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AMA

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

VOL.21, NO.1, WINTER 1990

Special Issue:

The Agricultural Machinery Industry in Japan

FARM MACHINERY INDUSTRIAL RESEARCH CORP.

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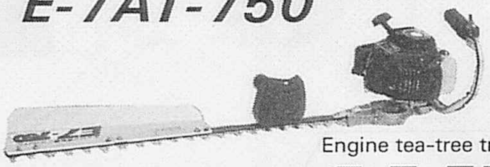
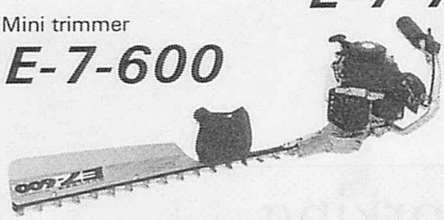
Engine tea-tree trimmer
E-7AT-750



Engine tea-tree trimmer
E-7-750

Mini trimmer
E-7-600

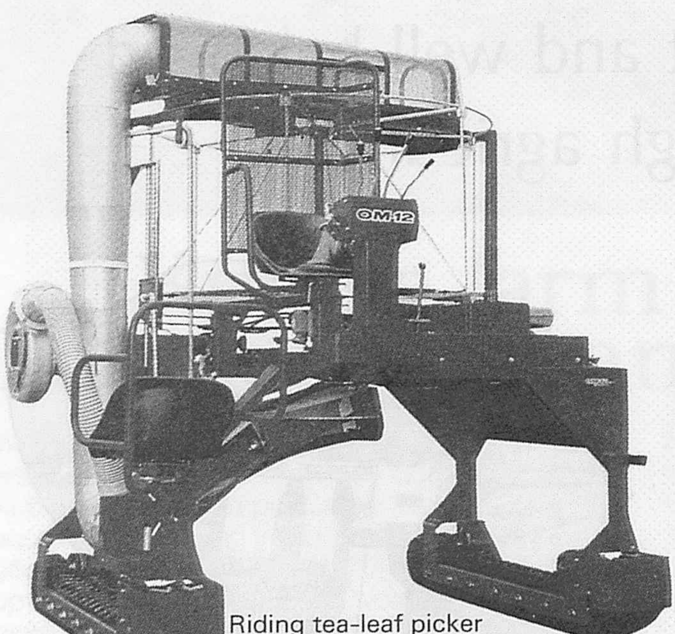


Clipper type tea-leaf picker V8-NEWZ2

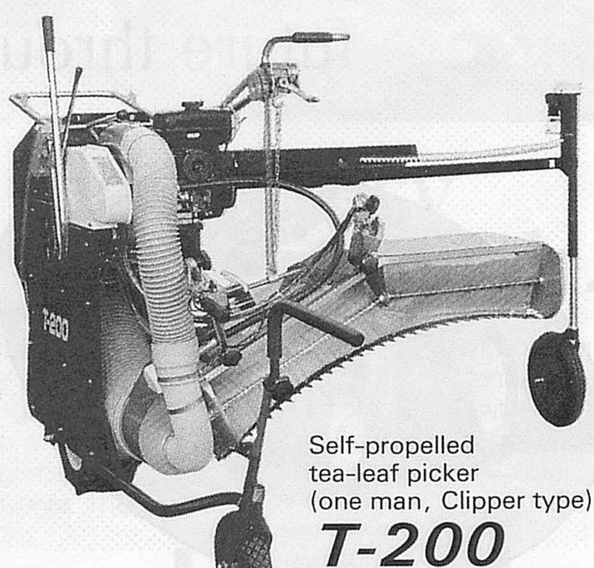
type	Clipper type tea-leaf picker V8-NEWZ2				
picking width	850mm	1,000mm	1,070mm	1,140mm	1,210mm
weight	11.4kg	11.95kg	12.15kg	12.35kg	12.6kg
engine	41.5cc(3.2PS)				

GUIDE TO OCHIAI

- Succeeded in devising Japan's first automatic tea-leaf picker in 1959.
- Received the Director of the Board of Scientific Technology Award in 1967.
- During the intervening period (1959-1967) obtained a number of patents, as well as receiving a variety of awards and prizes in the domain of science and technology.
- The top-ranking tea-leaf picker and tea-tree trimmer producer, holding 60% of the shares in the same line of business in Japan, surpassing the other manufacturers in sales and product, and leading the related business worlds in its expansion and development.



Riding tea-leaf picker
OM-12
- two operators
- weight/750kg



Self-propelled tea-leaf picker (one man, Clipper type)
T-200
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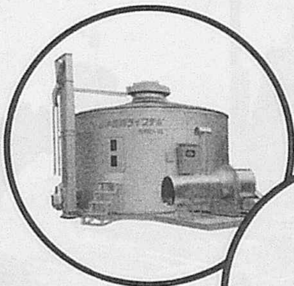
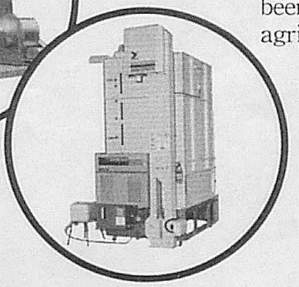
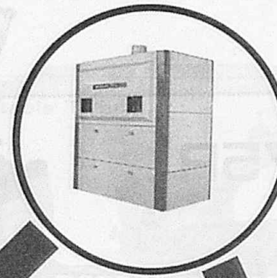


DRYING&STORAGE BIN

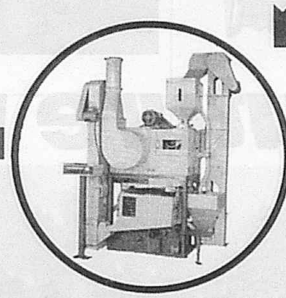


GRAIN DRYER

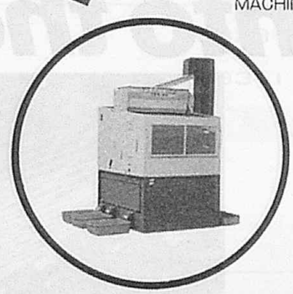


PRE-CLEANER

RICE WHITENING MACHINE (VERTICAL TYPE)



PADDY HUSKING MACHINE



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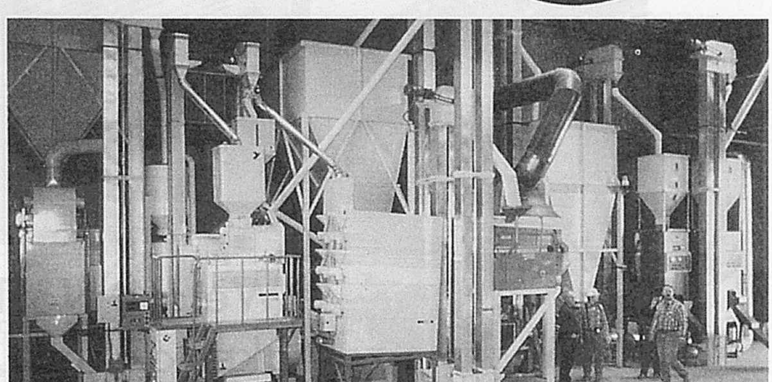

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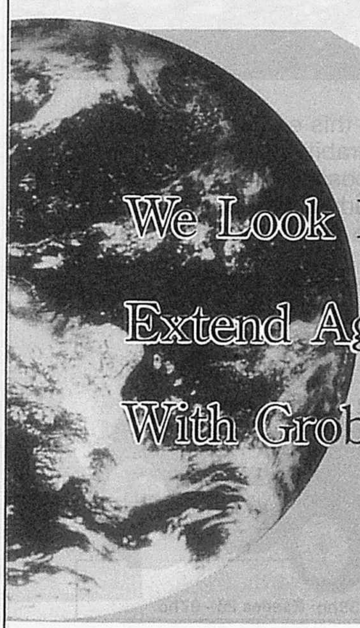

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This is the 66th issue since the issue, Spring of 1971

EDITORIAL

Greeting the 1990s

Through this special winter issue of the AMA, the entire AMA staff takes the oportunity to greet all AMA readers, contributors, co-editors and the general clientele a VERY HAPPY NEW YEAR!

In retrospect, we bid goodbye, not only to the last year just ended, but also to the last decade gone by. As we are ushered into the threshold of the 1990s, we suddenly realize that we are actually only another decade away from the 21st century. And as we have of sign of "How time flies" relief, we become aware that 1980s, we recall a few notable and relevant events that have taken place and their implications in the 1990s—events that we identify as areas of concern.

First of these areas of concern is the comparative change in world population on one hand and, on the other, available cultivated land areas, i.e., a fast rate in population increase against a stagnant, if not decreasing cultivated land areas—give and take a few pluses and minuses due to slopeland development and the encroaching urban spread, respectively. What this implies is a widening gap between food supply and demand. Unless the yields of crops and livestock are increased considerably soon, the food crisis that was experienced in the 1980s will continue to haunt mankind in the 1990s.

The second area of concern noted in the decade gone by is the threat of what is now fully recognized as the "greenhouse effect"—a phenomenon that highlights the urgent need for man to be in harmony with the ecological system about which the interactive relationship between man and the system has yet to be fully understood, hence an urgent need for basic research on this subject soon into the 1990s.

The third areas of concern pertains to the international tension brought about by such man's wickedness as terrorism, massacre, assasination and drug problem, among other. However, with the current efforts being exerted by the world powers and many other well-meaning world bodies and governments, the world situation should ease considerably in the 1990s.

The fourth area of concern pertains to the well-being of the world's teeming millions of rural dwellers and marginal farmers who comprise the majority of the population in most countries. They are usually the poorest of the poor who rightfully deserve a little more roof over their heads, a little more cloth on their backs and a little more food in their stomachs. Concerned governments are being called upon to put on some speed in the dissemination of agricultural technology and agricultural mechanization technology for the benefit of the marginal farmers and other rural dwellers.

It is in this fourth area of concern that this special winter issue of the AMA carries special sections introducing a large number of Japanese agricultural machinery industries—not only because they have hardly been disseminated in the past due to the language problem but more so because it is a response to the need for technology transfer to the less developed countries in the hope that farmers, big and small, might benefit from the Japanese experience.

Here's wishing one and all a more productive 1990!

Yoshisuke Kishida
Chief Editor

Tokyo, Japan
January, 1990

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AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

Vol. 21, No. 1, Winter 1990

Analysis of Tractor Test Procedure at the Nebraska Tractor Test Laboratory

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Abstract

Current test procedure at the Nebraska Tractor Test Laboratory is analyzed primarily based on the present test results (data and curves). The purpose of this analysis is to update the test procedure. The results indicated that the suggested Tractor Test Procedure could be more suitable to the present situation (advanced instrumentation and improved tractor performance) and the test length may be reduced by 14 hours. This will be beneficial to the companies as well as the tractor test laboratory.

Introduction

The Nebraska Tractor Test is so famous in the world that many country's tractor companies try to submit their tractor models to be tested in order to get credits in international market. During the testing career as long as 66 years, more than 1 600 tractor models coming from different countries have been tested. The test reports are mailed to the subscribers, relative magazines and tractor companies in the world to be used as an important data or basis for not only evaluating and selecting tractors but also studying and improving tractors.

The tractor test procedure is a law to test tractors. It should be updated as agriculture, industry of tractor (engine included) and testing technology develop constantly. In this paper, the authors discuss the current Nebraska Tractor Test Procedure with the test results and present some conclusions.

Testing and Analyzing

The current Nebraska Tractor Test Procedure consists of four types: Power Take-Off Test, Drawbar Test, Sound Level Test and 3-Point Test.

PTO Test

The PTO Tests are conducted indoor. The dynamometer is connected to the PTO with transmission shaft. The tests not only determine PTO performance but also estimate the engine behaviour.

1 *The characteristic temperature of the fuel system and tractor adjustment test*— In the current Nebraska Tractor Test, such a test is conducted only as an auxiliary test before official test. This is not reasonable because three objectives are to be achieved in the test.

a) To warm up the tractor until it reaches a certain stable temperature state in order to get reliable data.

b) To make necessary adjustment: let the tractor operate under its optimum conditions. It makes the testing results show the tractor performance more actually.

c) To determine the characteristic temperature of the tractor fuel system. According to a vast amount of testing and studying at the Nebraska Tractor Test Laboratory, it was found[1] that with every 5°C (or 9°F) increase in the fuel temperature, there would be an 1%–2% decrease PTO Horse Power. The amount depends upon engine type, size, tank location, amount of return, etc. This is because with the increase in temperature, the density and viscosity of the fuel decreases. It causes the fuel to produce less performance per unit of volume and higher seepage losses may occur in some pump systems. Therefore, every tractor before official test, the characteristic temperature of the fuel in the injection pump is determined and the fuel temperature is maintained at the predetermined level during all maximum power tests.

Thus it can be seen that the characteristic temperature of the fuel and tractor adjustment test provides a basis and lays a foundation for the following tests. So it

Table 1 Variation of Tractor's Average Performance with Operating Time

Tractor	Test 1597 Kubota M7030DT		Test 1599 Valmet 980 FWA		Test 1589 John Deere 3150		Test 1590 John Deere 4050	
Operated Minutes	PTO power (HP)	Specific fuel consumption (1b/hp.h)	PTO power (HP)	Specific fuel consumption (1b/hp.h)	PTO power (HP)	Specific fuel consumption (1b/hp.h)	PTO power (HP)	Specific fuel consumption (1b/hp.h)
10 min.	68.970	0.4250	87.85	0.425	96.280	0.426	105.730	0.406
20 min.	68.905	0.4245	88.02	0.425	96.290	0.426	105.550	0.407
30 min.	68.877	0.4246	88.016	0.425	96.150	0.426	105.710	0.407
40 min.	68.875	0.4245	88.00	0.425	96.080	0.426	105.793	0.407
50 min.	68.864	0.4246	87.99	0.425	96.054	0.426	105.81	0.407
60 min.	68.845	0.4240	87.98	0.425	96.066	0.426	105.79	0.407
70 min.	68.841	0.4240	87.97	0.4246	96.074	0.426	105.81	0.407
80 min.	68.840	0.4240	87.98	0.4246	96.087	0.426	105.83	0.407
90 min.	68.850	0.4240	87.99	0.425	97.073	0.426	105.833	0.407
100 min.	68.846	0.4240	88.00	0.425	96.066	0.426	105.888	0.407
110 min.	68.868	0.4240	88.01	0.425	96.069	0.426	105.888	0.407
120 min.	68.867	0.4240	88.01	0.425	96.063	0.426	105.887	0.407

should also be included in the official test codes.

2 *Two hours maximum power at engine rated speed test* – In this test, the maximum power the tractor is able to deliver continuously and the corresponding fuel consumption measured on PTO are determined. The test is performed for 2 h, and every 10 min to take reading and record it.

Table 1 shows four tractors' average power and specific fuel consumption in different testing period. **Figure 1** illustrates their variation with operating time. From **Table 1** we can see:

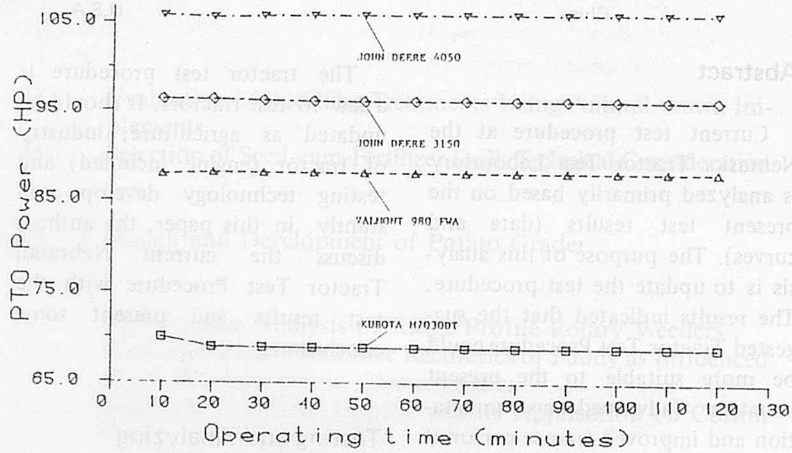

Fig. 1 Variation of tractors' average performance.

(1) As testing time goes on, the data measured become steady gradually.

(2) After 20–30 min, the first digit after decimal point for the PTO power becomes constant (In tractor test report, the two digits after decimal point is used. The first digit after decimal point is accurate, the second digit includes carried number.); after 1 h, the variation of PTO Horse Power tend to disappear **(Fig. 1)**. There is almost no difference in average of PTO power between 60 min and 100 min measurement **(Table 1)**.

(3) The average of specific fuel consumption becomes completely constant only after 20 min.

From the testing results above, we can come to the following conclusion:

The 2-hour maximum power at rated engine speed test could very possibly be reduced to ONE hour without losing any information on the tractor/engine performance.

3 *Two hours varying power test* – The test consists of six different load tests, each load being held constant for 20 min.

The load sequence is always the same:

a. 85% of the torque at maximum load

b. 0-load – this gives the so-called "high idle" speed of the engine

c. 1/2 x 85% of the torque at maximum load

d. Maximum load (full torque at rated engine RPM)

e. 1/4 x 85% of the torque at maximum load

f. 3/4 x 85% of the torque at maximum load

It is clear that in varying power tests the basic load standard is 85% of the torque at maximum load, that is, the 85% of the torque at maximum load is used as a rated (normal) load. This is unreasonable because according to the basic working principle[4], if a tractor /engine can always work on maximum load (at rated engine RPM), it is very desirable. But in the past time, the capability of diesel engine to overcome the excess load was not good. As a mater of record[4], the torque rise (a ratio of maximum load to rated torque) of diesel engine was only 1.05 – 1.15. The tractor, however, often works under varying loads. When the load increases the engine revolutions drop quickly and the engine even stalls. Therefore, at that time when the test procedure was worked out, 85% of the torque at maximum load had to be used as a normal load and 15% of that was set aside for torque reserve to overcome the excess load.

Due to the combustion process of diesel engine and performance of injection pump-governor have been greatly improved in the past few decades, this has resulted in improvement on capability for diesel engine to overcome the excess loads. Fig. 2 is a test result of John Deere 8850 tractor in accordance with OECD standard code. From the figure, we may see:

(1) The capability of coping with excess loads has been greatly improved. The torque rise is 1.25.

(2) After the load has exceeded its maximum value at rated engine RPM, the power of PTO/engine still tends to go up for a range of engine speed from 2100 – 1936 RPM while the engine torque increases with the load increases. This means that when the load of the tractor exceeded the maximum value, the tractor is not only able to overcome the heavier load, but also its productivity can increase.

(3) Even when engine's torque reachers maximum value, the specific fuel consupmtion is still kept at nearly minimum value.

All of these behaviors tell us that when the tractor/engine works on the exceeded load position (state) in certain range of the engine RPM, efficiency of both power and economy can be improved, comparing with maximum load as well as 85% of the maximum load.

According to record of the test materials[5] at the Nebraska Tractor Test Laboratory, this is an universal law resulting from improvement of internal combustion engine performance. Some tractors' (e.g., Steiger PTA-280) torque rise can reach 1.556; and after the loads exceed its maximum value at rated

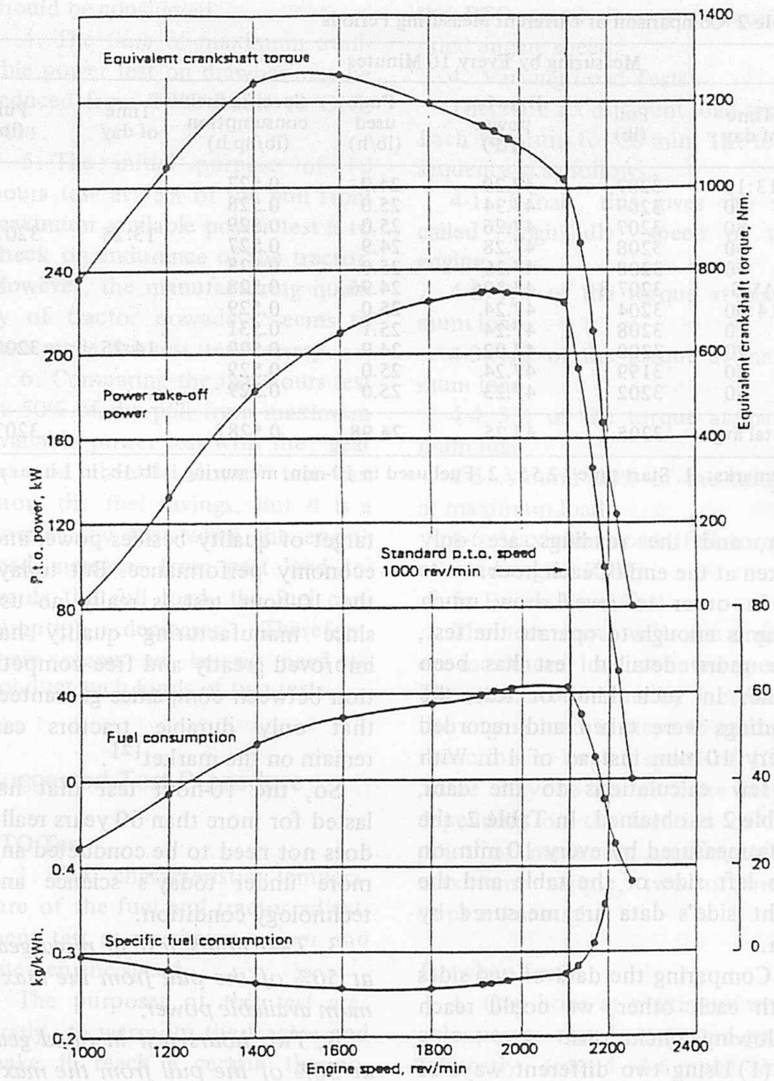

Fig. 2 PTO test and equivalent crankshaft torque.

engine RPM, the engine power keeps up the increase until the engine speed decreases to 70% of rated engine RPM.

The other respect in which the tractor performance has been improved is the use of the torque converter or automatic shift-down of the transmission. This makes it easy to change gears, and even to do so "on the go."

The facts above prove that there is no need to use 85% of the torque at maximum load as the normal load standard. The maximum load at rated engine speed ought to be used.

Drawbar Test

Drawbar tests perform on concrete track with the help of a test car, a number of load tractors and a lot of instruments. The tests consist of six different tests.

1. *Two hours test at maximum available power in a "rated gear" (mostly around 4-6 mph) and at rated engine RPM.* – This test is to show how much maximum power the tractor can transmit and the corresponding fuel consumption measured on drawbar. This, of course, is of great interest to users /farmers.

The test at the Nebraska Tractor Test Laboratory is conducted for

Table 2 Comparison of Different Measuring Periods

Measuring by Every 10 Minutes					Measuring by Every 1 h				
Time of day	Pull (lb)	Drawbar power (HP)	Fuel used (lb/h)	Specific fuel consumption (lb/hp.h)	Time of day	Pull (lb)	Drawbar power (HP)	Fuel used (lb)	Specific fuel consumption (lb/hp.h)
13:10	3207	47.29	24.9	0.527					
20	3209	47.34	25.0	0.528					
30	3207	47.26	25.0	0.529					
40	3208	47.28	24.9	0.527	13:25	3207	47.26	Not measured	Not measured
50	3208	47.36	25.0	0.528					
AVG.	3207.8	47.306	24.96	0.528					
14:00	3204	47.24	25.0	0.529					
10	3208	47.24	25.1	0.531					
20	3200	47.02	24.9	0.529	14:25	3200	47.22	Not measured	Not measured
30	3199	47.24	25.0	0.529					
40	3202	47.23	25.0	0.529					
Total avg.	3205.2	47.25	24.98	0.5287		3203.5	47.24	49.875	0.528

Remarks: 1. Start time 12.55. 2. Fuel used in 10-min. measuring is lb.1h; in 1-hour measuring is total in two hours.

2 h, and the readings are only taken at the end of each hour.

In order to reveal how much time is enough to operate the test, the more detailed test has been done. In such kind of test, the readings were taken and recorded every 10 min. instead of 1 h. With a few calculations to the data, **Table** 2 is obtained. In **Table** 2, the data measured by every 10 min. on the left side of the table and the right side's data are measured by 1 h.

Comparing the data of two sides with each other, we could reach following conclusions:

(1) Using two different ways of measurement, the average of drawbar power (HP) and the specific fuel consumption reached almost the same results separately (last line on **Table** 2).

(2) After 1 h from the first reading taken, the drawbar power and the specific fuel consumption basically reached a steady state.

So ONE hour is enough for this test to operate.

2. *10-hour continuous test in the rated gear at 75% of the pull obtained in maximum available power test* – This test started in 1920. The initial purpose was to test the endurance of a tractor because at that time, the manufacturing quality was not good, the endurance was a very important target of quality besides power and economy performance. But today, the 10-hour test is really no use since manufacturing quality has improved greatly and free competition between companies guarantees that only durable tractors can remain on the market[2].

So, the 10-hour test that has lasted for more than 60 years really does not need to be conducted any more under today's science and technology condition.

3. *Two hours test in rated gear at 50% of the pull from the maximum available power.*

4. *Two hours test in rated gear at 50% of the pull from the maximum available power, but in a higher gear and a lower throttle setting. This is called "gear up and throttle down" test.* – These two tests are used to compare the fuel consumption savings at part load.

(1) The "gear up and throttle down" is an operating method used in the farming operations. Such kind of farming operations have two features:

a) The loads are light (not heavy) and

b) The tractor travel speed is limited (not fast).

This is particularly true in cultivation and division harvest of wheat etc. Thus, if we use high gear (with the throttle full open) the tractor travel speed will be too fast, while we use lower gear the load is too low, causing the fuel consumption to increase. So we have to use the high gear and lower throttle setting.

Only a few farming operations are able to use this method.

(2) The need to save fuel in using "gear up and throttle down" method is illustrated in **Fig**. 3.

In the upper part of the figure it shows that engine response and the lower part shows the tractor travel speed for each gear.

Supposing the required speed of farming operation is V_1, and correponding load (power) is Ne_1.

From the figure, it may be seen that the gear II, III, IV may be used separately. But use different gear, the throttle must be set in different position (i.e., setting 1, 2, 3), and it must have different fuel consumption ($G_{T1} > G_{T2} > G_{T3}$). Because the $g_l = G_T/Ne$, if Ne keeps constant (Ne_1), the decrease

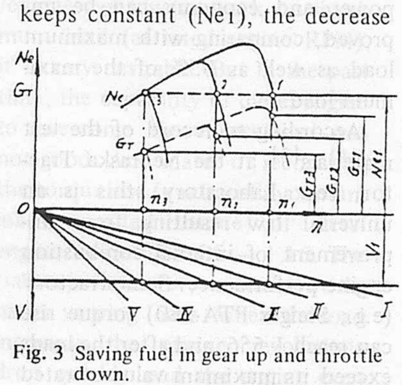

Fig. 3 Saving fuel in gear up and throttle down.

of G_T must cause the g_l to be decreased, that is, the fuel efficiency has been improved.

Comparing the operating state of the engine in one gear with after shifting into a higher gear, it can be seen that in higher gear, the engine load degree (the ratio of actual load to the maximum load at a certain throttle setting) has increased (in gear iv, the engine is in full load). This is a common law that when internal combustion engine operated on its part load, if the load degree can be increased, the efficiency of both power and economy will be improved. So if we want to know the fuel savings, the characteristic curve (like Fig. 2) may be taken and analyzed or compared with each other. There seems to be no need to conduct such kinds of two tests.

5 *Maximum power in selected gear tests* – These tests are to show how many gears of the tractor can be used in the heavier load farming operations.

6 *Lugging run* – The purpose of this test is to check the lugging ability – the capability of the tractor to overcome the heavier loads.

These two tests are necessary and the test contents are correct.

Summary

1. The characteristic temperature of the fuel and tractor adjustment test is a basis of PTO Test and Drawbar Test. It should be included in official test code.

2. According to testing data, the testing time of maximum power at rated engine speed on PTO may be reduced from TWO hours to ONE hour.

3. Under the present technology level of internal combustion engine and tractor, using 85% of the torque at maximum load to plan the varying tests does not seem to be adequate any more. Instead, the use of maximum power (full load) should be considered.

4. The time of maximum available power test on drawbar may be reduced from TWO hours to ONE hour.

5. The initial purpose of 10 hours test at 75% of the pull from maximum available power test is to check on endurance of the tractor. However, the manufacturing quality of tractor nowadays seems to have made this test unnecessary.

6. Comparing the two hours test at 50% of the pull from maximum available power test with the "gear up and throttle down" test can show the fuel savings. But it is a normal law that when the engine load increases from part load towards the full load, the fuel consumption decreases. Therefore, there seems to be no need to conduct such kinds of two tests.

Suggested Test Procedure

PTO Test

1. The characteristic temperature of the fuel and tractor adjustment test at maximum power and rated engine speed.

The purposes of this test are: firstly, to warm up the tractor and make it reach a certain thermodynamic state; secondly, to adjust the tractor to work under its optimum conditions, if necessary, and; thirdly, to determine the characteristic temperature of each fuel system of the tractor.

The test-operating time is to be determined according to the actual situation.

2. One hour maximum power test at rated engine RPM.

This test determines the maximum power that the tractor is able to deliver continuously and the corresponding fuel consumption measured on PTO.

3. One hour maximum power at standard PTO speed test. This either at 540 RPM or at 1000 RPM.

This test is only conducted if the PTO speed does not occur at rated engine speed.

4. Varying Load Tests

There are six different load tests. Each test runs for 20 min. The load sequence is as follows:

4-1. 0-load, this gives the so-called "high idle" speed of the engine.

4-2. 1/4 of the torque at maximum load.

4-3. 1/2 of the torque at maximum load.

4-4. 3/4 of the torque at maximum load.

4-5. Around 90% of the turque at maximum load.

4-6. Maximum load (full torque at rated engine RPM).

5. Excess Load Test

The test starts with the engine on maximum load at rated speed. Then each test runs by increasing the engine load in steps to produce reduction in engine speed of 10%. There may be six or more steps, depending on the location of the point of maximum torque. After maximum torque, two or more steps are enough.

Drawbar Test

1. One hour at maximum available power test in a "rated gear" (almostly around 4-6 mph) with full open throttle.

This test is to show how much maximum available power the tractor can transmit and the corresponding fuel consumption measured on drawbar.

2. Maximum power in selected gears tests

The purpose and requirement are all the same as before.

3. Lugging run test

This test is not only to test lugging ability of a tractor but also for its reliability. The condition and methods of the test are the same as before.

Sound Level Test (the same as before)

Hydraulic Lift Test (the same as before)

Conclusions

The Suggested Test Procedure has advantages as follows:

1. It is more adapted to the present technology level and actual situations.

2. The test results will be reported not only in the form of the table but also in the form of characteristic curve (current test procedure reported only in the form of table).

The form of table is clear at a glance, and one may see the data directly, but its data are separate, static and limited. The form of characteristic curve shows the varying regularity and tendency of the performance parameter measured as well as the value of specific point. Also, the data on the curve are unlimited, i.e., one may use the data as needed.

Clearly, using both forms to report the results would give more complete information on tractor performance. Especially, the characteristic curve has the value on researching and improving tractor (included engine).

3. There could be 14 hours reduction in testing time as compared with current test procedure. This is significant. Firstly, it shortens the whole test period. Secondly, the test time will be reduced mainly in drawbar tests. Thirdly, it has great economic efficiency. According to the payment of the Tractor Test Lab. staffs, plus the fuel and oil consumption and the fees for instruments and facilities, there would be savings of about US$1200 for each tractor model test.

4. Using the maximum load as the load standard in varying load tests is not only a great benefit of the tractor test but also guides tractor owners to improve efficiency of power and economy.

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Tractor Ownership Costs

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Abstract

A cost model for tractor ownership is presented. Results indicate that a 2-year old tractor is the best purchase option where annual use levels are less than 800 h. A reduction in the repair cost bill (by careful operation and maintenance) can result in a significant reduction in total ownership costs.

Introduction

The agricultural tractor is the contemporary "work horse" of agriculture and represents a significant capital investment and operational expense. It is imperative that the appropriate tractor is selected to suit the particular farm size and operational requirements. There are two overriding considerations to be taken into account in the selection process: i) The technical specification of the tractor (Ward, 1988) and ii) the cost, including the initial capital cost and subsequent operating costs.

This paper analyses the ownership costs of agricultural tractors and examines their sensitivity to different purchasing options and maintenance regimes.

Cost Model

The capital costs (TC) associated with the agricultural tractor are given below:

If $r = g$, then

$$TC = To/N.A \ (£/h) \quad (2)$$

or

If $r \neq g$, then

$$TC = To(1 + r)^N(r - g) / [(1 + g)(1 + r)^N - (1 + g)^N] / A \ (£/h) \quad (3)$$

where,

r = interest rate on investment (decimal)
g = rate of inflation (decimal)
N = years of ownership
A = annual use (h)

$$To = Io + MNP - SAL \quad (4)$$

where,

$$Io = Am\,[(1 + r)^N - 1] / (1 + r)^N r \ £ \quad (5)$$

where,

$$Am = P.\,i(1 + i)^N / [(1 + i)^N - 1] \ £/\text{annum} \quad (6)$$

where,

P = tractor cost (£)
i = interest rate (decimal) on borrowed money
MNP = maintenance costs (adjusted to account for inflation and interest rates)

$$= \sum_{n=1}^{N} M_n P(1 + g)^n/(1 + r)^n \ £ \quad (7)$$

where,

M_n = Cumulative repairs and maintenance in year n

$$= 0.01k\,(U_n^F - U_{n-1}^F) \quad (8)$$

where (Ward, 1985):

k = 0.042 (2WD) or 0.04055 (4WD)
F = 1.895 (2WD) or 1.923 (4WD)
U_n = accumulated use factor

$$= An/120 \quad (9)$$

SAL = Trade in value of the tractor, adjusted to account for inflation and interest rates

$$= SnP\,(1 + g)^N/(1 + r)^N \quad (10)$$

where, $Sn = 0.68\,(0.92)^N \quad (11)$

The above model can be used to evaluate the total costs as a function of annual use and projected ownership period and the contribution of repairs and maintenance costs can be evaluated.

Applications

Cost Components

Examination of Figs. 1 to 3 show that repair (including maintenance) costs become the dominant cost element at high annual use levels (in excess of 500 to 700 h), depending on whether the tractor is new or second hand. The repair cost equations are based on those presented by Ward (1988); and,

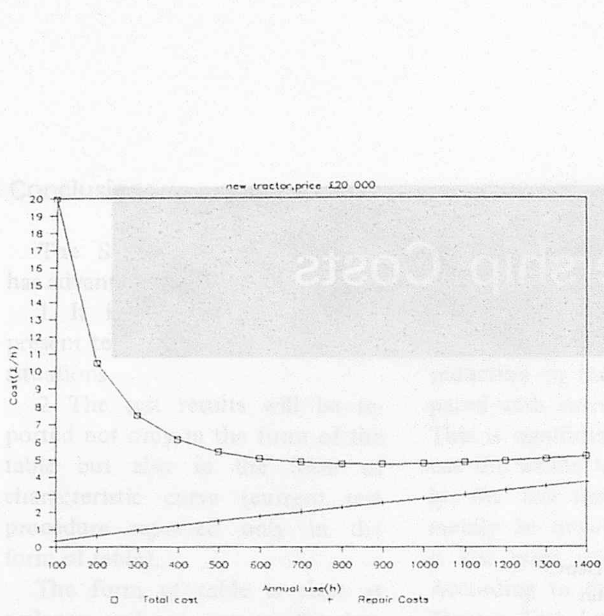

Fig. 1 Annual use vs ownership cost, new tractor, price £20 000.

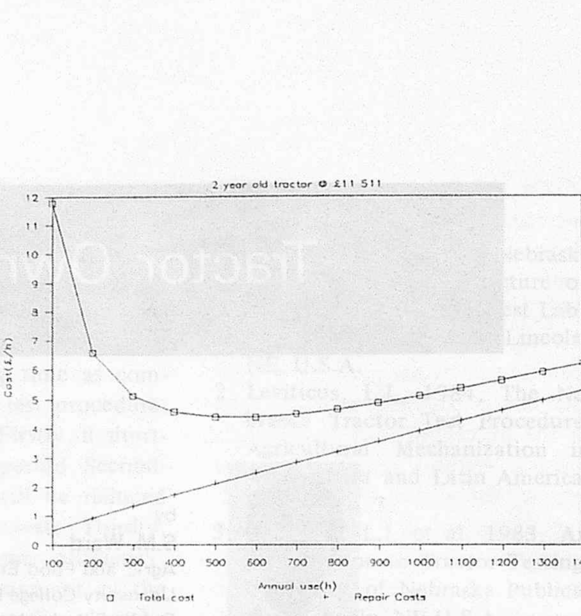

Fig. 2 Annual use vs ownership cost, 2-year old tractor, price £11 511.

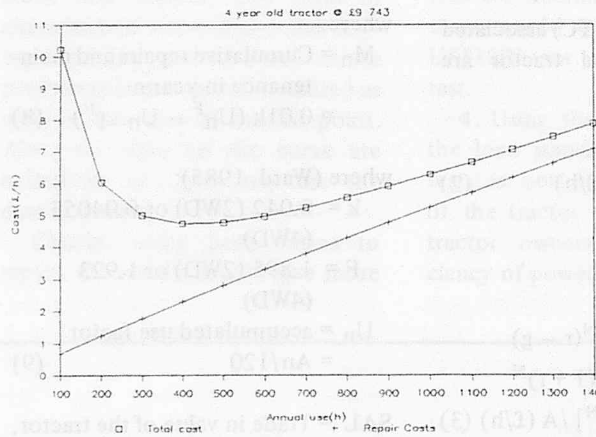

Fig. 3 Annual use vs ownership cost, 4-year old tractor, price £9 743.

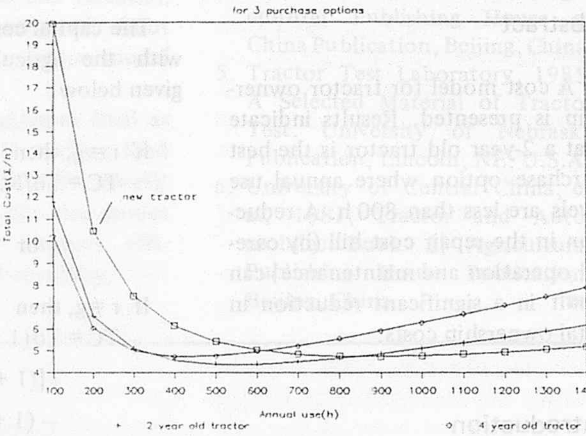

Fig. 4 Annual use vs ownership cost, for 3 purchase options.

while these equations represent the likely repair cost bill, actual repair costs can be reduced by careful maintenance and operation procedures. For example, a 20% reduction in the repair costs at an annual use level of 1 000 h would reduce the total ownership cost for a 4 year tractor by in excess of £1/h.

Purchase Option

It is clear from Figs. 1 to 3 that the total ownership cost of a tractor (viz. capital and interest repayments, repairs (including maintenance) and the salvage value), expressed as £/h, is dependent upon the annual use and the age of the tractor when purchased. For example, the purchase of a new tractor (valued at £20 000) has an ownership cost in excess of £7/h for a farmer with an annual use of 300 h, while the corresponding hourly cost, if the farmer purchased a 2 year old version of the same tractor (at £11 511), is approximately £5/h.

This latter effect is summarized in Fig. 4 which shows that:

1. New tractors are very expensive at annual use levels below approximately 500 h;
2. A 2-year old tractor is, in general, a better buy than a four year old tractor. This is due to the higher repair costs associated with the latter;
3. A new tractor is the best option where annual use levels are high;
4. Tractor ownership is prohibitively expensive at annual use levels less than 200 h.

Conclusions

The examples presented above show that good second-hand tractors (less than 4 years old) are the best option for farmers with low annual use levels but a new tractor is the preferred option where annual use levels are high but tractor ownership is prohibitively expensive at annual use levels less than 200 h.

The break-even point between buying a new or second-hand tractor is dependent on the repair costs and any reduction in repair costs (achieved through careful operation and maintenance of the tractor) will shift the threshold to the right (i.e. above 900 h). This is shown in Fig. 5 where a 20% reduction in repair costs results in

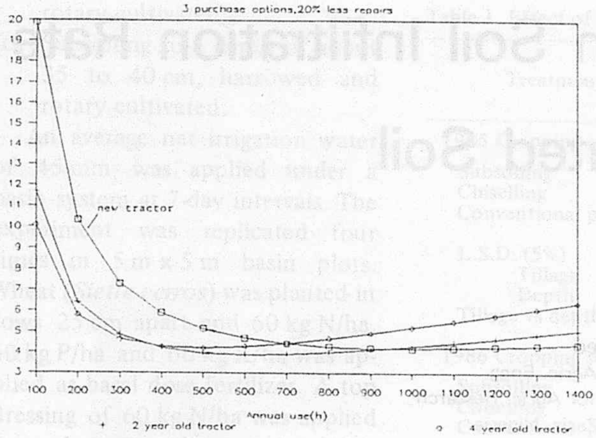

Fig. 5 Annual use vs ownership cost, 3 purchase options, 20% less repairs.

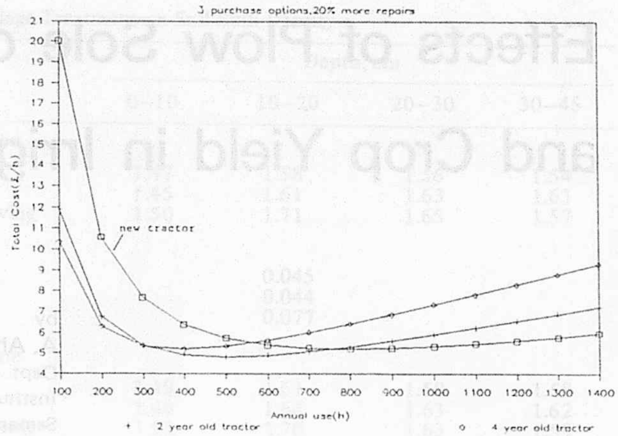

Fig. 6 Annual use vs ownership cost, 3 purchase options, 20% more repairs.

the threshold moving to above 900 h. Similarly, a 20% increase in repair costs results in the threshold value decreasing to less than 800 h (Fig. 6). Furthermore, the magnitude of the total costs is higher in the latter than the former, due to its sensitivity to repair costs.

The model presented above can be used to evaluate the ownership cost of other machines, with individual factors changed as appropriate (Ward, 1985). While the results presented in Figs. 1 to 6 indicate the trends associated with tractor ownership costs, nevertheless each farmer's circumstances are unique and the components of the model (e.g. rate of interest, tractor maintenance and operation procedure, purchase price, etc.) must be adjusted accordingly. The most efficient method of achieving the flexibility to adjust the model to each farmer's needs is by use of microcomputer spreadsheets. Indeed, the graphs presented here were generated in this manner.

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Effects of Plow Sole on Soil Infiltration Rate and Crop Yield in Irrigated Soil

by
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Abstract

The effects of plowsole on grain yield and soil infiltration rate were evaluated for an irrigated soil. The plowsole was shattered by chiselling and subsoiling to a depth of 25 to 30 cm and 35 to 40 cm, respectively. A randomized block design was used for wheat crop under a basin system.

The dense plowsole was located at 15 to 20 cm below the surface with an average bulk density of 1.71 g/cm^3. Breaking the plowsole by deep tillage increased grain yield at 5% probability level. Soil infiltration rate was increased by about 3 to 8-fold and the bulk density in the otherwise dense plowsole region was reduced to 1.61 and 1.58 g/cm^3 by chiselling and subsoiling respectively. In the second year, the deep tillage plots showed a decrease in soil infiltration rate, a slight increase in bulk density and no significant difference in grain yield. The results conclude that shattering the plow-sole can affect temporary improvement in crop yield but cannot be sustained for more than a year.

Introduction

Machinery traffic over the years results in a compacted layer at some depth just below the plow activity zone, commonly referred to as plowsole, and is characterized by abnormally high bulk density. The plowsole has the effects of reducing soil infiltration rate, restricting root penetration and could reduce soil water-holding potential. The effects of tractor traffic on soil compaction were studied by many researchers (Doneen and Henderson, 1953; Oni et al, 1982 and Adebayo, 1984). Deep tillage (chiselling or subsoiling) is often used to shatter the compacted layer. There is, however, a diverse opinion on the effects of deep tillage on grain yield. Robertson et al (1957) reported that subsoiling did not effect any significant increase in grain yield but is an advantage when moisture is limiting due to deeper root penetration giving the crop a larger soil-root-volume to extract more moisture. Rosenberg and Willits (1962) and Wiltsell and Hobbs (1965) reported an increase in crop yield after deep tillage. Duley (1957) reported that changes in soil physical properties brought about by tillage are often transitory. However, one generally accepted fact is that the development of plowsole to the extent that it affects crop yield takes several years.

Many of the irrigated lands are cultivated twice a year (rainfed and irrigated). On such soils, there is a heavier tractor traffic and plowsole could develop faster. The resulting low infiltration rate after soil compaction could cause longer irrigation application time with subsequent high labour costs. There may be a lower grain yield level and more frequent irrigation demand. This paper reports the findings of an investigation on the effects of plowsole on soil infiltration rate and grain yield for an irrigated wheat crop at Kadawa, Nigeria.

Methods and Materials

The experiment was conducted in the Kano River Project, Kadawa, Nigeria (11°8'N, 8°15'E), for two successive irrigated wheat cropping seasons during 1984-86. The soil of the experimental site is a deep loam texture and had been under intensive cultivation (twice a year) for almost 15 years. A completely randomized block design was used and tillage treatments were applied in the first year only and are as follows:

(a) Conventional plowing: The normal tillage in the area which consisted of plowing to a depth of about 10 to 15 cm, harrowed and followed by rotary cultivation before planting.
(b) Chiselling to a depth of about 25 to 30 cm, harrowed and

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rotary cultivated.

(c) Subsoiling to a depth of about 35 to 40 cm, harrowed and rotary cultivated.

An average net irrigation water of 45 mm was applied under a basin system at 7-day intervals. The experiment was replicated four times in 5 m x 5 m basin plots. Wheat (*Siette-cerros*) was planted in rows 25 cm apart and 60 kg N/ha, 60 kg P/ha and 60 kg K/ha was applied as basal dose fertilizer. A top dressing of 60 kg N/ha was applied 4 weeks after planting. Irrigation was cut-off 13 weeks after planting. In the first year, the crop was planted on 17th December but in the second year planting could not be done until 24th December which was very late. The optimum, planting time for the area is 15th November to 15th December.

After harvest, two plots were randomly selected from each tillage treatment and infiltration rate was measured using double-ring infiltrometers. On each tillage plot undisturbed soil samples were taken for determining soil bulk density. The soil core samples were taken from 0 to 45 cm depth with 10 cm increments. A total of our samples were taken for each depth increment.

Results and Discussions

Soil Bulk Density

The average soil bulk densities for different depths in respect of tillage treatments are given in **Table 1**. The density for the surface soil (0 – 10 cm) were low, about the same for all the treatments, ranged from 1.45 to 1.52 g/cm^3. In the first cropping year, there was a significant difference in bulk density between the tillage treatments at 5% probability level. This is clearly seen in the 10 – 20 cm as is shown in **Fig. 1a** and **Table 1**. The conventional plowing shows an abrupt increase in bulk density from 1.50 g/cm^3 on the surface to 1.71 g/cm^3 at 10 – 20 cm depth. The compacted layer (plowsole) is evident under the conventional plowing and is concentrated between 10 to 25 cm, consisting of two layers (10 – 20 cm and 20 – 30 cm). Taking average profile depths for these two layers, the plowsole can be said to exist between 15 to 25 cm from the surface. As for the other treatments (subsoiling and chiselling), the densities are quite low in this region indicating how the deep tillage effectively shattered the plowsole, resulting in a significant difference in bulk density between tillage treatments.

After the second cropping year, there was an increase in bulk density, especially in the subsoiled plots (**Fig. 1**). The density increased from 1.58 to 1.61 g/cm^3 for the subsoiling and from 1.61 to 1.64 g/cm^3 for the chiselled plots in the 10 – 20 cm layer.

Table 1 Effect of Tillage Treatment on Soil Bulk Density

Treatment	Depth, cm 0–10	10–20	20–30	30–45
1985 Cropping season				
Subsoiling	1.47	1.58	1.56	1.54
Chiselling	1.45	1.61	1.63	1.63
Conventional plowing	1.50	1.71	1.65	1.57
L.S.D. (5%)				
Tillage		0.045		
Depth		0.044		
Tillage vs depth		0.077		
1986 Cropping season				
Subsoiling	1.49	1.61	1.58	1.58
Chiselling	1.48	1.64	1.63	1.62
Conventional plowing	1.52	1.70	1.63	1.59
L.S.D. (5%)				
Tillage		NS		
Depth		0.035		
Tillage vs depth		NS		

NS: Non significant

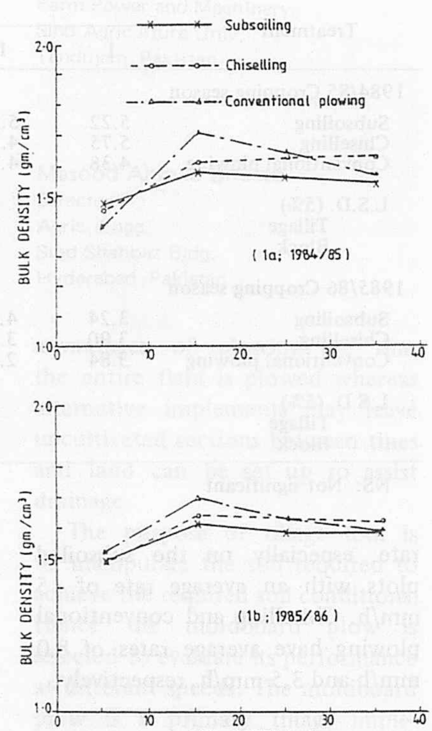

Fig. 1 Soil bulk density showing compaction at different depth.

Soil Infiltration Rate

The average soil infiltration rates for the two seasons are given in **Figs. 2a** and **2b**. The rate in the compacted soil was, on the average, 3.0 mm/h in the first year. This rate was increased by about 7- to 9-fold after subsoiling which showed an average rate of 25.0 mm/h. The chiselling increased infiltration by 2- to 3-fold with an average of 8.0 mm/h. This is another confirmation on the existence of plow-sole in the conventional plowing plots. At the end of the second cropping season, there was a decrease in infiltration

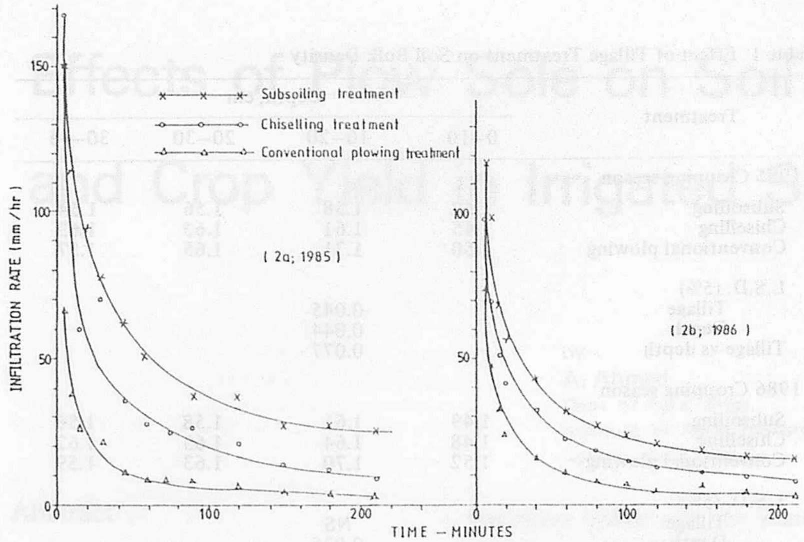

Fig. 2 Average soil infiltration rates from tillage treatment plots.

Table 2 Grain Yield of Wheat (t/ha) as Affected by Plowsole.

Treatment	Block				
	I	II	III	IV	Mean
1984/85 Cropping season					
Subsoiling	5.22	5.50	4.75	5.75	5.31
Chiselling	5.75	4.75	4.63	4.88	5.00
Conventional plowing	4.38	4.38	3.50	4.77	4.26
L.S.D. (5%)					
Tillage			0.635		
Block			NS		
1985/86 Cropping season					
Subsoiling	3.24	4.00	3.48	3.92	3.66
Chiselling	3.90	3.92	2.96	3.29	3.52
Conventional plowing	3.84	2.46	2.71	2.81	2.96
L.S.D. (5%)					
Tillage			NS		
Block			NS		

NS: Not significant

rate, especially on the subsoiled plots with an average rate of 15 mm/h. Chiselling and conventional plowing have average rates of 8.0 mm/h and 3.5 mm/h, respectively.

Grain Yield

The yields were higher in the first year than in the second year (Table 2). This difference in yields over the two years was attributed to late planting in the second year. There was a response in wheat yield to tillage treatments at 5% level, for the first year. The means from subsoiling and chiselling were not different but the conventional plowing diferred significantly from the others. This concluded that chiselling to a depth of 25 to 30 cm was sufficient to break the plow-sole and effect soil improvement. However, there was no response in yield by the tillage treatments. This indicates that the changes in soil physical properties brought about by deep tillage could not affect grain yield for more than a year, at least on these soils.

Conclusions

Plowsole has developed on these soils with an average bulk density of 1.71 g/cm^3 and is located at about 15 to 20 cm below the soil surface. Subsoiling improved the plow-sole region by reducing the bulk density to 1.58 g/cm^3 and increased infiltration rate by about 7 to 9 fold. Chiselling similarly loosened the plow-sole, reducing the bulk density to 1.61 g/cm^3 with subsequent increase in infiltration by about 2- to 3-fold. After breaking the plow-sole, there was an increase in grain yield for the first year only and chiselling to a depth of 25 to 30 cm is sufficient.

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Effect of Different Speeds on the Performance of Moldboard Plow

by

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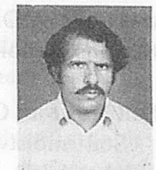

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Abstract

The speed has important effects on the type of work done. At normal soil conditions the higher the speed within normal limits, the greater is the pulverrizing effect. Keeping in view the importance of speed, a project was undertaken to study the effect of different speeds on the performance of the moldboard plow. The moldboard plow was tested in silt loam soil at 17.8% moisture content at three different plowing speeds. The performance parameters studied were depth and width of cut, draft of plow, field capacity, wheel slippage, soil transport and soil inversion.

It was found that field capacity and draft of plow increased as the speed is shifted to higher gears. It was also found that as the speed is increased the wheel slippage increased. The depth of cut decreased because the plow was dragged out little from the soil at higher speeds. It is suggested that high speed moldboard plow with small moldboard be designed and tested for better results.

Introduction

Plowing is the most important operation at the farm. The essential feature of plowing by moldboard plow is that a layer of soil is separated from the underlying sub-soil and is inverted so that any vegetation or manure present on the surface is plowed under and a layer of soil from below is brought to the surface where it is exposed to the action of weathering agents. Tillage and weathering modify the air spaces in the soil as well as the sizes of soil particles. Further advantages of plowing are that the entire field is plowed whereas alternative implements may leave uncultivated sections between tines and land can be set up to assist drainage.

The purpose of tillage tool is to manipulate the soil required to achieve the required soil conditions. Hence the moldboard plow is selected to evaluate its performance at different speeds. The moldboard plow is a primary tillage implement consisting of a warped surface equipped with cutting edges that crumble and invert the soil. The plow gives best the residue coverage and superior pulverization under ideal conditions.

The objective of the research was to evaluate the field performance of the moldboard plow at different plowing speeds. Speed has important effects on the type of work performed where the soil is in a normal condition for tilth formation, the higher the speed within normal limits, the greater is the pulverization effect.

Experimental Procedure and Methods

The Tandojam University farm was selected for evaluating the performance of the moldboard plow at different speeds. The parameters studied were draft, speed of operation, travel reduction, depth of operation, width of operation, soil inversion, and soil side transport.

All the performance variables were measured and recorded according to the recommendations of RNAM test codes and procedures for farm machinery, technical series No. 12, 1983. The instruments and machines used in the research work were: Belarus 10M3-6AA tractor, Ford-4600 tractor, mounted moldboard plow, hydraulic dynamometer (0-5000 lbs), stop watch, vernier caliper, ranging poles, steel tape (50 m), steel tape (small), soil sampler (core), sample containers, half-meter square frame, half-meter scale, physical balance, oven, polythene bags and white chalks.

Machines

Three-bottom 40-cm moldboard plow with general purpose moldboard with 21.5 cm extension of moldboard to improve soil pulverization and vertical clearance of 68 cm were tested. The moldboard plow was powered by a Belarus-10M3-6AA diesel tractor with 15.5-38 rear tires and 7.5-20 front tires.

Soil Type

The soil type available at Tandojam University Farm was selected. The soil was silt loam with sand 20%, silt 54.2% and clay 25.8%. The mechanical analysis of the soil was done by Drainage and Reclamation Institution of Pakistan (DRIP).

Soil Moisture Content

Soil moisture content on wet weight basis was determined by taking 8 samples of soil at depth of 20 cm from different locations of test plot which were randomly-selected locations. The wet soil samples were weighed in a physical balance and the weight of each wet soil sample was recorded. The samples were placed in a hot air oven maintained at 105°C for 24 h. The dried soil samples were reweighed in a physical balance and the weight was recorded. The soil moisture percent (wet weight basis) was calculated by using the formula:

Soil moisture (%) = [(Wt. of wet soil sample) – (Wt. of dry soil sample)/(Wt. of wet soil sample)] x 100

Data Collection

Operating Speed

Outside the long boundary of the test plot two poles 50 m apart were placed approximately in the middle of the test plot. On the opposite side, two poles were also placed in a similar position, 50 m apart so that all four poles form corners of a rectangle, parallel to at least one long side of the test plot. The speed was calculated from the time required for the tractor and implement to cover the distance of 50 m between the assumed line connecting two poles on opposite sides AC and BD (Fig. 1). A stopwatch was used to record the time of travel of tractor and implement for three gear speeds.

Working Width

The working width of an implement was measured by using a steel tape. The width was measured from the furrow wall to the total tilled area at four stations, 10,20, 30 and 40 m for each test run.

Working Depth

The working depth was measured with the half-meter scale. The depth was measured from the bottom of the furrow to the surface level of the soil at stations located at 10,20,30 and 40 m for each test run.

Soil Side Transport

Maximum lateral soil transport stations selected at 10,20,30 and 40 m for each run was measured with steel tape.

Wheel Slip

A simple method in determining the amount of travel reduction was used by making a mark with the chalk on the drive wheel of the tractor and a distance the tractor travelled in 10 revolutions with no

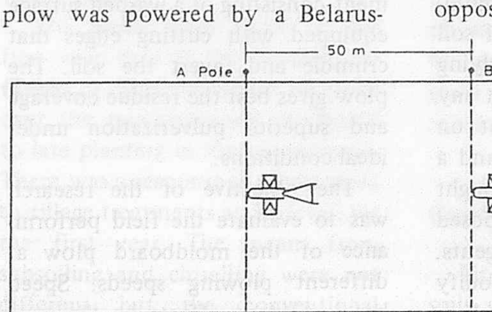

Fig. 1 Measuring of operating speed.

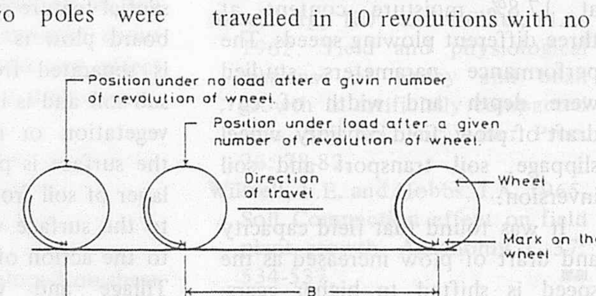

Fig. 2 Measuring of wheel slip.

load (A) and with load (B) was measured (Fig. 2). The travel reductions was calculated by using the formula:

Travel reduction (%) = [(Distance travelled with no load) – (Distance travelled with load)] /(Distance travelled with no load) × 100

$$T_R(\%) = \frac{A - B}{A} \times 100$$

Draft of Moldboard Plow

A hydraulic dynamometer was attached to the front of Ford-4600 tractor on which the moldboard plow was mounted. Another auxiliary Belarus tractor was used to pull the moldboard plow mounted tractor through the dynamometer. The auxiliary Belarus tractor pulls the moldboard plow mounted tractor in neutral gear but with the moldboard plow in the operating position (Narayanrao and Verma 1982 and RNAM 1983). The draft was recorded in the measured distance of 50 m as well as the time taken to traverse it. On the same field, the moldboard plow lifted out of the ground and the rear tractor was pulled to record the idle draft force. The difference gave the draft of the implement. The measurement of draft is shown in Fig. 3.

Soil Inversion

Before the operation of the moldboard plow (Fig. 4) the weeds and stubbles were collected from eight randomly selected places at the site by using half-meter square frame. The average weight of weeds and stubbles thus collected was recorded. After the operation of moldboard plow, the same procedure was repeated for collecting the weeds and stubbles left on the tilled soil surface at stations selected at 10,20,30 and 40 m. Hence the soil inversion percentage was calculated.

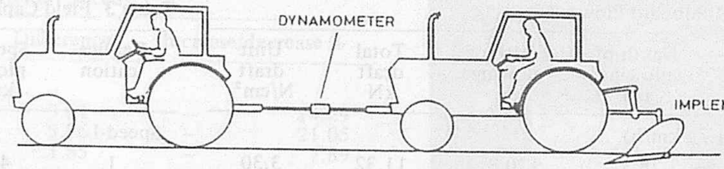

Fig. 3 Measuring of draft for a tractor-mounted implement.

$$F = \frac{W_P - W_E}{W_P} \times 100$$

where,

F = Soil inversion, percent

W_P = Weight of weeds and stubbles before implement operation, g

W_E = Weight of weeds and stubbles on the tilled surface after implement operation, g

Field Capacity

The field capacity of the moldboard plow was calculated in hectares per hour by using the Hunt's formula assuming 70% efficiency of the plow.

$$C = \frac{SWE}{10}$$

$$= 0.07\ SW$$

where,

C = Field capacity, ha/h

S = Speed of operation, km/h

W = Width of implement, m

E = Field efficiency, decimal

Results and Discussion

The research study was conducted with a view to determining the effect of different speeds on the performance of moldboard plow under depth of cut, width of cut, draft of plow, field capacity, wheel slippage, soil transport and soil inversion. The moldboard plow was tested in silt loam soil (Latif Farm) at three field speeds.

Draft of Moldboard Plow

The draft and unit draft of moldboard plow is shown in Tables 2 and 6. The parameters are recorded at three gear speeds. The data shows that the total draft is increased as the tractor speed is shifted from lower gear speed to higher gear speed. This is in agreement with the findings of Singh et al (1979), Davies et al (1982), Bainer et al (1972).

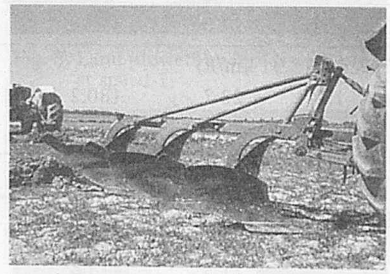

Fig. 4 Three bottom mounted mold board plow.

However, the unit draft remained nearly the same because at higher speeds the width of cut increased in proportion to the increase in draft. The depth of cut also decreased as the speed is shifted from lower gear speed to higher gear speed.

When the speed of tractor was shifted from speed-I to speed-II the depth of cut decreased to 14.3%. The decrease in depth of cut between speed-I and speed-III was 21.1%. However, 7.9% decrease in depth of cut was recorded when the speed was switched over to speed-III from speed-II.

The increase in width of cut between speed-I and speed-II; speed-I and speed-III was nearly the same which figured to 48.2% and 53.2%, respectively. However, the increase in width of cut was estimated at

Table 1 Soil Moisture Percentage (WB)

Soil sample no.	Weight of wet soil g	Weight of dry soil g	Moisture content %
1.	100	81.5	18.5
2.	99	80.0	19.19
3.	89	76.0	14.60
4.	93	77.0	17.20
5.	95	81.0	14.73
6.	96	76.5	20.31
7.	92	75.5	17.93
8.	101	82.0	18.18
Mean	–		17.58

Table 2 Total Draft and Unit Draft at Different Speeds by Moldboard Plow

Replications	Depth of plowing cm	Width of plowing cm	Total draft kN	Unit draft N/cm²
Speed-I (4.72 km/h)				
1.	28.5	120.3	11.32	3.30
2.	28.1	119.6	11.54	3.43
3.	25.5	119.5	11.10	3.64
Average	27.36	119.8	11.32	3.46
Speed-II (5.91 km/h)				
1.	23.7	180.2	13.54	3.17
2.	22.5	175.9	13.76	3.48
3.	24.2	176.5	13.32	3.12
Average	23.45	177.53	13.54	3.26
Speed-III (6.55 km/h)				
1.	21.2	189.1	14.49	3.61
2.	21.5	178.8	14.65	3.81
3.	22.1	182.7	14.87	3.68
Average	21.6	183.53	14.67	3.7

Table 3 Field Capacity of Moldboard Plow at Different Speeds

Replication	Speed of plowing km/h	Depth of plowing cm	Width of plowing cm	Field capacity ha/h
Speed-I				
1.	4.86	28.5	120.3	0.41
2.	4.71	28.1	119.6	0.39
3.	4.60	25.5	119.5	0.38
Average	2.72			0.39
Speed-II				
1.	5.76	23.7	180.2	0.73
2.	5.79	22.5	175.9	0.71
3.	6.19	24.2	176.5	0.76
Average	5.91			0.73
Speed-III				
1.	6.66	21.2	189.1	0.88
2.	6.55	21.5	178.8	0.82
3.	6.44	22.1	182.7	0.82
Average	6.55			0.84

3.4% between speed-II and speed-III. The increase in total draft amounted to 19.6% when the speed-I shifted to speed-II and an increase of 30.0% between speed-I and speed-III. These findings are in agreement with the work of Davies et al (1982). The plow showed only about 8.4% draft increase between speed-II and speed-III.

The plow showed decrease of 5.8% in unit draft between speed-I and speed-II, and an increase of 6.94% between speed-I and speed-III. However, the unit draft doubled to 13.5% when the speed-II was changed to speed-III.

Field Capacity and Soil Disturbance

Field capacity is one of the major parameters in evaluating the performance of moldboard plow. The data regarding the field capacity by the moldboard plow at speed-I, speed-II and speed-III is presented in Table 3. The comparison in percent is given in Table 6. The field capacity was greater at higher speeds than lower speeds. As the tractor speed is accelerated, field capacity was also increased.

When the speed-I was changed to speed-II, there was an increase of 87.2% in the field capacity. Between speed-I and speed-III, the increase in field capacity recorded was 115.4% whereas a small percentage of 15.1% was recorded when the speed-II was shifted to speed-III. This was due to the small depth of cut which was nearly the same for both speeds.

Table 4 Wheel Slippage of Moldboard Plow at Different Speeds

Replications	Distance travelled without load m	Distance travelled with load m	Wheel slip %
Speed-I			
1.	44.23	38.41	13.16
2.	43.50	37.60	13.56
3.	43.41	37.91	12.67
Average	–	–	13.13
Speed-II			
1.	44.14	37.51	15.02
2.	44.78	37.91	15.37
3.	44.16	36.85	16.55
Average			15.65
Speed-III			
1.	44.32	36.21	18.29
2.	44.27	36.59	17.34
3.	44.35	36.73	17.18
Average	–	–	17.60

Table 5 Soil Transport and Soil Inversion at Different Speeds by Moldboard Plow

Replications	Soil transport cm	Soil inversion %
Speed-I		
1.	172.5	85.22
2.	190.1	85.95
3.	188.3	88.18
Average	183.6	86.45
Speed-II		
1.	201.4	92.61
2.	205.3	91.13
3.	208.1	93.34
Average	207.3	92.36
Speed-III		
1.	225.4	97.04
2.	224.6	96.31
3.	233.9	95.93
Average	224.6	96.43

Wheel Slip

Wheel slippage affects the traction efficiency of the pulling machine. Less wheel slip means greater pulling efficiency of the machine. The data regarding the wheel slip is given in Tables 4 and 6.

The wheel slip was greater at speed-III than speed-II and speed-I. Also, at speed-II the wheel slip was greater than speed-I. The wheel slip at speed-I, speed-II and speed-III was 13.1%, 15.7% and 17.6%, respectively.

When the speed-I changed to speed-II, the increase in wheel slip was recorded to 19.2%. The increase in wheel slip recorded between speed-I and speed-III was 34.1%. However, 12.5% increase in wheel slip was noted when the gear speed-II was shifted to gear speed-III.

Table 6 Comparison of Moldboard Plow at Different Speeds

Speed-I	Speed-II	Speed-III	Difference	Increase/decrease %
Depth of cut				
27.36	23.45	–	3.91	14.29
27.36	–	21.6	5.76	21.05
–	23.45	21.6	1.85	7.89
Width of cut				
119.8	177.53	–	57.73	48.19
119.8	–	183.53	63.73	53.19
–	177.53	183.53	6.00	3.38
Total draft				
11.32	13.54	–	2.22	19.61
11.32	–	14.67	3.35	29.59
–	13.54	14.67	1.13	8.35
Unit of draft				
3.46	3.26	–	0.20	5.78
3.46	–	3.7	0.24	6.94
–	3.26	3.7	0.44	13.49
Field capacity				
0.39	0.73	–	0.34	87.18
0.39	–	0.84	0.45	115.38
–	0.73	0.84	0.11	15.07
Wheel slip				
13.13	15.65	–	2.52	19.19
13.13	–	17.60	4.47	34.04
–	15.65	17.60	1.95	12.46
Soil transport				
183.6	207.5	–	23.7	12.91
183.6	–	224.6	41.0	22.33
–	207.3	224.6	17.3	8.34
Soil inversion				
86.45	92.36	–	5.91	6.83
86.45	–	96.43	9.98	11.54
–	92.36	96.43	4.07	4.41

Fig. 5 Land plowed by moldboard plow at speed-1.

Fig. 6 Land plowed by moldboard plow at speed-2.

Fig. 7 Land plowed by moldboard plow at speed-3.

Soil Transport and Soil Inversion

Soil transport is the side throw of the soil by the moldboard plow during operation in the field. The higher the speed of operation, the more will be the side throw of the soil.

Soil transport and soil inversion at speed-I, speed-II and speed-III are given in Tables 5 and 6. It is evident from the data that the soil transport is nearly the same with different speeds.

The data in Table 6 shows that the soil transport increased by 12.9% when the speed-I is switched over to speed-II and 22.3% increased between speed-I and speed-III. There was a small increase in soil transport when the speed-II is shifted to speed-III which figured to 8.3%.

It is concluded that there is no effect of speed on soil transport, because the increase in soil transport is nearly the same when the speed was changed from speed-I to speed-II and speed-II to speed-III.

It is further concluded that there is no effect of different speeds on soil inversion. Very little increase in soil inversion was recorded between speed-I and speed-II which was only 11.5%. However, the higher the speed the more was the pulverization of soil (Figs. 5, 6 and 7). The soil tilth was improved at higher plowing speeds.

Conclusions and Suggestions

The field test to study the performance of moldboard plow at different plowing speeds was undertaken in silt loam (Latif Farm) soil during February 1986.

The draft, soil inversion, soil throw, and wheel slippage, field capacity are the important performance parameters which were taken into consideration for the study.

It is concluded that field capacity and draft of plow increased as the speed is increased from lower to higher gear speeds.

It is also concluded that as the speed is increased the width of cut and wheel slippage also increased and depth of cut decreased as the speed is switched over to higher gear speeds because the plow is dragged out little from the soil at higher speeds.

It is suggested that high speed moldboard plow with small moldboards be designed and tested for better results because the plow used in the study was a general purpose moldboard plow which was not suitable for plowing at higher plowing speeds. ■■

Evaluation of Puddling Treatments Using Animal-drawn Implements

by
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Abstract

In a 2-year field investigation on a calcareous sandy loam soil, puddling treatments using animal-drawn implements were evaluated for their puddling efficiency in terms of puddling index, cost and influence on the grain yield of rice. Puddling treatments consisted of two or four plowings by local or moldboard plow followed by planking and an additional treatment consisting of two plowings by local plow followed by one operation of bullock-drawn puddler and then planking.

Two plowings either by local or moldboard plow followed by planking were found to be sufficient to give the same puddling index (PI) and grain yield as four plowings. From the cost point of view, however, two plowings by moldboard plow followed by planking was cheapest and hence recommend to the farmers of the area.

Introduction

In several developing countries, the use of draft animal for carrying out various agricultural operations is very common. One can see a variety of locally-developed implements in several Asian and African countries where the use of draft animal is on the increase (Bansal and Thierstein, 1982). According to the National Commission on Agriculture (NCA 1976) about 47% of India's cropped area which is under holdings of less than 5 ha will continue to depend heavily on animal power. The same holds true for many a developing countries in Africa. (Kline et al, 1969; Shulman, 1979).

In Bihar, India, about 5.5 million ha are planted annually to rice. Animal-drawn puddling implements are in common use by the farmers for carrying out puddling operations at the time of transplanting of rice. However, in the absence of any precise information, farmers in the Gandek Command area of North Bihar carry out puddling by plowing the fields five to six times using local plow followed by planking (Mishra, 1981: Personal communication). The objective of this investigation, therefore, was to determine the appropriate level of puddling and the type of animal-drawn puddling implements which would be most economical and at the same time not to affect the yield adversely.

Materials and Methods

The experiment was carried out for two years (1982 and 1983) in a field with sandy loam soil texture at the Research Farm of Rajendra Agricultural University, Bihar, Pusa, India.

The following five puddling treatments were used:

T_1 – Two plowings (at 90° to each other) by local plow followed by one planking.

T_2 – Four plowings (at 90° to each other) by local plow followed by one planking.

T_3 – Two plowings (at 90° to each other) by moldboard plow followed by one planking.

T_4 – Four plowings (at 90° to each other) by moldboard plow followed by one planking.

T_5 – Two plowings (at 90° to each other) by local plow followed by one operation of bullock-drawn puddler followed by one planking.

Each of the five treatments were replicated four times in a randomized block design in a plot size of 10 x 10 m in 1982 and 8 x 8 m in 1983 with a head land of 0.5 m between the plots and 1 m between the blocks. All the plots received the same quantity of water whether supplied through irrigation or rainfall. Twenty cm high bunds (dykes) were made around the plots to prevent overflow from one plot to another in case of excess rainfall.

While carrying out puddling operations the actual time required

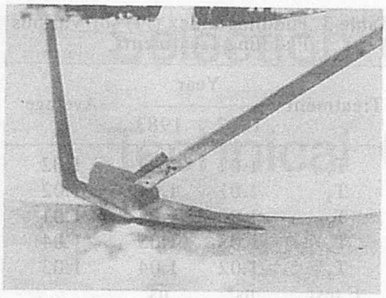

Fig. 1 Local plow used for puddling in T_1 and T_2.

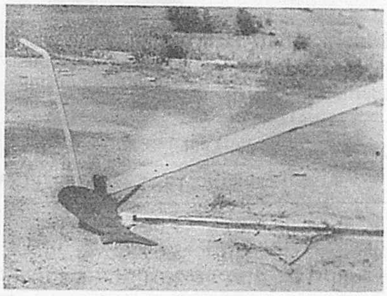

Fig. 2 Moldboard plow used for puddling in T_3 and T4

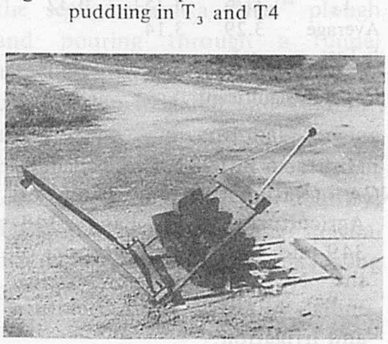

Fig. 3 Bullock-drawn puddler used in T_5.

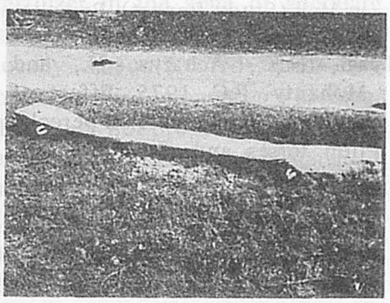

Fig. 4 Animal-drawn plank used in all puddling treatments.

for each treatment was noted and, subsequently, the number of working days required to carry out puddling in one hectare for each treatment was calculated. The cost of puddling was then calculated on per hectare basis for different puddling treatments by using the prevailing hiring charges of US$ 2.6/day at the University farm for a pair of bullocks, plow man and the implements. An attempt was also made to evolve a puddling index (PI) which can be measured in the field itself. For doing so, immediately after completion of a puddling treatment, 500 ml of soil-water suspension was collected and allowed to pass through a 6.35 cm diameter hole in the bottom of a measuring cylinder and the time was noted. The ratio of this time to that required for 500 ml of irrigation water to pass through the same hole was designated as puddling index (PI). At least five samples of soil-water suspension were collected from each plot for measuring the puddling index.

Twenty-two to 25 days old seedlings of paddy (*Oryza sativa L.*) cv. Pusa 2 – 21 were transplanted on 17 - 20 July in 1982 and 28 - 30 July in 1983. Fertilizer was applied at the rate of 100: 60: 40 kg N, P_2O_5 and K_2O respectively per hectare. Half of the nitrogen was applied at the time of transplanting, 25% at 35 days after transplanting and the remaining 25% at 55 days after transplanting in both years. Phosphorus and potassium were both applied in full doze at the time of transplanting. The crop was harvested on October 13 in 1982 and October 25 in 1983.

Results and Discussion

The date for 1982 and 1983 on number of work days (1 day = 8 h) required to complete puddling 1 ha for various treatments are given in **Table 1**. It is evident from the average values for two years that minimum time (6.1 days/ha) was required when puddling was done by two plowings using moldboard plow followed by one planking. Four plowings either by local or moldboard plow took nearly 1.8 times as compared with two plowings by the same plow. The time required for treatment consisting of two plowings by local plow followed by one opeartion of bullock-drawn puddler and then one planking was about 1.2 times (9.8 days) than that required for the treatment consisting of two plowings by local plow followed by planking. This excess time was required for carrying out additional operation by bullock-drawn puddler.

The maximum puddling time (14.8 days/ha) was taken when the field was plowed four times by local plow followed by one planking. Comparatively less time was required for similar opeartion in the case of moldboard plow than the local plow as the former covered greater area per unit time.

The corresponding data on the cost of puddling per hectare for various treatments for two successive years are presented in **Table 2**. As the cost is directly proportional to the time required for carrying out the treatment, it was found to be lowest (US$ 16.0) for the treatment consisting of two plowings by moldboard plow followed by one planking. The cost of puddling was highest (US$ 38.6) for the treatment that required four plowings by local plow followed by one planking. The cost for the remaining treatments was intermediate between these two extremes. Tyagi et al (1975) also found that puddling cost using local plow was higher than that of moldboard plow.

Table 3 contains the data on puddling indices as observed for various treatments. There were no significant differences in the puddling index for various treatments indicating thereby that the degree of puddling achieved by using different puddling implements did not differ.

Paddy grain yield data (15%

moisture content, weight basis) for 1982 and 1983 as influenced by various puddling treatments are given in Table 4. It is evident that puddling treatments did not affect the grain yield significantly. The grain yield for 1982 ranged from 3.26 to 3.31 t/ha and that for 1983 from 3.04 to 3.35 t/ha. Thus the average grain yield was slightly higher (3.29 t/ha) for 1982 than that for 1983 (3.14 t/ha). However, the differences were statistically non-significant.

Conclusions and Recommendations

From the results presented above it is evident that two plowings done at 90° to each other either by local or moldboard plow followed by one planking are adequate to puddle the light textured sandy loam soil for paddy transplanting. Since the time and cost involved in any operation are important considerations in recommending any practice for general use, the use of two plowings by moldboard plow followed by one planking is recommended because of its lowest time and cost involved. Also, the puddling index and grain yield obtained by this practices were similar to those obtained for other costlier methods of puddling, reinforces the recommendation.

In several countries in Africa, in general, and Tanzania in particular, where animal traction is catching up with the farmers and the improved designes of animal-drawn implements have been introduced, investigations like the one reported here should form the basis for recommending the appropriate technology to the local farmers.

Table 1 Number of Work Days per Hectare for Various Puddling Treatments

Treatment	Year 1982	Year 1983	Average*
T_1	7.9	8.4	8.1 ± 0.3
T_2	14.6	15.1	14.8 ± 0.3
T_3	6.0	6.3	6.1 ± 0.2
T_4	11.0	11.7	11.3 ± 0.5
T_5	9.4	10.2	9.8 ± 0.6

* Figure with ± are standard deviations for years.

Table 2 Cost of Puddling (US$/ha) for Various Puddling Treatments

Treatment	Year 1982	Year 1983	Average*
T_1	20.5	21.8	21.1 ± 0.9
T_2	38.0	39.3	38.6 ± 0.9
T_3	15.6	16.4	16.0 ± 0.6
T_4	28.6	30.4	29.5 ± 1.3
T_5	24.4	26.4	25.4 ± 1.4

* Figures with ± are the standard deviations for years.

Table 3 Puddling Index (PI) for Various Puddling Treatments

Treatment	Year 1982	Year 1983	Average
T_1	1.02	1.02	1.02
T_2	1.01	1.04	1.02
T_3	1.00	1.05	1.01
T_4	1.03	1.05	1.04
T_5	1.02	1.04	1.03
F test	ns*	ns	

* ns = non significant.

Table 4 Paddy Grain Yield (t/ha on 15% w/w Basis Moisture Content) as Influenced by Various Puddling Treatments

Treatment	Year 1982	Year 1983	Average
T_1	3.27	3.08	3.18
T_2	3.30	3.09	3.20
T_3	3.31	3.04	3.17
T_4	3.29	3.11	3.20
T_5	3.26	3.35	3.32
Average	3.29	3.14	
F Test	ns*	ns	

* ns = non significant.

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Selection of Seed-cum-Fertilizer Drill: Technical Considerations

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Pakistan

Abstract

In Pakistan, traditional seed placing methods are still in vogue. The hand broadcasting, dropping the seed behind a "desi" plough and pouring through a funnel attached to country plow are very common in irrigated and "barani" areas. The conventional sowing practices are one of the reasons for low crop yield in the country. These practices also hinder mechanized interculture and harvesting operations.

In order to mechanize crop sowing operation, a suitable drill is vital as it places the seed and fertilizer in the zone of adequate moisture and at desired depth. The locally manufactured drills are mostly for monocrop seeding. These are not properly designed for accurate metering and placing of seeds.

Power transmissions, metering and seed placement mechanisms of two imported seed-cum-fertilizer drills SPSC/200-NARDI and 1116-AITCHISON were studied to assess their suitability in Pakistan's agriculture. The Aitchison drill with infinitely variable speed oil-bath gearbox was found more suitable as it can deliver a wide range of seed rates to suit most of the common crops grown in the country. The soft and resilient sponge discs metering mechanism of the drill does little damage to the seed. The inverted "T" furrow openers are best suited for better seed germination. This drill can be used in both tilled and no-tilled field conditions and for direct seeding of wheat on rice stubble fields.

Introduction

Cereals, with the exception of rice, pulses and oil seeds are mainly sown by hand broadcasting in irrigated areas of Pakistan. These crops share the major cultivated areas in the country. **Table 1** shows the area planted to these crops (Anonymous 1987). The use of seed drill is very limited as is evidenced by the sale of only 5000 drills (locally made and imported) during 1984-85. The use of "kera" (dropping of seeds manually in a furrow opened by a desi plow and then covering it by planking) and "pora" (dropping of seeds through a funnel shaped tube attached behind a desi plow) are more common in barani areas as there is not enough moisture on soil surface and farmers have to place seeds to a depth of 8 cm or more in the soil.

The conventional practice of hand broadcasting randomly scatters the seeds on the soil surface. This results in seed damage by birds and poor germination due to insufficient soil moisture at the surface. The broadcast crops also lack evenly-spaced rows which hinder interculture and pesticide application operations. The old farmers are expert in even broadcasting but they are becoming scarce. The young generation is reluctant of doing this operation. The result is that increase in crop yield is not satisfactory despite better seed and high fertilizer inputs and good water management and pest control practices. Therefore, there is a need to mechanize the sowing operation.

Table 1 Crops Statistics

Crop	Area (000, ha)	Yield t/ha
Wheat	7556.000	1.886
Rice	2082.000	1.691
Maize	815.000	1.363
Cotton	2498.000	0.531
Gram	1055.000	0.567

Source: Ministry of Food & Agriculture (1986-87 E)

Literature Review

The proper placement of seed and application of basal dose of fertilizer can help in achieving better yeilds which are directly affected by healthy germination, crop stand and plant population. Sirohi (1980) reported that germination of seed was uniform and two days quicker with the use of seed drill as compared with kera. Timeliness in sowing is another important factor as it helps in taking full advantage of the soil moisture. The use of seed drill gave an increase of 12.5–32% over traditional methods (Roy and Vishwanathan 1977; Bahl et al 1980; Sharma et al 1983; Singh and Chancellor 1977). The germination of 224 seedlings/m^2 with the seed drill against 158 seedlings/m^2 achieved by the kera method was also reported by Sharma et al (1983).

Seed drills are used for random dropping and covering of seeds in furrows to give definite rows. There is a provision of simultaneous dropping and covering or just broadcasting of fertilizer by attaching another fertilizer box in a seed cum-fertilizer drill.

The operational requirements of a combined drill are (Hansen, 1962 and Bwernacki, 1972) as follows:

(a) The number of seeds placed simultaneously in particular rows should be roughly the same over each meter of row length. This criteria should be met for various kinds of seeds and fertilizer too and at various seeding and fertilizer application rates.
(b) There should be a provision of changing seed rate from 6-300 kg/ha.
(c) Metering of the required seeding and fertilizer application rate should be reliable and easy to adjust.
(d) Provision for changing row spacing between seeds and both vertical and horizontal distance between seeds and fertilizer deposition in soil.
(e) Placing of seeds at an appropriate depth and covering with soil layer.
(f) Seeds should not be injured by the seed metering and placement devices.
(g) Insensibility of working elements of the distributors to corrosive action of fertilizer by employing suitable structural material such as fibre glass, stainless steel and metal coating.
(h) Easy removal of the fertilizer left in the box and easy access to clean the inside of the machine.
(j) Operating efficiency of the drill should not be dependent on its inclination when seeding undulated fields and should remain unrelated to the travel speed (4-8 km/h).

The locally manufactured drills are mostly for seeding and are monocrop. These are used for sowing cotton and maize in irrigated area and peanut in barani area. There is no provision for fertilizer in these drills.

The locally built seed drills are not properly designed for accurate metering and placing of seeds. The fluted rollers have improper groove clearance which results in grain damage. There is also a substantial wear and tear of fluted rollers because of poor quality material used in their fabrication. There is only one fixed gear ratio between ground drive wheel and fluted roller shaft. The only possibility of changing seed rate is by varying the exposed length of fluted rollers under hopper orifices. The furrow opener (hoe type) does not make proper furrows and there is no provision to cover the seeds effectively.

The imported drills are multicrop and have provision for fertilizer application. These drills are very precise in metering and placing of seeds and fertilizers but are very expensive. These drills cost up to Rs.40,000 ($2300) per unit as compared with local seed drills being sold at prices ranging from Rs.5000 to 10 000 (US$300-570).

Very little work has been done on testing, evaluation and standardization of seed drills in Pakistan. As a result, no effort has been made for design/development of a suitable seed-cum-fertilizer drill. This paper describes the various components of imported drills (SPSC/200-NARDI and 1116-AITCHISON) with an objective to select a suitable design of seed-cum-fertilizer drill with the following capabilities.

(1) Can drill rice, wheat, maize, sunflower, chickpea, mungbean, cotton, and groundnut both in irrigated and barani areas under tilled and no-till field conditions;
(2) Can be operated with 35 kW tractor; and
(3) Can be manufactured locally at reasonable cost.

Materials and Methods

There is need for certain required plant population to achieve optimum crop yield. Suitable row spacing is also needed to facilitate the interculture and harvesting operations. The plant population and row spacing depend on the growth pattern of a particular crop and set of conditions.* "In upright crops, increased populations may increase the tendency for stalks to lodge or break, which is undesirable from the harvesting standpoint. Narrow row spacings in corn or cotton may increase yields but they also increase the costs of planting and cultivating and require changes in the design of harvesting equipment."

In order to find sowing and fertilizing variables of various crops mentioned in the previous section, the information was collected through literature search and personal discussion with commodity coordinators at the National Agricultural Research Centre, Islamabad. Table 2 shows various sowing and

*Narrated from Crop Planting Chapter of Principles of Farm Machinery, Third Edition by Kepner et al. 1978. Published by AVI Publishing Company, Inc. Westport, Connecticut, USA.

Table 2 Seed Sowing and Fertilizer Placement Variables of Different Crops.

Crop	Bulk density (gm/cm³)	Row spacing (cm)	Sowing depth (cm)	Seed rate kg/ha	Wt. of 100 grains (g)	Fertilizer requirement kg/ha Barani N	P	K	Irrigated N	P	K
Rice	0.467	30	3	100	2.4	–	–	–	125	100	–
Maize	0.777	75	5	30	21.4	80	40	–	150	75	–
Wheat	0.783	15	4	100	3.6	41	27	–	55	45	–
Chickpea	0.768	30	6	75	12.6	20	50	–	25	60	–
Mungbean	0.783	30	6	20	3.87	25	60	–	25	60	–
Sunflower	0.297	75	6		5.25	60	60	–	85	60	–

fertilizer variables. Two multicrop seed-cum-fertilizer drills have been imported by CIMMYT and Crop Maximization Programme of Pakistan Agricultural Research Council. These are 1116-Aitchison and SPSC/200-NARDI manufactured in New Zealand and Italy, respectively. These drills were studied for their power transmission, metering and seed placement mechanisms etc. The objective was to select a suitable drill design with the capabilities mentioned above.

Machine Details

1116-Aitchison Drill

Aitchison is a tractor rear-mounted drill (Fig. 1) mainly comprising of seed and fertilizer hoppers, depth control wheels, sponge feed metering mechanism, infinitely variable speed gear box to vary seed rate from zero to maximum and inverted "T" furrow openers. The input to the gear box can be changed by interchanging the sprockets A and B shown in Fig. 2. The drill sowing width is 2.4 m and it requires a 45-kW tractor. An initial setting for seed rate can be chosen from seed chart and then the operator can do his own calibration for his seed. The fertilizer rate can also be controlled by a lever with four different positions.

Power Transmission System: Power from ground wheel through chain and sprocket is taken to a shaft on which two sprockets are attached to transmit the motion (Fig. 2). One sprocket is used to

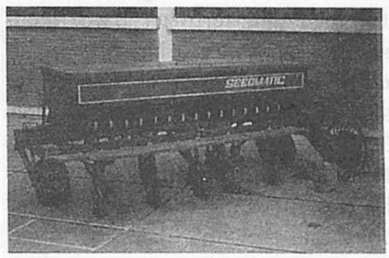

Fig. 1 Rear view of Aichison drill.

drive the fertilizer auger and others for the infinitely variable speed gear box.

Seed Metering Mechanism:

a) Infinitely variable speed gearbox: It takes the drive from sprocket A and rotates the input shaft. Two plastic cams with an eccentricity of 56 mm are spaced at an angle of 180° from each other on the shaft. These cams rotate two followers in the curved grooves with fixed vertical displacement. The followers are connected through flat bars to ratchet bearings mounted on the output shaft. The distance travelled by the followers on the curved grooves and hence output shaft speed is varied by changing the inclination angle of the grooves with the horizontal axis. This is achieved

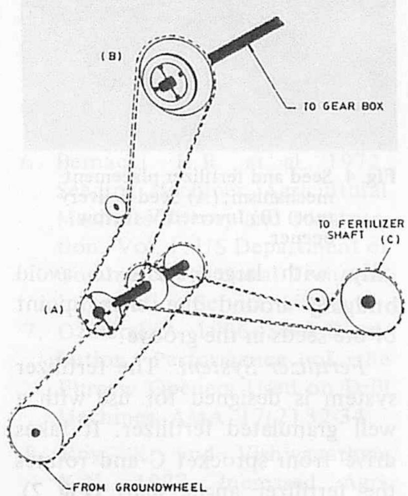

Fig. 2 Power transmission system.

through a spring-loaded lever used for the seed rate indexation. The output/ input speed ratio of the gear box was found to vary from 0.00 to 0.0559 (Table 3).

b) Seed feed mechanism–sponge feed: A soft and resilient sponge rotates against a specially shaped groove of seed metering plate. It envelops the seed irrespective of its shape and slowly pulls it down the groove where it is released and dropped down the seed tube (Fig. 3). The seed agitator is used

Table 3 Output/Input Speed Ratio of Gear Box for Various Seed Rate Index Lever Poisition

Seed rate index lever position	Ground wheel revolution (G)	Gear box input revolution (G x 38/17)	Gear box output revolution	Output/Input ratio
0	0	0.0	0	0.0
10	117	261.5	2	0.0076
15	74	165.4	2	0.0121
20	43	96.1	2	0.0208
25	26	58.1	2	0.0344
30	20	44.7	2	0.0447
35	17	38.0	2	0.0526
37.5	16	35.8	2	0.0559

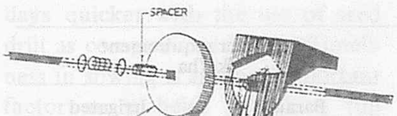

Fig. 3 Seed feed mechanism.

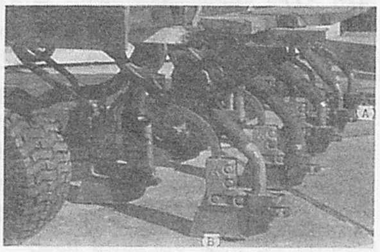

Fig. 4 Seed and fertilizer placement mechanism; (A) Seed delivery tube. (B) Inverted-V furrow opener.

only with larger seeds to avoid bridging around the entry point of the seeds in the groove.

Fertilizer System: The fertilizer system is designed for use with a well granulated fertilizer. It takes drive from sprocket C and rotates the fertilizer auger shaft **(Fig. 2)**. The fertilizer delivery rate is controlled by variable gate openings.

Seed and Fertilizer Placement Mechanism: This comprises of feed cups, delivery tubes and inverted 'T' furrow openers **(Fig. 4)**. There are two lines of feed cups, front for fertilizer and rear for seed. In each line, the feed cups are evenly spaced at 15 cm apart. The spiral delivery tubes are made of rubber plastic. These tubes are flexible in nature to compensate the furrow opener's impacts when operated in no-till fields. The inverted 'T' furrow openers create seed groove micro-environment best suited for better seed germination. The openers shatter the subsurface soil to facilitate the root and shoot penetration. Studies have shown 65% and 300% better plant establishment with inverted 'T' seeder in maize and mungbean, respectively, than seed dibling/covering by hand (Chaudhary et al, 1987). In narrow spaced crops, like wheat the fertilizer with this drill has to spread on the ground to avoid toxic effect by close contact of fertilizer with seed.

SPSC/200-Nardi Drill

This is also a tractor rear-mounted drill **(Fig. 5)** mainly comprising of seed and fertilizer hoppers, spring-loaded single disc openers, seed covering spring harrow, fluted roller metering mechanism for seed and fertilizer, two fixed-speed gear boxes driven independently by two ground wheels. Its sowing width is 1.62 m and requires 35 kW tractor. An initial setting for seed and fertilizer rates can be chosen from seed and fertilizer chart and then the operator can do his own calibrations.

Power Transmission System: There are two gear boxes, one on each side of the machine to drive half length of the seed and fertilizer metering shafts. The power to the transmission is provided by pneumatic ground wheels. There is a fixed gear ratio of 14/22, 14/23 and 14/14 for seed, fertilizer feed and seed and fertilizer agitator shafts, respectively, **(Fig. 6)**.

Seed and Fertilizer Metering Mechanism: The aluminium fluted rollers mounted on seed and fertilizer feeding shafts are located at seed and fertilizer hopper side walls. The seed and fertilizer delivery rates can be varied by changing the exposed length of fluted rollers through a lever. Agitators are provided to prevent the bridging and for smooth flow of seed and fertilizer. The flow of seed and fertilizer can be blocked to feed cups through sliding gates. There is a provision to increase the orifice area of seed hopper for large seeds. Since the seed has to flow between fluted roller grooves and side metal plates, there is some breakage of seeds for various crops found in seed damage test **(Table 4)**.

Seed and Fertilizer Placement Mechanism: This comprises of feed cups, delivery tubes and spring

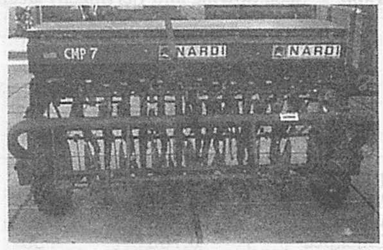

Fig. 5 Rear view of Nardi drill.

Fig. 6 Exposed view of Nardi gear box; (A) Seed metering drive. (B) Seed and fertilizer agitator drive. (C) Fertilizer metering drive.

loaded single-disc furrow openers. There are two lines of feed cups, one for seed and the other for fertilizer. In each line the feed cups are evenly spaced at 15 cm apart. The feed cups of each row are combined in a single unit before entering the spiral delivery tubes made of rubber. The single disc furrow openers are spring-loaded to vary the sowing depth. These are also equipped with scrapers to prevent clogging while working in wet soil conditions. These disc openers are suitable for

Table 4 Seed Damage Test for NARDI Drill

Crop	Seed damage (%)
Rice	0.27
Maize	0.23
Wheat	0.38
Chickpea	1.70
Mungbean	0.78
Sunflower	1.37

both shallow and medium drilling but have wider transverse sowing width (Ozmerzi, 1986). It is very difficult to adjust the exact spacing between consecutive rows of crops and between seed and fertilizer placement in this drill. There is also a shallow placement of seed and fertilizer in rows behind the tractor rear wheels than the rest of the rows.

Selection Criteria for Aitchison Drill

On the basis of description of both drills above-cited operational performance and desired capabilities of needed drill, the Aitchison drill, was found more suitable than the Nardi drill as explained below:

1. It has an infinitely variable speed oil-bath gear box which is very simple in operation and needs a little maintenance. It can give a range of speeds to obtain seed rates of all the crops mentioned earlier.
2. It has soft and resilient sponge discs mounted on feed shaft and hence causes no damage to the seed.
3. The distance between consecutive crop rows can be easily and accurately adjusted by eye bolts of clamps mounted on the frame.
4. The coiled shanks made of special steel spring back in case of an obstruction and serve as overload protection device.
5. It has inverted 'T' furrow openers which create seed groove micro-environment best suited for better seed germination.
6. The narrow edge furrow openers have brazed steel hardened tips and can work in no-till fields. A substantial savings in land preparation cost and precious time have been reported by the use of this drill in direct drilling wheat on rice stubble in rice-wheat cropping pattern (Byerlee et al, 1984).
7. It can be used for deep sowing in cultivated fields in barani area by placing hoe-type tines on existing furrow openers.
8. There are two pneumatic depth wheels to control accurate sowing depth.

Recommendations

There is a need to incorporate a few changes in the design of this drill for its adoption under Pakistani farming conditions. The following recommendations are made:

1. The existing steel ground wheel works very well in no-till field but does not provide good traction in cultivated fields. There is a need to replace it with treaded pneumatic wheel for working in both types of field conditions.
2. This drill needs 45-kW tractor and its working width has to be adjusted from 2.40 m to 1.80 m for its operation with 35-kW tractor, commonly found in Pakistan.
3. There is need for seed covering device to operate the drill in cultivated fields.
4. There is need to mount row marker similar to Nardi drill for maintaining accurate row spacing.

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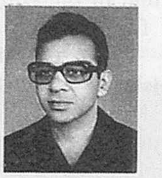
Design and Development of Potato Grader



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Abstract

Prototypes of potato grader were designed, developed and operated satisfactorily at the Central Potato Research Institute for the past few years for sorting seed potatoes for supply to the National Seed Corporation and various State Governments. This paper describes design considerations, constructional details, method of operation and field performance of these graders. On an average, these graders sorted 20/25 q/h of seed potato into 4 to 5 sizes employing 10-14 attendants. The screen efficiency of the oscillatory sieves ranged from 80 to 90% and average tuber damage was found to be within 2%.

Introduction

Grading of potato tubers is an important operation in potato production. Grading requirements vary with the end use of the potato. In India potato grading usually involves their sorting into two or more grades depending upon one or more parameters, viz. size, shape, colour, harvest damage and disease and insect infestation. Manual grading of potatoes by hand picking is very slow, labour intensive and costly. Disposal of potato from the fields is many a times delayed due to slow grading process which results in qualitative and quantitative losses. A few machines primarily for sorting potatoes into different size/grades were developed during the last two decades (Grover and Pathak, 1972; Singh, 1980; Verma and Kalkat, 1975) but none were acceptable to the users. Details of all such machines and important reasons for their non-acceptance by the users were discussed by Shyam (1984).

Sorting of potatoes into many different size or grades by manual sieving using a set of steel sieves with round holes of different sizes is common in Bihar State. Power-operated and hand-operated oscillating sieves, which employ commercially available mild steel sieves, have been successfully designed, developed and used extensively for potato grading at the Central Potato Research Institute (CPRI), Shimla. The design, development, construction, method of operation and performance of these graders are presented in this article.

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Note: The work was done at the Central Potato Research Station, Jalandhar – 144 003, India.

Materials and Methods

Design Considerations

The machine should be simple in construction and capable of sorting potatoes into 4 or 5 different size or grades with high sizing efficiency and 20 to 25 q/h throughput capacity. The four grades recommended by the CPRI, Shimla are: small – below 25 g, medium – 25 to 50 g, large – 50 to 75 g and extra large – above 75 g (Rana and Chauhan, 1985). The machine should have adequate provision for manual quality selection and also for bag filling and be suitable for handling freshly harvested field cured potatoes, i.e., total tuber damage should preferably be within 2%.

Selection of Sieves

The recommendations of CPRI on grading of potatoes is based on tuber weight rather than their geometric dimensions. Shyam (1982) reported that size-grading of potato tubers of K. Chandramukhi, K. Jyoti and K. Sindhuri varieties according to their maximum width resulted in lower grading error on weight basis as compared to grading according to thickness. Therefore, the commonly used steel sieves with circular perforations which sort potatoes according to width were selected for the machine. The size of perforations was computed using the quadratic regressions in square root of tuber weight on critical tuber width as suggested by Shyam (1982) for the tubers of K. Chandramukhi, K. Jyoti and K. Singhuri varieties.

Machine Parameters

In a study involving sorting of potatoes with an experimental power-operated oscillating sieves, the authors tried many different combinations of sieve speed, stroke length and sieve slope for satisfactory operation and high screen efficiency (1979). Sieves of 60 cm × 120 cm with round perforations of 50.4, 44 and 35 mm diameter were used. Screen efficiency of about 90% was obtained by providing little manual assistance to take care of the blinding of sieves perforations. Sieves of 60 cm wide were found easily accessible by hand to take care of blinding of the sieves. Screen efficiency of sieves of length lower than 120 cm was poor. A combination of medium sieve speed of 462 strokes/min, low stroke length of 31.75 mm, and sieve slope of 14.5% for which an average screen efficiency of 89.6% and throughput rate of 37 q/h was selected. Normal flow of potatoes on the sieves and very low sieve blinding was reported for such a combination of machine parameters. Further, low stroke length and sieve speed were desirable to keep machine vibrations at low level.

Construction and Development

The schematic diagram of the power-operated grader is shown in Fig. 1. It consists of a steel frame, power transmission system, a set of two oscillating sieves, a stationary sieve, feeding chute, sorting platform and bag filling device. The main frame was made of mild steel angle of 65 × 65 × 6 mm size. Two mild steel sieves of 120 × 60 cm size were fitted one over the other and suspended from top of the frame. The upper sieve had perforations of 50 mm diameter and the lower 40 mm diameter. Blind sheet of about 20 cm at the upper end and 53 cm at the lower end was provided along the length in both sieves. Before fitting the wooden frame on the sieves, commercially

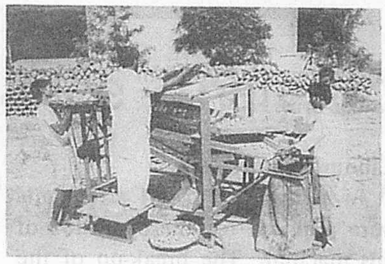

Fig. 1 Power-driven potato grader in operation.

available gasket insertion sheet of 2.5 mm thickness which is reinforced with fine cotton fibres was pasted on the sieves using commercially available adhesive and undersize holes of appropriate diameter were punched in the rubber sheet corresponding to each hole in the steel sieve. The values of cut widths as reported by Shyam (1982) in respect of tubers of three important varieties (**Table 1**) were used to select the size of sieve perforations. Sieves were staggered by about 10 cm along the slope. A stationary sieve of 90 cm × 60 cm size with 28% slope was provided below the oscillating sieves. The upper two sieves were oscillated by a single step V-belt (B Section) driven crankshaft. A single phase, 1 hp electric motor of 1440 rpm with speed reduction ratio of 6.25:1 was used to operate the sieves. Overflow from the upper sieve was discharged into a sorting platform with a gentle slope of about 20% to allow rolling down of potatoes under gravity. At the lower end of the sorting platform and the lower oscillating sieve separate provisions for hanging two gunny bags of 110 × 67 cm size, which are commonly used for 80 kg packings, were made. A flow diverter was provided with the bag filling device. The overflow from the lower stationary sieve was channeled into a basket. A wooden chute for manual feeding of potatoes with baskets or bags was provided above the upper sieve. A small platform for the attendant to ride on for easy feeding of potatoes into the machine was also provided. It discharged potatoes

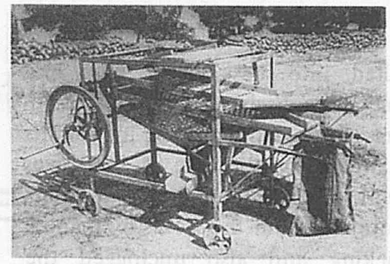

Fig. 2 Hand-operated potato grader.

Table 1 Values of Cut Widths in Respect of Tubers of Three Important Improved Varieties

Unit: mm

Tuber weight range, g	K. Chandramukhi	K. Jyoti	K. Sindhuri
<25	33.41	33.62	34.14
25–50	43.67	42.97	44.49
50–75	50.03	51.00	53.30

(Shyam, 1982)

onto the raised blind end of the upper sieve. To check the sideways movement of the oscillating sieve-block, one guide was provided on opposite sides of the sieve-block towards the lower end. In addition, four transport wheels were provided to facilitate moving from one field to another.

The hand-opearted grader (**Fig. 2**) was identical to the power-operated grader except for the power transmission system. A flywheel as used on the common manual chaff cutter was fitted on the driving shaft and a single step V-belt was used to increase the speed from driving shaft to crankshaft in the ratio of 1:6. The weight and the outer and cranking diameters of the flywheel used were 25 kg, 97 cm and 74 cm, respectively.

Method of Operation

The machine was installed on level ground and the lower half of each transport wheel was buried into the ground to provide stability to the machine during opeartion. After harvest, the potatoes were left in heaps in the field with suitable cover for a minimum period of 25 days for curing. Curing period could be shorter for late harvested crop. The cured potatoes were filled into baskets or bags and manually discharged into the feeding chute. One or two attendants standing by the side of the sieves kept on removing the undesirable potatoes from the sieves by manual picking and also unclogged the sieve perforations as and when necessary. The potatoes discharged on sorting platform and rolling down the lower blind portion of the lower oscillating sieve were also subjected to manual quality selection. When a bag was filled up, the flow of potatoes was diverted to the other bag and the filled up bag was replaced by an empty one. Small tubers discharged from the lower stationary sieve were collected into a basket and then transferred into bags manually. A view of the machine operation is shown in Fig. 1.

Results and Discussion

Prototypes of the hand-operated and power-operated potato graders were put to extensive field testing and their performance were noted:

Throughput

The average throughput of 25 q/h for the power grader and 20 q/h for the hand-operated grader were normally achieved. The average throughput was greatly influenced by continuity of feeding potatoes into the machine. Effective supervision was found important for ensuring uninterrupted feeding.

Screen Efficiency

Screen efficiency of the oscillating sieves varied between 80 and 90% and was in conformity with the results reported earlier by the authors (1979). In fact the flow of potatoes on the sieves was observed to be better in hand-operated machine than the power-operated one primarily due to the effect of varying the angular speed of the flywheel in hand-operation as compared to the uniform speed in power-drive.

Labour Requirement

In general, 10 to 14 attendants were required for the operation of this machine. The break-up of the attendants engaged was 7 to 9 for feeding, including filling of baskets, 2 for bagging and 1 to 3 for quality selection and unclogging of sieves. The hand-operated machine required one less attendant for feeding but required an additional attendant for rotating the flywheel.

Power Requirement

The average power requirement of the electric motor-operated grader was measured to be 450 W at 250 rpm of the crankshaft. Therefore, 1 hp (746 W) motor was provided on the machine. The hand-operated grader was easily operated by one man of average physique. During field operation it was found convenient to replace the operator every half hour with the other labourers attending the machine. The average speed of rotation of flywheel was found to vary from 30 to 35 rpm and the corresponding speed of crankshaft from 180 to 210 rpm.

Tuber Damage

Scuffed tubers (with surface abrasion damage to skin) and those with flesh damage were separated from each fraction and their percentages based on the weights of the corresponding fractions were taken as tuber damage. Tuber damage was found greatly dependent on maturity of crop and curing period. The average tuber damage for K. Chandramukhi, K. Jyoti and K. Sindhuri varieties at full maturity and after curing for a minimum period of 25 days was found to be about 3% in large tubers, 1% in seed-size tubers and negligible in small tubers. Longer curing period was necessary for immature crop and shorter for late harvested crop. Much of the damaged tubers were scuffed. Some of the damaged tubers, particularly large ones, sustained flesh damage to a shallow depth of less than 3 mm.

Long Duration Testing

Prototypes of the hand-operated and power-operated potato graders are being used satisfactorily at Kufri (HP), Modipuram (UP), Gwalior (MP), Patna (Bihar) and Jalandhar (Punjab) stations of the CPRI for the past few years for sorting seed potatoes into 4 graders. During the operation extra large tubers (generally >100 g) were hand picked from amongst the tubers discharged on the sorting platform. Some mechanical problems reported for the earlier prototypes were taken care of by effecting design changes such as strengthening the main frame, improving the joint between sieve hanger and sieve frame, replacing vertical mounting of bearings with horizontal mounting and using bearings of larger size. The drawings of the grader may be obtained from the Director, Central Potato Research Institute, Shimla-1, India. A few farm machinery manufacturers, including Punjab Agro-Industries Corp. Ltd., Chandigarh, India have undertaken the fabrication of this machine. The power-operated machine costs Rs. 6 000 to 8 000 (US$ 456 to 607) at Jalandhar and Ludhiana during 1985-86 and cost of grading seed potatoes at the CPRS, Jalandhar assuming 25 q/h throughput, employing 12 labourers hired at the rate of Rs. 15 (US$ 1.2) per day and 8 years as useful life of the machine with average 200 h of annual use was worked out to be Rs. 31.85 (US$ 2.4) per h or Rs. 1.25 (US$ 0.1) per q as against Rs. 3.75 (US$ 0.3) per q in manual potato grading by hand picking.

(Continued on page 49)

Performance Analysis of Ridge Profile Rotary Weeders

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Abstract

The development of appropriate technology for effective weed control is of utmost importance to small- and medium-scale farming systems in Nigeria where crops are commonly grown on the ridge. Research has shown that weeds account for about 50 – 75% reduction in yield due to lack of satisfactory weed control methods.

Two types of rotary weeders, as reported in this paper, were developed for the draught animal farming areas of Nigeria. These are the high clearance Straddle-row and the Emcot-attached (interrow) rotary weeders. Weeding performance of these two implements were compared with that of Strad, the commercially available rotary weeder and also with the manual method of weed control.

Results show that the draft requirement for the Straddle-row weeder averaged 1.0 kN when operared at a speed range of 0.60 – 0.62 m/s while that for the Emcot-attached rotary weeder averaged 0.80 kN for the same speed range. The draft of the Strad could not be monitored because of the fixed connection between the implement and the yoke. Weeding time was about 4.0 h/ha for both the Straddle-row and the Emcot-attached rotary weeders and about 3.0 h/ha for the Strad.

The resulting yields of crops experimented with, using the two prototype weeders, compared favourably with that from Strad. Though the manual method showed a slight advantage in yield, particularly for maize, the weeding time was considerably higher than for the ridge profile weeders.

Introduction

The major factor regarding increased food production in Nigeria is the inability of farmers to effectively control weeds at peak growing seasons (1). Weeds account for about 50 – 75% reduction in yield, particularly in the humid tropics where torrential rainfall significantly interrupts work on farms in the season.

Manual weeding is labour-intensive, accounting for about 80% of the total labour required for producing food in Nigeria (2). Clearly, therefore, the problem of weeds must be given high priority for boosting agricultural production. Weeds on the farm may be controlled chemically by the application of herbicides which kill weeds selectively without injuring the crops; or mechanically with appropriate weeding tools. Although the latter is safe and reasonably effective, the traditional method of hand-hoeing is time-consuming. A combination of mechanical and chemical methods, on the other hand, has the advantage of effectively controlling persistent weeds which evade control when chemical or mechanical methods of control are applied exclusively.

Existing or traditional farm tools are not totally effective for weed control in the manual and draught animal farming systems. Typical examples of such devices are the traditional hand-hoes (manual), and the very popular draught animal-drawn Emcot ridger which is suitable only for ridging. In 1890 the recognition of the problem of weeds on farms led to the development of the rotary hoe (3), but this development was relevant only to weeding on flat soil. The concept has, however, been adapted to ridge profile weeding.

Development of Ridge Profile Weeders

In Nigeria, ridge cultivation is widely practised by small- and medium-scale farmers. In the case of small-scale farmers, the need to boost agricultural production through effective methods of weed control led to the development of two types of draught animal-

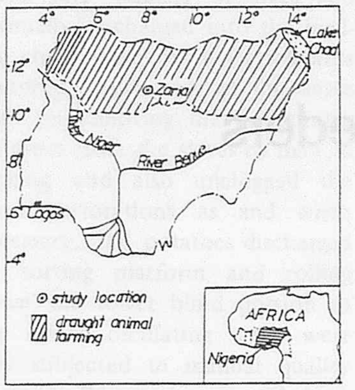

Fig. 1 Draught animal area in Nigeria.

drawn rotary weeders in regions of the country characterized by farming with draught animals (Fig. 1). These are: a) the high-clearance, Straddle-row rotary weeder, and b) the Emcot-attached rotary weeder.

The Straddle-row Weeder

This ridge profile weeder consists of two pairs of rotary hoes mounted on a straddling tool bar. This arrangement, which straddles the ridge, provides clearance for tall crops up to a crop height of 1 m, beyond which usually no weeding is necessary. The inclination of the rotary hoe to the ridge profile conforms with the angle of repose of the ridge, its alignment being such that the amount of weeds removed is maximized. The clearance between two adjacent hoes at their closest points at the top of

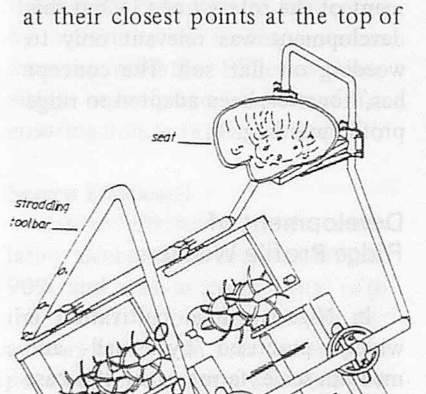

Fig. 2 Bird's-eye view of straddle row-weeder.

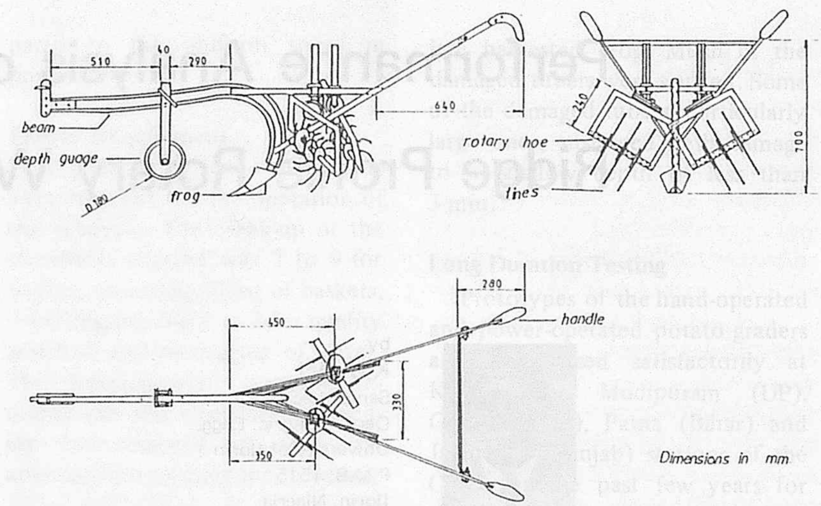

Fig. 3 Emcot rotary weeder.

the ridge ensures that the hoe tines do not injure crops above the ridge top. An isometric view of the straddle-row weeder is shown in Fig 2.

In order for this weeder to perform efficiently, it is important that weeding commences about two weeks after planting, as delayed weeding is likely to reduce the effectiveness of the tool. Suitable for weeding in cereals (corn, sorghum and millet), the straddle-row rotary weeder can also be used in legumes (peanuts and cowpeas) at early stages of growth.

The Emcot-attached Rotary Weeder

The effectiveness of the Emcot ridger, which is a draught animal-drawn tool-bar widely used by farmers practising draught animal farming in parts of Northern Nigeria, was inhibited by the lack of a suitable weeding attachment, the development of which has now enhanced its versatility.

The Emcot ridger, with its rotary weeder attachment, is 'inter-row' in its operation. It consists of a pair of rotary hoes mounted on the rear of the ridging body, each of the two hoes weeding one-half of adjacent ridges. The major advantage of this ridger is that its operation is not limited by crop height (Fig. 3). The tool-bar is hand-guided, unlike in the straddle-row

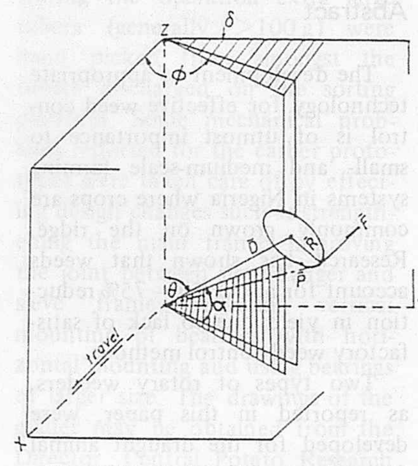

Fig. 4 Orientation of a rotary hoe.

weeder on which it is necessary for the operator to ride.

The straddle-row weeder and the Emcot weeder, both conform reasonably well with ridges constructed with animal-drawn and tractor-drawn ridgers, provided that the field is cleared of stumps and other obstacles likely to hinder their operation. They are also good pulverizers of soil, when the soil is moist but not too wet.

Analysis of Draft of Rotary Weeders

In the absence of suitable equipment to measure draft forces, or when it is difficult to access such equipment, analytical procedures can be employed usefully to predict the draft and, subsequently, the energy requirement of rotary weeders. Analysis of draft, the horizontal component of the force to be overcome along the direction of travel, of rotary hoes operating on inclined planes can be conveniently visualized with respect to the Euclidean vector space. The major vectors to be considered are the position vector, $\overline{P}$ and the radius vector, $\overline{R}$ (Fig. 4); the axis of rotation is defined by $\overline{D}$. The analysis is given in sections 3.1 and 3.2.

Incipient motion

At the incipient motion, the position vector, $\overline{P}$, is defined as:

$$\overline{P} = \overline{D} + \overline{R}$$

But $\overline{D}$ is defined as:

$$\overline{D} = |\overline{D}| \begin{bmatrix} \sin\theta\cos\phi \\ \sin\theta\sin\phi \\ \cos\theta \end{bmatrix} \quad \ldots \text{(i)}$$

Where:

$\overline{D}$ = varying length of the rotary hoe axle whose line of action is along axis of rotation.

θ = angle that $\overline{D}$ makes with Z – axis

ϕ = angle that $\overline{D}$ makes with the X – Z plane

Equation (i) shows that $\overline{D}$ is a product of the scalar quantity, $\overline{D}$ and the vector, $\overline{\lambda}$:

$$\overline{D} = |\overline{D}|\,\overline{\lambda}$$

where:

$$\overline{\lambda} = \begin{bmatrix} \sin\theta\cos\phi \\ \sin\theta\cos\phi \\ \cos\theta \end{bmatrix} \quad \ldots\ldots\ldots \text{(ii)}$$

Directed along the X, Y and Z axes, equation (ii) can be expressed as:

$$\overline{\lambda} = (\sin\theta\cos\phi)\underline{i} + (\sin\theta\sin\phi)\underline{j} + \cos\theta\,\underline{k} \quad \ldots\ldots\ldots\ldots \text{(iii)}$$

The vector components of equation (iii) are equal to the direction consines of the line of action of $\overline{D}$. The kinematic parameter, $\overline{\lambda}$ in equation (iii) is:

$$\lambda_x = (\sin\theta\cos\phi)\,x$$
$$\lambda_y = (\sin\theta\cos\phi)\,y$$
$$\lambda_z = (\cos\theta)\,z$$

Where

$$\overline{\lambda} = \lambda^2{}_x + \lambda^2{}_y + \lambda^2{}_z$$

Similarly, $\overline{R}$, the vector denoting the radius of the rotary hoe, is defined as:

$$\overline{R} = |\overline{R}| \begin{bmatrix} \cos\theta\cos\phi \\ \cos\theta\sin\phi \\ -\sin\theta \end{bmatrix} \quad \ldots \text{(iv)}$$

Where:

$|\overline{R}|$ = a scalar quantity denoting the varying radius of the rotary hoe.

Hence,

$$\overline{P} = \begin{bmatrix} |\overline{D}|\sin\theta\cos\phi + |\overline{R}|\cos\theta\cos\phi \\ |\overline{D}|\sin\theta\sin\phi + |\overline{R}|\cos\theta\sin\phi \\ |\overline{D}|\cos\theta - |\overline{R}|\sin\theta \end{bmatrix} \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(v)}$$

The pull is assumed to be in the positive X direction, as shown in Fig. 4. The force that the ground exerts on the end of the tine is:

$$\overline{F} = |\overline{F}| \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix} \quad \ldots\ldots\ldots\ldots \text{(vi)}$$

Where:

$|\overline{F}|$ = a variable that governs the force vector, $\overline{F}$.

The moment of the force vector, $\overline{F}$, about $\overline{D}$ is:

$$M_{\overline{D}} = \overline{D} \cdot \overline{P} \times \overline{F}$$

$$= \begin{bmatrix} \sin\theta\cos\phi & \sin\theta\sin\phi & \cos\theta \\ |\overline{D}|\sin\theta\cos\phi + |\overline{R}|\cos\theta\cos\phi & |\overline{D}|\sin\theta\sin\phi + |\overline{R}|\cos\theta\sin\phi & |\overline{D}|\cos\theta - |\overline{R}|\sin\theta \\ |\overline{F}| & 0 & 0 \end{bmatrix} \quad . \text{(vii)}$$

Applying the theorem of expansion of determinants, equation (vii) becomes:

$$M_{\overline{D}} = |\overline{F}| \times |\overline{D}| \times \begin{bmatrix} \sin\theta\cos\phi & \sin\theta\sin\phi & \cos\theta \\ \sin\theta\cos\phi & \sin\theta\sin\phi & \cos\theta \\ -1 & 0 & 0 \end{bmatrix} \quad \text{(a)}$$

$$+$$

$$|\overline{F}| \times |\overline{D}| \times \begin{bmatrix} \sin\theta\cos\phi & \sin\theta\sin\phi & \cos\theta \\ \cos\theta\cos\phi & \cos\theta\sin\phi & \sin\theta \\ -1 & 0 & 0 \end{bmatrix} \quad \text{(b)}$$

$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(viii)}$$

The first component of equation (viii), (a), goes to zero. The second component, (b), therefore, reduces to:

$$M_{\overline{D}} = |\overline{F}|\,|\overline{R}| \times (\sin^2\theta\sin\phi + \cos^2\theta\sin\phi)$$
$$= |\overline{F}|\,|\overline{R}|\sin\phi \quad \ldots\ldots\ldots \text{(ix)}$$

$\overline{F}$ is governed primarily by the tine size ($\overline{D}$, $\overline{R}$), depth of operation of the tool (soil factor), and, of course, the tool velocity.

Dynamic State

The dynamic state of the tool requires that the velocity vectors of each tine be determined with respect to the position vector. The peripheral velocity vector of the rotating tines, $\overline{V}_O$, is defined as:

$$\overline{V}_O = \omega\,\overline{D} \times \overline{P}$$

Where ω = angular velocity of the rotating tines

But $\overline{P} = \overline{D} + \overline{R}$

Therefore,

$$\overline{V}_O = \omega\,\overline{D} \times \overline{P} = \omega\,\overline{D} \times (\overline{D} + \overline{R})$$
$$= \omega\,\overline{D} \times \overline{R}$$
$$= \omega \times |\overline{R}|$$

$$\times \begin{bmatrix} i & j & k \\ Sin\theta\, Cos\phi & Sin\theta\, Sin\phi & Cos\theta \\ Cos\theta\, Cos\phi & Cos\theta\, Sin\phi & -Sin\theta \end{bmatrix} \quad (x)$$

Expanding equation (x) gives:

$$\bar{V}_o = -\underline{i}\,(\omega\,|\bar{R}|\,Sin\phi)$$
$$+\underline{j}\,(\omega\,|\bar{R}|\,Cos\phi)$$
$$+\{\underline{k}\;\;\omega\,|\bar{R}|\,(Sin\theta\, Cos\theta\, Sin\phi\, Cos\phi - Sin\theta\, Cos\theta\, Sin\phi\, Cos\phi)\}$$
$$= -\underline{i}\,(\omega\,|\bar{R}|\,Sin\phi) + \underline{j}\,(\omega\,|\bar{R}|\,Cos\phi) \;\ldots\ldots\; (xi)$$

The absolute velocity vector for each tine, $\bar{V}_a$, is defined as:

$$\bar{V}_a = \bar{V} + \bar{V}_o$$

Where

$\bar{V}$ = forward (translatory) velocity vector in the direction of pull = U_{xi}

Hence,

$$\bar{V}_a = \bar{V}_o + U_{xi}$$
$$= \underline{i}\,(U_x - \omega\,|\bar{R}|\,Sin\phi) + \underline{j}\,(\omega\,|\bar{R}|\,Cos\phi) \;\ldots\; (xii)$$

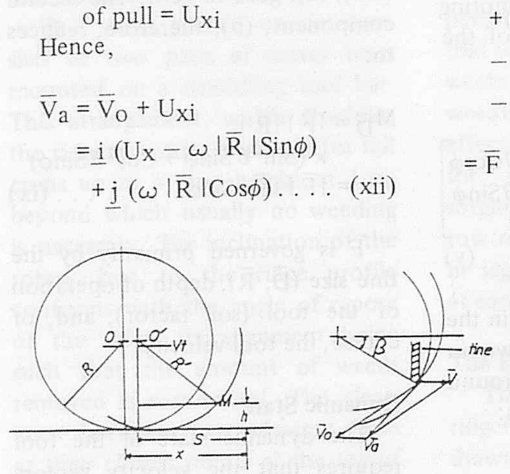

Fig. 5 Velocity components of a rotary hoe.

Based on our assumed direction of travel of the tool, $\bar{F}$ can be computed in terms of the changing magnitude of $\bar{F}$ ($|\bar{F}|$), a scalar quantity, and the tool velocity for the following reasons:

(a) the direction of the force on the tine is:

$$(\omega\bar{D} \times \bar{P} - U_{xi}) = \bar{d} \qquad \bar{d} \neq \bar{D}$$

(b) the force, itself, is a function of the tine velocity with respect to the ground and the direction of travel:

$$\bar{F} = f\,(|\omega\bar{D} \times \bar{P} - U_{xi}|)$$

Therefore, the force vector, $\bar{F}$, can be expressed as:

$$\bar{F} = |\bar{F}|\,\frac{\bar{d}}{|\bar{d}|}$$

$$= |\bar{F}|\,\{(\omega\,|\bar{R}|\,Sin\phi - U_{xi}) \,/\, [(\omega\,|\bar{R}|\,Sin\phi - U_{xi})^2 + (\omega\,|\bar{R}|\,Cos\phi)^2]^{1/2} - (\omega\,|\bar{R}|\,Cos\phi) / [(\omega\,|\bar{R}|\,Sin\phi - U_{xi})^2 + (\omega\,|\bar{R}|\,Cos\phi)^2]^{1/2}\}$$

$$= \bar{F}\;\;(\omega\,|\bar{R}|\,Sin\phi - U_{xi})$$

$$/(\omega\,|\bar{R}|\,Cos\phi)\,[1/[(\omega\,|\bar{R}|\,Sin\phi - U_{xi})^2 + (\omega\,|\bar{R}|\,Cos\phi)^2]^{1/2} \;\ldots\ldots\; (xiii)$$

Equation (xiii) suggests that the force vector, $\bar{F}$, and hence, the draft, is strongly influenced by the radius vector, $\bar{R}$, and the forward velocity vector, $\bar{V}$. This is further illustrated by the motion diagrams of the rotary weeder as shown in Fig. 5. In Fig. 5 (b), the angular rotation of the tine, at time t, is:

$$\beta = \omega t \qquad 0 \leq \beta \leq 90°$$

The absolute trajectory of motion for each tine with respect to the axis of rotation is cyclic and is only influenced by the kinematic parameter, $\bar{\lambda}$

where

$$\bar{\lambda} = \bar{V}_o / \bar{V}$$

As a rule, for any weeds to be dislodged, $\bar{\lambda}$ must be greater than 1 for all soil working rotary tools[4].

Further, the kinematic parameter of the rotary tines, $\bar{\lambda}$ is influence by the cutting angle (ϵ), the rake angle (γ), and the augular rotation of the rotary tines.

The first period (cycle) of the cyclic rotation of the rotary tines spans 90 degrees as illustrated in Fig. 5 (c, d, e). The performance of $\bar{\lambda}$ in terms of the cutting angle (ϵ) must, of necessity, be evaluated

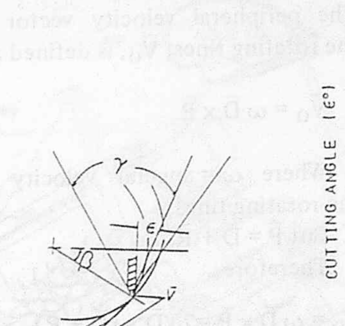
Fig. 5c Rake(γ) and cutting (ϵ) angles of rotating tine.

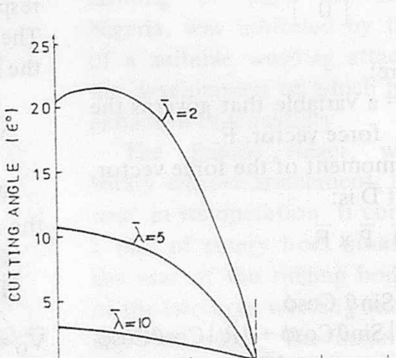

Fig. 5d Relationship between ϵ and β for different values of $\bar{\lambda}$.

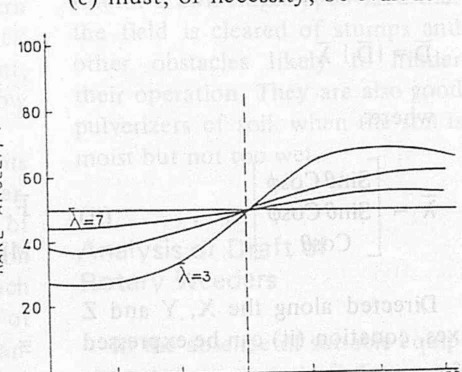

Fig. 5e Relationship between γ and β for different values of $\bar{\lambda}$.

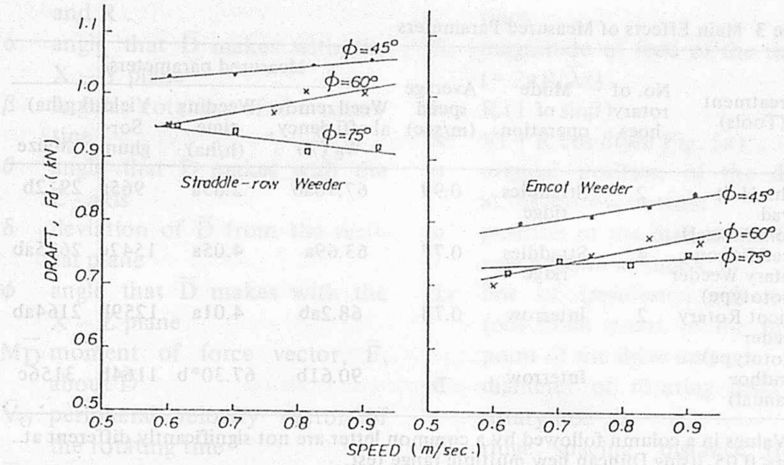

Fig. 6 Draft vs speed of rotary weeders.

Table 1 Parameter Selection for Design and Field Evaluation of Rotary Hoe

Parameter	Selection
Inclination of hoe with ridge profile, α	30-45°
Orientation of hoe in direction of travel	60°
Line of (resultant) pull, Lr	45-60°
Number of tines per side of disk, Z	5
Radius of tine, R	15 cm
Diameter of disk, d	15 cm
Angle between adjacent tines, β	36°
Ridge spacing, W	75-90 cm

at specified levels of β. The kinematic papameter of hoe tines ($\overline{\lambda}$), the cutting angle (ε) and the rake angle (γ) of the tines influence the working efficiency of the rotary hoe. Research has shown that $\overline{\lambda}$ value varies from 2 to 8 for Z value of to 5[5, 6]

The above analysis further suggests that the design and performance of rotary hoes are influenced by: i) radius of the hoe tines; ii) number of tines on each side of the rotating disk in the weeding plane; iii) kinematic parameter of hoe tines; and iv) weediness of the field.

Performance Evaluation

Parameter Selections

Preliminary investigations were conducted on the prototypes of these tools to determine the most optimum combination of tool parameters in order to achieve maximum weed removal and optimum draft. Investigations were conducted on a loamy soil during the growing season. The prototypes were designed based on the parameter selections shown in Table 1.

Field Investigations

Field evaluation of the two prototypes were carried out in groundnut, sorghum, maize and cotton fields, using randomized statistical design. These represent crops commonly grown at the study location. The rotor plates on each rotary hoe permitted variation in tool orientation with the direction of travel. The tool forward speed was monitored for each setting of tool parameter. The resultant pull along the line con-

Table 2 Performance Evaluation of Straddle-row and Emcot-attached Rotary Weeders

Tool	Tool parameters (degrees) θ	α	φ	Tool speed (m/sec) V	Resultant pull, Fr (kN)	Draft, Fd (kN) (Fr Cos45°)	Ave. weed weight (kg/m²)	Comments
Straddle row Rotary Weeder	60	30	45	0.60 0.70 0.82 0.91	1.46 1.46 1.49 1.50	1.03 1.03 1.05 1.06	0.14	Data collected from maize/cotton/ groundnut plots. Ridges constructed with Emcot and Ariana ridgers. Weeding commenced at 2½ weeks after planting. Average soil moisture content = 12.5% d.b.
	60	30	60	0.60 0.76 0.81 0.90	1.34 1.37 1.43 1.41	0.95 0.94 1.01 1.00	0.10	
	60	30	75	0.61 0.70 0.81 0.92	1.34 1.33 1.27 1.30	0.95 0.94 0.90 0.92	0.16	
Emcot-attached Rotary Weeder	60	30	45	0.64 0.75 0.84 0.91	1.12 1.15 1.17 1.20	0.80 0.81 0.83 0.85	0.12	Data collected from maize/cotton/ groundnut plots. Ridges constructed with Emcot and Ariana ridgers. Weeding commenced at 2 weeks after planting. Average soil moisture content = 10.5% d.b.
	60	30	60	0.60 0.75 0.84 0.92	0.99 1.06 1.10 1.09	0.70 0.75 0.78 0.77	0.09	
	60	30	75	0.62 0.70 0.81 0.90	1.02 1.05 1.03 1.06	0.72 0.74 0.73 0.75	0.23	

necting the hitch point of the tool to the yoke of the draught animals was monitored with a calibrated spring type dynamometer. The line of pull (Lr) was at 45° with the horizontal throughout the investigation. The time taken to traverse the length of each ridge was obtained with a stop watch.

The optimum selections for the tool parameters were θ of 60°, α of 30° and ϕ of 45°, 60° and 75°, respectively, as shown in Table 2. Three weedings were carried out and the weeds assessed by weed weights. A 0.5 m^2 iron frame was placed at randomly selected locations along the ridge profiles and weeds contained were carefully collected and weighed. The result was the average for three locations for each investigation. Weed assessment was carried out just before the second and third weedings respectively. Soil moisture content was determined at 0 to 10 cm soil depth at sample locations during each investigation.

The performance of the two prototypes were again compared with Strad, the commercially built straddle-row weeder and with the manual method of weed control (handhoeing). In each case, weeds were assessed by counting prior to and immediately after each weeding operation. The result is the average value over all weeding operations for the particular prototype. Fig. 7 illustrates the three rotary weeders.

Fig. 7 Prototype rotary weeders: left to right – Strad, Emcot-attached (interrow) rotary weeder, High-clearance straddle-row rotary weeder.

Table 3 Main Effects of Measured Parameters

Treatment (Tools)	No. of rotary hoes	Mode of operation	Average speed (m/sec)	Measured parameters+ Weed removal efficiency, W_e (%)	Weeding time (h/ha)	Yield (kg/ha) Sorghum	Maize
John Holt Strad (Commercial)	2	Straddles ridge	0.99	67.70ab	2.85a	965a	2912b
Straddle-row Rotary Weeder (Prototype)	4	Straddles ridge	0.77	63.69a	4.05a	1542c	2625ab
Emcot Rotary Weeder (Prototype)	2	Interrow	0.78	68.2ab	4.01a	1259b	2164ab
Handhoe (Manual)	–	Interrow	–	90.61b	67.30*b	1164b	3156c

+ Values in a column followed by a common letter are not significantly different at $p \leq 0.05$, using Duncan new multiple range test.
* Man-h/ha

Results and Discussion

Table 2 and Fig. 6 show that increasing the values decreases draft for the range of tool velocity experimented with. The value of 60° represents the optimum setting for each prototype. Statistical analysis of variance, using randomized design, showed that the treatment variation was significant when tested at 5% level. Table 3 gives the results of the main effects of the prototype weeders in comparison with handhoeing and the commercially available Strad. Despite higher speed of operation of Strad, its weed removal efficiency was not significantly different from the prototype weeders. Handhoeing gave good result in terms of weeding efficiency but weeding time was significantly higher than those of the prototype weeders. The yield of maize under manual method of weed control was also significantly higher than for the mechanical tools, otherwise, the yield results were comparable.

Conclusion

1. There is need to adapt existing technologies in solving agricultural mechanization problems in developing countries.
2. Development of draught animal-drawn rotary weeders can be optimized through appropriate combinations of design parameters.
3. Higher draft was experienced with the straddle-row rotary weeder than with the Emcot-attached rotary weeder. This was due to increased effort required to pull the straddle-row weeder together with the operator. The fixed connection of the Strad to the yoke of draught animals did not permit monitoring of its draft.
4. For the prototype tools, increasing ϕ values decreases draft. Optimum draft for maximum weed removal was attained at ϕ of 60°.
5. The cost of fabricating Straddle-row weeder was about U.S.$1 500 (1987). The Emcot-attached rotary weeder would cost about one-half that of Straddle-row weeder.

List of Symbols

$\bar{D}$ vector denoting axis of rotation of rotary hoe
$\bar{F}$ force vector
$|\bar{F}|$ magnitude of force (scalar quantity) in the direction of travel
$\bar{R}$ vector denoting the radius of rotary hoe
$\bar{P}$ position vector defined by $\bar{D}$

and $\bar{R}$

α angle that $\bar{D}$ makes with the X – Y plane

β angular rotation of the rotary tine

θ angle that $\bar{D}$ makes with the Z - axis

δ deviation of $\bar{D}$ from the vertical plane

ϕ angle that $\bar{D}$ makes with the X – Z plane

$M_{\bar{D}}$ moment of force vector, $\bar{F}$, about $\bar{D}$

$\bar{V}_o$ peripheral velocity vector of the rotating tine

$\bar{V}$ forward (translatory) velocity vector of the rotating tine

$\bar{V}_a$ absolute velocity vector of the rotating tine

Vt advance of the disk at time t

λ kinematic parameter of rotary hoe tines

z number of tines (rods) per side of disk

ω angular velocity of rotating tines

S magnitude of feed of the tines ($= 2\pi R/\lambda z$)

h $R(1 - \sin\beta)$

x $Vt + \bar{R}\cos\beta$ (see Fig. 5a)

o original position of the disk at the furrow bottom

o′ position of the disk at the furrow bottom at time t.

Lr line of (resultant) pull from tool hitch point to the hitch point of the drive unit

d diameter of rotating disks of rotary hoe

W ridge spacing: distance from centre to centre of two adjacent ridges.

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(Continued from page 42)

Design and Development of Potato Grader

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Total Milled and Head Rice Recoveries of Paddy as Influenced by its Physico-varietal Characteristics

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Abstract

Eleven paddy varieties representing different growth durations ranging from 100-190 days were tested for their milling quality (total milled and head rice) and bending strength at three levels of moisture content (12%, 14% and 16%). Used were five IR varieties and six Philippine traditional varieties. Results of the study show that grain moisture content and variety had profound effects on the milling quality. Higher values of total milled rice and head rice were observed at lower moisture content levels of 12%, wet basis. Bending strength of grains was inversely related to grain moisture content. Grains at lower moisture content levels had harder kernels as shown by their higher values of bending strength. This further explains the phenomenon on why milling at lower moisture content levels has higher values of total milled and head rice recoveries. Results of the study also reveal that the milling quality was also a function of growth duration as shown by the increasing trend of milling quality, particularly head rice recovery, with increasing growth durations.

Acknowledgements: The comments and suggestions of Dr. Carlos R. del Rosario, Dr. Emerico R. Mendoza and Dr. Bienvenido O. Juliano are gratefully acknowledged.

Introduction

One of the main problems that beset the rice industry is the degree of kernel damage during milling. In general, the volume of broken kernels ranges from 15.82-72.76%, with an average of 40.19% of the total milled rice for the rubber roll type rice mills (NFA 1985). Essentially, this offers a great loss because they lower the market value of the product. The ultimate goal of the rice industry is to achieve maximum total and head rice yields from the milling process and to keep loss in quality to the minimum. While there have been many identified factors affecting milling quality, its extent of increase or decrease at different moisture content levels as influenced by the grains physical properties, i.e., mechanical properties, is not yet known. Information on the effect of physical properties on growth duration is also scarce. In fact, no attempt has been undertaken to investigate the milling quality of paddy with very long growth duration as compared to those high yielding varieties which have shorter growth durations.

Therefore, a knowledge of the physical and varietal properties of paddy including its growth duration can be used to relate milling quality of paddy samples. Moreover, information obtained from mechanical properties yields a clearer understanding of the mechanical behaviour of the kernel, and why milling at lower moisture content yields higher milling quality. It also provides vital information as to the milling performance of varieties of different growth durations which prove useful to varietal improvement. Data generated in this study could also serve as benchmark information to rice breeders in screening potential varieties.

Review of Literature

Rice research scientists have already identified many factors affecting milling quality. Kunze (1985) has grouped these factors into two major divisions: the engineering and varietal factors. Engineering factors include harvesting, handling, drying, storage, transport and milling operations while varietal factors include the physical and mechanical properties of grain.

Stahel (1935) studied the correlation between moisture content and breakage with 11 Surinam rice varieties. Each variety was harvested between 20-24% moisture content and sun-dried. Results show that in all varieties, optimum head rice yield was recorded when paddy moisture ranged from 10-11%. Test results obtained by Stipe, et al (1971) show that the quality of milled rice is low when paddy is shelled at high moisture levels. Head rice recovery decreased at high moisture levels, particularly for long varieties. Medium grain varieties, however, show no significant differences at varying moisture levels. Experiments by Wasserman (1963) show that the drier the rough rice, the higher is the milling yield. Grain moisture affects the strength of the paddy in resisting the forces that break it with too little or too much moisture.

Of the varietal characteristics of paddy, grain size and shape are considered the most stable properties of the variety (Juliano, 1985). Grains are classified whether they are long, medium long or short. Grain shape refers to the length-width ratio of brown rice. As such, grains are subclassed as slender, medium slender or bold. Round grains are difficult to break, whereas the slender grains break rather easily (van Ruiten, 1979).

Closely related to grain size and shape is hull weight of paddy. In general, the weight of hull as a percentage of the weight of paddy ranges from 17-24%, with lower values for short and round grains while higher values for the long and slender grains (van Ruiten, 1979). He contends that varieties of lower hull weight results to higher milled rice recovery.

Another varietal character which has not been given attention is growth duration which refers to the number of days from sowing to maturity or harvest period. In his milling studies in Burma under the "Paddy and Storage Project," Andales (1985) found out that two Burmese varieties with growth duration ranging from 160-170 days had relatively higher milling recoveries than those with growth durations of 130-140 days.

One of the mechanical properties of grains that is most often used as an estimate of grain hardness and moisture content is its bending strength. While grain hardness has also been determined with instrumentation, its relationship to tolerance to grain cracking has not yet been determined (Juliano, 1985). Likewise, its relationship to milling quality has not been established.

Materials and Method

The main basis for the selection of paddy varieties was growth duration. Five IR varieties and six Philippine traditional varieties were used in the study. These were IR 58, IR 64, IR 54, *Rinato,* IR 42, IR 48, *Ampipit, Makan-kumpol, Piling-daniel, Mistiso* and *Balasang* representing 100, 110, 120, 125, 130, 140, 150, 160, 170, 180 and 190 days of growth duration, respectively.

Preparation of Test Materials

Grain samples of IR varieties and *Rinato* were freshly harvested from the IRRI experimental farms and manually threshed. The traditional varieties were collected from different parts of the country.

About one kg sample of cleaned threshed paddy was taken from which its initial moisture content was determined using the Brown Duvel method. The paddy were dried into three moisture levels using a laboratory grains drier at an average drying air temperature of 30°C. The dried samples were then placed in polyethylene bags and sealed in order to maintain their moisture content.

Milling Test and Grain Analysis

Standard procedures for determining milling quality was followed. For each variety and at specified level of moisture content, the grains were cleaned by passing through the Bate's aspirator twice to remove foreign impurities. From the cleaned sample, 200 g of paddy were hulled using the laboratory Satake rubber roll huller. Unhulled paddy were handpicked and separated from the brown rice, and weights of each part were measured. The collected brown rice were whitened through the Satake abrasive whitener at a retention time of 1 minute. The weight of total milled rice was recorded. Head rice was separeted using laboratory indented trays. The weight of head and broken rice were taken.

Bending Strength Measurement

For each variety and at each moisture content level 30 grains were manually dehulled from which 10 good brown rice kernels were selected. Their selection was based on the absence of fissures, flinty appearance and absence of chalkiness or "white belly" portion. Fissures were inspected using a Fiber Optic Illuminator, Model J-9745-00 (**Fig. 1**).

The bending strength of individual grains was measured using an Instron testing machine, Table Model 1140 (**Fig. 2**). Each good brown rice kernel was positioned across two parallel edges of the test cell base, designated as anvil. A plunger with an edge across its end was mounted on the crosshead, which was moved downward toward the grain at a crosshead speed of 50 mm/min until the rice kernel broke. Values of breaking force were read from a built-in pen recorder. The instrument uses a straingage type load cell in determining the breaking force of each kernel.

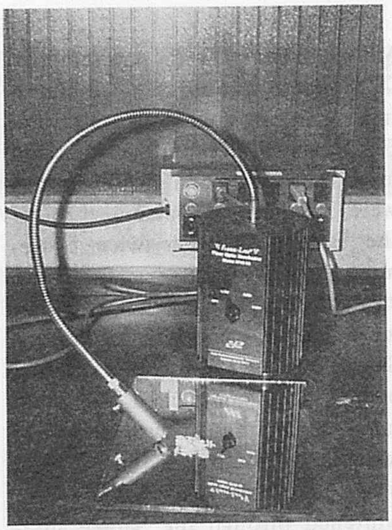

Fig. 1 Fiber optic illuminator (Courtesy of IRRI Cereal Chemistry Dept).

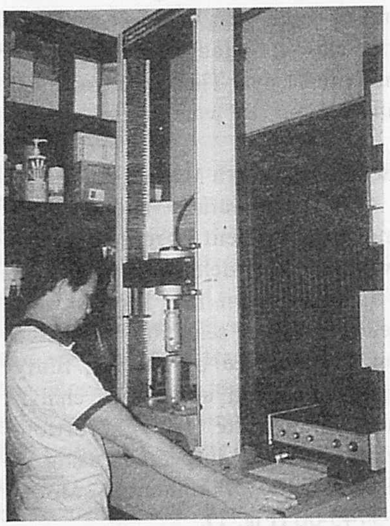

Fig. 2 Instron, Table Model 1140 (Courtesy of IRRI Cereal Chemistry Dept).

Results and Discussion

There were two sets of data collected for the study. The first set included test results at three moisture content levels of the six varieties raised at the IRRI experimental farms. The second set included an additional five traditional varieties with longer growth durations ranging from 150-190 days and tested at 14% moisture content level only. Discussions on the effect of moisture content and bending strength to milling yield were based on the first set of data involving the six varieties. The effect of growth duration, grain chalkiness and husk content were based on the 11 varieties using test results at 14% moisture content level.

Milling Quality

The milling quality of paddy is expressed in terms of the total milled rice and total head rice. Table 1 shows the total milled and

Table 1 Average Total Milled and Head Rice Recoveries and Bending Strength of Six Varieties at Three Levels of Moisture Content

Variety	Growth duration (days)	Moisture content (%)	Total milled rice (%)	Total head rice (%)++	Bending strength (kg)
IR 58	100	12	67.36	56.87	2.40
		14	66.17	55.52	1.81
		16	65.65	53.23	1.52
IR 64	110	12	68.39	57.62	2.35
		14	67.16	55.25	1.90
		16	64.89	52.23	1.78
IR 54	120	12	69.31	58.77	2.47
		14	67.66	55.97	2.06
		16	65.84	53.82	1.85
Rinato	125	12	70.12	60.07	2.26
		14	68.45	57.06	1.96
		16	66.72	54.75	1.24
IR 42	130	12	66.79	57.92	2.03
		14	65.19	54.68	1.21
		16	63.42	52.18	0.97
IR 40	140	12	68.95	58.62	2.15
		14	68.25	57.02	1.72
		16	65.41	53.02	1.05

++ Based on weight of paddy

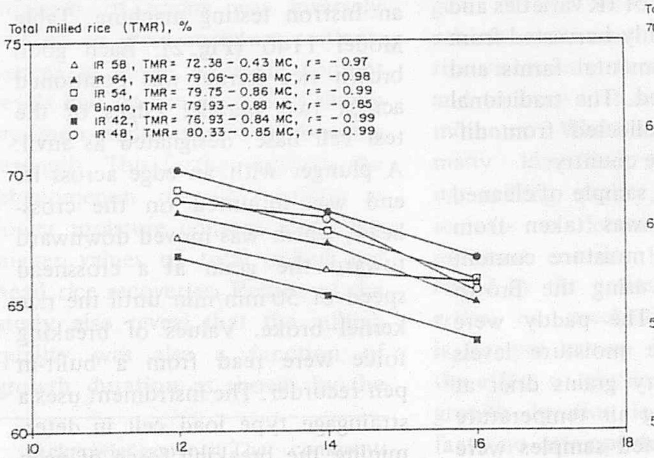

Fig. 3 Total milled rice of six varieties as affected by moisture content.

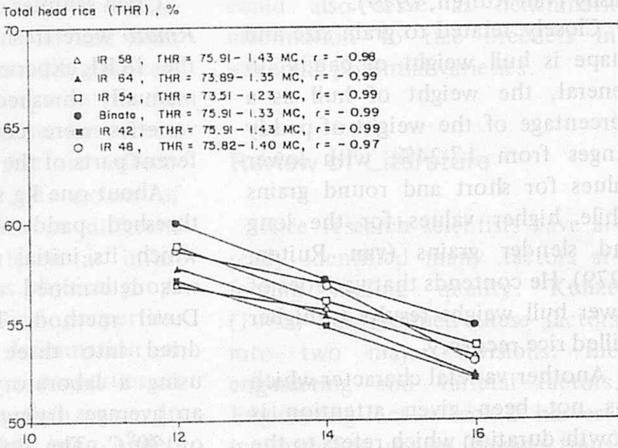

Fig. 4 Total head rice of six varieties as affected by moisture content.

head rice recoveries of the six varieties at three levels of moisture content, wet basis. Results of the analysis of variance for total milled and head rice for the six varieties at three moisture content levels were highly significant at 1% level. Moreover, the analysis of variance showed a significant interaction effect between moisture content and variety. It indicates that varietal differences do not remain the same at different moisture content levels and that total milled and head rice responses to moisture content vary with vareities. In all the varieties, lower grain moisture content had higher total milled and head rice than those with higher moisture content levels (Figs. 3 and 4).

Bending Strength

Table 1 shows the bending strength of the different varieties at three levels of moisture content. Analysis of variance for bending strength was highly significant at 1% level. Bending strength was significantly affected by moisture content. In all the varieties tested, the 12% moisture level had the highest bending strength and lowest at 16% as shown in **Fig. 5**. Higher moisture content levels imply softer grains while lower moisture content imply harder grains.

Bending Strength and Milling Quality

When the paired values between bending strength and total milled and head rice were plotted in a scatter diagram, it showed a general trend of increasing total milled and head rice as the bending strength is increased (**Fig. 6**). It must be noted that values in the upper right portion of the graph are those with lower moisture content levels. While those in the lower left portion are those with higher moisture content.

Effect of Growth Duration

While many factors have already been studied affecting milling yield, very little information is available on the effect of growth duration. Table 2 shows the total milled rice and total head rice for the 11 varieties representing different growth durations tested at 14% moisture content. Analysis of variance for total milled rice and total head rice was statistically significant with growth durations at 1% level of significance. In order to isolate the effect of growth duration, those varieties with long and slender grain size and very minimal chalky kernel were selected for investigation. These were IR 64, IR 54, IR 48, *Makan-kumpol* and *Balasang*, representing 110, 120, 140, 170 and 190 days growth duration. **Figures** 7 and 8 show the trend of total milled and head rice recovery with growth duration. Total milled rice was not significantly correlated with growth duration at 5% level of significance. For

Table 2 Summary of Mean Total Milled and Head Rice Recoveries of 11 Varieties Tested at 14% Moisture Content

Variety	Growth duration (Days)	Total milled rice (%)	Total head rice (%)	Grain size	Husk content (%)
IR 58	100	66.17	55.53	Medium-long slender	21.96
IR 64	110	67.17	55.25	Long slender	22.00
IR 54	120	67.66	55.98	Long slender	22.06
Rinato	125	68.45	57.06	Short bold	20.93
IR 42	130	65.19	54.68	Medium-long slender	21.83
IR 48	140	68.25	57.03	Long slender	22.76
Mistiso	150	59.96	41.93	Long slender (chalky)	25.34
Piling-daniel	160	68.20	58.13	Medium-long slender	23.60
Makan-kumpol	170	68.02	58.74	Long slender	24.03
Ampipit	180	66.94	56.85	Medium-long slender	23.36
Ralasang	190	68.15	63.86	Long Slender	23.79

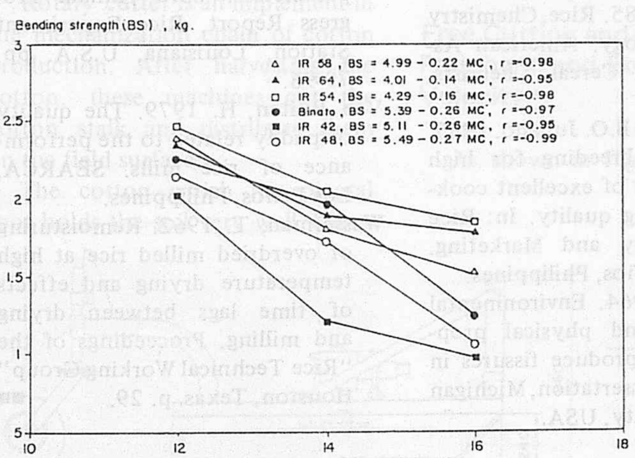

Fig. 5 Bending strength of six varieties as affected by mositure content.

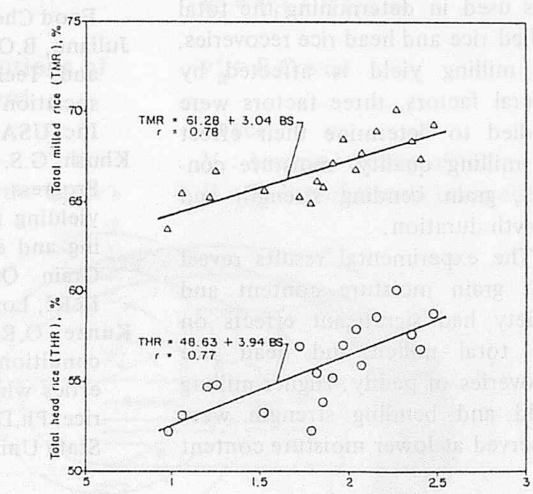

Fig. 6 Effect of bending strength on total milled rice and head rice recoveries.

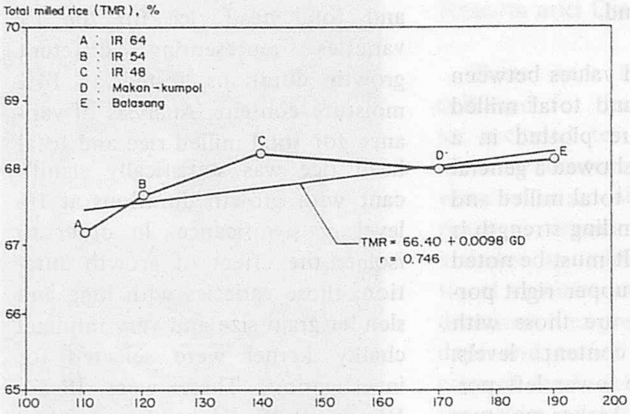

Fig. 7 Total milled rice of five varieties of different growth durations at 14% moisture content.

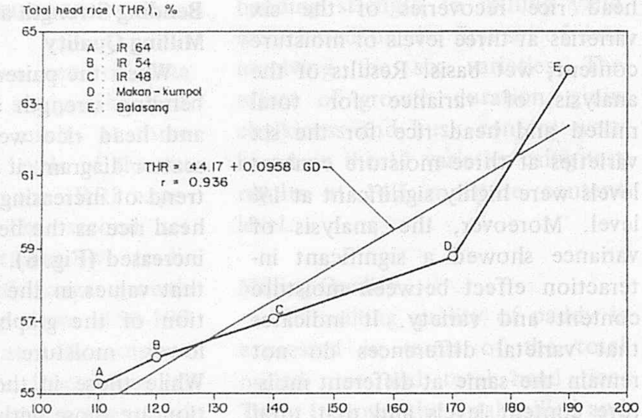

Fig. 8 Total head rice of five varieties of different growth durations at 14% moisture content.

total head rice growth duration was significantly correlated at 5%. *Balasang* has a high total milled rice despite its high husk content because it has low percentage of broken grains. This new finding indicates that milling quality is also a function of paddy growth duration, among others. It must be noted, that *Balasang* had an appreciable amount of total head rice of 63.86% as compared to the other varieties.

Summary and Conclusions

Standard laboratory method of assessing milling quality of paddy was used in determining the total milled rice and head rice recoveries. As milling yield is affected by several factors, three factors were studied to determine their effect on milling quality: moisture content, grain bending strength and growth duration.

The experimental results reveal that grain moisture content and variety had significant effects on the total milled and head rice recoveries of paddy. Higher milling yield and bending strength were observed at lower moisture content levels. As such, this explains why milling at low moisture levels gives higher milling yiled. Results also show an increasing trend in milling yield, particularly total head rice with increasing growth durations. As such, milling quality is also a function of growth duration.

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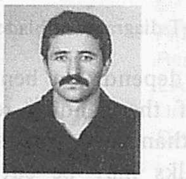
The Theory of Free Cutting and its Application on Cotton Stalk



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Abstract

Rotary cutters are produced by some small agricultural machinery factories in the Çukurova region of Turkey. These machines work according to the free cutting principle. Although rotary cutters are similar, there are some differnces among them. The aim of this study was to determine some properties of rotary cutters. These are peripheral velocity, energy of impact, curves of free cutting, cutting points, and force of cutting. This study was done in the laboratory and on field conditions.

Introduction

Rotary cutter is an implement in the mechanization chain of cotton production. After harvesting the cotton, these machines cut the cotton stalk and distribute them on the field surface.

The cotton which has pivotal root holds the soil very well. More-over moisture is reduced in the cotton stalks and some of the stalks dry up. The elastic structure of the stalk becomes brittle. When the cutting height is 10 or 15 cm, the diameter of stalks range between 10 to 25 mm.

The rotary cutter is a blade system which pivots horizontally on the vertical shaft and moves drawning on the field (Fig. 1). Power taken from the p.t.o. after passing over the conical gear box is transferred to the blade shaft. The cutting system consists of four blades with a clearance angle of 90°. Peripheral velocity of the blade is changed between 60-80 m/s, and running speed is about 800-1000 r.p.m.

Free Cutting and Relations of Peripheral and Forward Velocity

As shown in Fig. 2, the blade's axis which is capable of rotating about point "O" in horizontal plane, translates it along on X axis line. Forward and peripheral motion of blade's edge aa' sweeps the area between number "1" cycloids.

The edge bb' sweeps the area between number "2" cycloids. When the peripheral velocity is constant the width of the hatched area depends on the forward velocity of tractor. When the forward velocity is increased, some of the stalks cannot be cut. For this reason, a suitable ratio is found between the peripheral velocity of the blade and the forward velocity of the tractor. Equations of the path of point "a" are as follows.

$$x'_a = V_f t + R \sin \omega t \qquad (1)$$

$$y'_a = R \cos \omega t \qquad (2)$$

Hence,

V_f: Average velocity of tractor
R : Radius of tracing blade end

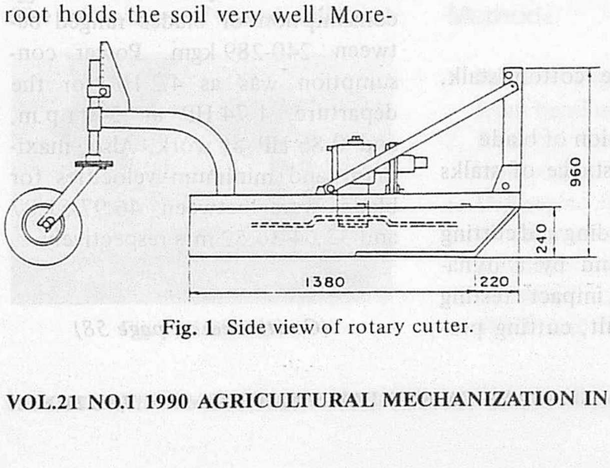

Fig. 1 Side view of rotary cutter.

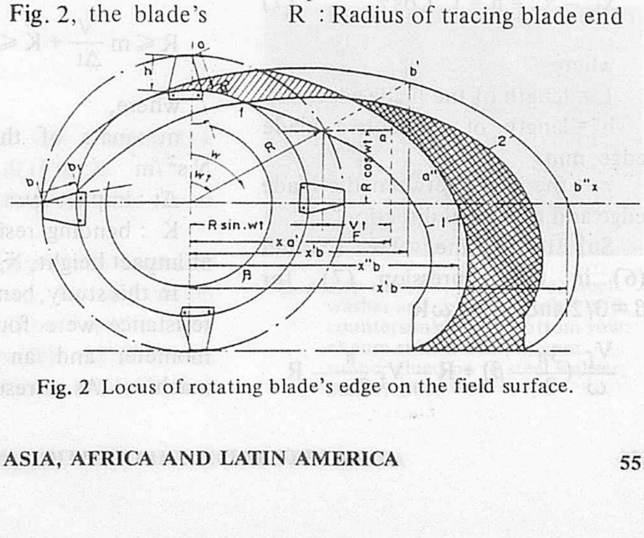

Fig. 2 Locus of rotating blade's edge on the field surface.

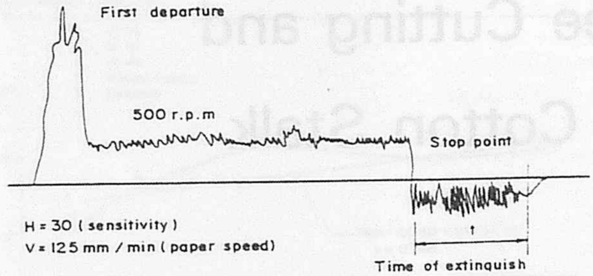

Fig. 3 Change of torque on the PTO.

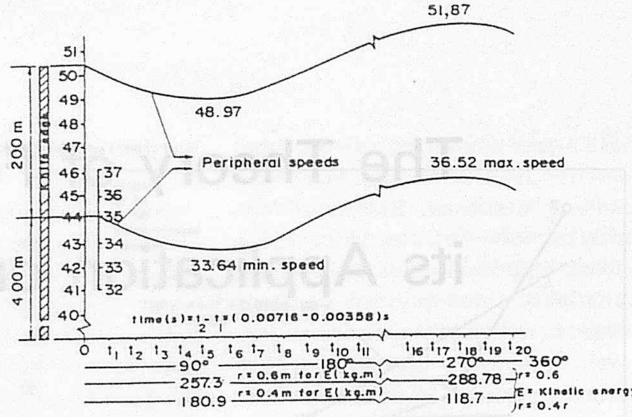

Fig. 4 Change of V-T diagrams of blade.

ω : Angular velocity of blade end

The situation of point b',

$$x'_b = V_f t + R\,\mathrm{Sin}\,(\beta + \omega t) \qquad (3)$$

$$y'_b = R\,\mathrm{Cos}\,(\beta + \omega t) \qquad (4)$$

Because of the phase differences between the blades, as $\pi/2$, $\omega t = \pi/2$, and $t = \pi/2\omega$.

Substituting this value in the expressions (1) and (2)

$$x''_a = V_f \frac{\pi}{2\omega} + R\,\mathrm{Sin}\,\omega \frac{\pi}{2\omega}$$

$$x''_a = V_f \cdot \frac{\pi}{2\omega} + R \qquad (5)$$

The second follower blade's edge bb' will cut x,

$$\omega t' = \frac{\pi}{2} + 2\pi - \beta = \frac{5}{2}\pi - \beta$$

Calculating the time t' and substituting the expressions (3) and (4),

$$x'_b = \frac{V_f}{\omega}\left(\frac{5\pi}{2} - \beta\right) + R \qquad (6)$$

For eliminating the unmoved area,

$$x''_b - x''_a = h = L.\,\mathrm{Cos}\,\tau \qquad (7)$$

where,

L = length of the blade edge, mm

h = length of the active blade edge, mm

τ = the angle between the blade edge and the travel direction

Substituting the values (5) and (6) in the expression (7), for $\beta = 3/2$ and $V_m = \omega R$

$$\frac{V_f}{\omega}\left(\frac{5\pi}{2} - \beta\right) + R - V_f \frac{\pi}{2\omega} - R$$

$$= h = L.\,\mathrm{Cos}\,\tau$$

$$\frac{V_f\pi}{\omega} \quad \frac{V_f\pi}{2\omega} = h = L.\,\mathrm{Cos}\,\tau$$

(1) (2)

$$\frac{2V_f\pi}{2\omega} \quad \frac{V_f\pi}{2\omega} = h \qquad \frac{V_f\pi}{2\omega} = h$$

Substituting this value to the above expression

$$\omega = \frac{V_m}{R}$$

$$\frac{V_f\pi}{2\frac{V_m}{R}} = \frac{V_f\pi}{1} \cdot \frac{R}{2V_m} = h$$

$$\frac{2}{\pi R} \cdot \frac{V_f \cdot \pi \cdot R}{2V_m} = h \frac{2}{\pi R}$$

$$\frac{V_m}{V_f} \geqslant \frac{\pi R}{2h} \geqslant \frac{\pi R}{2L\,\mathrm{Cos}\,\tau} \qquad (8)$$

Duration of the movement of the follower blade edges can be expressed as,

$$t = \frac{2\pi R}{4V_{nz}}$$

$$V_f t = L.\,\mathrm{Cos}\,\tau \qquad t = \frac{L\,\mathrm{Cos}\,\tau}{V_f}$$

If the resistance of cotton stalk is assumed as "R",

$$R \leqslant m\frac{V}{\Delta t} + K \leqslant m.a + K \qquad (9)$$

where,

m : mass of the cotton stalk, N s^2/m

Δt : impact duration of blade

K : bending resistance of stalks at impact height, N,

In this study, bending and cutting resistance were found by a dynamometer and an impact testing machine. As a result, cutting procedure depends on bending resistance. If the bending resistance is higher than cutting resistance, cotton stalks may be cut by rotary cutters. Power consumption which is taken from a tractor is measured by a torquemeter. This torquemeter is established between the rotary cutter and the tractor. Changing in torque of the p.t.o. is shown in Fig. 3.

Other basic engineering data for these cutters is the cutting velocity. These values are found according to the position of free cutting curves in Fig. 4. Peripheral velocity of the blade is calculated according to the first derivative of the horizontal and vertical distances with respect to time.

$$\frac{dx'}{dt} = R\,\omega\,\mathrm{Cos}\,\omega t + V_f$$

$$\frac{dy'}{dt} = -R\,\omega\,\mathrm{Sin}\,\omega t$$

$$V = \sqrt{V^2_{x'} + V^2_{y'}} \qquad (10)$$

Summary

As a result of this study, some basic engineering data were determined for rotary cutters. Energy consumption of blades ranged between 240-289 kgm. Power consumption was as 4.2 HP for the departure, 1.74 HP at 540 r.p.m. and 0.86 HP at work. Also, maximum and minimum velocities for blade were between 46.97-51.87 and 33.64-36.52 m/s respectively.

(Continued on page 58)

Adapting a Hand Mill to Hull Rice and Spelt Wheat

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Abstract

Construction of an inexpensive hand-operated huller for rice and spelt wheat using a hand mill is described. It is ideal for home and village scale usage. After hulling, the grains must be winnowed and the unhulled grains must be separated from the hulled grains.

Introduction

There are several machine designs for hulling rice. One common design is the two rubber roller system, with each roller rotating in opposite direction and different speed. Hulls are slipped off the kernels when grains are passed between the two rollers (Garboldi, 1974). Another rice huller design is the horizontal abrasive disk system, using one rotating disk and one stationary disk (Gariobold, 1974). The advantages of using rubber rollers are higher percentage of hulling, and less kernel breakage. The advantages of the abrasive disk system are ease of fabrication and of repair of the abrasive surface when it wears out.

The enclosed design uses a vertical abrasive disk system, (a hand mill, Fig. 1) to hull rice and spelt wheat. However, it incorporates some of the advantages of using rubber surfaces by replacing the stationary disk with a gum rubber disk. The abrasive rotating disk remains unaltered. This replacement of the stationary disk is not permanent, so the original purpose of the hand mill for grinding grains is retained.

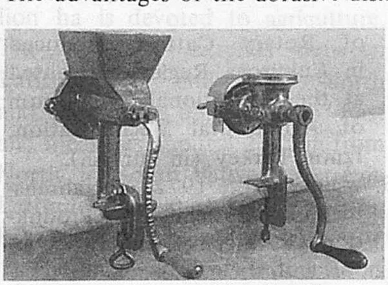

Fig. 1 Hand mills.

Materials

Materials required are one steel washer, one sheet of gum rubber, cyanoacrylate glue and a hand mill. The hand mills and stone disks described here are available from R&R Mill Co., 45 West First North Street, Smithfield, UT 84335, USA.

Methods

1. Remove auger and rotating disk from hand mill (Fig. 2).
2. Remove stationary disk from hand mill.
3. Determine the outside diameter of the stationary disk and obtain a suitably-sized steel washer. The "Corona" models 1CTSP and 4CKC and "Quaker City" hand mills use a 10 cm (4 inch) outside diameter steel washer with a 4.7 cm (1 7/8 inch) diameter hole (Fig. 3a). The "Bell" model 60 mill requires a 14 cm (5 1/2 inch) outside diameter steel washer. Drill out counter sink 3 holes on the washer for mounting onto hand mill (Fig. 3b).
4. Obtain a sheet of 3 mm (1/8 inch) thick gum rubber, of sufficient size to cover the steel washer. Gum rubber is preferred because it is relatively soft and

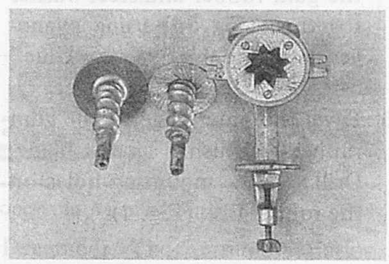

Fig. 2 Left to right: a) auger with stone rotating disk, b) steel burr disk, and c) view of the stationary disk.

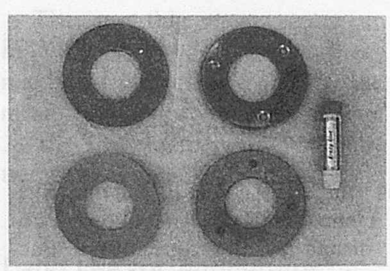

Fig. 3 Top row, left to right: a) steel washer and b) steel washer with countersunk holes. Bottom row: c) gum rubber disk, d) gum rubber glued on to steel wahser, and e) glue.

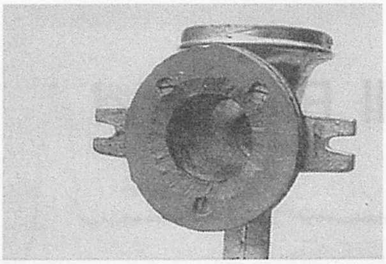

Fig. 4 Stationary gum rubber disk with beveled inner edge, mounted on to hand mill.

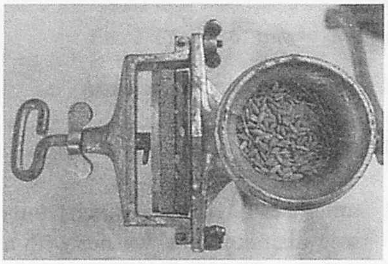

Fig. 5 Hand mill with stone rotating disk and rubber stationary disk.

abrasion resistant, although it is difficult to bond onto steel.

5. Cut the gum rubber to the shape of the steel washer (Fig. 3c). Rough up one side of the gum rubber and steel washer with a file. Clean the rough sides of the gum rubber and steel washer surfaces with acetone, or petroleum solvent. Glue the rough sides of the gum rubber and steel washer together (Fig. 3d) using cyanoacrylate glue (e.g., "Krazy Glue" or "Super Glue", (Fig. 3e).
6. Bevel the inner edge of the gum rubber disk using a razor blade. Drill out the mounting holes on the rubber disk (Fig. 4).

Table 1 Rice and Spelt Wheat Hulling Data Using a Modified Hand Mill with Stone and Steel Burr Rotating Disks

Disk	Rice			Spelt wheat		
	Rate (g/min)	Hulled (%)	Breakage (%)	Rate (g/min)	Hulled (%)	Breakage (%)
Stone	200	90	30	100	85	5
Steel	200	90	50	100	55	5

7. Mount gum rubber + washer onto hand mill (Fig. 4). Insert auger and rotating disk onto hand mill (Fig. 5).

Results and Discussion

Rice and spelt wheat hulling data are given in Table 1. The percentage of rice hulled varies from 85 to 95% depending on the rice cultivar and the spacing between the stationary rubber disk and the rotating abrasive disk. For spelt wheat, the percentage of hulling varies from 55 to 85 depending on the rotating disk material.

The results indicate a stone rotating disk, made from bond petrified carbon composite (Fig. 2a), is superior to a steel burr disk (Fig. 2b). The stone disk with greater friction, grabs the husks and pushes them through more vigorously, while the steel burr disk allows more grain slippage, resulting in a lower spelt wheat hulling rate, and a higher rice kernel breakage. Closer disk spacing increases the hulling percentage, kernel breakage and decreases the hulling rate (Table 1). The percentage of hulled rice is as low as 65 when the rotating disk is not parallel to the stationary disk. If the rotating disk is loosely attached to the auger shaft, grains wedge between the rotating disk and shaft keeping the rotating disk unparallel to the stationary disk. Well-made hand mills have bearings for both ends of the shaft and are able to maintain the rotating and stationary disks parallel to each other.

The described rice and spelt wheat huller using a hand mill is relatively inexpensive, easy to maintain and worn rubber disks are simple to replace. It is ideal for home, small scale farm and village usage.

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(Continued from page 56)

The Theory of Free Cutting and its Application on Cotton Stalk

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Comparative Study of Agricultural Mechanization in India and Indonesia

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Abstract

India and Indonesia have, in general, many things in common in agriculture. In this paper efforts have been made to identify some of the important aspects of agricultural mechanization for the mutual benefit of the two countries. Stress has also been laid on the areas of lateral cooperation between the two countries.

Location

India and Indonesia are on the eastern sub-continent of Asia, both surrounded by sea over their large perimeter. India has few islands but Indonesia has few thousand (main five islands are Sumatra, Java, Kalimantan, Sulawesi and Irian Jaya). Accordingly, it has its variations in climate and temperature.

India is a large agricultural country with total geographical area of 3 287 263 km^2 , of which 144 million ha is devoted to agriculture. The mainland extends between Latitudes 8° and 37°6′ North and Longitudes 68°7′–97°25′ East and measures about 3 214 km from North to South between extreme Latitudes and about 2 933 km from East to West Longitudes.

The land area of Indonesia is about 1 903 631 km^2, and its area

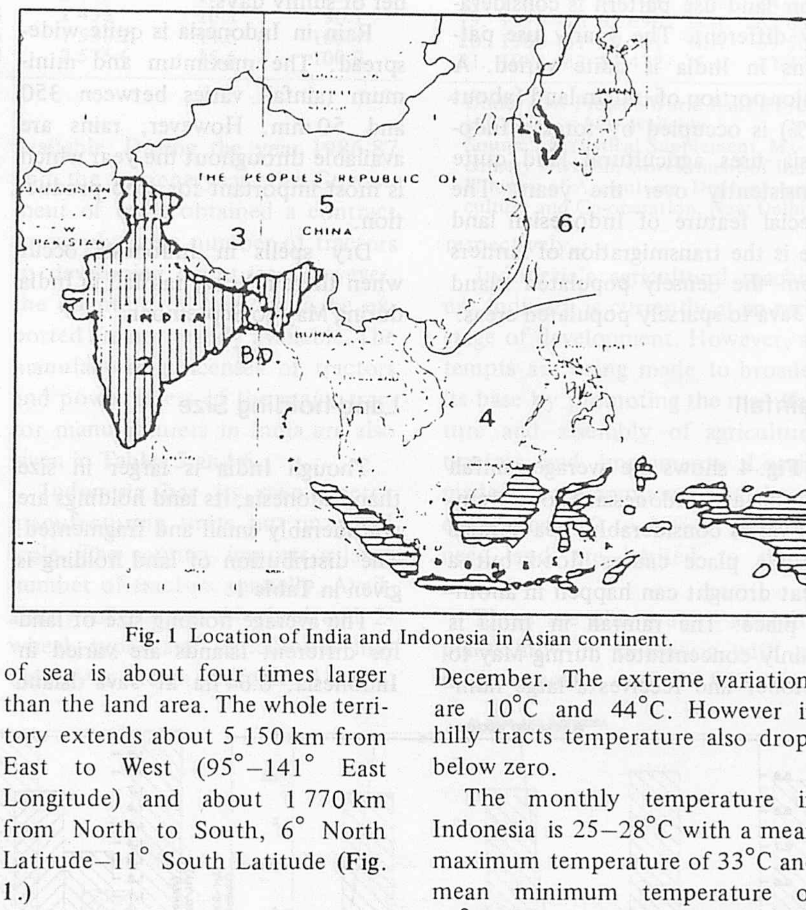

Fig. 1 Location of India and Indonesia in Asian continent.

of sea is about four times larger than the land area. The whole territory extends about 5 150 km from East to West (95°–141° East Longitude) and about 1 770 km from North to South, 6° North Latitude–11° South Latitude (Fig. 1.)

Temperature

India has a large variation as far as the temperature is concerned (Fig.2). The maximum temperature reaches 44°C in the months of April–May and lowest in January–December. The extreme variations are 10°C and 44°C. However in hilly tracts temperature also drops below zero.

The monthly temperature in Indonesia is 25–28°C with a mean maximum temperature of 33°C and mean minimum temperature of 21°C. The temperature in hilly tracts varies and usually it islow.

Land Use for Agriculture

The land use pattern for agriculture is shown in Fig. 3. Though both countries have large areas,

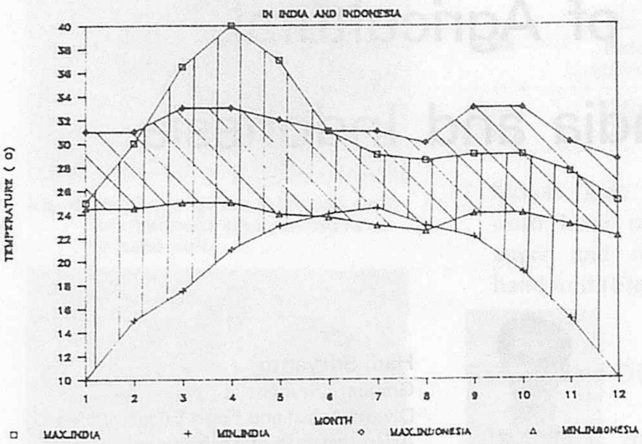

Fig. 2 Maximum and minimum temperature.

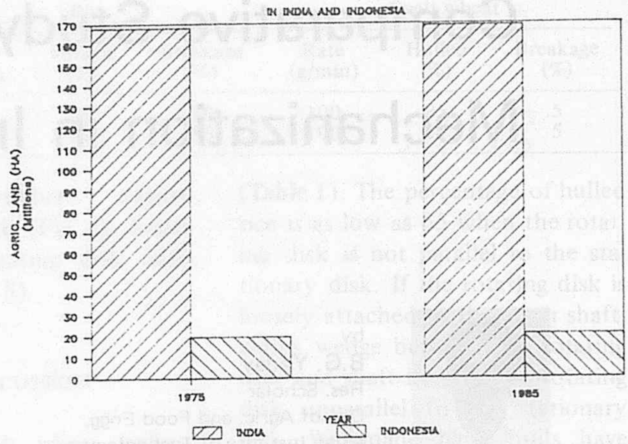

Fig. 3 Agricultural land area.

their land use pattern is considerably different. The yearly use patterns in India is quite varied. A major portion of Indian land (about 33%) is occupied by forests. Indonesia uses agricultural land quite consistently over the years. The special feature of Indonesian land use is the transmigration of farmers from the densely populated island of Java to sparsely populated areas.

Rainfall

Fig. 4 shows the average rainfall in India and Indonesia. Though rainfall varies considerably, heavy rains at one place causes flood but a great drought can happen in another place. The rainfall in India is mainly concentrated during May to October and receives a large number of sunny days.

Rain in Indonesia is quite widespread. The maximum and minimum rainfall varies between 350 and 50 mm. However, rains are available throughout the year which is most important for crop production.

Dry spells in Indonesia occur when there is heavy rainfall in India during May to September.

Land-holding Size

Though India is larger in size than Indonesia, its land holdings are considerably small and fragmented. The distribution of land holding is given in Table 1.

The average holding size of land for different Islands are varied in Indonesia. 0.64 ha at Java Island which is highly populated and 1.5 ha in other Islands outside.

Fertilizer Use

Fertilizer use in India was considerably low for many years. Some increase has been noticed only recently. The yearly use of fertilizer for crop production for India and Indonesia is shown in Table 2.

Crops Grown

The major crops of India are wheat, paddy, sorghum, millet, and maize. A comparative data on crop productivity in India and Indonesia is given in Figs. 5-7. It is observed that the number of crops grown in Indonesia is few but unit yields are

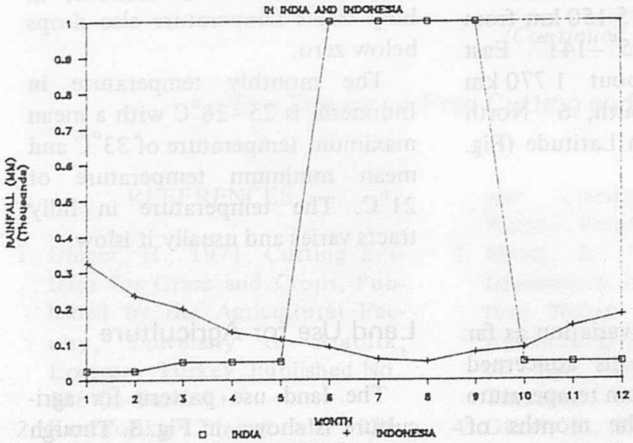

Fig. 4 Rainfall distribution.

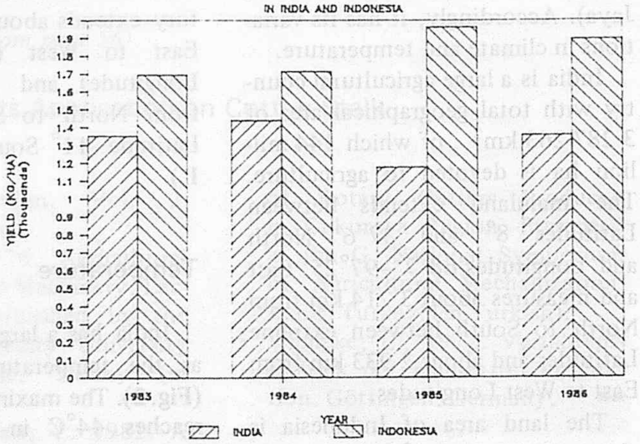

Fig. 5 Yield of maize.

Table 1 Agricultural Holdings, by Size in India

Size	Area (ha)	Total number of holdings (%)	Area under cultivation (%)
Small	up to 4	85	40
Medium	4 – 10	11	26
Large	10 and above	4	34

Table 2 Fertilizer Use in India and Indonesia

	India			Indonesia		
Year	Fertilizer N,P,K 10 kg	Area under principal crops 10 ha	Fertilizer kg/ha	Fertilizer N,P,K 10 kg	Area under principal crops 10 ha	Fertilizer kg/ha
75/76	2 509	30.5	82.2	489	14.4	34
77/78	4 034	28.2	143.1	615.4	14.4	42.9
78/79	4 511	31.3	144.3	763.4	15.5	49.2
79/80	4 941	32.2	153.6	855.7	15.1	56.7
80/81	5 230	30.8	169.9	1 173	15.4	75.9
81/82	5 724	31.1	183.8	1 435	16.1	90.1
82/83	4 865	33.2	146.5	1 530.2	14.5	105.4
83/84	6 626	27.8	238.8	2 575.6	15.6	100.9

Based on the information available.

Table 3 Indigenous Tractor Manufacture and Imports, India.

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

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

comparatively higher than in India for maize, rice, and other cereals.

Agricultural Mechanization Status

India has indigenous production of agricultural machinery and tractors (Table 3 and 7). Total availability of tractors and agricultural machinery is shown in Table 3. Some tractors are imported to meet the pressing demands of the farmers and Government agencies. The import of tractors was stopped during 1977-88. Additional information on the import of tractors is not available. During the year 1986-87 and the current year, the Government of India obtained a contract to supply large number of tractors to developing countries. However, the quantum of tractors to be exported are not readily available. The manufacturing licenses of tractors and power tillers of the major tractor manufacturers in India are also given in Tables 5 and 6.

Indonesia has its own tractor manufacturing units but in small scale. The country imports a large number of tractors annually. Availability of tractors (4-wheel and 2-wheel type) and agricultural machinery is shown in Tables 8 and 4, respectively.

Indonesia's agricultural machinery industry is currently at an early stage of development. However, attempts are being made to broaden its base by promoting the manufacture and assembly of agricultural tractors and implements. Locally made tractor components make up only about 10 to 15% of the total need and are limited to simple items.

There are nine tractor assembly plants now in Indonesia with annual capacity of 14 000 hand

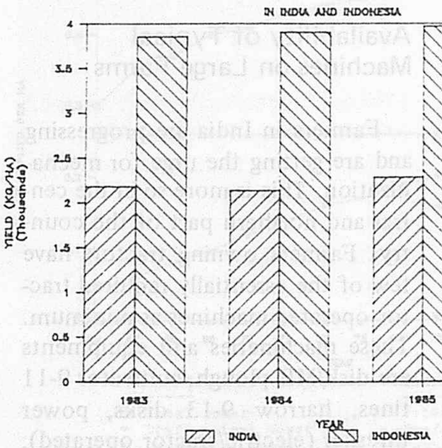

Fig. 6 Yield of rice.

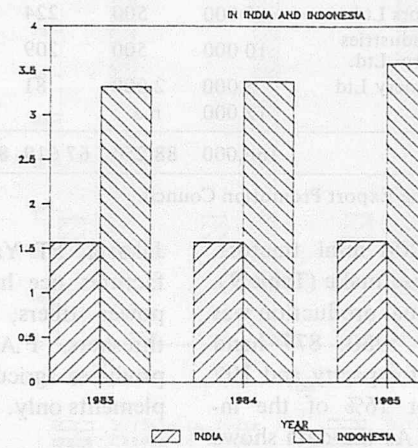

Fig. 7 Yield of other cereals.

Table 4 Distribution of Farm Machinery in indonesia (Unit: Number)

Type of machinery	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Tractor e)	10 500	10 800	11 300	11 800	13 000	13 000	13 800	14 200	14 800	13 603
7 – 8 Hp a)	692	759	1 132	1 650	1 650	4 337	3 777	6 443	7 642	–
12 – 15 Hp	74	44	287	1 110	1 110	1 368	5 072	2 543	2 253	–
40 – 60 Hp	130	145	174	661	661	701	419	849	–	
Crawler (90 Hp)	6	50	48	48	-	–	–	–	–	–
Power tiller	670	–	–	2 360	–	–	–	–	–	–
Hand sprayer c)	–	199,875	–	301 605	–	172 955	180 002	464 922	510 870	570 039
Mist blower	–	5 023	–	5 615	–	7 350	7 233	7 495	5 361	–
Power sprayer	–	25 420	–	44 441	–	1 379	775	893	901	–
Thresher										
Manual thresher	–	2 150	–	15 790	–	–	–	–	–	–
Power thresher	–	338	–	1 343	–	–	–	–	–	–
Dryer	–	–	–	–	–	103	1 244	1 121	1 111	975
Horizontal type	–	64	–	157	–	–	–	–	–	–
Vertical type	–	112	–	218	–	–	–	–	–	–
Cleaner	–	–	–	4	–	37	331	9 125	6 969	–
Rice mill (huller)	–	–	–	14 468	–	55 092	55 092	50 811	47 456	–
Manual weeder/cultivator	–	1 825 000	–	2 141 000	–	–	–	–	–	–
Power weeder/cultivator	–	270	–	350	–	–	–	–	–	–
Simple water life machine	2 732	2 732	–	3 424	–	–	–	–	–	–
Irigation pump d)	–	–	–	–	–	–	–	–	6 516	–

Source: a) Agricultural Development Planning Centre, 1983 Asian Statistical Yearbook on Food, Agriculture and Forestry 1970–1982. Bangkok, Thailand.
b) Asian Statistical Yearbook on Food, Agriculture and Forestry 1978–1984. Bangkok, Thailand.
c) Asian Productivity Organization, 1983, Farm Mechanization in Asia, Tokyo.
d) Biro Pusat Statistik, Agricultural Survey 1983 – 1984. Jakarta, Indonesia.
e) UN Statistical Yearbook 1975 – 1983.

Table 5 Licensed and Installed Capacities and Annual Production of Major Tractor Manufacturers, India, 1980-1983

Name of manufacturer	Capacity		Annual production			
	Licensed	Installed	1980	1981	1982	1983
Eicher Goodearth Ltd	17 000	13 500	10 635	12 477	9 732	8 010
Escort Tractors Ltd	10 000	7 500	6 001	7 304	7 286	6 930
Escorts Ltd	16 000	14 000	11 295	13 480	9 211	9 406
HMT Ltd	15 000	11 000	7 551	11 030	10 012	9 890
Punjab Tractors Ltd	12 000	10 500	8 113	10 106	7 465	5 941
Mahindra & Mahindra Ltd	15 000	14 000	11 599	13 732	10 579	xxxx
Kirloskar Tractors Ltd	10 000	2 000	2 153	1 663	647	575
Gujarat Tractor Corp. Ltd	7 000	2 500	1 019	2 002	372	867
Pittie Tractors Pyt Ltd	10 000	500	130	31	66	42
Harsha Tractors Ltd	10 000	1 000	795	897	245	115
Tractor & Farm Equipment Ltd	12 000	8 750	7 794	8 862	8 258	8 387
United Auto Tractors Ltd	5 000	500	224	150	225	–
Bihar State Agro-Industries Development Corp. Ltd.	10 000	500	209	433	114	23
Eicher Farm Machinery Ltd	5 000	2 000	81	2 105	2 441	2 389
Auto Tractors Ltd	12 000	n.a.	–	48	364	381
Total	166,000	88 250	67 619	84 320	68 067	62 811

Source: Engineering Export Promotion Council.

tractors and 1 200 mini tractors, largely of Japanese make (Table 9). However, the actual production was much lower in 1980: 877 hand tractors or 6% of capacity and 192 mini tractors or 16% of the installed capacity. As the data shows the largest plant is PT Indonesia in Jakarta. PT Yamundo also manufactures rice hullers and polishers, power tillers, rubber rollers and threshers. F.A. Sarasah industry produces agricultural tools and implements only.

Availability of Power for Agriculture

Both India and Indonesia have manual, animal (buffaloes and oxen) and mechanical power sources for use in agriculture. The details of power availability in India and Indonesia are shown in Figs. 8 and 9. The available power sources in India is 0.80 Hp/ha and in Indonesia 0.40 Hp/ha.

Availability of Typical Machines on Large Farms

Farmers in India are progressing and are getting the urge for mechanization. This is more so in the central and northern part of the country. Farmers owning tractors have few of the essentially required tractor operated machines as minimum. These machineries and equipments are disk/MB plough, cultivator 9-11 tines, harrow 9-13 disks, power thresher (electric/tractor operated), seed-cum-fertilizer drill, tractor

Table 6 India: Collaboration with Foreign Tractor Manufacturers

Indian company	Foreign company	Product: Type	Product: Model	Product: Power (hp)
Auto Tractors	Leyland, United Kingdom	Tractor	PRATAP-24	25
Eicher Tractor Co., Ltd.	Fabric Foresteran Germany, Fed. Rep.	Tractor	EICHER 242	24
Escorts Limited	Motoimport, Poland	Tractor	E-355/ADDC	45–47
			E-335/ADDC	35
			E-330	35
			E-345/ADDC	35
Escort Tractors Ltd	Ford Motor Co., United States	Tractor	Ford-3610	47
Gujarat Tractor Corp.	Motoikov, Zetor, Czechoslovakia	Tractor	G-453	45
			HWD-50	50
			G-614	61
Harsha Tractors Ltd.	V/O Tractorexport, USSR	Tractor	T-25 A1	35
Hindustan Machine Tools Ltd	Motokov, Zetor, Czechoslovakia	Tractor	Zetor-2511	25
			Zetor-5911	52
			Zetor-3511	35
			Zetor-4511	45
Kirloskar Tractors Ltd.	Klockner Humboldt Deutz AG, Germany, Red. Rep.	Tractor	D30006/	35
			D4006	43
			D6006	75
			D10006	100
Mahindra & Mahindra Ltd	International Harvester, United Kingdom	Tractor	B-275	35
			B-444	45
			H-500	50
Tractor & Farm Equipment Ltd	Massery Ferguson, United Kingdom	Tractor	MF-1035	35
			MF-245	47
United Auto Tractors	Romania	Tractor	U-445	45
			U-650	65
VST Tillers Tractors Ltd	Mitsubishi, Japan	Power tiller	Shakti AD8U	8–10
			Shakti AD8U	10–1
JK Satoh Agricultural Machine	Satoh of Japan	Power tiller	Jaykay Sato	7–9
Kerala Agro Industries Development Corp.	Kubota Ltd, Japan	Power tiller	KMP-200	9–12

trolley and irrigation pump.

In the northern part of India, owning a tractor is a great symbol of prosperity. Many farmers have purchased the tractor taking bank loans even when their land holding is not sufficient to justify owning a tractor. Few have enough foreign exchange and few sell their other properties to own the tractor.

Animal-drawn equipment are quite few such as MB plough, local blade harrow, patela harrow, animal-drawn seed-cum-fertilizer drill, and sickles for harvesting.

Farmers in India have come to a stage where they spend considerable time for agriculture where farm labour is sometimes not available and crop operations are specially time-bound or has threat of considerable losses due to weather conditions.

Records show that Indonesia has a number of agricultural machinery based on land-holding size as follows: power tiller, tractors with attachments, sprayers, power threshers, grain dryers, fertilizer applicators, bicycles for agricultural uses, rice huskers, trailers, and auto trailers.

Animal-drawn implements commonly used in Indonesia are the moldboard plough and comb-toothed harrow.

Hiring Agricultural Machinery

Indian Situation

Farmers in India, specially in the villages, have taken tractors and other implements as a symbol of social status. This situation has considerably changed and they have started renting the tractors to neighbours after completing their own tasks. This situation is due to high cost and scarcity of farm labour.

Cash and kind are used for farm labour payments in India. Farmers

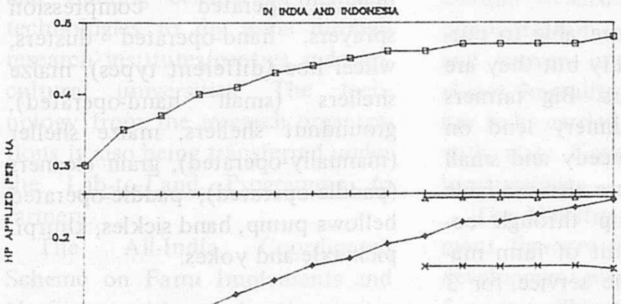

Fig. 8 Power available for agriculture.

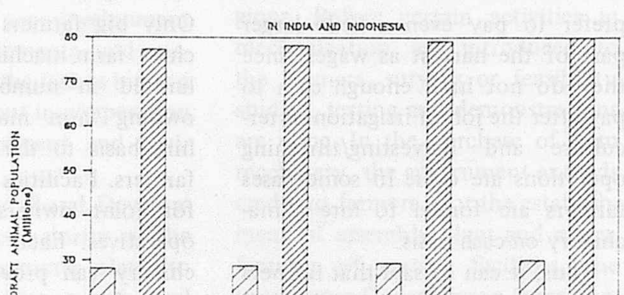

Fig. 9 Draft-animal population.

Table 7 All India; Agricultural Machinery and Implements (Unit: 1 000)

Items	1961	1966	1972	1977
Bullock and manually operated implements				
Wooden plough	38 372	39 923	39 294	40 766
Iron plough	2 298	3 523	5 359	6 258
Blade harrow or bakhar	–	–	11 738	11 497
Wet land puddler	N.C.	2 724	1 694	2 056
Earth levellers or scrapers	–	–	3 731	8 728
Seed drills/sowing device	N.C.	1 135	4 049	4 822
Cart (animal-drawn)	12 072	12 697	12 960	12 742
Maize shellers	N.C.	N.C.	175	226
Sugarcane crushers				
Worked by power	33	45	87	987
Worked by bullocks	590	650	681	673
Sprayers and dusters	N.C.	211*	448	559
Pump sets used for irrigation and persian wheels				
Oil engines with pump sets	230	471*	1 557	2 162
Electric pump sets	160	415	1 618	2 313
Persian wheels	600	680	638	621
Tractor operated implements				
Mouldboard plough and disc plough	N.C.	N.C.	57	81
Disc harrow	N.C.	N.C.	56	105
Cultivators or tillers	N.C.	N.C.	81	149
Levellers or scrapers	N.C.	N.C.	49	96
Seed-cum-fertilizer drills	N.C.	N.C.	25	36
Seed planter	N.C.	N.C.	9	16
Rotary cultivator	N.C.	N.C.	6	9
Trailer	N.C.	N.C.	55	117
Other tractor-operated implements	N.C.	N.C.	18	21
Power-driven machines and miscellaneous equipments				
Wheat threshers	N.C.	349*	183	350
Paddy threshers	N.C.	–	14	–
Threshers for other crops	N.C.	–	10	10
Maize shellers	N.C.	N.C.	16	17.2
Harvester combines	N.C.	N.C.	N.C.	1 268
Power chaff cutters	N.C.	N.C.	142	200
Other power-operated equipment	N.C.	N.C.	34	38

* Figures for 1972 Census are not strictly comparable with 1961 and 1966 Censuses in respect of these implements. N.C. = Data not collected.

Source: 1. Indian Agriculture in Brief, Sixteenth Edition; Directorate of Economics and Statistics, Ministry of Agriculture. 2. Machinery Division, Ministry of Agriculture, Dept. of Agriculture and Co-operation, New Delhi.

Table 8 Indonesia: Manufacture of Agricultural Tractors, 1976–80

Year	Production		
	Hand tractor	Mini tractor	Total
1976	30	–	30
1977	44	–	44
1978	280	25	305
1979	550	150	700
1980	877	192	1 069

Source: Indonesia Commercial Newsletter No. 185 (November 1981).

Table 9 Distribution of Small Tractor Manufacture in Indonesia

Name of company	Production capacity (no. of units)	
	Head tractor	Mini-tractor
PT Agrindo	400	600
CV Buma Sakti	400	–
PT Indotani	3,000	1,000
PT Karya Hidup Sentosa	2 400	–
PT Linggar Wastu Jaya	400	–
PT Martani	240	–
CV Musuh Hama	60	–
PT New Ruhak Indonesia	720	
PT Yamindo	2 000	500

Source: Department of Industry (Jakarta, 1983).

prefer to pay even a little larger part of the harvest as wages since they do not have enough cash to pay after the job of irrigation, interculture and harvesting/threshing operations are over. In some cases farmers are forced to hire a machinery on cash basis.

Thus, it can be said that formers in India do not have enough capacity to pay for the hiring charges of the machinery.

Indonesian Situation

Though Indonesian farmers are small and poor, they are usually owner-operators of small farms. Only big farmers are able to purchase farm machinery but they are limited in numbers. Big farmers owning farm machinery lend on hire basis to the needy and small farmers. Facilities are also available for joint ownership through co-operatives. Each unit of farm machinery can provide service for 3 to 6 farmers. A few government agencies are available for giving the machinery on hire basis.

Typical Machines/Hand Tools on Small Farms

Indian Farm

The following major equipments are available on small farms in India: Phawra, axe hoe, hoe, animal-drawn harrow and cultivator, local ploughs, blade harrow, patela harrow, seed-cum-fertilizer drills, land levellers, paddy puddlers, manually-operated compression sprayers, hand-operated dusters, wheel hoe (different types), maize shellers (small hand-operated), groundnut shellers, maize sheller (manually-operated), grain cleaners (paddle-operated), paddle-operated bellows pump, hand sickles, khurpi, pick axle and yokes.

Indonesian Farm

The most common farm implement found among typical Indonesian farms are: puddlers, sprayers (power-operated)/hand-compression sprayers, pedal threshers, pedal-operated grain cleaners, winnowers, sickle, hoe, mold-board plough, comb-toothed harrow, rice huskers, grain dryers.

Agricultural Mechanization Research Efforts

Agricultural machinery research in India is carried out by major organizations as the state agricultural universities and other institution. The basic aims of the institutions engaged in research and development of farm machinery are:

a) To design and develop new equipment and select previously designed equipment with proven technology for large-scale production, industry-oriented development of the products.

b) To develop new technology for equipment suited to prevailing local conditions;

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

e) To train village artisans, and farmers in the operation, maintenance and repair of farm machineries.

The Indian Council for Agricultural Research (I.C.A.R.) although primarily responsible for education, research and development programmes in the country in agriculture, has established farm science centres (Krishi Vigyan Kendra) and training centres to transfer technologies to the users through research institutes/centres and agricultural universities. The technology from the research organizations is also being transferred under the Lab-to-Land Programme to farmers.

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

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

The Ministry of Rural Development finances the majority of the development programmes related to farmers, village artisans and rural youths being undertaken by various Government, private and voluntary organizations in India.

On the other hand, the objective of agricultural development in Indonesia is to increase the production of food crops, hence the farmers' income. The use of farm machinery and its development is considered part of the means to attain this objective. The Government budget for farm machinery development is still very low compared to the total national Government budget or to the budget for agriculture. General international assistance is available through the USAID, ESCAP, Colombo Plan, JICA, Kennedy Round and UNDP in the form of procuring farm machinery or equipment and obtaining information on their operations.

Government schemes for promoting the use of farm machinery are already established in some regions: Tajum Pilot Scheme in Central Java, Tani Makmur Pilot Scheme in West Java, West Sumatra, South Sulawesi, Lampung, etc., Agricultural Development Centre in West, Central, East Java, North Sumatra and South Sulawesi, Agricultural Machinery Training Centre in Jakarta (Pasarminggu), and the Industrial Extension Service on manufacturing farm machinery equipment in Jakarta (Pasarminggu).

The Indonesian Government policy on agricultural mechanization emphasizes that the uses of farm machinery should be in comformity with the natural and socio-economical conditions of the regions. Before certain activities in mechanization are introduced to the farmers, surveys or feasibility studies, testing and demonstrations are done. In the purchase of farm machinery, the government extends credit to farmers. For the establishment of assembly plant and manufacturer of certain facilities, the Investment Coordination Board coordinates the work.

Manpower for Agricultural Mechanization

The most important input for the mechanization of agriculture in any country is its manpower. The development of manpower is, therefore, imperative.

In India there are 27 state agricultural universities offering education in agriculture to meet the manpower needs of the country. Of these 17 universities offer agricultural engineering programme. In all the 17 institutions produce approximately 265 graduates each year in addition to masters and Ph.D degree holders. In addition to the civil, mechanical, electronics and electrical engineering degrees offered, a large number of these institutions offer agricultural engineering diploma. These diploma holders are good assets for handling various jobs in the field of agricultural engineering. The overall education system in the field of agricultural engineering in India is need-based.

Indonesia has 27 agricultural universities offering education in agriculture in the country. Quite a few of these universities offer Bachelor, masters, and doctoral degrees in agricultural engineering.

The agricultural universities in Indonesia works on Land Grant Colleges patterned after U.S.A. Many faculty members have been trained in U.S. universities. Agricultural research in Indonesia has increased many-fold but Indonesia had shortage of trained scientific and training staff. Consequently, there is still a shortage of scientists and technical manpower.

The Government of Indonesia has many foreign aid projects for manpower development from the World Bank, FAO, and IRRI project on rice on various aspects of crop production. This has benefitted Indonesia a great deal. Not only acquiring training and using the knowledge for research but they also develop enough skills to organize similar trainings in Indonesia later, which is most important.

Conclusion and Recommendations

India and Indonesia have comparable situations as far as the basic inputs are concerned regarding the agricultural mechanization, except in few cases. It was noted that the productivity of a few of the selected crops in Indonesia had higher productivity than in India. Mechanization has, to a great extent, taken place in Northern and Western part of India. Other states in the country are making due efforts to mechanize agriculture. There are areas where both countries can make cooperative approach in developing their agriculture as follows:

a) Indian experience can be beneficial in developing tractors and power tiller industries in Indonesia at a comparatively much cheaper price;

b) Experience in dry land agriculture and related technology can bring certain specific benefits in Indonesia;

c) In developing manpower in Indonesia, the Indian experience will be quite useful;

d) Rubber production technology and many other special crops from Indonesia may benefit India greatly;

e) Other areas of mutual cooperation can be worked out to derive the maximum benefits for both countries.

Though there exists cooperative efforts on technology transfer between the two countries, there are still scope for further improvements.

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Utilization of Solar Energy with Far-infrared Rays for Drying Animal Feed

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Introduction

Before the economic reform in the country the domestic animals and fowls were raised by peasants using sweet potato, maize powder, rice chaff, vegetables as well as grass as feeds. Due to lack of scientific ways the domestic animals and fowls have been developed since economic reform. Mainly, this is realized with the means of factory, which not only appears in national farms but in suburban areas of cities and towns as well. Feed factories use scientific methods with mixed feed consisting of fish powder, maize powder and anti-epidemic medicine. Hence, these materials after mixing must be made in shape of round pieces with water and then dried.

There are many means for drying in practice, one of which is to use a combination of solar energy with far-infrared rays. This method is very economical and efficient which is the subject of this paper.

Construction of Equipment

In order to use solar energy the equipment had been built outside. It is similar to a small house with a saw-shaped roof of grass, which is waterproof and toward sun as shown in Fig. 1. There is a drying bed inside of the equipment for placing trays filled with the round pieces of feed. The far-infrared element is installed at inside of the wall. The chimney is used for exhalation of vapor. In order to obtain high efficiency of heat utility the internal side of wall and the door had been smeared by heat isolating material. Also, the door must be sealed when closed.

The controller's box can be placed in the building not far from the drying equipment.

This equipment is appropriate for small scale production. For larger scale the drying equipment may be made in the type of tunnel and solar energy can lead to a water-heating device via the pipe line installed in the drying equipment. There is a conveyer, on which the feed is placed, moves through the tunnel slowly and the moving speed is adjustable according to humidity of dried feed. This drying equipment is appropriate for large scale and continuous production.

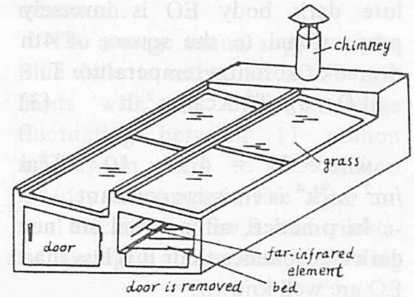

Fig. 1a Drying equipment: Type of house.

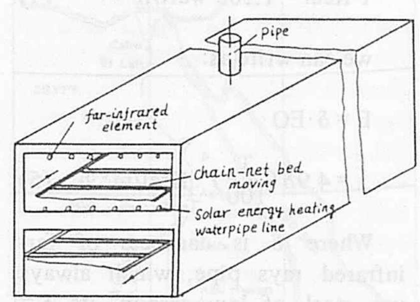

Fig. 1b Drying equipment: Type of tunnel.

Technical Consideration and Design

Technical consideration

i) The capacity of the drying equipment must match the production of the round pieces of feeds of 500 kg/h;

ii) Emissivity of the far-infrared rays always is taken 1-2 Watt/cm^2.

iii) Drying effect must satisfy that humidity of feeds less than 14%;

iv) Temperature of dried feed shall not exceed 70°C.

Design and Calculation

i) Selection of element: First of all the absorbing wave length of the heated material may be measured. For maize as basic feed material, the element must have wavelenth of 3 μm-5 μm.

ii) Determination of temperature: It is well known, that wave length carrying maximum energy is inversely proportional to the absolute temperature T:

$$\lambda m = C/T \quad (1)$$

where C = 0.2886 cm degree

$$T = \begin{cases} 721^\circ k \text{ as } \lambda m = 4\mu m; \\ 577^\circ k \text{ as } \lambda m = 5\mu m. \end{cases} \quad (2)$$

Therefore, operating temperature is about 304 – 448°C.

iii) The emissive energy of absolute dark body EO is inversely proportional to the square of 4th degree of absolute temperature T:

$$EO = \delta_0 \cdot T^4 \text{ Kcal/m}^2\cdot h \quad (3)$$

where δ_0 = 4.9 × 10^{-8} Kcal /$m^2 \cdot h \cdot {}^\circ k^4$ is emissive constant.

In practice, all matters are not dark body hence their E is less than EO are well known:

$$1 \text{ Kcal} = 1.163 \text{ watt/h} \quad (4)$$

we can write as:

$$E = \delta \cdot EO$$

$$= 4.9\delta\left(\frac{T}{100}\right)^4 \text{ Kcal/m}^2\cdot h \quad (5)$$

Where δ is darkness of far-infrared rays pipe, which always use steel of low carbon, its δ = 0.8–0.9.

Thus the emissive energy of far-infrared rays pipe is:

$$E = 4.9 \times 0.85\left(\frac{721}{100}\right)^4$$

$$= 1.309 \text{ watt/cm}^2 \quad (6)$$

iv) Consumption of heat:

The equation of heat blance is:

$$Q_\Sigma = Q_v + Q_h + Q_a + Q_l \quad (7)$$

Where Q_v – a heat energy for vaporing moisture;

Q_h – heat for heating dried material;

Q_a – heat carried off by vapor through chimney.

Q_l – heat lost by housing of equipment.

This portion of energy can be written as follows:

$$Q_v = W\cdot R \text{ Kcal/h} \quad (8)$$

$W = G \dfrac{W_1 - W_2}{100 - W_2}$ is vaporized humidity;

R = 580 – 1100 Kcal/kg is vaporizing heat of feed.

W_1 and W_2 are humidity of feed before and after drying.

G = 500 kg/h – weight of feed dried.

$$Q_h = (G - W)(T_2 - T_1)C \quad (9)$$

Where T_2 = 70°C

T_1 is environment temperature.

C = 0.48 Kcal/kg. degree is ratio heat (heat absorption capacity) of feed.

$$Q_a = MC(T_2 - T_1) \text{ Kcal/h} \quad (10)$$

Where M = 3600 q·γ kg/h;

q = 0.15 m^3/sec is flow quality of the heated air with vapor.

γ = 0.598 kg/m^3 is gravity of vapor.

C = 0.242 Kcal/kg. degree is ratio heat of air.

Hence Q_a = 4000 Kcal/h

$$Q_l = \frac{\lambda(t_2 - t_1)}{b} S \quad (11)$$

Where t_2 = 70°C – temperature inside of equipment.

t – temperature outside of equipment.

λ = 0.04 Kcal/m·h·c is heat-conducting eff. of isolating material.

b = 40 mm is thickness of isolating material.

S is heat lost area m^2.

vi) Required power of equipment.

$$N = \frac{A\cdot Q_\Sigma}{864} \text{ kW} \quad (12)$$

Where A = 0.7 – 0.9 is the effect of far-infrared rays.

Installing the Far-infrared Element

To ensure safety, the elements should not be allowed to contact with other metal parts and the distance between elements should be about 100 mm. To prevent bending of the heated element, the few supporters are used to support long element, which are connected to power supply in parallel for single phase or by means of 'Y' connection for three phases.

The temperature control is carried out by heat-resistor or thermometer with contact as the temperature sensor that is a discontinuous automatic control. ■■

Nile Water Resources of the Sudan: Present and Future Utilization

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Abstract

According to the 1959 Nile Waters Agreement the Sudan's share of the Nile Waters was set at 18.5 milliards ($x10^9$ m^3), whereas that of Egypt was 55.5 milliards as measured at Aswan. Sudan is predominantly an agricultural country and of the estimated 84 million ha suitable for arable crop production, only about 7 million ha are actually planted to crops of which 2 million are irrigated. Nile Waters are the main source for irrigation in the Sudan and at present about 18.26 milliards are drawn of the 20.35 milliards share as measured in Sennar. With the projected short and medium term expansion a deficit of 7 milliards will be encountered by the year 1990. About 45 milliards of water is being lost from the Nile basin in the swampy areas of the Sudd region in the Southern Sudan. Water conservation projects are sought to increase yields. Jonglei I which is under way would promote an additional 2.13 milliards to Sudan's share. The Nile basin countries cooperation is sought in this respect in order to promote further projects and for better utilization and control of the Nile waters.

The Nile Waters – A Valuable Resource

The River Nile is considered to be one of the longest rivers in the world (Fig. 1). It flows from its headwaters at the Kagera River in Rwanda to the Mediterranean for some 6 650 km. The Nile Basin covers 9 countries, namely; Rwanda, Burundi, Tanzania, Kenya, Uganda, Zaire, Ethiopia, Sudan and Egypt. Bahr El Jebel brings in water to the Sudan from Uganda. From Mongalla to Malakal in the Southern Sudan, the river flows through an extensive swampy area known as the Sudd. River Sobat together with Bahr el Jebel and Bahr el Gazal form the White Nile. The White Nile which has a very low gradient falling 12 m in 800 km meets the Blue Nile at Khartoum. The Blue Nile originates from Lake Tana in Ethiopia. Within the Sudan the Blue Nile receives water from the Dinder and Rahad torrential streams. From Khartoum northward the river Nile flows some 1 500 km in Sudanese Territory with the River Atbara joining 300 km North of Khartoum.

Table 1 shows the average annual discharges at different points in the Nile and its tributaries. The average flow was considered to be 84 milliards ($x10^9$ cubic meters) based on the 82-year record (1870-1952). However, the flow fluctuated from 150 milliards as its record high to 42 milliards as its record minimum.

The average annual supply of the Blue Nile is estimated at 50 milliards with the daily discharge fluctuating between 11 million m^3/day in April to 535 million m^3/day in August. The total annual discharge of the Rahad tributary averaged 10 milliards flowing

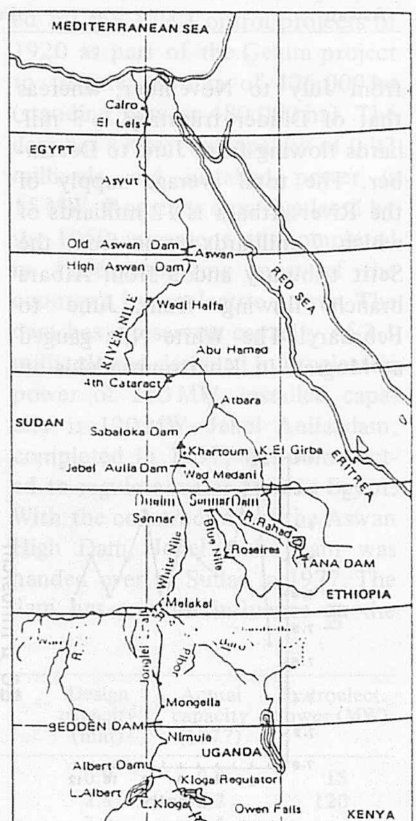

Fig. 1 The Nile Basin.

Table 1 Discharge at Different Points in the Nile and its Tributaries

Location	Time of water demand at Aswan		Av. disch. during time of demand	Av. anuual discharge
Victoria Nile, Albert Nile, B.El Gabal	From	to	10^9 M	10^9 M
Lake Victoria, Owen Falls	June 5	Sept. 10	11.1	20.5
Behind Lake Kioga	Sept. 10	Feb. 10	9.2	19.5
Exit of Lake Albert	Sept. 4	Feb. 10	10.5	23.5
Lake Albert discharge at Mangala	Sept. 4	Feb. 10	10.0	22.3
Khors and Steeams discharge at Mangala	Sept. 4	Feb. 10	1.5	4.7
Mangala at Bahr El Gabal	Sept. 14	Feb. 20	11.5	27.0
Discharge of Bahr El Gazal	Dec. 23	July 1	0.2	0.6
White Nile before Sobat (8)	Dec. 23	July 1	7.4	14.4
River Sobat				
El Nasir	Feb. 25	July 14	3.3	12.4
Doleib Village, end of Sobat (10)	Dec. 23	July 1	3.3	13.6
Malakal, (8) + (10)	Dec. 23	July 1	11.0	28.0
Mogran before Jebel Awlia dam (12)	Jan. 13	July 19	10.0	26.0
Blue Nile and tributeries				
Exit of Lake Tana	Jan. 4	July 9	0.7	3.8
Roseiris	Jan. 4	July 13	6.0	50.0
Dindir discharge	Jan. 10	July 17		3.0
Rahad discharge	Jan. 12	July 17		1.0
Khartoum (17)	Jan. 13	July 18	2.0	52.0
Tomaniyat. (12) + (17)	Jan. 13	July 18	16.0	78.0
El Hasanab	Jan. 16	July 20	16.0	78.0
River Atbra discharge	Jan. 16	July 20	1.0	12.0
Main Nile behind R. Atbra	Jan. 16	July 20	16.0	88.0
Aswan	Feb. 1	July 31	14.0	84.0

from July to November, whereas that of Dinder tributary is 3 milliards flowing from June to December. The total average supply of the River Atbara is 12 milliards of which 7 milliards come from the Setit tributary and 5 from Atbara branch flowing from June to February. The White Nile gauged at Mogran in Khartoum yields an average annual supply of 26 milliards. With the daily flow ranging between 54 million m^3/day on April to 114 million m^3/day in November. Bahr el Gazal contributes only about 0.6 milliards annually to the White Nile although the system yields 14 milliards the rest being lost in the swampy area, whereas Bahr el Jebel looses 14.3 milliards in the Sudd region out of the 27 milliards discharge, only 13.8 milliards entering the White Nile. The total annual average supply of the Sobat basin at Malakal is 13.6 milliards. With the daily discharge fluctuating between 8 million m^3/day in April and 66 million m^3/day in November. The total annual losses due to spillage into the swampy area in this basin amounts to about 4 milliards in the Baro tributary and another 4 milliards in the Machar Marches. The Main Nile at El Hasnab, North of Khartoum, gauges 78 milliards annually with another 12 milliards added by the Atbara River. At Aswan the River Nile yield is based on the annual average of 84-milliards. Fig. 2 shows the average annual hydrographs in million m^3/day. The

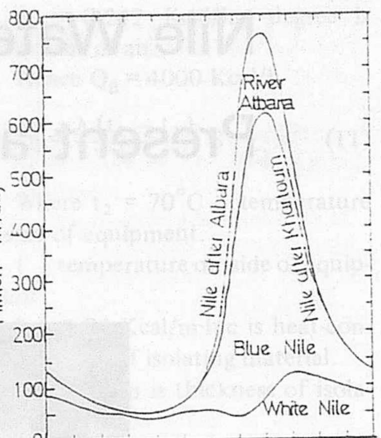

Fig. 2 Nile water hydrographs.

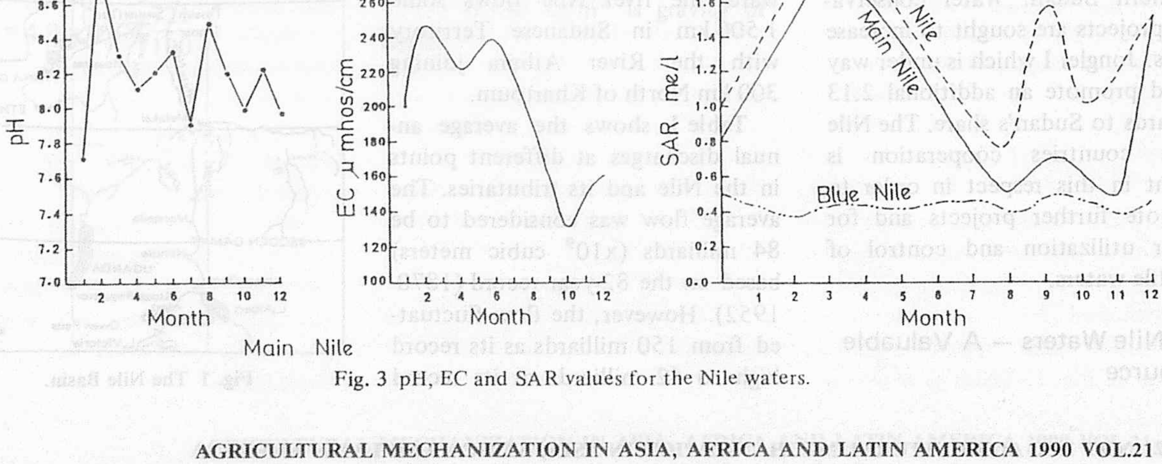

Fig. 3 pH, EC and SAR values for the Nile waters.

water quality of the White and Blue Niles was appraised according to the United States Salinity Laboratory to vary from C_1-S_1 when the Niles were high to C_2-S_1 when the Niles were low. The White Nile is generally more saline than the Blue Nile. The Niles contain considerable bicarbonates. The Blue Nile was found to contain a safe level of bicarbonate (RSC<1.2 me/l). The White Nile had a higher level in June (RSC<2.5 me/l), a marginal level in May and a safe level during the rest of the year. The Blue Nile has a low salinity level (EC<250 umho/cm) for the year except for May and June (250<EC<750 umho/cm). The White Nile has a medium salinity level (250<EC<750 umho/cm) in April, May and June and a marginal level of 250 umho/cm in Feb., March, July, October and December. There is no sodium hazard (S_1), but some degree of leaching is required with continuous irrigation, especially in areas like the black soils of the Gezira where soil water conductivity is low. Fig. 3 shows the pH, EC and sodium absorption ratio (SAR) of the Nile waters.

Nile Water Agreements

The first agreement ever signed was in 1891 when the United Kingdom (occupying Etypt and Sudan) signed a treaty with Italy (occupying Ethiopia) by which it was agreed that no works would be constructed on the River Atbara which would affect the flow to the Nile. In 1902 a treaty was signed with Ethiopia not to construct any works on the Blue Nile, Lake Tana or Sobat basin without the consent of the UK and Sudan. In 1906 treaties were signed between France, Italy and UK to safeguard British and Ethiopian interests. Also, in the same year, UK and the Republic of Congo singned an agreement by which the latter would not restrict waters entering Lake Albert without the consent of Sudan. A number of water control measures were proposed by the Nile Control Projects of 1920. Dams at Sennar, the outlet of Lake Tana and the Blue Nile together with conservation works in the Sudd and storage measures on the equatorial lake of the upper Nile were proposed. Sennar dam was constructed in 1925. In 1929 the Nile waters agreement was concluded by Britain (on behalf of Sudan) and Egypt which ensured Egypt's right of 48 milliards and Sudan's right of 4 milliards. Egypt was further guaranteed the entire flow from Jan. 19th to July 15th annually. Jebel Aulia dam was completed in 1937. In 1949 an agreement was reached between Egypt and Britain on the construction of Owen falls dam at the outlet of Victoria which was completed in 1954. In 1952 Egypt and Sudan agreed to raise Sennar dam by 1 m and Jebel Aulia dam by 10 cm. The second Nile waters agreement signed by Egypt and Sudan in 1959 regulated the construction of the High Dam (Completed 1971). Also based on the total annual average yield of 84 milliards and 52 milliards being the aquired rights of both countries, 22 milliards were redistributed with 10 milliards being considered as losses at Aswan Lake (Lake Nasir). Out of this 22 milliards Sudan's share was 14.5 and Egypt's share was 7.5 milliards. This brought the Sudan's share to 18.5 milliards and Egypt's share to 55.5 milliards. The agreement stipulated the formation of a permanent joint technical comission to undertake the gauging of the Nile, to draw plans for the increase of the Nile yield, to draw up the working arrangements for any works to be constructed on the Nile basin and to consider and reach a unified view regarding other riparian countries' claim, and that any such accepted claims would be equally shared by the two countries. Following a series of discussions Egypt, Sudan, Uganda, Kenya, Tanzania and UNSF agreed in 1976 to construct the hydrometeorological survey of the catchments of Lake Victoria, Kayoga and Albert. Borandi and Rwanda joined the project in 1972 and Ethiopia joined the technical committee of this project as an observer.

Nile Water Control and Conservation

Table 2 shows the existing dams in the Sudan and their storage capacities. The Sennar Dam was proposed by the Nile Control projects of 1920 as part of the Gezira project to irrigate an area of 126 000 ha (standing now at 480 000 ha). The dam has a reservoir capacity of 0.93 milliards and installed power is 15 MW. Roserires dam regulated by the 1959 agreement was completed in 1966 supplying most of the country's hydroelectric power. The dam has a reservoir capacity of 3.1 milliards and designed hydroelectric power of 210 MW, installed capacity is 120 MW. Jebel Aulia dam, completed in 1937, was constructed to regulate water flow to Egypt. With the construction of the Aswan High Dam, Jebel Aulia dam was handed over to Sudan in 1977. The dam has a major influence on the

Table 2 Exisiting Dams in the Sudan

Dam	Site	Construction year	Design capacity (mld)	Actual capacity (1977)	Hydroelect. power (MW)
Sennar	Blue Nile	1925	0.9	0.8	15
J. Aulia	White Nile	1937	2.5	2.2	120
Roserires	Blue Nile	1966	3.0	2.4	—
Kh. el Girba	Atbara River	1966	1.3	0.7	9

Table 3 Water Conservation Projects and Sudan's Share

Tributary	Natural losses (mulliard)	Conservation title	Project increment (mld)	Increment at Aswan (mld)	Sudan's benefit (mld)
Bahr el Jebel and Zaraf	14	Jonglei I	4.75	3.85	2.13
		Jonglei II	4.25	3.44	1.91
Bahr el Gazal	12		7.00	5.67	3.16
Sobat & Machar	19		4.00	3.24	1.80

Table 4 Sudan's Estimated Future Share of the Nile Waters in Milliards/Year

Year	At Sennar		Loss	At Aswan	
	Additive	Cumulative		Additive	Cumulative
1977	–	20.35	1.85	–	18.50
1982/83	1.98	22.33	0.18	1.8	20.30
1984–90	1.78	24.11	0.11	1.62	21.92
1990–2000	1.00	25.11	0.09	0.91	22.83
2000–	3.12	28.23	0.28	2.84	28.23

White Nile with a back water effect of 600 km, and a capacity of 3.0 milliards. Khashm el Girba dam was constructed at Atbara River in 1966 for irrigation of the resettlement area in New Halfa. Storage and hydropower in the region are currently provided by the dam with a designed power of 9 MW and a reservoir capacity of 0.90 milliards. Heavy siltation has reduced the actual capacity to about 50%.

In view of the fact that at present, considerable amounts of the Nile Basin water is lost in the Swamps of the Sudd region of Bahr el Jebel, Bahr el Zeraf, Bahr el Gazal and Sobat basin, efforts are being made to minimize these losses. Jonglei I is already under way involving a 280 km long canal with a capacity of 20 million m^3/day to bypass the Sudd region and divert part of the Bahr el Gebel flow into Sobat river near the confluence with the White Nile, thus reducing evaporation losses from the areas of the marshland. The project is expected to yield 4.75 millicards of which Sudan's share is 2.13 milliards and would meet the country's need in 1990. Jonglei II aims at water storage in the equatorial lakes and increasing the conveyance capacity of Bahr el Jebel and increasing the canals' capacity to 43 million m^3/day. Jonglei II is expected to yield 4.25 milliards of which Sudan's share is 1.91 milliards. Over the year storage on River Baro together with the training and banking of 23 km of this river would provide an extra annual yield of 4 milliards presently lost due to spillage into the swamps. Another project aims towards the diversion of the 4 milliards now lost in the Machar Marshes through a canal from Machar, Adar to Melut on the White Nile. Projects also include the construction of storage reservoirs and diversion canals to conserve about 7 milliards out of the 14 milliards currently lost in the swamps of Bahr el Gazal basin which encompasses about 14 major streams beside other tributaries. Table 3 and 4 show the short term conservation projects and expected gains. Studies are being made on the Bahr el Jebel tributary of Kunti river which yields 0.25 milliards annually to irrigate the sugar, tea and coffee fields near Kutri between Torit and Lago.

Upper Atbara and Setit project studies have been completed to store 1.3 milliards on Atbara branch and 0.3 on Setit for irrigation of about 260 000 ha and generate 20 MW of electricity and to supplement Khashm el Girba dam which was affected by siltation problems. Heightening of Roseires dam is sought to increase the storage in the dam. The main Nile projects are mainly directed towards hydroelectric power generation at Sabaloka, Marawi and the fourth and fifth cataracts.

Present and Future Nile Water Utilization

Out of the 84 million ha available as arable lands only 7 million ha are put under cultivation for crop production of which 5 million ha are under rain fed agriculture and 2 million under irrigation.

Table 5 summarizes the annual water demand, whereas Table 6 gives the details. The utilization of water in the Sudan is steadily increasing and the Sudan has almost used up its share. It is predicted that before 1990 the total will have reached the agreement limit and further development will depend on water conservation projects.

From Table 5 it is evident that of the 20.35 milliards which is the Sudan's share from the 1959 Agreement, only 2.091 milliards are left.

Abstraction of water for irrigation accounts for the largest use of Nile waters and shown by Table 6 the Gezira scheme uses up about one-third of the total consumption. With the advantages gained by construction of dams in storage, flow regulation and power generation, yet evaporation losses from the associated reservoirs are very high.

Figure 4 shows the present and projected water needs until the year 2000, whereas Table 7 summarizes

Table 5 Present Nile Water Utilization

River system	Annual consumption (mlds)	Irrigated area (ha)
Blue Nile	11.977	1,246,535
White Nile	2.840	260,395
Atbara	1.839	156,237
Main Nile	1.603	176,396
Total	18.229	1,839,563

Table 6 Nile Water Utilization by Various Projects

	Water utilization (mld)	Area (ha)	Crops
Blue Nile :			
Gezira	6.20	820 000	Cotton, wheat, groundnut
PAPC	0.750	123 400	Cotton
Abu Naama	0.109	12 600	Kenaf
Sennar	0.382	155 400	Sugarcane
Rahad (I)	1.139	126 000	Cotton, groundnuts
Suki	0.310	35 700	Cotton, groundnuts
Gunied	0.550	35 700	Sugarcane
Sennar dam	0.450	–	Evaporation
Roseires dam	0.550	–	Evaporation
White Nile :			
Kenana	1.225	42 000	Sugarcane
PAPC	1.910	148 380	Cotton
Assalaya	0.516	16 800	Sugarcane
K. el Girba	1.600	147 840	Cotton, wheat & groundnuts
K. el Girba dam	0.350	–	Evaporation
J. Aulia dam	0.610	–	Evaporation

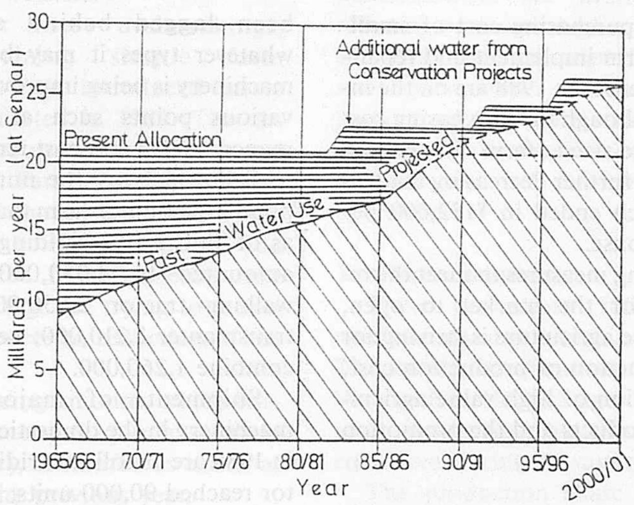

Fig. 4 Water supply and demand.

the areas to be cultivated and water required therefor. It is seen that by the year 2000 a deficit of about 7 milliards will be needed if these programs have to be fulfilled.

Conclusion

Water, a vital resource, seems to be in short supply for future development of agriculture in the Sudan. The Sudan, being the world food basket as claimed, is one of the countries where agriculture investment is sought. Water shortage could be but one of the restraints. Capital, skilled labour, machinery and research as tools of modernization of agriculture are some of the major problems encountered. Very low irrigation efficiencies have been reported in some of the major irrigated schemes in the country. Higher irrigation efficiencies should be targeted by better water management and introduction of sprinkler and drip irrigation in appropriate areas. Efforts should be continued to implement water conservation projects and to increase Nile water yields.

Table 7 Proposed Irrigated Areas and Water Requirement

River system	Required annual consumption (mld)	Proposed area (ha)
Atbara (upper Atbara and Setit)	2.190	26 815
Blue Nile (Rahad phase II)	4.800	596 388
White Nile	2.300	117 597
Total	9.290	974 800

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The Present State of Farm Machinery Industry

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Outlook of Agriculture

Trend of Agriculture

Agricultural production in 1988 showed decreasing tendency for two years running.

The plowland of rice field, under oversupply, decreased 36,000 ha to 2,100,000 ha. As to wheat, the plowland was 396,000 ha and the crop was 142,000 t, which results showed an increase over the preceding year. Soybean resulted in the yield of 277,000 t (decrease of 4% compared with the preceding year).

The amount of imports, like cut flowers and pet food, are continuously on increase. In 1988 the import of onion and raw silk showed a sharp increase.

Farming population remains a decreasing tendency.

Farm houses are gradually decreasing to 4,240,000 farm houses in 1988. Of all these farm houses, full time farm houses are only 610,000 houses.

Farm income in 1988 was as much as that of the preceding year. Incomes besides farming increased. In consequence, the total income increased by 2.8% compared with the previous year. The ratio of farming income to the total income is 13% on the average.

The purchasing cost of small-sized farm implement and repairing expenses in 1988 are on the increase, though the purchasing cost of large-sized farm implement showed further decreasing tendency, which ended in ¥182,000 per farm house.

Taking measures to meet the request for the market to open, Japanese agriculture is striving for the reduction of production cost, production of high value agricultural products and the promotion of exports.

Trend of Farm Mechanization

Agricultural mechanization in Japan has remarkably progressed in the field of lowland rice, chief crop, in a short period since 1955. Thus, continuous system of lowland rice has completed. 98% of rice crop is transplanted and 99% of rice crop is harvested by farm machinery in 1988. As to rice crop, working hours per 10a amounted to 48.1 hours — in 1960 they were 117.8 hours.

In recent years farm machinery for rice crop is developed to be larger-sized, higher-efficient and more commonly used. In addition, farm machinery for field crops and livestock farming is being developed and improved, which has been lagged behind so far, whatever types it may be, farm machinery is being improved from various points such as performance, saefty and cost reduction.

Followings are the number of popularization of farm machinery as of Jan. 1, 1989: riding tractor amounted to 2,050,000 units: walking tractor 2,650,000; rice transplanter 2,210,000; head feed combine 1,260,000.

Shipments of major farm machinery in the domestic market in 1988 are as follows: riding tractor reached 90,000 units; walking tractor 214,000; transplanter 85,000; power pest control 255,000; power reaper 647,000; head feed combine 66,000; dryer 60,000; huller 39,000.

Recently there is a larger demand for used farm machinery. In 1987 the rate of used machinery in the distributing amount is as follows: riding tractor forms 41%; transplanter 32%; combine 33%.

The total investment in farm machinery per farm household reached ¥176,000 in 1988.

Measure of Farm Machinery

The budget of agricultural, forestry and fishery for 1989 amounted to ¥3,158.9 billion, which shows a decrease of 0.4%

compared with the preceding year. This budget was chiefly made up to realize high productivity in the industry of agriculture, forestry and fishery, and to supply agricultural, fishery products stably in response to the national demand.

In introducing farm machinery, for two years running, measures are being taken to introduce farm machinery suitable for operating scale, and make efficient use of its machinery, expand the market for used farm machinery, and use farm machinery in safety. These measures aim chiefly at reducing production cost of agricultural products and securing safety for farming workers.

Under these undertakings, 'Popularizing simple farm machinery' is introduced newly and promoted in 1989. This attaches importance to fundamental function. Farm machinery, which is cut off about ten per cent of old one, is being developed and popularized. In consequence, these undertakings are trying to render great services to reduction of the cost.

Financing amount, which enables farmers to purchase farm machinery, is limited as much as that in the previous year.

Farm Machinery Industry

Output of Farm Machinery

The output of farm machinery, which has been about the ¥150 billion p.a. from 1968 to 1972, increased sharply in 1973 and 1974. In 1977 the output reached ¥659 billion. Farm machinery for rice crop, which is most popular one, has been used more and more widely for these years. While, it decreased sharply to ¥536.7 billion in 1978 because farmers have been unwilling to invest in machinery under the policy to reduce the acres for rice planting since 1973. This policy aimed at improving over-production of rice.

Since then, the output remained about ¥500 billion p.a. except ¥627.3 billion in 1980. The output has gradually become better to ¥638.8 in 1984, to ¥667.8 billion in 1985, and to ¥674.3 billion in 1986 because international markets are developed and domestic demands are stimulated for high value-added products. But, in 1987 domestic sales and exports are inactive, and consequently the output ended in ¥585.8 billion. In 1988, when the tendency lasted, the results decreased to ¥549.8 billion again.

Japanese farm machinery manufacturers are striving for reducing cost with higher rate of supplying parts and materials and spot production. Besides, the manufacturers are also striving for extending its business to other industries and for improving its operation.

The Manufacturers

There are about 500 farm machine manufacturers in Japan. This number is about one half of the numbers 10 years ago. But the total production by them kept equal level during the same period.

The production share of the biggest 4 companies amounts to 88% of the total. Everyone of the companeis sells more than 50 billion yen per annum. They manufacture wide range of farm machinery and sell also original equipment manufacturers' products.

There are 21 medium-scale manufacturers whose annual sales range 10-50 billion yen. These manufacturers are specialized in limited items and supply products to some of the biggest companies.

Remaining 95% are smaller scale companies selling under 50 billion yen each, manufacturing implements for tractor, food processing machine, mahcine for dairy farming and machine for fruits culture.

Trend of Farm Machinery Production

In 1988 the amount of farm machinery production was ¥549.9 billion, which decreased by 6.1% over the preceding year and meant a decrease by 18.4% over the year before last. These decreasing tendency is caused by decreasing demand in domestic market under reducing the acres for rice planting and the reduction of rice prices. Besides, this is caused by the reduction of exports under high Yen-rate.

Production of major farm machinery is as follows: riding tractor decreased by 4% over the preceding year to 173,000 units.

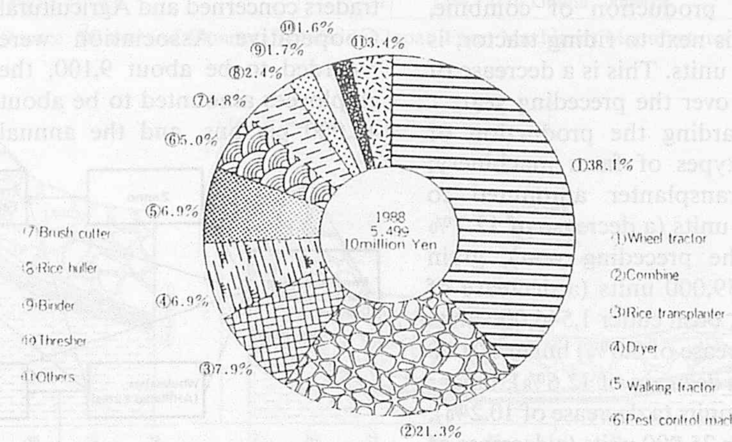

Fig. 1 Production of farm machinery

Table 1 Yearly Production of Farm Machinery

Unit: Number, Million Yen

Year	Farm machginery total		Raiding type tractor		Waking type tractor		Rice transplanter		Power sprayer		Power duster		Blower sprayer	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1977	—	658,960	266,344	232,938	370,473	50,722	279,635	53,565	219,975	11,204	238,960	7,841	6,205	6,917
1978	—	536,663	202,138	189,761	341,593	44,061	196,836	43,293	169,234	10,151	260,211	8,458	7,227	6,972
1979	—	581,594	239,157	235,585	330,912	45,165	169,779	41,053	192,761	11,564	211,070	7,952	8,338	9,033
1980	—	627,261	202,963	220,984	322,699	46,474	210,206	53,592	210,494	12,728	263,910	10,421	9,795	10,999
1981	—	533,201	178,827	205,904	384,735	50,150	141,618	39,359	171,009	10,535	158,645	6,552	5,864	6,286
1982	—	581,005	179,350	220,294	446,248	55,469	130,092	41,966	177,231	10,773	177,231	7,148	6,426	7,666
1983	—	564,923	170,968	197,038	420,935	51,618	128,514	51,178	171,540	10,345	151,193	6,062	6,514	7,820
1984	—	638,803	201,357	240,051	361,649	45,299	131,966	54,219	166,226	10,720	242,289	8,746	6,651	8,091
1985	—	667,895	209,652	247,100	278,581	41,398	132,909	53,835	170,968	10,479	222,877	7,755	7,200	8,361
1986	—	647,265	209,078	254,010	268,307	37,026	134,433	64,541	157,774	9,754	184,132	6,374	7,121	9,535
1987	—	585,810	179,884	215,379	276,286	38,778	92,861	50,181	144,734	8,396	165,241	6,028	6,231	8,296
1988	—	549,854	172,761	209,278	276,684	37,644	81,022	43,554	181,805	9,851	161,763	5,999	8,696	9,958
(1989)	—	551,600	178,000	213,450	280,000	38,410	75,000	39,780	170,000	9,370	157,000	5,870	7,500	9,120
Year	**Grain reaper**		**Bush Cutter**		**Power thresher**		**Grain Combine**		**Rice husker**		**Dryer**		**Grain polisher**	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1977	116,466	22,187	576,806	13,447	72,106	16,808	172,908	143,396	75,658	15,464	161,845	54,533	100,774	4,718
1978	96,557	19,100	700,679	16,252	66,509	16,808	117,098	103,482	68,008	12,721	113,121	40,156	98,283	5,111
1979	92,590	19,168	874,818	18,194	76,183	18,732	94,374	94,605	97,275	19,865	103,825	34,601	88,094	4,476
1980	83,902	19,129	824,237	19,461	75,718	20,703	105,817	120,661	113,451	25,371	99,075	39,840	79,084	4,397
1981	58,479	13,811	771,561	19,762	52,861	15,866	82,777	96,059	68,041	15,922	68,994	28,790	65,181	4,387
1982	55,526	13,174	816,882	19,630	50,190	16,056	84,730	111,304	74,024	18,044	76,815	34,060	76,855	4,661
1983	60,835	14,862	1,159,508	23,031	45,720	14,469	80,9733	112,118	60,991	14,302	75,442	36,461	64,639	3,686
1984	59,177	14,698	1,429,203	30,553	46,879	15,276	94,598	128,121	67,522	15,394	77,099	40,020	77,113	4,996
1985	51,061	12,274	1,350,990	24,573	42,901	15,163	102,593	157,222	80,231	19,661	76,571	42,634	75,314	3,843
1986	55,587	13,777	1,496,433	27,191	41,295	15,246	93,080	150,188	72,000	19,060	73,798	44,590	66,891	3,537
1987	45,867	10,292	1,421,007	24,569	29,126	10,430	78,656	131,265	57,087	16,300	65,378	44,192	61,367	3,083
1988	41,204	9,313	1,546,010	26,160	24,811	8,900	64,412	117,132	49,866	13,137	58,097	37,649	58,982	2,932
(1989)	41,000	9,240	1,600,000	27,780	24,200	8,720	64,000	116,070	46,000	15,040	58,300	37,630	58,000	2,800

Source: ''Survey of Status of Machinery, Production'' by the Ministry of International Trade and Industry. Data by Japan Agr. Machinery Manufacturers' Assn. and Land Internal Combustion Engine Manufacturers' Assen.

Note: Data for 1989 are forecast by Farm Machinery Industrial Research Corp.

Half of the production is exported to foreign countries. By sizes, those under 30 PS forms 84% of all riding tractor.

The production of walking tractor amounted to 277,000 units which remained as many as the preceding year. By sizes, small size machinery under 5 PS is being given more and more weight.

The production of combine, which is next to riding tractor, is 64,000 units. This is a decrease of 18.1% over the preceding year.

Regarding the production of other types of farm machinery; rice transplanter amounted to 81,000 units (a decrease of 12.7% over the preceding year), grain dryer 59,000 units (a decrease of 11.1%), bush cutter 1,546,000 units (an increase of 8.8%) huller 50,000 units (a decrease of 12.6%), binder 41,000 units (a decrease of 10.2%), thresher 25,000 units (a decrease of 14.8%) (Fig. 1 and Table 1).

Trend of Farm Machinery Market

In Japan distribution system for farm machinery is roughly divided into two major channels: the traders concerned and Agricultural Cooperative Association (**Fig. 2**). As of June, 1985, the retail shops for farm machinery including the traders concerned and Agricultural Cooperative Association were recorded to be about 9,100, the employees amounted to be about 44,000 persons, and the annual sales amounted to be ¥946.5 billion.

According to the governmental survey by Ministry of Agriculture, Forestry and Fishery in 1987, the total sales by Agricultural Cooperative Association reached ¥364.7 billion.

Under the declining demand for rice crop machinery, the distribution industry is making efforts to expand facilities and technique. Agricultural Cooperative Association is grappling with the reduction of farmer's operating cost.

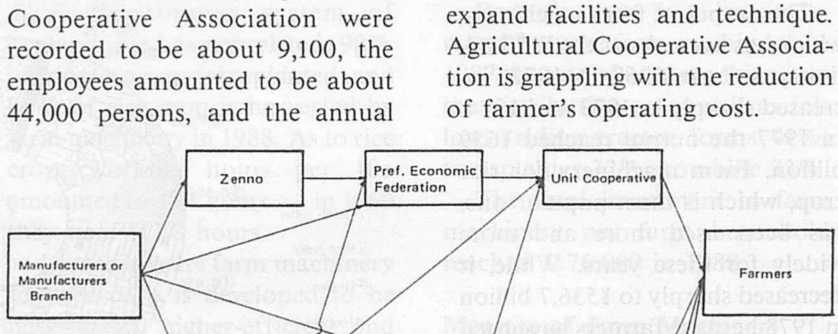

Fig. 2 Distribution channel of farm machinery

Export and Import of Farm Machinery

Export

In 1988 the exports of farm machinery amounted to ¥130.5 billion, which showed a decrease of 5.6% over the preceding year. The ratio of the exports to the total amounts ¥549.9 billion of the production ended in 23.7%.

About 45% of the total exports was for North America. In particular, exports for the United States reached ¥52.2 billion (in 1987 it was ¥70.5 billion).

As for the types of farm machinery, tractor was chiefly exported. The 1988, 172,000 units were produced. Of the machinery 84,000 units were exported, which amounted to ¥57.8 billion. Seeing by sizes, the exported tractors under 30 PS amounted to 81,142; those from 30 PS to 50 PS were 14,000; those more than 50 PS were 27,000. Major farm machinery, next to tractor, is huller which exports were 99,000 units and ¥20.4 billion(**Table 2**).

Our exporting system has recently changed. Even finished machinery as well as parts, accessaries, and semi-finished machinery is manufactured in foreign countries. Japanese machinery formed a larger market abroad.

Table 2 Export of Farm Equipment 1988

Unit: FOB Million Yen

Year	Unit	Value	Ratio	Major destinations
1983		162,483		
1984		185,380		
1985		190,305		
1986		150,792		
1987		135,354		
1988		130,492	100.0	
Farming tools	—	3,069	2.4	U.S.A., West Germany
Spade, shovel	32,358	225	0.2	Nigeria, Hong Kong, Taiwan
Fork	893	14	0.0	Taiwan, Senegal
Hoe	24,125	128	0.1	Singapore, U.S.A.
Other tools	—	2,702	2.1	U.S.A., West Germany, U.K.
For soil preparation	—	65,675	50.3	U.S.A.
Plow	2,715	245	0.2	Belgium, Iraq, Sri Lanka
Disk harrow	186	30	0.0	Taiwan, Laos, Peru, Butan
Cultivator	4,413	317	0.2	U.S.A., Taiwan
Others	936	66	0.1	Taiwan, Italy
Seeder, planter	1,891	713	0.5	Taiwan
Fertilizer distributor	305	9	0.0	China, Canada
Parts		570	0.4	U.S.A.
Power tiller	81,966	5,797	4.4	France
Wheel Tractor	83,940	57,830	50.0	U.S.A.
~30 ps	67,119	38,898	29.8	U.S.A.
30~50 ps	14,054	13,881	10.6	U.S.A.
50 ps~	2,767	5,051	3.9	U.S.A., Australia
Pest control Machines	—	2,120	1.6	Netherlands, U.S.A., Taiwan
Manual sprayer	1,617,203	203	0.2	Burma, Burundi
Power sprayer	36,700	1,357	1.0	Iran, Netherlands, Taiwan
Duster	24,233	443	0.3	France, Rwanda, U.S.A.
Others	24,951	117	0.1	U.S.A., Taiwan
For harvesting and preparating	—	50,649	38.8	U.S.A., France
Lawn mower	300,881	15,876	12.2	France, U.S.A.
Bush cutter	985,322	20,446	15.7	U.S.A., France
Grass cutter	15,694	282	0.2	U.S.A., Italy
Mower	271,382	7,738	5.9	U.S.A., France, Italy
Hay making machine	5	1	0.0	China
Baler	35	9	0.0	Greece, Australia
Combine	925	1,737	1.3	Taiwan
Thresher	228	89	0.1	Nigeria, Ivory Coast
Digger				
Other harvesters	1,714	248	0.2	Yemen, Taiwan, Madagascar
Washer, separator	151	332	0.3	Sri Lanka, India
Blade, knife—		1,100	0.8	U.S.A., Italy
Parts	—	2,792	2.1	U.S.A.
For grain processing machines	—	3,729	2.9	Vietnam, U.S.A., Nigeria
Grain separator	822	1,254	1.0	Vietnam, Philippines
Rice husker	347	372	0.3	Indonesia, U.S.A.
Grain polisher	811	927	0.7	Vietnam,Indonesia
Others	189	315	0.2	Bolivia, Nigeria
Parts	—	862	0.7	Nigeria, U.S.A.
Chain Saw	218,243	4,734	3.6	France, U.S.A.
Parts	—	598	0.5	U.S.A., France
Farm Trailer	22	14	0.0	Ghana, Nigeria

Source: Ministry of Finance. Totaled by Japan Farm Machinery Manufacturer's Ass.

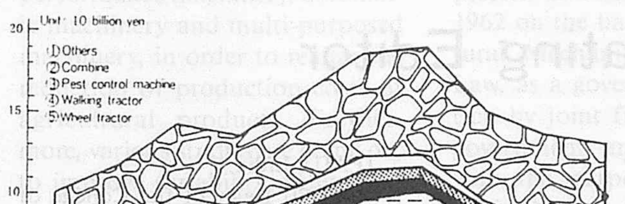

Fig. 3 Export of farm machinery

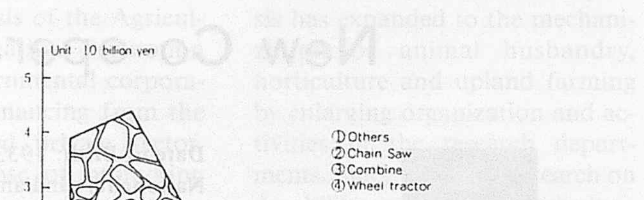

Fig. 4 Import of farm machinery

Table 3 Import of Farm Equipment 1988

Unit: CIF Million Yen

Year	Unit	Value	Ratio	Exports
1983		20,496		
1984		15,812		
1985		15,303		
1986		17,425		
1987		20,949		
1988		23,095	100.0	
Farming tools	—	479	2.1	Korea, China, Taiwan
Spade, shovel	571,308	202	0.9	Korea
Fork	30,839	25	0.1	Austria
Hoe	360,480	52	0.2	China
Other tools	—	201	0.9	China, Taiwan, Korea
For soil preparation	—	9,772	42.3	U.K
Plow	268	52	0.2	Netherlands, Norway
Disk harrow	5	5	0.0	U.S.A., U.K.
Others	1,042	181	0.8	Italy, France, Netherlands
Seeder, planter	1,374	377	1.6	Finland, Denmark
Fertilizer distributor	3,109	227	1.0	U.S.A., Netherlands
Parts	—	531	2.3	Netherlands
Power tiller	90	5	0.0	Korea, Italy
Wheel Tractor	3,340	8,395	36.3	U.K.
~30 ps	1,111	2,137	9.3	U.K.
70~	2,229	6,257	28.3	U.K.
Pest control Machines	1,345,261	977	4.2	Taiwan, U.S.A.
For harvesting and preparating	—	8,636	37.4	U.S.A., France
Lawn mower	21,076	1,696	7.3	U.S.A.
Grass cutter	925	114	0.5	U.S.A.
Mower	1,887	707	3.1	France
Hay making machine	2,685	1,054	4.6	Netherlands
Baler	1,398	1,603	6.9	France
Combine	218	1,816	7.9	Belgium, Italy
Thresher	5	19	0.1	U.S.A.
Digger	36	47	0.2	Italy
Other harvesters	911	737	3.2	U.S.A., France, Italy
Washer, separator	18	27	0.1	U.S.A., Netherlands, Denmark
Blade, knife	—	105	0.5	U.S.A.
Parts	—	711	3.1	U.S.A.
For grain processing machines	—	1,430	6.2	Switzerland
Grain separator	255	457	2.0	West Germany, U.S.A., U.K.
Flour mill	141	674	2.9	Switzerland
Others	83	201	0.9	U.K.
Parts	—	98	0.4	U.S.A., Switzerland, U.K.
Chain saw	46,267	1,532	6.6	West Germany, Sweden
Parts	—	205	0.9	West Germany
Farm trailer	66	64	0.3	West Germany, Denmark

Source: Ministry of Finance. Totaled by Japan Farm Machinery Manufacturer's Assn.

Import

In 1988 the import of farm machinery amounted to ¥23.1 billion, which means an increase of 10.2% over the preceding year.

Followings are the major imported farm machinery: tractors amounted to 3,340 units and chainsaw were 46,000. In particular, tractors over 30 PS formed 67 per cent (**Table 3**). ■■

New Co-operating Editor

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Feature: Farm Machinery Industry in Japan

Prospect of the Institute of Agricultural Machinery, BRAIN

edited by
Planning Department
Institute of Agricultural Machinery, BRAIN.
Omiya-shi, Saitama-ken, 330 Japan

Introduction

The mechanization of Japanese agriculture really started during the 1950's when the power tiller was brought into practical use. After that, the mechanization for rice farming has rapidly advanced by developing tractors, rice transplanters, combines, dryers, etc. The development of mechanization has contributed to labor saving, the improvement of agricultural productivity and the increse of the income of farm workers. Today, it is a proven fact that agricultural machinery is not only a driving force but also an indispensable factor for agricultural production.

In recent years, emphasis has been placed on the fields related to research and development of high-performance machinery, automatic machinery and multi-purposed machinery, in order to realize the reduction of production costs of agricultural products. Furthermore, various studies are going on, to improve durability, safety and ease of operation of agricultural machines and to establish the efficient use of them. It has also been important to develop and improve the machinery in the fields of horticulture and livestock farming that have been backward in mechanization.

In such a background, the Bio-oriented Technology Research Advancement Institution (BRAIN), which is a governmental corporation, is playing an important role in the domain of research and testing on agricultural machinery in the country. Here, we introduce the outline of the Institute of Agricultural Machinery (IAM), BRAIN and its activities on research and testing.

History of IAM

IAM, the predecessor of the present BRAIN, was founded in 1962 on the basis of the Agricultural Mechanization Promotion Law, as a governmental corporation by joint financing from the government and private sector, with the purpose of promoting agricultural mechanization through research, development and testing of agricultural machinery.

In the beginning, the main office was in Konosu city in Saitama prefecture, and was moved in 1964 to its present location in Omiya city in Saitama prefecture. The organization at that time consisted of the survey and information division, the general affairs department, 1st research department, 2nd research department and the testng department. After that, IAM developed by enlarging the research departments, strengthening the testing department and creating the experimental farm and the planning department from year to year.

In the initial period, from its foundation to 1969, the research in IAM was centered on the development of machinery for rice farming, and IAM played an important role in establishing mechanized rice farming systems, particularly by developing rice transplanters and harvesters.

Since 1970, the research emphasis has expanded to the mechanization of animal husbandry, horticulture and upland farming by enlarging organization and activities in the research departments. Since 1976, the research on durability and safety of agricultural machinery has been intensified. Furthermore, since 1978, IAM has worked to develop urgently needed machinery to be used for upland fields which has been converted from paddy fields ac-

Acknowledgment: We would like to express our grateful thanks to many researchers in IAM, who extended their kind assistance to this report.

cording to the government's plan to reorganize paddy field utilization, and to develop energy-saving machinery. With regards to the research fruits, IAM developed new machinery such as up-cut rotary tiller, low volume sprayer, soybean reaper, spiral-flow thresher for soybean, cabbage harvester, rice husk gasification system, etc.

In addition, IAM developed the combine for multi-crops and high performance rice transplanter from 1984 toward 1985. These have the newly developed threshing or planting mechanism and have become of major interest as the important machines for the reduction of production costs.

As for testing activites, IAM is designated to carry out the National Tests based on the Agricultural Mechanization Promotion Law. In 1966, IAM was also designated as the testing station for "the test by OECD standard test code for agricultural tractors". Furthermore, the Safety Tests for agricultural machines was initiated in 1976 to ensure the safety of farm workers. The testing department of IAM is in charge of these tests and has contributed a great deal to the improvement and spread of useful machines to farmers.

In 1986, IAM was reorganized into BRAIN.

Establishment of BRAIN

BRAIN was founded in October 1986 as a legally approved corporation, inheriting whole properties and activities of the previous governmental corporation IAM which made a speciality of research and testing for the promotion of agricultural mechanization. Beside these activities for agricultural mechanization, the new institution meets also the contemporary national needs to stimulate and promote biotechnological research in private enterprises, and

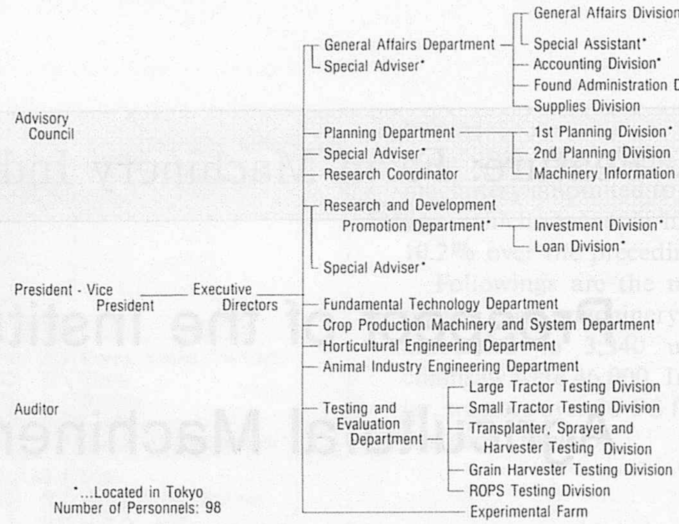

Fig. 1 Organization of BRAIN

this is being attained through investment and accommodating loans by BRAIN.

The agricultural mechanization promotion departments of the institution are granted, as a whole, to be cited as IAM even after the establishment of the institution, and IAM still assumes the principal role in the domain of research and testing on agricultural machinery as a sole and competent organization in our country.

In October 1988, IAM reorganized itself into a fresh lineup to augment its technical potential in fundamental and initiative research.

Organization

Fig. 1 shows the overall organization chart of the present BRAIN. In **Fig. 1**, * marks indicate the departments, whose office is in Tokyo, to promote the research and development on biotechnology in private enterprises. The number of total personnels of BRAIN is 98. And among them, IAM has 80 personnels. IAM is located at Omiya City (about 20 km away, north of Tokyo) with an area of about 18 ha. The experimental farm with an area of 16 ha is situated about 20 km north of Omiya City and cultivates many kinds of crops for research and testing activities.

Research Activities

IAM has four research departments in order to develop and improve agricultural machinery. Research in each department is conducted in close contact with related governmental, prefectural and industrial research institutes. The following show the organization and research area of these departments.

Fundamental Technology Department

The fundamental technology department puts stress on fundamental and initiative studies which are to be prosecuted without being restricted by existing frameworks of crops and machinery. This department consists of the following five laboratories.

(1) Agricultural Automation Laboratory
(2) Biotechnology Engineering Laboratory
(3) Ergonomics Laboratory
(4) Machine Dynamics and Reliability Laboratory
(5) Rural Resources Management Laboratory

Crop Production Machinery and System Department

The crop production machinery and system department aims at research and development for crop production machinery to increase the yield and working efficiency in the fields of paddy and upland farming. This department consists of the following five laboratories.

(1) Soil Management Machinery Laboratory
(2) Planting System Laboratory
(3) Crop Tending Machinery Laboratory
(4) Harvesting System Laboratory
(5) Drying and Processing Equipment Laboratory

Horticultural Engineering Department

The horticultural engineering department aims at research and development for horticultural machinery and storage system. This department consists of the following three laboratories and a workshop.

(1) Orchard Machinery Laboratory
(2) Vegetable Machinery Laboratory
(3) Postharvest Technology Laboratory
• Workshop (manufacturing, reconstructing and repairing machines for research and testing)

Animal Industry Engineering Department

The animal industry engineering department aims at research and development for animal industry machinery and apparatuses. This department consists of the following three labortories.

(1) Forage Crop Producing Machinery Laboratory
(2) Feed Processing Machinery Laboratory
(3) Livestock Raising Machinery Laboratory

Testing Activities

As in **Fig. 1**, the testing and evaluation department consists of five testing divisions to carry out National Tests, Safety Tests, IAM Tests and OECD Tests. Furthermore, this department conducts research on development of testing and evaluating methods including improvement of installation for testing, as well as on data processing in relation to evaluating activities. The following show the outline of National Tests, Safety Tests, IAM Tests and OECD Tests.

1) National Test

The National Tests are carried out on the basis of the Agricultural Mechanization Promotion Law, to determine performance, durability and ease of operation of current machinery. The kinds of machinery to be tested, testing codes and standards are determined and announced by the Minister of Agriculture, Forestry and Fisheries. The test results are reported to the Minister, and the name of the approved models and the outline of their test results are made available to the public.

2) Safety Test

The Safety Tests are conducted on the basis of the rules prepared by the Safety Testing Advisory Committee, to decide whether machines tested meet the safety requirements or not.

3) IAM Test

The IAM Tests are conducted on the basis of the Test Regulations. There are the Group 1 Tests and Group 2 Tests in IAM Tests. The Group 1 Tests are carried out according to our test codes and are applied to important machinery selected by IAM. The test reports are made available to the public. The Group 2 Tests are mainly conducted for manufacturers according to the test procedures agreed upon with them. The test reports can only be published with the consent of the applicants.

4) OECD Test

As mentioned above, IAM is designated as the OECD testing station in Japan. The tests of tractors and safety cabs/frames are carried out in accordance with OECD standard codes.

Publicity Activities

To fully exhibit the public nature of BRAIN, the Institution exerts to offer its technical fruits for general use by various fields concerned. Clerical works for these activities are assigned to the Planning Department. The following show only main subjects of publicity activities.

(1) Technical Guidance.
(2) Management of industrial properties.
(3) Acceptance of consigned research.
(4) Acceptance of trainees from official or private organizations and from developing countries.
(5) Publication of research and test reports.
(6) Collecting, sorting and furnishing of information on new domestic and foreign machinery.
(7) Management of showroom and museum.

Highlights of Research Activities

Out of the wide-ranging research and development activities of IAM, given below are the highlights of programs in progress, with short descriptions of recent advancements.

Autonomous Land Vehicle for Agriculture

Fig. 2 shows a view of the autonomous straight treveling test of the prototype vehicle with the terrestrial magnetism sensors. The object of this research is to make a land vehicle travel autonomously along the most suitable course by comparing the detected position of vehicle with the taught information of working field. It will be expected to save man-power, to free an operator from the uncomfortable or dangerous work and to improve work accuracy in the field machine works.

Grafting Robot for Fruit-vegetables

Fruit-vegetables are grafted in order to avoid the damages by soil contagious diseases and pests. The prototype grafting robot as shown in **Fig. 3** mass-produces grafted nursery plants. It consists of the following functional components: controller, nursery plants hand, conveyor arms, cutters and clipper. These devices are driven by pneumatic power and are controlled by a computer. 1 cycle time from holding seedlings to releasing a grafted nursery plant requires about 7 seconds. On cucumber grafting test, the percentage of successful grafting was 85%.

Combine for Multi-Crops

Fig. 4 shows the new combine equipped with screw type threshing and separating mechanisms, which is adaptable not only to rice but also many other crops such as wheat, barley, soybean, buckwheet, etc. This combine has a reciprocating cutter-bar with 2.1 m width and mounts a 60 PS engine. As results of transferring this technology to manufacturers concerned, the combines for multi-crops equipped with the new threshing mechanism are put into practical use and are used in paddy and upland farming fields recently.

High Performance Rice Transplanter

Fig. 5 shows the prototype of the high performance rice transplanter developed in 1985. This transplanter has the rotary planting mechanism which consists of eccentric planetary gears. Therefore, this mechanism enables high speed planting work, one and half times faster compared with the conventional crank type planting mechanism. The actual field capacity of the prototype is about 0.4 ha/h. This technology has been transferred to many manufacturers concerned and the high performance rice transplanters are becoming widely used on paddy fields recently.


Fig. 2 Autonomous land vehicle

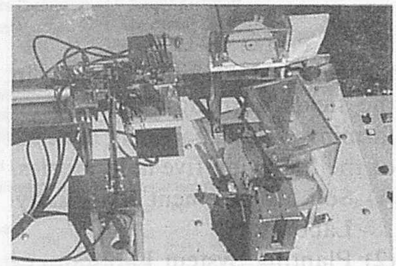
Fig. 3 Grafting robot


Fig. 4 Combine for multi-crops


Fig. 5 High performance rice transplanter

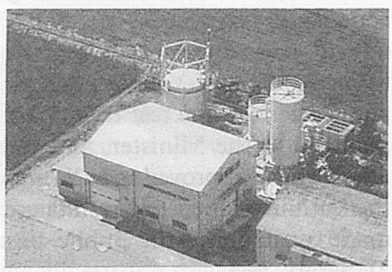
Fig. 6 Rice husk gasification and utilization system

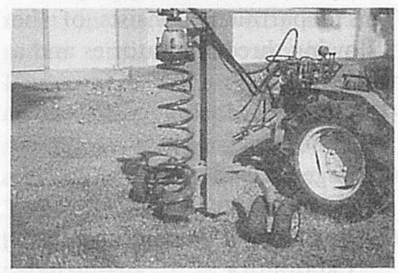
Fig. 7 Deep tiller with coil screw

Rice Husk Gasification and Utilization System

Fig. 6 shows an overview of the pilot plant (10 ha scale of paddy field) for paddy drying and processing which was constructed at the experimental farm of IAM. In this plant, rice husk is gasified by a gas furnace of the updraft type and moving layer form. The generated busk gas is used both as the heat source for the circulating type dryer and the electric power source for driving the equipment of this plant.

Deep Tiller with Coil Screw

Fig. 7 shows the new deep tiller equipped with the coil screw. The coil screw is made of spring steel, and looks like a cork screw for wine bottles. The screw penetrates into hard soil up to 80 cm while turning, and it can break the soil and dig a hole by pulling up by hydraulic cylinder. The soil sticking around the coil screw is removed easily by reversing it. Tractor-mounted type tiller and self-propelled type tiller have been developed and are put into practical use for soil management in orchards.

Non-Destructive Quality Sensor for Fruits

Fig. 8 shows the soft touch sensor named "HIT Counter" for

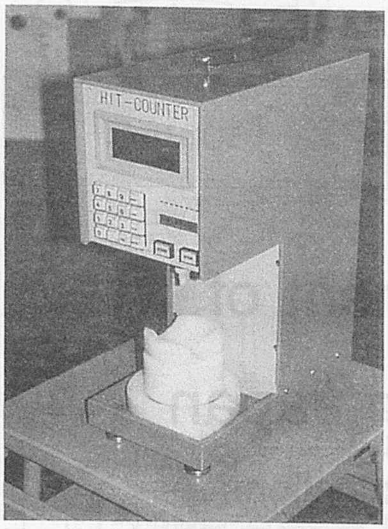

Fig. 8 Non-destructive quality sensor

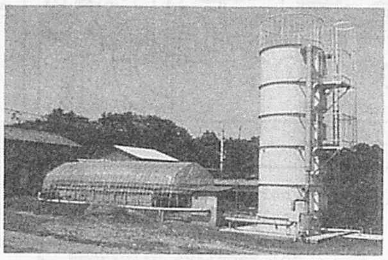

Fig. 11 Deodorant apparatus

evaluating the softness, which is in close relation to ripeness, of kiwifruit, muskmelon, pear, pineapple, etc. "HIT" stands for the initials of Hardness, Immaturity and Texture of sample. In this sensor, the sample is pushed instantly and softly at a constant velocity within an elastic limit by a plunger with a loadcell, and the softness of the sample is indicated as a count value.

Sugarcane Harvester

Fig. 9 shows a commercialized small cane harvester named Model NB-11 (windrower type) with a 9 PS diesel engine. Four experimental harvesters were developed and improved by the IAM from 1967 to 1971, and commercialized from 1972 as NB models. These harvesters were introduced for testing and demonstration into the following countries; Mauritius, Panama, Surinam, Egypt, Paraguay, Thailand and Sri Lanka. furthermore, chopping type harvesters for

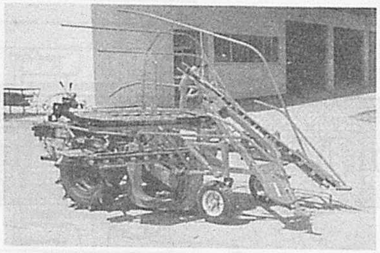

Fig. 9 Sugar cane harvester

Fig. 10 Pasture renovator

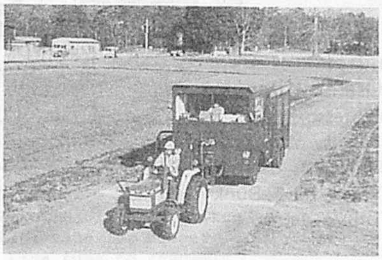

Fig. 12 Drawber performance test

green cane have been put into practical use by IAM.

Pasture Renovator

Fig. 10 shows the new pasture renovator, which is composed of fertilizer applicator, rotary tilling device, seeder, press wheels and herbicide applicator. This machine makes easy renovation without plowing of deteriorated grassland possible. The tilling device of this machine opens narrow 10 furrows of 4 cm width at equal spacing. Grass seeds are sown on the furrow bottom and packed by the wheels. Herbicide is used in order to enfeeble old vegetation. This renovator is mounted on the three point hitch of a tractor of more than 60 PS at PTO.

Deodorant Apparatus

Fig. 11 shows an overview of the deodorant apparatus for animal waste management using bio-filter which is made of the mixture of rock-wool and some or-

Fig. 13 Combine harvester test

ganic matters to support a population of bacteria. The bio-filter absorbs malodorous substances from composting equipment or drying equipment for animal waste and bacteria decompose them to inodorous substances.

Drawbar Performance Test

Fig. 12 shows a view of the drawbar performance test of a wheeled tractor on the test track. Drawbar performance is measured by dynamometer-car equipped with eddy-current dynamometer and data acquisition system using microcomputer. The dynamometer-car is used for the National Tests and the OECD Tests. Total weight is 10,000 kg. Maximum possible drawbar pull is about 6,000 kgf. Maximum possible drawbar power is about 130 PS. Usable speed is 2.2 km/h to 20 kg/h, restricted for safety reasons. At the same time, the noise of tractor at the driver's ear is measured at drawbar load.

Combine Harvester Test

Fig. 13 shows a view of the performance test of a combine harvester in the National Tests. The National Test of combine harvesters consists of tests on quality of work, rate of work and ease of operation in the paddy fields, and tests on durability in the laboratory. Standards on the performance test in paddy fields are as follows.

① Total grain losses should be less than 3%.
② The rate of damaged grains should be less than 1%.
③ The rate of rubbish in grain outlet should be less than 1%.

■■

Feature: Farm Machinery Industry in Japan

Research and Development of Agricultural Machinery in Japan

— Focusing on High Technology Applications —

by
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Introduction

Recent research and development with emphasis on high technology application in the field of agricultural machinery in Japan is briefly described in this article. Main fields of application are new farm machinery with much higher field capacity, automation of farm machinery, agricultural robots, energy saving and alternative energy development and biotechnological equipments and devices.

Machines with Higher Capcity

The development of new machines is greatly aided by computer calculation and design. A 4WD tractor uses engine power more effectively especially in paddy field. However, a comparatively large turning radius and disturbance of the soil by the wheels in turning are serious problems in a small field. Braking force and side force act on each front and rear wheel causing a slippage as illustrated in **Fig. 1**. To eliminate this, a new mechanism was developed to rotate the front wheels twice as fast as the rear wheels when the steering angle of the former exceeds 40 degrees. This device reduced turning radius, time and rut depth. A huge number of computer calculations on the basis of kinematic differential equations were required in the invention of this device[1]. Until quite recently the rice transplanting mechanism used in Japan was composed of a quadric crank mechanism which caused vibration and was thus inappropriate for high speed operations. A transplanting mechanism with eccentric gear trains solved this problem, and made the travel speed about two times faster than the conventional one (**Fig. 2**). Computer facilitated the design of a mechanism with an adequate orbit[2].

Automation of Farm Machinery

Automation has been achieved

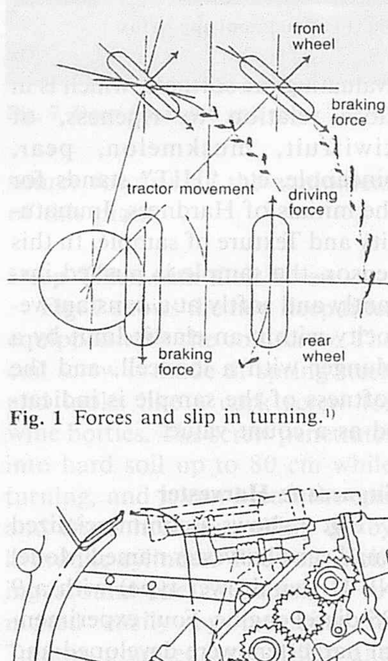


Fig. 1 Forces and slip in turning.[1]

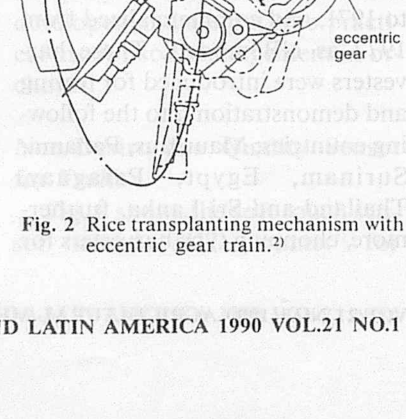
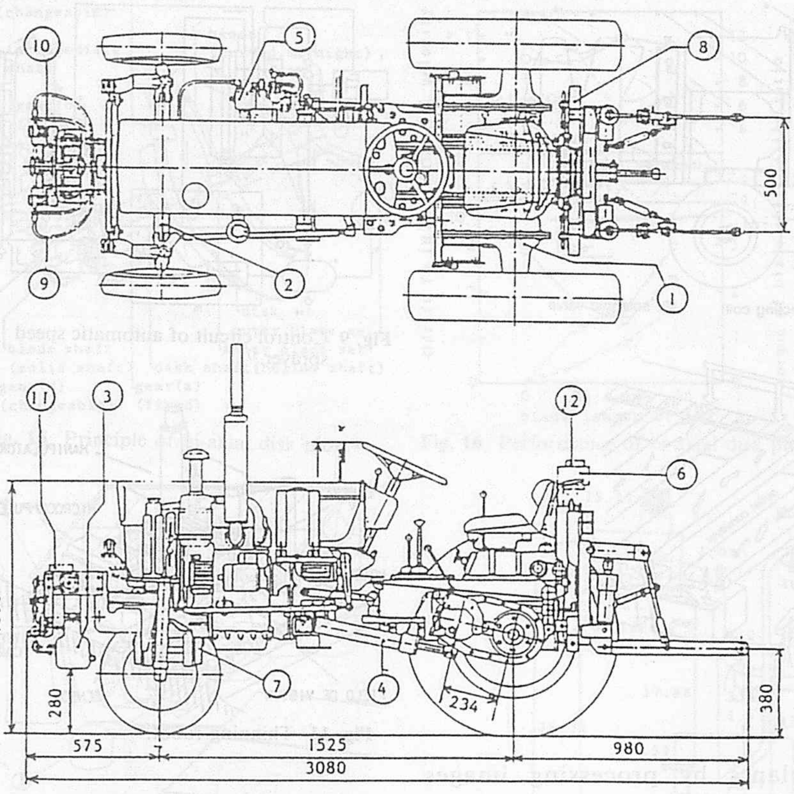


Fig. 2 Rice transplanting mechanism with eccentric gear train.[2]



1. Rear wheel suspension
2. Parallel link for front axle
3. Pendulum sensor
4. Hydraulic cylinder for attitude control
5. Flow divider
6. Pilot valve
7. Front axle bracket
8. Parallel link for hitch
9. Line tube for damper
10. Line tube to transmit pendulum displacement
11. Longitudinal spring-mass sensor
12. Lateral spring-mass sensor

Fig. 3 Trial made by hillside tractor with attitude control.[3)]

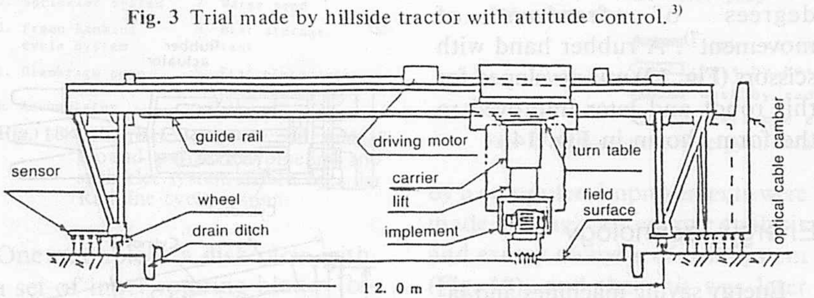
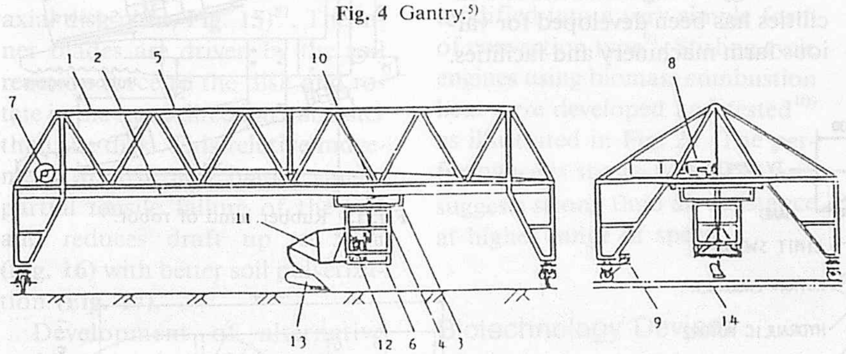


Fig. 4 Gantry.[5)]



1. guarder
2. carrier guide
3. turn table
4. center carrier frame
5. chain for driving carrier
6. low carrier frame
7. motor for driving carrier
8. torque meter
9. motor for driving carriage
10. lift for low carrier frame
11. three-point hitch
12. lifting device for implement
13. implement
14. rails

Fig. 5 Carrier-driving type gantry.[4)]

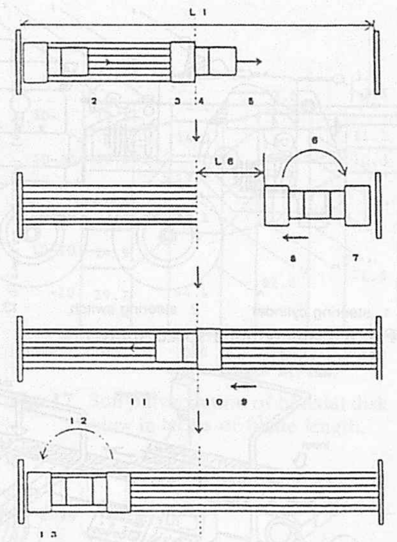


Fig. 6 Operation method with carrier-driving type gantry.

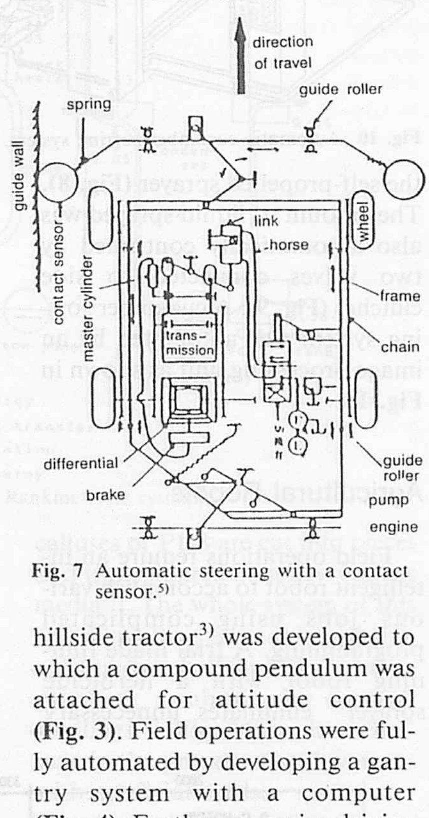


Fig. 7 Automatic steering with a contact sensor.[5)]

in all phases of farm mechanization to make jobs easier and the work done more accurate. Some examples are as follows: A trial hillside tractor[3)] was developed to which a compound pendulum was attached for attitude control (**Fig. 3**). Field operations were fully automated by developing a gantry system with a computer (**Fig. 4**). Further, a carrier-driving type gantry[4)] was designed to activate this system using 630W photovoltaic unit (**Fig. 5**). The means of operation with this model gantry with a 7m span is illustrated in **Fig. 6**. Spraying is a typical operation for which full automation has long been greatly desired. A speed sprayer was automatically guided by a contact sensor (**Fig. 7**) and a guiding AC cable system[5)] buried underground which steered

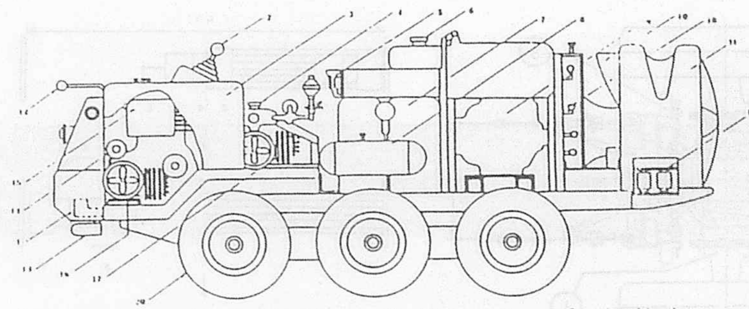


Fig. 8 Cable-guided speed sprayer.[5)]

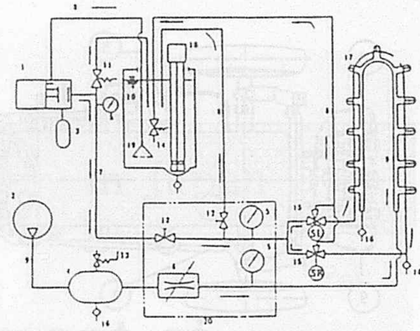


Fig. 9 Control circuit of automatic speed sprayer.[5)]

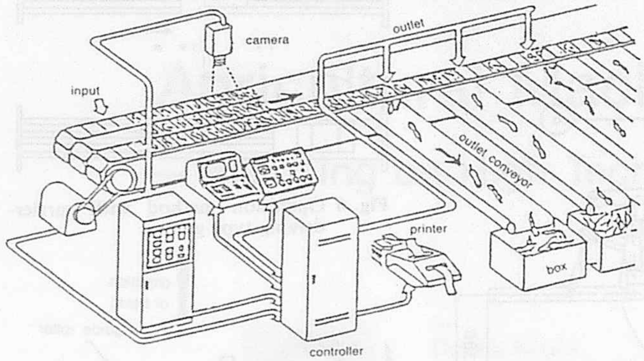


Fig. 10 Automatic cucumber sorting system.

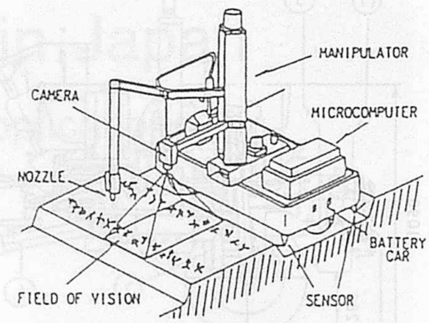


Fig. 11 Thinning robot.[6)]

the self-propelled sprayer (**Fig. 8**). The amount of liquid sprayed was also automatically controlled by two valves connected to side clutches (**Fig. 9**). A cucumber sorting system was automated by an image processing unit as shown in **Fig. 10**.

Agricultural Robots

Field operations require an intelligent robot to accomplish various jobs using complicated programming. A trial made thinning robot with a herbicide sprayer[6)] eliminates unnecessary plants by processing images through a TV camera (**Fig. 11**). Demand is also very high for a fruit harvesting robot. **Figure 12** shows an orange harvesting robot with a sliding arm which has a four degrees of freedom of movement[7)]. A rubber hand with scissors (**Fig. 13**) was developed for this robot and later improved to the form shown in **Fig. 14**.

Energy Technology

Energy saving machines and facilities has been developed for various farm machinery and facilities.

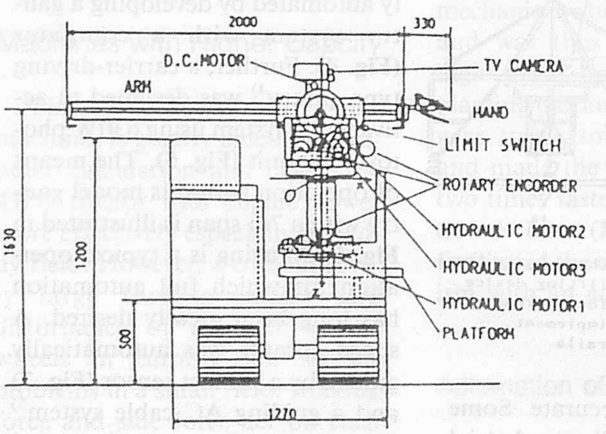


Fig. 12 Fruit havesting robot.[7)]

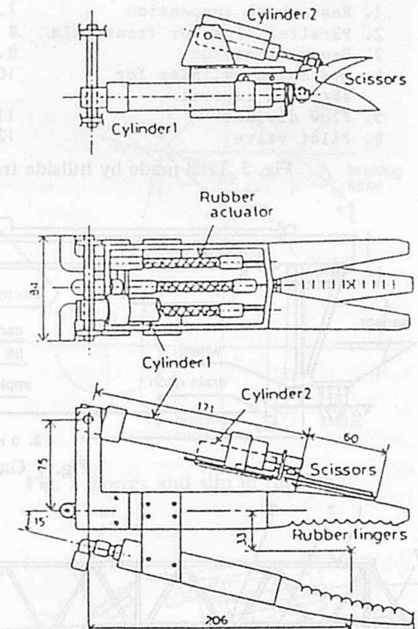


Fig. 13 Rubber hand of robot.[7)]

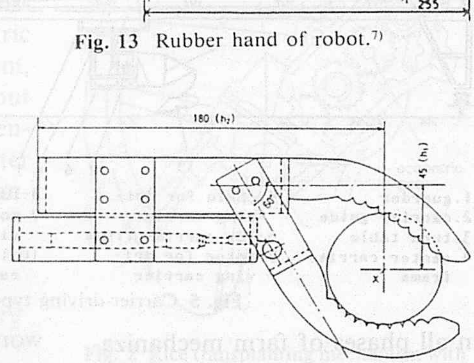


Fig. 14 Improved orange picking hand.

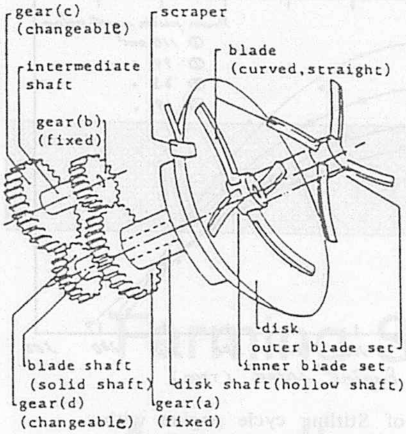


Fig. 15 Principle of bi-axial disk plow.[8)]

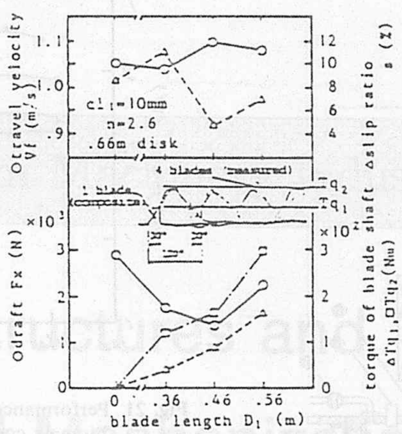


Fig. 16 Performance of bi-axial disk plow.

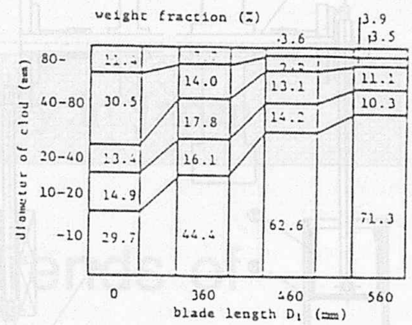


Fig. 17 Soil pulverization of bi-axial disk plow in terms of blade length.

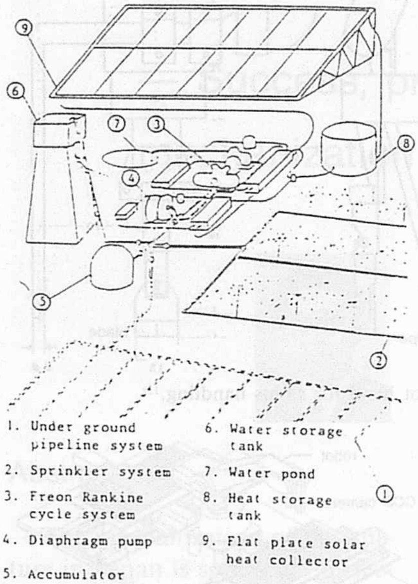


Fig. 18 Schematic diagram of underground perforated pipeline and sprinkler system driven by solar Rankine cycle system.

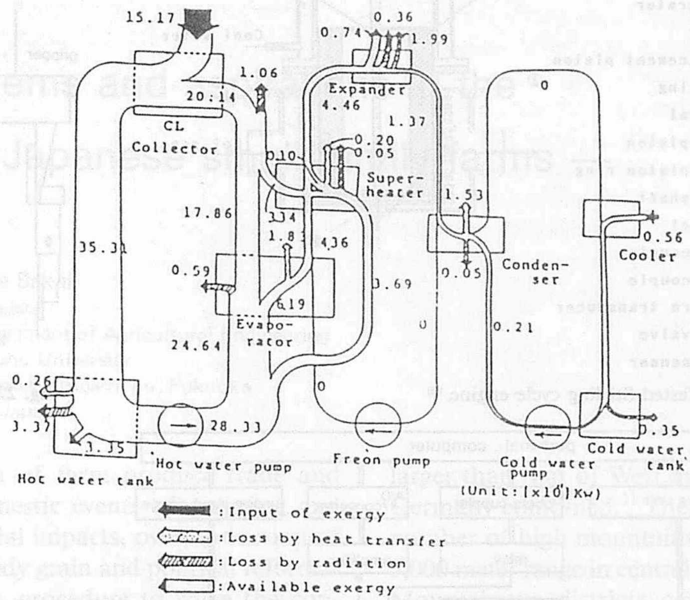


Fig. 19 Flowchart of exergy in solar Rankine cycle system.

One example is a disk plow with a set of inner rotating blades (bi-axial disk plow, **Fig. 15**)[8)]. The inner blades are driven by the soil reaction force to the disk and rotate in the same direction but faster than the disk. This relative movement of disk and blades causes partial tensile failure of the soil and reduces draft up to 50% (**Fig. 16**) with better soil pulverization (**Fig. 17**).

Development of alternative energy for agriculture has been attempted with solar, wind, hydraulic, geothermal and biomass energy. **Figure 18** is a schematic diagram of a Rankine cycle solar pumping system for irrigation with flat plate solar heat collectors and controlled by a computer. Improvements were made through an energy analysis and exergy analysis of this system (**Fig. 19**), and the unit was later modified into a very simple form of convection type[9)]. Stirling cycle engines using biomass combustion heat were developed and tested[10)] as illustrated in **Fig. 20**. The performance is shown in **Fig. 21** and suggests strong fluid air resistance at higher range of speed.

Biotechnology Devices

Sophisticated and automated devices are also needed for biotechnological operations such as tissue culture and cell fusion. **Figure 22** illustrates a robot hand for micro propagation in which calluses or PLB are cut into pieces and transplanted on a new culture media[11)]. The whole system of this callus handling robot is installed in a clean bench (**Fig. 23**). A transplanting robot for small seedlings[12)] (**Fig. 24**) is also necessary in the process of cultivations with artificial seeds.

Conclusions

The research and development of agricultural machinery in Japan in recent years has been described and some typical examples were shown. Continued efforts on this line are essential to the future development of agriculture worldwide.

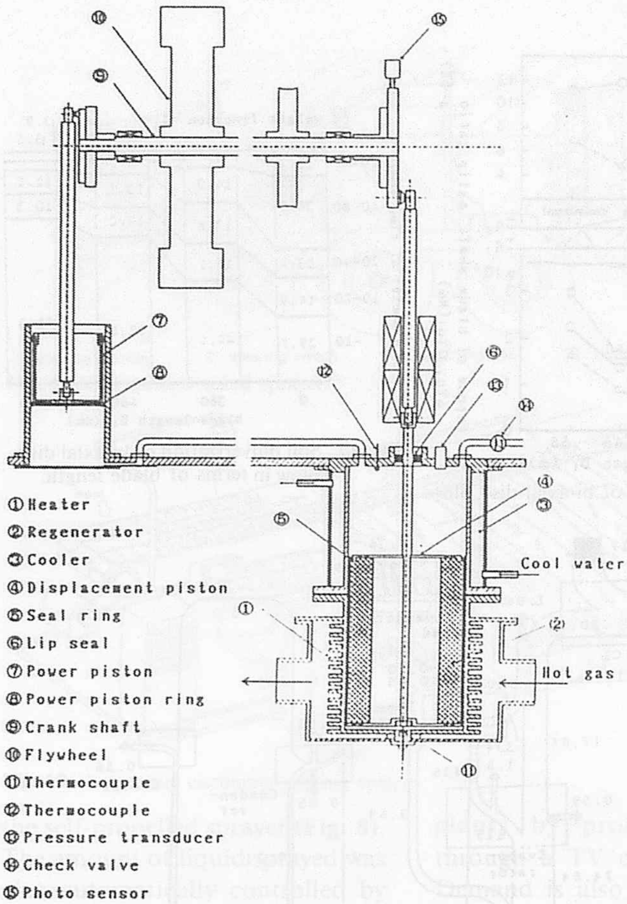


Fig. 20 Tested Stirling cycle engine.[10]

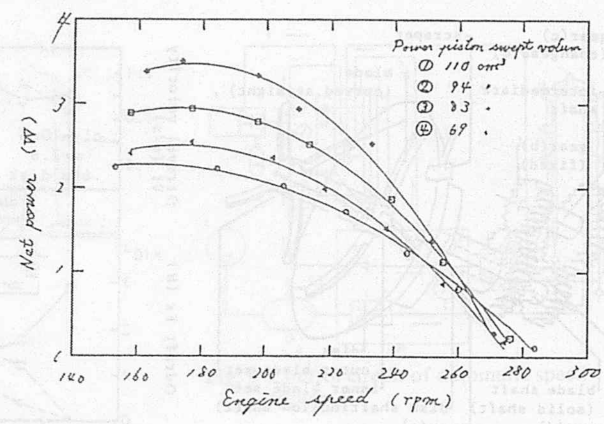


Fig. 21 Performance of Stirling cycle engine with biomass combustion heat.[10]

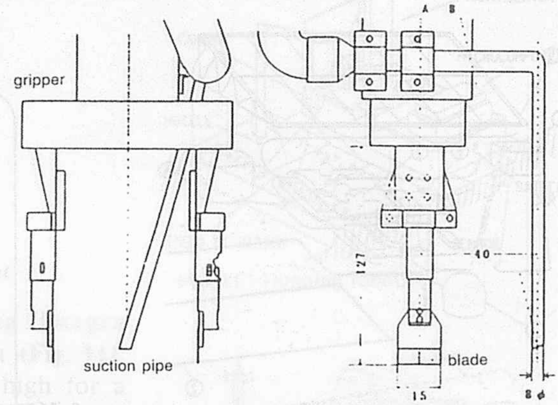


Fig. 22 Robot hand for callus handling.[11]

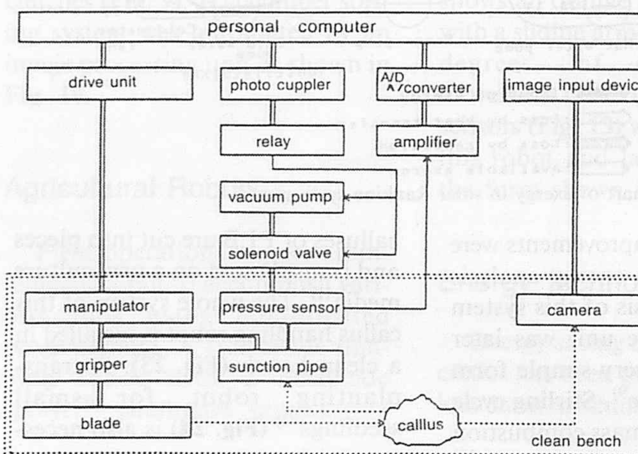


Fig. 23 System of callus handling robot.[11]

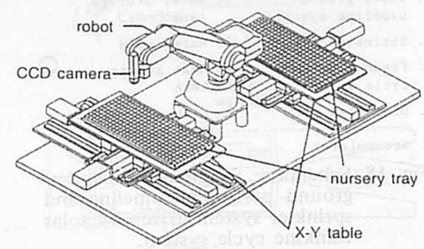


Fig. 24 Transplanting robot for small seedlings.[12]

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Farming Structures and Trends of Agricultural Mechanization in Japan

— Success, problems and aspirations in the mechanization of Japanese small family farms —

by
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Abstract

The mechanization of agriculture in Japan is somewhat different from that in Euro-American countries because of the cultivation of paddy rice as the main crop in Asia. Most Asian countries that cultivate paddy rice have an agriculture characterized by small family farms similar to Japan.

This paper deals with Japan's experience of the success and problems in farm mechanization which has supported her miraculous high growth and changing society since the 1950s, and explains several important trials and their results such as land reform after World War II and changes in the structure of farm land including the attitude and achievements of small family farms, the unique diffusion and development of small scale mechanization, the structural change of farm households and their economic trends, liberalization of farm produce trade and domestic events of cropping and social impacts, overproduction of paddy grain and political reformation procedure to solve the contradiction of her mechanized farming systems, governmental and public policies for th establishment of efficient mechanization systems for the 1990s and so forth.

Geographical and National Conditions

Japan is a country of islands lying in the subtropical, temperate and sub-frigid zones in eastern Asia. She consists of four main islands, as shown in **Fig. 1**. These are Hokkaido, Honshu, Shikoku and Kyushu from north to south. Tokyo, the capital city, lies at 35° north latitude, or about the same as north Algeria and Morocco.[1)]

Her land area is about 377,000 km^2, which is slightly smaller than the land area of France but a little larger than that of West and East Germany combined.[1)] There are a number of high mountains of the 3,000 meter range in central Japan. Mountainous districts cover the greater part of Japan, so agricultural area is only 14% of the nation's total land area, and there are no wide and flat plains, unlike continental countries.

Now in 1989, 123 million peo-

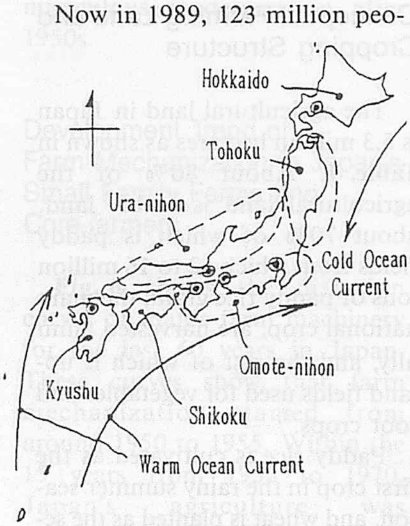

Fig. 1 Japan.

ple live in these limited habitable regions, and the population density is 325 persons/km^2. The annual rate of population increase was about 1.1% in 1970, 0.9% in 1980 and 0.7% in 1985.

Japan is located in a part of the monsoon Asian region, east of the Asiatic Continent, and its climate is greatly affected by seasonal winds. Winds from the south cause a hot climate during summer, while winds from the north continent cause a very cold winter.[1]

As shown in **Fig. 1**, the biggest island Honshu is divided into Tohoku, Ura-nihon according to the geographical weather conditions.

There are two warm ocean currents from the south and one cold ocean current from the north. Accordingly, Kyushu, Shikoku and Omote-nihon have a warm climate but Hokkaido, Tohoku and Ura-nihon have a cold climate with heavy snowfall in the winter.

The annual mean rainfall is 1300 to 1400 mm/year, which is about two to three times as much as that in Euro-American countries. This is a characteristic common to paddy rice cropping regions in Asia. **Fig. 2** shows the variation of rainfall and temperature in Japan.[2]

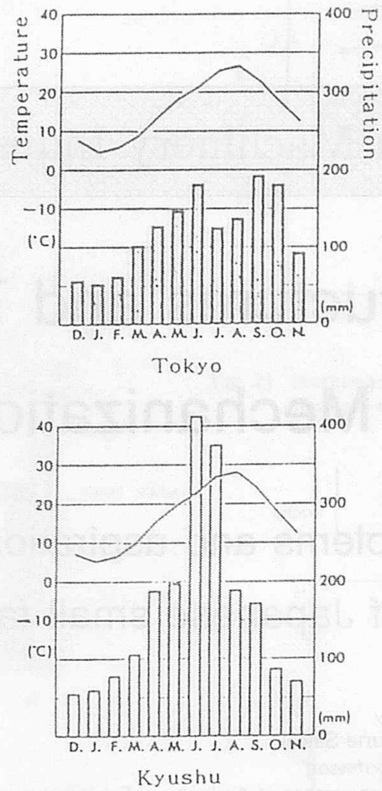

Fig. 2 Climate condition.[1]

Concept of Farming Land and Cropping Structure

The agricultural land in Japan is 5.3 million hectares as shown in **Table. 1**. About 80% of the agricultural land is arable land, about 70% of which is paddy fields from which 12 to 16 million tons of paddy rice grain, the main national crop, are harvested annually, and the rest of which is upland fields used for vegetables and root crops.[3]

Paddy rice is cultivated as the first crop in the rainy summer season, and wheat is planted as the second crop in the winter season on the same paddy fields which have a good drainage function with regard to excess irrigation water.

It was traditionally common for Japanese farmers to cultivate wheat as a second crop in paddy fields. Soybeans were also usually planted along the side shoulders of the levee and farm roads around the small paddy fields until the 1950s. Of course, many kinds of beans, root crops and vegetables were planted on upland fields all over Japan.

Many kinds of fruit trees such as oranges, apples, persimmon, grapes, etc. were planted in hilly districts in general, because flat districts in Japan have to be used for paddy fields.

Japan has a small area of permanent meadows and pastures, because Japanese had a national custom of not eating beef and dairy products till the Meiji era, about 100 years ago, for their protein sources were mainly fish and beans. Although Euro-American culture influenced people to eat animal protein, the pasture land is only 12% of the entire agricultural land. (Consequently Japan has been importing about 70% of concentrated feeds for the livestock industry since the 1970s.)

Table 1 Agricultural Land in Japan, 1988. 3)

- agricultural land (5.3 m ha)
  - arable land (4.2 m ha)
    - paddy fields (2.9 m ha)
    - upland fields (1.3 m ha)
  - land under permanent crops (0.5 m ha)
  - permanent meadows & pastures (0.6 m ha)

Thus, when 80 million people had to live in a new but almost destroyed Japan of critical shortage of foods in 1945 after the World War II, the most important and urgent task was the reconstruction of national agriculture as a base of the country.

Revolutionary Change of Farm Land Ownership and Population Structure After the War.

The proportion of farmers to the total employed population in Japan in the 1930s to the 1940s was about 50%. Thus, Japan was still an agricultural country before World War II. About one-third of the total number of farm households were rich land owners, but the rest were poor tenants or owner-tenants.

When the war ended, Japan became a free democratic country, and achieved a prominent land reform from 1946 to 1950 under the principle of a "landed farmer" who cultivates his crops on his land by himself. **Fig. 3** shows the change of the farm land ownership after the reform.

The Agricultural Land Reform Law was formulated on the basis of the idea originated by the representative from England,[4] and enforced in 1946. This refor-

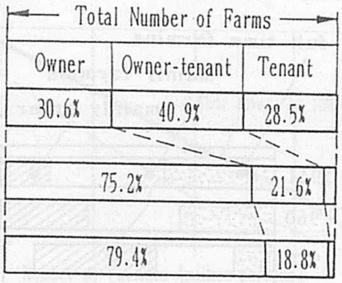

Fig. 3 Farm land ownership in Japan.[2]

Table 2 Number of Households by Size of Cultivated Land in Operation.[3] (%)

	1941	1950	1960	1970	1975	1985
Under 0.5 ha	32.9	40.8	38.0	37.7	40.5	42.8
0.5 ~ 1.0 ha	30.0	33.0	31.8	30.2	29.2	27.1
1.0 ~ 2.0 ha	27.0	21.7	23.6	24.1	22.0	20.4
2.0 ~ 3.0 ha	6.2	3.4	3.8	4.8	5.0	5.5
Over 3.0 ha	3.5	2.0	2.5	3.0	3.3	4.2
Exceptions	0.4	0.1	0.3	0.2	0.0	0.0
Total	100.0	100.0	100.0	100.0	100.0	100.0
Number (in 1,000)	5,412	6,176	6,057	5,342	4,953	4,376

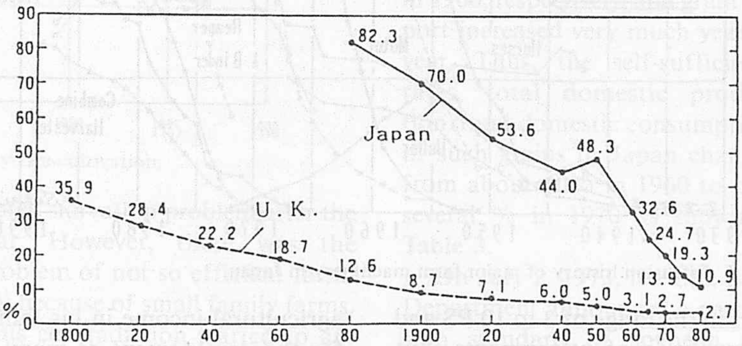

Fig. 5 Reducing the ratio of farmers' population to total employed population, U.K. & Japan.[1] (%)

mation was based not on "Down with Land Owners" as a revolutionary standpoint, but on "Food Production Increase" without class strife.[4]

Thus, the holding of farm land for a farming family had to be less than 3 hectares in Japan, except for Hokkaido where it had to be less than 5 hectares, though this changed to 12 hectares later. And it was prohibited for the owner and the tenant to have private transaction of land. Their land was to be bought or sold by only the government itself.

Then, rich owners' excessive farm lands were bought and sold by the government to all the tenant families, and the tenant had almost disappeared from Japan by 1950. In 1952, the Agricultural Land Law was enforced in order to abolish the tenant system.

At that time, the total agricultural land of about 6 million hectares was cultivated by about 6 million farm households, which

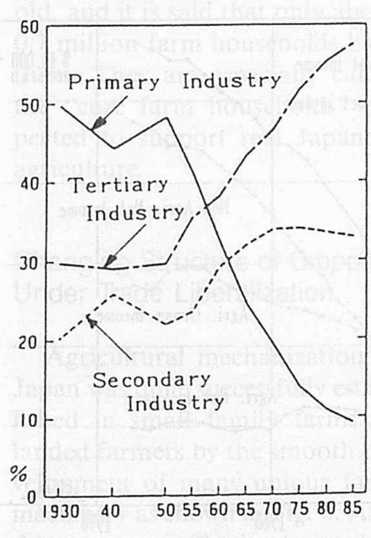

Fig. 4 Employed population ratio in each industry in Japan.[1]

resulted in small family farms with an average of only about one hectare/farm household. The classification of farms by size after 1941 is shown in **Table 2**.

Most farmers were quite contented as land owners at that time and acted not only to achieve productive farming in order to solve the national starvation problem after the war, but also to support the high growth of Japan's economy and industries, because:

In general, it is certain that the modernization of a country should not be based on monocultural industries but on the development of many industrial fields. Specifically, in order to realize the smooth growth of various industries, the process of growth should be supported by the flow of human resources from the primary industry to the secondary and tertiary industries without destroying the national agriculture.

Fig. 4 shows mutual changing trends in the rate of the employed population in three industrial fields in Japan. It is clear that the development of the secondary and tertiary industries was supported by the influx of human resources from the primary industry, especially since 1950. **Fig. 5** shows that Japan's rate of reduction of farmers was dramatically high along with the high growth of Japan's economy, as if Japan was trying to achieve what took 200 years to happen in England within several decades.

It can be said that the concurrent quick diffusion of farm mechanization in Japanese small family farms became one of the very effective causes that enabled the nation to achieve this miraculous modernization after 1950s.

Development Trend of Farm Mechanization in Japan's Small Family Farms and Core-farmers

Fig. 6 shows the diffusion curves of major farm machinery for the last 60 years in Japan. These curves show that farm mechanization started from around 1950 to 1955. Within the 15 years from 1955 to 1970, Japan's agriculture was mechanized with small hand trac-

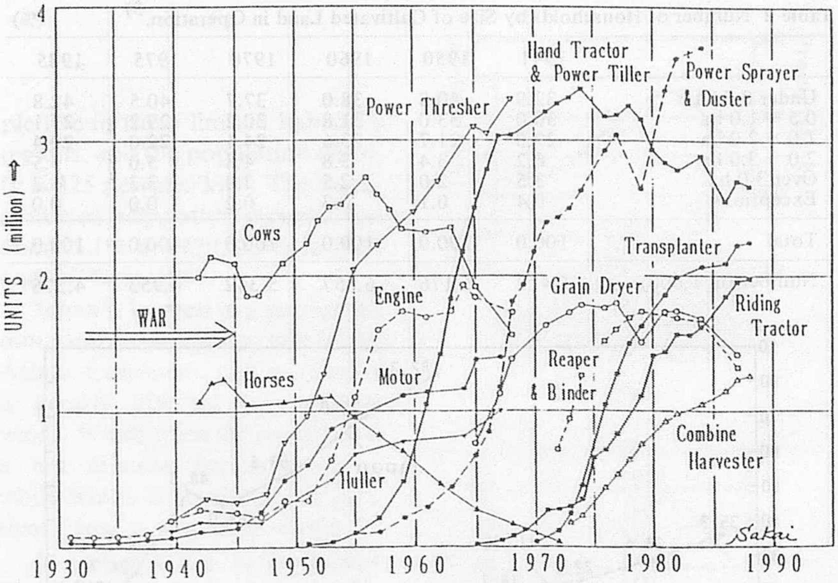

Fig. 6 Diffusion history of major farm machinery in Japan.

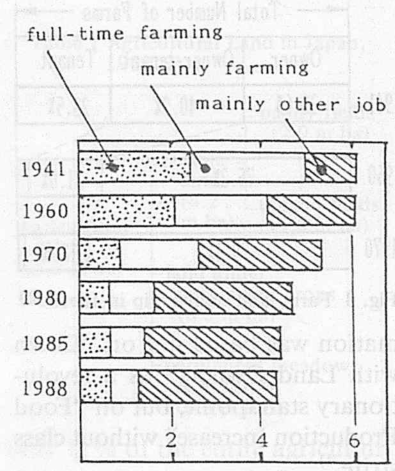

Fig. 7 Number of farm households of full and part time farming.[1]

tors in the range of 3 to 10 PS and many knds of attachments, but without riding tractors, as the first step. Then, as the second step from around 1970, the use of riding tractors of 9 to 20 PS with small transplanters and harvester machines started.[5)6)7)]

These machines changed gradually to bigger ones, 13 to 40 PS tractors, 2 to 8-row transplanters, 1 to 4-row reaper-binders and 2 to 8-row combine harvesters, and Japan's traditional farming of paddy production by small family farms was at last fully mechanized in 1980s.

This development process of Japan's mechanization was done step by step but quickly and excessive manpower had been efficiently absorbed into other industries along with national high growth since 1950. Moreover, besides the reduction of the total number of farmers as mentioned above, many farming families started to become part-time farming households who also assisted other industries, although the total number of farm households did not decrease so remarkably as shown in **Fig. 7**.

Namely, the Japanese farmer after the land reform in 1946 have been in the habit of never selling his farm land to others but being a part-time farmer who can earn both agricultural and non-agricultural income in his family, for the development of many industries has covered not only city areas but also the whole country and offered many kinds of jobs to the mechanically-minded farmers.

Fig. 8 shows the 50 years' trend of the total income for an average farm household of about 1 hectare in 1955 to 1.3 hectares in 1988 in Japan.[3)] Agri-income is smaller than non-agri-income nowadays. However, this table shows that Japanese small farming families are rich. Farmers' richness means national richness.

Fig. 9 shows that the farmer has been improving labor productivity by mechanized small farming. When animal-powered farming in 1955 shifted perfectly to hand tractor farming in 1970 as expressed in **Fig. 6**, the average labor hours per hectare for paddy production changed from about 2,000 to 1,000 hr/ha, a reduction by half, and then, to almost 500 hours, a further reduction by half, when hand tractor farming shifted to small riding tractor farming in 1988.[3)]

On the other hand, the rate of the total number of farmers to the total employed population in Japan reduced to almost one-fifth in the same period as shown in **Fig. 4**. Namely, about 20 million farmers in 1950 had decreased to

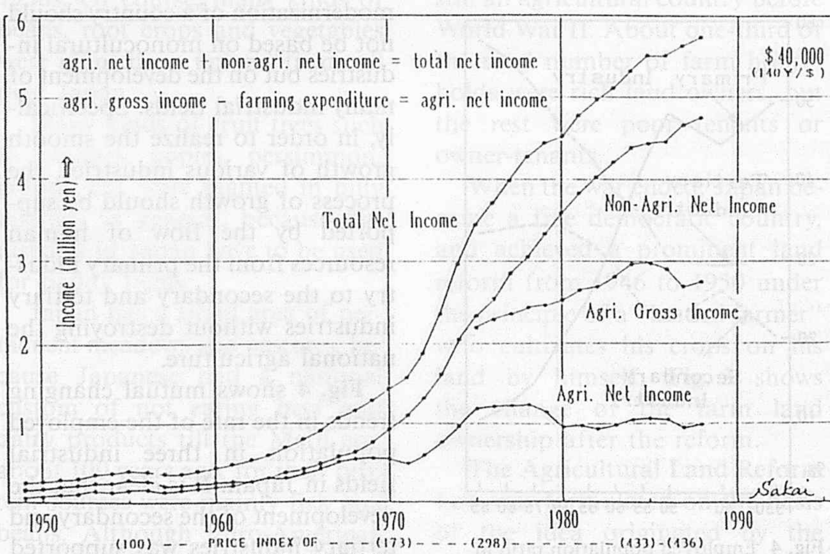

Fig. 8 Income trend of Japanese average farm household.

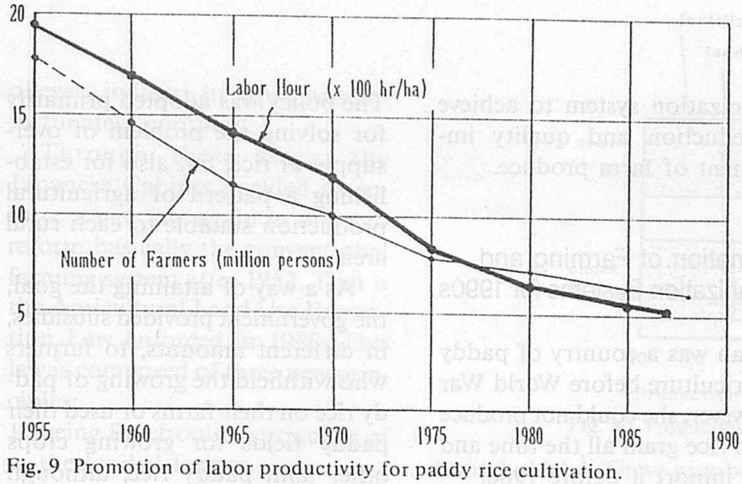

Fig. 9 Promotion of labor productivity for paddy rice cultivation.

about 6 million by 1988 as shown in **Fig. 9**. And moreover, about 80% of them were old men of more than 60 years of age and women since the 1960s.

Namely, to mechanize all Japan farming was not to mechanize selected family farms as a minority by use of big machinery driven by special drivers, but to mechanize all small family farms as a majority, and to develop farm machinery that met the following conditions:

1. to be driven by farmers themselves, even by women or old men
2. to work in paddy rice fields
3. to be owned by a small farm family as a landed farmer

Presently, Japanese agriculture retains about 1.2 million stout male-farmers of less than 60 years old, and it is said that only about 0.7 million farm households have them. They are especially called the "core farm households" expected to support real Japanese agriculture.

Changing Structure of Cropping Under Trade Liberalization

Agricultural mechanization in Japan was quite successfully established in small family farms of landed farmers by the smooth development of many unique farm machinery as shown in **Fig. 6**. And this was very effective to modernize the farms and to solve the national starvation problem after the war. However, there was the problem of not so efficient farming because of small family farms. This contradiction started to appear through conventional cropping systems in around 1970.

It was traditionally common for Japanese farmers to cultivate wheat, barley and soybean in their small farms until the 1960s. However, the prices of many commodities such as seeds, fertilizers, chemicals, water, especially farm land and labor wages became expensive, production prices of such grains became higher than those of foreign products in the international market. Then, in 1960s, such a practice could not be continued because of the pressure of trade liberalization on wheat, barley, soybeans, etc. which led to the import of cheaper equivalents from foreign countries such as the United States, Canada, China and so forth.

The annual harvest of 3 to 4 million tons of wheat and barley and 0.4 to 0.5 million tons of soybeans in 1950s quickly disappeared in 1960s, and annual productions in 1973 to 1977 became almost one-tenth and one-quarter of those in 1960, respectively, and grain import increased very much year by year. Thus, the self-sufficiency rates, total domestic production/total domestic consumption, of such grains in Japan changed from about 40% in 1960 to only several % in 1970 as shown in **Table 3**.

On July 2, 1973, the U.S. State Department announced a permission standard of soybean and other farm produce export to control inflation at home, and enforced it on the same day.[1] The newspaper, the June 29, 1973 issue of Asahi Shinbun, reported "The United States exports its farm produce all over the world, and Japan is the largest market for all kinds of U.S. farm produce except corn. If the exports of U.S. farm produce to Japan stops totally, one-quarter of the Japanese population will be on the brink of starvation and three-quarter of it will have no dairy products."[1]

When the United States temporarily imposed restrictions on soybean exports in July 1973 because of their domestic inflation, the prices of soybeans and other imported farm produce rose sharply with a social crisis in Japan.[2]

Table 3 Self-sufficiency Currents of Foodstuff in Japan. (%)

	1960	1970	1975	1980	1985	1987
rice	102	106	110	87	107	100
wheat	39	9	4	10	14	14
barley	107	34	10	15	15	15
soybean	28	4	4	4	5	6
grain	82	46	33	31	31	31
fruit	100	84	84	81	77	75
meat	91	89	77	81	81	76
egg	101	97	97	98	98	99
milk 1)	89	89	82	82	85	78
mean	90	78	74	73	71	71

1); including products from milk.

similar to oil crisis in 1973. This crisis caused by the United States and the crisis caused by the Arabs have substantiated the argument that it is dangerous to depend on foreign countries for food and energy.[1)]

Hence, Japan started to try to restore her agriculture by reforming laws and the establishment of modern farming systems, as explained in the following section, and it was somewhat recovering, for Japan produced more than 1.4 million tons of wheat and barley and 0.3 million tons of soybeans in 1988.

Table 3 shows the changing self-sufficiency rates of agricultural foodstuffs in Japan. She is a country of about 70% self-sufficiency in foodstuffs on a grand average, and keeping perfect saturation of the main food, paddy rice.

In 1988, Japan had restricted the import of 22 farm products. However, the United States has demanded over the last several years that Japan should lift import restrictions on beef and oranges. Then, in 1988, the Japanese government lead by the Liberal Democratic Party agreed to increase the import quota of these products to achieve free trade gradually within three years.

In 1989, the Liberal Democratic Party suddenly had to become an opposition party in the House of Councilors, because the Socialist Party was elected by farmers and consumers in most rural and urban areas in Japan. They said the lifting of import restrictions became one of the very important reasons for the election event.

Nowadays, as mentioned above, Japan's agriculture has come to be greatly influenced by international market prices of farm produce and trade liberalization, so that her farming is again undergoing structural reformation by the establishment of more efficient farm mechanization system to achieve cost reduction and quality improvement of farm produce.

Reformation of Farming and Mechanization Systems for 1990s

Japan was a country of paddy rice agriculture before World War II. However, she could not produce enough rice grain all the time and had to import it before 1968.

From the 1940s to the 1960s, however, paddy production was improved year by year, and at last there was an oversupply after three years' continuous rich harvest from 1967.[3)] The optimum amount of brown rice in stock at the end of October before new harvest could be one million tons in general. But the stock in 1970 quickly approached more than six million tons.[3)]

It was not until then that Japan experienced such problems of overproduction as the lack of storing technology and facilities, marketing practices, increasing subsidies and expense as a national deficit for storing, impossibility of export because the Japanese rice variety is different from the usual Indian variety common in many other Asian countries, etc.

Although its production price was not so much higher than that of the similar variety of rice in U.S. at that time when the exchange rate was 360 ¥/$, it became quickly higher due to the dollar devaluation relative to the yen since 1971.

In order to cope with these circumstances, production adjustment was carried out experimentally in fiscal 1969 and 1970, and then it was incorporated into the policy of rice production adjustment and conversion, which was based on a Cabinet decision on the promotion of conversion of paddy fields to other farm products in 1971, and put into effect at the beginning of fiscal 1971. The policy was adopted primarily for solving the problem of oversupply of rice, but also for establishing a pattern of agricultural production suitable to each rural area.

As a way of attaining the goal, the government provided subsidies, in different amounts, to farmers who withheld the growing of paddy rice on their farms or used their paddy fields for growing crops other tahn paddy rice, although subsidies to farmers withholding the growing of rice were suspended in fiscal 1973.[1)]

In the same period of the latter part of the 1960s, Japan had a critical experience of the destruction of wheat and soybean cultivation under trade liberalization. The cause of the destruction was higher production prices of those grains than the international prices, because of the conventional farming under the domestic condition, that is, a small family farming system under the Agricultural Land Law enforced in 1952.

In 1970, the law was changed to remove the limit on the area of farm land holding for one farm household, in order to shift to larger scale farming. However, very few farmers responded to it. No farmer wanted to sell their farm land to other farmers. Thus, in the following years, the Law was reconsidered to make tenancy easier and to allow rental farms, for example, from a part-time farmer to any full-time farmer. However, farmers did not change their basic attitude of cultivating their farm lands by themselves under the important principle in the old Agricultural Land Law, and they never forgot a historical fact that the farm land owner had lost his land under the tenancy.

In those days in 1973, Japan had the soybean crisis, as mentioned in the fifth section, and also the world happened to have the oil and energy crisis. The reformation of every industry in Japan was unfortunately confused.

Through these steps, the Japanese Cabinet decided to enforce a new law again in order to reform basically the conventional farming system after 1952. That is the Agricultural Land Use Promotion Law enforced in 1980. This law is composed of three new principles:

1. being free from the principle of the landed farmer
2. legalizing the lease of farm land
3. legalizing the contract of farm work

In the last 20 years, especially after 1980, the Government, the Agricultural Cooperative Society and prefectural governments have continued active leadership of establishing group farming and their mechanization systems, such as the establishment of a paddy rice post-harvest processing and storing centre in the main rice producing regions all over Japan, assisting the advanced districts to form the "farm machinery and labor link system" originated and developed by West Germany in 1960s, and grouping family farms based on the contract system with bigger farm machinery by a leading farmer or what we call a core farmer and so forth.

Although farmers in general were conservative, they came to realize the necessity of farm reformation because of many phenomena of cropping and farming problems related to the difficulty of the promotin of agricultural income as shown in **Fig. 8**.

Then, in 1985, 455 thousand farm households, about one-tenth of all farm households in Japan, joined three systems, i.e., the cooperative utilization systems of farming facilities and machinery (about 390,000 farm households), the contractors (about 61,000 farm households) and the collaborating farm systems (about 30 thousand households).[3] These numbers are increasing. **Fig. 10** shows the average production costs of larger scale and small scale mechanized farming according to the statistical data in Japan.[8]

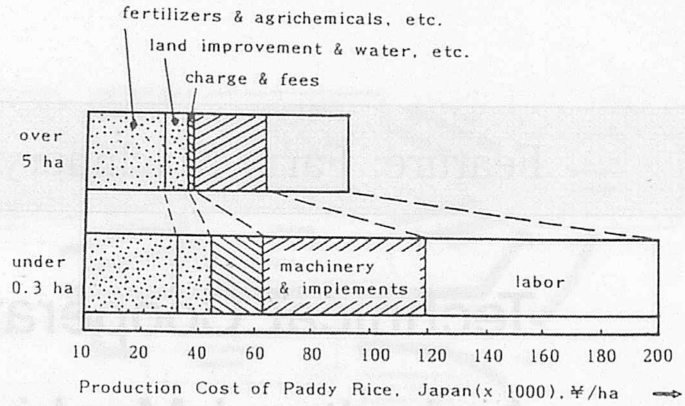

Fig. 10 Production costs according to scale.[8]

In the private sector, professional contractors even as company systems that undertake farm works are increasing all over the country. In order to promote such activities led by the man of abiity to manage efficient machine operation and mechanized farming to reduce production cost in a district unit, an examination system that qualifies the core farmer has been established in as many prefectures as possible since 1972. The qualified person can be titled a Nogyo-kikai-si in Japanese, i.e., farm machinery and mechanization instructor. Now, more than 70% of all prefectures in Japan have already established this system. By 1989, 59,732 farmers had been qualified as instructor and joined the leading activities of modern utilization of farm machinery.

For an actual example, these several years, the author himself has been invited to give lectures in the study meetings held by the association of Nogyo-kikai-si in Fukuoka prefecture of Kyushu island **(Fig. 1)**, and then, has a schedule to give a memorial lecture to the first joint meeting consisting of six associations of Nogyo-kikai-si in eight prefectures of Kyushu and western Japan on January 19th, 1990.

In Japan, many farmers are eager to study as well as work. Their existence itself is the hope of Japanese agriculture and mechanization, even if there are some problems.

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Feature: Farm Machinery Industry in Japan

Technical Cooperation of Agricultural Machinery in Japan

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Introduction

Japan's Official Development Assistance (ODA) is classified into three types: Grant Aid, Technical Cooperation and Loan Aid.

Out of above mentioned three types of ODA, this report will explain mainly technical cooperation programs.

Japan's technical cooperation programs employ the following mechanism. The Ministry of Foreign Affaires prepares the plans for these programs as well as the requests for the required budget. Its implementation is the responsibility of the Japan International Cooperation Agency (JICA). Technical cooperation programs are composed of the following items.

1. Acceptance of trainees
2. Dispatch of experts, survey teams and volunteers from the Japan Overseas Cooperation Volunteers (JOCV)
3. Provision of equipment and materials related to the work of the persons mentioned above;
4. The project-type cooperation, which represents the combination of three type of cooperation mentioned above 1-3.
5. Development survey and development cooperation project.

Among above mentioned technical cooperation, I will describe 1. and 4., agricultural mechanization training programs and the project-type technical cooperation especially for agricultural mechanization cooperation.

There are two types of training programs. One is group training courses. The other is the individual training courses which are organized in accordance with specific requirements of a region or a country. There are four courses concerning agricultural machinery in Japan through JICA as follows.

1. Farm Mechanization Course
2. Farm Machinery Design Course
3. Agricultural Machinery Maintenance and Repair Course
4. Post-Harvest Rice Processing Course

Concerning the project-type technical cooperation for agricultural machinery, JICA has many projects, among those agricultural development project. I will select two project namely;

1. Rice Mechanization Pilot Project in The Arab Republic of Egypt
2. The center for Development of Appropriate Agricultural Engineering Technology in The Republic of Indonesia

Technical Training

As part of the government-sponsored technical cooperation, Japan has been providing training opportunities to people from developing countries for a long time. This kind of cooperation is intended to provide specialized training so as to contribute to the social and economic development of the countries of origin of the trainees.

The government of Japan established the Japan International Cooperation Agency (JICA) in 1974 and its sole agency for the integration and implementation of Japan's technical cooperation with developing countries for technical cooperation, particularly in the area of human resources.

JICA conducts such activities as training programs has been regarded as one of its core activities ever since the agency's establishment. Under the training program, which comprises both group training courses and individual training courses, JICA today accepts more than 4,000 overseas participants every year for training in Japan.

Government-sponsored technical cooperation programs of Japan are implemented on the basis of requests from developing countries. When the request for training is presented by the authorities of a developing country through the Japanese embassy, JICA studies the possibility of accepting the request, under the policy laid by the Ministry of Foreign Affairs.

The requests from various countries are presented on A2 and A3 forms. The A2 form is for describing in concrete terms the contents of desired training program for each trainee. The A3 form is for personal data about the trainee. The system for accepting trainees are classified into group training and individual taining. Individual training is subdivided into counterpart training and ad hoc individual taining.

There are four courses in the field of agricultural machinery in JICA. Two courses out of four courses as mentioned before. One is course for agricultural machinery maintenance and repair. Course conducted the facilities and institution are in Osaka International Training Center under JICA and the member plants of Japan Farm Machinery Manufacturers Association. Description of training are based on lectures, practices and observation tours. Main items of lectures and practices are maintenance and repair of Japanese made agricultural machineries, such as small and midium type of tractor and hand tractor, various kinds of prime movers for agricultural use, rice transplanter and various kinds of seeder, pump, inter-cultivater, harvesting machines including

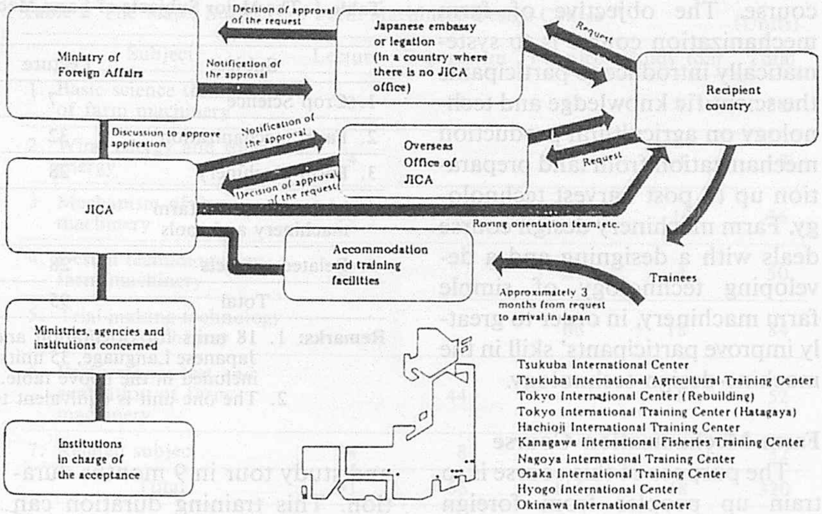

Fig. 1 Mechanism for acceptance of trainees.

threshing machine and dryer etc. Duration of training is seven months from June to December and number of participants to be accepted within ten trainees.

The other course is namely the Post-harvest Rice Processing Course. This Course is conducted by the Tokyo International Center, JICA and Ministry of Agriculture, Forestry and Fisheries. Description of this course' training are post-harvesting technology for rice after harvest by lectures, practice in the machine making factory and observation tours. Some training items of leactures and practices are food situation of Japan and importance of rice, production and export of agricultural machinery, rice control system, characteristics of Japonica and Indica and so on. Duration of training is three months from August to November and number of participants to be accepted within 15 trainees.

Above mentioned both training course, the participants should have good working knowledge of English. And they should be in good health, both physically and mentally, to undergo the training. Applicants age should be not more than 40 of age for Agricultural Machinery Maintenance and Repair Course, and be not more than 45 of age for Post-harvest Rice Processing Course.

Technical Training for Farm Machinery in TIATC

Tsukuba International Agricultural Training Centre (TIATC) started its activities in April, 1981 as the succession of organization of Uchihara International Agricultural Training Centre (UIATC) and has received 1,447 participants from 72 countries in its history of 29 years upto 1989.

The objective of the TIATC training is not only to provide the participants on the rational agricultural technique used in Japan, but also to advise participants utility the know-how of agricultural ability to be applied and developed in any circumstantial agriculture of their respective countries. And the centre is annually offered nine group training courses in 1989 for a period of about 10 months in the field of rice cultivation, agricultural machinery, irrigation and drainage and vegetable production, and also we have individual training for agriculture.

There are two courses in the field of agricultural machinery, namely farm mechanization course and farm machinery design course. The objective of farm mechanization course is to systematically introduce to participants the scientific knowledge and technology on agricultural production mechanization from land preparation up to post harvest technology. Farm machinery design course deals with a designing and a developing technology of simple farm machinery, in order to greatly improve participants' skill in the machine-design technology.

Table 1 The Major Subjects of Farm Mechanization Course

(Units)

Subject	Lecture	Experiment	Practice	Study tour	Total
1. Crop Science	7				7
2. Farm mechanization	32	39		20	91
3. Farm machinery	28	41	48	21	139
4. Maintenance of farm machinery and tools			30	3	33
5. Related subjects	28		15	4	47
Total	95	80	93	48	316

Remarks: 1. 18 units for orientation and evaluation in Tsukuba, 40 hours for the Japanese Language, 35 units for self study and 14 units for others are not included in the above table.
2. The one unit is equivalent to half day.

Farm Mechanization Course

The purpose of this course is to train up peoples from foreign countries, who are nominated or recommended by their governments and are presently government-officer in charge of farm mechanization. By nine months of the training period, the objectives of this course are to systematically introduce participants to the scientific knowledge and technology on farm mechanization such as: mechanization planning by economical view and its selection, introduction and utilization of farm machinery, and field performance tests of farm machinery before its introduction to their countries.

According to the above mentioned, the training curriculum is mainly based on two major subjects. One is agricultural mechanization such as effective introduction of machinery (Planning, inspection and selection), its utilization and systematic mechanized farming concerned with rice production and other some upland crops such as beans and so on, maintenance technique of farm machinery and modification of farm tools. The other is related subject to mechanization such as: rice cultivation, beans cultivation, land improvement and cooperative use of farm machinery in Japan, etc.

They are covered in the course by lecture, experiment, practice and study tour in 9 months duration. This training duration can cover all the process especially rice cultivation in Ibaraki-Pref. in Japan, where training centre is located. So that participants can perfectly learn all farm machines which are used from tillage to post-harvesting works. First, participants not only practice on the basic operation of farm machinery but also study on history, structure and developed process of those machines by lectures. In order to give them more technical know-how on trouble shooting and minor repair of farm-use small engines, the practice of diesel and gasoline engiens are carried out as practice curriculum.

Following the above contents of this course, participants have a chance to visit farm house as farm household practice, in order to know not only the situation of utilization and systematic mechanized farming in Japan, but also to understand the social, economical farming condition and a custom of Japanese farmers.

Farm Machinery Design Course

Recently, it can be said that an establishment of an effective farm working method is of urgent necessity to the developing countries in mechanization, in order to increase production of food-stuffs. Besides, a development of their farm machinery industry has been appeared in every place. For this cause the transfer of design technology for adapted farm machinery to the field condition is strongly expected. Therefore, farm machinery design course is offered to introduce a scientific knowledge and a technology on the designing of farm machinery, mainly for crop production to the participants who are engaged in the design, research and development works.

As a rule, when a new or suitable farm machine is developed, the following process should be perfectly considered as planning design, designing, drawing, trial-making and its performance test. This process is mainly a subject of the training course which contains a lecture, practice, experiment and study tour for this farm machinery design course with 9 months duration. The participants of this course have a chance to design and do trial-making of simple farm machinery by their own hands to greatly improve their skill in the machine design technology. 12 kinds of simple farm machinery are selected for a planning-design, designing, drawing, trial-making and their performance tests. In the case of 1989 they are as follows:

(1) Design, trial-making and performance test of Garlic Seeder

(2) Design, facrication and performance test of manual rice seeder for Indica variety

(3) Developing of power rice seeder for Thailand
(4) Study on rice husk furnace as heater for Dryer
(5) Design of lowland manual weeder
(6) Design, trial-making and testing for axial-flow fan of Dryer
(7) Study on designing and trial-making of vertical pump
(8) Design and fabrication of pedal thresher on trial basis
(9) Design, trial-making and performance test of throw-in type power thresher
(10) Designing and trial-making of manually operated winnower
(11) Design, trial-making and performance test of Tractor mounted type direct seeder for wheat
(12) Design, trial-making and testing of upland weeder

The participants are not only given lecture of designing theory and trial-making technology, but also basic science technology of the above mentioned farm machinery. How to cope with the problem in the development technology of agricultural machinery, because the designing technology of new or suitable machines greatly vary according to characteristics of the cultivated crops and field condition. Some ideas and designing parameters of these simple farm machines are not only given by University professors and researchers of agricultural experiment stations, institutes and agricultural machinery companies in Japan, but also by the participants' basis knowledge and experience which they have learned before in their respective countries.

Table 2 The Major Subjects of Farm Machinery Design Course (Units)

Subject	Lecture	Experiment	Practice	Study tour	Total
1. Basic science technology of farm machinery	23	14	17	4	58
2. Wind energy and solar energy	4			4	8
3. Mechanism of farm machinery	18		8	10	36
4. Design technology for farm machinery	22		24	4	50
5. Trial-making technology of farm machinery			66	18	84
6. Performance test and evaluation of farm machinery		44		8	52
7. Related subject	24	8			32
Total	91	66	115	48	320

Remarks: (1) 16 units for orientation and evaluation in Tsukuba, 20 hours for the Japanese language, 34 units for self-study, and 8 units for others are not included in the table.
(2) The course does not cover such special requests as training on manufacturing technology in companies.

The Project-type Technical Cooperation

JICA's technical cooperation programs, the acceptance of trainees, the dispatch of experts, and the grant of equipment constitute three basic components. These three can be implemented separately, but in the interest of better coordination and effectiveness, they are some times combined to form a technical cooperation scheme which is called "project-type technical cooperation". These three components integrated into a specific development project will serve it comprehensively and systematically, from its planning to follow-up evaluation.

Project-type cooperation falls under the following five categories: (1) technical cooperation centers, (2) health and medical cooperation, (3) population and family planning cooperation, (4) agricultural, forestry, and fisheries development cooperation, and (5) industrial development cooperation.

In order to develop manpower resources needed to foster economic and social development, technical cooperation centers seek comprehensive cooperation in vocational training, research and development, experimental work, improvement of production techniques, and upgrading of engineers and skilled workers.

The medical and family planning field involves sending medical experts and equipment to countries suffering from diseases or population pressure. JICA also accepts medical training from these countries.

In the agriculture field, JICA is taking steps to apply the experiences and techniques of Japanese agriculture to the developing countries. This program is intended to contribute to an increase in food production, the improvement of farmers' incomes and living standards through the increase of productivity. The field of cooperation cover rice cultivation, dry-field farming, livestock farming, forestry and fisheries. The forms of cooperation include integrated rural development projects, model farms for technical upgrading in a model area, research and educational cooperation at research institutes and university, technical guidance at agricultural extention centers and experimental station, etc.

The objectives of cooperation in the area of industrial development are to foster industrial

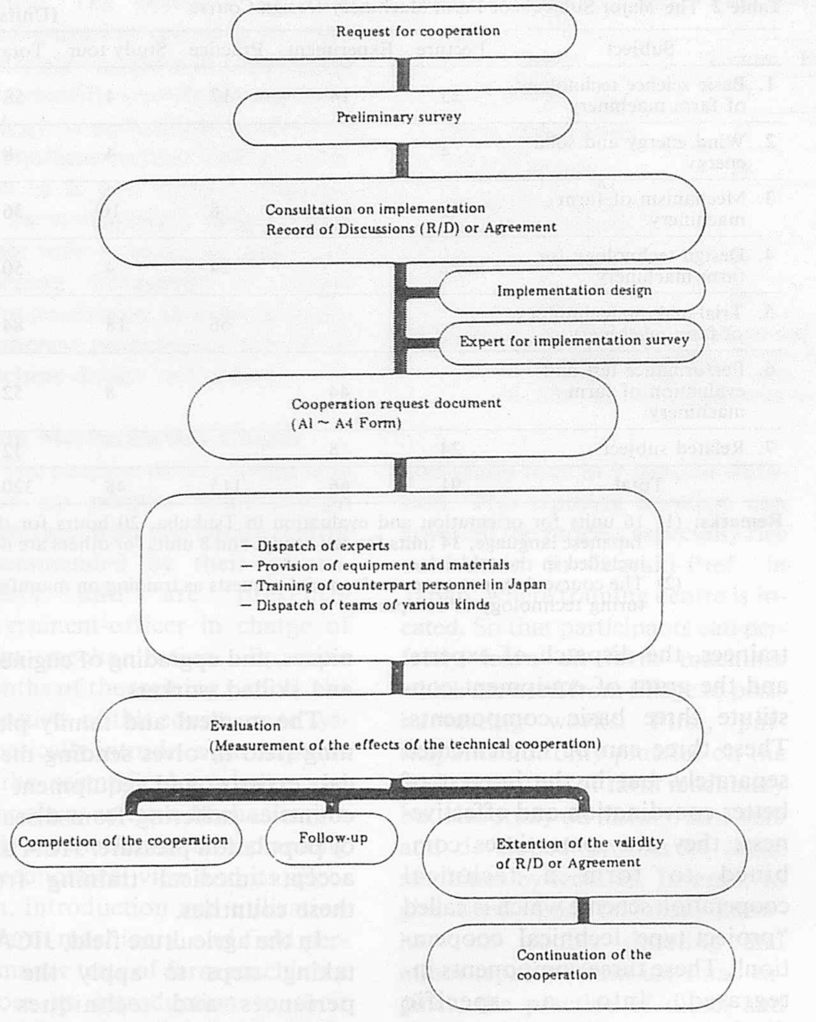

Fig. 2 Procedure of the project-type technical cooperation.

growth and effective resource utilization, and to make wide use of local labor. The program extends technical cooperation for research and development of appropriate technology, development of manpower resources, technical consultancy services, basic surveys related to the geological features and mineral deposits, etc.

Included also in project-type technical cooperation are joint research projects between Japanese researchers and those of developing countries designed for further research and development of technology well-suited to the economic, social, and natural environment of the developing countries concerned.

Acricultural Cooperation Program

The agricultural cooperation program was started in 1967 and expanded to include forestry cooperation in 1977. As an example, this program offers coopertion for the development of human resources as well as for improving technology in the fields of rice cultivation, up-land farming, sericulture, livestock breeding, forestry, and fish farming, and so on. At the same time it aims at improving the infrastructure required for the autonomous development of agriculture, forestry and fisheries.

Concrete examples of activities under this program are as follows:

(1) Cooperation in the establishment of training centers and model farms;
(2) Cooperation in the improvement and diffusion of technology;
(3) Cooperation in improving the production infrastructure such as irrigation and drainage;
(4) Cooperation in regional agricultural development projects;
(5) Cooperation in agricultural training and research centers, and experimental laboratories.

In 1987, cooperation was extended to 78 agricultural, forestry and fisheries projects; a total of 573 experts were dispatched and agricultural equipments, experiment and test equipments, and chemicals equivalent to 3,045 million yen were supplied.

Rice Mechanization Pilot Project in Arab Republic of Egypt

The Rice Mechanization Pilot Project was inaugurated in 1981 as a technical cooperation program supported by the government of Japan and the Arab Republic of Egypt. The project aims to establish an appropriate mechanical farming system for rice pproduction by introducing technical innovations at the sites of rice production along the Nile Delta in Egypt.

The first phase of the project from 1981 up to 1986 for 5 years was a successful demonstration of the effectiveness of mechanized cultivation technologies as modified and applied to existing condition in Egypt. The current phase of the project,. which extends to 1990, the research and development side will concentrate on guaging the technical feasibility of direct seeding cultivation practice as an alternative economic way of increasing productivity.

The objective of the Rice Mechanization Pilot Project is to establish a mechanized rice cultivation system in response to the national goals for attaining self-

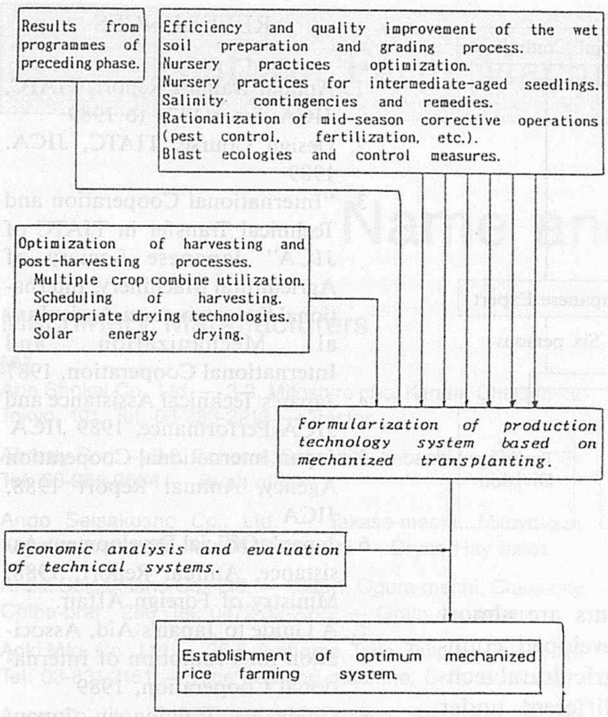

Fig. 3 Improvement of technical elements in the production system based on mechanized transplanting.

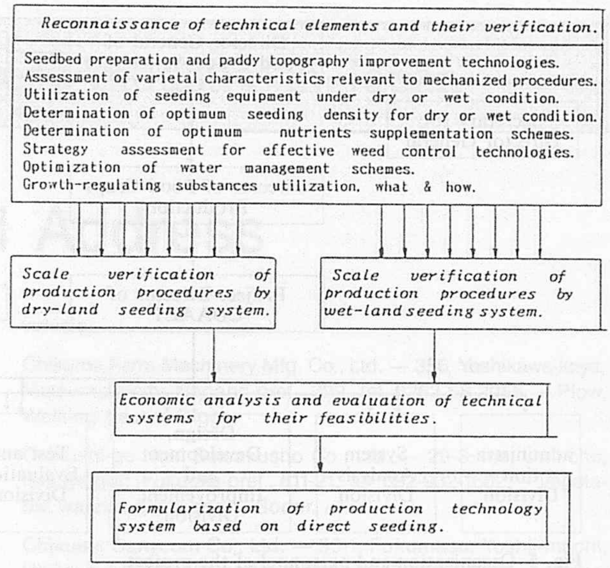

Fig. 4 Feasibilities assessment of mechanized direct seedling cultivation.

sufficiency in food and overcoming the labor shortage in the villages of Egypt. In other words, the system has been developed for the purpose of achieving increased land and labor productivity by mechanization technical development program.

Technical cooperation programs for the research and development

The Center for Development of Appropriate Agricultural Engineering Technology (C.A.A.E) Project in the Republic of Indonesia

The Development of Appropriate Agricultural Engineering Technology Project in Indonesia was started Feb. 1987. The project will be carried out for the purpose of developing appropriate agricultural machinery through the activities of the Center for Development of Appropriate Agricultural Engineering Technology, thus contributing to agricultural development in the Republic of Indonesia.

Japanese Technical Cooperation through advice and guidance will be implemented at the Center in line with the following activities;

(1) System Analysis for Agricultural engineering
(2) Design, Development and Improvement of Agricultural Machinery
(3) Test and Evaluation of Agricultural Machinery
(4) Training

The C.A.A.E project was started from 1987, and the project has passed almost two years, overall activities of this project are as follows;

(1) In system analysis, survey and collecting information on agricultural situation has been carried out. Economical analysis of the machineries under developing in the project was done. And simulation of farm work operation system in connection with cropping pattern was performed.
(2) In design, development and improvement, prototype machines of power tiller and reaper were designed. Insufficient performance of steering in soft paddy field was recognized, therefore, it is being modified. Basic studies on the thresher for rice and soybean and the husk furnace for dryer were carried out.
(3) In test and evaluation, current test code of tractor, thresher and dryer were reviewed and made revised test codes in draft. Test and evaluation of machines which were developed in the Center and applied by manufacturers and importers. Preparation and arrangement of testing facilities and instruments has been carried out.
(4) In training, compilation of many textbooks and preparation of teaching material for training are preparing. Training of four courses composed of repair and utilization of agricultural machineries was executed.

The overall activities of the work plan in further cooperation will be as mentioned below;

The evaluation of machines developed in the project will be start-

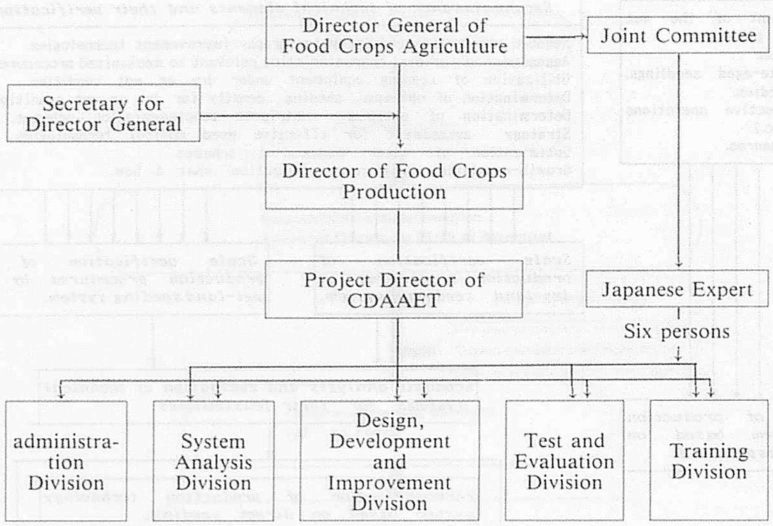

Fig. 5 Organization and personnel of the project.

ed besides the present work. Design of soybean planter and peanut sheller will be included.

Exchange of technical information with RNAM and IRRI in the Philippines will be continually carried on.

Conclusion

For effective and efficient national development of developing countries, it is essential to first consolidate the indispensable requirements (Basic Human Needs), including the social infrastructure consisting of education, public health and hygiene, roads, electricity and agriculture, etc. For many developing countries, however, it is difficult to conduct all necessary work relating to the consolidation of such an infrastructure on the basis of self-reliance. In case of technical transfer and technical cooperation of agricultural machinery, it can be siad that in the most developing countries, main farm machinery such as tractors and implements are almost imported from developed countries. In general, agricultural technology is quite different under their circumstances according to countries and areas. Therefore, the appropriate or intermediate technology is very important. Sometimes it is not right way to utilize as same as Japanese operation way directly to such tropical countries.

Technology is not always common in a world, because of different natural features. In case of agricultural technology, there are remarkably difference between country and country. Therefore, some Japanese agricultural machinery are not applicable to utilize. It will be influenced by agricultural environment.

Utility of the proper technology in the developing countries ought to be done to find out her original farming method by invention, idea and modification, according to her characteristics of farming, manufacturing technology and socio-economic condition.

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Feature: Farm Machinery Industry in Japan

Name and Address

Machinery Manufacturers

[A]

Abe Shokai Co., Ltd. — 3-2, Mitoshiro-cho, Kanda, Chiyoda-ku, Tokyo, 101. Tel. 03-233-2213 — Tractor.

Ahresty Corp.— 3-9, 2-chome, Sakashita, Itabashi-ku, Tokyo, 174. Tel. 03-966-9654 Bush cutter.

Ando Seisakusho Co., Ltd. — Takase-machi, Mitoyo-gun, Kagawa-pref., 767. Tel. 0875-72-5405 — Dryer, Hay baler.

Anzai Seisakusho Co., Ltd. — 1305-1, Ogura-machi, Chiba-city, Chiba-pref., 280. Tel. 0472-32-2222 — Grain separater.

Aoki Mfg. Co., Ltd. — 26-5, 2-chome, Taito, Taito-ku, Tokyo, 110. Tel. 03-831-2151 — Rice pearling machine, Crasher, Sorter.

Aporo Co., Ltd. — 19-8, Kawakitanakamachi, Neyagawa-city, 572. Tel. 0720-22-2059 — Explosion scarecrow.

Arimitsu Industrial Co., Ltd — 3-21, 2-chome, Fukae-kita, Higashinari-ku, Osaka, 537. Tel. 06-973-2010 — Power sprayer, Power duster, Speed sprayer, High-pressure washer, Pump.

Asaba Sangyo Co., Ltd. — 1443-2 Kitanagaike, Nagano-city, Nagano-pref., 380. Tel. 0262-44-0206 — Pest control machine, Pump.

Asafu Co., Ltd. — 4-14, 4-chome, Midori, Sumida-ku, Tokyo, 130. Tel. 03-634-6381 — Rice huller, others.

Asagoe Kikai Seisakusho Co., Ltd. — 216, Senoo Okayama-city, Okayama-pref., 701-02 Tel. 0862-82-0211 — Straw mat maker.

Asahi Jidosha Co., Ltd. — 5, Ogawara, Susaka-city, 382. Tel. 0262-45-1752 — Speed sprayer.

Atago Co., Ltd. — 32-10, Honcho, Itabasi-ku, Tokyo, 173. Tel. 03-964-6131 — Sugar meter.

[B]

Bizen Mfg. Co., Ltd. — 9-20, Ryou-machi, Sakata-city, Yamagata-pref., 998. Tel. 0234-23-7135 — Seedling box carrieh, Ridge sheet setting machine, Pulverizer for nursery, ridger, Soil scattering machine.

Brother Industry Co., Ltd. Mishin Jigyobu — 1-32, Myoondori, Mizuho-ku, Nagoya-city, 467. Tel. 052-824-2392 — Sewing machine.

Bunmei Noki Co., Ltd. — 11-4, 1-chome, Korimoto-cho, Kagoshima-city, 890. Tel. 0992-54-5121 — Cutter, Rice cake maker, Chopper, Sugar cane harvester.

[C]

Capital Industry Co., Ltd. — 53-5, 3-chome, Kami-ishihara Chofu-city, Tokyo, 182. Tel. 0424-83-2623 — Power sprayer, Speed sprayer, Pump.

Chigusa Co., Ltd. — 4-5, 3-chome, Kosaka, Matsuyama-city, Ehime-pref., 790. Tel. 0899-43-4306 — Mono rail, Transport vehicle.

Chikuma Farm Machinery Mfg. Co., Ltd. — 356, Yoshikawa-koya, Matsumoto-city, Nagano-pref., 399. Tel. 0263-58-2055 — Plow, Walking tractor, Digger.

Chikushi-go Noki Seisakusho Co., Ltd. — 29-3, Ino, Umi-cho, Kasuya-gun, Fukuoka-pref., 811-21. Tel. 092-932-1662 — Vegetable washer & polisher , Sorter.

Chikusui Canycom Co., Ltd. — 90-1, Fukumasu, Yoshii-machi, Ukiha-gun, Fukuoka-pref., 839-13. Tel. 09437-5-2195 — Transport vehicle, Manure spreader.

Chofu Seisakusho Co., Ltd. — 2-1, Chofuogi-cho, Shimonoseki-city, 752. Tel. 0832-48-1111 — Heater, Boiler.

Chugoku Kogyo Co., Ltd. — 15-10, Hatchobori, Naka-ku, Hiroshima-city, 730. Tel. 082-221-8111 — Silo, Manure making facility.

Chuo Boeki Corp. — 9-29, Matsugamoto-cho, Ibaraki-city, 726. Tel. 0726-22-2441 — exporter.

Chuo Chikuken Co., Ltd. — 2-16-10, Kogokita, Nishi-ku, Hiroshima-city, 733. Tel. 082-271-4232 — Silo unloader, silo slurry tank, Feeder.

Chuo Kogyo Co., Ltd. — 1310, Hiro, Hirokawa-cho, Arita-gun, Wakayama-pref., 643. Tel. 0737-63-3030 — Sprayer, High-pressure washer.

CI Kasei Co., Ltd. — 18-1, 1-chome, Kyobashi, Chuo-ku, Tokyo, 104. Tel. 03-535-4571 — Water culture system.

Circle Tekko Co., Ltd. — 3-12, 3-chome, Saiwai-cho, Takikawa-city, Hokkaido, 073. Tel. 0125-22-4351 — Transplanter, Nursery equipment.

Cornes & Co., Ltd. — Maruzen-blg. 3-10, 2-chome, Nihonbashi, Chuo-ku, Tokyo, 103. Tel. 03-272-5771 — Forage crops machinery, Wafering plant, Barn cleaner.

[D]

Daisen Co., Ltd. — 20, Yanagime, Shimoji-cho, Toyohashi-city, 440. Tel. 0532-54-6521 — Green house.

Daishin Co., Ltd. — 3-23-1, Seyasu-cho, Ogaki-city, 503. Tel. 0584-75-5011 — Pump, Sprayer, Bush cutter, High-pressure washer.

Daiwa Seiko Co., Ltd. — 90, Mizubashiri, Higashiosaka-city, 578. Tel. 0729-62-1551 — Rice sorter, Rice huller & mill.

Delica Co., Ltd. — 1618, Idegawa-cho, Matsumoto-city, Nagano-pref., 390. Tel. 0263-25-5665 — Manure spreader.

Denyo Co., Ltd. — 10-2, 4-chome, Kamitakada Nakano-ku, Tokyo, 164. Tel. 03-228-1111 — Generator, Welder.

[E]

Ebara Seisakusho Co., Ltd. — 11-1, Asahi-machi, Haneda, Ota-ku, Tokyo, 144. Tel. 03-743-6111 — Pump, Hydraulic system.

Egunaru Seiki Co., Ltd. — 1887, Mitsushima, Kadoma-city, 571. Tel. 0720-83-0651 — Egg washer & sorter.

Eiwa Sprinkler Co., Ltd. — 7754-1, Yawatajuku-Kita, Fuchu-city, 183. Tel. 0423-65-3721 — Sprinkler.

Electrolux Japan Ltd. — 3-8, 3-chome, Kaigan, Minato-ku, Tokyo, 108. Tel. 03-452-3051 — Mower, Forestry machine.

Elta Co., Ltd. — Hakonegasaki, Mizuho-machi Nishitama-gun, Tokyo, 190-12. Tel. 0425-56-0184 —Bush cutter, Transport vehicle.

Etobus Co., Ltd. — 23-6, Sinsen-machi, Sibuya-ku, Tokyo, 150. Tel. 03-465-0844 — Vegetable & fruit sorter, Heating machine.

Etsunan Works — 76-8, Misazima, muika-machi, Minamiuonuma-gun, Niigata-pref., 949-66. Tel. 0257-72-2243 — Straw processor.

[F]

F.T.S. Co., Ltd. — 3-537, Kyokushin-cho, Asahikawa-city, Hokkaido, 078-11. Tel. 0166-65-7468 — Pump, Hervester.

Fuji Heavy Industry Co., Ltd. — 1-chome, Nishishinjuku, Shinjusku-ku, Tokyo, 160. Tel. 03-347-2111 — Engine, Farm machinery, Forestry machinery.

Fujihira Kogyo Co., Ltd. — 11-6, 6-chome, Hongo, Bunkyo-ku, Tokyo, 113. Tel. 03-812-2271 — Animal husbandary machinery, Poultry implement, Soil injector.

Fujii Noki Mfg. Co., Ltd. — 285, Koike, Tsubame-city, Niigata-pref., 959-12. Tel. 0256-64-5511 — Thresher, Dryer, Snow plow.

Fujika Co., Ltd. — 16, Kanda Matsunaga-cho, Chiyoda-ku, Tokyo, 101. Tel. 03-253-7161 — Heating system.

Fujiki Noki Seisakusho Co., Ltd. — 2-6, 3-chome, Zenkonji-cho, Higashiosaka-city, 597. Tel. 0729-87-5505 — Plow, Mulcher, Digger.

Fuji Robin Industries Co., Ltd. — 8-1, 1-chome, Nishishinjyuku, Shinjyuku-ku, Tokyo, 160. Tel. 03-348-2416 — Engine, Generator, Walking tractor, Bush cutter.

Fuji Seisakusho Co., Ltd. — 23-13, 5-chome, Honmachi, Shigi-city, 353. Tel. 0484-73-1235 — Can harvester.

Fuji Trailer Mfg. Co., Ltd. — Yoshida-cho, Nishikanbara-gun, Niigata-pref., 959-02. Tel. 0256-92-6611 — Trailer.

Fukusen Seisakusho Corp. — 5799, Okiura, Hikino-cho, Fukuyama-city, 721. Tel. 0849-41-5801 — Fog generator.

Fukutome Seisakusho Co., Ltd. — 1-37, 1-chome, Kishidado, Higashiosaka-city, 577. Tel. 06-722-2255 — Milker, Dairy machinery.

Furukawa Kogyo Co., Ltd. — 6-1, 2-chome, Marunouchi, Chiyoda-ku, Tokyo, 100. Tel. 03-212-6551 — Tractor, Shovel.

Furuta Denki Co., Ltd. — 7-9, Hottadori, Mizuho-ku, Nagoya-city, 467. Tel. 052-872-4111 — Fan.

Fuzi Heavy Industry Co., Ltd. — 7-2, 1-chome, Nishishinjuku, Shinjuku-ku, Tokyo, 160. Tel. 03-347-2111 — Engine, Farm machinery, Forestry machinery.

[H]

Hamada Seisakusho Co., Ltd. — 11541-3, Hiromachi, Kure-city, 737-01. Tel. 0823-72-3232 — Dung dryer, deodorizing facility.

Hanaoka Sharyo Co., Ltd. 17-10, 2-chome, Shirakawa, Koto-ku, Tokyo, 135. Tel. 03-643-5272 — Transport vehicle.

Harada Sangyo Co., Ltd. — 520-1, Fujinami, Ageo-city, Saitama-pref., 362. Tel. 048-786-5555 — Bean sorter.

Hara Noki Co., Ltd. — 19-1, Aza-hamada, Fukue, Atsumi-cho, Atsumi-gun, Aichi-pref., 441-36. Tel. 05313-3-0555 — Transport vehicle.

Harasawa Seisakusho Co., Ltd. — 990-1 Sakashita-cho, Shibukawa-city, 377. Tel. 0279-23-5828 — Floss remover cocooning frame.

Hatsuta Industrial Co., Ltd. — 4-39, 1-chome, Chifune, Nishiyodogawa-ku, Osaka, 555. Tel. 06-471-3354 — Power sprayer, Power duster, Speed sprayer, Pump.

Hayashi Tekkosho Co., Ltd. — 24, Tsunoda, Koike-cho, Toyohashi-city, 440. Tel. 0532-45-3253 — Chopper, Mixer.

Hitachi Koki Co., Ltd. — 6-2, 2-chome, Otemachi, Chiyoda-ku, Tokyo, 100. Tel. 03-270-6131 — Bush cutter, Chain saw.

Hitachi Reinetsu Co., Ltd. — Okisudacho-blg., 23-2, 1-chome, Kanda Suda-cho, Chiyoda-ku, Tokyo, 101. Tel. 03-255-7181 — Heat pump.

Hitachi Seisakusho Co., Ltd. — 4-6, Kandasurugadai, Chiyoda-ku, Tokyo, 101. Tel. 03-258-1111 — Motor, Generator, Pump.

Hoden Mfg. Co., Ltd. — Minamishozakai-cho, Nishikyogoku, Ukyo-ku, Kyoto, 615. Tel. 075-313-6060 — Rice huller, Rice & wheat mill, Chopper, Crusher.

Hokkai Ford Tractor Co., Ltd. — 661, 7-chome, Kotoni 3-jo, Nishi-ku, Sapporo-city, Hokkaido, 063. Tel. 011-621-8181 — Tractor, Combine, Other farm equipments.

Hokuei Nogyo Co., Ltd. — 3-2-30, Kitaokasu-2jo, Higashiku, Sapporo-city, 065. Tel. 011-781-5115 — Beat planter.

Hokusatsu Co., Ltd. — 10-2-39, Honmachi-nijo, Higashi-ku, Sapporo-city, 065. Tel. 011-781-1988 — Trailer, Transport vehicle.

Hokuto Koki Co., Ltd. — Satsusei-blg., 1-48, 9-chome, Nishi, Hachikenkyujo, Nishi-ku, Sapporo-city, 063. Tel. 011-641-4235 — Hay drying & wafering facility.

Hokutou Engineering Co., Ltd. — 3-8, Nishi, Minami-2jo, Chuo-ku, Sapporo-city, 060. Tel. 011-221-0801 — Husk furnace.

Honda Farm Machinery Co., Ltd. — Kurisawa-cho, Sorachi-gun, Hokkaido, 068. Tel. 0126-45-2211 — Puddling rotor, Pan breaker, Fertilizer spreader, Bean thresher.

Honda Motor Co., Ltd. — 1-1, 2-chome, Minamiaoyama, Minato-ku, Tokyo, 107. Tel. 03-423-1111 — Engine, Walking tractor, Binder transplanter, Generator, Pump lawn mower, Snow plow.

Honda Will Co., Ltd. — 7-25, Chuwa 7jo, Asahikawa-city, 070.Tel. 0166-61-7441 — Fertilizer drill, Bean harvester, Broadcaster.

Hosokawa Seisakusho Co., Ltd. — Toyoshina-cho, Minamiazumi-gun, Nagano-pref., 399. Tel. 0263-72-3141 — Rice mill.

Howa Kikai Kogyo Co., Ltd. — 1-1-2, Kaniya, Nishi-ku, Hiroshima-city, 730. Tel. 082-263-7711 — Wood piece crusher.

[I]

Ida Co., Ltd. — 4-7, Honcho, Kitami-city, 090. Tel. 0157-23-4493 — Stone picker.

Igarashi Kikai Kogyo Co., Ltd. — 187, Oshikiri, Mikawa-machi, Higashi-Tagawa-gun, Yamagata-pref., 997-13. Tel. 0235-66-2018 — Leveler, Husk container.

Igarashi Seisakusho Co., Ltd. — 2-19, 1-chome, Kohasi, Kamo-city, 959-13. Tel. 0256-52-0427 — Hand sprayer.

Ikeno Sangyo Co., Ltd. — 2100-60, Satte-Kogyo-Danchi Kami-Yoshiba, Satte-city, 340-01. Tel. 0480-48-0811 — Pest control machine, Pump.

IKS & Co., Ltd. — 8-2, 1-chome, Marunouchi, Chiyoda-ku, Tokyo, 100. Tel. 03-214-4631 — Engine, Pump, Generator.

Imamura Kikai — 103, Kihara, Kitakawasoemachi, Saga-city, Saga-pref., 840. Tel. 0952-29-6644 — Flower separater implement.

Inada Co., Ltd. — 3915-3, Aza-Nakao, Kasada Kasaoka, Toyonaka-cho, Mitoyo-gun, Kagawa-pref., 769-15. Tel. 0875-62-5858 — Transport vehicle.

Inami Co., Ltd. — 212 Oka, Inami-machi, Kako-gun, Hyogo-pref., 675-11. Tel. 0794-92-0013 — Dryer, Bush cutter, Rice mill.

Interfarm Products Co., Ltd. — 35-1, 4-chome, Koyama, Nerima-ku, Tokyo, 176. Tel. 03-998-0602 — Speed sprayer, Fog machine.

Inter-Tractor Service Co., Ltd. — Kita-1-5-1, Nishi-23-jo, Obihiro-city, Hokkaido, 080-24. Tel. 0155-37-3291 — Tractor.

Iony Co., Ltd. — 2-16, 6-chome, Sinkawa, Mitaka-city, Tokyo, 181. Tel. 0422-48-1111 — Rice mill, planter.

Iseki Engineering Co., Ltd. — 3-6, Kioi-cho, Chiyoda-ku, Tokyo, 102. Tel. 03-263-0365 — Water plant.

Iseki & Co., Ltd. — 3-6, Kioi-cho, Chiyoda-ku, Tokyo, 102. Tel. 03-238-5265 — Walking & riding type tractor, Tractor implement, Rice transplanter, Thresher, Binder, Combine, Dryer, Rice huller, Transport vehicle, Other farm equipment & materials.

Ishida Noki Co., Ltd. — Ogida, Gonohe-machi, Sannohe-gun, Aomori-pref., 039-07. Tel. 0178-67-2766 — Trailer, Tobacco havesting implement.

Ishii Mfg. Co., Ltd. — 15-2, Aza-Soda, Tsubone, Sakata-city, Yamagata-pref. 999-77. Tel. 0234-93-2211 — Grain blower, Thrower, Combine cutter.

Ishikari-zoki Co., Ltd. — 2-7, Yura, Kurisawacho, Sorachi-gun, Hokkaido, 068-01. Tel. 0126-45-2815 — Puddling rotor, Harrow rotor, Broadcaster, Lime sower, Manure spreader.

Ishikawajima-shibaura Machinery Co., Ltd. — 32-7, 5-chome, Sendagaya, Shibuya-ku, Tokyo, 151. Tel. 03-358-4211 — Engine, Generator, Walking & riding type tractor, Tractor implement, Transplanter, Planter, Pump, Self-propelled thresher, Binder combine, Dryer, Other farm equipment & materials.

Ishino Seisakusho Co., Ltd. — 20-54, Sakoto-machi, Houfu-city, 747. Tel. 0835-22-1708 — Oil press.

Isuzu Motor Co., Ltd. — 22-10, 6-chome, Minami-Oi, Sinagawa-ku, Tokyo, 140. Tel. 03-762-1111 — Engine, Generator, Transport vehicle.

Iwafuji Kogyo Co., Ltd. — 7-2, 1-chome, Nisi-Shinjuku, Sinjuku-ku, Tokyo, 160. Tel. 03-342-2281 — Back hoe, Crawler tractor.

Iwatani Sangyo Co., Ltd. — 4-8, 3-chome, Honcho, Chuo-ku, Osaka-city, 541. Tel. 06-267-3468 — Hay dryer, Poultry Equipmnt.

Iwata Keitei Kojo Co., Ltd. — 32-8, 5-chome, Nisi-Nippori, Arakawa-ku, Tokyo, 116. Tel. 03-891-6621 — Parer.

Iwata Sangyo Co., Ltd. — 1-20, Samukawa-machi, Chiba-city, Chiba-pref., 260. Tel. 0472-22-6351 — Feeder, Water cup.

Iyo Shoki Co., Ltd. — 146, Izumi-machi, Matsuyama-city, 790. Tel. 0899-57-6914 — Monorail.

Izumi Tekko Co., Ltd. — 23-Hidari-7, Sanjo-dori, Asahikawa-city, Hokkaido, 078-11. Tel. 0166-31-5261 — Bale throw.

[J]

Japan Pioner Co., Ltd. — 16-4, 1-chome, Hamamatsu-cho, Minato-ku, Tokyo, 105. Tel. 03-434-7991 — Chain saw, Bush cutter.

Joetsu Noki Co., Ltd. — 465, Hitotsuyashiki-shinden, Sakae-cho, Minamikanbara-gun, Niigata-pref., 959-11. Tel. 0256-45-4593 — Vegetable washer.

Jyonishi Agricultural Machinery Co., Ltd. — 4-1, Motoayano, Minakuchi-cho, Koga-gun, Shiga-pref., 528. Tel. 0748-62-4110 — Fertilizer distributor, Land preparation implement.

[K]

Kaaz Corporation — 387-1, Gomyo, Saidaiji, Okayama-city, Okayama-pref., 704. Tel. 08694-2-1111 — Bush cutter, Mower, Pump, Pruner, Digger.

Kaihatsu Koken Co., Ltd. — 2-580, Kitaichiijo, Horomi-cho, Iwamizawa-city, Hokkaido, 069-03. Tel. 0126-26-2211 — Snow plow, Trencher, Bush cutter.

Kakuichi Co., Ltd. — Yamato Bldg., 3-1, 5-chome, Koujimachi, Chiyoda-ku, Tokyo, 102. Tel. 03-264-4723 — Stock house, Green house.

Kamakura Seisakusho Co., Ltd. — 7-11, 2-chome, Kita-Aoyama, Minato-ku, Tokyo, 107. Tel. 03-403-4311 — Fan, Ventilator.

Kanaoka Kogyo Co., Ltd. — 2-10, Yutaka-cho, Tonami-city, Toyama-pref., 939-13. Tel. 0763-33-3050 — Dryer, Drying facilities, Rice huller.

Kanazawa Sharyo Co., Ltd. — 1-27, 1-chome, Hosai-machi, Kanazawa-city, 920. Tel. 0762-62-1511 — Farm vehicle.

Kaneko Agricultural machinery Co., Ltd. — 21-10, Nishi-2, Hanyu-city, Saitama-pref., 348. Tel. 0485-61-2111 — Grain dryer, Drying facilities, Moisture meter, Nursery equipment, Animal breeding machinery & equipment.

Kaneko Shubyo Co., Ltd. — 50-12, 1-chome, Furuichi-machi, Maebasi-city, 371. Tel. 0272-51-1611 — Green house materials.

Kanriu Industrial Co., Ltd. — 1526-1, Hirooka, Shiojiri-city, Nagano-pref., 390-07. Tel. 0263-52-1100 — Rice mill, Dryer, Moisture meter, Nursery facilities.

Kansai Sangyo Co., Ltd. — 1666, Minamikawase-cho, Hikone-city, Shiga-pref., 522-02. Tel. 0749-25-1111 — Rice hull, Processing equipment.

Kanto Giken kogyo Co., Ltd. — 990-1, Sakashita-cho, Shibukawa-city, Gunma-pref., 377. Tel. 0279-23-2668 — Hose guide, Minitomato sorter.

Kanto Noki Co., Ltd. — 493, Yokokura-shinden, Oyama-city, Tochigi-pref., 323. Tel. 0285-27-3271 — Rotary, Ridger, Carrier, Walking tractor.

Kanzaki Kokyu Kogyo Seisakusho Co., Ltd. — 18-1, 2-chome, Inadera, Amagasaki-city, 661. Tel. 06-491-1111 — Mission, Gear, Hydraulic system.

Karui Industry Co., Ltd. — 46-1, Imonocho, Yamagata-city, 990-01. Tel. 0236-45-5710 — Pump, Crusher.

Katakura kiki Kogyo Co., Ltd. — 7160, Matsumoto-machi, Imai, Matsumoto-city, Nagano-pref., 390-11. Tel. 0263-58-4711 — Thresher, Cultivator, Transplanter.

Katayama Seisakusho Co., Ltd. — 31-1, Wakitahon-cho, Kawagoe-city, Saitama-pref, 350. Tel. 0492-42-2600 — Trencher, Dryer, Vegetable washer.

Kato Pump Seizo Co., Ltd. — 768 Nisikata, Inabe-machi, Inabe-gun, Mie-pref., 511-03. Tel. 0594-74-2660 — Pump.

Kawabe Noken Sangyo Co., Ltd. — 1219, Yanokuchi, Inagi-city, Tokyo, 206. Tel. 0423-77-5021 — Trencher, Stone picker, Snow plow.

Kawamoto Seisakusho Co., Ltd. — 11-39, 4-chome, Osu, Naka-ku, Nagoya-city, 460-91. Tel. 052-251-7171 — Pump.

Kawasaki Giken Co., Ltd. — 348-1, Kanaya-kawara, Kanaya-cho, Haibara-gun, Shizuoka-pref., 428. Tel. 0547-46-1113 — Tea picker, Pruner, Deep plow.

Kawasaki Heavy Industry Co., Ltd. — 1-18, 2-chome, Nakamachi-dori, Chuo-ku, Kobe-city, 650-91. Tel. 078-341-7731 — Engine.

Kawashima Agricultural Machinery Manufacturing Co., Ltd. — 2-61, Dosho-machi, Yonago-city, Tottori-pref., 683. Tel. 0859-22-9341 — Transport vehicle, Bridge.

Keibunsha Seisakusho Co., Ltd. — 739-6, Yamate, Yoshida-cho, Takada-gun, Hiroshima-pref., 731-05. Tel. 08264-3-1201 — Nursery cabinet, Nursery equipment, Seeder.

Kett Electric Laboratory — 8-1, 1-chome, Minamimagome, Ota-ku, Tokyo, 143. Tel. 03-776-1111 — Moisture meter.

Kihara Mfg. Co., Ltd. — 3106-1, Nishi Akiho-cho, Yoshiki-gun, Yamaguchi-pref., 754-11. Tel. 083984-2211 — Tobacco dryer, Related machinery.

Kimiya Noki Seisakusho Co., Ltd. — 105, Aza-Kasahara, Tsukanome, Sanjo-city, 955. Tel. 0256-33-1337 — Walking tractor implement, Carrier.

Kinsei Co., Ltd. — 10, Honmachi, Ono-city, 675-13. Tel. 07946-2-2391 — Lawn mower, Bush cutter, Cutlery.

Kioritz Co., Ltd. — 5-1, 7-chome, Simo-Renjaku, Mitaka-city, Tokyo, 181. Tel. 0422-48-6111 — Pest control machine, Chain Saw, Bush cutter.

Kioritz Echo Bussan Co., Ltd. — 5-1, 7-chome, Shimorenjaku, Mitaka-city, Tokyo, 181. Tel. 0422-49-5941 — Pest control machine, Engine, Tractor, Rice transplanter, Fertilizer drill, Cultivator, Bush cutter, Chain saw, Hay harvester, Snow plow, Pruner.

Kitahara Denboku Co., Ltd. — 4 Higashi, Kita-19-jo, Sapporo-city, 065. Tel. 011-711-6136 — Electric pasture fence, Ciro.

Kitasiba Denki Co., Ltd. — 9, Tennohara, Matsukawa-machi, Fukusima-city, 960-12. Tel. 0245-67-6704 — Fan, Ventilator.

Kito Co., Ltd. — 2000 Tsukiji-Arai, Showa-machi, Nakakoma-gun, Yamanashi-pref., 409-38. Tel. 0552-75-7575 — Hanger, Chain, Carrier.

Kiya Seisakusho Co., Ltd. — 10-1, 1-chome, Arajyuku-cho, Kawagoe-city, Saitama-pref., 350. Tel. 0492-42-3555 — Thresher, Experiment machinery, Soybean thresher.

Kobashi Kogyo Co., Ltd. — 684, Nakaaze, Okayama-city, 701-02. Tel. 0862-98-3111 — Tillage hoe, Rotor, Harrow, Seeder-fertilizer, Transplanter, Snow plow.

Kobayashi Musen Kogyo Co., Ltd. — 8-7, 1-chome, Nishinakanobu, Shinagawa-ku, Tokyo, 142. Tel. 03-783-6301 — Electric fence.

Koei Sangyo Co., Ltd. — 96-1, Miyashita, Iyo-city, Ehime-pref., 799-31. Tel. 0899-83-1414 — Mono rail, Lift.

Kokkosha Co., Ltd. — 132-1, 1-chome, Hoshizaki, Minami-ku, Nagoya-city, 457. Tel. 052-822-2658 — Rice cake maker, Vegetable washer, Cultivator, Furrow opener, Cutter.

Kokuekisha Co., Ltd. — 53, 2-chome, Shigaminamidori, Kita-ku, Nagoya-city., 462. Tel. 052-911-0238 — Mixer, Bark scraper.

Kokusai Bussan Co., Ltd. — 21-1, 2-chome, Maejima, Naha-city, Okinawa-pref., 900. Tel. 0988-67-1187 — Cane harvester, Tractor.

Komatsu Seisakusho Co., Ltd. — 3-6, 2-chome, Akasaka, Minato-ku, Tokyo, 107. Tel. 03-584-7111 — Tractor, Transport vehicle.

Komatsu-Zenoah Co., Ltd. — 142-1, 2-chome, Sakuragaoka, Higashiyamato-city, Tokyo, 189. Tel. 0425-61-2141 — Engine, Bush cutter, Chain saw, Power duster, Power sprayer, Pump, Digger.

Komiya Seisakusho Co., Ltd. — 1174, Fukai-nakamachi, Sakai-city, Osaka, 593. Tel. 0722-78-2081 — Power sprayer, Rotary pump, High pressure washer.

Konma Mfg. Co., Ltd. — 4-26, Izumicho, Tsuruoka-city, Yamagata-pref., 997. Tel. 0235-23-1111 — Thresher, Soybean thresher, Rice huller, Combine, Rice transplanter, Binder.

Koseki Noki Co., Ltd. — 4217-1, Nagasaki, Nakayama-cho, Higashimurayama-gun, Yamagata-pref., 990-04. Tel. 0236-62-3037 — Trencher, Ditcher, Levee layer, Cultivator, Furrow opner, Cutter, Chopper.

Koshin Ltd. — 12, Kami-hachinotsubo, Kotari, Nagaokakyo-city, Kyoto-fu, 617. Tel. 075-954-6111 — Pump, Drum cleaner.

Koshin Seiki Co., Ltd. — 1884, Katsura Aza Tsukigome, Shippou-cho, Ama-gun, Aichi-pref., 497, Tel. 0560-42-1166 — Draying plant, Dung fermentation plant, Feeder.

Koyo Engineering Co., Ltd. — 698-1, Nishiasuma Ohmiya-city, Saitama-pref., 331. Tel. 048-622-0002 — Bridge carrier, Vehicle, Cabin.

Kubota Ltd. — 2-47, 1-chome, Shikitsu-Higashi, Naniwa-ku, Osaka, 556-91. Tel. 06-648-2111 — Engine, Tiller, Tractor, Tractor implement. Rice transplanter, Binder, Combine, Other farm equipment & materials.

Kubota Noki Seisakusho Co., Ltd. — 1101-12, Hassamu, Nishi-ku, Sapporo-city, 063. Tel. 011-663-8282 — Mower, Crawler, Snow plow, Onion transplanter, Onion harvester, Potato picker.

Kumagai Noki Co., Ltd. — Kumanomori, Bunsui-cho, Nishikanbara-gun, Niigata-pref., 959-01. Tel. 0256-97-3259 — Winnower, Soybean thresher, Snow plow, Dust blower.

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Seiwa Sogo Setsubi Co., Ltd. — 1-30-8,, Tsunematsu, Amagasaki-city, 661. Tel. 06-433-2834 — Vegetable washer.

Sekiguchi Frame Seisakusho Co., Ltd. — 2642, Kuragano-cho, Takasaki-city, Gunma-pref., 370-12. Tel. 0273-46-3131 — Trailer, Transport vehicle, Green house.

Sekisui Kagaku Kogyo Co., Ltd. — Dozimakanden-blg., 4-4, 2-chome, Nishitenman, Kita-ku, Osaka-city, 530. Tel. 06-365-4122 — Gardening facility, Water culture plane.

Sekiya Agricultural Machinery Co., Ltd. — 922, Kitagawara, Masaki-cho, Iyo-gun, Ehime-pref., 791-31. Tel. 0899-84-2232 — Car parking facility, Parking lift, Washer.

Senba Noki Co., Ltd. — 1063, Anjoji-cho, Matsuyama-city, 790. Tel. 0899-79-1065 — Fruit sorter, Box maker, Box sealer.

Shalfaif Shokai Inc. — 17-2, Kitasanjo-nishi, Chuo-ku, Sapporo-city, 060. Tel. 011-611-7844 — Broadcaster, Hay making implement.

Shikoku Mfg. Co., Ltd. — 2-5, 1-chome, Kinuyama-cho, Matsuyama-city, Ehime-pref., 791. Tel. 0899-24-7161 — Transport vehicle, Metering & sorting device Cutter.

Shimizu Kogyo — 2480, Dogane, Tsubame-city, Niigata-pref., 959-12. Tel. 0256-64-2831 — Pulverizer, Fertilizer mixer, soybean seeder.

Shin Caterpiller Mitsubishi Ltd. — 3700, Tana, Sagamihara-city, Kanagawa-pref., 229. Tel. 0427-62-1121 — Tractor, Trencher, Loader.

Shin-daiwa Kogyo Co., Ltd. — 35, Shin-ujigami, Chiyoda-cho, Yamagata-gun, Hiroshima-pref., 731-15. Tel. 082672-6011 — Chain saw, Bush cutter, Pump, Generator.

Shingu Shoko Ltd. — 4-2, 2-chome, Toyo, Koto-ku, Tokyo, 135. Tel. 03-649-7141 — Chain saw, Bush cutter.

Shinkowa Sangyo Co., Ltd. — 149-1, Nagabuse, Mishima-city, Shizuoka-pref., 411. Tel. 0559-77-1830 — Cutter, Nursery cabinet washer, Vegetable washer, Bush cutter.

Shinko Denki Co., Ltd. — 12-2, 3-chome, Nihonbashi, Chuo-ku, Tokyo, 103. Tel. 03-274-1111 — Electric chain saw.

Shinko Giken Co., Ltd. — 666-5, Kokubu, Ueda-city, 386-01. Tel. 0268-22-7135 — Mulberry harvester, Other equipment for sericulture.

Shinsho Co., Ltd. — 10-16, 4-chome, Shoko Center, Nishi-ku, Hiroshima-city, 733. Tel. 082-278-0072 — Electric chain saw, high-pressure washer.

Shinwa Co., Ltd. — 5-1-2, Otsuka-cho, Takatsuki-city, 569. Tel. 0726-75-5973 — Ventilator, Automatic curtain.

Shinwa Zoki Co., Ltd. — 4-1-4, Funaderadori, Nada-ku, Kobe-city, 657. Tel. 078-882-2210 — Bush cutter.

Shiraishi Koki Engineering Co., Ltd. — 322, Nishinosato, Hiroshima-cho, Sapporo-gun, Hokkaido, 061-11. Tel. 011-375-3241 — Snow plow.

Shirakawa Nokigu Seisakusho Corp. — 6-2, Minami, Higashi-10-jo, Obihiro-city, 080. Tel. 0155-22-1678 — Fertilizer drill, Potato planter.

Shizuoka Seiki Co., Ltd. — 4-1, Yamana-cho, Fukuroi-city, Shizuoka-pref., 437. Tel. 0538-42-3111 — Dryer, Moisture meter, Heater, Rice cake maker.

Shoshin Speed Sprayer Co., Ltd. — 2156. Ogawara, Suzuka-city, Nagano-pref., 382. Tel. 0262-45-1611 — Speed sprayer.

Showa Bridge Hanbai Co., Ltd. — 1361-1, Kakegawa, Kakegawa-city, 436. Tel. 0537-24-0630 — Bridge.

SK Denki Kogyo Co., Ltd. 1-2, 6-chome, Omotemachi, tomakomai-city, Hokkaido, 053. Tel. 0144-34-7000 — Grazing Equipment & material.

Sogo Sangyo Co., Ltd. — 3-2, 4-chome, Osaki, Shinagawa-ku, Tokyo, 141. Tel. 03-495-2591 — Crusher, Feed mixer.

Sowa Denki Seisakusho Co., Ltd. — Sayama-kogyodanchi, 337, Kashiwabara, Sayama-city, Saitama-pref., 350-13. Tel. 0429-54-5151 — Generator, Motor.

Spee Co., Ltd. — 3225-1, Nakasho, Kurashiki-city, Okayama-pref., 710. Tel. 0864-62-2211 — Rice huller, Rice sorter, Rubber roll.

Star Farm Machinery Mfg. Co., Ltd. — 1061-2, Kamioto, Chitose-city, Hokkaido, 066. Tel. 0123-26-1123 — Forage crops harvester, Tractor implement, Cutter, Dairy equipment & facility.

Stihl Japan Sales Ltd. — 8-14, 1-chome, Nakahara, Mitaka-city, Tokyo, 181. Tel. 03-307-6161 — Chain saw, Bush cutter.

Sudo Noki Co., Ltd. — 1-12, Konan, Ashoro-cho, Ashoro-gun, Hokkaido, 089-37. Tel. 01562-5-2650 — Hay elevator, Forage blower.

Sugano Farm Machinery Mfg. Co., Ltd. — 300, Aza-Tenjindai, Mano, Miho-mura, Inashiki-gun, Ibaraki-pref., 300-04. Tel. 0298-86-0031 — Plow, Subsoiler.

Suiden Co., Ltd. — 2-4-24, Ousaka, Tennoji-ku, Osaka-city, 543. Tel 06-772-2241 — Ventilator.

Sukigara Agricultural Machinery Co., Ltd. — 38, Sairinji, Yahagi-cho, Okazaki-city, Aichi-pref., 444 Tel. 0564-31-2107 — Digger, Mulcher, Cultivater, Land leveler.

Sumika Nogyo Kaihatsu Co., Ltd. — 2-7, Yokobori, Higashi-ku, Osaka-city, 541. Tel. 06-204-1241 — Irrigation system.

Sun Hope Co., Ltd. — 4-20, 1-chome, Nakameguro, Meguro-ku, Tokyo, 153. Tel. 03-710-5675 — Sprinkler.

Sun Kikai Kogyo Co., Ltd. — 1675-5 Naka-baru, Kase-cho, Saga-city, 849-02. Tel. 0952-25-3685 — Seeder, Land roller, Tractor implement.

Suzue Agricultural Machinery Co., Ltd. — 144-2, Gomen-cho, Nankoku-city, Kochi-pref., 783. Tel. 0886-64-2121 — Walking & riding tractor, Binder, Bean harvester, Transmission.

Suzuki Zidosha Kogyo Co., Ltd. — 300, Takatsuka, Kamimura, Hamana-gun, Shizuoka-pref., 432. Tel. 0534-40-2305 — Engine.

Suzutec Co., Ltd. — 44-3, Hiraide-kogyodanchi, Utsunomiya-city, Tochigi-pref., 321. Tel. 0286-64-1111 — Tractor implement, Nursery equipment.

[T]

Tabata Noki Seisakucho Corp. — 2-7. Inadamachi-higashi, Obihiro-city, 080. Tel. 0155-48-2324 — Seeder, Fertilizer Driller, Potato planter.

Tachiyama Seisakusho Co., Ltd. — 1, 4-chome, Takenouchi, Hiwada-machi, Koriyama-city, Fukushima-pref., 963-05. Tel. 0249-58-2331 — Paddy harrowing rotor, Broadcaster, Manure spreader.

Taiki Industry Co., Ltd. — 3-3, Seishin-cho, Okayama-city, 700. Tel. 0862-52-1178 — Dryer.

Taisho Co., Ltd. — 1027, Motoyoshida-cho, Mito-city, Ibaraki-pref., 310. Tel. 0292-47-5411 — Electric-heated nursery equipment, Tractor implement, Rice sorter, Mushroom dryer.

Taisho Farming Machine Co., Ltd. — 327, Uratsu, Yonago-city, Tottori-pref., 689-35. Tel. 0859-27-0121 — Mushroom dryer.

Taiwa Noki Co., Ltd. — 186, Seki, Toyama-city, 939, Tel. 0764-29-5656 — Rice sorter, Rice huller & mill.

Taiyo Co., Ltd. 9-26, Futaba-cho, Kochi-city, 788. Tel. 0888-82-8161 — Tine, Tillage implement, Blade.

Taiyo Kogyo Co., Ltd. — Miki-blg., 12-1, 3-chome, Nihonbashi, Chuo-ku, Tokyo, 103. Tel. 03-273-0753 — Green house, Heater, Nursery materials.

Taiyo Kogyo Co., Ltd. — 8-4, 4-chome, Kigawahigashi, Yodogawa-ku, Osaka-city, 532. Tel. 06-306-3111 — Green house, Cold store, Silo container.

Taiyo Sangyo Co., Ltd. — 14-17, 1-chome, Miyahara, Yodogawa-ku, Osaka-city, 532. Tel. 06-391-5121 — Mono rail.

Taiyo Tanko Co., Ltd. — 3950, Fushida, Kochi-city, 781-51. Tel. 0888-46-1230 — Tine.

Takachiho Kogyo Co., Ltd. — i-49, Wakamiya-cho, Kanazawa-city, 920. Tel. 0762-21-5303 — Screw harvester, Screw rotor, Mission.

Takahashi Suiki Co., Ltd. — 9-35, 3-chome, Sakaecho, Soka-city, Saitama-pref., 340. Tel. 0489-31-3545 — Vegetable washer, Sorter.

Takakita Co., Ltd. — 2828, Natsumi, Nabari-city, Mie-pref., 518-04. Tel. 05956-3-3111 — Harrow, Plow, Broadcaster, Seeder, Farm wagon, Mower.

Takara Keiki Seisakusho Co., Ltd. — Ichirigi, Yanai-city, 742. Tel. 0820-22-0389 — Rice huller mill, Metering device.

Takeshita Sangyo Co., Ltd. — 68-4, Honmachi, Yanagawa-city, 832. Tel. 09447-3-7111 — Hot air heater.

Takezawa Sangyo Co., Ltd. — 200, Kasamatsu, Nishisaiwai-cho, Toyohashi-city, 440. Tel. 0532-45-5648 — Greenhouse heater.

Taki Farm Implements & Tools Co., Ltd. — 1400, Shinnobe, Befu-cho, Kakogawa-city, Hyogo-pref., 675-01. Tel. 0794-37-8881 — Seeder, Soil sterilizer, Tractor implement, Farm tool

Takuma Co., Ltd. — 3-21, 1-chome, Dozimahama, Kita-ku, Osaka-city, 530. Tel. 06-346-5161 — Soil sterilizer.

Tama Fureki Sansho Co., Ltd. — 14-9, 2-chome, Hatsudai, Shibuya-ku, Tokyo, 151. Tel 03-379-2434 — Flower sorter, Fog generator.

Tanaka Kogyo Co., Ltd. — 6-10, 1-chome, Yatsu, Narashino-city, Chiba-pref., 275. Tel. 0474-72-1111 — Engine, Generator, Pump, Bush cutter.

Tanaka Koki Co., Ltd. — 15, Kaido-machi, Omura-city, Nagasaki-pref., 856-02. Tel. 0957-55-8181 — Potato digger, Tractor implement.

Tanaka Mfg. Co., Ltd. — 2228, Kamitsu-cho, Kurume-city, Fukuoka-pref., 830. Tel. 0942-27-1371 — Transport vehicle.

Tanifuji Kikai Kogyo Co., Ltd. — 6-7, 3-chome, Kudanminami, Chiyoda-ku, Tokyo, 102. Tel. 03-265-6231 — Electric weeder.

Tani Kikai Kosakusho Co., Ltd. — 3-10-7, Kujo, Nishi-ku, Osaka-pref., 550. Tel. 06-581-8976 — Rice mill, Rice sorter.

Taninaka Sangyo Co., Ltd. — 1-23, 1-chome, Nishi, Sakurano-cho, Sakai-city, Osaka-fu., 590. Tel. 0722-29-1949 — Chopper.

Terada Pump Co., Ltd. — 3-17, Shinonome-cho, Yamato-takada-city, Nara-pref., 635. Tel. 0745-52-5101 — Pump.

Tiger Co., Ltd. — 10-1, Yamadaichiba, Suita-city, Osaka, 565. Tel. 06-878-5425 — Explosion scarcrow, Bush cutter, Hodge trimmer.

Tiger-kawashima Co., Ltd. — 4290, Fujioka, Fujioka-cho, Shimotsuga-gun, Tochigi-pref., 349-13. Tel. 0282-62-3001 — Rice sorter, Sprouter.

Tobi Kogyo Co., Ltd. — 888-14, Kanaokanishi-cho, Okayama-city, 704. Tel. 08694-8-3600 — Transport vehicle, Animal exerciser.

Tobu Ryoju Engine Hanbai Co., Ltd. — 4-5, 3-chome, Iwamoto-cho, Chiyoda-ku, Tokyo, 101. Tel. 03-866-6955 — Engine.

Tohata Co., Ltd. — 17, Komodakawakubo, Shichinohe-cho, Kamikita-gun, Aomori-pref., 039-25. Tel. 0176-62-3034 — Trailer, Manure spreader, Walking tractor.

Tohoku Pioner Co., Ltd. — 1105, Kunomoto-nikko, Tendo-city, 994. Tel. 0236-54-1211 — Water culture plant.

Tokachi Noki Co., Ltd. — 8-2, Nishihachijo, Memuro-cho, Kasai-gun, Hokkaido, 082. Tel. 0155-62-2421 — Fertilizer, Seeder-fertilizer, Poteto harvester, Beat harvester, Manure spreader.

Tokai Industry Co., Ltd. — 32, Midorien, Ogaki-city, Gifu-pref., 503. Tel. 0584-78-6131 — Pest control machine, Pump, High-pressure washer.

Tokyo Rasonic Co., Ltd. — 6-5, 2chome, Yaesu, Chuo-ku, Tokyo, 104. Tel. 03-274-2835 — Moisture meter.

Torii Kinzoku Kogyo Co., Ltd. — 3-7, Kanamono-cho, Higashiosaka-city, 577. Tel. 06-723-2433 — Bridge.

Touichi Co., Ltd. — 19-11, Minami-cho, Itabashi-ku, Tokyo, 173. Tel. 03-973-0011 — Lapping machine.

Toyosha Co., Ltd. — 55, Joshoji-16, Kadoma-city, Osaka, 571. Tel. 0720-81-8181 — Tractor, Power disk, Rotary, Pan-breaker, Trencher, Mulcher, Other implement.

Toyo Agricultural Machinery Co., Ltd. — 2-5, Kita 1-chome, Nishi 22-jo, Obihiro-city, Hokkaido, 080-24. Tel. 0155-37-3191 — Tractor implement, Harvester.

Toyo Rice Cleaning Machines Plant Co., Ltd. — 12, Kuroda, Wakayama-city, 640. Tel. 0734-71-3011 — Rice pearling machine.

Toyo Umpanki Co., Ltd. — 15-10, 1-chome, Kyomachibori, Nishi-ku, Osaka, 550. Tel. 06-441-9151 — Tractor, Transport vehicle.

Tsuchiya Kikai Seisakusho Co., Ltd. — 18-5, 4-chome, Morishita, Koto-ku, Tokyo, 135. Tel. 03-634-0781 — Lawn Mower, Snow plow.

Tsuchiya Tokushu Nokigu Seisakusho Co., Ltd. — 3-2, 1-chome, Kita, Nishi-21 jo, Obihiro-city, 080. Tel. 0155-37-2161 — Milker, Dung disposer.

Tsukiji Sakudo Kogyo Co., Ltd. — 30-7, 2-chome Shofu, Shizuoka-city, 420. Tel. 0542-71-7158 — Cable way.

Tsukishima Kikai Co., Ltd. — 17-15, 2-chome, Tsukuda, Chuo-ku, Tokyo, 104. Tel. 03-533-4111 — Hay dryer.

Tsurumi Manufacturing Co., Ltd. — 16-40, 4-chome, Tsurumi, Tsurumi-ku, Osaka-city, 538. Tel. 06-911-2355 — Pump.

[U]

Uchida Sangyo Co., Ltd. — 10-2, 4-chome, Hatchobori, Chuo-ku, Tokyo, 104. Tel. 03-553-6551 — Feeder.

Ueda Noki Co., Ltd. — 1649, Sigeno-Otsu, Tobu-machi, Chiisagata-gun, Nagano-pref., 389-03. Tel. 0268-62-1338 — Plow, Digger.

Ueda Rakunoki Kogyo Co., Ltd. — 14-20, 2-chome, Matsue, Edogawa-ku, Tokyo, 132. Tel. 03-652-4161 — Milk pasterizer.

Ueno Nokigu Seisakusho. — 70, Hon-dori, Niseko-machi, Abuta-gun, Hokkaido, 048-15. Tel. 0136-44-2452 — Rotary Harrow.

Umeya Kou Shoten Co., Ltd. — 443, Kurami, Samukawa-machi, Kouza-gun, Kanagawa-pref., 253-1. Tel. 0467-75-0155 — Vegetable & fruit sorter.

Uotani Tekko Co., Ltd. — 35, Inugai-machi, Gojo-city, 637. Tel. 07472-2-3632 — Cane harvester.

Ushikubo Seisakusho Co., Ltd. — 588, Takamatsu-cho, Ashikaga-city, Tochigi-pref., 326-03. Tel. 0284-71-9211 — Trailer, Dryer.

[V]

Vicon Japan Co., Ltd. — 90, Kamitoda, Toda-city, Saitama-pref., 335. Tel. 0484-44-1073 — Mower, Mower conditioner.

[W]

Wado Sangyo Co., Ltd. — 410, Jissoji, Hanamaki-city, Iwate-pref., 025. Tel. 0198-24-3221 — Tractor implement, Snow plow.

Wako Trade Co., Ltd. — 7-20, 6-chome, Kitashinagawa, Shinagaku, Tokyo, 141. Tel. 03-447-1411 — Chain saw, Pump.

[Y]

Yamada Machinery Industrial Co., Ltd. — 1508, Kogo, Iwaoka-cho, Nishi-ku, Kobe-city, Hyogo-pref., 674. Tel. 078-967-1481 — Bush cutter, Chain saw, Earth augar.

Yamaguchi Denki Kogyo Co., Ltd. — 11-9, 3-chome, Ikejiri, Setagaya-ku, Tokyo, 154. Tel. 03-413-0501 — Warning device against falling down.

Yamaha Hatsudoki Co., Ltd. — 2500, Shingai, Iwata-city, 438. Tel. 05383-2-1111 — General purpose engine, Snow plow, Outboard motor.

Yamamoto Mfg. Co., Ltd. — 404, Oinomori, Tendo, Tendo-city, Yamagata-pref., 994. Tel. 0236-53-3411 — Dryer, Drying facility, Cutter, Waste crusher, Bean thresher & sorter.

Yamamoto Sangyo Co., Ltd. — 532, Yato Tashima, Toyoda-cho, Iwata-gun, Shizuoka-pref., 438. Tel. 0538-32-9211 — Green house, Melon cleaner.

Yamamoto Seisakusho Co., Ltd. — 3-7-19, Oguri, Matsuyama-city, 790. Tel. 0899-31-2251 — Rotary, Trencher.

Yamasaki Seiki Kenkyu-sho Inc. — 18, Ojoin-cho, Saga, Ukyo-ku, Kyoto-city, 616. Tel. 075-871-8815 — Moisture meter for rice & wheat, Other measuring device.

Yamatake Hanewell Co., Ltd. — 12-19, 2-chome, Shibuya, Shibuya-ku, Tokyo, 150. Tel. 03-486-2031 — Splinkler.

Yanagihara Seisakusho Co., Ltd. — 1-19-1, Nakagosho, Nagano-city, 380. Tel. 0262-26-2485 — Cleaner, Fruit sorter.

Yanase & Co., Ltd. — 6-38, 1-chome, Shibaura, Minato-ku, Tokyo, 105. Tel. 03-452-4311 — Green house farming machinery, Engine.

Yanmar Agricultural Equipment Co., Ltd. — 1-32, Chaya-machi, Kita-ku, Osaka-city, 530. Tel. 06-376-6321 — Engine, Tiller, Cultivator riding tractor, Tractor implement, Rice transplanter, Binder, Combine, Other general agricultural machinery.

Yanmar Diesel Co., Ltd. — 1-32, Chaya-machi, Kita-ku, Osaka-city. 530. Tel. 06-376-6299 — Diesel engine.

Yasuno Noki Co., Ltd. — 346-2, Beppu, Onishi-cho, Ochi-gun, Ehime-pref., 799-22. Tel. 0898-53-3013 — Winnower, Cage.

Yoka Iron Works Col., Ltd. — 200, Asakura, Yokamachi, Yabu-gun, Hyogo-pref., 667. Tel. 0796-62-7111 — Cutter, Seeder.

Yokohama Ueki Co., Ltd. — 15, Karasawa, Minami-ku, Yokohama-city, 232. Tel. 045-261-4181 — Sprayer, Gardening tool.

Yokomizo Tekko — 657-1, Kaminosho, Setaka-machi, Yamato-gun, Fukuoka-pref., 835. Tel. 09446-2-3190 — Soil disinfector, Fertilizer distributor.

Yokoyama Denki Seisakusho Co., Ltd. — 1234, Nakamaruko, Nakahara-ku, Kawasaki-city, 211. Tel. 044-411-6111 — Silo, Feed tank.

Yoneyama Kogyo Co., Ltd. — 121, Minamisaya-cho, Matsuyama-city, Ehime-pref., 791-41. Tel. 0899-72-0354 — Tree rack.

Yoshitoku Noki Co., Ltd. — 7-23, 1-chome, Yamaya Niitsu-city, Niigata-pref., 956. Tel. 0250-24-0012 — Metering & packing device, Snow plow, Power thresher for seed.

Components and Parts Manufacturers

[A]

Asahi Sakudokan Co., Ltd. — 4-2-41, Kamikita, Hirano-ku, Osaka-city, 547. Tel. 06-793-0151 — Control wire.

Atom Kogyo Gijutsu Kenkyusho Co., Ltd. — 2185-2, Fukui, Miki-city, 673. Tel. 07948-2-1738 — Bush cutter blade.

[B]

Bando Kagaku Co., Ltd. — 6-1-12, Miyukidori, Chuo-ku, Kobe-city, 651. Tel. 078-232-2923 — Rice husking roller, Belt.

Ban Kogyo Yohin Co., Ltd. — 27-1, 2-chome, Higashinihonbashi, Chuo-ku, Tokyo, 103. Tel. 03-861-7411 — Belt, Hose.

Bridgestone Co., Ltd. — 10-1, 1-chome, Kyobashi, Chuo-ku, Tokyo, 104. Tel. 03-567-0111 — Tire, Crawler.

[D]

Daido Gomu Co., Ltd. — 307-1, Minato-cho, Marugame-city, 763. Tel. 0877-22-6254 — Rubber roller for rice husking.

Daido Kogyo Co., Ltd. — I-197, Kumasaka-cho, Kaga-city, 922. tel. 07617-2-1234 — Chain, Wheel.

Daikin Kogyo Co., Ltd. Yuki jigyobu — Umeda-center-blg., 2-4-12, Nakazakinishi, Kita-ku, Osaka-city, 530. Tel. 06-373-1201 — Hydraulic system.

Diesel Kiki Co., Ltd. — 6-7, 3-chome, Shibuya, Shibuya-ku, Tokyo, 150 Tel. 03-400-1551 — Jet pump.

[E]

Enuma Chain Seisakusho Co., Ltd. — 1-30, Chikata-cho, Daiseiji, Kaga-city, 922. Tel. 07617-2-0286 — Chain.

[F]

Fujikoshi Co., Ltd. — 20, Ishikane-cho, Toyama-city, 930. Tel. 0764-23-5111 — Bearing.

Fuji Kikai Co., Ltd. — 24-3, 2-chome, Iwakami-cho, Maebashi-city, 371. Tel. 0272-31-3113 — Transmission.

Fuji Kosan Co., Ltd. — Nagata-cho-blg., 4-3, 2-chome, Nagata-cho, Chiyoda-ku, Tokyo, 100. Tel. 03-580-3576 — Lubricant, Fuel oil.

Fukoku Hatsujo Co., Ltd. — 36, Tsuzumine Kawasaki-ku, Kawasaki-city, 210. Tel. 044-233-6391 — Plate spring, Spring.

[H]

Hanaoka Sangyo Co., Ltd. — Rotary-blg., 1-27, Kandanishiki-cho, Chiyoda-ku, Tokyo, 101. Tel. 03-295-3066 — Tire, Caster.

Hashimoto Seisakusho Co., Ltd. — 1-29, 2-chome, Shinonome-nishi-cho, Sakai-city, 590. Tel. 0722-33-7301 — V-pulley, Specific screw.

Hikari Keikinzoku Kogyo Co., Ltd. — 1050, Ejiri, Seto-cho, Akaiwa-gun, Okayama-pref., 709-08. Tel. 08695-2-2121 — Agricultural machine parts.

Hisamatsu Sangyosha Co., Ltd. — 11-7, Nakamura Kakiuchi, Terado-cho, Mukou-city, 617. Tel. 075-933-7788 — Bush cutter, Pump, Tractor implements.

Howa Kogyo Co., Ltd. — Sugaguchi, Shinkawa-cho, Nishikasugai-gun, Aichi-pref., 452. Tel. 052-502-1111 — Transmission.

[I]

Iida Denki Kogyo Co., Ltd. — 5-14, 1-chome, Shimomeguro, Meguro-ku, Tokyo, 153. Tel. 03-492-0525 — Magnet, Electric parts.

Ikeuchi Co., Ltd. — Yanoshige-blg., 8-2, 6-chome, Nishitenman, Kita-ku, Osaka-city, 530. Tel. 06-364-9081 — Nozzle.

Imoto Co., Ltd. — 657, Kobayashi, Bessho-cho, Miki-city, 673-04. Tel. 07948-5-1248 — Cutter blade, Binder blade, General blades for agricultural machines.

Inoue Brush Seisakusho Inc. — Minamizato, Shimen-cho, Kasuya-gun, Fukuoka-pref., 811-22. Tel. 092-936-4555 — Brush.

Ishino Gasket Kogyo Co., Ltd. — 3-3, 2-chome, Toranomon, Minato-ku, Tokyo, 105. Tel. 03-501-8851 — Gasket, Filter.

Ito Kogyo Co., Ltd. — 1-3-23, Hokkai, Nishinari-ku, Osaka-city, 557. Tel. 06-568-6271 — Synthetic rubber, Packing.

Izumi Chain Co., Ltd. — 100-1, Hakozukuri, Hannan-cho, Sennan-gun, Osaka-fu, 599-02. Tel. 0724-76-1121 — Chain.

[K]

Kaga Kogyo Co., Ltd. — 1-542, Uetake-cho, Omiya-city, 330. Tel. 048-663-2061 — Chain.

Kanazawa Tsushosangyo Co., Ltd. — 6-1, 1-chome, Sotokanda, Chiyoda-ku, Tokyo, 101. Tel. 03-253-5331 — Break, Spring.

Kangyo Inc. — 36-2, Tomoe, Bessho-cho, Miki-city, 673-04. Tel. 07948-2-7361 — Blade for binder & combine.

Kansai Shoji Co., Ltd. — 5-12-4, Nakamoto, Higashinari-ku, Osaka-city, 537. Tel. 06-972-7433 — Pulley, Engine parts.

Kansai Yokyo Co., Ltd. — 3-15-10, Honmachi, Miki-city, 673-04. Tel. 07948-2-0022 — Saw blade for bush cutter.

Kayaba Kogyo Co., Ltd. — Trade Center-blg., 4-1, 2-chome, Hamamatsucho, Minato-ku, Tokyo, 105. Tel. 03-453-3503 — Hydraulic system.

Keihin Seiki Seisakusho Co., Ltd. — 386, Ichinotsubo, Nakahara-ku, Kawasaki-city, 211. Tel. 044-411-6301 — Evaporator, Valve.

Kinsei Kogyo Co., Ltd. — 353-6, Nishinasuno-cho, Nasu-gun, Tochigi-pref., 329-27. Tel. 0287-36-1077 — Pulley, Hitch.

Kinzonoko Kogyo Co., Ltd. — 2366, Fukui, Miki-city, 673-04. Tel. 07948-2-2108 — Bush cutter blade, General cutlery.

Kodama Jushi Kogyo Co., Ltd. Yokoi Kojo — 1700-1, Yokoi, Kobe-cho, Anpachi-gun, Gifu-pref., 503-23. Tel. 058427-5051 — Tank, Seedling box carrying frame.

Kokusan Denki Co., Ltd. — 3744, Ooka, Numazu-city, 410. Tel. 0559-21-5930 — Engine, Electric parts.

Koyo Seiko Co., Ltd. — 2, Kabayanishinomachi, Chuo-ku, Osaka-city, 542. Tel. 06-271-8451 — Bearing.

Kureha Gomu Kogyo Co., Ltd. — 2-11, Azuchi-cho, Chuo-ku, Osaka-city, 541. Tel. 06-271-8291 — Rubber manufactures.

[M]

Maruzen Orimono Co., Ltd. — 540, Kinzoji-cho, Zentsuzi-city, 765. Tel. 0877-62-1100 — Band for binder.

Matsumoto Seisakusho Co., Ltd. — 423, Hiratsu, Yoneda-cho, Kakogawa-city, 675-02. Tel. 0794-31-0968 — Hydraulic system.

Matsui Waltershide Co., Ltd. — 2-21-15, Itabashi-ku, Tokyo, 174. Tel. 03-969-2571 — Universal joint.

Midori Mark Seisakusho Co., Ltd. — 1-5, 2-chome, Komagata, Taito-ku, Tokyo, 111. Tel. 03-843-2011 — Mark, Plate.

Mikuni Kogyo Co., Ltd. — Uenofuji-blg., 16-5, 3-chome, Ueno, Taito-ku, Tokyo, 110. Tel 03-833-2731 — Evaporator, Fuel pump.

Minagawa Noki Seizo Co., Ltd. — 205, Shimookama, Shimoda-mura, Minamikanbara-gun, Niigata-pref., 955-01. Tel. 0256-46-2010 — Cutlery.

Mitsuboshi Belt Co., Ltd. — 4-1-21, Hamazoedori, Nagata-ku, Kobe-city, 653. 078-671-5071 — Belt, Pulley.

Mizuuchi Gomu Co., Ltd. — 461, Shimo, Okayama-city. Tel. 0862-79-3211 — Rice husking rubber roller, Other rubber manufactures for agricultural machines.

[N]

Nabeya Kogyo Co., Ltd. — Kurachimukaiyama, Seki-city, 501-32. Tel. 0575-23-1121 — V-pulley, Flexible shaft.

Nichiden Co., Ltd. — Asahi-nakayama-blg., 5-4, 3-chome, Hongo, Bunkyo-ku, Tokyo, 113. Tel. 03-815-2321 — Control machine parts, Machine parts.

Nihon Blade Co., Ltd. — 5-1, Toya-cho, Takamatsu-city, 760. Tel. 0878-21-5872 — Tine, Cutting blade.

Nihon Denchi Co., Ltd. — 1, Inobaba-cho, Nishinosho, Kichijoin, Minami-ku, Kyoto-city, 601. Tel. 075-321-1211 — Electric cell, Battery.

Nihon Flex Kogyo Co., Ltd. — 3-64, Higashiarioka, Itami-city, 664. Tel. 0727-82-6521 — Control cable.

Nihon Greener Co., Ltd. — 1-1-12, Shinsenri-nishimachi, Toyonaka-city, 560. Tel. 06-833-5021 — Soil amendment.

Nihon Kikaki Seisakusho Co., Ltd. — 1-12, 5-chome, Kitashinagawa, Shinagawa-ku, Tokyo, 141. Tel. 03-443-0241 — Evaporator.

Nihon Piston-ring Co., Ltd. — 2-6, 4-chome, Kudankita, Chiyoda-ku, Tokyo, 102. Tel. 03-234-4171 — Piston ring.

Nihon Tokushu Togyo Co., Ltd. — 14-18, Takatsuji-cho, Mizuho-ku, Nagoya-city, 467. Tel. 052-871-2111 — Plug for agricultural use.

Nikken Rasu Kogyo Inc. — 3-9-4, Ohira-cho, Fukushima-ku, Osaka-city, 553. Tel. 04-461-9361 — Punch cutting steel net, Steel sheet.

Nikko Seisakusho Co., Ltd. 3-15, Shibamachi, Miki-city, 673-04. Tel. 07948-2-6964 — Weeding blade.

NOK Co., Ltd. — 12-15, 1-chome, Shibadaimon, Minato-ku, Tokyo, 105. Tel. 03-432-4211 — Seal, Packing, O-ring.

NTN Toyo Bearing Co., Ltd. — 1-25, Kyomachibori, Nishi-ku, Osaka-city, 550. Tel. 06-443-5011 — Bearing.

[O]

Oiless Kogyo Co., Ltd. — 8, Kirihara-cho, Fujisawa-city, 252. Tel. 0466-44-4811 — Bearing.

Okada Tire Kogyo Co., Ltd. — 1-1, 2-chome, Shiratori, Katsushika-ku, Tokyo, 125. Tel. 03-690-2121 — Tire, Tube.

Okamoto Riken Gomu Co., Ltd. — 27-12, 3-chome, Hongo, Bunkyo-ku, Tokyo, 113. Tel. 03-813-4111 — Tire, Tube.

Okubo Haguruma Kogyo Co., Ltd. — 3030, Kamiichi, Atsugi-city, 243. Tel. 0462-85-1131 — Gear, Transmission.

Omark Japan Co., Ltd. — Toranomon Kotohira-kaikan, 2-8, 1-chome, Toranomon, Minato-ku, Tokyo, 105. Tel. 03-503-6716 — Saw chain, Sprocket.

Ono Sokki Co., Ltd. — Shinjuku NS-blg., 4-1, 2-chome, Nishi-shinjuku, Shinjuku-ku, Tokyo, 160. Tel. 03-342-9181 — Metering device.

Osaka Grip Kako Co., Ltd. — 5-27-2, Takaida-hondori, Higashiosaka-city, 577. Tel. 06-782-4353 — Grip.

Osaka Pipe Kako Co., Ltd. — 3-7-22, Fukaekita, Higashinari-ku, Osaka-city, 537. Tel. 06-981-7984 — Pipe bending treatment.

Otake Seiki Co., Ltd. — 1-2-63, Minamino-cho, Atobe, Yao-city, 581. Tel. 0729-93-6437 — Bush cutter blade.

Otsu Tire Co., Ltd. — 9-1, Kawahara-cho, Izumiotsu-city, 595. Tel. 0725-21-1111 — Tire.

[R]

Riken Piston-ring? Kogyo Co., Ltd. — 13-5, 1-chome, Kudankita, Chiyoda-ku, Tokyo, 102. Tel. 03-230-3911 — Piston ring.

Rucus.CAV Co., Ltd. — 1-3, Kiyohara-kogyodanchi, Utsunomiya-city, 321-32. Tel. 0286-67-5131 — Fuel sprayer, Electric parts.

[S]

Sanwa Seikyo Co., Ltd. — 61, Kasa, Miki-city, 673-04. Tel. 07948-2-0416 — Weeding blade, Circular saw.

Sanyo Chain Seisakusho Co., Ltd. — 1-70, Showa-cho, Tsuyama-city, 708. Tel. 0868-22-3050 — Chain.

Sanyo Kinzoku Co., Ltd. — 301-1, Torimachi, Miki-city, 673-04. Tel. 07948-2-0928 — Bush cutter blade, Reaping blade for binder & combine.

Sanyo Riki Co., Ltd. — 976, Shimokurusu-cho, Ono-city, 675-13. Tel. 07946-3-4321 — Binder blade, Combine blade, Cutter blade.

Sasaoka Tekko Co., Ltd. — 2468, Kanda, Suzaki-city, 785. Tel. 0889-42-2433 — Tillage blade.

Seibu Kosaku Co., Ltd. — 107, Kamiuchimagi, Asaka-city, 351. Tel. 0484-56-0934 — Mechanical press manufacturing, Mechanical manufacturing.

Seikosha Co., Ltd. — 1-9-1, Higashikonahama, Sumiyoshi-ku, Osaka-city, 558. Tel. 06-674-2501 — Mark, Name plate.

Sekisui Jushi Co., Ltd. — Dozima-kanden-blg., 2-4-4, Nishitenman, Kita-ku, Osaka-city, 530. Tel. 06-365-3204 — Orchard rack.

Shimazu Seisakusho Co., Ltd. Yuatsukikibu — 25, Nishinoin-oiwake-cho, Ukyo-ku, Kyoto-city, 615. Tel. 075-312-2123 — Hydraulic system.

Shinano Kuatsu Kogyo Co., Ltd. Tokyo Eigyosho — 36-9, 6-chome, Akabanenishi, Kita-ku, Tokyo, 115. tel. 03-905-1141 — Machine Tool.

Shinetsu Polymer Co., Ltd. — 3-5, 4-chome, Nihonbashi-honmachi, Chuo-ku, Tokyo, 103. Tel. 03-279-1712 — Plastic materials.

Shingen Kogyo Co., Ltd. — 2-2-52, Otsuka, Miki-city, 673-04. Tel. 07948-2-1115 — Blade, Grinder.

Shinwa Controls Co., Ltd. — Sinbashi-Shinwa-Kokusai-blg., 7-7, 2-chome, Higashishinbashi, Minato-ku, Tokyo, 105. Tel. 03-433-8545 — Electromagnetic valve pump.

Showa Boeki Co., Ltd. Beibaku Kizai Honbu — 1-18-27, Edobori, Nishi-ku, Osaka-city, 550. Tel. 06-441-5501 — Unhusked rice bag.

Showa Gomu Kagaku Kogyosho Co., Ltd. — 15-3, 4-chome, Tateishi, Katsushika-ku, Tokyo, 124. Tel. 03-691-5141 — Tire, Tube.

Soft-Silica Co., Ltd. — Yotsuya-blg., 2-1, Yotsuya, Shinjuku-ku, Tokyo, 160. Tel. 03-353-3651 — Soil amendment.

Starteng Kogyo Co., Ltd. — 4-4, 4-chome, Momoi, Suginami-ku, Tokyo, 167. Tel. 03-399-0141 — Lever, Recoil starter.

Sumitomo Gomu Kogyo Co., Ltd. — 1-1-1, Tsutsui, Chuo-ku, Kobe-city, 651. Tel. 078-231-4141 — Tire, Tube.

Suzuki Brush Seisakusho Inc. — 1-2, Mukaida, Kubo-cho, Toyokawa-city, 442. Tel. 05338-8-3511 — Brush for agricultural machinery.

[T]

Taisan Kogyo Co., Ltd. — 23-13, 5-chome, Ikegami, Ota-ku, Tokyo, 146. Tel. 03-753-0121 — Thermo-control device.

Taito Seiko Co., Ltd. — 1-21, 1-chome, Higashishinbashi, Minato-ku, Tokyo, 105. Tel. 03-572-3231 — Band for binder.

Tanaka Sangyo Co., Ltd. — 5-17-6, Shonainishimachi, Toyonaka-city, 561. Tel. 06-332-7185 — Nursery box, Combine net bag.

Teikoku Pistonring Co., Ltd. — 9-9, 1-chome, Yaesu, Chuo-ku, Tokyo, 103. Tel. 03-272-1811 — Piston ring.

Teikoku Sangyo Co., Ltd. — 2-2-8, Nakanoshima, Kita-ku, Osaka-city, 530. Tel. 06-227-1821 — Band for binder.

Tenma Gosei Jushi Co., Ltd. — 2345, Ozaki, Noda-city, 270-02. Tel. 0471-29-3101 — Nursery box.

TK Kikaki Co., Ltd. — 5-10, Kotobuki-cho, Toyota-city, 471. Tel. 0565-28-2311 — Evaporator.

Toa Juko Co., Ltd. — 607-3, Torimachi, Miki-city, 673-04. Tel. 07948-2-5321 — Tillage blade.

Tohoku Gomu Co., Ltd. — 1-1-1, Koriyama, Sendai-city, 982. Tel. 022-248-1131 — Rubber roller for rice husking.

Tokushu Piston Seisakusho Co., Ltd. — 3-167, Otake, Yao-city, 581. Tel. 0729-41-2288 — Piston chamber for pest control machine.

Tokyo Uchinuki Tekko Co., Ltd. — 4-4, 2-chome, Showazima, Ota-ku, Tokyo, 143. Tel. 03-765-7711 — Punch cutting steel net.

Tosei Kogyo Co., Ltd. — 1-28-4, Tadao, Machida-city, 194-02. Tel. 0427-92-0658 — Tillage blade, blade.

Toyo Kasei Kogyo Co., Ltd. — 2-1, 4-chome, Nishidai, Itabashi-ku, Tokyo, 175. Tel. 03-934-8228 — Tank & basket for dryer.

Tsubakimoto Chain Co., Ltd. — 4-17-88, Tsurumi, Tsurumi-ku, Osaka-city, 538. Tel. 06-911-1221 — Chain.

Tsumura Co., Ltd. — 46, Tomoe, Bessho-cho, Miki-city, 673-04. Tel. 07948-2-0771 — Blade, Chip saw.

[W]

Wakayama Gomu Co., Ltd. — 13-10, 2-chome, Kanamachi, Katsushika-ku, Tokyo, 125. Tel. 03-600-5601 — Milker liner, Hose, Packing.

[Y]

Yachiyo Co., Ltd. — 6-1, 2-chome, Ueno, Taito-ku, Tokyo, 110. Tel. 03-835-0158 — Bush cutter blade.

Yahata Byora Co., Ltd. — 1-1-5, Kitakuhozi, Yao-city, 581. Tel. 0729-92-2881 — Screw.

Yamakyu Chain Co., Ltd. — 15-16, 2-chome, Takanawa, Minato-ku, Tokyo, 108. Tel. 03-445-8511 — Chain.

Yokogawa Denki Co., Ltd. — 2-9-32, Nakamachi, Musashino-city, 180. Tel. 0422-54-1111 — Controller for green house farming.

Yokohama Eiroquip Co., Ltd. — 10-5, 5-chome, Shinbashi, Minato-ku, Tokyo, 105. Tel. 03-437-3511 — Hydraulic hose.

Yokohama Gomu Co., Ltd. — 36-11, 5-chome, Shinbashi, Minato-ku, Tokyo, 105. Tel. 03-432-7111 — Tire.

Yoshimitsu Kokan Co., Ltd. — 2-1-15, Sonezakishinchi, Kita-ku, Osaka-city, 530. Tel. 06-344-4631 — Steel pipe.

Yushin Co., Ltd. — Takagi-blg., 7-2, 1-chome,Shinbashi, Minato-ku, Tokyo, 105. Tel. 03-502-5241 — Agricultural machine parts & accessories, Metering device, Electric parts.

Yushin Co., Ltd. — Takagi-blg., 7-2, 1-chome,Shinbashi, Minato-ku, Tokyo, 105. Tel. 03-502-5241 — Agricultural machine parts & accessories, Metering device, Electric parts.

ABSTRACTS

The ABSTRACT pages is to introduce the abstracts of the article which cannot be published in whole contents owing to the limited publication space and so many contributions to AMA. The readers who wish to know the contents of the article more in detail are kindly requested to contact the authors. The requests from the readers for publishing the whole contents among the articles introduced here may also be sent to editorial staff. Regarding the article of many requests, the publication of whole contents will be reconsidered.

Automatic Formation of Constraint Equations for Farm Machinery Selection: Han Kuanjin; Gao Huanwen; Feng Yuntian, Beijin Agric. Engg. Univ., China

The "working amount" method has long been used in farm machinery selection in China due to its simplicity, but it only ensures that field operations are finished within demanded periods. In contrast, the "programming selection" method, such as linear or non-linear programming, can make better results because it takes into account all the effective factors such as the available field operation days, working amount, machinery capacities and its costs, timeliness, losses, etc. Why couldn't this method substitute the conventional "working amount" method and get a wide application? One of the main reasons is that large amount of constraint equations in programming method have to be done by hand. To overcome the problem, this paper presents a multi-functioned software PG-1 which can form the constraint equations automatically by computer in farm machinery selection.

Energy Analysis of Major Crops in Thailand: Gajendra Singh, Prof. of Agric. Engg.; Pramot Kammueng, Former Graduate Student; V.M. Salokhe, Visiting Faculty Member, Agric. and Food Engg. Div., Asian Institute of Technology, Bangkok, Thailand

During 1984, 245 farmers were interviewed to collect information on energy input and output for the production of five major crops in eight provinces in three geographic regions of Thailand. According to major source of power for tillage operations these farmers were classified into three categories, namely, animal, power tiller and tractor farmers. Energy from human, animal and mechanical sources used in performing all field operations from land preparation to harvesting (including threshing) and material inputs, i.e., seeds, fertilizers and chemicals, were included in energy inputs. Energy output was accounted in terms of crop yields.

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Universities & Colleges

Department of Agricultural Engineering, Faculty of Agriculture, Hokkaido University — Nishi 9, Kita 9, Kita-ku, Sapporo City, 060. Tel. 011-716-2111

Department of Agricultural Engineering, Faculty of Agriculture and Veterinary Medicine, Obihiro University of Agriculture and Veterinary Medicine — Nishi 2-11, Inada-cho, Obihiro City, 080. Tel. 0155-48-5111

Department of Dairy Science, Faculty of Dairy Science, Rakuno Gakuen University — 582, Midori-cho, Bunkyodai, Ebetsu City, 069. Tel. 011-386-1112

Course of Agricultural Machinery, Hokkaido Junior College, Senshu University — 160-1, Bibai, Bibai City, 079-01. Tel. 1266-3-4321

Department of Agricultural Engineering, Faculty of Agriculture, Hirosaki University — 3, Bunkyo-cho, Hirosaki City, 036. Tel. 0172-36-2111

Faculty of Engineering for Animal Husbandry, School of Veterinary Medicine and Animal Sciences, Kitasato University — Sanbongi, Towada City, 034. Tel. 0176-23-4371

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Department of Agricultural Engineering, Faculty of Agriculture, Utsunomiya University — 350, Mine-machi, Utsunomiya City, 321. Tel. 0286-36-1515

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Department of Agriculture and Forest Sciences, Faculty of Agriculture, Miyazaki University — Nishi 1-1, Kibanadai, Gakuen, Miyazaki City, 889-21. Tel. 0985-58-2811

Department of Agricultural Engineering, Faculty of Agriculture, Kagoshima University — 1-21-24, Korimoto, Kagoshima City, 890. Tel. 0992-54-7145

Department of Agricultural Engineering, College of Agriculture, University of the Ryukyus — 1, Senbaru, Nishihara-cho, Chuto-gun, 903-01. Tel. 09889-5-2221

National Research & Experimental Agencies

National Agriculture Research Center — 3-1-1, Kannondai, Tsukuba City, 305. Tel. 02975-6-8481

National Institute of Animal Industry — 2, Ikenodai, Kukisaki-cho, Inashiki-gun, 305. Tel. 02975-6-8600

National Grassland Research Institute 768 — Senbonmatsu, Nishinasuno-cho, Nasu-gun, 329-27. Tel. 0287-36-0111

Vegetable and Tea Research Institute — 360, Kusawa, Anou-cho, Age-gun, 514-23. Tel. 05926-8-1311

National Institute of Sericultural and Entomological Science — 1-2, Owashi, Tsukuba City, 305. Tel. 02975-6-6026

Tropical Agriculture Research Center — 1-2, Owashi, Tsukuba City, 305. Tel. 0298-38-6313

Forestry and Forest Products Research Institute — Matsunosato 1, Kukisaki-cho, Inashiki-gun, 305. Tel. 0298-73-3211

Hokkaido National Agricultural Experiment Station — Hitsujigaoka 1, Toyohira-ku, Sapporo City, 061-01. Tel. 011-851-9141

Tohoku National Agricultural Experiment Station — Akahira 4, Shimo-Kuriyagawa, Morioka City. Tel. 0196-41-2145

Hokuriku National Agricultural Experiment Station — 1-2-1, Inada, Joetsu City, 943-01. Tel. 0255-23-4131

Chugoku National Agricultural Experiment Station — 6-12-1, Nishifukatsu-cho, Fukuyama City, 721. Tel. 0849-23-4100

Shikoku National Agricultural Experiment Station — 1-3-1, Senyu-cho, Zentsuji City, 765. Tel. 0877-62-0800

Kyushu National Agricultural Experiment Station — 496, Izumi, Chikugo City, 833. Tel. 0942-52-3101

Bio-oriented Technology Research Advancement Institution — 1-40-2, Nisshin-cho, Omiya City, 331. Tel. 048-663-3901

Public Research & Experimental Agencies

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Hokkaido Prefectural Tokachi Agricultural Experiment Station — 2, Minami 9-sen, Shinsei, Memuro-cho, Kasai-gun, 082. Tel. 0155-62-2431

Aomori Agricultural Experiment Station — 1-1, Sakaimatsu, Kuroishi City, 036-03. Tel. 0172-52-4311

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Miyagi Prefectural Agricultural Research Center — Higashikongouji 1, Kawakami, Takadate, Natori city, 981-12. Tel. 022-382-0121

Akita Agricultural Experiment Station — 111, Konakajima, Niida, Akita city, 010-14. Tel. 0188-39-2121

Yamagata Prefectural Agricultural Experiment Station — 6060-27, Minorigaoka, Yamagata City, 990-02. Tel. 0236-44-5571

Fukushima Prefecture Agricultural Experiment Station — Wakamiyamae 20, Tomita-machi, Kohriyama City, 963. Tel. 0249-32-3020

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Tochigi Prefectural Agricultural Experiment Station — 1080, Kawaraya-cho, Utsunomiya City, 320. Tel. 0286-65-1241

Gunma Agricultural Research Center — 1251, Egi-machi, Maebashi City, 371. Tel. 0272--69-9121

Saitama Agricultural Experiment Station — 1372, Kubojima, Kumagaya City, 360. Tel. 0485-21-5041

Chiba Prefectural Agricultural Experiment Station — 808, Daizenno-cho, Chiba City, 280-12. Tel. 0472-91-0151

Agricultural Research Institute of Kanagawa Prefecture — 496, Teradanawa, Hiratsuka City, 259-12. Tel. 0463-58-0333

Niigata Agricultural Experiment Station — 857, Nagakura-cho, Nagaoka City, 940. Tel. 0258-35-0047

Toyama Agricultural Research Center — 1124-1, Yoshioka, Toyama City, 939. Tel. 0764-29-2111

Ishikawa Agricultural Experiment Station — Bo 295-1, Saida-cho, Kanazawa City, 920-01. Tel. 0762-57-6911

Fukui Agricultural Experiment Station — 52-21, Henguri, Ryo-machi, Fukui City, 910. Tel. 0776-54-5100

Nagano Agricultural Research Center — 492, Ogawara, Suzaka City, 382. Tel. 0262-46-2411

Gifu Prefectural Agricultural Research Center — 729, Matamaru, Gifu City, 501-11. Tel. 0582-39-3131

Shizuoka Agricultural Experiment Station — 678-1, Tomigaoka, Toyoda-cho, Iwata-gun, 438. Tel. 0538-35-7211

Aichi-ken Agricultural Research Center — 1-1, Sangamine, Yazako, Nagakute-cho, Aichi-gun, 480-11. Tel. 05616-2-0085

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Shiga Prefectural Agricultural Experiment Station — 516, Dainaka, Azuchi-cho, Gamou-gun, 521-13. Tel. 0748-46-3081

Kyoto Prefectural Research Institute of Agriculture — Wakunari 9, Amarube-cho, Kameoka City, 621. Tel. 07712-2-0424

Osaka Agricultural Research Center — 442, Shakudo, Habikino City, 583. Tel. 0729-58-6551

Hyogo Prefectural Agricultural Institute — Kou 1533, Minaminooka, Befu-cho, Kasai City, 679-01. Tel. 07904-7-1117

Nara Prefectural Agricultural Experiment Station — 88, Shijo-cho, Kashihara City, 634. Tel. 07442-2-6201

Tottori Agricultural Experiment Station — 260, Hashimoto, Tottori City, 680-11. Tel. 0857-53-0721

Shimane Agricultural Experiment Station — 2440, Ashiwata-cho, Izumo City, 693. Tel. 0853-22-6650

Okayama Prefectural Agricultural Experiment Station — 1174-1, Kouda oki, Sanyou-cho, Akaiwa-gun, 709-08. Tel. 08695-5-0271

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Kochi Prefectural Institute of Agricultural and Forest Science — 2874-4, Hakawa, Ino-cho, Agawa-gun. Tel. 0888-93-0421

Fukuoka Agricultural Research Center — 587, Yoshiki, Chikushino City, 818. Tel. 092-924-2936

Saga Agricultural Experiment Station — Nanri, Kawazoe-cho, Saga-gun, 840-23. Tel. 0952-45-2141

Nagasaki Agricultural and Forestry Experiment Station — 3118, Kaizu-cho, Isahaya City, 854. Tel. 0957-26-3330

Kumamoto Prefectural Agricultural Research Center — 3801, Sakae, Koshi-cho, Kikuchi-gun, 861-11. Tel. 096-248-6444

Oita Prefectural Agricultural Research Center — 65, Kitausa, Usa City, 872-01. Tel. 0978-37-1141

Miyazaki Agricultural Experiment Station — 5851, Minemae, Shimonaka, Sadowara-cho, Miyazaki-gun, 880-02. Tel. 0985-73-2121

Kagoshima Agricultural Experiment Station — 4938, Hosoyamada, Kushira-cho, Kimotsuki-gun, 893-16. Tel. 0994-62-2001

Okinawa Prefectural Agricultural Experiment Station — 4-222, Sakiyama-cho, Shuri, Naha City, 903. Tel. 0988-84-3415

SIMA 90 – 61st International Farm Machinery Show
March 4-11, 1990, Parc d'Exposition
Porte de Versailles Paris, France

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A data with tropical farming – Each year, a large tropical farming section at the SIMA entertains a considerable number of vistiros from Africa, Asia and Latin America. On display will be a wide range of equipment for improving farm productivity and profitability under conditions peculiar to tropical and subtropical regions.

For information contact:
SIMA
24, rue du Pont
92522 NEULLY-SUR-SEINE
Cedex France

MILAX 90 – Malaysian International Livestock, Agriculture and Technology Exhibition
October 9-12, 1990 at The Changkat Pavilion Kuala Lumpur, Malaysia

Agricultural production, which in 1988 accounted for 21.2% of Malaysia's GDP remains a cornerstone of the economy. This sector grew by 4.8% in 1988 and this growth is expected to be sustained as a result of the Government's commitment to improve public and private sector productivity.

The livestock industry has experienced healthy growth of 10% over the past 2 years as a result of increased production of beef, lamb, poultry and pork. The fishing industry in the meantime, has recently entered a new era with the increasing exploration of deep sea fishing and the rapid development of the fish farming sector.

Since the announcement of MILAX-90 – the Malaysian International Livestock, Agriculture and Food Technology Exhibition, companies from 18 countries have made bookings. These include those from Australia, Austria, Canada, Denmark, Italy, Japan, Hong Kong, Netherlands, Federal Republic of Germany, France, India, Thailand, Philippines, Sweden, Singapore, USA, U.K. and Malaysia – the host country. In addition, national groups participation are currently being planned. Over 250 companies are expected to display the latest technology for the agriculture, livestock and food production and processing industries when MILAX 90 is staged in Kuala Lumpur.

MILAX 90 will be held at a new venue – the Changkat Pavilion, to accommodate the features of livestock display and animal shows. The livestock display and animal show will occupy the adjoining hall. Co-ordinated by the Department of Veterinary Services, a wide range of livestock will be on display.

MILAX 90 will focus on the development of the livestock and poultry industry. In 1987, Malaysia's production of livestock totalled M$2 billion and contributed 3% to the GDP.

Impressive growth in the poultry and pig rearing sectors in recent years has made Malaysia self sufficient in chicken meat, eggs and pork with excess for export. Sheep production is targeted by the Ministry of Agriculture to reach one million by 1995. At the same time, milk collection will increase 8 fold from 11.5 million litres in 1987 to 85–90 million litres by the year 2000.

The Malaysian livestock sector will enter a new stage of development with its intensification of the livestock-plantation crop integration strategy.

For further information contact:
Overseas Exhibition Services Ltd
11 Manchester Square
London W1M 5AB, U.K.

Agriculture & Food Indonesia 90
The 5th Indonesian Agriculture and Food Production & Processing Exhibition
October 23-27, 1990, Jakarta, Indonesia

As Indonesia enters its fifth Five Year Development Plan (Repelita

V), agriculture is top of the Government priority list for investment and expansion. The Indonesian economy has recently experienced a dramatic upswing, and this is clearly reflected in the buoyancy of the agriculture and food processing sector. Just two illustrations of this strength are Indonesia's recently achieved self-sufficiency in rice production, and projected increase of 33% in rubber production by 1990.

The exhibit profile includes agricultural inputs of all kinds for crop production, irrigation and dairy and poultry livestock husbandry.

New at Agriculture & Food Indonesia 90 is machinery, equipment, materials and services for food production and processing.

For further information contact:
Agriculture & Food Indonesia 90
11 Manchester Square
London W1M 5AB U.K.

EIMA — International Exhibition of Agricultural Machinery Manufacturers
November 8-12, 1989, Bologna Fairgrounds, Bologna, Italy

EIMA is ideologically aiming towards the next twenty years to come which will go beyond the year 2000. It will further qualify its specialization and will be increasingly more diversified in order to answer in advance the emerging needs of its exhibitors and visitors.

This is the underlying inspiration for ZOOTECH, the new exhibition dedicated to the mechanization for animal raising which will take place on the Modena Fairgrounds; this represents a significant commitment for UNACOMA which, in collaboration with ANCOZOO, will organize this zootechnical sector of EIMA. ZOOTECH offers an ulterior opportunity for those industries operating in the sector of mechanical technologies for zootechnics, as well as a specialized exhibit for visitors, Italian and foreign operators and those who raise cattle, sheep, swine, poultry and rabbits, who will be able to find, in an exposition area dedicated exclusively to zootechnical themes, the best solution for the diverse problems of stock raising. Thus XX EIMA has added another attraction with ZOOTECH and begins with an innovative step its next twenty years of activity.

EIMA '89 is an occasion for meeting and debates on the past twenty years of mechanization in technical, economic and social terms and on prospects for the future. UNACOMA will again offer its initiative of a competition for new technical developments reserved for EIMA exhibitors which has always been a successful event in the past editions.

Massey-Ferguson Tractor Purchase Credit Facility for Uganda Farmers

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"The issuing of credit implies there must be trust. The development of trust implies confidence." So said one of Uganda's women members of President Yoweri Museveni's cabinet, Victoria Sekitoleko – the country's Agriculture Minister. Her significant words were said at a ceremony near the northwestern town of Masindi to several hundred farmers who received the keys for a fleet of new Massey-Ferguson MF 365 tractors.

The occasion represented, for the first time under Museveni's new government of reconciliation, the offer of a revolving credit facility

by a commercial bank to Ugandan farmers to buy tractors and farm implements. Victoria Sekitoleko's ministry was the initiator of the scheme working closely with Barclays and Akamba (Uganda) Limited, the Massey-Ferguson distributor in the country.

Barclays' Edred Bowman told the farmers the bank was providing a facility totalling US$75 000 (Uganda Shillings 150 million) to small scale farmers specifically on an informal pay back system organized by the bank with identifiable farmers groups. "The quicker the tractors are paid back the quicker the revolving credit can be used for farmers groups in other parts of Uganda", Mr. Bowman told the audience, the project was dependent on the availability of a tractor supplier who could guarantee field service and parts supply, said Mrs. Sekitoleko.

The Minister explained to farmers that Akamba (Uganda) Limited had met this requirement, not only as a result of its fast developing sales, parts and service facility at its Kampala operational base, but also as it had invested in fully equipped mobile service units capable of providing on the spot help to farmers.

Akamba's mobile truck units represent an investment equivalent to US$160 000. Each is equipped with a three man technical crew experienced in engine and gear box repair, electronics and hydraulics. ■■

Engine and Tractor Power (U.S.A.)

By Carroll E. Goering

Students in colleges of agriculture and other students with an interest in engines and motor vehicles are the primary audience for whom this textbook was written. Although the primary focus is on farm tractors, many of the concepts in the book also apply to automobiles, trucks, self-propelled combines, and other vehicles.

Engines and vehicles merit study because they have transformed society. In early American society, it was necessary for nearly everyone to live on farms to produce food and fiber. The mechanization provided by farm tractors gives modern U.S. farmers the ability to grow food and fiber for many people, so that less than 5% of the current population are farmers. The remainder are free to enter industry or become doctors, lawyers, astronauts, and so forth. At the same time, the automobile has given people freedom to travel easily across the length and breadth of the country. In contrast, most of the population in less developed countries must live on the land to produce food, and transportation usually is primitive.

The purpose of the book is illuminate the principles of construction, operation, and maintenance of engines and tractors. Mathematical equations and problems often provide the best means to illuminate such principles, but the mathematics here is at a level that is accessible to the nonengineer. A prerequisite course in algebra is assumed. A course in physics also would be helpful, but is not essential.

Size: 24 x 15 cm, Pp 404, Hardbound

Price: U.S.$34.50

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

Knowledge Engineering in Agriculture (U.S.A.)

edited by J.R. Barrett and D.D. Jones.

Knowledge is the capital of the future learned from the experiences of the past! This book can help you develop the technologies for using knowledge as a strategic resource for greater competitiveness within agriculture. Throughout agriculture, the drive for more efficient production, harvesting and processing has become of major concern. Artificial Intelligence (AI) offers unprecedented promise to help manage knowledge to improve efficiencies. Much can be accomplished through better engineering of knowledge.

The uniqueness of knowledge engineering comes out of AI. *Artificial* means that the processes occur within the computer rather than within a human mind, and *Intelligence* means that there is capacity to apprehend facts and propositions, and to reason and infer from established information and descriptions of relationships.

American agriculture faces continuing problems in the next, and last, decade of the 20th century. Agriculture faces a serious financial squeeze in addition to traditional problems related to markets, weather and environmental protection, that is not likely to be easily alleviated. This book is dedicated to helping to solve agriculture's ill-structured problems.

Preparation of this book was entirely through electronic media. The first drafts were written on computers and submitted via disks or electronic mail. Editing and assembly was accomplished using Purdue's VAX™/Sun™ workstation environment, with the help of a few PC's. The figures were prepared from sketches and the illustrations drawn electronically. The camera-ready text was prepared using UNIX™, TROFF™, AutoCAD™, Germlin and Writer's Work Bench. There was no cut-and-pasting or white-outing.

The equivalent of peer review was accomplished. Each author critically reviewed two chapters other than their own and their suggestions were included to the extent that three chapters were required to be completely rewritten. Technical editing was done both by a retired Technical Editor of the American Society of Agricultural Engineers, and by a retired Area Director of the Agricultural Research Service, USDA.

Size: 23 x 15 cm, Pp 214, Hardcover

Price: U.S.$43.00

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

Dictionary of Technology Promotion Institutions in Asia & the Pacific (India)

The main objective of the Asian and Pacific Centre for Transfer of Technology (APCTT) is to assist the developing countries of Asia and the Pacific in strengthening the capabilities to develop, transfer, adapt and apply technology.

Through the programmes supported by UNDP, APCTT has evolved and tested various mechanisms for technology transfer, which have been successfully adopted by many national institutions. Presently, APCTT is testing the feasibility of creating a network of relevant institutions in the Asian and Pacific region.

The "Directory of Technology Promotion Institutions in Asia and the Pacific" is one of the efforts to facilitate the promotion of technology utilization and information networking in the region. It is hoped that the Directory, besides serving as a reference material, will also promote useful and effective interaction among the technology promotion institutions, enterprises and entrepreneurs, thus ultimately contribute to enhancing technical co-operation in this field among the developing countries of the region.

Size: 24.5 x 17 cm, Pp 356, Paper cover

Published by UN-ESCAP, Asian & Pacific Centre for Transfer of Technology, 49 Palace Road, Bangalore 560 052, India

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Theory, Construction and Calculations of Agricultural Machines Vol. 1
(Russian Translations Series 66)
(Netherlands)

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by Bosoi, Verniaev, Smirnov, Sultan-Shakh

The book presents technological and agronomic requirements of operations performed by machines and units. The technical data for these machines are also given. The theory, construction and calculations of machines and implements are discussed in relation to soil working, harvesting cereal crops, root crops and grasses and post harvest treatment of grains. Great attention is paid to the theory of tillage tools and soil cutting with blades suited to different soil-climatic zones.

The second edition (the first published in 1951) has been radically revised keeping in view the new course program and supplemented with material on the principles of designing farm machinery. The book is illustrated with examples of modern farm machines.

Contents: General information. Technological process of plowing. Plows for primary and special cultivation. Working tools of moldboard plows. Lifting and adjusting mechanisms of plows. Forces acting on the plow and their effects of plow balance. Draft of plows. Disk plows and disk harrows. Machines and implements for cultivation, grading and compacting of soil. Cultivators. Machines with powered working tools. Machines to combat wind erosion. Combined soil – working and sowing machines. General. Machines for sowing. Machines for application of fertilizers in the soil. Planting and transplanting machines.

Size: 23.5 x 15 cm, Pp 314, cloth-bound

Price: Hfl.100.—

Published by: A.A. BALKEMA Publishers, P.O.Box 1675, 3000 BR Rotterdam, Netherlands

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Computer Modelling in Agricultural Mechanization
(Ireland)

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by Shane M. Ward

The main objective of this book is to provide an introduction to the use of computers in the modelling of agricultural mechanization systems. This is particularly important in view of the fact that mechanization systems are the largest items of capital investment on many farms, with total investment costs exceeding IR£100,000, in many cases. While, in the past, computer modelling has been somewhat removed from practical on-farm applications, recent developments in computer technology (particularly in microcomputers) have made it possible for agricultural advisers, and indeed farmers, to obtain access to a computer. The potential of this new technology is vast and has a major role to play in the advancement of agricultural technology and management practices.

This book illustrates the development of computer-based model of silage mechanization systems; but the approach adopted is generalized and can be applied, equally well, to other agricultural mechanization systems. It was specifically avoided to introducing complex concepts in modelling theory but, rather, have structured the content of the book in a format that can be readily understood by a person with no previous knowledge of systems modelling or computer programming.

Size: 21 x 15 cm, Pp 110, paper cover

Published by Boole Press Limited. P.O. Box 5, 51 Sandycove Road Dun Laoghaire Co. Dublin, Ireland

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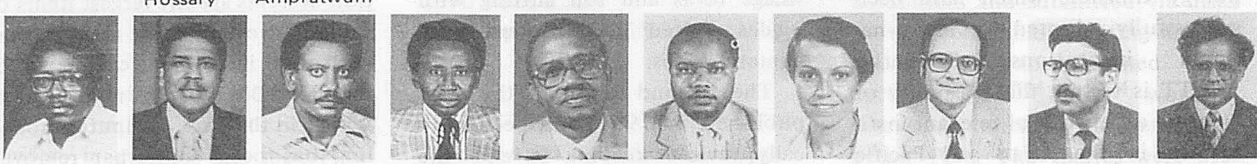

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AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA (Vol. 20, No. 4, Autumn 1989)

(Continued from page 115)

ABSTRACTS

For rice production the energy input on tractor farms in North and Central region was 4 033 and 4 217 kWh/ha, respectively, compared to 3 019 and 2 490 kWh/ha in the same regions on power tiller farms. The highest energy output/input ratio for rice production was 14.2 on tractor farms in North-east region, while the lowest was 2.9 only on tractor farms in Central region. For maize production the energy input on power tiller farms in North region was only 300 kWh/ha which was much less than the energy input on other farms in various regions. For maize production the highest energy output/input ratio was 11.5 on power tiller farms in North region and the lowest ratio was 6.6 on tractor farms in the Central region. Compared to rice and maize production, the energy ratios for sugarcane production was very small varying from 3.3 to 4.6 due to greater energy input requirement in the form of farm machinery, fuel and chemical fertilizer and seeds. Due to greater manure and nitrogen applied in Northeast region the energy input for cassava production was very high compared to North and Central region. The energy ratio in the Northeast region was only 1.8 compared to 6.2 and 5.9 in North and Central region, respectively. For cotton production the energy inputs and outputs for North and Northeast regions did not vary much. The average energy ratios on tractor farms for rice, maize and sugarcane found in this study were also compared with the energy ratios obtained in some other countries.

Traffic Compaction and Tillage Effects on the Performance of Maize (Zea mays L.) in Sandy Loam Soil of Nigeria: K.C. Oni, Dept. of Agric. Engg., Univ. of Illorin, P.M.B. 1515, Illorin, Nigeria

The effects of repeated traffic of a 45-kW agricultural tractor on a maize cropped farm land subjected to different tillage treatments were investigated. Experimental design comprised three tractor passes, 0, 5 and 10, and, five tillage methods, disk ploughing followed by disk harrowing (DPH), deep strip tilling (STD), shallow strip tilling (STS), paraploughing (PP) and no tillage (NT), respectively.

Results show that the soil dry bulk density increased with depth up to 10 cm soil depth and was significantly influenced by tillage methods and compaction levels. Soil resistance to cone penetration increased with soil depth and was higher for no tillage (NT) than other tillage methods for all compaction levels. Root length density varied exponentially with soil depth and showed a greater root exploration at shallow depth than at greater depth. Its effect was significant at $P \leqq 0.05$.

The effects of depth of seed placement, seedling emergence, plant height and kernel yield of maize were not statistically significant at $P \leqq 0.05$ for all tillage methods and all compaction levels.

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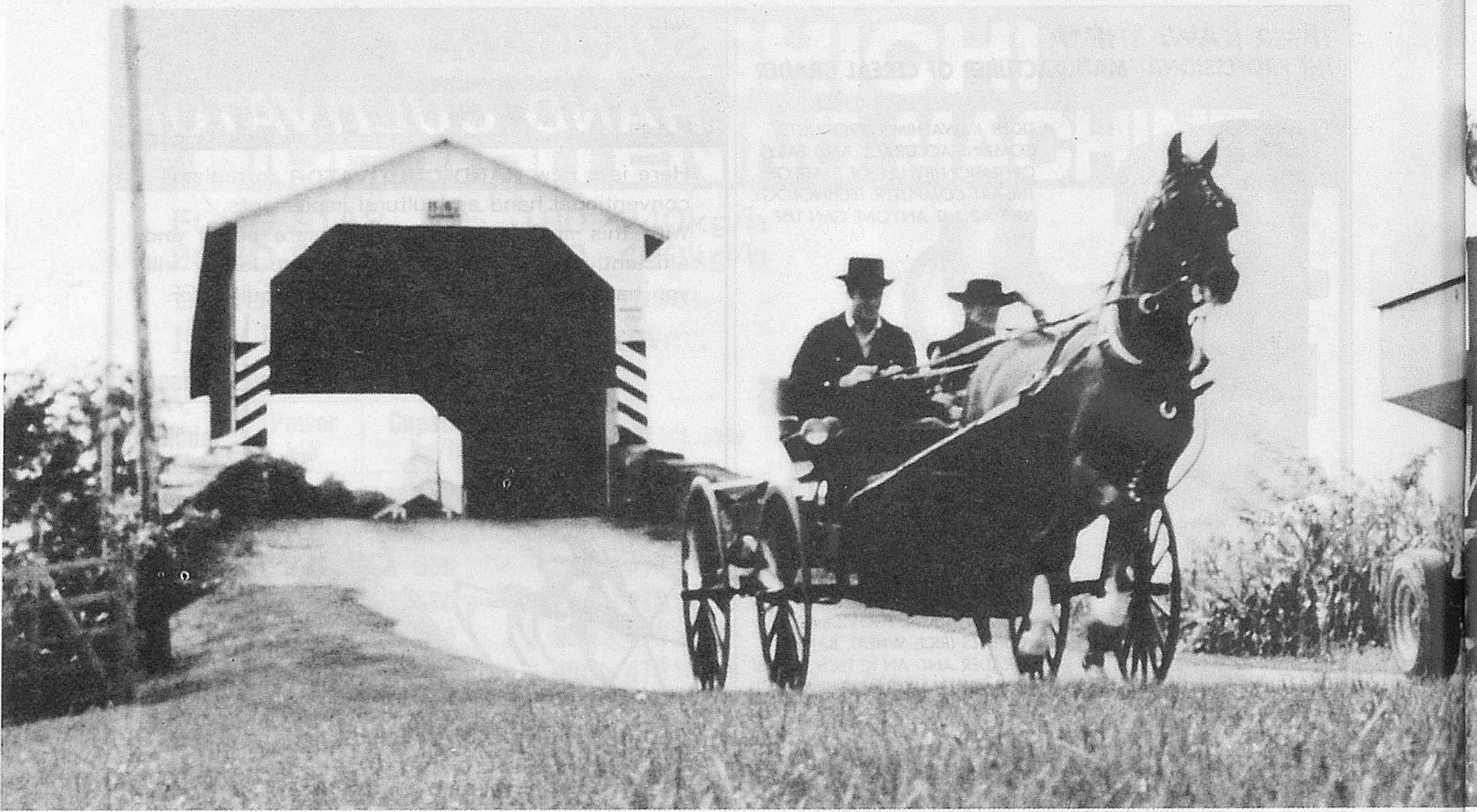

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