designed, fabricated and developed. Electrostatic force was used for metering the small seeds. Pick up pins, made of ebonite, were fixed on a rotating wheel which derives power from the driving wheel through a chain — sprocket transmission. Hill-to-hill spacing can be changed by varying the number of pickup pins on the rotating wheel. The pickup pins rub against a piece of woolen cloth and get small amounts of electrostatic charge. This charge picks up 1-4 seeds from the secondary seed hopper and the seeds are released into the delivery funnel by a metallic scraper and pass through the seed tube into the furrow. The furrow is covered and pressed by a press wheel behind the metering device. The planter was tested in the laboratory as well as in the field in order to evaluate its performance and accuracy. Seed rate was very low at 0.36 kg/ha of jute at 30 cm hill and row spacing. The field capacity was 0.077 ha/h, with average speed 0.5 m/s and field efficiency of 89%. The average power required to push the planter was about 30 watt.

Introduction

Precision metering and placement of small seeds for optimum yield has been a problem for many years. As the size of the seeds decreased, the magnitude of the problem generally increases. Farmers in developing countries have no suitable low-cost planter for sowing small seeds. As a result, they either broadcast or manually dibble seeds into holes made along rows of crops. Broadcasting makes weeding very difficult and dibbling needs a large number of hands which are often scarcely available at the peak of the sowing season. Human labour is also becoming more expensive every year in developing countries. Keeping in view the above problem, it was decided to develop a suitable manually-operated planter for planting small seeds for the benefit of farmers in developing countries.

Literature Review

Researchers have attempted to find a solution to the problem of planting very small seeds like jute, mustard, sesamum, carrot, onions, cauliflower, tomato and amaranth. They used various techniques such as fluid planting, pneumatic planting, pressure differential planting, microcomputer controlled planting, planting of clay — coated seeds, supersonic seeding system and punch planting. Elliot (1966) was the first to report that pregerminated seed could be planted using an extrusion of gel. Getzke et al (1967) designed a fluid planter which achieved mechanical singulation using a conventional plate type mechanism. Fieldler and Summer (1972) patented a fluid planter utilizing a flexible vane pump for planting. Roger (1977) developed design principles for a fluidic seed meter which would have a means of "feeding back" the meter's performance so that the meter could compensate a missed seed. Hiron and Balls (1978) developed a fluid planter which eliminated mechanical damage that may occur when seeds travel through a pump. Giannini et al (1967) developed a vacuum seed pick up planter to select and space single small seeds. Short and Humber (1970) developed a planetary vacuum seed metering device. According to Sial and Persson (1984) precise metering of small horticultural seed has been a problem due to a large variation in seed lift height, seed orientation, brush off device and seed injection. Currah (1978) described a device which singled out and dispensed seeds using a pressure differential. Searcy (1982) developed a precision metering system for pregerminated seeds using optical sorting and a control system governed by a microprocessor. Wilkins and Lenker (1981) also developed a microprocessor controlled precision planter. Searcy and Roth (1982) developed a metering system in which microcomputer detected seed presence with photoelectric devices and drive the metering device with stepping motors. Another approach for using small seed and irregular but viable seeds has been to pellet raw seed with clay — binder coating (Allen et al 1983). It was reported by Roger (1977) that seeds introduced into a supersonic air stream and allowed to accelerate to supersonic speed would penetrate completely into the soil and themselves unaffected to the extent that they would germinate and grow in a normal way. Jafari and Fornstrom (1972), Heineman et al (1973), Wilkins et al (1979) and Srivastava and Anibal (1981) developed precision punch planters. Wilkins coated seeds with a material containing iron oxide (Fe_3O_4) which is attracted to magnetic punches.

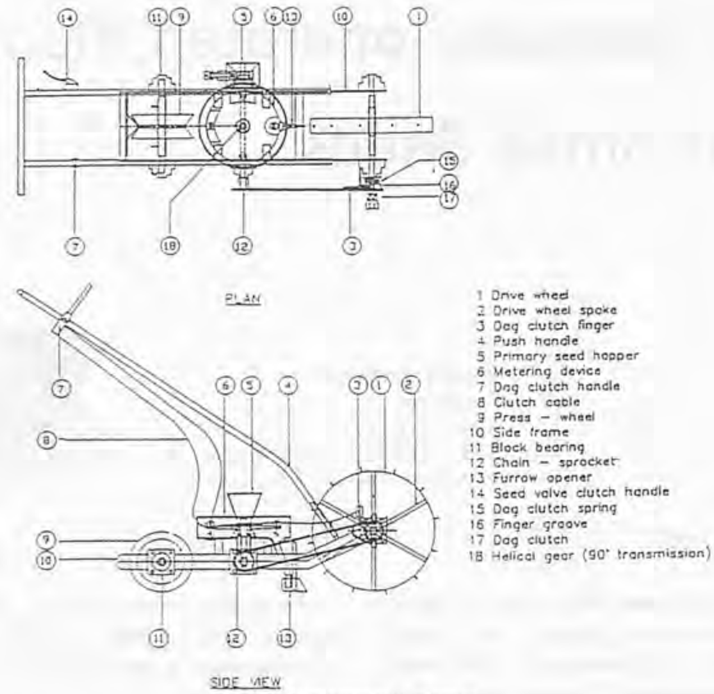


Fig. 1 Electrostatic planter.

Design and Development

Major Components

The major components of the machine (**Fig. 1**) are:

1. Seed hopper (primary and secondary)
2. Seed metering device
3. Seed tube
4. Driving wheel
5. Shoe type furrow opener
6. Shaft
7. Clutch
8. Press - wheel
9. Frame
10. Marker

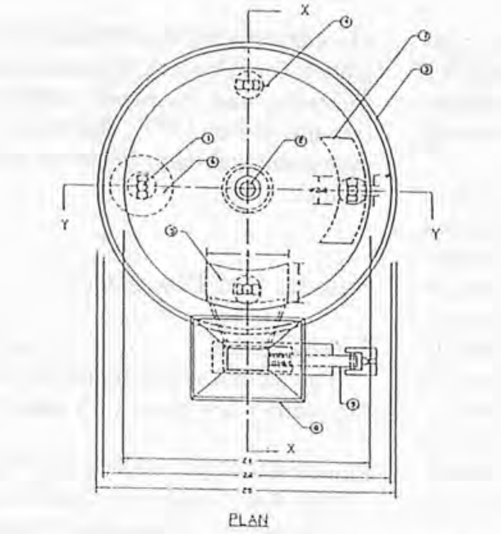
Delivery funnel — The tube of the delivery funnel was designed parabolic in shape to reduce the rebounding of seeds against the wall of the seed tube, thereby improving the uniformity of seed's delivery to the furrow.

Seed hopper — The seed hopper was designed for refilling seeds twice per hectare. Dimension of the hopper top was 100 m × 80 mm and the bottom was 30 mm × 15 mm. Its shape is like frustum of prism with a height of 100 mm. The material for the hopper is transparent plastic with 3 mm thickness. Based on these dimensions, the actual volume of the hopper is 309×10^{-6} m^3 which is adequate to cover seeds in a half-hectare field.

Seed metering device — In this planter the small seeds was metered by using electrostatic charge developed at four pickup pins, each attached to a bar by a screw. The pickup pins are spaced 90° apart. The rotating wheel and four pickup pins rotate as a unit in the horizontal plane. The center shaft of the rotating wheel gets power from the driving wheel by suitable gear and chain — sprocket transmission. The tip of the pickup pins were made of ebonite and the electrical charge was created when they were rubbed against a woolen cloth that was mounted over a leaf spring to maintain pressure. By the rotation of the wheel, when charged tip pins just come over the secondary seed hopper, they picked up single or group of small seeds at their tips. The seed was released by a metallic scraper at the top of the seed tube and passed into the furrow opened by the furrow opener (**Fig. 2 a,b,c**).

Seed tube — The seed tube was made of plastic pipe with 20 mm inside diameter, 2 mm thickness and 100 m in length.

Driving wheel — The diameter (D) of driving wheel was determined by the distance of dropping hill. For this design the distance between the consecutive hills was 300 mm and the number of pick up pins was 4. One revolution of the metering device gave 4 hills to cover $4 \times 300 = 1\,200$ mm. Then $\pi.D = 1\,200$. Therefore, $D = 382 \approx 400$ mm.



All dimensions in cm

SL No	PARTS	MATERIAL	SIZE
1	Pick up pin	Hard rubber	#1 cm Plate(1cm x 2.2cm)
2	Center shaft	Steel	1.5 cm dia
3	Housing	Plastic	20 cm
4	Screw		
5	Seed hopper with housing		
6	Seed tube tunnel with housing		
7	Rubbering material wool		
8	Primary seed hopper		
9	Valve with spring		

Fig. 2 (a) Plan of metering device.

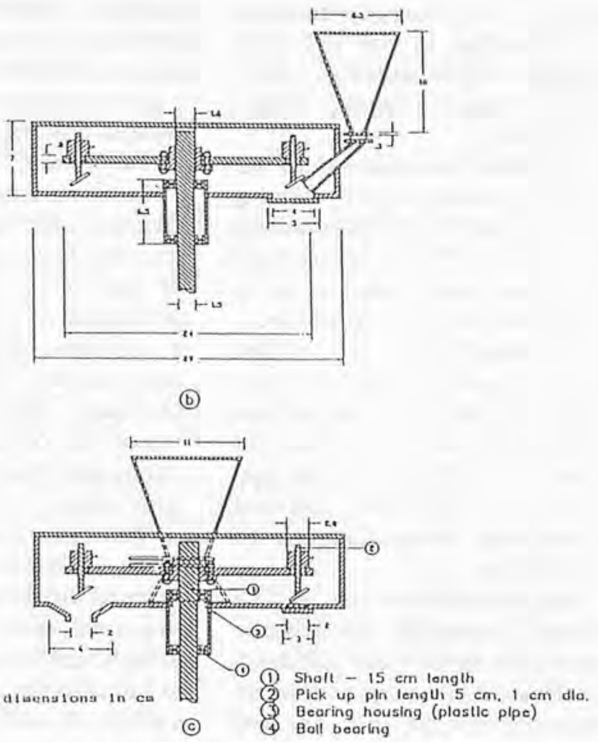


Fig. 2 (b) Section X-X, (c) Section Y-Y.

Furrow opener — A shoe type single furrow opener fabricated out of MS sheet was fitted on the bottom face of the frame. Its length can be changed to facilitate desired penetration in the soil to open a furrow of required depth for placement of seeds in the moist zone of the soil. The lower end of the seed tube was fitted between the wings of the furrow opener.

Press - wheel — Press wheel was made of MS plate. It has two parts so that the width can be adjusted according to need. Each half is tapered inside to give less pressure on the soil above the seeds. The outer diameter was 200 mm, inner diameter was 150 mm and the width was 35 mm for each half.

Gear and chain-sprocket — In order to transmit power for the metering device from driving wheel shaft to the horizontal shaft, a chain (bicycle chain 127 mm pitch) and two 70 mm diameter sprockets with 16 teeth were used. Two helical gears 19 teeth each were used to transmit power from the horizontal shaft to the vertical shaft of the metering device.

Clutch — A dog clutch was used to connect and disconnect the metering device shaft from the driving wheel shaft. The dog clutch was attached to the extended end of the driving wheel shaft. In order to engage and disengage the metering device through the dog clutch, a bi-cycle brake cable with its end located near the handle of the planter was used.

Frame and shaft — The frame was made of MS plate. The furrow opener, shafts, driving wheel, clutch, push handle, press-wheel, metering device and chain-sprocket were attached to the frame. To connect the shafts to the frame, nuts and bolts and block bearing were used. A push handle was attached to the frame to push the planter manually.

Materials and Methods

Laboratory Performance Test

The following laboratory performance tests were undertaken.

Test of metering mechanism — The objective of this test was to examine the performance of the metering mechanism the result of which can provide the basic data for field performance.

In the case of electrostatic planter the driving wheel was jacked up and the metering device was rotated by turning the wheel for 20 revolutions. The delivery rate per hectare was calculated knowing row spacing, weight of seeds discharged from the delivery tube and distance travelled by the seeding machine in 20 revolutions. Tests with 10 replications were carried out.

This test was also undertaken by running the machine with full outfit over greased board or a layer of white powder of lime at the same speed as in the field. The seeds were trapped on the board or the layer of powdered lime at the point where they fell. The parameters measured, observed and recorded in the test were damage to seeds caused by metering mechanism and pattern of seed deposition.

The life of the woolen cloth was tested in the laboratory by running the metering device continuously with a 24V, 15W DC motor until the woolen cloth failed to create charges on the pick up points.

Germination test — Certified 100 jute seeds of variety C. *Capsularis* / C. *Olitorius* were kept on a filter paper soaked with water in a petri dish. After 3 days the germinated seeds were counted to calculate the percentage of germination.

Seed distribution test — The manually-operated electrostatic planter for small seeds was operated over the greased plastic/paper sheet spread on the floor. The seed distribution test was conducted in order to determine the number of seeds per meter length of row, distance of seeds per hill, width of seed interrows and pattern of distribution. This test was conducted with 10 replications.

Field Performance Test

The field performance test was conducted in order to obtain actual data for overall machine performance, operating accuracy, work capacity, field conditions and field efficiency.

The field was prepared to create optimum conditions for germination. The field was ploughed by disc plough, harrowed by disc harrow and tilled twice by a rotavator and levelled by leveller/ladder. The field plots of 50 m × 10 m were marked by bamboo stakes and rope. The test was conducted with four replications and one treatment.

The seeds used for this test were the same as those used for the metering mechanism test (laboratory performance test). Each plot measured 0.05 ha for this machine. The plot was rectangular with the sides in the ratio of 5:1 as far as possible. The parameters that were measured and observed were as follows:

Performance and accuracy — These parameters considered seed rate, spacing of planted rows, distance between hills, population of seeds planted in a unit area, population of established plants in a unit area, ratio of established plants to seeds planted, depth of planting, slippage of driving wheel, ease of handling and operation, soil moisture content, and cone index.

Work rate and labour requirement — Measurements were made of this actual average travelling speed, actual number of operating hours, time spent for turning at head-land, time spent for supply of seeds, time spent for adjusting the machine, working capacity, field efficiency, required number of workers and man hours, draft and push force, and power requirement.

Operational Cost

Whenever a new technology is introduced, the basic question which arises in the mind of a common user is whether the new technique is economical to adopt or not. Hence, in order to understand the scope of decision making for adopting new technology, the cost of operation of the electrostatic planter for jute seeds was analyzed following the standard method (Donnel Hunt, 1977). The break-even point was determined for the planter.

Results and Discussion

Specifications

The technical specifications of the planter are given in **Table 1**.

Functional Test

The functional test was conducted in the laboratory. Each component of the planter functioned very well. During turning at the head-land, the dog clutch worked very well to disconnect power from the driving wheel to metering device and no seed metering occurred. The planter turned very well in the head-land by the handle.

The life of the woolen cloth for continuous operation was 97 hours in the laboratory test. Theoretically, the woolen cloth should be changed after sowing a 7.5 ha area, based on the field capacity of the unit. However, taking into account the dusty environment in the field it was decided that the woolen cloth be changed after sowing a 5 ha field.

Table 1. Specifications of the Manually-operated Electrostatic Planter for Small Seeds

Item	Specification
Total length	1.4 m
Total width	0.43 m
Total height	0.90 m
Total weight	30 kg
Number of rows	1
Working width	0.30 m
Row spacing	0.30 m
Hill distance	0.30 m
Number of seeds per hill	1-4
Maximum depth of planting	30-50 m
Type of metering mechanism	Electrostatic force is used to pickup seeds
Seed rate	0.36 kg/ha
Refilling seed	twice/ha
Capacity	13.00 h/ha (0.077 ha/h)
Power requirement	30.00 W
Power source	Manual
Number of operator	1
Approximate price	3000.00 Baht (US$120 approximately)
Made at	Agricultural and Food Engineering Division Asian Institute of Technology Bangkok 10501, Thailand

Table 2. Pattern Distribution Test

Repli-cation	Row spacing (cm)	Hill spacing (cm)	Number of seeds /meter	Number of seeds /hill
1	0.30	0.30	16	2
2	0.31	0.31	14	3
3	0.29	0.29	10	5
4	0.32	0.32	13	2
5	0.28	0.29	15	4
6	0.29	0.30	17	6
7	0.30	0.31	18	2
8	0.33	0.30	12	3
9	0.31	0.32	9	4
10	0.32	0.29	11	3
Mean	0.30	0.30	13	3

Table 3. Seed Rate at Laboratory Test

Plant seed	Effective dia. (m)	Working width (m)	No. of revolutions of wheel	Total weight (g)	Seed rate kg/ha
Jute	0.42	0.30	20	0.289	0.37
Egg plant	0.42	0.30	20	0.696	0.88
Chilli	0.42	0.30	20	0.398	0.50

Table 4. Percentage Slip of Driving Wheel of Planter

Block	No. of revo-lutions	Time (sec)	Distance (m)	Velocity (m/s)	Theoretical distance (m)	Slip percent
B1	10.92	32	15	0.46	13.69	9.64
B2	10.70	27	15	0.54	13.44	10.17
B3	10.73	28	15	0.53	13.48	11.42
B4	10.50	31	15	0.48	13.19	13.71
Mean	10.71	30	15	0.50	13.45	11.24

Pattern Distribution Test

The result of pattern distribution test are shown in **Table 2**.

Seed Rate at Laboratory Test

Table 3 shows the seed rate measured for jute, egg plant and chilli. **Table 4** shows the slip of the driving wheel of the planter in four replications. The average slip was about 11% at average velocity of 0.5 m/s. **Table 5** shows the field capacity and field efficiency of the planter. The average field capacity was 13 h/ha and the average field efficiency was about 89%. The operator used a continuous pattern in operating the planter **(Fig. 3)**. However, the efficiency can be increased by choosing other alternative patterns.

Table 5. Field Capacity and Field Efficiency of Electrostatic Planter*

Block	Turning time (sec)	Unproductive time (sec)	Productive time (sec)	Total time (sec)	Field capacity (h/ha)	Field efficiency (%)
B1	235	235	2 440	2 675	14.86	91.21
B2	225	225	1 995	2 220	12.33	89.86
B3	250	250	1 910	2 160	12.00	88.42
B4	240	240	2 100	2 340	13.00	89.74
Mean	237.50	237.50	2 111.25	2 348.75	13.04	89.80

*Field size 50 m × 10 m, Row spacing 0.30 m.

Table 6. Power Required to Push the Manually-operated Electrostatic Planter

Tractor gear	Time (sec)	Distance (m)	Velocity (m/s)	Force N Lower	Force N Higher	Force N Ave.	Power required (watt)
I	94	15	0.16	78	151	114	18
II	65	15	0.23	62	129	96	22
III	32	15	0.45	45	167	105	48
Mean	63	15	0.28	62	149	105	30

Power Requirement

The values of the draft and power required to push the planter manually are shown in **Table 6**. The average draft for pushing the planter was 105 N. This corresponds to 30 W of which 23 W were used to overcome the rolling resistance of the driving wheel and 7 W to push the furrow opener — is within the capacity of a man or woman worker. The manually operated electrostatic planter was operated by one man or woman. The total draft to push the planter is quite low compared with other manually-operated planters. The lower draft is partly due to the use of ball bearings in the drive wheel, press-wheel and metering device shaft and narrow width of furrow openers used.

Germination Test

The average germination of the seed in a petri dish was 91.40% and the coefficient of variance 3.19%. The damage to the seeds passing through the metering device was zero. Certified seeds were used in the test.

The germination rate of jute seeds in the soil bin **(Fig. 4)** was 87% and 53% in the field. Heavy rain which caused standing water in the lower plots of the field was the main factor contributing to a low germination percentage.

Fig. 3 Field operation of manually-operated electrostatic planter.

Fig. 4 Germination test of jute seeds in the soil bin.

Economic Analysis

For the break-even analysis, the electrostatic planter and single-

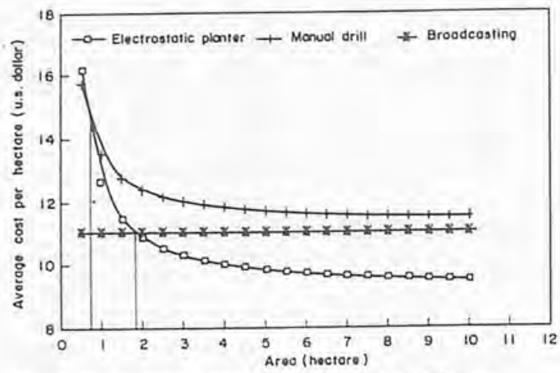


Fig. 5 Break-even Analysis of Electrostatic Planter.

row push type manual seed drill (Alam, 1988) were compared **(Fig. 5)**. At current wage levels, the planter has a break-even level at 0.75 ha/year compared with 1.8 ha/year for the manual seed planter that used the broadcasting method.

Conclusion

The electrostatic planter can be substituted for broadcasting and for single-row push type manual drill to reduce labour requirement during peak season, to reduce seed rate per hectare and to reduce operational drudgery.

REFERENCES

Ahmmed, Sultan. 1990. Development of a manually operated electrostatic planter for small seeds. M. Eng. Thesis AE - 90. Asian Institute of technology, Bangkok, Thailand.

Elliot, J.G. 1966. Improvements relating to the sowing of seeds. U.K. Patent no 1045, 732.

Gatzke, H.E.M.S. Ariens and V.G. Doty. 1967. Method and apparatus for hydraulic seed seed metering and planting. U.S. patent no. 33, 22, 080.

Fielder, M.L. and J.N. Summers. 1972. Volume displacement seed planter, matrix and method of planting seed. U.S. patent no. 36, 48, 631.

Rohrbach Roger P. and Ha Kim Kun. 1972. A fluidic seed meter? Transaction of ASAE 15 (6): 1003-1004, 1009.

Hiron, R.W.P. and R.C. Balls. 1978. The development and evaluation of an air pressurized fluid drill. Acta Horticultures 72: 109-120.

Giannini, G.R., W.J. Chancellor and R.E. Garrett. 1967. Precision planter using vaccum for seed pick-up. Transactions of ASAE. 10 (5): 607-610, 614.

Short Ted. H. and G. Humber Samuel. 1970. The development of Planetary Vacuum Seed Metering Device. Transactions of ASAE 13: 803-805.

Sial Fallak, S. and P.E. Petsson Sverker. 1984. Vacuum Nozzle Design for Seed Metering Device. Transaction of ASAE 27: 688-696.

Currah, I.E. 1978. Fluid drilling. World Crops, 30 (1): 22-24.

Searcy, S.W. 1980. Development of a precision metering system for pregerminated seed. Unpublished ph.D. dissertation. Oklahoma State University, Stillwater, OK.

Wilkins, D.E. and D.H. Lenker. 1981. A microprocessor controlled planter. Transaction of ASAE 24 (1): 2-4.

Searcy, Stephen, W. and O. Roth, Lawrence. 1982. Precision metering of fluid drilled seeds. Transaction of ASAE 25: 1563-1566.

Allen, R.R., L.D. Hoolingsworth and J.D. Thomas. 1983. Sun-flower planting and emergence with coated seed. Transaction for ASAE. 26: 668.

Rogers, J.A. 1977. Preliminary assessment of a supersonic seed sowing device, Journal of Agricultural Engineering Research, 2 (1): 97-100.

Jafari, Javad, V. and K. James Fornstorm. 1972. A precision punch planter for sugarbeets. Transactions of ASAE. 15 (3): 569-571.

Heiemann, W.H. Jr., J.W. Cary and Dilworth A.E., 1973. Experimental machines for autodibble planting. Transaction of ASAE 16 (4): 656-659.

Wilkins, D.E., Adrian, P.A. and Conley, W.J., 1979. Punch planting of vegetable seeds. Transaction of ASAE 22 (4): 746-749.

Hunt, D. 1977. Farm power and machinery management, Laboratory Manual and Workshop, Iowa State University press, Ames, Iowa.

Alam. A. 1988. First Report of the Consultant, Jute Seeder Development Project, IJO, Dhaka.

Srivastava, A.K. and M.E. Anibal. 1981. A punch planter for conservation tillage. ASAE Paper No. 81-1020, St. Joseph, MI: ASAE.

Development of a Hand-operated Rotary Sieve Cleaner-cum-Grader for Sesame Seed

by
R. Visvanathan
Krishi Vigyan Kendra
Kattupakkam 603203
India

V.V. Sreenarayanan
College of Agric. Eng.
Tamil Nadu G.D.N. Agric. Univ.
Coimbatore 641003, India

K.R. Swaminathan
Prof. and Dean
College of Agric. Engin.
Tamil Nadu G.D.N. Agric. Univ.
Coimbatore 641003, India

Abstract

A rotary sieve type cleaner-cum-grader for sesamum seed was developed that is suitable for removing small- and large-sized impurities from the sesamum seeds and grading the seed into two grades. The capacity of the unit is 125 kg/h. Its effectiveness was 71%.

Introduction

Sesamum (*Sesamum juncea*), a major oilseed in India, is grown for edible oil purposes and contains 48-52% edible oil. The oilcake has good potential as cattle feed. The sesamum seed obtained after threshing contains foreign materials and impurities. The presence of these impurities in the sesamum seeds affect the quality of the oil and oilcake. Hence, it is essential to clean the sesamum seeds for seed as well as oil extraction purpose. The manual separation of the seed is very time consuming and an inefficient one. , Also, the method of separation using vibratory or reciprocating screens and aspirators are difficult as the seed is with flat surface and low weight. Hence, a rotary screen cleaner-cum-grader that is suitable for removing both undersized and oversized impurities and grading the seeds into two grades.

Construction and Operation

The unit consisted mainly of a feed hopper rotary sieve assembly, mainframe outlets and cover. The rotary sieve assembly is made was 150 cm long and 36 cm in diameter. In the sieve assembly, a screw of 12 cm pitch and 30 cm inner diameter is provided to convey the sesamum seed. The rotary sieve assembly was divided into 3 parts along the length equally at 50 cm apart and the circumference was provided with sieves of sizes ISS 100, ISS 180, and ISS 240 in that order from the feeding end. The whole sieve assembly was mounted on a hollow shaft of 50 mm outer diameter and 40 mm inner diameter with 3 spokes. A handle was attached to the shaft at the feeding end of the sieve assembly in order to rotate the sieve assembly at a speed of 30-35 rpm. The whole assembly was mounted on two wooden bearings in the main frame made of mild steel L angle section.

A feed hopper with feed regulator, of capacity of 15 kg was mounted above the sieve assembly. The seeds flow from the hopper to the sieve. In the sieve assembly, the seed flow was in transverse direction and were cleaned and graded through the sieve perforations. Four inclined outlets were provided for the collection of impurities and cleaned products. A semi-circular cover was provided above the sieve assembly to avoid spilling of the seeds when the sieve assembly was rotated. The overall view of the unit is shown in **Fig. 1**.

Fig. 1 Hand-operated cleaner-cum-grader for sesamum.

Cleaning and Grading Efficiency

The sieve cleaner cum-grader cleaned and graded the seeds into 4 fractions as small-sized impurities, grade-1 (cleaned), grade-2 (cleaned) and large-sized impurities. (Let W_T be the total mass of the feed to be cleaned and graded. In the seed, let W_1, W_2, W_3 and W_4 be the mass of the individual fractions of the feed material corresponding to the sieve sizes S_1, S_2, S_3 and S_4 used in the unit) **(Fig. 2)**.

After cleaning and grading, the fraction of the feed material obtained through the product outlets may be Q_1, Q_2, Q_3 and Q_4. Hence,

$$W_1 + W_2 + W_3 + W_4 = W_T \quad ...(1)$$

$$Q_1 + Q_2 + Q_3 + Q_4 = W_T \quad ...(2)$$

Let q_1 be the mass of fraction of the material other than the required size available in the fraction Q_1. Similarly q_2, q_3 and q_4 are the fractions available in Q_2, Q_3 and Q_4.

Hence, the purity of the product obtained at different outlets after cleaning and grading is:

$$P_1 = \frac{Q_1 - q_1}{Q_1} \quad ...(3)$$

$$P_2 = \frac{Q_2 - q_2}{Q_2} \quad ...(4)$$

$$P_3 = \frac{Q_3 - q_3}{Q_3} \quad ...(5)$$

and

$$P_4 = \frac{Q_4 - q_4}{Q_4} \quad ...(6)$$

The fraction yield, ratio of material in the fraction to the initial mixture, obtained through the outlets were:

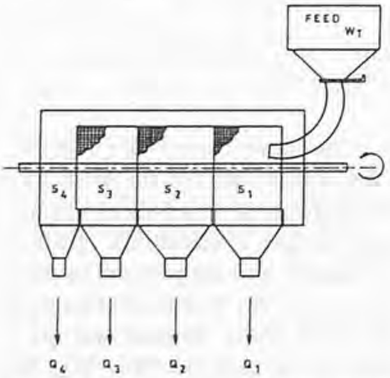


Fig. 2 Schematics of the cleaner-cum-grader.

Table 1. Values of Various Terms Used in Calculating Effectiveness

S_i	Particle size	W_i	Q_i	q_i	a_i	p_i	Fr_i	Ex_i
S_1	ISS 100	4 (W_1)	10 (Q_1)	1.08 (q_1)	0.008 (a_1)	0.892 (p_1)	0.020 (Fr_1)	2.230 (Ex_1)
S_2	ISS 100 / ISS 180	138 (W_2)	148 (Q_2)	17.50 (q_2)	0.276 (a_2)	0.882 (p_2)	0.296 (Fr_2)	0.946 (Ex_2)
S_3	ISS 180 / ISS 240	268 (W_3)	222 (Q_3)	54.00 (q_3)	0.536 (a_3)	0.757 (p_3)	0.444 (Fr_3)	0.627 (Ex_3)
S_4	ISS 240	90 (W_4)	120 (Q_4)	5.00 (q_4)	0.180 (a_4)	0.958 (p_4)	0.240 (Fr_4)	1.277 (Ex_4)

$$Fr_1 = \frac{Q_1}{W_T} \quad ...(7)$$

$$Fr_2 = \frac{Q_2}{W_T} \quad ...(8)$$

$$Fr_3 = \frac{Q_3}{W_T} \quad ...(9)$$

and

$$Fr_4 = \frac{Q_4}{W_T} \quad ...(10)$$

Let a_1, a_2, a_3 and a_4 be the fractions of each size corresponding to the sieves S_1, S_2, S_3 and S_4 in the total feed as:

$$a_1 = \frac{W_1}{W_T} \quad ...(11)$$

$$a_2 = \frac{W_2}{W_T} \quad ...(12)$$

$$a_3 = \frac{W_3}{W_T} \quad ...(13)$$

and

$$a_4 = \frac{W_4}{W_T} \quad ...(14)$$

Therefore, the degree of extraction, ratio of component in the yield r fraction of the same component in the initial mixture were:

$$Ex_1 = \frac{Q_1 - q_1}{W_1} = p_1 = \frac{Q_1}{W_1} = p_1 \frac{Q_1/W_T}{W_1/W_T} = p_1 \frac{Fr_1}{a_1} \quad ...(15)$$

Similarly,

$$Ex_2 = p_2 \frac{Fr_2}{a_2} \quad ...(16)$$

$$Ex_3 = p_3 \frac{Fr_3}{a_3} \quad ...(17)$$

$$Ex_4 = p_4 \frac{Fr_4}{a_4} \quad ...(18)$$

The overall effectiveness for the n-component mixture into n-fractions (Chang Joo chung, 1986) was evaluated by the completeness of the extraction of each component in a pure form as:

$$E = \sum_{i=1}^{n} Fr_i \left(\frac{p_i - a_i}{1 - a_i} \right) \quad ...(19)$$

Based on the equations (1) to (18), for the system of 4 components mixture into 4-fractions, the effectiveness of separation was calculated from equation (19).

The standard test sieves ISS 100, ISS 180 and ISS 240 were used to separate the feed into fractions corresponding to the sieves S_1, S_2, S_3 and S_4 (above ISS 240). The weights and values of various terms of the above equations are given in **Table 1**. These values are substituted in equation (19) and the effectiveness was calculated at 70.5%.

Conclusion

The hand-operated cleaner-cum-grader was evaluated for its effectiveness which was 70.5%.

REFERENCE

Chang Joo Chung. Rice Milling Technology. In post-harvest prevention of paddy/rice loss. Council of Agriculture, Republic of China, pp. 236-239, 1986.

Design and Development of WFST Machinery

by
Li Gou-Qiang
Chief Engineer, No. 2 Office
Shanxi Research Institute for Agricultural Machinery
Beiyin Taiyuan Shanxi, Postal No. 030031, China

Abstract

This paper introduces the conceptions of Water Preserving, Fertilizer Gathering and Soil Improving Tillage (WFST). The structual peculiarities of WFST machines have been studied. The paper proposes a method for calculating the cross-sectional dimensions of WFST furrows, analyses the horizontal layout of machinery assemblies, the longitudinal stability of loading forces and other parameters used to design WFST machinery.

Introduction

High Yield Furrow Tillage is another name for WFST. Developed from traditional sloping dry land tillage, WFST is a non-irrigational tillage particularly used in China. Owing to its evident effect on water and soil conservation and larger increment in crop harvests WFST has spread to about one million *mu* (66 667 hectares) in China at Shandong, Shanxi, Neimenggu, Helongjiang and other places. From the reports of large areas it has increased yield about 50% to 100%. Even in years of drought WFST keeps high and stable yields.

In order to solve the probelms of heavy labour and low efficiency we have studied and manufactured special machineries for WFST. Using and analyzing the results of investigations and experiments, this paper inquires into the WFST concept and its machinery designs.

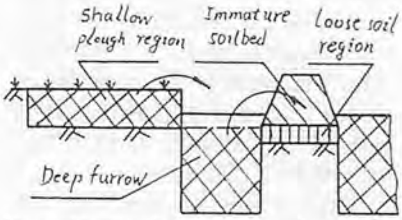


Fig. 1 Sketch of WFST technology.

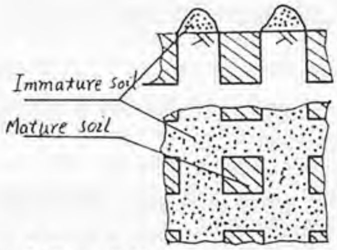


Fig. 2 Cross field.

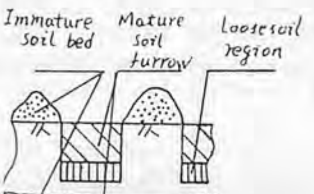


Fig. 3 Strip field.

Requirements and Effect of WFST

The basic plowing requirements of WFST are as follows: Strip the top soil with width equal to two times the furrow width and depth equal to 12 ~ 15 cm. Ditch in immature subsoil into the furrow and make bed beside it. Dimensions of furrow are 35 ~ 45 cm depth and 35 cm width. The height of bed is 12 ~ 15 cm and width is 35 cm. Then backfill top soil of double furrow width into the immature soil furrow (namely, fill top soil of double width into one width furrow). Sow seeds into furrow. The bed of immature soil may lie fallow or plant beans in it for the sake of maturation. Turn up the soil every two or three years. **(Fig. 1)**.

As shown in our historical documents there were two kinds of dry sloping land tillage-cross field (qu-field) and strip field (*chuan*-field) tillage in ancient times (**Fig. 2** and **Fig. 3**). The basic principle of cross field and strip field tillage is somewhat similar to WFST. Similarly, it also contains striping top soil, furrowing and backfill top soil into furrow and hereafter sowing seeds in furrows. The only difference between them are the

Table 1. Contrast of Labour Used and Crop Increase by Various Dry Sloping Land Till

Type of tillage	Increment wheat per *mu* (kg) (=0.66 are)	Labour (man-day)
Conventional	24.5	5.5
Cross field	85.5	15.2
Strip field	84.0	14.5
WFST	increase 50~100%	15.0

dimensions of furrows and beds. However, cross field and strip field tillage needed very hard labour, but under normal conditions they could double crop yields compared to conventional tillages. According to the investigation at Shanxi Shuide Water and Soil Conservation Station by the Central Research Institute of Agricultural Machinery, the contrast of labour used and crop increased by various dry sloping land tillage with WFST **(Table 1)**.

Thus it can be seen that the method of ploughing and increment of WFST are nearly identical with field and strip field tillage.

Calculation of WFST Furrow Sections

As cross-sectional dimensions of WFST furrow are essential in WFST design their accurate calculation should be made. The width of the WFST's furrows varies with agronomic technology

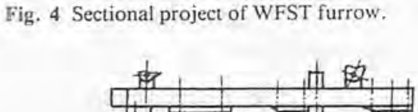


Fig. 4 Sectional project of WFST furrow.

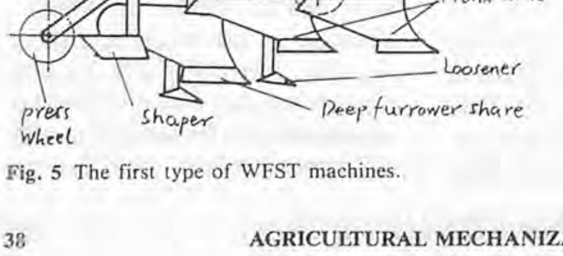


Fig. 5 The first type of WFST machines.

and plant spacing of crops. For the investigation of relationship between crop spacing, furrow section and other parameters, we introduce a proportional coefficient called Ratio of Immature and Mature Soil Areas. By means of this ratio formulas for calculating the cross-sectional dimensions of WFST furrow project can be derived **(Fig. 4)**:

D-furrow width
f-furrow depth (take 35 cm)
e-width of bed bottom
g-width of bed top
d-mature soil area
c-immature soil area

Given: Immature soil volume expanding coefficient: $\sigma_1 = 1.4$

Mature soil volume expanding coefficient:

$\sigma_2 = 1.1$

(Note: according to neutral loam soil).

Then

Immature soil area expanding coefficient

$\sigma_3 = 1.4\wedge(2/3) \approx 1.25$

Mature soil area expanding coefficient

$\sigma_4 = 1.1\wedge(2/3) \approx 1$

Ratio of immature and mature soil areas

$$d/c \approx 1.25 \quad (1)$$

And

$$d = a \cdot \sigma_4 \quad (2)$$

$$c = b \cdot \sigma_3 \quad (3)$$

Suppose ploughing depthh is kept constant the cross-sectional dimensions of WFST furrow may be calculated by the following formulas:

$$d = d/f = a \cdot \sigma_4/f \quad (4)$$

$$e = 2b \cdot \sigma_3/h\text{-}g \quad (5)$$

The ratio of immature and mature soil area will remain constant while the width of plant furrows changes.

WFST Machineries and Types

Most studies of WFST machineries adopt the share structure with various patterns of layout. According to the pattern of horizontal layout there are four types of WFST machines.

The main structural feature of first type is three shares' pattern with front shares for shallow plough and rear share for deep plough. **Fig. 5** shows the main structure and its horizontal layout is shown in **Fig. 6a**.

The WFST machine model 1LX-2(70) studied in Shanxi province is a typical representation of the second type. Its main peculiarities are as follows: Pattern of deep ploughing front share and shallow ploughing rear share is chosen. Shallow ploughing share is a whole big single share equippped with bed shaper and harrowing roller. This model has been appraised in 1989 and put into production. Now 500 machines have been manufactured and more then 400 000 *mu* (26 667 ha) have been ploughed by them. Hence, up to the present it is the most popular model in China. **Fig. 6b** shows its horizontal layout.

The third type adopts a pattern

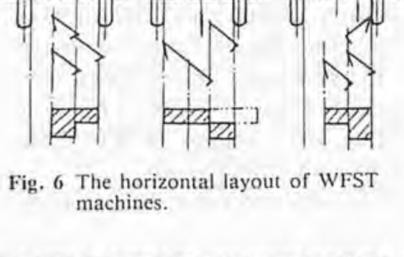


Fig. 6 The horizontal layout of WFST machines.

of three shares with front and rear share for deep and middle share for shallow ploughing. As the share's tips face toward left and right separately, this type of machine has smaller rotary torque and better longitudinal stability. Its horizontal pattern is shown in **Fig. 6c**.

The fourth type of WFST machinery can plough in both directions. Its main structural pattern is of three shares with front share for deep and rear shares for shallow ploughing. It adopts patttern as **Fig. 6b** and equipped with steel wire roller harrower, furrower and bed shapper.

Horizontal Pattern and Longitudinal Stability of WFST Machinery

The necessary condition for no sideslip to tractor during ploughing is that the resultant force of reactive forces on plough assemblies in horizontal plane must coincide with the tractor's longitudinal symmetrical plane. Usually the tread of tractor must be smaller or equal to ploughing width, otherwise sideslip or misploughing at field edges will occur.

The horizontal pattern design of WSFT machinery influences longitudinal stability directly. Longitudinal stability of machinery is a necessary condition for normal operation of the WFST machine. In order to complete all working process of WFST once, a 36 ~ 58.7 kW (50 ~ 80 HP) tractor should be used to match 1.2 ~ 1.4 t reactive force of WFST machine. As the width of ploughing is much smaller then the tread of present 50 ~ 80 HP tractor, some sideslip will occur only occasionally during ploughing.

After various patterns of assemblies' layout were analyzed and tested we recomend several horizontal layout patterns as shown in **Fig. 6** where pattern is a three shares' layout with front shares shallow and rear share deep. Its sectional view of furrow is shown in **Fig. 4**. Pattern b is big share's layout with each ploughing line overlapping one another preceding the share's tip. Pattern c is of left and right side facing the share's tip.

From the three types of layout it is evident that pattern b is better than pattern a and pattern c due to its smaller e value and offset torque (line of resultant reactive forces is nearly at 1/2 equal parts of ploughing cross-sectional area).

It is necessary to point out that although the position of line of drawing force plays an important role in straight line drive, in practice the side component force is another essential factor. If the problems of influence of sidewise force do not solve the structural design its effect on straight line drive may even exceed that of the position of drawing force. This may be explaned in **Fig. 7**. For pattern 6c shown in **Fig. 6** though e value of drawing force line is large, a share toward left has set a reverse torque. From **Fig. 7** it can be shown that:

$M_1 = e \cdot fd$

$M_2 = e_1 \cdot fs_1$

$M_3 = e_2 \cdot fs_2$

$e_1 > e$ and $e_2 > e$

As e_1 and e_2 are much greater than e, an increase of M_2 and M_3 caused by the increment of e_1, e_2 and fs_1, fs_2 may be greater than M_1. Therefore, on the point of view of straight drive the influence of positions and magnitudes of fs_1 and fs_2 often go beyond drawing force fd of the machine. As in pattern 6c by taking the measures of equipping share toward left and other methods to equilibrium sidewise force evident effect is obtained in practical experiments.

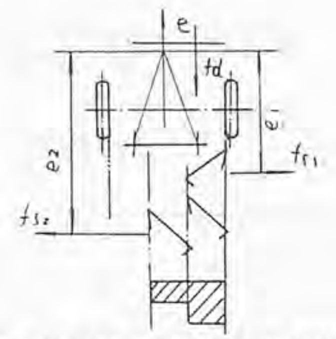


Fig. 7 The horizontal force of WFST machine unit.

Parameter of Mounting and Stability of Plow Body

As for ensuring the stability of front and rear shares' tips at different ploughing depths in pattern 6b, selecting a resonable mounting parameter is important. It is difficult to ensure the stability of rear big ploughing share by means of ordinary method for mounting parameter selection. According to our experiment, for normal operation of machine equipped with spring rollers the ground pressure of rolling wheel should be greater than 150 ~ 200 kg while the rear share's ploughing torque is greater than 10 kgf-M. The position of instantaneous center should be lower than that of ordinary plow. If offset drawing force is large the horizontal accumulating angle β should use smaller value between 15° and 20°.

The preceding data were obtained from our experiments and they can be used as reference only.

Essentials of Design of Deep Ploughing Soil Lifting and Ditching Plow Body

Based on experiments and investigations we have studied and analyzed the surface curve of plow share according to the requirements of high yield furrow tillage.

1. As high yield furrow is

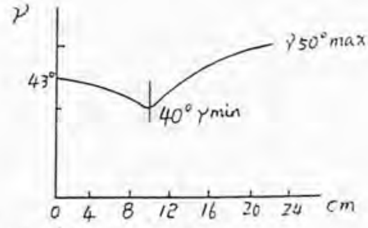


Fig. 8 Variation of γ.

trapezoidal in shape (**Fig. 4**) the curved surface of plow should be so designed as the soil can be lifted to a certain height, rolled and moved thus immature soil bed is to be made. Therefore, below line of plouging depth greater γ° should be used and variation between γ and γ° min should be very small to cause the turned soil being lifted fast and less sidewise movement. Above the line of ploughing depth γ min ~ γ max = 7° ~ 10°. The variation curve of γ is shown in **Fig. 8**. As the furrower body mainly operates in immature soil, no special requirements are needed for turning the soil. But the soil should be finely broken for easy rolling and bedding.

2. Modification of the share's derivative curve. As the share for deep ploughing operates in immature soil, its resistance is much greater than ordinary share. In order to minimize ploughing resistance, to lift deep immature soil freely and break soil finely the position of derivative curve should be designed at 2/3 ~ 1/2 portion of share length. The value of curve opening L/h should take upper limit to reduce resistance. The angle of soil lifting should take lower limit ($\epsilon > 26°$). The tangent line angle ω:

$$\omega = 90 + \epsilon + \Delta\epsilon$$

$\Delta\epsilon$ takes greater value.

In short, the selection of parameters for deep plow body during its design can not be rigidly adhered to traditional plow design theories. They must be modified and determined gradually on the basis of experiments.

For further decreasing the resistance and improving the effect of making immature soil bed, ditching plow may develop toward the mode of roll combined with scurry.

Design of Bed Shaping, Rolling and Harrowing Mechanism

Rolling and harrowing operation is one of the means for increasing crop yield due to its soil preservation and its increasing rate of seed emergence. The WFST machinery studied are often equipped with roll and harrow devices. Seeding may be done directly after ploughing.

Considering the condition of tractor mounting weight demands for pressure on ground, the roller wheels can not be too heavy. In order to gain better rolling effect (as standard press down ploughed soil layer 20 ~ 40 mm) it is reasonable to use elastic mounting roller wheels. Pressing force $Q < 1.47 \times 100$ N. Land pressure = $2.94 \times 10\,000 \sim 3.92 \times 10\,000$ pa. Diameter of the roller wheel should take smaller value.

Land pressure of roller wheel may be calculated as follows:

$$q = \frac{Q}{L \cdot (b/2)} = \frac{2Q}{Lb} \ (g/cm^2)$$

where

q = pressure to land (g/cm^2)
Q = weight of roller wheel (g)
L = length of roller wheel (cm)
b = chord length of roller wheel's support curve (cm) may be measured from land surface directly.

Of course, setting spring to roller wheel is not the most ideal method. Too week spring can not press land well and too strong spring will influence the share to insert too deeply into the soil.

Conclusion

The WFST is a dry land tillage method particularly used in China. It has spread widely in large farming areas in recent years. The successful study of WFST machinery helps the developmewnt of this new drought-resistant technology.

REFERENCES

Beijing P.R. China Machinery Publishing House (1960.8) "Handbook of Agricultural Machinery References Material."

Construction, Operation and Test of a Bamboo Drip Irrigation System


by
Md. Abdul Baqui
Principal Agric. Engineer
Farm Machinery and Post Harvest Technology Div.
Bangladesh Rice Research Institute
P.O. BRRI, Gazipur 1701, Bangladesh

Honorato L. Angeles
Dean
College of Engineering
Central Luzon State Univ.
Munos, N.E. 3120, Philippines

Abstract

A low-cost bamboo drip-irrigation system was designed, constructed and tested in 1990 in the Central Luzon State University (CLSU) Philippines. Its field performance was evaluated and compared with another low-cost drip irrigation system, namely: polyethylene-polytube (PE-polytube) and with a commercial drip system.

The average field emission uniformity of the low-cost drip systems was obtained up to 95%. Application efficiencies were as high as 96 to 98% which are quite acceptable for such a low-cost system.

Clogging of low-cost emitters by rapid algae infestation was a major problem in drip irrigation systems. However, it was expected that a suitable irrigation interval would allow enough time to dry the emitter and algae infestation would be minimized. Based on the test results, the PE-polytube drip system was identified as the better alternative to the commercial drip-system in terms of cost efficiency and durability. The bamboo drip-system needs further study with chemically treated bamboos.

Introduction

Importance of the Study

Drip irrigation is a method that applies small quantities of water to the soil surface through small openings. This method of irrigation can drastically reduce the irrigation water requirements of the crop without decreasing the yield. Probably, the high investment cost limits its application, specially in the developing countries.

The potential advantage of drip irrigation is the ability to maintain the soil at a highly moist yet unsaturated condition. In this manner, soil air remains at a continuous phase of exchanging gases with the atmosphere. Properly managed drip irrigation seems to offer the best opportunity at present to optimize the use of water, nutrient and air regimes at the root zone of a plant.

Use of Bamboo as Pipeline

Bamboos have myriad uses as a construction material owing to its physical structure. The diameter-length of internodes and wall thickness of certain species vary to a certain degree and it was expected that a number of species may satisfy the requirements for the raw materials in designing a drip-irrigation system. Its cylindrical and hollow structure with its rigid cross-walls give its resistance to collapse from bending. Furthermore, tissues of high tensile strength are concentrated near the surface giving it a high mechanical strength and a firm resistant shell (McLure, 1953). The outer covering is highly cutinized and infiltrated with silica making it a good protective covering (Puruganan, 1959). The hardness of bamboos in fact showed that it approximates mild steel (Espinosa, 1930). The size and shape of bamboo renders their handling, storage and transport easy and economical. Bamboos, however, have some limitations. They have very limited durability. Experience indicates that it is easily destroyed by termites, powder-pest beetles and decay fungi. In general, under ordinary conditions in contact with the soil, its average life is 1 to 3 years (Esguerra, 1989).

Objectives of the Study

The general objective of the study was to design and test a drip-irrigation system using bamboo (*buho* Philippines local name) and other locally available materials. The specific objectives were as follows:

i) To identify and recommend the best alternative to the commercial drip system.

ii) To develop construction techniques and hydraulics related to bamboo laterals and low-cost emitters.
iii) To operate a drip system at a very low pressure.
iv) To recommend and suggest further modification/improvement of the proposed system based on field test results.

Fig. 1 Locally available bamboos used for drip pipeline.

Fig. 3 Calibrating a low-cost polytube emitter in the field.

Fig. 2 Making of bamboo pipe.

Fig. 4 Assembly of fittings in a bamboo drip irrigation system.

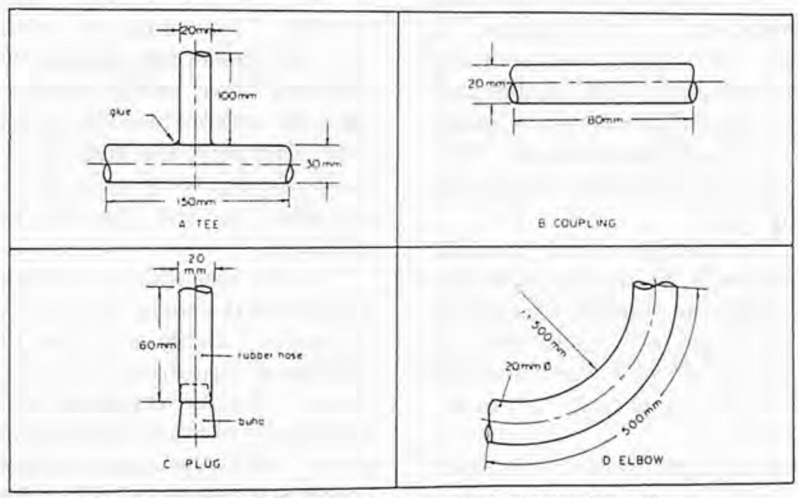


Fig. 5 Design dimensions of fittings for a low-cost drip irrigation system.

Materials and Methods

It has been reported that there are nearly 30 species of bamboos in the Philippines, 17 of which are erect and the rest are climbing (Brown, 1920).

Among the species available in the Philippines the local bamboo (*buho*) (*Chatachyum umanpao* (Blanco) Merrillianus) **(Fig. 1)** was found to be the most suitable for use in the drip system because of its less taperness and longer internodes to simplify couplings.

Construction of Components and Fittings

Making of Bamboo Pipes

Selected bamboos were dried, sorted and reduced to a uniform length (2 to 4 m) by drilling the internodes with help of a long mild-steel rod (usually 4-5 m long) anchored on bench **(Fig. 2)**. The excessive tapered portions were discarded to make two pipes uniform. However, for PE — Polytube system locally manufactured thin polyethylene pipes (used for clectrical conduit) were used.

Low-cost Emmitter

Three mm (1/8 in) diameter polyethylene tube (polytube) was selected for use as outer covering of the low-cost emitter **(Fig. 3)**. Different kinds of cotton threads, polyethylene cordage (rope), and plastic straw were inserted into the polytube for flow regulation. Due to an infinite number of combinations between polytube and cordage (thread), a series of comparative tests were conducted with randomly selected threads/cordages inserted into the polytube in order to select the best material for flow regulation.

Low-cost Fitting

Different sizes of ordinary rubber hose (12-20 mm dia) cut into pieces were used as fittings for the bamboo drip system **(Figs. 4** and **5)**.

System Layout, Field Network Design and Installation

In order to simplify the installation, a surface single-lateral drip system was designed and installed at the Central Luzon State University (CLSU), Philippines grapeyard **(Fig. 6)**. Repeated checking was made by allowing a flow of water through the pipes to discover any crack, ant-holes or any kind of damage before assembling the fittings. The excessive tapered

Fig. 6 A bamboo drip irrigation system in operation.

bamboos were discarded to enable the pipes to be fitted into a particular hose size. Sometimes, rubber washer (spacer) was used for beter fitting of coupling joints. Leakage from the coupling joints were completely checked by wrapping the joints with scrap bicycle inner tube. Ant-holes were closed by putting liquid adhesive (mighty bond). The bamboo laterals were then drilled and polytube emitters were installed on it by applying liquid adhesive (mighty bond). For the commercial system a recommended punching tool was used.

Water Source

Three oil drums (220 liter capacity) were placed on an elevated structure to create necessary pressure heads (1.5-2 m) for an individual system. However, the commercial system was directly connected to the CLSU domestic water supply line to obtain the recommended operating pressure (5 to 45 m).

Tests and Evaluation

Before conducting the test all systems were operated about two months until an acceptable performance was observed. Necessary data were collected for determining irrigation efficiency and uniformity. Tests on bamboo pipeline and emitter hydraulics were performed in the laboratory. The application efficiency (Elq) and the emission uniformity (Eu) were calculated for estimating how well a system can perform.

Results and Discussion

Hydraulic of Bamboo Pipe

Due to lack of available information on the hydraulics of bamboo as pipeline, laboratory tests were conducted to determine friction head loss due to flow of water through it. The test results indicate that bamboos with a diameter within 15 mm to 28 mm may be used for low-pressure (1.5-5 m) irrigation systems **(Fig. 7)**.

Hydraulics of Final Emitter Model

In the trial operation, it was found that a 7-cm cordage length inserted into a 30-cm long polytube cover gave the longer trouble-free performance. Therefore, a series of laboratory tests were conducted by varying the cordage length of 2, 5 and 7 cm at different pressure heads with 15, 30 and 50 cm length of polytube. The test results are presented in **Fig. 8**. New emitters show a similar trend like commercial emitters at a very low head (1.5-2 m).

Emission Uniformity and Application Efficiency

Field emission uniformity of the alternative drip systems were obtained up to 95% **(Table 1)** which may be considered excellent for these low-cost drip systems when compared to that of a commercial drip system (89%). Similarly, application efficiencies from 96 to 98% are quite acceptable for such kind of systems. The possibility of under irrigation in all low-

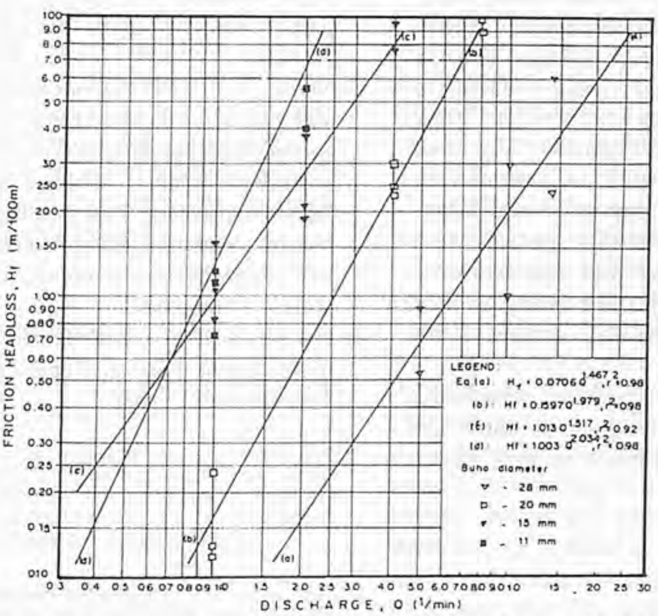


Fig. 7 Friction loss (Hf) in m/100m bamboo pipes vs flowrate (l/min).

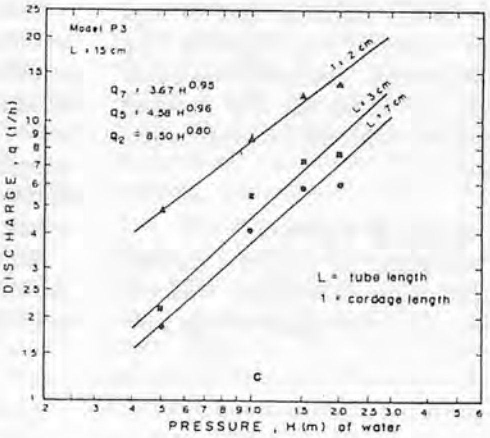


Fig. 8 Pressure vs discharge curves for low-cost polytube emitter of various setting of cordage length.

Table 1. Comparative Field Performance of Alternative Drip Irrigation System

Irrigation system	Uniformity (EU') Before adjustment (%)	After adjustment (%)	G (l/plant/day)	Application efficiency (ELQ)			
				G' (l/plant/day)		100G/G' (%)	
				Before adjust-ment	After adjust-ment	Before adjust-ment	After adjust-ment
Bamboo-polytube	93.50	94.70	16	16.59 (4.15)	16.61 (4.15)	96.46	96.34
PE-polytube	90.75	93.88	16	16.44 (4.11)	16.36 (4.09)	97.32	97.80
Commercial	—	89.00	16	—	14.68 (3.67)	—	108.99*

Note: Figures within parentheses are the average emitter discharges (l/h)
* - G' < G (underirrigated).
G : Design gross volume of H_2O required. (l/plant/day).
G' : Volume of H_2O actually applied. (l/plant/day).
Elq : Efficiency of low-quarter (%).
EU' : Actual emission uniformity (%).

cost drip systems was less than that of the commercial system.

Problems and Solutions

Removing of Bamboo Internodes

Major problems were encountered in removing the bamboo internodes with a long steel rod. Bamboos easily get cracked with a very slow pull-push action of the steel rod. This problem was partially minimized by using the smallest possible size of steel rod.

Leakage

It was observed during the field operation that bamboos with comparatively small diameter were much better than those with large diameter. However, water leakage through the cracked laterals, manifold, mainline and fittings was checked by reparing the components. The repair was made only by replacing the cracked portion of the bamboo with a new one.

Clogging of Emitters

Clogging of emitters through rapid algae infestation was the most severe problem for the low-cost emitters. More than 55% reduction in discharge was observed within 14 days of daily irrigation. However, reduction in discharge after a week was below 5%. During operation the emitters were cleaned manually with the help of a stick. **(Fig. 9)**.

Conclusions and Recommendation

Among the three drip systems (bamboo-polytube, PE-polytube, and commercial), the PE-polytube drip system was the best alternative to the commercial drip system. It is trouble-free and more durable than any other alternative drip system. Therefore, this can be recommended for use in farmer's fields in areas where water supply is limited and expensive. Low-level techniques used in fabrication, installation, operation and maintenance of the new systems were very effective and can easily be adopted with the existing level of know-how by the farmers themselves.

Suitable irrigation scheduling should be designed to allow the polytube emitters to dry, hence prevent rapid algae infestation.

Fig. 9 Cleaning of alage infested low-cost emitter in the field.

The bamboo-polytube system cannot be recommended unless the economic life of bamboos are increased by other means. In order to increase life expentancy of bamboos, studies need to be undertaken to determine if chemically treated bamboos can be more durable and useful.

REFERENCES

Purugganan V.A. 1959. Research Study on the Use of Bamboo as Reinforcement in Portland Cement Concrete. Bureau of Public Highway. Philippines.

Espinosa, J.C. 1930. Bonding and Comparative Strengths of Common Philippine Bamboo. Philippines, Jou. Sci. Vol. 41. pp. 121-135.

Esguerra, A.T. 1989. Development and Testing of Bamboo Drip Irrigation System on Grapes. An Unpublished Report. College of Agro-Engineering. Don Mariano Marcos Memorial State University (DMMMSU) Bacnotan, La Union, Philippines.

Brown, W.H. 1920. Minor Products in Philippine Forests. Bureau of Forestry Bull. 1 (22).

Rear-mounted Mini-boom for Knapsack Sprayers

by
N.K. Awadhwal
Project Engineer
Agric. Eng. Div.
International Rice Research Institute
P.O. Box 933; 1099 Manila, Philippines

G.R. Quick
Agricultural Engineer
Agric. Eng. Div., IRRI
P.O. Box 933; 1099 Manila, Philippines

E.F. Cabrido
Research Assistant
Agric. Eng. Div., IRRI
P.O. Box 933; 1099 Manila, Philippines

Abstract

A rear-mounted mini-boom for knapsack sprayers was designed and tested. It has a 2-m swath and allows an operator to walk ahead of the spray. Operator exposure to pesticides from the mini-boom was significantly lower ($P < 0.05$) than for a conventional knapsack sprayer. The spray pattern of the mini-boom was more uniform than the spray pattern of a conventional knapsack sprayer. Requirements of water and labour, and effectiveness of pesticide application of the mini-boom do not differ significantly ($P < 0.05$) from that of a knapsack sprayer. The mini-boom attachment is simple in construction, inexpensive and can be made by small-scale fabricators.

Introduction

Knapsack sprayers are the most commonly-used piece of equipment among small-scale farmers in Asia. It is most likely to be the principal means of pesticide application on small farms for the foreseeable future. Sprayer users are exposed to pesticides while mixing and pouring chemical, during the actual spraying operation, and while servicing equipment (Zandstra, 1987). Operators of conventional knapsack sprayers invariably carry the hand-held lance in front and have to walk into the spray mist and treated foliage (Matthews, 1985), which exacerbates exposure to pesticides. Adaptations of the knapsack sprayer lance has been developed in the past to either improve distribution of spray droplets (Tunstall, Metthews and Rhodes, 1961: 1965) or increase the speed of spraying (Johnstone, Huntington and King, 1975). In order to improve safety, wide-angle nozzles were fitted on to the back of a sprayer tank (Fernando, 1956) so that the operator could walk clear of the spray. However, adjustment of nozzles could not be done easily. Limited attention has been devoted to reducing operator exposure from conventional knapsack sprayers. This paper reports on the development of a mini-boom for attaching to the tank of a knapsack sprayer to reduce operator exposure and improve targeting efficiency.

Note: Mention of a comemrcical product is made for specific information only and should not to be construed as a product endorsement by the International Rice Research Institute (IRRI).

Acknowledgements: We thank Mr. J.R. Abengania, Mr. Willie Silon and Ms. G.U. Malabanan for their assistance.

Materials and Methods

A simple mini-boom for mounting on the tank of knapsack sprayers was designed and tested. It consists of an aluminum boom-pipe (outer diameter 10 mm), fitted with 4 spray nozzles (Teejet XR 8002 VS) at 0.5 m spacing. The boom-pipe is attached to a frame having provision for clamping the unit on the tank of a knapsack sprayer. The delivery hose of the knapsack sprayer is connected to the mini-boom through a cut-off valve (**Fig. 1**). A pawl and ratchet is provided to adjust the height of the mini-boom which can be easily operated even while spraying. The mini-boom is held at a distance of about 90 cm behind the operator. It covers a 2-m swath and allows the operator to walk safely ahead of the spray (**Fig. 2**). The mini-boom attachment weighs approximately 1.3 kg and it should be marketable for about US$ 15.00.

Test Procedures

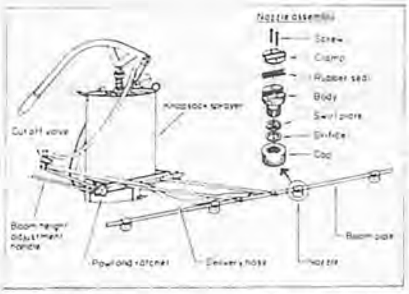


Fig. 1 Rear-mounted mini-boom for knapsack sprayer.

Fig. 2 Mini-boom attached to a knapsack sprayer.

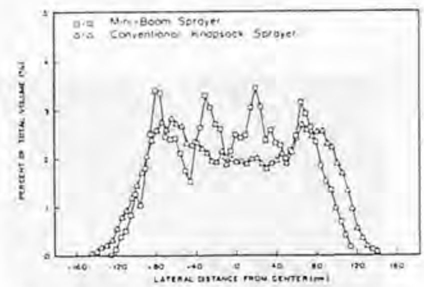


Fig. 3 Spray distribution across 2-m swath width.

A commercially-available spray table (Lurmark) was used to study the spray pattern of the mini-boom and compare it with that of a knapsack sprayer fitted with a Teejet XR 8004 VS nozzle. During the tests, the mini-boom and the knapasack sprayer lance were held at a height of 50 cm above the spray table. The volume of water collected in the graduated cylinders at different locations on the spray table were measured and expressed as percent of the total volume collected in each test. In order to determine spray pattern, the mean volumes of water collected (%) were plotted against location of the cylinders.

Replicated field trials were conducted in randomized block design with 5 replications to evaluate performance of the mini-boom and to compare it with that of the conventional knapsack sprayers. Herbicide (2,4-D) was applied at the rate of 0.8 kg a.i./ha, in a field without any crop. The efficacy of weed control was observed 15 days after the application of the herbicide. Requirements such as time, water and labour were also recorded. In another experiment, the operator exposure from the rear-mounted mini-boom was compared with that of the conventional lance under similar operating conditions. The pesticide solution was simulated using an aqueous solution of fluorescent dye (Fluorescein sodium). The simulated pesticide was applied with both applicators. The deposists on the operator's protective clothing were collected for 2 min periods with the help of polythene sheet samplers. The quantity of the dye deposits were determined with a Fluorometer (Sequoi-Turner model 450). The volume of the simulated pesticide falling on a unit area of the operator's body was determined. These measurements were done when the wind direction was at 30°-150° across the operators direction of travel and wind speed was below 10 km/h.

Results and Discussion

Results of the exposure tests show that the operator had significantly lower ($P < 0.01$) contamination while using the mini-boom compared to that of a knapsack sprayer. The mean dye deposits on the operator's body below the waist (area 0.368 m^2), in a 2 min spraying period, were 0.432 ml/m^2 for the mini-boom applicator and 1.233 ml/m^2 for a knapsack sprayer. This reflects a reduction of 65% on deposits of pesticide on the operator.

The mini-boom covers a 2-m swath which is about the same width covered when the operator swings the lance from side to side. The spray pattern determined with a spray table shows that the distribution of spray across the 2-m swath of the mini-boom had a coefficient of variation (CV) of 18.3% compared with the CV of 22.4% for the knapsack sprayer for the same swath width. The coefficient of uniformity (CU), an index of uniformity of spray distribution (Bode et al. 1968), was 97.1% for the mini-boom and 92.5% for the knapsack sprayer. The CV and CU of the mini-boom were significantly ($P < 0.05$) different from the CV and CU of the knapsack sprayer. This indicates that the mini-boom has more uniform spray deposit than the knapsack sprayer. The distribution of the spray liquid discharged from the pesticide applicators held at optimum height (50 cm) are shown in **Fig. 3**.

Field experiments show that the mini-boom performed as well as the knapsack sprayer in the application of herbicides. One foliage application of 2,4-D by the mini-boom and knapsack sprayer reduced weed intensity by 62.3% and 61.22%, respectively. The final weed intensities did no differ significantly ($P < 0.05$). The mini-boom sprayed behind the operator and required about the same quantity of water (210-220 l) and labour (14 man-h) to cover one hectare as required for the knapsack sprayer.

Conclusion

The mini-boom attachment sprays behind the operator and generally reduces exposure to pesticides. Its requirement of water and labour, and effectieness of pesticide application are similar to that of a conventional knapsack sprayer. The mini-boom is simple in construction and can be fabricated in small workshops.

(Continued on page 53)

Mounted Implement for Sugarcane Stool Destruction

by
P. Musonge
Dept. of Chem. Eng. and Chem. Tech.
Imperial College of Science, Tech. and Medicine
University of London
London SW7 2BY, U.K.

P.G. Kaumbutho
Lecturer
Dept. of Agric. Eng.
P.O. Box 30197
Nairobi, Kenya

J.N. Kamau
R & D Engineer
Mumias Sugar Co.
P.O. Private Bag
Mumias, Kenya

Abstract

In an attempt towards achieving a more efficient mechanical method for destroying sugarcane stools, an implement comprising of a pair of disc gangs, two mouldboard plough bottoms and four disc coulters, mounted on a sturdy toolframe was designed and fabricated. A comparative study was done on the performance of the prototype implement against two mechanical and one chemical method of sugarcane stool destruction. Based on the field evaluation conducted, it is arguable that the designed implement has a potential as a method of sugarcane stool destruction under rainfed sugarcane production conditions.

Introduction

Sugarcane stool is a mass of primary, secondary and tertiary stalks with viable buds which would regenerate under suitable conditions (**Fig. 1**). It results from the harvested plant crop and the subsequent ratoon crops. Frequently after the cane is cut, there arises the need to plough out the stable when the yield of the ratoon crop falls below acceptale levels, or as a direct control measure for sugarcane diseases.

Before replanting the sugarcane fields, the stools of the previous crop have to be destroyed. This avoids the likelihood of regenerating shoots (normally referred to as volunteers or Rogues) transmitting diseases such as ratoon stunting disease (RSD), smut, mosaic and leaf scald, to newly planted crop. Volunteer eradication also ensures savings in hand-weeding and limits the possibility of mixing sugarcane varieties (Drew, 1984), allowing for optimal yield from the subsequent crop.

Sugarcane stool destruction with conventional land preparation equipment (mould board ploughs, disc ploughs and disc harrows) has proved to be ineffective, especially in high rainfall areas (Dicks et al., 1981; Iggo, 1974). Apart from the use of conventional land preparation equipment singly, other methods of cane stool destruction that have been tried include a combination of different operations on the stubble such as stool inversion by the mould board followed by several harrowing operations. Regenerating shoots are then removed by hand before replanting. Annon (1979/80) reported that this method consumes large

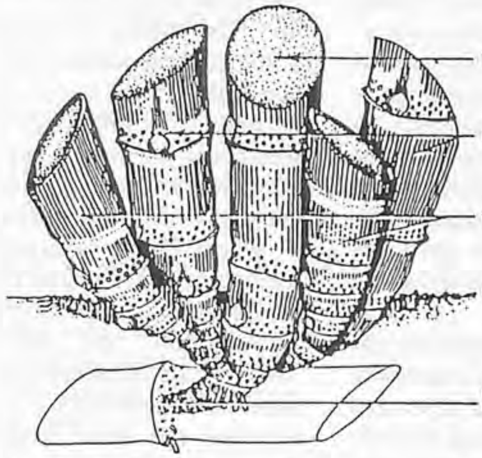


Fig. 1 A cane stool showing the primary, secondary and tertiary stalks from which stalks of succeeding orders develop (Humbert, 1968).

Acknowledgement: We wish to thank the management of Mumias Sugar Company Limited for agreeing to fund this study. Our gratitude is due to Mr J. Katua (Agricultural Engineer) and Mr Wanjala (Agronomist), both of Mumias Sugar Company. Special thanks to Farm Engineering Limited (Kisumu, Kenya) and Mr A. Oliyo of Mumias Sugar Company for the untiring effort in the fabrication work.

amounts of fuel and requires a long fallow period or a smother crop to ensure the complete elimination of volunteers. It, consequently, reduces productivity.

Non-conventional implements have also been used in an attempt to achieve efficient mechanical destruction of sugarcane stools. In one such attempt (Dicks et al., 1981), a mechanical stool eradicator similar in principle to a potato lifter with a system of screens and beater bars for separating the soil and the stools was developed. The machine operated successfully in sandy soils but could not cope adequately when operated on heavier soils.

The methods that have proved to have the ability to kill cane stool shave either been too expensive or have no time-considerations of the period over which land may be kept unproductive economically. This has justified the interest and the need to develop more efficient and cheaper mechanical systems of cane stool destruction.

Literature Review

Various researchers, either directly or otherwise, have pointed out the need for efficient sugarcane stool destruction after the harvest of the last ratoon crop and before planting new cane.

Ongoma et al. (1986), pointed out the order of economic importance of sugarcane diseases in Kenya as sugarcane smut, ratoon stunting disease (RSD), sugarcane mosaic virus (SMV) and leaf scald. This underscores the need for sugarcane stool eradication in Kenya.

Iggo (1974), reported on the encouragement of sugarcane growers to grow only pure and disease-free seedcane as a foundation for good sugarcane crop. He pointed out that the efforts that are put into procuring healthy seedcane can be lost if the fields to be planted contained diseased volunteer plants from the previous crop. It is, therefore, important to eradicate the volunteers so as to obviate transmission of disease to new crop.

Presently, economic necessities have taken precedence over the need for disease control, resulting in the shortening of fallow periods between the ploughing period and replanting. Generally, the fallow period is now often too short to allow for adequate elimination of volunteer regrowth which is particularly difficult to detect when the same sugarcane variety is replanted in the field.

Chemical method of controlling the cane stool has proved to be effective. The discovery that Glyphosate (N-Phosphonomethyl Glycine) eradicates sugarcane when applied to actively growing cane focused attention on chemical eradication of the old crop (Iggo, 1971). Previously, Baird et al. (1971) had reported that residue was harmful to subsequent plant growth. However, Dicks et al. (1981) stated that the escalating cost of glyphosate has revived interest in cheaper mechanical systems of stool destruction, particularly on flatter fields.

Turner (1980) studied the performance of a herbicide "Roundup" for killing sugarcane. He noted that the achievement of an acceptable kill by use of chemicals depends on suitability of the weather at the time of application and over the period required for the chemical to take effect.

Weeks (1985) reported on the availability of various forms of accelerated stool destruction. He noted that the mechanical methods are intended to slice the stools horizontally so as to separate the shoot nodes from their roots. This, he stated, can be achieved using power tillers which are effective but slow and expensive.

Broussard (1985), proposed an implement configuration which included a disc coulter, a blade plough and a disc gang for the purposes of stool destruction.

In an attempt to reduce the costs of sugrcane stool eradication, a ripper was modified and tested on heavy soils (Anonymous, 1983). This performed the necessary mechanical manipulations successfully at working depths of 150mm and forward speeds of between 4 km/h and 5 km/h. Higher operating speeds tended to separate plant material from the soil to a greater extent, but the depth of operation became erratic.

Design of the Implement

The original concept underlying the design of the implement was based on the field trials conducted earlier on Sugarcane Stool Destruction (MSC 1, 1985). From these trials and observations, it was suggested that the designed implement should be able to perform the following tillage operations:

1. Slice the stools horizontally at a preset depth bellow the ground;
2. Cut vertically, the horizontally sliced stools:
3. Overturn the slices to expose the root-mass to weather, and
4. To separate the overturned root-mass to allow for faster desiccation

Other requirements were that:

1. The implement should be of the fully-mounted type to utilize the advantages in manoeuvrability, weight, cost, transportability and for the purposes of depth control on irregular surface of the field;
2. There should be provisions for adjusting the severity of separation of the stool mass; and
3. The soil engaging tools should

be so adjustable as to allow the change in orientation (depth and width of cut) of the individual tools.

A constraint governing the design process was that the implement should be designed for Category 2 tractors of 80-100 Hp (60-75kW).

Trials were conducted on sandy, loamy sand and sandy clay loam soil types to compare the performance of different equipment combinations when used singly, in shaving and separating the stool mass for the purpose of desiccating them. From the results obtained in these trials and the intended mechanism of mechanical stool destruction, two "Ransome" mouldboard Plough bottoms of discs of 610 mm (24 inches) diameter each, were chosen as the tool combination to be used in the implement.

The particular depth of cut using a mouldboard plough which gave a cut through the stools at depth enough to sever the budding section of the stem was established to be about 150 mm. Since draught values are moderately low in sandy soils while much higher in clay soils (Reed, 1948), the limiting condition for the design required that the sugarcane stool destruction implement should stand the expected draught in clay soils when working at the specified speed and depth.

ASAE Standards D 230.4: Draught and Power Requirements (ASAE, 1989) was used to estimate the forces causing stress on the tool frame.

For a mouldboard plough bottom equipped with high speed mouldboards, coulters and landsides, and working in silty clay soils (ASAE, 1989):

$$D = 7 + 0.049S^2 \qquad (1)$$

Where
D = Draught in Newtons (N)
S = Speed in km/h

For disc harrows working in clay soils, draught per unit mass (D) at any speed, typical working depth is:

$$D = 14.7M \qquad (2)$$

Where
D = Draught in Newtons (N)
M = Mass in kilograms (kg)

Assumptions

(1) A maximum working depth of 150 mm and a parabolic profile for the sugarcane rows was assumed;
(2) A width of cut (farrow slice) of 254 mm (10 inches) was considered for the mouldboard bottom;
(3) Maximum speed of operation of 11.69 km/hr with a minimum slip of 15% was assumed;
(4) A lever-arm of 500 mm was assumed for both the mouldboard plough bottom and the disc gangs; and
(5) Soil engagement tool loading is a uni-directional cyclic load with a factor of safety of 3.

Equations (3) through Equation (8) were used to decide on the dimensions, to check on the failure of different components of the tool frame, and to check the static and dynamic stability of the prime-mover to be used with the implement.

For Bending Stresses

$$\frac{M}{I} = \frac{f}{y} \qquad (3)$$

Where
M = bending moment
I = section moment of inertia
y = perpendicular distance between the point of consideration adn the neutral axis of the beam

For Torsion

$$q = \frac{T}{2dBD} \qquad (4)$$

Where
q = shear stress
T = torque applied
d = thickness of hollow beam section
B,D = side dimensions of the box-section beam

For Direct Stress

$$f = \frac{F}{A} \qquad (5)$$

Where
f = stress
F = direct stress applied
A = area of section under load

For Deflection

$$d = \Sigma \frac{Ax}{EI} \qquad (6)$$

Where
d = linear deflection of the beam
A = area of the bending moment diagram
x = distance of the centroid of bending moment diagram to the point of application of load
E = Youngs Modulus
I = section modulus of inertia

For static stability of the tractor unit used,

$$R_f + \Sigma d_i W_i + F_t n = W_t p \qquad (7)$$

Where
R_f = ground reaction at the front wheels of the tractor
L = length of the wheelbase
W_i = weight of the various tool attachments used on the frame from the rear axle of the tractor
d_i = distance of the corresponding weights W_i above
F_t = total weight of toolframe
l = distance of the centre of gravity of toolframe from the rear axle
W_t = total tractor weight including weigh of ballasts

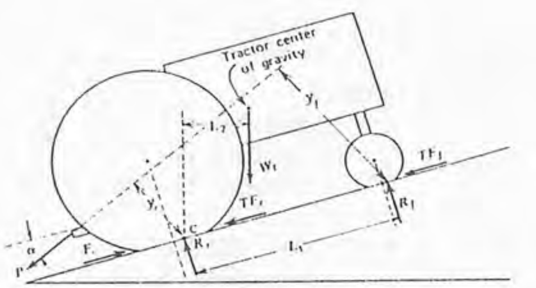


Fig. 2 Free body diagram illustrating the calculation of the reaction R_f on the front axle of a two wheel drive tractor (Liljedaal, 1989).

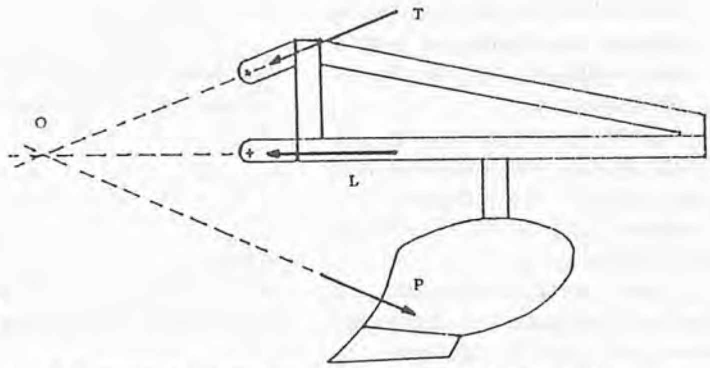


Fig. 3 Illustration of a fully mounted implement with the lower links unconstrained.

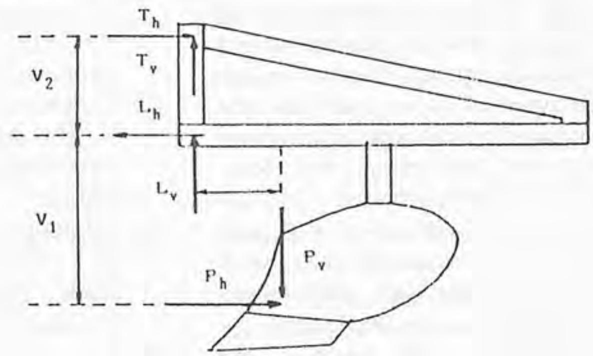


Fig. 4 Free body diagram of a fully mounted implement.

p = distance of the centre of gravity of the tractor from the rear axle

For the dynamic stability of the tractor unit used considering the free-body-diagram in **Fig. 2** (Liljedaahl et al., 1989),

$$P_s = \frac{W_t L_s}{y_r} \qquad (8)$$

Where

P_s = maximum safe drawbar pull for steering stability

L_s = horizontal distance of the centre of gravity of tractor from the point of contact between the ground and the drive-wheels

y_r = perpendicular distance of line of pull p to point C

For the calculation of shear and tensile stresses at the hitch point, consideration was as in the illustration on **Fig. 3**. The corresponding free-body-diagram is as in **Fig. 4**. For static equilibrium,

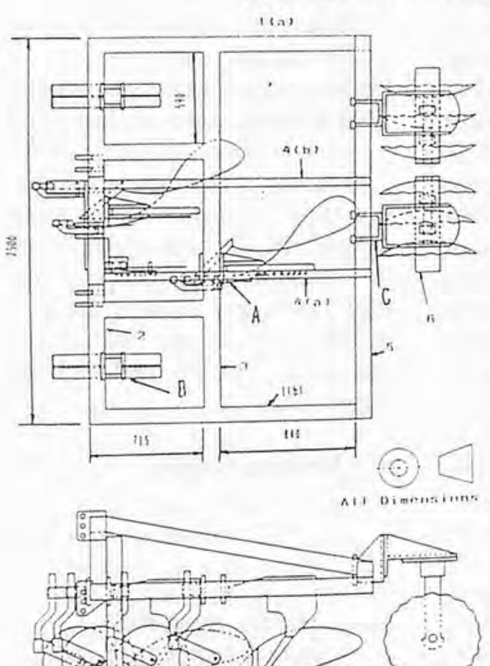
$$L_v + T_v - P_v = 0 \qquad (9)$$

$$T_h + P_h - L_h = 0 \qquad (10)$$

$$L_v V_2 = P_h V_1 - P_v H_1 + P_h V_2 \qquad (11)$$

Hence

$$L_h = \frac{P_h V_1 - P_v h_1}{V_2} + P_h \qquad (12)$$



PART NO.	DESCRIPTION	SPECIFICATION	QTY
8	MOULDBOARD		2
7	DISC COULTER	-	4
6	DISC GANGS	-	2
5	MAIN FRAME DISC GANG ATTACHMENT	100110018.3 MS	1
4(a), 4(b)	PROPS	100150I4mm MS	2
3	MAIN FRAME MOULDBOARD ATTACHMENT	100110018.3mm MS	1
2	MAIN FRAME MOULDBOARD ATTACHMENT	100110018.3mm MS	1
1(a), 1(b)	MAIN FRAME LATERAL	100110018.3mm MS	2

Fig. 5a Assembly drawing of the final prototype.

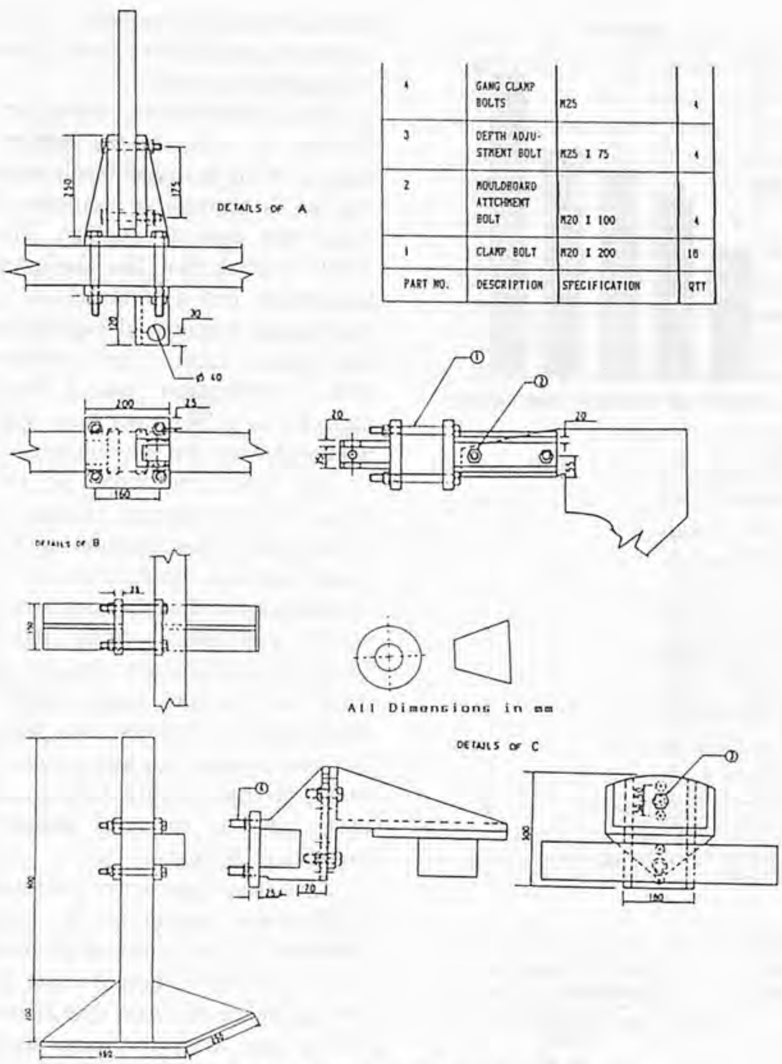
Neglecting the counteracting effect of the disc coulters and the disc gangs on the mouldboard suction, force P_v may be calculated from;

$$P_v = P_m + W+p \qquad (13)$$

Where

P_m = vertical suction on the mouldboard bottoms

W_p = weight of the implement



PART NO.	DESCRIPTION	SPECIFICATION	QTY
4	GANG CLAMP BOLTS	M25	4
3	DEPTH ADJUSTMENT BOLT	M25 X 75	4
2	MOULDBOARD ATTCHMENT BOLT	M20 X 100	4
1	CLAMP BOLT	M20 X 200	16

Fig. 5b Details of section of the prototype implement.

Fig. 5c Prototype CSD implement mounted on a Ford 6610 tractor.

Fig. 5d Partial front view of the CSD implement.

The dimensions of members 1(a), 1(b), 2, 3, 5 (**Fig. 5a**) was 100 × 100 × 6 mm box section, and members 4(a) and 4(b) was 100 × 50 × 4 mm box section. **Figure 5(b)** gives details of various sections of te prototype implement. The hitch points were made from a 25.4 mm mild steel plate. The final prototype of the CSD implement was as in **Fig. 5(c)** and **5(d)**.

For members 2, 3, and 5 (**Fig. 5a**), the estimated critical stresses are those due to the draught on the mouldboard bottoms and the disc gangs. Substituting values in equations 1 and 2 and by iteration, the estimated draught per mouldboard bottom and per disc gang were 3480 N and 3883 N, respectively. The corresponding torques are, therefore, 1740 Nm and 1942 Nm for the mouldboard bottom and a disc gang, respectively. Substituting these values in equation 3 through equation 6, maximum shear stress (q) is 16.2 Nmm^{-2} For members 1, and 1(a), maximum working stress which is a combination of direct stress and bending stress is 12.8 Nmm^{-2}. Considering on assumed yield stress of 200 Nmm^{-2} for mild steel, the design members were considered safe. For the props (members 4 and 4(a)) working stress is 198.1 Nmm^{-2}. This was thought to be safe considering that the units were to be joined to other frame members in the toolframe structure.

Field Trials of the Prototype

Field trials were conducted to compare the performance of the prototype sugarcane stool destruction tmplement against three traditional methods used in the MSC nucleus estate, namely:

1. Single pass blade ploughing operation.
2. Double pass harrowing operation; and
3. Chemical treatment using "Roundup" (N-Phosphonomethyl Gliycine)

The experimental set-up was a randomized complete block design (RCBD). The objective was to observe for several weeks the effect of the treatments on the number of regenerating sugarcane shoots. Plots with no treatment were used as control. Different experiments were conducted on sandy clay loam, sandy loam and loamy sand soil types. The results of a tiller count, done five weeks after treatment application, are

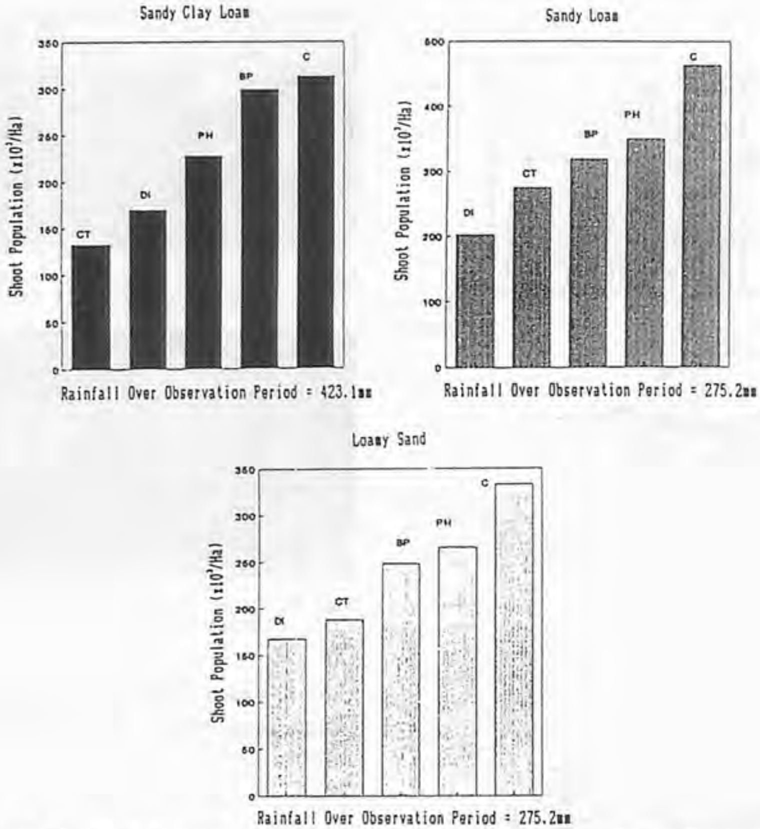


Fig. 6 The effect of five treatments on the number of regenerating shoots, five weeks after treatment application on three soil types.

Table 1. Costs for Cane Stool Destruction Methods

Operation/Implement	Estimated Field Capacity (ha/h)	Cost[1] of Owning and Operating (US$/ha)
CSD implement	0.59	25.60
Parmeter harrow	0.70	42.70
Blade plough	0.54	26.80
Chemical method	0.67	175.60

[1]Exchange rate as in February 1992 (1US$ = KSh 28.78).

shown in **Figure 6**. The costs for the four methods of sugarcane stool destruction compared are shown in **Table 1**.

On sandy clay loam, there was no statistically significant difference between harrowing and CSD implement operation. However, the chemical treatment was significantly different (statistically) from all other treatments.

On sandy loam soil type, the CSD implement operation was significantly different from all other operations.

On loamy sand soil type, the CSD implement operation returned the lowest count of tiller regeneration, although the difference from the bade ploughing operation and the chemical application was statistically insignificant.

Conclusions and Recommendations

A tool frame which can hold two 356-mm mouldboard plough bottoms, four 460-mm plain disc coulters and two disc gangs each having three 610-mm serrated discs was designed, fabricated and tested under field conditions. The implement could perform all operations that are thought to be necessary for effective destruction of sugarcane stools.

Field experiments were performed to compare the performance of the designed implement against three possible methods of sugarcane stool destruction. The results reveal that the designed implement has a potential as a mechanical method of sugarcane stool destruction. It had the least cost of operation, and a field capacity of 0.59 ha per hour was achieved with the implement.

The final prototype of the designed implement required modification (development) of the depth control mechanism. It is recommended that detailed stress analysis, preferably strain gauge based measurements should be done on the tool frame. These measurements will not only point out weaknesses, but also areas of excess strength where weight and cost may be reduced without sacrificing strength.

Cane stool destruction, being a preliminary operation in land preparation for sugarcane production, a study on actual costs or savings accruing from operations before and after the cane stool destruction operation should reveal more information on the implement's potential as a procedure for sugarcane stool destruction.

The use of skids as the depth control device required operation on fields free of sugarcane trash. Otherwise, the skids collected trash which adversely affected the implement operation. In the development of the prototype CSD implement, it is recommended that the skids be replaced by depth control wheels which would roll over trash and result in minimal effect on the implement operation.

REFERENCES

ASAE, 1989. American Society of

Agricultural Engineers (ASAE) Standards -34th Edition. The Society of Engineers in Agriculture, 2950 Niles Road, St. Joseph MI 49085-9659.

Annon, 1979/80. Annual Report 1979/80. South African Sugar Experiment Station, Mt Edgecombe, Natal 4300.

Anonymous, 1983. Cane Stool Destruction. South African Sugar Experiment Station, Mt Edgecombe, Natal 4300.

Baird, D. D., R. P. Upchurch Homesley and I. E. Franz, 1971. Introduction of a New Broad Spectrum Post-emergence Herbicide Class with Utility for Herbaceous Perennial Weed Control. Proceeds of the 26th North Central Weed Science Society Conference.

Broussard, V. K. 1985. Cane Stool Destruction. Correspondence to Mumias Sugar Company Ltd. Broussard Cane Equipment, P. O. Box 558, St. Martinville, Lousiana 70582, United States of America.

Dicks, E. N., E. Meyer, and G. C. Payn. 1981. A new approach to mechanical stool eradication. Proceeds of The South African Sugar Technologists' Association, June 1981. South African Sugar Experiment Station, Mount Edgecombe, Natal 4300.

Drew, P. 1984. Stool Destruction: Booker Agriculture International, Correspondence to Mumias Sugar Company Ltd. (Kenya). Booker Agriculture International Ltd., Bloomsburry House 74/77, Great Russel Street, London WC1B 3DF.

Humbert, R. P. 1968. The Growing of Sugar Cane. Elselvier Publishing Company, 335 Jan van Galestraat, P. O. Box 211, Amsterdam, The Netherlands.

Iggo, G. A. 1974. A new chemical (Glyphosate) for killing sugarcane. Proceeds of The South African Sugar Technologists' Association, June 1974. South African Sugar Experiment Station, Mount Edgecombe, Natal 4300.

MSC I, 1985. Cane Stool Destruction Trial Report. Research and Development Section, MSC, 1985. Unpublished.

Ongoma, G. L. B. and M. O. Osoro. 1986. Major sugarcane diseases in Kenya. The Kenya Sugar Journal of The Kenya Society of Sugar Technologists', November 1986.

Reed, I. F. 1948. Disk Ploughs and their Operation. United States Department of Agriculture Farmers' Bulletin No. 1992. USDA, Washington DC.

Turner, P. E. T. 1980. The efficiency of Roundup for killing sugarcane. Proceeds of the South African Sugar Technologists' Association, June 1980. South African Sugar Experimant Station, Mount Edgecombe, Natal 4300.

Weekes, E. D. 1985. Mumias Sugar Company. Agricultural Engineering Visit, 1985 (Unpublished). Booker Agriculture International Limited, Bloomsburry House 74/76. Great Russel Street, London WC1B 3DF. ■■

(Continued from page 46)

Rear-mounted Mini-boom for Knapsack Sprayers

REFERENCES

1. Bode, L.E., Gebhardt, M.R. and Day, C.L. 1968. Spray-deposit patterns and droplet sizes obtained from nozzles used for low-volume application. Trans. ASAE 11:754-761.
2. Fernando, H.E. 1956. A new design of sprayer for reducing insecticide hazards in treating rice crop. FAO plant Protection Bull., 4:117-120.
3. Jonstone, D.R., Huntington, K.A. and King, W.J. 1975. Development of hand spray equipment for applying fungicides to control Cercospora disease of groundnut in Malawi. J. Agric. Engng. Res., 20:379-389.
4. Pingali, P., Awadhwal, N.K. and Quick, G.R. 1990. Environmental and health effects of pesticides in Philippines rice production: implications for equipment design. *In* Proc. of the International Agricultural Engineering Conference: Agricultural Systems and Environment, Ed. V.M. Salokhe and S.G. Ilangantileke, Vol.4:1457-1465. Bangkok, Asian Inst. of Technology.
5. Tunstall, J.P., Matthews, G.A. and Rhodes. 1961. A modified knapsack sprayer for the application of insecticides to cotton. Cotton Gr. Rev., 38:22-26.
6. Tunstall, J.P., Matthews, G.A. and Rhodes. Development of cotton spraying equipment in Central Africa. Cotton Gr. Rev., 42:131-145.
7. Zandstra, I. 1987. Lever-operated knapsack and hand-held sprayers used in agriculture in developing countries: A review of their safety and efficacy. Manuscript Rreport No. IDRC-MR 169 e. International Development Research Center (IDRC), Ottawa. ■■

Grain Harvesting in China as an Example of the Mechanization Process

by
Mark D. Schrock
Prof.
Dept. of Agric. Eng.
Kansas State Univ.
Manhattan, Kansas 66506
U.S.A.

Abstract

In many geographic regions, Chinese agriculture is land-efficient and labor-intensive. This study compares the agricultural mechanization process in China with other countries and uses the proportion of a country's labor force that is engaged in agriculture as an indication of the degree of mechanization. A strong relationship is found to exist between the size of the agricultural work force and a country's gross national product (GNP) per capita. Current and proposed grain harvesting methods in China are compared on an economic basis in order to illustrate the mechanization process. The cost estimates indicate that Chinese grain harvesting machines can replace manual labor at a cost of $0.05 to $0.11 per hour.

Introduction

In terms of crop production, Chinese agriculture made remarkable progress during the decade of the 1980s. Grain production rose from 305 million t in 1978 to 407 million t in 1984, and cotton nearly tripled during the same period. The increased production resulted primarily from increased yields; the land area under cultivation declined by about 4% between 1978 and 1984. (Ray, 1986).

Although China achieves very high land productivity, its labor productivity in agriculture is low by Western standards. Manual labor is widely used to till the soil, plant the crops, control weeds, and harvest grain. Approximately 69% of China's workforce is directly involved in agricultural production, compared with less than 10% in most industrialized countries (Ray, 1986).

China has a well-developed ability to design and produce tractors and other farm machinery, hence mechanization is underway. Tractors in use rose from 1.9 million units in 1978 to 5.4 million units in 1986 (CAAMS, 1987). However, a gap still exists between the capability to produce machines and the limited usage of machinery in agriculture, indicating that mechanization in that country is being limited by economic and social constraints rather than by the technical barriers that governed the agricultural mechanization of the West.

Mechanization and Economic Development

The primary purpose of agricultural mechanization is to reduce labor, so the percentage of a nation's total work force that is employed in agriculture can be regarded as a rough indicator of the degree of mechanization. **Figure 1** is a plot of the gross national product (GNP) versus the percentage of the country's labor force that is employed in agriculture (Ray, 1986). For the 108 countries shown, the data strongly suggest that agricultural mechanization and economic development must occur concurrently. Note that only two countries in the world achieve a GNP of over $5 000 per capita while using over 20% of their work force in agriculture. Those two countries are oil exporters which serve as "exceptions that prove the rule."

A model was regressed to the work force data shown in **Fig 1** (the two "exception" countries ere excluded from the regression). The form of the model was:

$$Y = a X^b \quad (1)$$

where:

Y = GNP in US$ per capita
X = agricultural work force as a % of total
a = model coefficient

Contribution No. 90-599-J from the Kansas Agricultural Experiment Station.

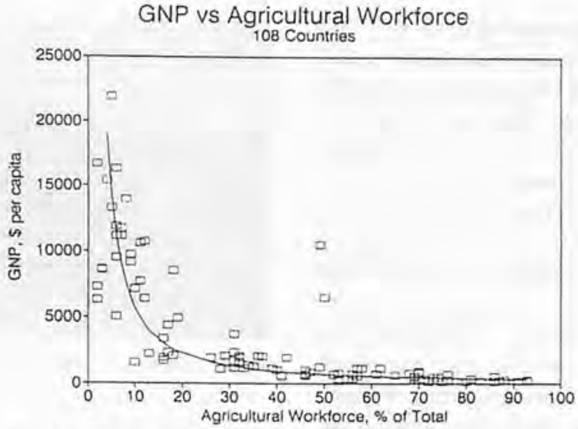


Fig. 1 GNP for 108 countries vs their percent of total workforce employed in agriculture (source: Ray, 1986).

(\$119002)
b = model exponent
(−1.3219)

The r^2 value of the regression model is 0.848.

The model implies that as a country's agricultural work force is reduced, improvements in per capita GNP will occur slowly at first, with the most rapid improvements occurring after the agricultural work force drops below 20%. In the vicinity of 70% agricultural work force, the model predicts that reducing the proportion of workers in agriculture by 1% will increase the GNP by about \$8 per capita, or about 1.8%. At a 20% agricultural work force, each additional 1% reduction in agricultural work force will increase the GNP by about \$160 per capita, or about 7%. In general, when the percentage of agricultural work force is cut in half, the GNP per capita is multiplied by about 2.5.

Between 1965 and 1980, the position of all 108 countries shown on **Fig. 1** moved toward the left. The rate of movement was dependent on the stage of mechanization and other factors. The low-income countries, which employed 50 to 95% of their workers in agriculture, decreased their proportion of agricultural workers at an average rate of about 0.4% per year. Middle-income countries, with 10-75% agricultural work force, moved to the left at a rate averaging about 0.8% per year. The industrial market economies, which were well mechanized before 1965, averaged about 0.4% per year movement to the left. A few countries mechanized their agriculture very rapidly, reducing their proportion of agricultural workers by 1.5% to 2% per year between 1965 and 1980 (Ray, 1986).

In the author's opinion, the extremely low labor cost prevailing in rural areas constitutes the single greatest barrier to China's agricultural mechanization. Chinese farmers are making a logical decision with their liberal use of labor in crop production, because labor is an inexpensive, accessible resource for most of them. Off-farm employment opportunities are not plentiful enough to raise the value of farm labor.

As the Chinese economy develops and industrial labor demand increases, urban labor rates are likely to rise and pull workers out of agriculture. China currently has about 660 million people of working age (between 15 and 64), so each 1% movement to the left on **Fig. 1** implies that 6.6 million agricultural workers are transferred into other industries. The agricultural machineries that replace the first 6.6 million workers must compete with very low wages for manual labor, because the per capita GNP moves up only slightly with initial substitutions.

The high intensity with which China farms its land may encourage mechanization. Pingali et al. (1987), in a study of sub-Saharan Africa, pointed out that high intensity annual and double cropping systems are more likely to be mechanized than fallow and bush-fallow systems. This is partly due to the need to meet more stringent time constraints with the intense systems. In China, high cropping intensity also has negative implications with regard to mechanization. In areas where two or more crops are grown each year, a rapid "turn around" is needed to maximize the growing season of both crops. This limits the opportunity for using tillage machines to 30 days per year or less, making it difficult to accumulate the annual use needed to economically justify the use of farm machineries.

Pingali et al. (1987) also concluded that tasks using large quantities of muscle power and little human judgement (such as primary tillage and irrigation pumping) are likely to be among the first to be mechanized. As the process continues, machinery will become competitive with more tasks that use both muscle and judgement, such as grain harvesting. Relatively high judgement tasks, such as weeding, will become candidates for mechanization after labor rates rise still further.

A Cost Comparison of Four Grain Harvesting Options

In the fringes surrounding

Chinese urban areas, rising agricultural labor rates are driving the substitution of machinery for manual labor. During the fall of 1988, several rice harvesting operations were observed in the Shanghai area, and interviews with operators produced sufficient data to allow the costs of operating the machines to be estimated. At the time, the cost of labor for harvesting rice was about $1.35 per man-day. For this report, local Chinese Renminbi currency was converted at the rate of 3.7 RMB per $ U.S.

The four machines observed were:

1. *SP Comb* — The self-propelled combine was imported from Japan. This machine cut the crop at ground level and conveyed the plant so that only the head was fed into the threshing cylinder **(Fig. 2)**. It used a rather complex system for combing the heads upright and delivering the plants to the threshing cylinder. It was propelled across the field on a set of rubber tracks, providing it with good mobility in wet soil conditions. The price of the machine was reported at $37,800.

2. *Mtd Comb* — The mounted combine was manufactured in China, for attachment to tractors of about 37 kW **(Fig. 3)**. A header located in front of the tractor cut a swath about 2.2 meters wide, and the entire plant was conveyed to an axial-flow cylinder installed transversely at the rear of the tractor. An air blast performed a limited amount of cleaning on the material that passed through the open concave, but a conventional cleaning shoe was not used. Price of the attachment was reported at $2,700.

3. *Mtd Stripper* — The mounted stripper was a Chinese experimental unit that had many similarities to the mounted combine, but it used a "half-feeding" threshing device that threshed only the head portion of the crop **(Fig. 4)**. The cutting platform was located in front of the tractor, and the stalk of the plant was grasped by opposed chain conveyers, which fed the crop to the threshing cylinder located at the rear of the tractor. The unit was not yet in production, but the selling price for the attachment was projected at $5,400.

4. *Windrow* — The windrower was an attachment to a small two-wheeled walking tractor: both the tractor and the windrower were of Chinese manufacture **(Fig. 5)**. The windrower cut the crop with a rotating knife and placed it in a swath on the ground. The windrower represents an intermediate level of mechanization, because it does not thresh or clean the grain. The price of the attachemt was reported at $320.

Base Case Cost Estimate

The four machines were compared by calculating the net cost of the labor that was saved by their use. This "labor replacement cost" was expressed in $/h. A lower labor replacement cost indicates a more desirable harvesting system which should be adopted earlier in the mechanization process. First, a "base case" analysis was performed using estimates of the various coefficients. Later, the sensitivity of the labor replacement cost to changes in various parameters was examined.

One of the most important estimates needed in the analysis was the amount of labor consumed by the traditional harvest method. The traditional method is here defined as a) cutting the crop with a sickle, b) bundling and turning the crop as it dries on the ground, c) transporting the unthreshed crop to the threshing area, and d) threshing and cleaning the grain. Interviews of Chinese farmers indicated labor requirements from 400 to 750 man-h/ha for the total operation.

Fig. 2 Imported self-propelled rice combine.

Fig. 3 Tractor-mounted combine of Chinese manufacture.

Fig. 4 Experimental tractor-mounted "stripper" combine.

Fig. 5 Walking tractor-mounted windrower.

Quick and Buchele (1978) placed the labor requirement for cutting an unspecified crop with a short scythe at 100 h/ha. Singhal and Thierstein (1987) reported labor demands of 150 man-h/ha for hand threshing of rice and 20 man-h/ha for threshing with the IRRI thresher. Gaiser and Esmay (1981), in a study of rice harvesting in Indonesia, estimated the labor requirement for cutting with a sickle and threshing by beating at 262 man-h/ha. They also estimated the labor requirement of the traditional Indonesian "ani-ani" cutting and foot treading at 1 157 man-h/ha. Given the wide disparity of labor inputs in the literature, a relatively conservative value of 450 man-h/ha was used in the base case.

Table 1 shows the "base case" economic comparison of the four rice harvesting concepts. The annual machine use of 100 h is intended to reflect the 10-day duration of one crop harvest per year on a typical farm using manual methods. This was assumed so that the total length of the harvest was similar for both manual and mechanized methods, implying similar timeliness charges for all systems.

The initial purchase price and capacity of each of the systems were reported by the users. The life of the harvesting machines in hours and the salvage value were estimated per ASAE Data D230.4 (1986). Depreciation and interest were estimated using a "capital recovery factor," per ASAE Engineering Practice EP391.1 (1986). Miscellaneous fixed costs, including housing, insurance, and taxes were estimated at 2% of the machine's initial list price. For the base case shown in **Table 1**, inflation was set to zero. During the sensitivity analysis, inflation was considered by modifying the interest rate of the capital recovery factor, using the method suggested by Bartholomew (1981).

Table 1. Base Case Analysis for Four Rice Harvesting Machines

Labor Demand for Manual Harvest		Global Variables:	
Cutting, h/ha	150	Interest, %	10
Bund & Turn, h/ha	100	Fuel, $/kg	.35
Transport, h/ha	100	Grain, $/kg	.17
Threshing, h/ha	100	Yield, kg/ha	5000
Total h/ha	450	Use, h/year	100
		Inflation, %	0

Mechanization Options	SP Comb	Mt Comb	Mt Strip	Windrow
Initial Cost, $	37800	2700	5400	320
Capacity, ha/h	.2	.4	.3	.13
Use, h/year	100	100	100	100
Capacity, ha/year	20	40	30	13
Fixed Cost				
Estimated Life, h	2000	2000	2000	2000
Est. Life, years	20.00	20.00	20.00	20.00
Real Int. Rate, %	10.00	10.00	10.00	10.00
Salvage Value, %	5.56	5.56	5.56	5.56
Dep. & Int., $	4403.28	314.52	629.04	37.28
Misc. Fixed, $	756.00	54.00	108.00	6.40
Total Fixed, $	5159.28	368.52	737.04	43.68
Operating Costs				
Engine Power, kW	21	37	37	5
Fuel Cost, $/kg	.35	.35	.35	.35
Est. Fuel Flow, kg/h	3.9	6.9	6.9	.9
Fuel Cost, $/ha	6.87	6.05	8.07	2.52
Fuel Cost, $/year	137.45	242.17	242.17	32.73
Lube Cost, $/year	20.62	36.32	36.32	4.91
Total Life Repair, %	50	90	90	150
Annual Repairs, $	945.00	121.50	243.00	24.00
Tractor Costs				
Purchase Price, $		4860	4860	622
Estimated Life, h		10000	10000	10000
Total Use, h/year		1500	1500	1500
Est. Life, years		6.67	6.67	6.67
Real Int. Rate, %		10.00	10.00	10.00
Salvage Value, %		39.00	39.00	39.00
Dep. & Int. $		819.92	819.92	104.94
Misc. Fixed, $		97.20	97.20	12.44
Total Fixed, $		917.12	917.12	117.38
Total Life Repair, %		120	120	120
Annual Repairs, $		874.80	874.80	111.96
Allocation Factor, %		6.67	6.67	6.67
Net Trac. Cost, $	.00	119.46	119.46	15.29
X-Labor Annual Cost	6262.34	887.97	1377.99	120.60
Labor				
Crew Size	6	6	6	1
Labor Used, h/year	600	600	600	100
Lab Replaced, h/year	9000	18000	13500	1950
Net Lab Saved h/year	8400	17400	12900	1850
Lab Rep Cost, $H	.75	.05	.11	.07

For three of the four harvesting machines, a tractor is required. The annual use of the tractor in hours was set at 1 500 for the base case based on interviews with local operators. A large uncertainty exists in this parameter since the annual use of tractors in China has been estimated by others at 700 h (CAAMS, 1990). Because the harvester utilizes only a part of the tractor's annual operating time, tractor costs wree allocated to the harvester based on the hours of use.

Operating costs, including fuel, lubrication, and repairs were calculated based on ASAE EP391.1 (1986). Because repair data for the machines under study were not available, the ASAE total lifetime repair multipliers were used.

The "X-Labor Annual Cost" includes all annual costs except labor and was calculated by adding the harvester fixed costs to the fuel, lubrication, repairs, and tractor costs. The "Labor Replacement Cost" was then calculated by dividing the "X-Labor Annual Cost" by the net labor savings that resulted from the use of the machine.

The base case analysis indicates that the high initial cost of the imported self-propelled combine places it at a serious cost disadvantage when compared to the other three alternatives. The least-cost option for the base case is the mounted combine, followed by the windrower and the experimental mounted stripper. The labor replacement costs of the three Chinese machines are $0.05 to $0.11 U.S./h. This compares favorably with the reported manual labor cost of $1.35 per day in the Shanghai area, and is consistent with the growing interest of mechanized harvesting techniques there. Inland labor rates were much lower (reported labor rates in the Luoyang area were $0.54 to $0.81/day), and discouraged mechanization there.

Sensitivity Analysis

Due to the fact that many of the input values used in this study were poorly defined or derived from North American data, it was important to examine the influence of changes in those values. Grain loss, annual harvester usage, manual labor usage, inflation, and the annual tractor usage were examined.

1. Grain Loss

The grain losses produced by the various machines of this study were not evaluated. However, the loss levels produced by the manual harvest were reported in the general range of 8% by Gaiser and Esmay (1981). Pinar (1987) compared the rice harvest losses in Turkey for six different manual and mechanical harvesting methods and reported totral harvest losses of 6.63% to 9.12%.

The effect of a change in gross grain income on the labor replacement cost is shown in **Fig. 6** with the base case shown at 0%. The sign convention used in the calculation is that an increase in the loss for the mechanical system over the manual system is considered a positive percentage. A reduction in grain loss substantially reduces the labor replacement cost.

2. Annual Use of Harvester

The annual hours of use directly changes the "per hour" cost of operation. The influence of annual hours on labor replacement cost is shown in **Fig. 7**. The increase in labor replacement cost becomes serious below 50 h/year.

All four machines in this study are too large for a single Chinese farmer to own and operate. For example, either of the mounted combines are capable of harvesting a typical or southern Chinese farm in less than one hour. An organizational mechanism must be developed to consolidate sufficient work to justify mechanization. Machinery cooperatives and "custom" machine operations are being used for this purpose in some villages.

3. Manual Harvest Labor Demand

The "labor replacement cost" obviously depends on the amount of manual labor that is replaced by mechanical harvesting. If the "base case" manual labor estimate is in error, the labor replacement cost will respond in an inverse relationship. The influence of the manual labor assumption on the labor replacement cost is shown in **Fig. 8**.

4. Inflation

If interest rate is constant, higher inflation lowers the real cost of capital. Machines replace labor and usually have a lifespan of several years, henee a machine effectively substitutes today's capital for tomorrow's labor. To study the influence of inflation on the labor replacement cost, the apparent interest rate was held constant at 10% while inflation was increased from 0% to 30%.

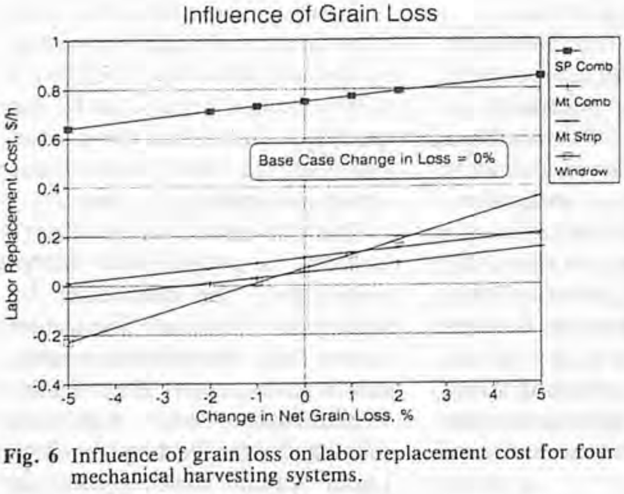


Fig. 6 Influence of grain loss on labor replacement cost for four mechanical harvesting systems.

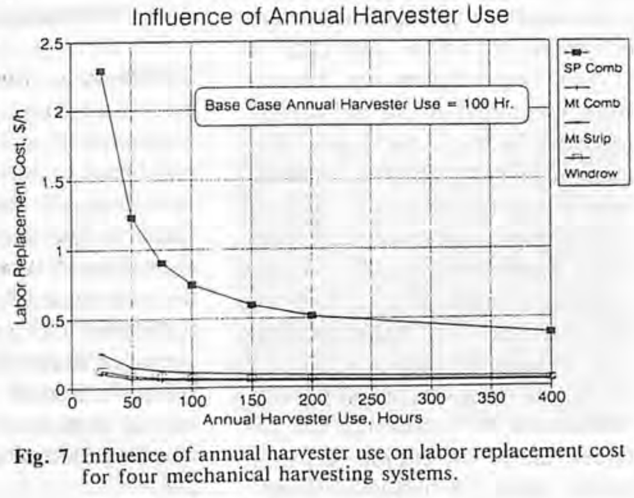


Fig. 7 Influence of annual harvester use on labor replacement cost for four mechanical harvesting systems.

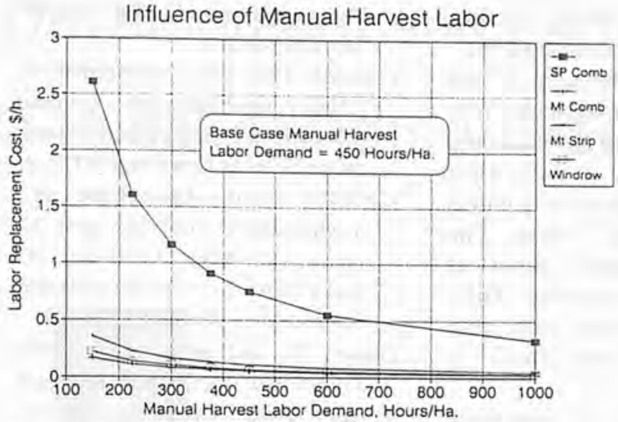


Fig. 8 Influence of manual harvest labor requirement on labor replacement cost for four mechanical harversting systems.

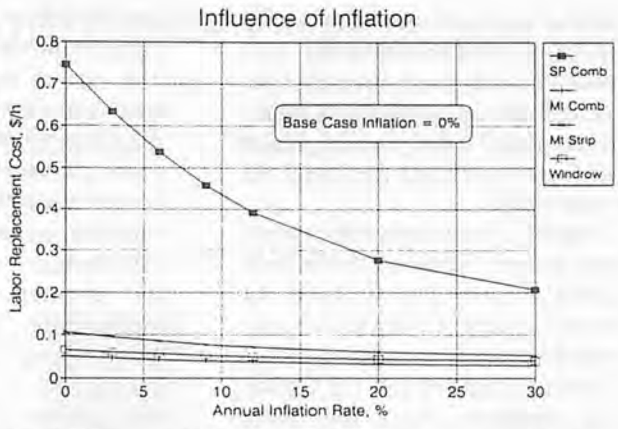


Fig. 9 Influence of inflation on labor replacement cost for four mechanical harvesting systems.

Inflation values of over 10% produce negative real interest rates but such anomalies have occurred in the past and, in fact, were occurring in China as the study was conducted. The results **(Fig. 9)** show that an inflation rate of 20% reduces the labor replacement cost of the four machines by 32% to 63%.

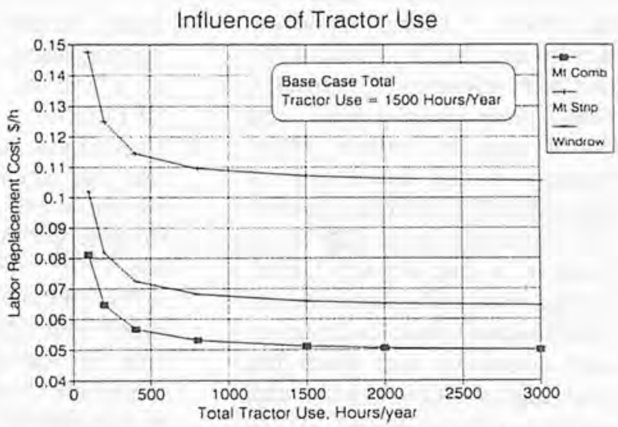


Fig. 10 Influence of annual tractor use on labor replacement cost for three mechanical harvesting systems.

5. Annual Tractor Usage

In China, agricultural tractors are used widely to transport freight and to a lesser extent for land preparation in agriculture. This analysis assumes that the mounted harvesting machines would be powered by tractors that are also used for such other functions. Lower total tractor usage will result in a larger portion of the tractor costs being charged to the harvesting operation which increases the labor replacement cost.

The total annual use of the tractor was varied from 100 to 3000 h, and ther results are shown on **Fig. 10.** Serious increases in the labor replacement cost occur when total tractor use falls below about 500 h. Note that 100 hours of annual use for the tractor requires that the tractor be used only for harvesting. This implies an upper bound on the labor replacement cost for a self-propelled combine of Chinese manufacture, because a dedicated tractor requires the added capital expense of an engine and drivetrain, without the productivity benefits of a complete self-propelled design.

Discussion

This study is not intended to comprehensively compare harvesting options, but rather to illustrate the difficulty involved in designing machinery to compete with inexpensive labor. In a broader sense, there is likely to be an equilibrium point between "opportunity" labor costs and mechanization at any specific point in time. As China develops its manufacturing and export economy, off-farm employment opportunities should increase. If people are given the job mobility to pursue such opportunities, rural labor values will move upward, creating a "pull" toward greater mechanization in agriculture. There is evidence that this process has begun in the Shanghai area.

In order to complement the pull of urban employment, a "push" toward mechanization can be created by the availability of appropriately sized, efficient, and durable machines. Given China's small farm size, this is a difficult task if each farm is considered as a stand-alone unit. Custom machine operations and machinery cooperatives are effective means of expanding the scale of operations to the economic threshold of mechanization. The results of this study indicate that current harvesting machines begin to compete with manual labor when they are used for about 50 h annually.

Finally, it is interesting to compare current harvesting methods in China and the United States. In Kansas, much of the wheat is harvested by hired "custom cutters," a practice that reduces the capital and timeliness costs for many farmers. The "custom rate" for harvesting wheat and hauling it to the point of market is approaching $50/ha. Custom operations vary in size, but a typical eight-man crew will operate three combines, three grain trucks, and several support vehicles which represent a new investment of about $500 000. Such an operation will typically harvest 120 ha of wheat in a day. In the United States, the aforementioned "equilibrium" point favors much more machinery and much less labor than in China, but the total cost of harvest is similar for the two countries.

Conclusions

1. There is a strong relationship between a country's per capita GNP and the percent of its work force that is employed in agriculture. This relationship implies that agricultural mechanization must accompany economic development.
2. The rate of movement of the work force from agriculture to other segments of the economy proceeds slowly at first, then accelerates as the country enters "middle income" status. The urbanization again slows as the country becomes fully mechanized, with less than 10% of its work force in agriculture.
3. Mechanization of the rice harvest in central China is beginning. Under the "base case" assumptions of this study, current Chinese harvesting machinery can replace labor at a cost of about $0.05 to $0.11/h.
4. Current machinery sizes dictate that the machinery be shared among several farmers in order to generate sufficient annual use.
5. At current labor costs and currency exchange rates, the total cost of the manual harvest method in China is comparable to the cost of the mechanized harvest in the United States.

REFERENCES

ASAE. 1986. Agricultural machinery management data. ASAE D230.4.

ASAE. 1986. Agricultural machinery management. ASAE EP391.1.

Bartholomew, R. B. 1981. Farm machinery costing under inflation. Transactions of the ASAE 24(4):843-845.

CAAMS. 1987. The development of China's mechanization. Chinese Academy of Agricultural Mechanization Sciences Newsletter 4(3):5-9.

CAAMS. 1990. Agriculture and mechanization over the past 20 years. Chinese Academy of Agricultural Mechanization Sciences Newsletter 6(1/2): 2-4.

Gaiser, D. and M. Esmay. 1981. Traditional rice harvest loss and labor values in Indonesia. Transactions of the ASAE 24(5): 1162-1166.

Pinar, Y. 1987. Grain losses of harvesting and threshing of paddy in Turkey. Agricultural Mechanization in Asia, Africa, and Latin America 18(4): 61-64.

Pingali, P., Y. Bigot, and H.P. Binswanger. 1987. Agricultural mechanization and the evolution of farming systems in sub-saharan Africa. The Johns Hopkins University Press.

Quick, G.R., and W.F. Buchele. 1978. The grain harvesters. American Society of Agricultural Engineers. p.172.

Ray, A. (ed.). 1986. World development report 1986. The World Bank. Oxford University Press.

Singal, O.P, and G.E. Thierstein. 1987. Development of an axial-flow thresher with multi-crop potential. Agricultural Mechanization in Asia, Africa, and Latin America 18(3): 57-65. ■■

Development and Performance Evaluation of a Pedal-operated Groundnut Decorticator

by
Ajaya Kumar Dash
Res. Asst.
Dryland Agriculture Res. Project
Orissa Univ. of Agriculture and Tech.
Bhubaneswar, Orissa, India

D.K. Das
Prof. and Head
Dept. of Farm Machinery and Power
College of Agric. Eng. and Tech.
O.U.A.T., Bhubaneswar, Orissa, India

S.K. Dash
Reader
Dept. of Farm Machinery and Power
College of Agric. Eng. and Tech.
O.U.A.T., Bhubaneswar, Orissa, India

Abstract

A pedal-operated decorticator was developed to decorticate groundnut economically with minimum of manual effort. An experimental model was first fabricated to determine the dimensions and positions of different parts and then the decorticator was fabricated. The performance of the decorticator was evaluated at different sieve clearances taking ICGS-44, Kadri-3, ICGS-11 and AK-12-24 varieties of groundnut at 7.45, 8.6, 11.45 and 13.2% moisture content, respectively. The optimum shelling capacity was found to be 72 kg/h. The germination of kernel was 94.2%. The cost of decrotication of groundnut was calculated at $0.004/kg.

Introduction

The State of Orissa is situated between 17°50′ and 22°30′N latitude and the medians of 81°21′ to 87°38′E longitude. The State has 6.56 million ha of cultivated area. Groundnut is a major oilseed crop grown in this State. In order to increase the domestic availability of edible oils, emphasis has been laid on accelerating the production and processing of oilseeds through various oilseed development programmes. In this context, the Government of India appointed in May, 1986 a Technology Mission on oilseeds in order to harness the best production and processing of oilseed crops (Annonymous 1987-88).

Groundnut is grown on 7.5 million ha in India and the annual production is 6 million. The groundnut cultivation in the State of Orissa has increased from 105,000 ha in 1976-77 to 323,000 ha in 1985-86 producing 119,000 t and 464,000 t, respectively (**Table 1**).

Decortication of groundnut is a tedious and time consuming process among the post-harvest operations. One person can decorticate about 5 kg of pod manually in one day. The labourers engaged in hand-picking develop fatigue in their fingers. The manually operated rotary type groundnut decorticator developed earlier satisfies the needs of the farmers to some extent. Considering the energy expenditure rate in agricultural operations, bicycling is found to be minimum, stepping up and down is maximum and hand cranking being intermediate (Bhattacharya, 1978). It was, therefore, felt necessary to develop a low cost paddle operated decorticator that is simple in construction and easy in operation with less cost and minimum repair and maintenance.

Table 1. Total Area, Production and Yield of Groundnut in Orissa, India (1976-86)

Year	Area (thousand ha)	Production (thousand tonne)	Yield rate (kg/ha)
1976-77	105	119	1,132
1977-78	119	145	1,216
1978-79	144	192	1,333
1979-80	175	123	703
1980-81	172	231	1,340
1981-82	216	292	1,352
1982-83	275	322	1,173
1983-84	258	399	1,545
1984-85	298	387	1,301
1985-86	323	464	1,437

SOURCE: Agricultural Statistics of Orissa, Directorate of Agriculture and Fod Production, Government of Orissa, Bhubaneswar.

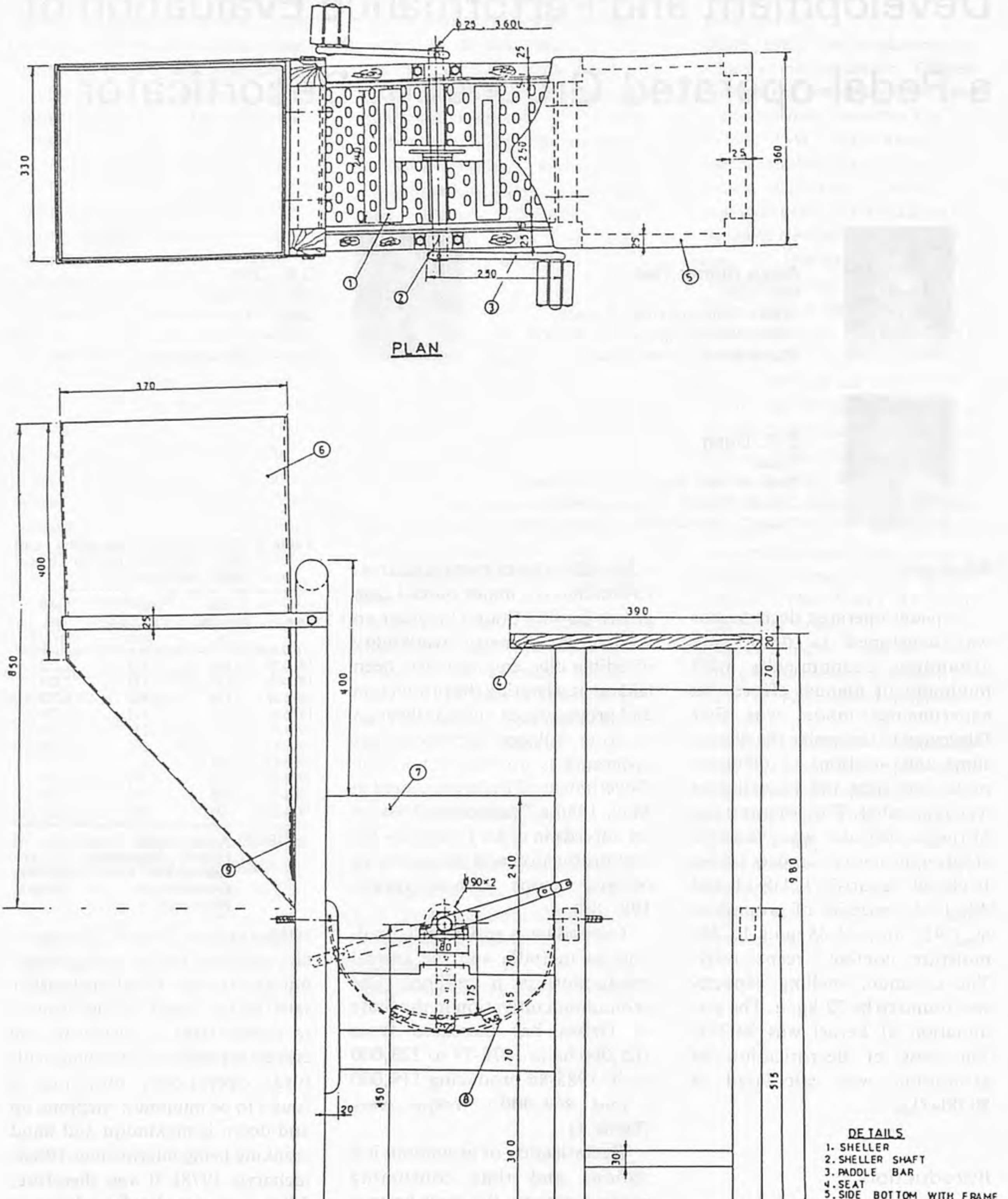


Fig. 1 Design details of paddle-operated groundnut decorticator.

Materials and Methods

The major components of the decroticator are sheller, sheller shaft, sieve, pedal, decortication chamber and hopper with shutter. The sheller consists of three mild steel plates and tapered pegs are welded to each plate. The three plates are arranged in curvilinear manner, so that while oscillating, it makes a half circle. This unit is attached to the sheller shaft by a vertical plate through a put-and-bolt arrangement. In the vertical plate, a slotted groove is made so as to fix it in different positions through bolting. This is being done to adjust the clearance between sheller and sieve. The clearance can vary from 22 mm to 34 mm.

The design of the sheller shaft is primarily based on the maximum torque to be transmitted and maximum bending moment acting on the shaft. Two pedals through the pedal-bars are attached to the sheller shaft by cotter pin arrangement. The shaft is supported by two bush bearings. The detailed design of the decorticator with its components is shown in **Fig. 1**. The sieve is made of cold rolled sheet of 1 mm thickness. Elliptical holes were provided on the sieve to allow maximum-sized kernel and to restrict the passage of minimum size of pod. The decortication chamber cover is made of G.I. sheet to check the over-throw of undecorticated pods by oscillation of the sheller.

The hopper is designed to store 20 kg of pod and is made of G.I. sheet. It is supported by 25 mm mild steel flat. The lower part of the hopper is tapered with an uniform slope of 45° towards the decortication chamber. A shutter is provided at the outlet of the hopper which can be sasily moved up and down manually to control feed rate.

The main frame of the decorticator is made of seasoned sal wood and is designed for minimum vibration during opertion. A handle bar is provided for comfort of the operator and is rounded for better grip. The operator's seat is made of wood. The height and horizontal distance of the seat from the sheller shaft are determined from the experimental model (**Fig. 2**) by ergonometry analysis and are 525 mm and 355 mm, respectively, for an average human height of 168 cm.

Fig. 2 Experimental model.

Fig. 3 Developed groundnut decorticator.

The developed decorticator was tested taking ICGS-44, Kadri-3, ICGS-11 and AK-12-24 at 7.45, 8.6, 11.45 and 13.2% moisture content, respectively, with different sieve clearances of 22 mm to 34 mm (**Fig. 3**).

Results and Discussion

The clearance between the sheller and sieve plays an important role on the shelling capacity of the decorticator. It is clear from **Fig. 4** that the capacity of the

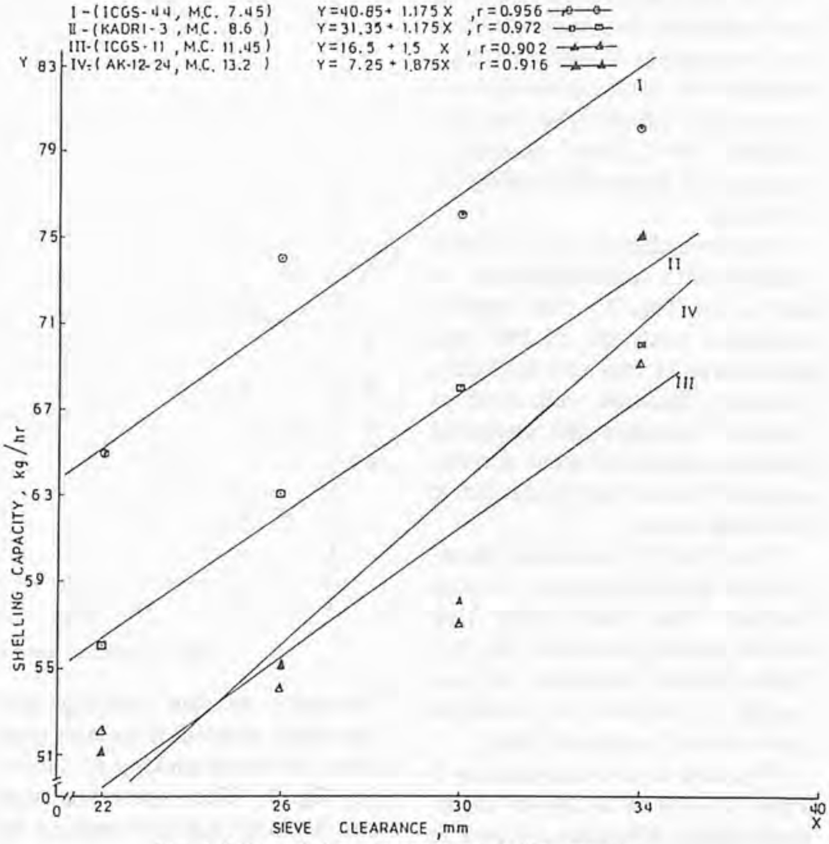


Fig. 4 Effect of sieve clearance on shelling capacity.

Fig. 5 Groundnut decorticator in operation.

decortication increases with an increase in clearance. The equations and correlation coefficients are presented in the same figure. It has been observed that the smaller-sized pods fall down undecorticated through the sieve. The highest capacity of 80 kg/h has been achieved with the ICGS-44 variety (**Fig. 5**).

The percentage of broken kernel decreases with an increase in sieve clearance and vice versa as shown in **Fig. 6**. The minimum breakage of 0.5% was observed at 34 mm clearance in ICGS-44 and the maximum breakage of 6.8% was observed at 22 mm clearance with the AK-12-24 variety. This is due to the fact that the pods get jammed in 22 mm clearance resulting in higher percentage of breakage.

The sieve clearance has a direct relation with unshelled pods as shown in **Fig. 7**. The highest unshelled pods of 12.8% was observed at 34 mm with the Kadri-3 variety. The linear relationships between clearance and unshelled pod percentage and their correlation coefficients are presented in the same figure.

The effect of mechanical decortication on germination was also studied. The results show that 94.2% kernels are viable. The rest, 5.8%, kernels have either physiological constraint or invisible mechanical damage or both.

The cost of the decroticator is about US$39. The cost of decortication per kilogram of pod in case of developed decorticator

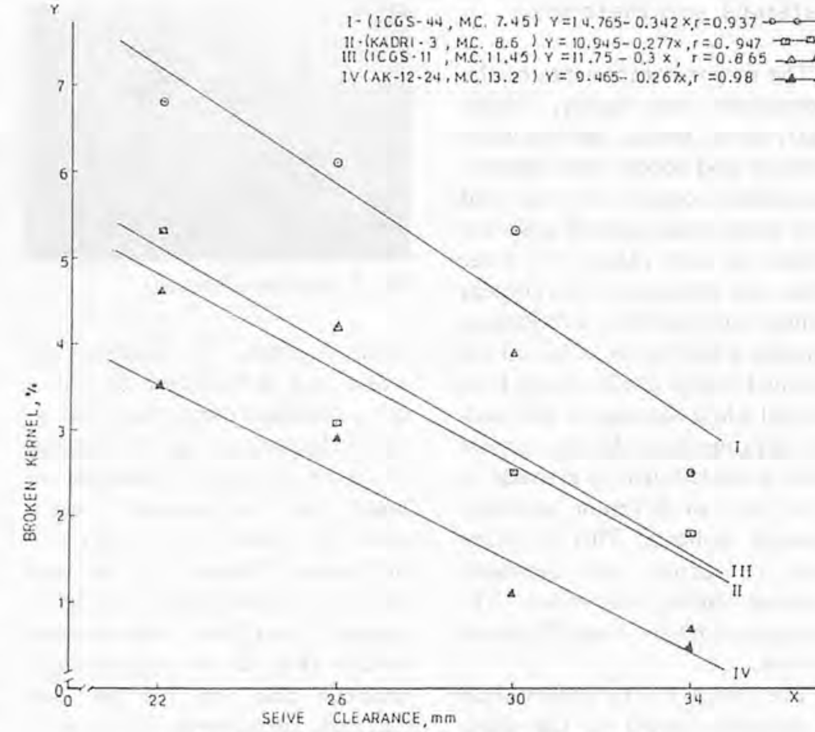


Fig. 6 Effect of sieve clearance on broken kernel.

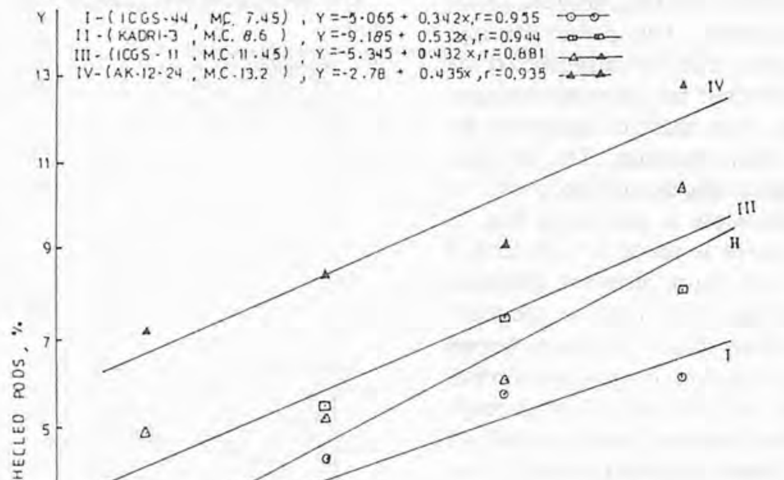


Fig. 7 Effect of sieve clearance on unshelled pods.

decreases as the holding size increases, whereas it remains constant for hand picking as shown in **Fig. 8**. The operating cost per hour of use is found to be US$0.28. Considering an annual use of 200 h, the cost of decrotication using the decorticator is US$0.004/kg as compared to US$0.17/kg by hand picking method.

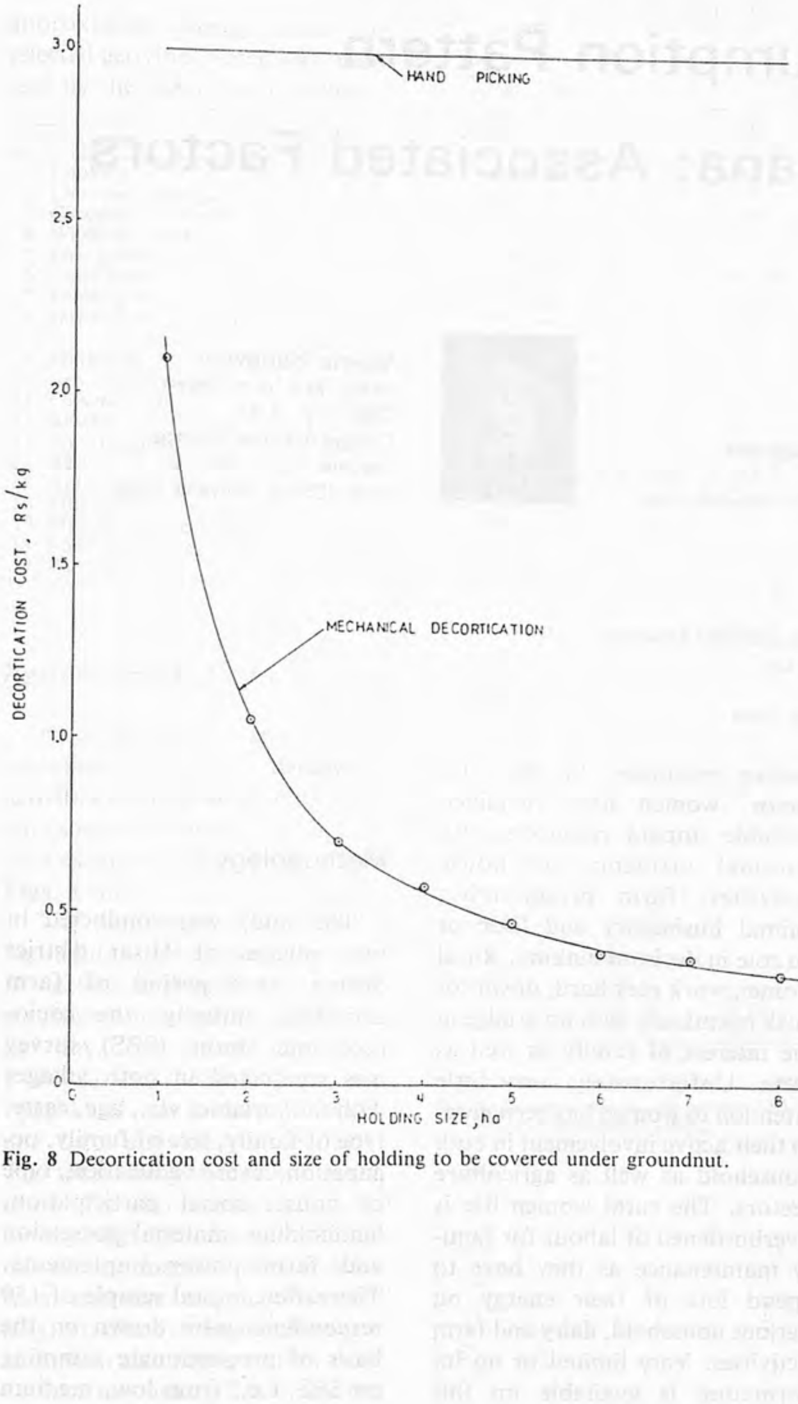


Fig. 8 Decortication cost and size of holding to be covered under groundnut.

Conclusion

The optimum speed of the sheller is 65 oscillations/min and its optimum shelling capacity is 72 kg/h as compared to 5 kg/day by hand-picking. The cost of decortication is much less than the cost of hand-picking. The operation of the machine is very easy as it is operated through leg muscles only. The maintenance cost is negligible and can be maintained by small farmers at the village level.

REFERENCES

1. Annonymous (1987-88). Report of Currency and Finance, Economic Review, Reserve Bank of India.
2. Bhattacharya, S., (1978) Optimum location of man and a hand operated rotary device. Unpublished M. Tech. Thesis, Agril. Engg. Deptt., IIT, Kharagpur, India.
3. Dash, A.K., (1989) Design, Development and Evaluation of a paddle operated groundnut decorticator. Unpublished M. Sc. (Agril, Engg & Tech.) Thesis, OUAT, Bhubaneswar, India. ■■

Energy Consumption Pattern in Rural Haryana: Associated Factors

by
Sunita Narang
Asst. Prof.
Family Resource Management
Krishi Vigyan Kendra
Sadalpur, Hisar 125004, Haryana, India

Veena Sangwan
Assoc. Prof. and Head
Dept. of F. R. M.
College of Home Science
Haryana Agric. Univ.
Hisar 125004, Haryana, India

Achla Malaviya
Assoc. Prof.
Dept. of Home Science Extention Education
College of Home Science
Haryana Agric. Univ.
Hisar 125004, Haryana, India

Abstract

Women are the major performers of work in rural households of Haryana, India. A study on energy expenditure of rural women in daily household, dairy and farm work, conducted in two rural villages of Hisar district of Haryana shows that rural women usually spent 2 904.5 cal. per day on various activities. The total energy at the disposal of rural women was considerably different among the women belonging to various socio-economic status (SES) categories. The correlation data highlighted that various factors, namely; socio-economic status, family outside contact, value orientation, motivation change proneness and attitudes have a significant influence on energy consumption pattern.

Introduction

The economic development of any region is an outcome of effective utilization of available human resources. In the rural sector, women have remained invisible unpaid resources with minimal influence on house activities, farm productivity, animal husbandry and little or no role in decision making. Rural women work very hard, down-to-dusk relentlessly with no grudge in the interest of family as well as farm. Unfortunately, very little attention to women has been given to their active involvement in both household as well as agriculture sectors. The rural women life is overburdened of labour for family maintenance as they have to spend lots of their energy on various household, dairy and farm activities. Very limited or no information is available on this aspect. Therefore, the present investigation was conducted with the specific objectives:

(i) To determine the energy consumption on various activities by rural women according to socio-economic status.
(ii) To isolate the association of crucial factors with the energy consumption pattern of rural women.

Methodology

The study was conducted in two villages of Hisar district during slack period of farm activities. Initially, the socio-economic status (SES) survey was conducted in both villages with the variables viz., age, caste, type of family, size of family, occupation, level of education, type of house, social participation, landholding, material possession and farm power implements. Thereafter, a total sample of 150 respondents were drawn on the basis of proportionate sampling on SES, i.e., from low, medium and high SES strata. Energy input was analysed on the basis of time spent. Energy was calculated on the basis of calorie requirement per minute (min.) for various activities given by Steidle and Bratton (1968). Some modification in cal. requirement per min. was done with the help of judges and experts on the subject. The approximate energy costs for selected activities which was finalized by the experts is as follows:

Activity	Energy cost
1. Cooking	2 cal/min
2. Cleaning of house	3 cal/min
3. Cleaning of utensils	2 cal/min
4. Washing clothes	4 cal/min
5. Fuel gathering	3 cal/min
6. Child care	2.5 cal/min
7. Fetching water	4 cal/min
8. Darimaking/weaving/stitching	2 cal/min
9. Marketing	3 cal/min
10. Any other (service)	2.5 cal/min
11. Personal care	2.5 cal/min
12. Rituals	1.5 cal/min
13. Entertainment	1.5 cal/min
14. Rest	1 cal/min
15. Animal care/cleaniness	3.5 cal/min
16. Milking activities	3 cal/min
17. Making dung cakes	4 cal/min
18. Fodder activities	3.5 cal/min
19. Farm activities	5 cal/min

Results and Discussions

Attempts have been made to calculate energy input in various activities by rural women of different socio-economic strate. The data is presented in **Table 1** and **Figs. 1 and 2.**

The data reported in **Table 1** highlight the average energy input in various activities. In general, a rural woman spent 2 904.5 cal. per day. The energy input was 1 460.50 cal., 680.33 cal. and 763.33 cal. on household, dairy and farm activities, respectively. The total energy input was maximum for household activities among high SES, for dairy activities among medium SES and for farm activities among low SES **(Fig. 1)**. The findings of Singal *et al.* (1990) also reported that rural women use nearly 2 900 calories per day on work, sleep, rest and leisure.

Table 1 further shows that, in general, among various activities, farm activities demanded maximum energy (763.33 cal.) followed by cooking (432.67 cal.), making dung cakes (276 cal.), fodder activities (171.5 cal.), washing clothes (157.33 cal.), animal care

Table 1. Average Energy Expenditure on Household, Dairy and Farm Sectors According to Socio-economic Status

Activities	Average energy expenditure in calories per day — Socio-economic status: Low (n = 75)	Medium (n = 45)	High (n = 30)	Total (N = 150)
1. Cooking	404	414	480	432.67
2. Cleaning of house	87	120	129	112
3. Cleaning of utensils	90	94	132	105.33
4. Washing clothers	176	172	124	157.33
5. Fuel gathering	183	129	66	126
6. Child care	157.50	100	125	127.5
7. Fetching water	116	100	80	98.67
8. Dari making/weaving	74	126	158	119.33
9. Marketing	3	3	6	4
10. Service (Govt/Pvt)	45	2.5	10	19.17
11. Personal care	45	45	52.50	47.5
12. Rituals	4.5	3.0	4.5	4
13. Entertainment	22.5	28.5	63	38
14. Rest	55	75	77	69
Overall on household activities	1 462.50	1 412	1 507	1 460.50
15. Animal care	115.50	157.50	150.50	141.17
16. Milking activities	72	111	93	92
17. Making dung cakes	224	296	308	276
18. Fodder activities	154	192.5	168	171.5
Overall on dairy activiites	564.50	757	719.50	680.33
19. Farm activities	1 050	755	485	763.33
Total energy per day	3 077	2 924	2 711.50	2 904.16

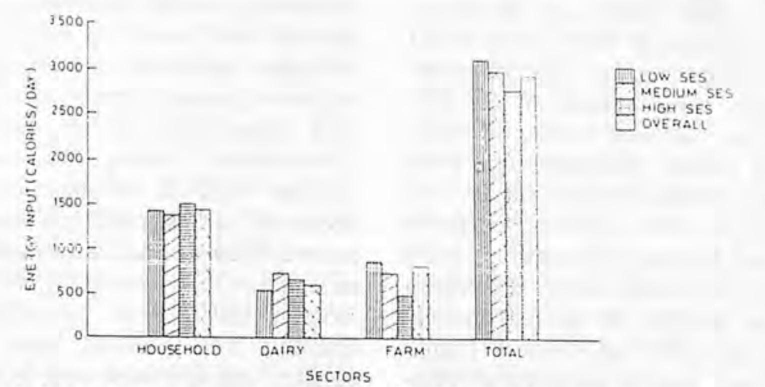


Fig. 1 Average energy use pattern in household, dairy and farm sectors according to socio-economics status.

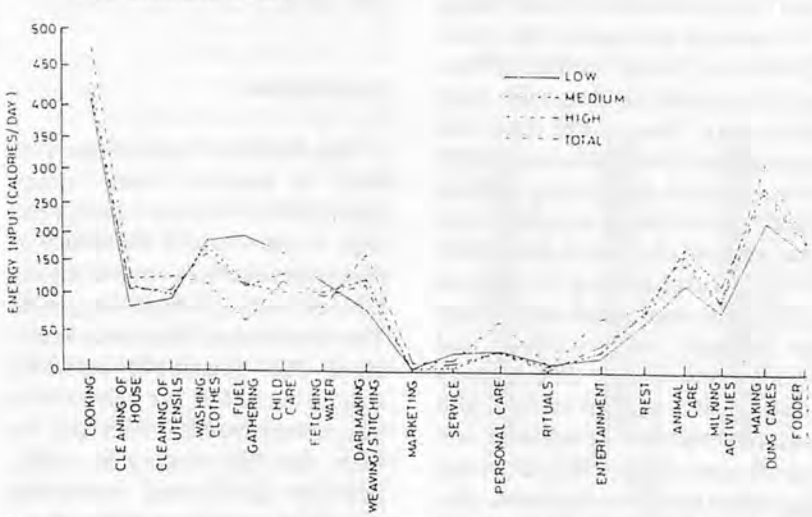


Fig. 2 Average energy input in home and dairy activities according to socio-economic status.

(141.17 cal.), child care (127.5 cal.), fuel gathering (126 cal.), dari making/weaving (119.33 cal.), cleaning of house (112 cal.), cleaning of utensils (105.33 cal.), fetching water (98.67), milking activities (92 cal.), rest (69 cal.), entertainment (38 cal.) marketing and rituals (4 cal. each). Among household activities, maximum energy input was on cooking and minimum on entertainment and personal care. The energy input was negligible in marketing and rituals, i.e., only 4 cal.

High SES women spent maximum energy on cooking, cleaning of house, cleaning of utensils, dari making/weaving/stitching, marketing, personal care, entertainment, rest and making dung cakes. This may be due to many reasons, viz., large family size, big house, less burden of work, more social participation, etc. On the other hand, rural women of low SES spent maximum energy on washing clothes, fuel gathering, child care, fetching water, service and farm activities. This may be due to more burden of household, dairy and farm work and to the reason that majority of the respondents of low SES had nuclear family system and of young age as highlighted during SES survey which was conducted before undertaking the research problem in the field. Therefore, young women at less age have small children who need more care, thus, more time and energy. Sethi and Sharma (1989) also reported that young women spent more energy on child care due to small children in the household. A rural woman of medium SES spent more time and energy on animal care, milking and fodder activities. The reason may be that women of low SES had less number of animals and the women of high SES, although had more number of animals, also had farm labourers to perform dairy activities also. And their help resulted into less energy input by rural women of high SES on dairy activities. The data is presented in **Fig. 2**.

Table 2. Coefficient Correlation of Independent Variables with Energy Utilization Pattern

Independent variables	Energy utilization pattern			
	Low SES	Medium SES	High SES	Overall
SES	0.5327*	0.5369*	0.5669*	0.8366*
Family outside contact	0.3092*	0.3692*	0.3975*	0.5251*
Value orientation	0.3605*	0.5173*	0.3359	0.6171*
Motivation	0.3145*	0.5178*	0.2809	0.5858*
Change proneness	0.2938*	0.4227*	0.2344	0.5475*
Attitude	0.2161	0.4964*	0.3865*	0.5762*
't' value	0.2319	0.2960	0.3370	0.1580

*Significant at 0.05 level of significance.

Association of Crucial Factors

The correlation data in **Table 2** shows that all variables, viz., socio-economic status, family outside contact, value orientation, motivation, change proneness and attitude were positively and significantly correlated with energy utilization pattern, irrespective of SES. When SES was taken into consideration among low and medium SES, all variables were positively and significantly correlated except of one, i.e., attitude among low SES. Among high SES women only three variables, namely; SES, family outside contact and attitudes were positively and significantly correlated with energy utilization pattern.

Conclusion

The findings highlight the fact that, in general, rural women spent 2 904.5 cal. each energy per day. A considerable difference of energy expenditure existed among various socio-economic categories. The total energy input was maximum for household activities among high SES, for dairy activities among medium SES and for farm activities among low SES. Among household activities maximum energy expenditure was on cooking and minimum on entertainment and personal care. The various variables, namely; socio-economic status, family outside contact, value orientation, motivation, change proneness and attitudes were positively and significantly correlated with energy utilization pattern.

The present study thus points towards the need to access the new appropriate techniques which could reduce their time and energy expenditure.

REFERENCES

Sethi, N. and Sharma, D.N. (1989). Role of women in rural domestic activities — animate energy use patterns in Hisar district — A case study. Papers presented in International Workshop on "Women and development — A critical appraisal of Household level research methodologies" held at M.S. Universiyt of Baroda, Gujarat from 5-14th July, 1989.

Singal, S., Kaushik, S. and Sethi, N. (1990). A study on energy expenditure pattern of rural women. Paper presented in proceedings of the XXVI, Annual Convention, held at Department of Agricultural Engineering, Yaryana agric. Univ. Hisar from 7-9th Feb. 1990.

Steidle, R.E. and Bratton, E.C. (1968). Work in the home. John Willey and Sons, New York: 308.

■■

Development and Prospects of Farm Transport Machinery in China

by
Yang Shengping
Engineer
National Test Center of Agric. Machinery Quality
Chinese Academy of Agric. Machinery Sciences
Beijing, China

Hu Xiaoan
Engineer
Dept. of Farm Transport Machinery
Chinese Academy of Agric. Machinery Sciences
Beijing, China

Introduction

Since 1979, the Chinese government has attempted to improve incentives and administration at all levels in the agricultural economy. The major thrust of these reforms has been the restructuring of institutions in rural areas and adjustment in agricultural price policy. The most important reform has been the introduction of the Production Responsibility System, a system of designing to link the income of individual workers or households or groups to the output arrising directly from their efforts (Yang, 1989). A series of structural reforms have significantly reduced the scale of production from commune level to individual household level. Under this environment of individual household level, a unique small farm mechanization system developed very rapidly. In general, it has the following features:

1. The small-size (less than 15 kW) two- and four-wheeled tractors, three-wheeled farm tricycle and four-wheeled farm transport vehicle, as well as farm transport boat played a main role in mechanized input in the farm household production. The household production contains three aspects: on-farm, off-farm and non-farm activities. The total income of farm households owning small tractor, for example, in main rice farm area of North China, from on-farm, off-farm and non-farm are respectively 29%, 6% and 65%, but farm households without small tractor were 41%, 2% and 57% (Liu, 1989).

2. Most of the farm transport machineries are now owned by individuals. In 1988, in terms of estimate, private ownership of small-sized tractors, medium and large tractors and farm trucks were 94.5%, 71.2% and 68.4% of the amount, respectively (**Fig. 1**). The rest were owned by unit of ownership of all people, collective and group (Sha, Ren and Han, 1991).

3. The existance of this small farm system is accompanied by an extremely small area under cultivation and an extremely high density of rural populaton. In 1989, the average farm area of each farm household was only 2.11 *mu* (0.14 ha.).

4. Nearly 40 percent of farm work was replaced by farm machinery (Lu, 1991), and farm transportation represented over 40% of the entire farm operation activities (Sha, 1986).

In 1989, there were 52,000,000 kW of farm transport power. Adding the present power of 60-70% from small tractors, that means about 38,000,000 kW served as transportation. The total farm transport power reached 90,000,000 kW in fact, and their capacity of transport was 2,920,000 t km/h which was about 65% of the carrying capacity of farm labor force, animal force and farm transport machinery (Hua, 1991). Income of farm transport machinery operation was about 31.3 billion yuan which took up 66% of total farm income of farm.

The boom of farm transport

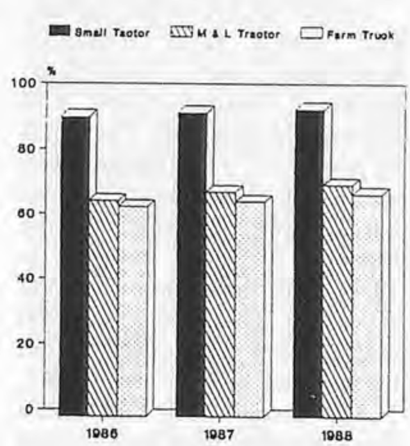


Fig. 1 Individually-owned rate of farm transport machinery.

Acknowledgement: The authors gratefully acknowlege the help of Mr. Sha Ligong, senior engineer, expert of farm transport machinery, CAAMS, for his valuable advice, suggestions and provided references, and Mr. Wang Ruinin, senior engineer, CAAMS, for English language improvement.

machinery used in the rural area of China during the last decade has become an interesting subject to discuss. It is very significant to research and analyze the development and prospects of farm transport machinery in the country. It will provide useful information describing the characteristics of farm transportation, history of development to sustain growth in crop production to increase farm-level profits, and it will provide basic data to policy makers and investors for making decisions regarding investment in farm and farm transport machinery, price reform and rural extension program.

Table 1. Farm Power and Transport Machinery in China

Year	Item						
	Power (mil. kW)	L&M tractor (1 000)	S tractor (1 000)	F truck (1 000)	Barrow (1 000)	Cart (1 000)	F boat (1 000)
1962	8	55	1	8	3 670	833	
1965	11	73	7	11	8 757	1 335	
1978	118	557	1 373	74	29 634	2 488	66
1979	134	667	1 671	97	32 624	2 477	84
1980	147	745	1 874	138	35 170	2 398	108
1981	157	792	2 037	175	41 260	2 337	130
1982	166	812	2 287	206	48 415	2 345	145
1983	180	841	2 750	275	55 634	2 586	173
1984	195	854	3 295	349	59 450	2 852	223
1985	209	852	3 824	430	61 144	2 875	235
1986	230	866	4 526	499	62 413	3 050	263
1987	248	881	5 300	550	65 107	3 482	292
1988	266	870	5 958	591	66 341	4 178	319
1989	281	848	6 543	625	66 948	4 312	

Source: Statistical Yearbook in 1990, Sha, Ren and Han, 1991.
L—Large, M—Medium, S—Small, F—Farm.

Development of Farm Transport Machinery

The farm transport machinery mainly includes tired barrow, horse-drawn cart, two- and four-wheeled tractor and trailer, three-wheeled farm tricycle, farm truck, and farm transport boat, etc. They have had different experiences of manufacture, popularity and use since the founding of the People's Republic of China.

Tired Barrow and Horse-drawn Cart

First of all, the simple, popular and useful farm transport machinery were researched, designed, manufactured and popularized after 1949. Two kinds of model of 350 (single-wheel) and 650 (double-wheel) of tired barrow were appraised by the Ministry of Light Industry in 1959, and their output in the same year amounted to 129,900 units. Based on model of tired barrow, two kinds of new model, JL325 (single-wheel) and JL650 (double-wheel) were designed and appraised by the Ministry of Ag. Machinery Industry in 1963. In China there were 16 manufacturers which produced the tired barrow in 1964. Their output increased sharply and reached 1,980,000 units in 1970, and 5,150,000 units in 1978. The average annual growth rate of output was over 21% from 1959 to 1978, but it decreased to 7% by some reasons from 1980 to 1989 (**Table 1**).

Besides tired barrow, horse-drawn cart was also one kind of main farm transport machinery in those years. In 1959, its production amounted to 156,000 units, 150,000 units in 1965, 90,000 units in 1970 and 111,000 units in 1978. By the end of 1967, there were 27 manufacturers that manufactured horse-drawn cart in China. **Table 1** shows that there were 2,398,000 units in use in 1980, 4,312,000 units in 1989, and the average annual growth rate during this period was 6.7%. So the tired barrow and horse-drawn cart which were the most popular means of farm transportation have been used more and more widely in China.

Two- and Four-Wheeled Tractors and Trailers

In 1952 China set up the first tractor station and imported some power machines as a pilot project for testing and popularization purposes (Wang, 1983). The first tractor factory was set up and began mass production in 1957. Then a number of tractor factories were set up to be able to produce small-, medium- and large-sized tractors (5 to 55 kW), The small tractors are two-wheeled walking tractors (under 11 kW). The use of small tractors in China began in 1956. Gongnong-7 walking tractor (5.15 kW) was developed on the basis of tests to select suitable models in 1968. After 1965, Gongnong-12, Gongnong- 10 and other models were developed. These tractors are mainly used for paddy, rotary cultivation, plowing operation and transportation. After considering some problems of walking tractors, small four-wheeled tractors were adopted in some provinces in North China. The structure of these tractors is simpler than that of ordinary tractors but is more complex than that of walking tractors (Kong, 1983). There were 17 walking tractor manufacturers each with a production capacity of over 10,000 units and there were 2,287,000 small tractors in use in 1982, and 6,543,000 in 1989. The average annual growth rate in the number of the small tractors was over 16% from 1982 to 1989.

Trailers, which are drawn by small-, medium- and large-sized tractors, are main farm and forest transport implements in China, and about 60% farm transport was completed by tractor-trailer. Small trailers, single-axle type, are drawn by walking and four-wheeled tractors (under 11 kW), and their carrying capacities are from 0.5 to 2 t. Medium and large trailers, two-axle types, including self-dumping and no-dumping, are drawn by medium- and large-sized tractors (over 15 kW), and their carrying capacities are from 2 to 12 t. There are about 300 trailer manufacturers of the 2 to 12 t capacity. There are about 300 trailer manufacturers, and their output is only to follow the output of tractors each year.

Farm Transport Equipments

Farm transport equipment, which include farm trucks and farm tricycles, are new kinds of farm transport machinery which have developed to suit the situation and characteristics of rural area in China, especially since 1979. They have features of simple structure, light weight, low price and diesel/petrol engine.

Farm Trucks

The farm trucks mainly included two types, one with petrol engine, another with diesel, and both are registered and used in rural areas of China. The farm trucks with petrol engine, have been manufactured and used in rural areas of China since the 1960s. They are able to suit long-distance transportation. Their carrying capacities are from 2 to 5 t, and their highest speed reached in Italy, Austria, Swiss and Germay during the 1960s. Now they are still used in rural areas of Europe. The farm vehicle was improved based on small four wheeled tractor in China during the last decade (Sun and Feng, 1991). Their advantage and features are between tractor and light truck. Their carrying capacities are from 1 to 2 t, and their highest speed was from 30 to 50 km/h. They have high-clearance to suit especially short-distance field transportation. Their power are below 28 kW, and their capacities of being driven uphill are equal to or over 25%. There were about 80 manufacturers of farm vehicles, 8,000 units of output in 1984, 18,014 units in 1986, and 80,000 units in 1988.

Farm Tricycles

The farm tricycle was designed based on structure and feature of motor-tricycle. Its adoption was very rapid throughtout the country during recent years. Their carrying capacity is from 0.5 to 0.75 t, power is less than 9 kW, and highest speed is limited under 40 km/h for traffic safety, and their capacity of being driven uphill is greater than or equal to 18%. In 1986, there were only 19 manufacturers of farm tricycle, but they are now reaching over 120 in the whole country. The output of farm tricycle increased rapidly from 1985, but 240,000 units in 1990. The output value of farm tricycle was 0.8 billion yuan (US$154 million) which contributed nearly 6% of the country's total output value of farm machinery in 1989.

Farm Transport Boats

Farm transport boats consists of the body of boat, diesel engine and gearing. Their feature is an assembly of power transmission, propeller and steering gearing so as to realize the purpose of simple structure, lower price, and easy driving. They have a 42 kinds of types from 2.21 to 17.65 kW, carrying capacities from 12 to 150 t, speed under 15 km/h (Shen, 1991). Usually the farm transport boats with carrying capacities under 30 t, 30 to 80 t and over 100 t are installed, respectively, gearing with one, two, three or four units. The farm transport boats appeared in Jiansu and Zhejian provinces, and in South China in the 1960s. They have gradually become a main farm transport machinery in regions of network of waterways and inshore fishing. They are now to complete the second largest number of farm transportation that is only less than two-wheeled walking tractor in rural area of China. Going through 20 years development and approvement, in 1986, there were about 60 manufacturers of farm transport boat gearing, and the output amounted to 740,000 units in 1986, 200,000 units in 1988, and 130,000 units in 1989.

Characteristics of Farm Transportation

An increase in farm transport machinery in China has substituted not only more and more for farm work and promoted farm production, but also production of trade products and promoted rural economic prosperity. The amount and scope of farm transportation are large and wide, which included transport in farms, forest, animal husbandry, sideline, fishery and commodity distribution between rural areas and cities. According to estimates, the average value of 10,000 yuan of farm production came from 110 to 150 t transport facilities. There are about 12 billion transport farm vehicles, which distribute 15 t to every farm families in rural China each year. The value of farm transport operation was about 40-50% of total value of farm production operation, and this figure reached 60% in areas of hillsides. In 1981, the transport distance of 52.7%, 28.9%, 11.7% and 6.6% value of total farm transport were, respectively, from 1 to 5km, 6 to 20 km, 21 to 50 km (Chen, 1986). The average distance of farm transport was 18.8 km, the average value of farm transport was 0.5-0.7 t/ha., and the average value of farm transport operation was 2.1-2.7 t km/ha.

China has a great variety of terrain and climate. It is mountainous with a total area of 9.6 million square meters—only 1.47

million m^2 cultivated (15%), 1.25 million m^2 forest (13%) and 0.17 million square meters rivers and lakes (1.7%). The geographical distribution of the total land area of China is shown in **Fig. 2**. Many fields of farm land, orchard and grazing land are located hillsides. Rural roads reached 618,000 km which occupied 67.5% of the total national roads in 1983. But over 90% of rural roads were fourth grade or worse with width from 1.5 to 5 m.

In China about 40% of industry materials, especially about 70% of light industry materials, were from rural areas during the last decade. Usually, farm transportation takes up 60-70% of total operation of farm machinery, and total income of farm machinery are, respectively, from farm transportation (70-80%), postharvest and farm products processing services (20%) and farm production (10%) **(Fig. 3)**.

The economic level of rural China is still low compared with developed countries. The average operation on farm land was only 0.3 ha per labor force, and the average income of each farm people was 601.51 yuan (US$127.4) in 1989 **(Fig. 4)**, however, it was about 4.5 times in 1978. **Table 2** shows the cases of possession of farm transport machinery per 100 farm households from 1985 to 1989. An increase rate in possession of small walking tractors was the fastest that reached 78% from 1985 to 1989. Large numbers of farm transport machinery owned were tired barrow, but small numbers of farm trucks in 1989. So most farmers are interested in low price, simple structure and high applicability, however, it will be still difficut to purchase high price transport machinery at least in the near future.

Table 2. Possession of Farm Transport Machinery per 100 Farm Households

Item	Year				
	1985	1986	1987	1988	1989
Farm truck	0.25	0.19	0.28	0.35	0.28
L & M tractor	0.35	0.43	0.4	0.48	0.47
Small tractor	2.71	3.1	3.75	4.33	4.84
Horse-drawn cart	5.49	6.52	7.05	7.56	7.68
Tired barrow	36.86	41.82	41.36	41.32	41.18
F. trans. boat	0.74	0.24	0.27	0.57	0.35

Source: Statistical yearbook in 1990.
L—Large, M—Medium, F—Farm.

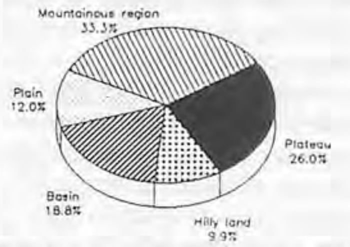


Fig. 2 Geographical distribution in China, 1989.

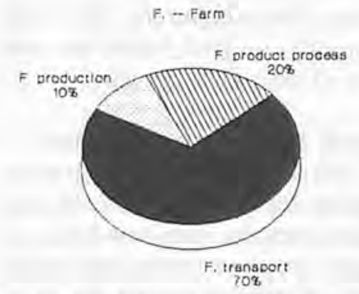


Fig. 3 Distribution of income from farm machinery operation, 1989.

Evaluation of Prospect of Farm Transport Machinery

Depending on low level of farm transportation in China, two- and four-wheeled tractors and trailers, three-wheeled farm tricycles, farm vehicles and farm transport boats are still mainly used in the suburbs of towns, cities and plain areas where the living standard is slightly higher. There are less in number of those machineries in hilly areas. Almost half of the farm transportation facilities was represented by manual and animal. They will continuously play an important role in China's agricultural mechanization. It is estimated that up to the year 2000, the level of farm transport mechanization will reach 70% from 50% in 1990, and the rate between on-farm and non-farm labor force will be reduced from 90% in 1984, 60% in 1990 to 44.6%, as well as amount of farm machinery power will be increased from 2.95 billion kW in 1990 to 3.6 billion kW (Lu, and Chen, 1984). According to the National Eighth Five-Year Plan, up to 1995, there will be 1,060,000 large- and medium-sized tractors, 8,000,000 small-sized tractors, 1,000,000 farm trucks, 400,000 farm vehicles and 350,000 farm transport boats in use. The large- and medium-sized tractors will consist of 75% with power over 22 kW and 25% with power between 15 to 22 kW, and the tractors with power from 22 to 58 kW and over 58 kW will be 60% and 15% of amount, respectively. The small-sized tractors will consist of 50% with power from 8 to 11 kW, 30% with power under 8 kW and 20% with power from 11 to 15 kW.

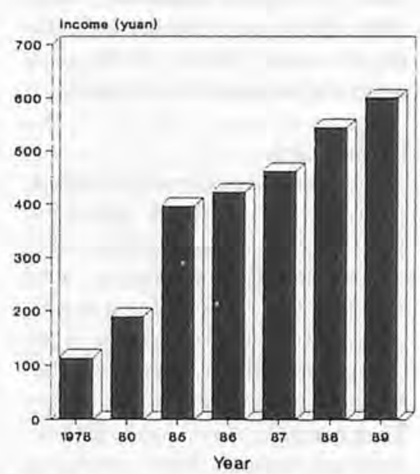


Fig. 4 Average income of each farm operation per year.

The characteristics of farm machinery investment in China was that national investment was taken as the key link from 1949 to 1979, collective and individual were taken as the key link after 1979. The total investment on farm machinery will reach 17.14 billion yuan in 2000 (**Fig. 5**). The fund source will be from individuals, 70%; bank loan, 20%; and government, 10%.

The trend in farm transport machinery in China is light in weight, small in size, simple and comfortable in structure and cheap price. Development work and new product design should be strengthened to further improve the quality, reliability and working life, reduce fuel consumption, vibraton and noise level. The special type and use of farm transport machinery also need to develop such as cold storage truck, rural short distance bus, repair implement truck, engineering vehicle and various vehicles for transportation of live fish, poultry, domestic animals, bee, sugarcane, herbage, tea, fruit and wood.

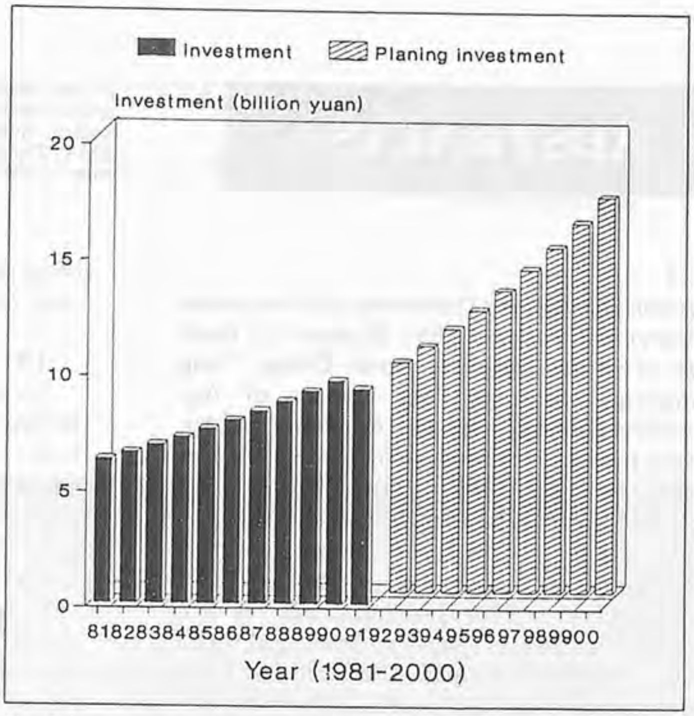


Fig. 5 Investment and planned investment of farm machinery in China.

REFERENCES

Chen Buda, (1986) The State and Development of Farm Vehicle in China, Presented at conference of farm transportation and farm transport machinery of China, in Beijing.

Hua Guozhu, (1991) The Trend and Characteristics of Agricultural Mechanization in China, Presented at the International conference of agricultural mechanization, Beijing, China.

Information Report of Farm Transport Tricycle, 1990. Association of farm transport tricycle, No. 2 and 3.

Kong Depong, Ling Tongsen and Xu Guangqin, (1983) Small Tractors in China, AMA, vol. XIV, No. 1, Winter, 1983.

Liu Xiaoqiu, (1989) The Impact of Small Farm Mechanization on Rice Growing Farm Households: A Case Study of Chinese Rice Areas in Selected Rice Growing Areas of North China, Master of science thesis, Thammasat University, Bankok, Thailand.

Lu Guoyin and Chen Shuxian, (1983) The Prediction of Chinese Agricultural Mechanization in 2000, Research paper, Chinese Academy of Agricultural Mechanization Sciences.

Lu Yunjian, (1991) The Changes in Rural Area by Agricultural Mechanization in China, Agricultural Mechanization in China, June, 1991.

Sha Ligong, (1986) Farm Transport Machinery Industry in China, Ministry of Machinery Industry of China.

Sha Ligong, Ren Wanchao and Han bing, (1991) Strategy Research of Farm Transport Development in Rural China for 2000, Research report of National Committee of Science.

Shen Pei, (1991) Discussion of Propeller Design Problems of Farm Transport Boat, Presented at the international conference of agricultural mechanization, Beijing, China.

Statistical Yearbook of China, 1990. National Statistical Bureau.

Statistical Yearbook of Chinese Agricultural Machinery, 1987. Ministry of Machinery Industry of China.

Summary of Association Annual Meeting of Chinese Farm Transport Tricycle, 1988.

Sun Qinwei and Feng Wuli, (1991) Chinese Farm Transport vehicle, Presented at the international conference of agricultural mechanization, Beijing, China.

Wang Wanjun, (1983) Profile of the Development of Agricultural Mechanization in China, AMA, vol. XIV, No. 1, Winter, 1983.

Yang Shengping, (1989) Optimizing Machine Ownership and Use under the Individural Responsibility System: A Case Study of Hebei Province, North China, Master of science thesis, University of the Philippines at Los Banos, Laguna, Philippines.

ABSTRACTS

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

172

Optimizing Machine Ownership and Use under the Individual Responsibility System—A Case Study of Hebei Province, North China: Yang Shengping, National Test Center of Ag. Machinery Quality, Chinese Academy of Ag. Mechanization Sciences, No. 1, Beishatan, Deshengmen Wai, Beijing, China; Bart Duff.

The objective of this study was to select the optimal machinery set for ownership and use under the Production Responsibility System (PRS) using a 0-1 Mixed Integer Programming model. An efficient solution algorithm has been developed which can be implemented using standard Linear Programming (LP) computer code. The LP problem for the machinery sets is solved and the information generated from the solution is used to eliminate sub-optimal machinery sets.

The model and solution procedure were applied to a typical rice farm in Funing county, Hebei province, North China. Profit-maximizing sets were calculated for alternative landholding size, requirements for each farming activity of rice and corn, different investment levels and rising prices for inputs.

173

Effect of Different Sowing Methods and Seed Rates on the Growth and Yield of Wheat Crop: Bukhari, S, Prof.; Jamro, G.H, Director Farms; Ibupoto, K.A, Asst. Prof.; Pirani, S.A, Lecturer, Farm Power and Machinery, Sindh Agriculture Univ., Tandojam, Pakistant.

An experiment was carried out to study the effects of different sowing methods and seed rates on the growth and yield of wheat crop, at the Latif Experimental Farm, Sindh Agriculture University, Tandojam during 1988-89.

The results of sowing methods, seed rates and their interaction were highly significant for plant height, number of spikes per square meter, weight of grains per spike, 1000 grain weigh grain yield per plot and grain yield per hectare. But the length of spike for methods of sowing and also length of spikes and number of spikes per square meter for interaction of methods and seed rates were not significant.

The performance of drilling and highest sowing rate of 150 kg per hectare and their interaction were better among the sowing methods, seed rates and their interaction under Tandojam conditions.

181

To Develop Portable Irrigation Modules for Efficient Water Use: Sahoo, N.N, Reader, College of Agric. Eng. and Tech., O.U.A.T., Bhubaneswar, 751003; Satyanarayana, Prof., Dept. of Agric. Eng., I.I.T., Kharagpur, West Bengal 721302; Mishra, P.K, Sr. Scientist, (Eng.), CRIDA, Hyderabad 500659, India.

Currently used irrigation modules for regulating flows have some intrisic limitations. The major drawbacks are their large sizes meant only for use at the heads of branch channels, distributories as well as minors to control the flow from the main canal up to the minor canals. However, no such control systems are in use for controlled flow from minor and field channels directly to the fields. Often a fixed outlet for the command loses vitally its functional ability when the head falls below a value and creates the problem of scarcity of water in the fields. Keeping these facts and needs of the farming community in view, the research was carried out to develop portable irrigation modules possessing the functional efficiency to deliver constant discharge within specified modular ranges.

190

Machinery-Crop Selection at Maximum Tractor Power Utilization in Nigeria: Ademosun, O.C, Dept. of Agric. Eng., Federal Univ. of Technology, Akure, Nigeria.

The level of mechanization of Nigerian agriculture is low because of high cost-to benefit ratio of farm machinery, especially as it pertains to tractor usage. This is due to the few hours of tractor utilization per annum. This paper describes the establishment and application of a model for maximizing tractor power utilization. The sizes of the implements that can be coupled to the different categories of tractor hitch for the various operations were determined. A model was established for the determination of machinery-crop matching at maximum tractor utilization. A linear programming simplex technique was applied to solve the model using relevant data on Nigerian agriculture. The crop combination and the farm size for each crop, resulting in maximum tractor utilization, were obtained for

INQUIRY and REQUEST to AMA

Please let us know your need. We shall promptly reply them. Inquire on any catalog listed in the advertisement in this issue. We shall try our best to serve you. We welcome articles of interest to agricultural mechanization.

Fill in the reverse side of this card and send us by sealed letter.

FARM MACHINERY INDUSTRIAL RESEARCH CORP.

7-2 Kanda Nishikicho Chiyoda-ku Tokyo-Japan 101

ADVERTISED PRODUCTS INQUIRY

Product	Advertiser	Vol., No., Page

EDITORIAL REQUEST TO AMA

Your Name :

Address :

Occupation :

SUBSCRIPTION/ORDER FORM

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA (AMA)

Issued Quarterly

Subscription Rate (includes surface mail postage)

Annual (4 issues) ------------ ¥.6,000
Single copy ------------ ¥.1,700

Back Issues (1971−75, ¥.2,000 per copy)
(1976−77, ¥.1,200 per copy)
(1978−80, ¥.1,500 per copy)

★Spring, 1971	☐Vol.7 No.2, Spring, 1976	★Vol.9 No.4, Autumn, 1978
★Vol.2 Autumn, 1971	☐Vol.7 No.3, Summer, 1976	☐Vol.10 No.1, Winter, 1979
☐Vol.3 No.1, 1972	☐Vol.7 No.4, Autumn, 1976	☐Vol.10 No.2, Spring, 1979
☐Vol.3 No.2, Summer, 1972	☐Vol.8 No.1, Winter, 1977	☐Vol.10 No.3, Summer, 1979
★Vol.4 No.1, Spring, 1973	☐Vol.8 No.2, Spring, 1977	☐Vol.10 No.4, Autumn, 1979
☐Vol.4 No.2, Autumn, 1973	☐Vol.8 No.3, Summer, 1977	★Vol.11 No.1, Winter, 1980
★Vol.5 No.1, Summer, 1974	☐Vol.8 No.4, Autumn, 1977	★Vol.11 No.2, Spring, 1980
☐Vol.6 No.1, Spring, 1975	☐Vol.9 No.1, Winter, 1978	☐Vol.11 No.3, Summer, 1980
★Vol.6 No.2, Autumn, 1975	☐Vol.9 No.2, Spring, 1978	☐Vol.11 No.4, Autumn, 1980
☐Vol.7 No.1, Winter, 1976	★Vol.9 No.3, Summer, 1978	★: Indicates issues out of stock.

☐ **Abstract and Index, 1971-80 (Special Issue, 1983)**

(Check issues and number of copies you wish to order)

Back Issues from 1981, ¥.1,700 per copy (Vol. 12 No. 1 and No. 4 are out of stock)
Abstract and Index, Special Issue, 1983, ¥2,000 per copy.

Vol._____No._____, ________19_____, ________copy/copies

(check one)

☐ Please invoice me/us

☐ I/We enclose remittance for ¥ ____________

* *

Name: ________________________________

Firm: ________________________________

Position: ________________________________

Address: ________________________________

(block letters)

FARM MACHINERY INDUSTRIAL RESEARCH CORP.
7, 2-chome, Kanda Nishikicho, Chiyoda-ku,
Tokyo 101 Japan
Tel. (03)−3291−3671~4, 5718

STAMP

FARM MACHINERY INDUSTRIAL RESEARCH CORP.

7, 2-CHOME, KANDA NISHIKICHO, CHIYODA-KU

TOKYO, 101 JAPAN

1st FOLD HERE

2nd FOLD HERE

each tractor-implement hitch category.

192

Optimum Harvesting Period and Yield Potential of Soybean: Saxena, B.B, Scientist S-2, Central Institute of Agric. Eng., Nabibagh, Berasia Road, Bhopal-18; Ojha, T.P, Dy. Director General (Eng.), I.C.A.R., Krishi Bhavan, New Delhi-1; Datta, A.C, Assoc. Prof., Agric. Eng. Dept., I.I.T., Kharagpur, Midnapore (WB), India.

Harvesting crops at the proper time ensures minimum damage and loss of grain during threshing and other losses in subsequent handling and processing operations. Soybean, a rich protenious crop is more susceptible to shattering even when the crop is grown under optimum agronomical conditions. This loss becomes excessive if rain comes during harvest. An optimum period of harvest for two local soybean varieties (JS-2 and JS-7244) of Madhyapradesh were selected and trials were conducted in two consecutive years. The data on grain yield, moisture content of grain and shattering losses of soybean showed highly significant variation in yield when harvested during 70-102 for JS-2 variety and 85-118 days after sowing (DAS) for JS-7244 variety. An optimum period of harvesting was statistically determined which was 85 to 93 DAS for JS-2 and 100 to 112 DAS for JS-7244 varieties, while the yield values during the above periods ranged between 12.9 to 14.8 q/ha and 13.8 to 14.8 q/ha, respectively. Shattering losses were 0.42 q/ha on 93 DAS and increased thereafter and showed 7.8 q/ha on 102 DAS for JS-2 variety. The shattering loss was relatively less for JS-7244 than JS-2 and started beyond 112 DAS.

194

Drying Characteristics of Single Layer of Shelled Coconuts: Patil, R.T, Graduate Res. Assoc.; Thakor, N.J. Graduate Res. Assoc.; Sokhansanji, S, Prof. of Agric. Eng., Dept. of Agric., Eng., Univ. of Saskachewan, Saskatoon, Canada.

Shelled coconuts at initial moisture content of 46.2% wb were dried in single layer in a mechanical dryer having provision for recirculation of exhaust air. The drying temperatures were varied from 50° to 80°C at air velocity of 1 m/s. The instantaneous moisture content with drying time was monitored and three mathematical models, namely; single term, two term and Pages Model were fitted to the data. The drying constant obtained by the single-term model was correlated with temperature with Arrheneous equation. The optimum temperature was 70°C with drying time of 23 hours.

199

Efficacy of Agricultural Polymers for Increased Moisture Retention in Free Water and Coarse Soils: Aslam, M, Scientific Officer; Ahmad, S, Princ. Scientific Officer, Water Resources, National Agric. Research Centre, Islamabad, Pakistan.

The expansion rate, moisture retention and effectiveness of two selected agricultural polymers (aquastock and aquasorb) were measured in free water and sand at room temperature and atmospheric pressure. The aquastock was of coarse texture and the aquasorb was of fine texture. The experiment was conducted in good quality irrigation in water whereas distilled water was used to develop baseline for expansion in free water. The potential water retention in free water was 29% and 21.5% from that of distilled water for aquastock and aquasorb, respectively. The reduction in potential water retention in irrigation water was mainly due to the pressence of calcium and magnesium bicarbonates. Constant expansion rate was achieved after 240 minutes where aquasorb behaved efficiently from that of aquastock. The effective retention in free water of 39 and 49 g of water per g of polymer was achieved for aquastock and aquasorb, respectively. The effective retention in free water was 38% and 50% of the potential retention for aquastock and aquasorb, respectively. The low effective retention in free water indicated that the selected polymers were not efficient in expansion repeatibility. The effective retention was reduced further in sand by 13.5% from that of free water. This was mainly due to the characteristics of soil matrix. This revealed that the economics of polymers use may be worked out for specific situations prior to the large scale adoption for commercial plant production. However, the use of polymers for seed and root treatment could be economically attractive to reduce the germination problems and transplantation shock in areas where water is at premium. ■■

The Royal Show

July 4-7, 1994
Stoneleigh Park, Warwickshire, U.K.

Significant developments are planned over the next two years for the Royal International Agricultural Exhibition, at the National Agricultural Centre, Warwickshire, England and which in 1994 takes place from 4th-7th July.

The exhibition organizer, the Royal Agricultural Society of England, is stepping up its plans to improve facilities at the International Centre, the central point for overseas visitors, and introduce initiatives to make it easier for visitors to meet those companies radiating from the Centre who are interested in doing overseas business.

The RASE is also developing a number of specialist areas linking in with the central theme of the exhibition. Each will deal with the issues, advice and technology affecting a particular sector of farming, food and the countryside.

For 1994, the exhibition will cover machinery, arable, livestock, farm woodland and forestry, renewable energy sources, food marketing, agribusiness, the rural economy, countryside management and scientific developments.

By 1995 some areas will have been relocated and other new features introduced, to create a more natural link between the sectors. For example, the arable area will move closer to the machinery sector and the various livestock features will be consolidated in one part of the exhibition.

RASE Chief Executive, Charles Runge comments, "The Royal is, and will continue to be, the place for agriculturalists to get alongside the latest issues and developments affecting their area of business. It will remain one of the places to make new contacts as well as reaffirm old ones, talk strategy and policy, and conduct business."

For further information contact, Amanda Sands, RASE Press Officer on +44 203 696969.

Greenhouse Systems Automation, Culture, and Environment Conference

July 20-22, 1994
Hyatt Regency Hotel
New Brunswick, New Jersey, U.S.A.

A unique educational opportunity for greenhouse professionals. This conference will provide in-depth information on the engineering principles of greenhouse system design and management. Presentations focusing on current technology and case studies will relate the fundamentals to day-to-day management decisions.

Everyone involved in the greenhouse industry will benefit from this educational experience. The intended audience includes greenhouse production systems owners and their advisors and managers, equipment suppliers and manufacturers, cooperative extension educators, designers, writers and publishers within the industry, teachers, government policy makers, and regulators.

The conference consists of four half-day sessions. The **Automation** session will discuss sensors for monitoring the greenhouse environment, controllers and computers for decision making, and machines and layouts for efficient operation. The **Culture** session will discuss water and nutrient delivery and other factors that affect plant growth and response. The **Environment** session will discuss systems used to control heat, lighting, and the gaseous environment within the greenhouse. The last session will focus on integrating the systems discussed in the first three sessions to create an efficient and profitable greenhouse that minimizes environmental impact.

Each evening will include opportunities for focused learning. On the first evening, workshops will be offered; topics will be chosen based on input from conference registrants on their registration forms. During the second evening, teams of participants will each design a greenhouse system. The designs will be reviewed during the last session on the following day.

For information contact:
NRAES, 152 Riley-Robb Hall, Cooperative Extension, Ithaca, NY 14853-5701 TEL (607) 255-7654, FAX (607) 255-4080

5th International Course in Draught Animal Technology

Sept. 23-Dec. 16, 1994
The University of Edinburgh (CVTM) / Larenstein International Agricultural College, The Netherlands

Aims: The course aims at furnishing the participants with all the knowledge and skills required to understand and manage the complexity of draught animal technology. After completion of the course the participants will be able to:

- evaluate potentials and constraints of DAT with regard to other energy sources.
- analyze the economic feasibility of DAT for various farming systems.
- develop and extend technical skills and recommendations to farmers, extension services and rural craft centres.
- develop specific training programmes on DAT for farmers.
- advise extension workers on the methodology of including a DAT-concept in their services.

Methods: A variety of methods ranging from lectures to case studies and workshops, group and individual assignments will be used. This strategy is geared towards putting into operation existing and newly acquired knowledge and its application to individual field conditions. Many learning elements will be based on participants sharing their individual experiences.

Entry requirements: Participants are expected to hold a diploma or B Sc in Agriculture. Practical work experience in the field of Draught Animal Technology of at least three years is required. As the course organizers recognize the role of women in agricultural development, women are particularly requested to apply.

- The costs of the DAT course are Dfl 19,000 (US$10,000 as per 1/2/1994) all in.
- Closing date for application: 15 June 1994

For more information write to the course administrator: Frans van Delft, Larenstein International Agricultural College, P.O. Box 7, 7400 AA Deventer, The Netherlands Phone: + 5700 84600, Fax: + 5700 84608

Harvest and Postharvest Technologies for Fresh Fruits and Vegetables

February 20-24, 1955
Guanajuato, Mexico

Sponsored by: ASAE — the Society for engineering in agricultural, food, and biological systems
Mexican Association of Agricultural Engineers

Hosted by: University of Guanajuato. Located in central Mexico, this is the heart of the winter fruit and vegetable industry. The site is also near Ipapuato, a popular family tourist attraction area.

Purpose: The conference will focus on the latest developments to improve handling, storage, transporting and exporting of fruits and vegetables. The conference will provide a forum to disseminate information on technologies that reduce damage during harvesting and processing.

Abstract Submission: An abstract is indicative of final paper quality; therefore, authors are urged to prepare quality abstracts. The abstract should be approximately 200 words and must emphasize objectives and resuls. Inclusion of tentative or final conclusions will greatly strengthen paper proposals and abstracts. Abstracts of applied research will be given priority over basic research. Completed projects will be given priority over those in progress.

Topic Areas: Papers are being solicited that address topics including but not restricted to the following:

- Handling
- Postharvest treatment
- Packing
- Storage
- Packaging
- Economics
- Transportation
- Harvesting
- Quality assessment

For conference content information contact:
Gerry Thierstein, Phone: 303.225. 6915, Fax: 303.224.3458

For other information contact: Jon Hiler, Meetings & Conferences Manager, ASAE, 2950 Niles Road, St. Joseph, Michigan 49085-9659. Phone: 616.428.6327. Fax: 616.429.3852.

International Symposium on Automation and Robotics in Bioproduction and Processing

April 4-7, 1955
Kobe University, Kobe, Japan

Agriculture is, in principle, a complex process in which many factors are involved and must be optimized. Farm mechanization in our world in future will also require optimized systems through automation. A severe labor shortage in rural sectors and some crops like fresh vegetables and fruits will necessitate the use of a robot similar to man's hands.

Agriculture in the coming century will take a more integrated form and will include relevant bioproduction and processing industries such as biomass production and conversion as well as biotechnological processes. Mechanization must meet these integrated demands.

This international symposium will focus on automation-related topics such as sensors, instrumentations, control and various technologies for machinery, facilities and robotics in the agricultural, forestry, fisheries, biotechnological and food processing industries.

It is hoped that this symposium and the planned two-day excursion associated with it will contribute to the development of new technologies in the broader field of agricultural engineering in the coming century.

Sponsor: Japanese Society of Agricultural Machinery (JSAM)

Co-sponsors: CIGR, JAICAE, AAAE, ASAE, SASJ, SICE.

Symposium Date and Venue: April 4-7, 1955, Kobe University, Faculty of Agriculture, Nada-ku, Kobe 657, Japan Tel: +81-78-881-1302, Fax: +81-78-802-4534

Official Language: English will be the official language of the Symposium. No interpretation will be provided.

Scientific Program: The program will include oral presentations and posters.

Titles: The symposium will cover fundamental as well as applied aspects of automation and robotics in all industrial sectors related to bioproduction and processing, e.g. agriculture, horticulture, forestry, aquaculture, animal husbandry, biotechnological product processing, biomass utilization and food industry. Papers on sensors, automatic measurement as well as control systems and robotics for farm machinery, energy and environmental aspects, greenhouse, product distribution, storage, sorting and packaging and food processing are also among areas of major interest. Subject area will be:

- Sensors and Interfaces
- Instrumentations
- Laboratory Intelligent Systems
- Mathematical Modeling and Simulation
- Image Data Processing
- Microcomputer Based Control Systems
- Automated Mechanics and Systems
- Autonomous Vehicles
- Robotics
- Information and AI Technology
- System Engineering
- On-site Reports on Applications
- Innovations in Equipment Design and Control
- Appropriate Technology in Automation

Chairman & Symposium Secretariat: Prof. Minoru Yamazaki, Department of Agricultural Engineering, Faculty of Agriculture, Kyoto University, Sakyo-ku, Kyoto 606-01, Japan Tel: +81-75-753-6163, Fax: +81-75-753-6173, E-mail Address: a51224@sakura.kudpc.kyoto-u.ac.jp

New Cutting Tool Announced (Australia)

SHEARIGHT announces the market introduction of a new hand held cutting tool for cutting plastic hose, tubing, and other non-metallic shapes up to 16 mm (5/8 inch) — outside diameter. Tough, durable engineered plastics and stainless steel blade provide light weight, long term performance in a wide range of appli-

cations. Autoclavable, it is also suitable for wet or immersed applications over long periods of time.

SAFE — Blade is exposed only when inserting material to be cut/trimmed; SQUARE CUT — Clean, quick and safe: bias cut can be made if desired; PIERCING/SLICING — Action does not crush, upset or distort material cut; SIMPLE — Blade removal for sharpening or replacement: No tools needed; PATENTED — It is different, and it works, and it has many uses.

For full details:
Write: SHEARIGHT
Box 1
4/17 Canley Vale Road
Canley Vale NSW 2166
Australia

Hockman-Lewis Offers Fogmaster Line of Cold Foggers (U.S.A.)

WEST ORANGE, NJ — Fogmaster foggers are used for a wide range of applications in the commercial, hospital, food, industrial, domestic, and agricultural fields. Now, they are available internationally through Hockman-Lewis Limited, a leading export management company with distributors located throughout the world.

These electric-powered foggers provide precise dispersal of mists and sprays and offer the versatility to adapt to different requirements, from low to large droplet space spraying. The foggers calibrate the exact flow desired, regardless of the viscosity or density of either oil- or water-based chemicals.

Fogmaster foggers have adjustable heads for better aiming of the mist or spray. Their tanks are made of durable aluminium and have a capacity of 1 gallon (3.785 liters).

Hockman-Lewis offers three models of the foggers: the Tri-Jet, with a three-vortex nozzle; the Pow-R-Jet, for automatic one-step dispersal; and the Micro-Jet/ULV, a versatile low-volume fogger.

More information and names of local distributors are available from Hockman-Lewis Limited, 200 Executive Drive, West Orange, NJ 07052, U.S.A. Phone (201) 325-3838. Fax: (201) 325-7974. Telex: 13-8693. ■■

Proceedings of the 1993 International Workshop on Agricultural Mechanization April 7, 1993 School of General Education Hirosaki University Hirosaki, Japan

(Japan)

The workshop this year is the 4th international workshop on the agricultural mechanization since the first meeting was held in 1989. The international workshops so far which were one of the programs at the annual meeting of the society each year have provided significant opportunities to understand teh agricultural situations in foreign countries, particularly in developing countries and to exchange technological knowledge.

This year, fourteen papers will be presented by participants from eleven foreign countries in the meeting with the theme "Searching Today for a Better Tomorrow." Twelve of them are current participants in JICA training course (11: group training of Farm Machinery Design, 1: individual training) and two foreign students studying in Japan.

The workshop was organized by The International Committee, Japanese Society of Agriculutral Machinery (JSAM); Collaborated by Tsukuba International Agricultural Training Center, JICA and Farm Machinery Industrial Research Corp.

Engineering Principles of Agricultural Machines ASAE Textbook No. 6

(U.S.A.)

by A.K. Srivastava; C.E. Goering; R.P. Rohrbach

This book is written as a textbook for a course in agricultural machines in an engineering program. The book is designed to be used in an upper level undergraduate course. The prerequisites are statics, strength of materials, and differential equations. However, knowledge of dynamics and fluid mechanics would be helpful. The book may also be used in a lower division course by not covering hte theoretical part of each chapter without loss of continuity.

The objectives of the book are: 1) to discuss the methods and equipment used to accomplish the various operations employed in production agriculture; 2) to present agricultural machines as a system of subcomponents performing different functions; and 3) to present the engineering principles governing the operation of machines used in agricultural production.

The concept of dividing a machine into subsystems is discussed in Chapter 1. Every agricultural machine can be divided into functional, power, and framing subsystems. This book focuses on the functional systems and the power systems. Chapters 2, 3, and 4 cover the power systems. Chapters 4 through 10 discuss machines used for production operations from tillage to harvesting. Chapter 11 covers materials handling while machinery management is covered in Chapter 12.

An approach to teaching agricultural machines by preparing a "process diagram" is presented in this book. A "process diagram" breaks a machine down into several functional processes, for example, a sprayer may be divided into processes of pumping, mixing and agitation, metering, and atomization. The instructors are encouraged touse this approach as it provides a common thread while discussing different machines. An effort has been made to maintain uniformity of format in Chapters 5 through 11. The material is generally presented under the titles of methods and equipment, functional processes, and performance. The book does not cover the framing subsystems.

Size: 23 × 15.5 cm, soft cover, 601 pp. Published by the American Society of agricultural Engineers, 2950 Niles Road, St. Joseph, Michigan 49085-9659, U.S.A.

Proceedings of the 5th International Congress on Mechanization and Energy in Agriculture October 12-14, 1993 Kusadasi, Turkey

(Turkey)

It is become necessary to increase or at least maintain the agricultural production potential of Türkiye, one of the rare self-sufficient countries in terms of agricultural production, even in a position of reaching a high level of industrialization. An increase in production on a farm together with an increase in profitability can only be achieved through a rational and appropriate mechanization.

The provision of discussions on recent Research and Development studies in international level by its professionals and exchange of knowledge, is an essential step towards development of agricultural mechanization and improvement of international cooperation.

The 5th of the International Congresses on "Mechanization and Energy in Agriculture," which is arranged every three years, has been organized by the Ege University, Faculty of Agriculture, Department of Agricultural Machinery with the support of some related organizations, to be held in Kuşadası Aydın on 12-14 October 1993.

This publication consists of the papers of those scientists who put forward and discuss their views and opinions in detail throughout the

Congress.

Size: 27.5 × 19.5 cm, 636 pp, soft cover. Published by Ege University, Faculty of Agriculture, Dept. of Agricultural Machinery, Bornova-Izmir, Turkey.

Irrigation Management for Crop Diversification in Bangladesh.

(Bangladesh)

by: M.R. Biswas; M.A.S. Mandal

In recent years there have been considerable interests in crop diversification for increasing farmers' income, reducing production risk and improving soil fertility and human nutrition. One of the key requirements for this strategy is to raise irrigation management capabilities for growing non-rice crops in rice-based systems.

This book is the outcome of an extensive multidisciplinary field research aiming at identifying the potentials for and constraints to irrigated crop diversification.

The key issues addressed in this book are:

- Are there improved production technologies for growing non-rice crops?
- How to improve irrigation management for rice as well as non-rice crops?
- Are irrigated non-rice crops profitable in rice-based systems?
- Is investment in irrigation tubewells profitable?

The study shows that there are potentials and opportunities for growing non-rice crops, especially vegetables in dry season, but it requires adjustments in crop and irrigation management practices. According to the study, irrigated vegetable based cropping patterns proved to be highly profitable and that the returns to investment in shallow tubewells appeared to be high.

Replete with primary field level data from four agro-ecological zones of Bangladesh, this book will interest policy makers, researchers, agricultural extension agents and all those involved in irrigation management for crop diversification.

Size: 22 × 17 cm, 236 pp, hardcover. Price Tk 400.00. Published by the University Press Limited, Red Crescent Bldg, 114 Motijheel C/A, P.O. Box 2611, Dhaka 1000, Bangladesh Fax 880 2 833212.

Full Steam Ahead J.I. Case Tractors & Equipment 1842-1955

(U.S.A.)

by: David Erb and Eldon Brumbaugh

At the age of 24, Jerome Increase Case began building a threshing machine that both separated and cleaned the grain. While there were other threshing machines, the high quality construction and operation made these first machines an instant success with farmers. Before long, the J.I. Case name was known throughout the world.

Full Steam Ahead moves through more than 100 years of Case farm machinery from threshing machines and steam engines to gas tractors and even Case cars. With over 700 photos and detailed text, the book chronicles many of the early design and development stages of some of Case's most popular equipment.

Step back in time and relive some of the testing of early Case tractors such as the two-cylinder models and the grey era tractors. Follow the discussions of prototype testing, component selection and engine design, as well as serial number references.

Entertaining facts also capture some of the flavor and history of the time. Find out why in the 1930s one Case executive disliked oil filters and storage batteries; why Rochester, Wisconsin, was almost the home of the J.I. Case Company; or why engineers once advised steam engine operator to "... pull hard on the whistle and run for it!"

Whether you're a Case equipment lover or just fond of farm machinery, this book has something for everyone.

Size: 28.5 × 22 cm, 343 pp, hardbound. Published by the American Society of Agricultural Engineers, 2950 Niles Road, St. Joseph, Michigan, U.S.A. ■■

INSTRUCTIONS 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 printed, double-spaced, under 4,000 words (approximately equivalent to 8 pages of AMA-size paper) ; and those that
g. are supported by authentic sources, reference or bibliography.
h. written on floppy disc.

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, the main author is given an article on floppy disc with AMA true format. Co-authors can get a copy from main author.
d. Complimentary copies: Following the publishing, three successive issues are sent to the author(s).

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. Article must be sent on 3.5 inch floppy disk with MS DOS format (e.g. Word Perfect, Word for DOS, Word for Windows.....) along with one printed copy.
b. The data for graphs and the black & white photographs must be enclosed with the article.
c. 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
d. The printed copy must be numbered (Arabic numeral) successively at the top center whereas the disc copy pages should not be number. 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".
e. The data for the graph must also be included.
f. 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.
g. 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.
h. 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).
i. Indicate by footnotes or legends any abbreviations or symbols used in tables or figures.
j. Convert national currencies in US dollars and use the later consistently.
k. Round off numbers, if possible, to one or two decimal units, e.g., 45.5 kg/ha instead of 45.4762 kg/ha.
l. 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.

Co-operating Editors


T P Ojha


S R Verma


Soedjatmiko


M Behroozi-Lar


J Sakai


B A Snobar


C J Chung


C C Lee


I Haffar


M Z Bardaie


E S Eldin


M Afzal


A D Chaudhry


A Q Mughal


R M Lantin


R P Venturina


S Illangantileke


S F Chang


T S Peng


S Phong-supasamit

S.R. Verma
Prof. of Agricultural Engineering, College of Agril. Engg., Punjab Agricultural University, Ludhiana - 141004, India

Soedjatmiko
Head of Subdirectorate of Agric. Engineering, Ministry of Agriculture, Jakarta, Indonesia

Mansoor Behroozi-Lar
President, Iranian Society of Agricultural Machinery Engineers, P.O. Box 31585-574, Karaj, Iran

Jun Sakai
Professor, Dept. of Agric. Engineering, Faculty of Agriculture, Kyushu University 46-05, Hakozaki, Higashi-ku, Fukuoka 812, Japan

Bassam A. Snobar
Professor & chairman, Plant Production Dept., Faculty of Agriculture, University of Jordan, Amman, Jordan

Chang Joo Chung
Professor, and Dean, College of Agriculture and Life Sciences, Seoul National University, Suweon 441-744 Korea 103

Chul Choo Lee
Research Professor, Seoul Woman's University, Mailing Adress: Rm. 514 Hyundate Goldentel Bld. 76-3 Kwang Jang Dong Ku, Seoul, Korea

Imad Haffar
Assistant Professor of Agric. Mechanization, Dept. of Soils, Irrigation and Mechanization, Faculty of Agriculture and Food Sciences, American University of Beirut, Beirut, Lebanon

Muhamad Zohadie Bardaie
Professor and Deputy Vice Chancellor (Development Affairs), Universiti Pertanian Malaysia, 43400 UPM, Serdang, Selangor, Darul Ehsan, Malaysia

ElTag Seif Eldin
Mailling Address: Dept. of Agric Mechanization, College of Agriculture, P.O. Box 32484, Al-Khod, Sultan Qaboos University, Muscat, Sultanate of Oman

Mohammad Afzal
Senior Engineer (Mechanization Engineer), Farm Machinery Institute, National Agric. Research Centre P.O. NIH, Islamabad, Pakistan (Mailling Address: 30 Savage Cresent Palmerston North 5301, Newzealand)

Allah Ditta Chaudhry
Professor and Dean Faculty of Agric. Engineering and Technology, University of Agriculture, Faisalabad, Pakistan

A.Q. Mughal
Professor, Faculty of Agricultural Engineering, Sind Agriculture University, Tandojam, Sind, Pakistan

Reynaldo M. Lantin
Agricultural Machinery Expert, Regional Network for Agricultural Machinery, c/o United Nations Development Programme P.O. Box 7285 ADC Pasay City Metro Manila, Philippines

Ricardo P. Venturina
President & General Manager, Rivelisa publishing House, 215 F, Angeles St. cor Taft Ave. Ext., 1300 Pasay City, Metro Manila, Philippines

S. Illangantileke
Head, Dept. of Agric. Engineering, Faculty of Agriculture, University of Peradeniya, Sri Lanka (Mailing Address: Div. of Agric. & Food Engineering, Asian Institute of Technology, GPO 2754 Bangkok 10501, Thailand

Sen-Fuh Chang
Professor, Agric. Machinery Dept. National Taiwan University, Taipei, Taiwan

Tieng-song Peng
Deputy Director, Taiwan Agricultural Mechanization Research and Development Center, FL. 9-6, No. 391 Sinyi Road, Sec. 4, Taiwan

Surin Phongsupasamit
Associate Professor, Dept. of Mech. Engineering, Faculty of Engineering, Chulalongkorn University, Ban 10330, Thailand

Chanchai Rojanasaroj
Research and Development Engineer, Dept. of Agriculture, Ministry of Agriculture and Cooperatives, Bang-Khen, Bangkok 10900, Thailand

Gajendra Singh
Professor of Agric. Engineering, Div. of Agricultural & Food Engineering, Asian Institute of Technology, GPO 2754, Bangkok 10501, Thailand

Yunus Pinar
Associate Professor, Agric. Engineering Dept., Faculty of Agriculture, University of Ondokuz Mayis, Kurupelit, Samsun, Turkey

—EUROPE—

Anastas Petrov Kaloyanov
Professor & Head, Research Laboratory of Farm Mechanization, Higher Institute of Economics, Sofia, Bulgaria

Pavel Kic
Associate Professor, University of Agriculture Prague, Faculty of Agric. Engineering, 165 21 Praha 6-, Suchdol, Czechoslovakia

Henrik Have
Prof. of Agric. Machinery and Mechanization at Institute of Agric. Engineering, Royal Veterinary- and Agricultural University, Agrovej 10 DK2630 Tastrup, Denmark

Giuseppe Pellizzi
Director of the Institute of Agric. Engineering of the University of Milano and Professor of Agric. Machinery and Mechanization, Via G. Celoria, 2-20133 Milano, Italy

Aalbert Anne Wanders
Staff Member, Dept. of Development Cooperation, Netherlands Agricultural Engineering Research Institute (IMAG), Wageningen, Netherlands

John Kilgour
Senior Lecturer in Farm Machinery Design at Silsoe College, Silsoe Campus, Silsoe, Bedford, MK45 4DT, UK ■■


C Rojanasaroj


G Singh


Y Pinar


P Kic


A P Kaloyanov


H Have


G Pellizzi


A A Wanders


J Kilgour

BACK ISSUES

(Vol. 24 No. 1, Winter 1993 ~)

NEW TECHNOLOGY IN GRAIN POSTHARVESTING

by Ritsuya Yamashita
Professor emeritus of Kyoto University, Professor of Kinki University

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

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

This book covers from processing just after harvesting through adjusting, packing and distribution to possible and necessary future techniques from quality, taste and low cost production of rice points of view.

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

Price: Japanese ¥6,000 (US $65.00). including air mail postage.
Size: 21cm × 15cm, soft cover, 208 page
Published by Farm Machinery Industrial Research Corp.,
Shin-Norin Build., 7, 2-chome, Kanda Nishikicho, Chiyoda-ku, Tokyo 101 Japan
Phone: 03 (3291) 5718. Fax: 03 (3291) 5717.

The Updated Version of the AMA Computerized Index Available

A computerized index of technical articles in Agricultural Mechanization in Asia, Africa and Latin America has been compiled for the year 1971 through 1992. Each citation includes truncated versions of the title, first and second authors' names and four keywords. Year, issue and page number of each article are given. The citations along with software for searching the database are all included on a single computer diskette for use with IBM compatible type computers.

Anyone wishing to receive this may contact William Chancellor, Biological and Agricultural Engineering Department, University of California, Davis, CA 95616, USA, and the database along with searching software and documentation will be sent by airmail on a 5 1/4-inch, 360 kbyte diskette. Those wishing some other type of diskette should send one formatted diskette with their request. There is no charge. Any special customs or postal designation or specifications required should be stated in the request. Annual updates will be available in the future.