International specialized media for agricultural mechanization in Asian developing countries.

AMA

AGRICULTURAL MECHANIZATION IN ASIA

VOL. VIII, NO. 3, SUMMER 1977

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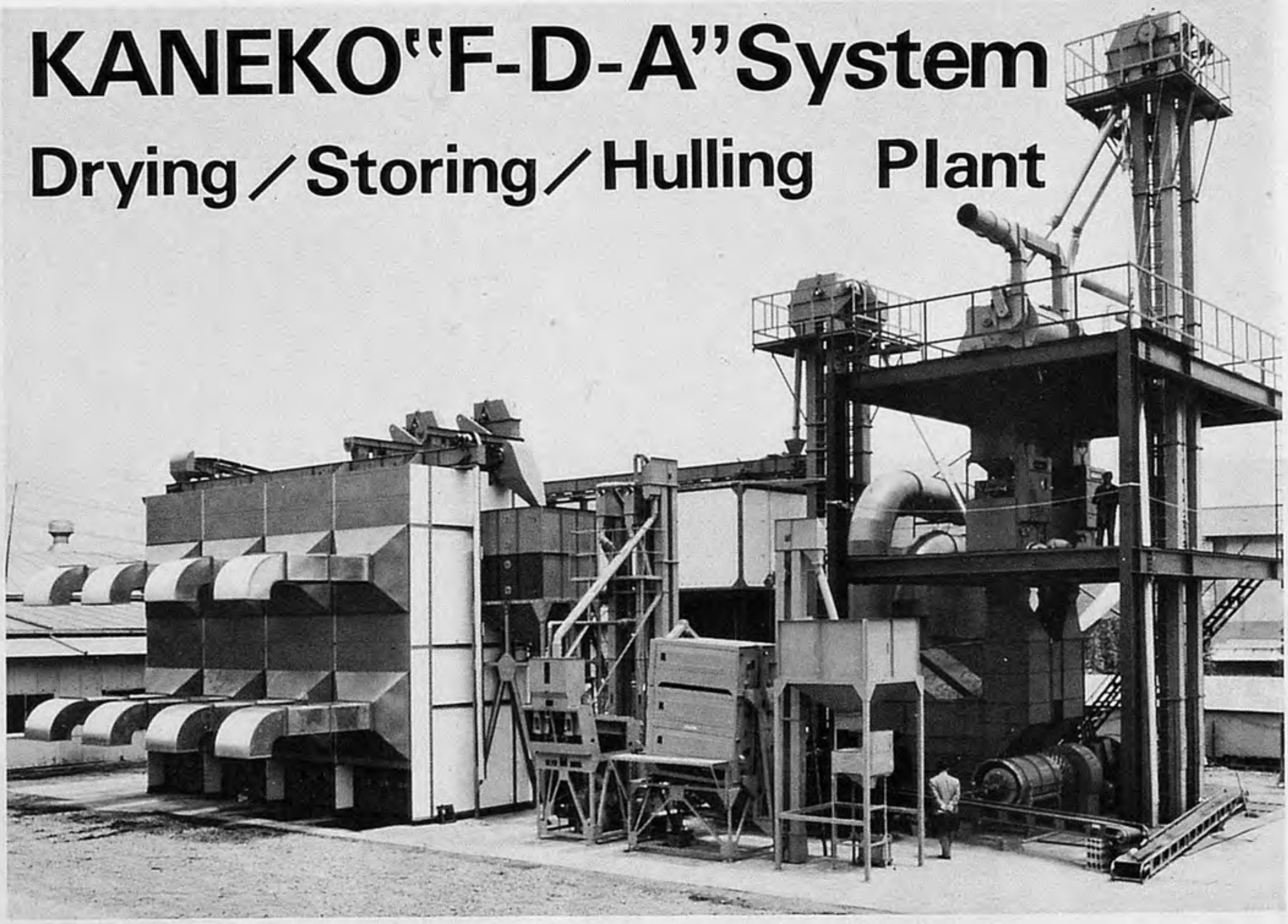

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In this stage, it exhibits the optimum function in continuous drying and simultaneous rough-separating.
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Thus, drying is completed easily and effectively in the "F-D-A" system with the KANEKO originated two-tier drying process employed.

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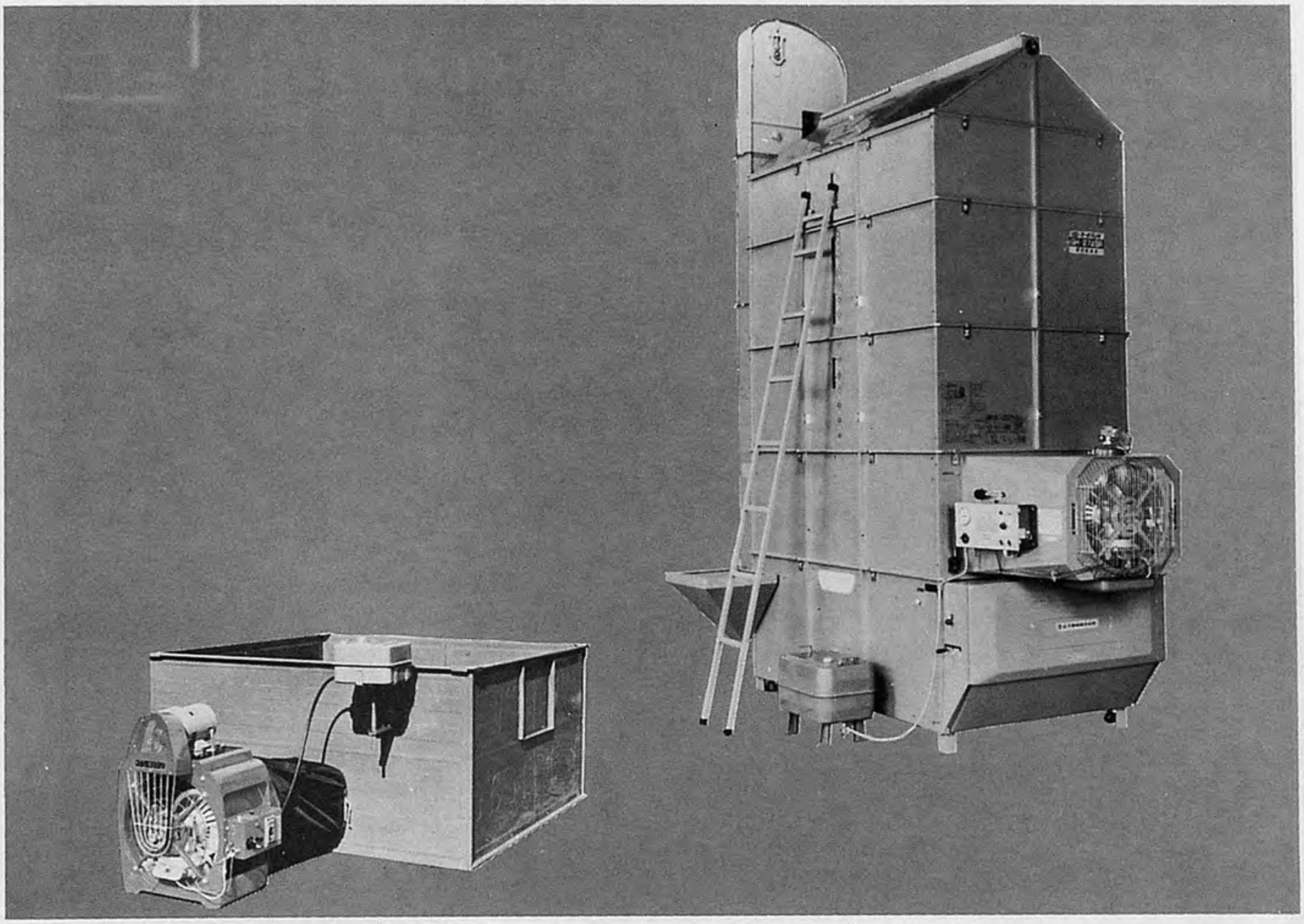

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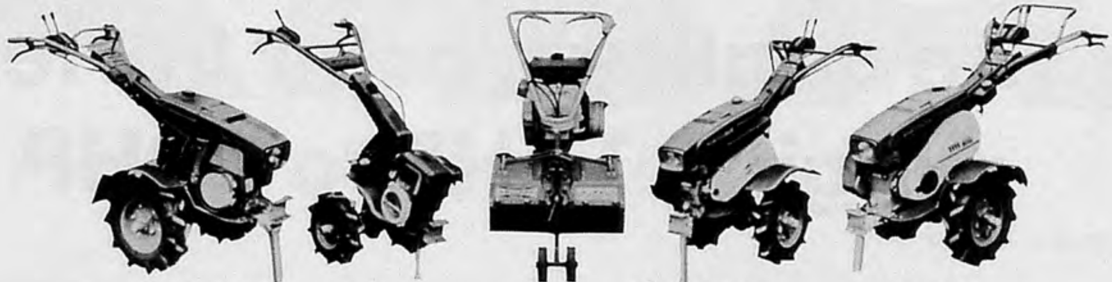

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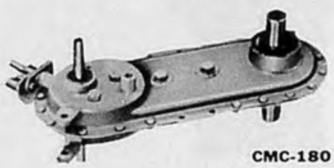
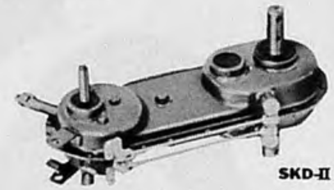
We believe you can find the satisfaction with MAMETORA AGRICULTURAL MACHINERY.
We have not only the tiller but also the transmission under oder.

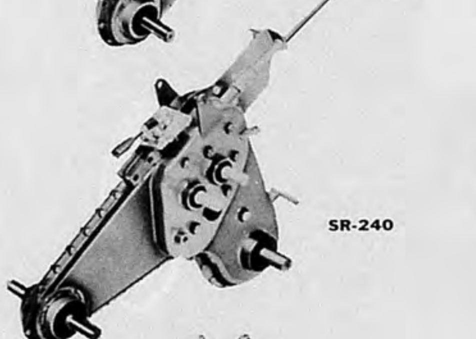
MRV3



CMC-180



SKD-II



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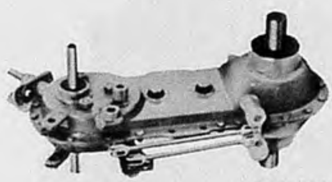

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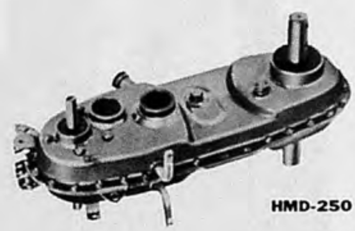
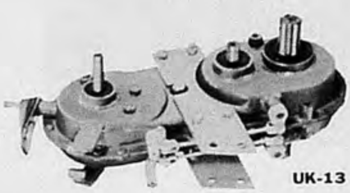


HMD-250



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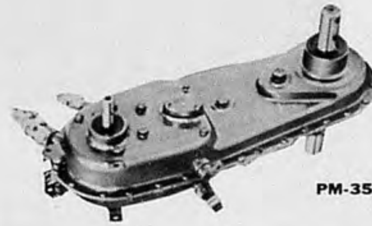

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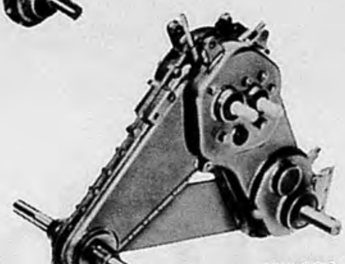

JAN-800

Model		MC-80	MCF-130K	CMC-180	DMC-180	DMC-II	SKD-18	SKD-II	SKD-III	HMD-250	PM-350	UK-13	MH-750	MT-40
Applications (PS)		1·8~2·5	2·0~3·5	3·0~4·5	3·0~4·5	3·0~4·5	3·0~4·5	4·5~6·0	4·5~6·0	5·0~7·0	6·0~8·0	3·0~4·5	3·0~4·5	3·0~4·5
Shifiting Stages		F1	F1, R1	F2, R1	F2, R1	F3, R1	F2, R1	F2, R1	F3, R1	F4, R2	F6, R2	F2, R1	F1, R2	F1, R2
Sidecluch		—	—	—	—	○	○	○	○	○	○	○	○	○ with Lock
Gear Ratios		F_1=1:21·71	F_1=1:18·16	F_1=1:25·41	F_1=1:25·41	F_1=1:41·31	F_1=1:21·21	F_1=1:31·06	F_1=1:66·07	F_1=1:70·03	F_1=1:53·97	F_1=1:32·13	F_1=1:25·54	F_1=1:37·62
			R_1=1:27·24	F_2=1:15·38	F_2=1:15·38	F_2=1:19·40	F_2=1:10·28	F_2=1:11·34	F_2=1:18·96	F_2=1:38·73	F_2=1:37·41	F_2=1:16·92	R_2=1:29·37	R_1=1:32·83
				R_1=1:35·58	R_1=1:35·58	F_3=1: 9·35	R_1=1:21·33	F_1=1:44·52	F_3=1:11·43	F_3=1:15·81	F_3=1:18·50	R_1=1:32·77	R_1=1:20·22	R_2=1:10·69
						R_1=1:49·91			R_1=1:81·09	F_4=1: 8·74	F_4=1:19·42			
										R_1 1:105·04	F_5=1:13·47			
										R_2 1:23·71	F_6=1: 6·66			
										:	R_1=1:66·67			
											R_2=1:24·0			
Dimensions	A	170	170	170	170	202	192	192	224	234	243·5	192	192	192
	B	434	434	434	435·5	532	492	492	545	578·5	603 3	467	467	467
	C	289·5	289·5	289·5	289·5	344·7	336·75	336·75	336·75	319·7	402·5	409·9	287	287
	D	15	15	15	15	16	16	17	19	19	19	16	16	16
	E	31	31	31	31	31	31	31	31	34·5	34·5	31	31	31

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AGRICULTURAL MECHANIZATION IN ASIA

VOL. VIII, NO. 3, SUMMER 1977

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Preface

Recently, I received a copy of "Space Settlements" —A Design Study—, from NASA, USA. This is a report on the study of human beings' living in space. I also obtained "War on Hunger" by USAID. Comparing these two publications, I was shocked to know the fact that there is a large gap between the space planning of agriculture in the former book and the starvation actually existing in the world, dealt with in the latter one.

The problem of starvation has not been solved in the long history of human beings. But I wish that the problem will have completely been solved when a space era comes. I think it is farm mechanization in developing countries we are involved in, that becomes a key to the history of human beings. By spreading more farm machinery in developing countries easily manufactured, sold and used, we can make it possible to double at least, the present productivity of agriculture. In other words, it means, a mass release of farm population that occupies more than 70% in the entire population, at present. The population released by mechanization can be committed to a various kind of possiblity of human beings. Without this revolution, our dream of living in space will never come ture.

From this point of vew, I do not think the report by NASA has nothing to do with our work. However, the most urgent problem to be solved immediately is the starvation and malnutrition in developing countries. I believe that the world is going to be better by effort of many people.

We would appreciate your cooperation and help to AMA to fill in the gaps in communication in order to promote the farm mechanization in developing countries, furthermore.

July, 1977

Chief Editor

Yoshisuke Kishida

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AGRICULTURAL MECHANIZATION IN ASIA

Vol. VIII, No. 3, Summer, 1977

New Power Tiller Developments at The International Rice Research Institute

by
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Manager,
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Taxila, Pakistan.

The power tiller design and development work at IRRI is part of an overall program being undertaken to assist in the mechanization of small rice farms. Mechanization may be considered as the application of various sources of energy and appropriate mechanical equipment to improve crop production and processing. In Asia, most very small farms are adequately serviced by hand tools and animal draught equipment while the relatively large farms have access to tractors and other modern equipment. A sizable group of small farmers with farms of 2-10 hectares[1] are, however, largely without adequate sources of power to meet the increasing energy input requirements of modern rice culture. The objective of IRRI's power tiller development work is improvement in the power base for this group of farmers.

Japanese power tiller designs evolved from rotary tillers used for garden work in the Western World during the 1920s. The Japanese adapted them for rice mechanization.

Sakai[2] reported the introduction of rotary tillers began in Japan with the import of walking type garden tractors, e.g. the *Utilita* from the United States and the *Simar* from Switzerland (**fig.** 1). These machines were redesigned and tested thoroughly to meet local field conditions. In 1953, locally made hand tractors began to appear in Japan. One of the 1940-50 models is shown in **Figure** 2. Due to poor sealing against mud and water, their use was limited to shallow preparatory tillage and interrow cultivation. These early designs made little impact at the farm level.

The "Deeper Plowing-Higher Yield" campaign following World War 11 forced Japanese designers to improve existing machines. From 1953 to 1955 hand tractors with rotary cultivators were introduced for submerged field

(a) Silhouette of Simar (1921)

(b) Silhouette of Utilia (1921)

Fig.1

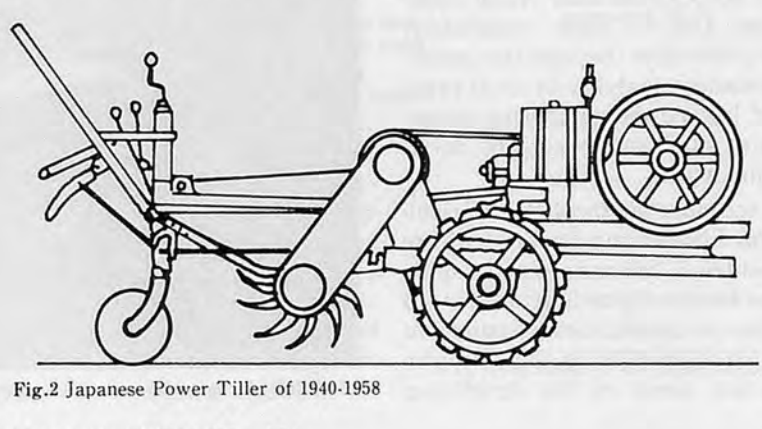

Fig.2 Japanese Power Tiller of 1940-1958

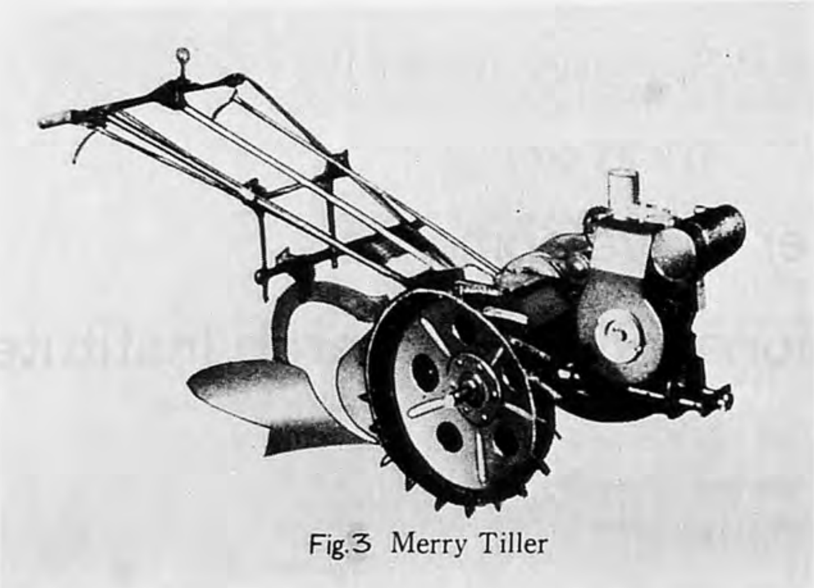

Fig.3 Merry Tiller

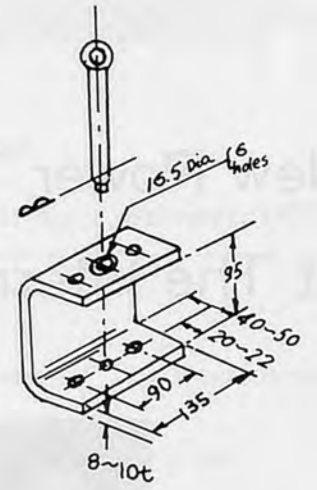

Fig.4 Power Tiller hitch point

operation.

In 1953 the Japanese imported a few 2.5 hp tiller from the United States under the "Merry Tiller" brand name (**Fig. 3**). Although this machine was not ideally suited to Japanese field conditions, the designers obtained many new ideas for improvement of their own machines, such as attaching animal farm tools, reversible Nippon ploughs, ridgers, racks, and small trailers. The Japanese standardized the hitch points for power tillers (**Fig. 4**), which enabled implement manufacturers to supply standard quality farm implements and make the machines more versatile.

The equipment developed in Japan is, in general, sophisticated and designed for light soils. These designs have limitations for adoption in other Asian countries. Due to their complexity, they are both beyond the manufacturing capability of local firms and beyond the purchasing capacity of small farmers in the developing world.

Activities in the IRRI Agricultural Engineering Department are oriented toward encouraging small-scale manufacturers to produce agricultural equipment which is specific to the rice production needs of the developing countries. Considerable emphasis has been given to land preparation equipment. A small 5-7 hp single axle, lightweight power tiller was developed and released by IRRI in 1972. The retail price of this locally producible design was almost 50 percent less than imported tillers in the same horsepower category (**Fig. 5**). After the release of the design, more than 2500 IRRI-designed power tiller were sold in the Philippines in 1973. This number was two and a half times greater than sales during the previous three years which were composed of the more sophisticated imported machines. More than 10,000 IRRI design power tillers were produced through 1976.

With the increasing cost of gasoline, IRRI has received numerous inquiries regarding the feasibility of using a diesel engine with the 5-7 hp power tiller. Accordingly, work to modify this tiller was initiated to allow use of 4-5 hp diesel engine as the power source.

Fig.5 IRRI 5-7 hp single axle Power Tiller

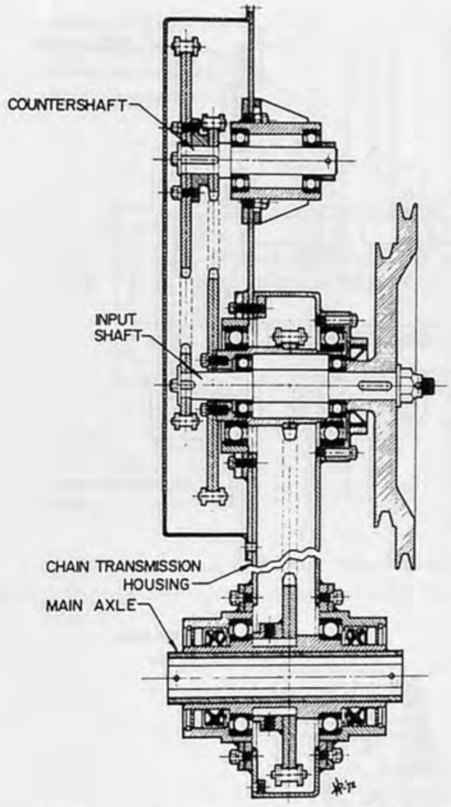

Fig.6 Schematic drawing of 5-7 hp. IRRI Power Tiller Transmission

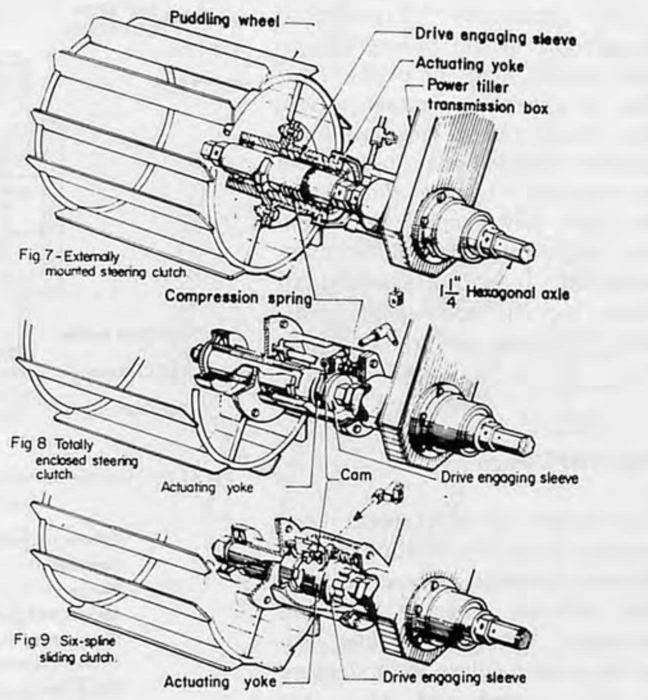

Fig.7 Externally mounted steering clutch (above). **Fig.8** Totally enclosed Steering clutch (middle). **Fig.9** Six-spline sliding clutch (below).

The weight of the diesel engine is three times that of the gasoline engine. There are problems in balancing the machine and in achieving mobility and maneuverability when used in flooded soils.

The present IRRI 5-7 tiller has a single axle on which the two ground wheels are mounted. The design configuration makes it difficult to install steering clutches except on the final drive axle (**fig.6**). Accordingly, an externally mounted steering clutch was designed in 1975 (**fig.7**). When this open clutch was operated under a completely submerged conditions, clogging with mud occurred, preventing proper functioning. A Totally enclosed steering clutch was subsequently designed (**figs. 8 & 9**). This type was difficult to disengage under loaded conditions due to the high torque on the final axle.

With the experience gained from these steering clutches, a new clutch was designed to further reduce the actuating force required to disengage the clutches (**fig. 10**). Although the disengaging mechanism functioned satisfactorily, problems were encountered with the durability of the materials used in the jaw clutch. Clutches were manufactured and heat treated from three different types of materials available in the local market:

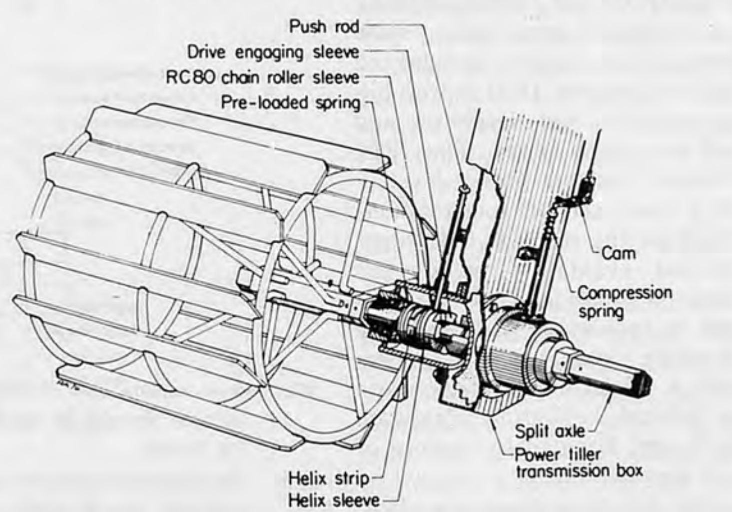

Fig.10 Enclosed helical steering clutch

a) ordinary steel with a surface hardness after carburizing of RC[a] 58-61

b) tool steel with a surface hardness of RC 58-61

c) low carbon alloy steel with a surface hardness after

[a] Unit of hardness in the Rockwell scale "C"

carburizing of RC 58-61 and a core hardness of RC 33-38

All materials experienced catastropic brittle failure due to high impact loads or plastic flow due to excessive contact stress. An analysis of these failures clearly indicated that installation of workable steering clutches at the final drive would be expensive, bulky, and beyond the manufacturing capability of small shops lacking goog heat treatment facilities and quality control.

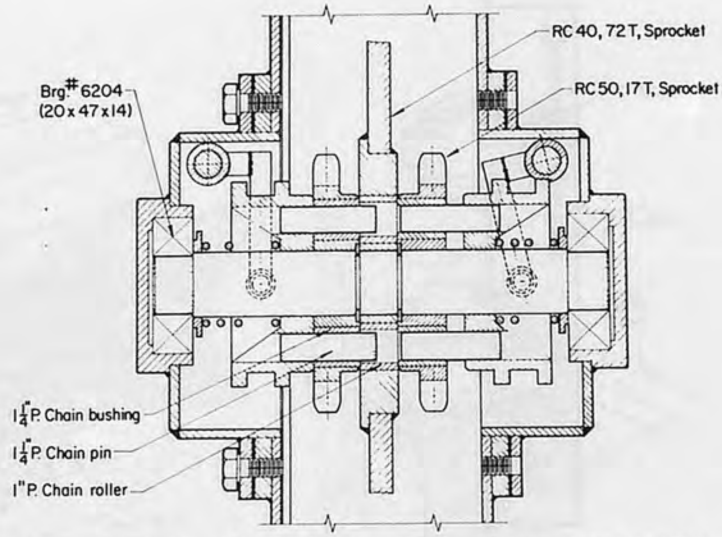

Fig.11 Cross-sectional view of IRRI 6-8 hp Power Tiller with pin steering clutches.

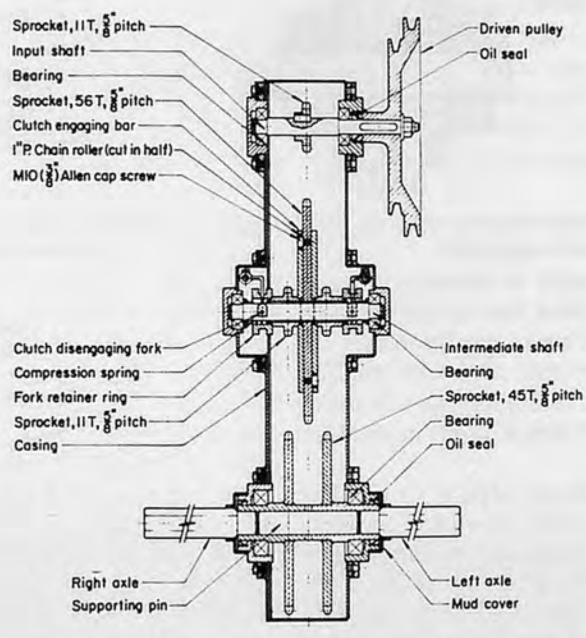

Fig.12 Cross-sectional view of IRRI 6-8 hp Power Tiller with steering clutches.

Improved Design

A review of IRRI farm level surveys from the Philippines indicated farmers desired a tiller that offered steering clutches. However, farmers owning imported power tillers with steering clutches complained that the clutches often failed and parts replacement was both expensive and difficult due to non-availability of repair parts. Also, some farmers and dealers commented that the existing IRRI power tiller design lacked durability and had too many parts. The IRRI Product Planning group developed a new set of specifications based on the surveys, field tests, internal evaluation work, and other information. Personal visits and a review of the available literature indicated that tillers with a 4-5 hp diesel engine were in demand in Burma, Pakistan, India, and Bangladesh because of high gasoline prices.

The following design specifications were initially prepared for the first prototype:

1. capable of accepting lightweight 4-5 hp diesel engine in addition to gasoline and kerosene engines
2. employ single-size chain and similar-sized sprockets in transmission
3. steering clutches should be optional
4. weight should be in 100-150 kg range
5. the machine should accept current tools and accessories
6. capable of upland and intercropping work with use rotary tools
7. retail price of about ₱5000[b] in the Philippines

Based on these specifications, a new single case power tiller was designed. The first prototype had a pin-type dog clutch which utilized readily available heat treated components (**fig. 11**). The pins used in the jaw clutches were standard RC-100 (1-1/4" pitch) chain pins which engage chain bushings of the same size. All parts were standard, factory hardened items. The first prototype used two sizes of sprockets and chains. A 13 tooth and 72 tooth sprocket set, with 1/2" pitch chain was used on the first reduction. The final reduction consisted of 17 tooth, and 45 tooth sprockets and a 5/8 inch

[b] Present exchange rate/US$ 1=₱.40.

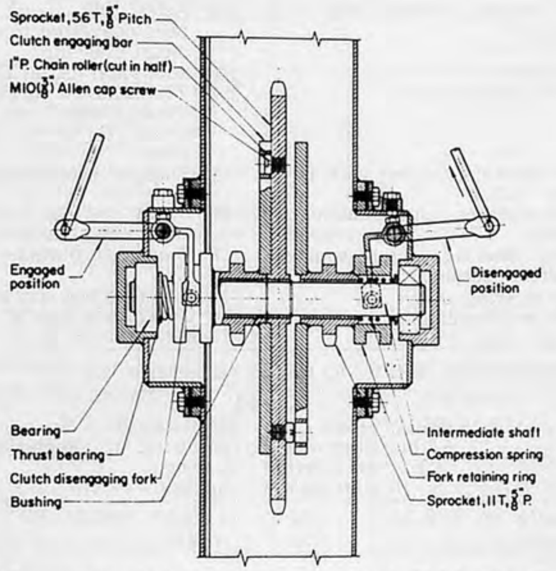

Fig.13 Cross-sectional view of steering clutches for 6-8 hp Power Tiller

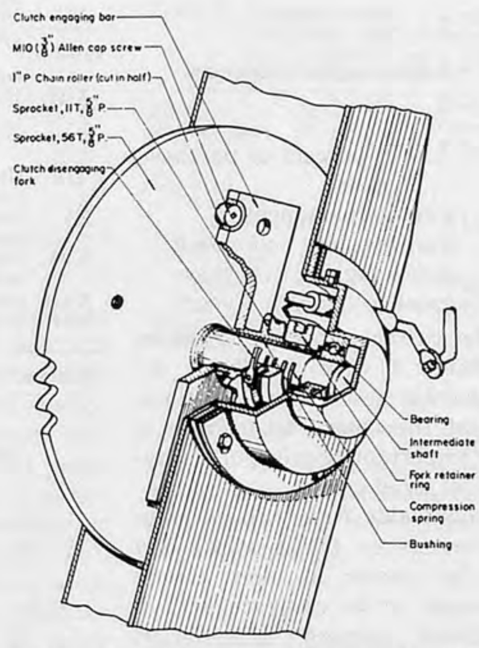

Fig.14 Cut-away view of steering clutches for 6-8 hp Power Tiller

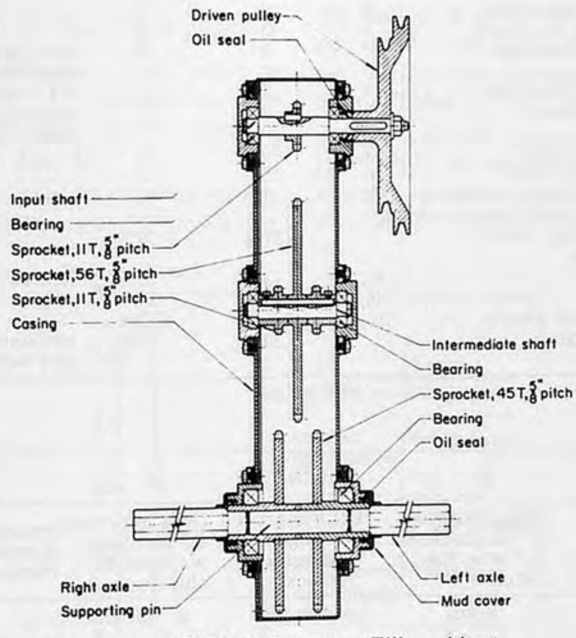

Fig.15 Cross-sectional view of IRRI 6-8 hp Power Tiller without steering clutches.

pitch chain.

The tractor was field tested for more than 100 hours inspected. No major defects were noted except for minor wear on the pins and bushings. This prototype served as the basis for the final design in which efforts were made to further reduce the number of component parts. The final design used identical size chain in the first and final reductions (**Fig.** 12). An improved "bar clutch" was designed which engages two M-10 Allen cap screws mounted on each side of the driven sprockets on the first reduction drive (**Figs. 13 & 14**).

For manufacturers wishing to produce the tiller without steering clutches, the same design and parts are used (**Fig. 15**) excluding the parts for the steering clutch mechanism. Six new power tiller prototypes have been built, four without and two with steering clutches for further tests and trials. Their disposition and status are shown in **Table 1.**

A comparison of the existing single-axle power tiller and the new design is given in **Table 2.** The new 6-8 hp unit with steering clutches has 28 percent fewer inventory items, is 14 percent lower in cost, and has a 72 percent higher horsepower rating.

Cost Comparison

Table 3 compares the costs of the improved IRRI power tiller with alternative models currently available in the market. Annual depreciation and other fixed costs for the power tillers are distributed over all field tasks for which the machine is used in the year.

The following assumptions were made in preparing the table.

1. Average depreciation per year (D)

$$D = \frac{P - d}{N}$$

P : Purchase price
d : Salvage value
N : Life in years

2. Annual interest cost (I)

$$I = \frac{(p + d)\, r}{2}$$

3. Annual repair expenses

$$R = \frac{p \times k}{N}$$

k : 45 percent of purchase price

4. Life of components
   - transmission : 8 years
   - diesel engine : 8 years
   - gasoline engine : 4 years

The variable cost items shown in **Table 3** were based on departmental test reports. Estimation of the annual usage rate is very important because of its impact on fixed costs.

From **Table 3** one can estimate the breakeven (B/E) work load for the farmer to meet annual payments or to compare with a computed annual depreciation ratio.

$$B/E = \frac{FC}{TR - VC}$$

FC : Fixed cost

TR : Total revenue

VC : Variable cost

Using the operating costs shown in **Table 3**, the breakeven point expressed in hours/days of annual operation can be calculated using a ₱14 per hour or ₱450 per hectare contract rate for power tillers in Laguna. Combined field operations of plowing

Table 1. Testing status of IRRI 6-8 hp power tillers.

Ser. No.	Description	Hours Tested	Remarks
PT1	Single axle 5-7 hp power tiller	76	Tested on dynamometer and intermediate shaft, bolts broken
XI	Tiller with pin type dog clutches with 5 hp diesel engine	120	Tested in the field
XII	Unit with steering clutches and 7 hp gasoline engine	100	After 100 hours field tests converted to 6.5 hp diesel tiller for
〃	with diesel engine	380	additional test at IRRI
XIII	Unit with steering clutches	250	Transmission tested on dynamometer and converted to 4.5 hp diesel tiller
XIV	Unit without steering clutches with 4.5 hp diesel engine	5	Shipped to Indonesia
XV	Unit without steering clutches with 7 hp gasoline engine	80	Under test at farmer's field in Bay region
XVI	Unit without steering clutch equipped with 6.5 hp diesel engine	8	Shipped to Burma
XVII	Unit without steering clutch	17	Damaged and scrapped
XVIII	Unit without steering clutch	220	Undergoing test at present time

Table 2. Comparison between IRRI 5-7 hp and 6-8 hp power tillers

Description	MODEL: IRRI 5-7 hp PT1	Single case tiller without steering clutches	Single case tiller with steering clutches	Remarks
Horsepower rating*	2.34	4.02	4.02	
Horsepower increase		+72%	+72%	
No. of repair parts				
a) throttle cable	1	1	1	
b) belt	1	1	1	
c) idler assy.	1	1	1	
d) chain size	3	1	1	
e) no. of sprockets	6	6	6	
f) size of sprockets	6	3	3	
g) no. of bearings	8	6	6	bearings are smaller than
h) size of bearings	4	2	2	PT1 model
i) no. of seals	3	3	3	seals are smaller than PT1 model
j) no. of bolts	102	70	72	
k) sizes of bolts	10	5	5	
l) transmission casings	2	1	1	
m) no. of repair parts reduction (inventory items)		−37%	−28%	
Weight (kg)				
Tiller	85	74	76	without engine
Wheels	36	36	36	
Diamater of wheels	510mm	660mm	660mm	
Cost reduction		−20%	−14%	without engine and implements

* Based on effective chain life of 2000 hours.

Table 3. Power tiller ownership and operational costs

Item	I	II	III	IV	V	VI
Designation	Imported 7-8 hp gasoline	IRRI 5-7 hp gasoline	IRRI improved 6-8 hp gasoline w/o steering clutches	IRRI improved 6-8 hp gasoline w/steering clutches	IRRI imported 4-5 hp diesel w/ steering clutches	Imported 4-5 hp diesel w/ steering clutches
Initial Cost (Pesos)[a]	15,175	8,975	8,000	8,250	10,097	17,025
Machine Life (years)	8	8	8	8	8	8
Field Capacity (hrs/ha)[b]	32	32	32	32	32	32
Annual Fixed Costs (Pesos)						
Depreciation[c]	1,707.19	1,009.69	900.45	928.13	1,135.88	1,915.30
Interest[d]	1,001.55	592.35	534.50	544.50	673.96	1,136.42
Tax & Insurance[e]	303.50	179.50	160.00	165.00	201.94	340.50
Repairs[f]	853.59	504.89	450.23	464.06	567.94	957.66
Total	3,865.83	2,286.43	2,045.00	2,101.69	2,579.72	4,349.88
Variable Costs (Pesos/hr)						
Fuel						
gasoline[g]	2.57	2.57	2.57	2.57	—	—
diesel[h]	—	—	—	—	0.49	0.49
Lubrication oil[i]	0.12	0.12	0.12	0.12	0.12	0.12
Wages[j]	3.00	3.00	3.00	3.00	3.00	3.00
Total	5.69	5.69	5.69	5.69	3.61	3.61

[a] Agricultural Engineering report for National Food & Agricultural Council (including additional engine cost to provide 8 year machine life).
[b] Agricultural Engineering Department Economic Survey & Field Test Reports.
[c] Salvage value at 10 percent.
[d] Interest rate at 12 percent.
[e] Tax & Insurance at 12 percent.
[f] Repair co-efficient at 45 percent to initial cost.
[g] Gasoline at pesos 1.43/lit.
[h] Diesel at pesos 1.16/lit.
[i] Lubrication oil at pesos 6/lit.
[j] Wages of two operators at pesos 12/day.

Table 4. Relationship between daily use and annual use breakeven (B/E)

Machine	Hours	Days	Hectares
Imported 7 hp gasoline power tiller	462	52	14.5
IRRI 5-7 hp gasoline power tiller	273	34	8.5
IRRI improved 6-8 hp gasoline power tiller w/o steering clutches	245	30.5	7.7
IRRI improved 6-8 hp gasoline power tiller w/ steering clutches	251	31.4	7.8
IRRI 4-5 hp diesel tiller w/ steering clutches	247	30.9	7.7
Imported 4-5 hp diesel tiller with steering clutches	416	52	13

and harrowing normally take 4 days or 32 hours per hectare.

Example :

B / E Power tiller I

$$= \frac{\text{P}3,865.83\ \text{F.C.}}{\text{₱}14.06/\text{hr T.R.} - \text{₱}5.69\ \text{V.C.}}$$

We can also calculate the necessary hectarage to cover depreciation by dividing the B/E hours by working hours per hectare. In the case of power tiller I, the result is:

$$\frac{461.73}{32} = 14.43 \text{ hectares annually}$$

The breakeven point using a similar set of calculations are shown for other power tillers in **Table 4** & **Fig. 16.**

We can see from the results that both the new IRRI 6-8 hp gasoline tiller without steering clutches and the diesel powered model with steering clutches have the minimum breakeven hours. The cost difference between diesel and gasoline powered units will be greater in countries where the cost of gasoline is three or four times higher than diesel fuel.

Land preparation costs with the water buffalo, using the current contract rate, are 25 pesos per day of 6 hours or 4.17 pesos per hour. The costs of operation per hectare are shown in **Table 5**. From **Table 5**, we can see the cost of animal plowing is less than with the power tiller. Harrowing, however, is less expensive with the tiller. However, the

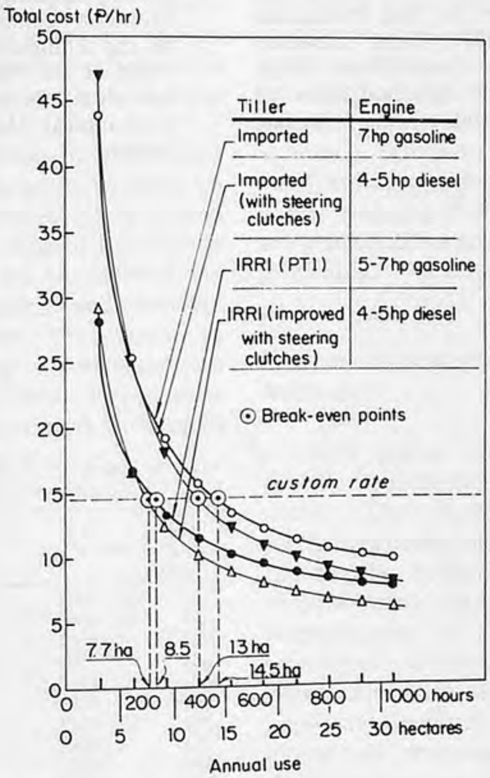

Fig.16 Relationship between total cost and annual use.

Table 5. Contract rates in Laguna for paddy land preparation by carabao and power tiller hectare (1976-77)[6]

Machine (Operation)	Rate ₱/hr	Mean Time Hour	Cost of Operation ₱/ha
Carabao			
Plowing (once)	₱4.17	35	₱146.00
Harrowing (9 to 13 passes)	₱4.17	83	₱346.00
		Total	P492.00
Power Tiller			
Plowing (once)	₱14.00	13	P182.00
Harrowing (3-4 times)	₱14.00	19	P266.00
		Total	P448.00

overall land preparation cost is lower with the tiller than with the water buffalo.

Summary and Conclusion

This report outlines the design and development efforts in producing a second generation IRRI power tiller. The first commercial design relesed in 1972 used a gasoline engine and a transmission system utilizing sprockets and chains which enabled local production at low cost. The sharp increases in fuel prices in recent years have caused a measurable change to diesel power for the prime mover. Farmers using the early IRRI power tiller experienced difficulty in maintaining and operating the machine resulting from a lack of durability and maneverability. These two major considerations led to the design of a new 6-8 hp tiller which accommodates a diesel engine and a simple set of steering clutches of novel design.

Encouraging results obtained from initial tests with the machine led to further development work and the final design is nearing formal release to interested manufacturers. A cost analysis of the machine shows that inspite of a higher horsepower rating the new transmission not only has fewer inventory parts but also has an estimated 14 percent lower manufacturing cost compared with the earlier designs.

An economic comparison of the improved model with the earlier IRRI and imported power tillers available in the Philippines has shown both lower total average costs and breakeven hours. The new model with its design simplicity, low cost, greater durability and maneuverability should find wide market acceptability and will add appreciably to IRRI's line of rice production machinery designs for the developing world.

For additional information and other programme activities the following offices may be contacted.

Agricultural Engineering Department, International Rice Research Institute, P.O. Box 933-Manila, Philippines.

IRRI-Pakistan Machinery Programme, C/O LAPSA, P.O.Box 1237, Islamabad, Pakistan.

IRRI-Thai Machinery Programme, P.O.Box 2453, Bang-Kok, Thailand.

FOOTNOTES

[1]Khan, A. U. & Policarpie, J. S., 1972, Mechanization Technology for Small Tropical Farms, IRRI Saturday Seminar, September 2nd.

[2]Sakai, J., , History of the Development and Classification of Japanese Power Tillers and Hand Tractor of Multipurpose Performance, Agricuitural Mechanization in Asia, Spring 1973 Publication.

[3]Nichols, F.E., 1974, Research and Development of Low-Cost Technology for Rice Production at IRRI, 1974. Paper presented at Experts Consultation Meeting on the Mechanization of Rice Production, Ibadan, Nigeria.

[4]IRRI Agricultural Engineering Department, 1976, Semiannual Progress Report No. 22, January 1976 to June .

[5]IRRI Agricultural Engineering Department, 1975 Semiannual Progress Report No. 20, January 1975 to June 1975.

[6]Johnson, Stanley S., 1969, Performance and Economics of Use of Small Equipment in Tropical Monsoon Countries, The Case of the Philippines. Paper presented at the 1969 annual meeting of the Japanese Society of Agricultural Machinery, Kyoto, Japan. ■ ■

Fig.17 IRRI 6-8 hp Power Tiller.

Crop Intensification for the Asian Rice Farmer

by
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Multiple cropping indices in Asian countries vary from 111 to 184 (**Table 1**). Most countries have cropping intensities below 140, which indicates that considerable potential exists for the introduction of additional crops into the cropping systems of these countries.

A closer analysis of the reasons for the wide range in cropping intensity encountered in the region provides some idea of the factors that need to be taken into account in research and development programs that seek to achieve crop intensification (Dalrymple, 1973). Intensive cropping is associated with small land holding or high labor-land ratios (**Fig. 1**), the availability of improved crop varieties, improved cropland (irrigation, drainage), the availability of farm machinery and a high demand for farm products. The rapidly increasing results from research focused on crop intensification indicate, however, that under most rainfed and partially irrigated cropping regimes at least one additional crop can be grown profitably.

Table 1. Multiple cropping indexes of Asian countries.

Country	Period	Multiple dropping index
Burma	1965—66	111
Bangladesh	1968—69	119
India	1966—67	114
Indonesia	1964	126
Japan	1967	126
South Korea	1969	153
Pakistan	1967—68	108
Philippines	1960	136
Taiwan	1969	184
South Vietnam	1960	112

Source: Dalrymple, Dana G. (1973)

Crop Intensificatin Research Methods

There exists various methods for the introduction of additional crops. The most appropriate method depends on the length of the growing season. The shortest seasons often require the use of intercropping or relay cropping techniques. Growing seasons of intermediate length represent an important potential for greatly intensified cropping systems. In these production situations the researcher seeks to lengthen the effective growing season by a variety of methods, alone or in combination. These include :

- the use of shorter duration varieties
- the use of techniques which allow earlier planting at the beginning of the rainy season
- the harvesting at physiological maturity
- the overlapping of growing periods by relay and intercropping
- the extension of the growing season into the dry season by the use of crops tolerant to drought
- the use of techniques for efficient soil moisture utilization, and
- the use of the supplementary irrigation

In situations where double cropping is already and the researchers seek to identify means for the inclusion of an extra crop, one way to increase the effective growing season is often by the reduction of the turnabout time between crops.

The selection of additional

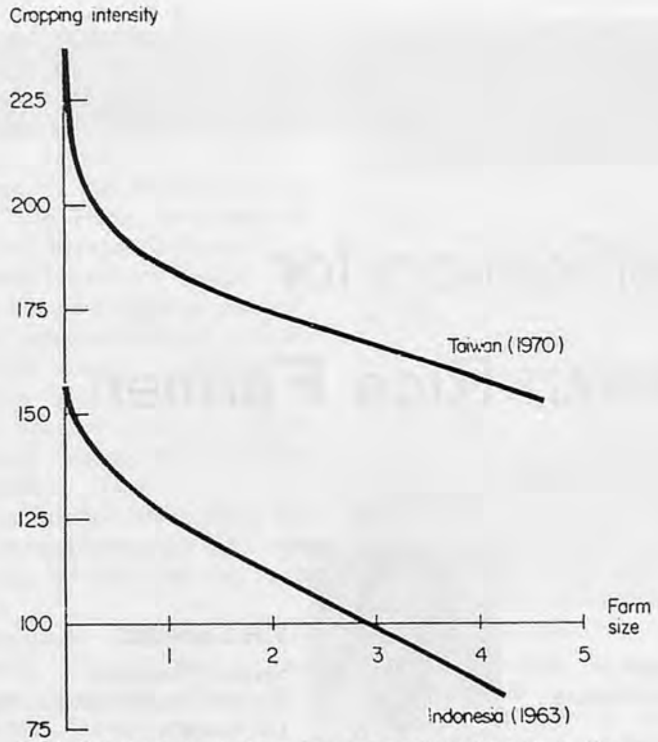

Fig.1. Relation between farm size and cropping intensity in Taiwan (Wang and Yu, 1975) and Indonesia (Birowo, 1975). Cropping intensity measured by the multiple cropping index defined as : (Crop area harvested during a year divided by the total area) x 100.

crops will depend on the characteristics of the part of the growing season in which they are to be seeded. In addition to these physical-biological considerations, other factors come into play such as the availability of markets, product, prices, input requirements and the type of government support available.

A prominent example of the application of these techniques is the use of the dry seeding rice establishment method in combination with early maturing rice varieties. This has allowed the introduction of an additional rice crop in rainfed areas with intermediate rainfall duration and the introduction of an additional upland crop in areas with short rainfall duration.* Similar techniques are being applied in Indonesia and Thailand in rainfed and partially irrigated areas.

Another example is the use of intercropping and relay cropping which allowed the development of a higly efficient cropping system for the Imperata cylindrica infested areas of South Sumatra. This pattern starts with the planting of upland rice intercropped with corn (2-m spacing). Cassava is planted into the corn rows 30 days after rice seeding (DAS). Corn is harvested at 85 DAS and rice is harvested at 130 DAS. The cassava canopy is at the level of the upland rice canopy at the time of rice harvest. The space vacated by the rice crop is then used for the planting of peanuts followed by rice beans. This cropping pattern minimizes land preparation, keeps the Imperata down by virtually continuous shading and light tillage and distributes labor and cash flow throughout the year.

Besides the availability of water, several other factors can limit the introduction of additional crops into a cropping system. These may be related to the soil type (ability to cultivate the soil after paddy rice production, water holding capacity), the amount of labor available at certain times of the year or the ability to control weeds or insects in the crops to be introduced. Cash availability (credit) and the demand structure for the product (markets) often determine if a pattern is suitable for a certain area. For this reason the cropping systems research methodology (**Fig. 2**), developed by IRRI in cooperation with national programs, advocates the use of site related research.

Small research teams are assigned to develop intensified cropping patterns for a defined region. They consist of 4-6 professionals, some of which are at the M. Sc. level composed of agronomists, an economist, one or two plant protection specialists and a crop scientist. These teams live in the research area and establish a modest office (rented house). They are assisted by village level workers (8-15) in their daily activities. The cropping systems research process starts with site description, followed by cropping pattern design and cropping pattern testing. All experimental work is conducted on farmers' fields and most of it is managed by farmers. The research teams at the sites are supported in aspects of research design, analyses, and interpretation by experienced cropping systems researchers of national research institutions.

The cooperation between the research team at the site and local extension workers is of great importance, particularly for the baseline survey, the selection of farmer cooperators and the testing of cropping patterns. It should be stressed to extension staff and farmers that the research team does not establish demonstrations. Rather, it seeks to involve farmers at an eary

※ Intermediate rainfall duration is 5-6 months of average rainfall above 200 mm/mo plus at least 3 months with rainfall between 100 and 200 mm. Short rainfall is 3-5 month of average rainfall above 200 mm/mo plus at least 2 months with rainfall between 100 and 200 mm.

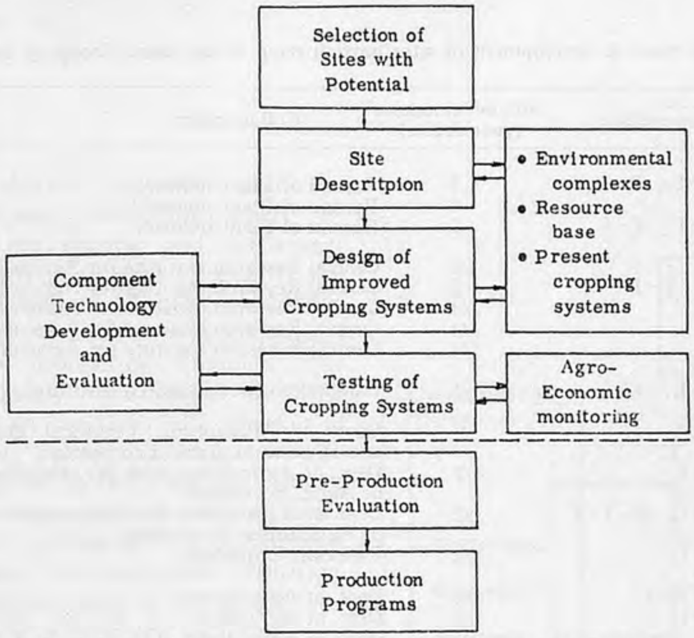

Fig.2. Components of the site-related cropping systems research methodology.

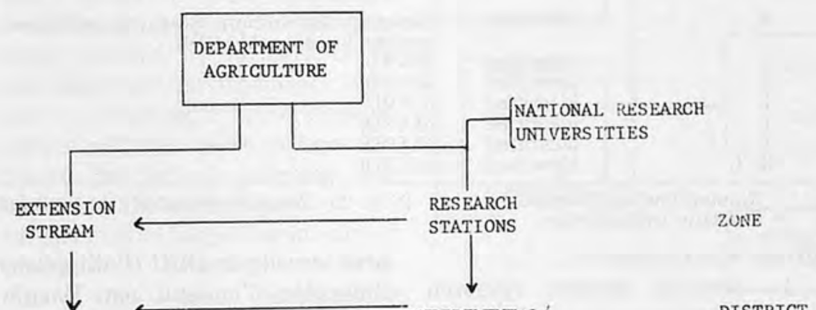

Fig.3. Site related research in relation to extention programs.

stage in the generation of production methods for the area. Pattern trials can fail and farmers should be aware of this.

The most appropriate way to link the research team to the extension or production programs will depend on the national institutional structure. Using the extension structure discussed Benor and Harrison at this meeting, the team should interact frequently with extension officers at the Block and Village extension worker level. Research design and interpretation of results should, however, involve subject matter specialists and supervisory research and extension staff at the subdivision level (Fig. 3).

The Asian Cropping Systems Network

The site related cropping systems research methodology is now being applied in 15 locations is South and Southeast Asia (Carangal, 1976). Another 9 locations have been identified to start operations in 1977 (Table 2). These locations form the Asian Gropping Systems Network. Its objectives are:

1. To provide a mechanism for joint program planning and interview between the national programs of the region and IRRI;
2. To provide a series of data points on the Asian agroclimatic grid for determining the cropping systems potential in major zones of the region;
3. To develop cropping systemp technology for the major rice growing regions in Asia;
4. To enable IRRI to extend relevant methodology and technology into national programs; and
5. To provide a mechanism for long term upgrading national efforts.

Selection of sites

The test sites should be carefully selected. They should represent major agroclimatic zones of the rice-growing areas of Asia. The selected sites when viewed together (as a spectrum) should represent the physical and social environments of rice-growing areas in Asia. At least one test site will be selected from each major rice-growing country. This will help the collaborating country start or expand cropping

Table 2. Location, description, collaborators and state of development of sites participating in the Asian Cropping Systems Network.

Location	Description	Site development (year active)	Collaborators
Philippines			
1. Oton and Tigbauan, Iloilo	R-L, P-1	2	Bureau of Plant Industry
2. Tanauan, Batangas	U	4	Bureau of Plant Industry
3. Manaoag, Pangasinan	R-L, P-1	2	Bureau of Plant Industry
Indonesia			
4. Bandarjaja Gunuing Sugih, Lampung	U, P-I	1	Central Research Institute for Agriculture
5. Jatibarang, Indramayu	I, P-I	1	Central Research Institute for Agriculture
6. Baturaja, South Sumatra	U	1/4	Central Research Institute for Agriculture
7. May Abung, Lampung	U	1/4	Central Research Institute for Agriculture
8. Tulangbawang, Lampung	U	1/4	Central Research Institute for Agriculture
Bangladesh			
9. Joydebpur	R-L, I	1	Bangladesh Rice Research Institute
Thailand			
10. In Buri, Singhburi	P-I, I	1	Dept. of Agriculture, Technical Division and Division of Agric. Economics
11. PiMai, Nakhon Ratchasima	R-L	1/2	Dept. of Agriculture, Rice Div. and Division of Agric. Economics
12. Ubon, Ratchathani	R-L, P-I-T	1/2	Dept. of Agriculture, Rice Div. and Division of Agricultural Economics
13. Bangpae, Rajburi	R-L	1/2	Kasetsart University
Sri Lanka			
14. Walagambahuwa	P-I-T	1/2	Dept. of Agriculture
15. Alankara and Moragani, Katupota	R-L	1/2	Dept. of Agriculture
16. Kurundankulama	U	Identified	Dept. of Agriculture
Burma			
17. Yezin	P-I, R-L	Identified	Agricultural Research Institute
Malaysia			
18. Kaula Nerang	R-L	Identified	Malaysia Agricultural Research and Development Institute (MARDI)
19. Krian	I	Identified	MARDI
20. Tanjung Karang	I	Identified	MARDI
21. Negeri Sembilan	I	Identified	MARDI
22. Kemubu	I	Identified	MARDI
23. Besut	I	Identified	MARDI
24. Kuala Brang	R-L	Identified	MARDI

U - Upland rice; I - Irrigated rice; R-L - Rainfed lowland (bunded); P-L - Partially irrigated rice; P-I-T - Partially irrigated rice tank fed

systems research in their country. The test site should:

1. represent a major agro-climatic zone;
2. be rainfed or partially irrigated with low cropping intensity and with potential for increasing intensity;
3. represent priority development areas of the host country;
4. have competent scientific leaderphip avalable, not only to implement the cooperative research but also to plan with research leaders from other cooperating countries to overall research strategy of the entire program;
5. have scientists who carry out cropping systems research; and
6. have country instituional support for the proposed test sites.

Cropping Systems Working Group.

For more effective implementation of the collaborative research in the network a working group was created to:

1. develop general research plans
2. review and evaluate research data from the test sites
3. discuss research approaches and methodologies, and
4. help IRRI in developing its research program.

The members of the working group are program leaders from collaborating countries and IRRI, the network coordinator, and selected scientists from outside the region. There are 10 countries represented in the working group with one representative each. These are Bangladesh, Burma, India, Indonesia, Malaysia, Nepal, Philippines, Thailand, and South Korea and Sri Lanka. The group meets twice a year. The meeting place rotates among collaborating countries to give the members an opportunity to observe and learn from other's work not only in the collaborative research but also in the national cropping systems research program. Meetings were held already in IRRI (Pnilippines), Indonesia, Thailand, and Bangladesh. Discussion in previous meetings were concentrated on research methodologies, varietal testing, efficient collaboration in the network, and review of the general research program in each participating country. Future emphasis will be placed on: the discussion of research results, the incorporation of these results in a general framework; the standardization of methods and measurements; and the extrapolation of results obtained to other sites in the network.

Site Description

The first activity of cropping systems research team is to describe the existing cropping systems in the selected area. The team needs to identify the different production complexes occurring in the region and to relate these to differences in the environment (physical and economic). An example of environment classification based on production complexes is that used in Lampung, Indonesia, where irrigation regime and settlement periods were used to stratify the environment. Another example, based on environment complexes (The production complex was dominatly rice-fallow) is that used in the IRRI-BPI (Bureau of Plant Industry, Philippines) site at Iloilo. In this case soil texture and topographic position were used to classify the enviroment. These environmental stratifications are used in the design and testing of cropping patterns.

The cropping systems encountered in the different production complexes represent the alternatives selected by farmers to fit the different environments. Unless a thorough understanding exists of the relationships between the actual cropping systems and the environment, it will be difficult to judge the impact of alternative cropping patterns. There has been considerable debate about the optimality of the farmers' choice of cropping pattern for his environment. Assuming optimality, researchers have no alternative but to change the enviroment (structural intervention) or to resort to management techniques that have not been evaluated by farmers, thus removing an information processing constraint. The identification of the structural and information (component technology) constraints can be of great help in the design of improved cropping systems.

The descriptive phase also determines the socioeconomic conditions in the region such as farm size, family size, tenancy, labor cash and power availability and cost as well as cropping frequencies throughout the year and the technological history of the site. It is important that the village level and regional extension workers and supervisors are involved in these surveys and in the selection of farmer cooperators.

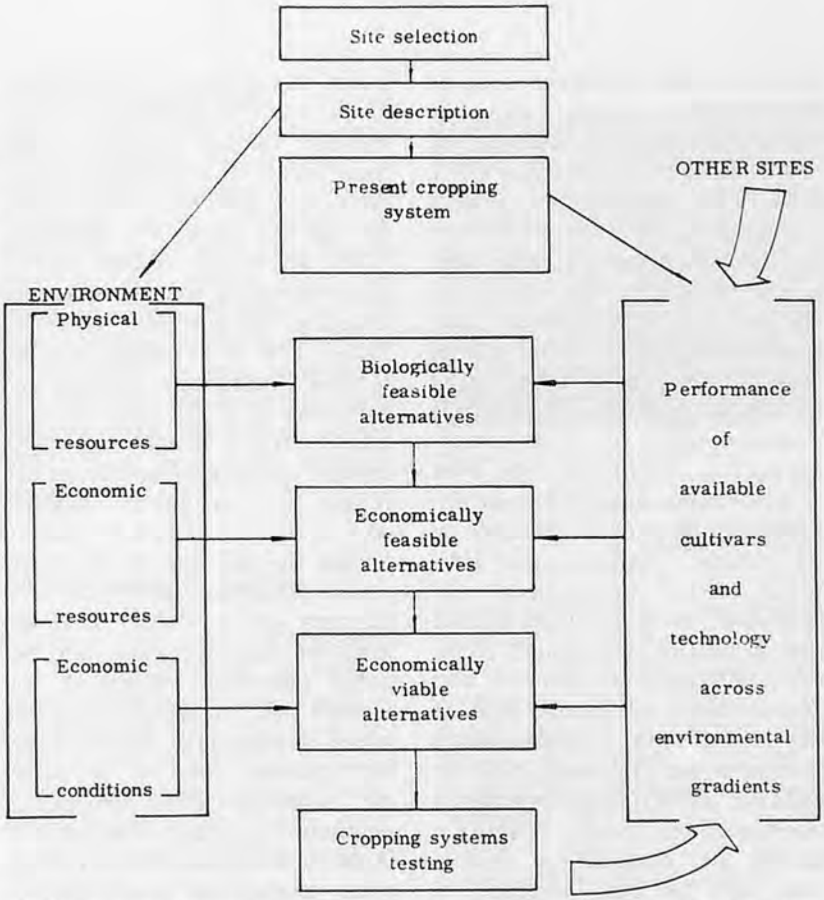

Fig.4. Schematic presentation of the design of alternative cropping systems for a selected environment.

Cropping Systems Design

The Asian Cropping Systems Working Group defined cropping systems design as: A synthetic activity which employs the physical and socioeconomic site characteristics obtained at the descriptive stage together with knowledge of the effect of these characteristics on the performance of cropping patterns, to identify intensified patterns that are well adapted to the site. The design activity (**Fig. 4**), therefore, is focused on a certain environmental complex.

In addition there is a limited assembly of available component technology that can be employed for cropping systems design. This technology consists of cultivars, tillage practices, planting methods, plant population considerations, knowledge about optimal spatial relations between intercrops, crop interactions, effects of crop combinations and cropping sequences on weeds, insects, and diseases, water management methods, and pest control methods, be they manual, by pesticides, crop resistance, or escape. It also includes accumulated knowledge about the performance of cultivars and the management practices under different environmental conditions, such as drought, saturated soil, high precipitation and humidity during the crop establishment and harvest periods, temperature and daylength variations, extreme soil conditions and predictable flooding.

Cropping pattern design and the specification of component technology for the pattern is done by the research team at the site in site in cooperation with their supervisors in the national programs (Departments, Institutes or Universities). Cropping svstems programs have obtained considerable experience in the management of various crop intensification techniques such as intercropping, relay cropping, sequential cropping and ratoon cropping (Herrera and Harwood, 1973; Baker and Norman, 1975).

Intercrops and relay crops have been found to use available light more efficiently. By choice of cultivars, planting times, and spatial arragements, crops can be ordered in height and density so that total leaf area duration is extended while for each component crop, maximum leaf area occurs during a period in which high solar energy is available to its canopy (Herrera and Harwood, 1973; Sooksathan and Harwood, 1975). Nutrient uptake and utilization was found to be more efficient in corn-rice and corn-soybean intercrops than in the respective monocultures (Suryatna and Harwood, 1976). In addition, intercropping provides a mechanism to reduce effects of insects and diseases on production such as the incidence of cornborer and the effect of downy mildew (Suryatna and Harwood, 1976). Canopy manipulation can also be used to reduce weed populations (Litsinger and Moody, 1976). Intercropping can reduce losses from damage to one crop through yield compensation by other crops in the canopy (For simulated canopy loss, see Liboon and Harwood, 1976 and for reduction of drought risks see description of the corn/sorghum intercrop used in El Salvador by Cutie', 1975). These effects on productivity combine so that most welldesigned intercrops result in a 20 to 40 percent increase in overall productivity over sole crops (Herrera and Harwood, 1973; Syarifuddin et al., 1974). Yearly labor requirements of intercropped patterns are higher than those for monoculture, but the labor demand is better distributed throughout the year (Norman, 1974).

Intensification of cropping systems for rainfed or irrigated paddy rice revolves primarily about the inclusion of additional crops in the sequence. Where monthly rainfall is high (> 200 mm) for 4 to 5 months the rice crop can generally be followed by an upland crop or intercrop. When 6-8 months of high rainfall are expected a double paddy rice cropping pattern can be established. This often requires the use of short maturing varieties and dry seeding of the first crop. In addition to a double rice crop, drought tolerant upland crops can follow rice to utilize available soil moisture and low rainfall during the tail end of the rainy season (Harwood and Price, 1976; Herrera et al., 1976). This description does not take into account important effects of soil texture and topographic position, which substantially modify cropping pattern potential in paddy rice systems. The topographic position of a paddy determines if farmers accumulate water from other paddies for a rice crop or drain the paddy when needed for good establishment of a direct (wet or dry) seeded crop or for a shift to upland crops while rainfall has not completely subsided. Light textured soils have shown much less potential for double rice cropping patterns but allow great flexibility for the establishment of upland crops after rice (Palada, Tinsley, and Harwood, 1976; IRRI, 1976). There is a great need to incorate present knowledge of farmers' decision making into manageable design criteria. These criteria should probably include: returns to cash, labor, and land in comparison to their cost in the region; cash requirements in comparison to its availability, the level of indebtedness required in comparison to actual cash income of the farm; and risk as a function of yield variations (preferably the subjective estimates of farmers) and levels of cash input. Another criteria to be considered is the return to the factor most critically limiting to crop intensification: water available to the cropping systems. The rainfall use efficiency of cropping patterns tested by IRRI in farmers' fields under rainfed bunded situations varied widely, but reached from 3 to 4 kg/mm rain for the most efficient patterns (**Table 3**). These are similar to those obtained by Rastogi (1974) and Krantz and Kampen (1974) and these indexes may provide a point of comparison for the efficiency of cropping systems across different rainfall regimes. Equally important design criteria relate to biological stability. These include the avoidance of erosion, maintenance of soil fertility, avoidance of buildup of pests and avoidance of a reduction in subsoil water availability.

Table 3. The grain yields and net returns per mm rain of eleven cropping patterns in a rainfed bunded rice growing area. Iloilo, 1975; rainfall during crop season ranged from 1882 to 2114 among locations.

Cropping patterns	No. tested	Total yield (kg grain/mm)	Returns[a] (US$/mm)
Rice	10	1.7	0.12
Rice-corn	8	3.3	0.15
Rice-sorghum	3	3.2	0.16
Rice+corn/peanuts	2	2.7	0.50
Rice-corn/mung	2	2.1	0.09
Rice-mungbeans	9	2.2	0.12
Rice-cowpeas	10	2.2	0.10
Rice-soybeans	6	2.0	0.07
Rice-peanuts	6	2.1	0.34
Rice-rice	31	4.5	0.32
Rice-rice-pulses	13	4.7	0.29

[a] Returns over variable costs, including family and exchange labor, but excluding cost of land

IRRI's Cropping Systems Program

The ability to design cropping systems will continue to increase as more information becomes available about the performance of crops and management techniques in different enviroments. To achieve this IRRI's cropping systems research program has been structured to allow research in

Soil and crop management

—use of crop intensification techniques

—crop establishment methods

—tillage methods

Environmental classification

—effect of climate } on cropping
—effect of soil types } pattern
—effect of landscape } performance

Weed control

—for dry seeded rice

—by use of plant densities and canopy types

—by crop rotations and inter-cropping

—mechanical control

—chemical control

Insects and diseases

—occurrence in relation to environment

—occurrence in relation to cropping pattern

—evaluation of yield losses

—Pest- "stable" cropping patterns

Economics of cropping systems

—baseline survey methods

—realtion of resource base to type of patten used by farmers

—economic performance of cropping patterns

—evaluation of institutional intervention needs

—evaluation of impact from the introduction of multiple cropping technology

Applied research & training

—methods of applid research

—formulation of production programs

—training methods

—training materials for national programs.

Table 4. Number of trainees in the six-month course on cropping systems.

Country	1974	1975	1976[a]	Total
Bangladesh	—	2	2	4
Burma	—	—	3	3
India	—	—	3	3
Indonesia	6	11	10	27
Japan	—	—	1	1
Malaysia	—	1	4	5
Israel	1	—	—	1
Nepal	—	—	1	1
Philippines	4	5	3	12
South Korea	1	—	1	2
Sri Lanka	1	—	2	3
Thailand	2	6	6	14
Total	15	25	36	76

[a] Trained on September 20 -March 11, 1977.

This research team provides back up and inspiration for cropping systems researchers in national progorams. Staff members visit colleagues in national programs to discuss methods and results obtained. They provide training at the short course and advanced degree level (**Table** 4) and respond to requests from the Asian Cropping Systems Working Group for the development of specific research methods.

Photo.1 Cropping Systems Testing
Rice-rice-cowpea pattern being tested in 1,000 sqm. Picture shows first rice crop with early maturing variety. Rice in the background is also first rice crop of farmers. Location: Indramayu, Indonesia.

Cropping Systems Testing

During this phase of research the designed cropping pattern and their management are tested in farmers, fields. At this time the assumptions made in the cropping systems research process, particularly those at the design stage, are to be verified. These assumptions are:

1. The proposed system is biologically suited to an important physical environmental complex of the site. Yields of crops in the pattern should therefor be adequate and biological instability should not occur.
2. The systems requirement for economic resources, such as cash, labor, and power are not beyond their availability
3. The management of the pattern specified at the design stage is optimal
4. The system satisfies economic performance criteria such as net returns to farm resources and returns to cash inputs.

The testing process is undoubtedly the activity that requires most time and research personnel of all those described in the cropping systems research process. The monitoring of patterns and the data collection system must be at the same time manaqeable and sufficiently rigorous to allow reliable estimates of cropping pattern performance, their resource requirements and the farmers reactions to them. Identified management bottlenecks should preferably be attacked on the research station, but may at times require on-site studies.

A major activity of cropping pattern testing is the fine tuning of the component technology. It rarely occurs that the patterns' management identified at the design stage is adequate. For this reason reason onsite research compares different varieties, planting methods, fertility regimes and insect and weed management methods. A pattern's agronomic performance, its input requirements and its optimal component technology allow an economic evaluation of its suitablility according to the performance criteria established for that purpose.

An important aspect of the testing methodology is the on-farm nature of cropping pattern testing. In this case, on-farm testing connotes not only that patterns are to be tested on farmers' fields but also that they are to be manageed by farmers (Harwood, 1975).

It can be argued that there are efficient research methods for testing the first and third as-

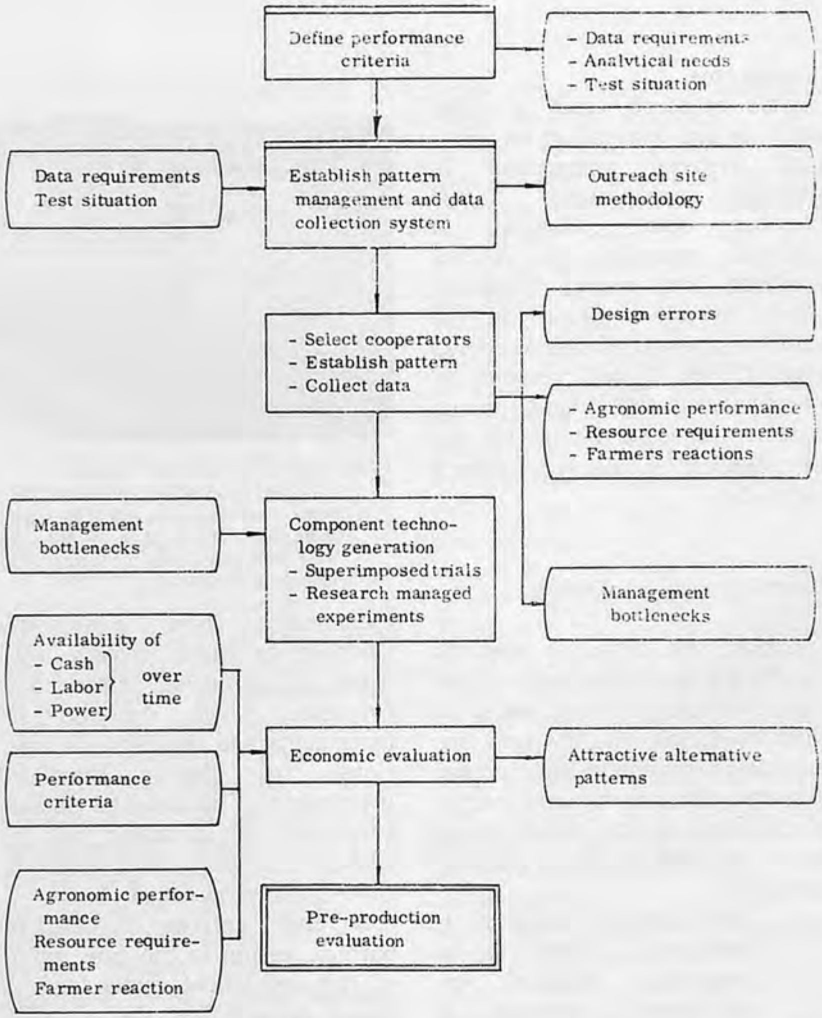

Fig.5. Testing of cropping patterns.

sumptions listed above on the research station or under research management in farmers' fields. After an initial investment in measurement and survey methodology, time and labor requirements of most operations can be estimated with sufficient accuracy to allow testing of the second and fourth assumption. Why then insist on farmers' management and large sized plots (700—1000 sq m) for cropping pattern testing ? The reasons found in IRRI's cropping systems program are the following :

1. Many management problems do not manifest themselves in small plots. The researcher has complete control over timing of operations and often makes subtle modifications in pattern management to avoid problems. The location of research managed trials is rarely selected at random within a defined environmental complex, and is often determined with the experiment in mind.
2. Resource conflicts of the proposed cropping system with existing ones are difficult to measure in research managed trials because labor and power inputs are supplied by the researcher.
3. Farmers' modifications of cropping patterns and their management, particularly the timing of operations, are tell-tale indications of resource conflicts. Farmers' observations, although not easily interpreted, provide variable insights about the potential and the limitations of cropping systems tested under their magement
4. By using superimposed treatments that do not interfere with the farmers' operations, the component technology specified for a pattern can be more realistically evaluated under farmers' management than in research managed trials.

These reasons all point to a need to expose the researcher to the farmers' reality and to arrive at an interactive method for the identification of new cropping systems. Undoubtedly this requires a careful structuring of the test situation to which the farmer is exposed. Farmers' observation must be interpreted with caution and the interpretation given to them must be fed back to the farmer for verification. The results of cropping pattern traials, particularly the farmers' reactions to introduced pattern and technological components should be continuously shared with extension personnel in the region, who will participate in the selection of the better performing patterns and component technology for pre-production testing.

Applied Research and Pre-production Testing

Applied research evaluates alternative cropping patterns in many sites that are representative of the environmental complexes for which the patterns were designed. To be effective, applied research must involve research institutions as the source (or sanction) of new technology and must involve organizations responsible for the formulation of production programs as the recipient of the results obtained. It is important to note that a structured decision is required to enter a particular technology into the applied research phase. Similarly, the results of applied research determines what technology will be accepted for inclusion into production or extension programs.

As in cropping pattern design and testing, the specification of the environmental complex is very important. Applied research testing must provide extension or production agencies not only with alternative cropping systems that are well specified as to their management, but must also clearly delineate the situations to which those cropping systems are adapted. The domain of adaptation of a recommended alternative cropping system must therefore be specified in terms that can be used to stratify the action of production programs. This requires that this domain can be mapped or associated with existing geographical boundaries, or can be expressed in site differentiating criteria that can be handled by extension agents on the basis of simple observation.

A combination of these methods for stratifying a recommendation for alternative cropping systems is usually required to arrive at a sufficient fit of the recommendation to the environmental variability encountered. The importance of fine adjustment of a recommendation to the environment is directly reflected in the increased benefits derived from the recommendation and the reduced risks associated with its adoption (**Table** 5). In cropping systems research, the recommendations are prone to vary even more widely than those for P-fertilization illustrated in **Table** 5, and the increased benefits and reduced risks obtained from an appropriate atratification of cropping systems recommendations will undoubtedly be more substantial.

To achieve location specificity for recommended cropping systems is not easy, because applied research is located at a cross road of institutional activity. This author contends that a thorough regionalization of research and extension is the most efficient solution. Research and extension can then be addressed to a specific region very much along the lines described for the cropping systems research process (**Fig.** 2). Once classified, as to environment, these sites can utilize results from those working in similar environments. They can also provide a valuable framework for biological research developing new component technology and for research in agricultural development process such as the adoption of new technology, constraints to increased production and institutional analyes.

Pre-production testing follows applied research, formulating the type of institutional support required for an efficient implementation of the recommeneded practices. This activity focuses on training of extesion personnel and on the availability of credit, seed, and agricultural chemicals. In general, it identifies and prepares the institutional and personnel requirements for the implementation of the recommended practices on a wide scale. Pre-production testing also evaluates the performance of a recommended practice on a large scale.

Table 5. Estimated phosphorus requirements and net gains and risks associated with various P-recommendation strategies based on geographical divisions of Eastern Cundinamarca (Colombia). From Zandstra, 1974.

Strategy	P2O5 (kg/ha) recommended	a/ required	Expected gain ($/ha)	Risk ($/ha)
1. Five townships combined	20	20	8.30	7.90
2. Two groups of townships	0,41	15	12.60	6.20
3. Three groups of townships	0,19,41	18	15.30	7.20
4. Separate townships	0,14,18,20,41	20	15.70	5.90

a/ Kg P2O5/ha required assuming all corn farmers applied recommended rate.
b/ Expected value of the loss of those recommended to apply.

Photo.2 Pilot production of sorghum planted after rice. Location: Tanauan, Batangas, Philippines.

This task should be the responsibility of the extension organizations at the district, zone, and national or state level. Using the information obtained from on-farming cropping systems research and subsequent applied research, the institutional support needs to be structured such that inputs, credits, and market are available for the recommended cropping patterns (Zandstra, Swanberg, and Zulberti, 1975). Because of results from multiple cropping research, production programs in the Philippines are now changing from a commodity orintation -- in which technical assistance and credit is provided for each commodity-- towards a cropping systems orientation -- in which technical assistance and credit is provided for the whole cropping sequence selected by the farmer and the extension worker -- (Gomez, 1976).

Conclusion

Cropping systems research can provide substantial benefits in increased food production and increased incomes for the Asian rice farmers. The cropping systems research process developed by the Asian Cropping Systems Working Group provides a useful framework in which to attack the complex interactions between cropping systems performance and environmental conditions. In this framework, research activities progress (at times in a simultaneous fashion) from site selection, site description, cropping systems design, component technology generation, cropping systems testing, and pre-production testing to the formulation of production programs.

The link between farmers oriented site related research in cropping systems and extension requires careful study. In this, the site specifictity of agricultural production recommendations needs to be kept foremost in mind. Decision making about recommended cropping systems and component technology needs to be formalized and the final decision on recommended practices needs to be at the local (block) level. Agricultural extension and site related research should combine in their effort to thoroughly understand the farmers decision making before concluding that introduced production methods are superior to existing ones.

As farmers practices are normally in tune with their resource structure and institutional constraints, extraints, extension services at the local and regional level (block subdivision) must accept the responsibility for the intervention required to allow farmers on escape from the low input-low risk-low return production methods.

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Assessing Quantitative and Qualitative Losses in Rice Post-Production Systems

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Introduction

There is a general consensus that the major source of expanded output in land-short countries must either be increased cropping intensity, higher yields or a combination of these components. Higher. and less variable yields appear to harbor the greatest potential for short and medium-term increases in total production, although higher yields and increased intensity are not mutually exclusive options.

When focusing on the yield component as a source of increased output, we need to know at what point yield is measured. While field yield accurately reflects the realized biological potential of the rice plant, it may not represent the economic return to the farmer or the quantity ultimately available for consumption. Evaluating the latter requires knowledge of post-production and marketing systems and the efficiencies of these systems.

Current interest in post-production related activities is partially the result of the increased yields possible from the modern varieties. Losses which were formerly small in absolute terms, tend to expand proportionately with increased farm level yields making their magnitude and value more significant than in the past. In addition, there has been increased interest in the potential (and possibly low-cost) in-reases in output available through use of improved post-production systems. Lastly, the conditions necessary to achieve higher cropping intensities may require significant modification in existing harvesting, handling, threshing and drying operations to allow timely "turnaround" intervals between crops.

Unfortunately, much of the conjecture surrounding projected gains from reduced losses and improved cropping efficiency attributed to "modernized" post-production operations is not supported by empirical evidence. Lack of information which identifies and quantifies the sources and characteristics of improvements in these operations is particularly acute at the field and village level where paddy is grown and large quantities are retained for consumption.

While there are obviously several economic and technical factors which affect post-production losses (including the variety grown, weather, and availability of labor), we attempt in this paper to pinpoint the sources and levels of grain loss in rice post-production systems which can be alleviated through introduction of improved techniques, management, economic policies or institutional innovations.

Review of Past Research

Beginning in 1973, IRRI initiated work to investigate the magnitude and nature of field grain losses in paddy production. A field study undertaken to assess harvest losses (Samson & Duff, 1973) indicated significant differences in loss levels when comparing a) varieties, b) wet and dry seasons, and c) moisture content at the time of harvest. In a related series of experimental trials at IRRI, losses ascribable to handling, bundling, stacking and field drying were also investigated. Total paddy losses approximated 1 to 3 percent for the harvest operation and 2 to 7

Paper presented at an FAO Workshop on Post-Harvest Rice Losses, Alor Star, Malaysia, March, 1977.

percent for intermediate handling steps.

In an attempt to assess the qualitative changes resulting from these operations, total milled and head rice recoveries were recorded for both the harvesting and experimental handling trials. Significant decreases in both total and head rice were observed due to delays in the time of harvest with the greatest change being recorded between head rice recovery and moisture content at the time of harvest.

In 1973-74, a comprehensive survey of rice milling and field level operations was undertaken (Toquero & Duff, 1975). One hundred and eighty rice mills and approximately 600 farmers were surveyed in three regions of the Philippines. These surveys were designed to inventory existing rice post-production operations. The preliminary results have been summarized in a number of working papers issued by the IRRI Engineering Department and listed in the attached biliography.

Based on the results of the foregoing research, a series of pilot area trials were planned and implemented to assess the impact of alternative systems of technology at both the farm and rice mill level. Sites for evaluating field farm level operations were located in four villages of Central Luzon and three villages in the Bicol River Basin area. The preliminary findings from these systems trials are the subject of this report.

Objectives

The major objectives of the study are: a) to develop a suitable research methodology to determine the nature and characteristics of grain loss at the farm and mill level, b) to inventory and assess technical efficency in traditional and improved farm and mill level post-production systems, c) to examine the economics of traditional and improved systems, and d) to determine the institutional factors constraining use of improved techniques and systems.

The Methodology of Farm Level Trials

Four systems involving alternative combinations of technology and management were utilized in the farm level trials (Fig. 1). Harvesting in all four systems was carried out with the use of scythe or sickle.

System I exemplifies the traditional technology commonly used by farmers. Threshing was entirely a manual operation with the operator using either a threshing frame ("hampasan"), flail, stick or manual treading. Threshed paddy is sun-dried prior to storage or milling. System I acted as a control against which the results from other systems were compared.

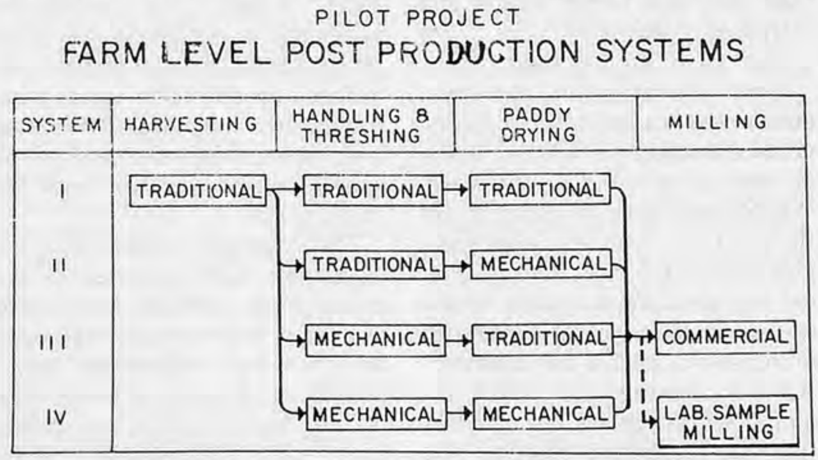
Improved technology was used in System IV in which paddy was mechanically threshed with the axial-flow thresher and subsequently dried in a twin-bed batch dryer.

Systems II and III combine elements of traditional and improved systems in the threshing and drying operations. In System II, threshing was also performed manually, but a twin-bed batch dryer was used to remove moisture prior to storage. In System III, the mechanical thresher was utilized immediately following harvest, although the paddy was sun-dried.

Systems I and IV have a minimum paddy requirement of 1.75 tons each to permit replicated commercial milling tests. Systems II and III require a minimum of 1.0 ton each. Depending on the minimum requirement per system, one or more paddy fields were used for each system treatment. When more than one field was required, every attempt was made to ensure that a uniform variety and planting dates were employed.

The area of the field(s) selected for each system was carefully measured and recorded. Farm maps were also prepared as guides in planning and scheduling farm operations.

Crop-cut samples were taken for each system to measure the



MEASUREMENTS (for each system)

o Crop cut samples	o Post threshing output	o Post drying output	o Total rice
o Paddy samples	o Paddy samples	o Paddy samples	o Head rice
o Moisture content	o Moisture content	o Moisture content	o By products

Fig.1. Farm level post-production system.

potential yield at the field level. To obtain actual area yields, plots were measured and the grain from each was weighed following threshing and again following drying. All yield and weight measurements were corrected for moisture content and impurities. To determine the quality of paddy and milled rice, 750g samples were taken following each operation in each system and later dried, milled and analyzed in the laboratory.

Quantitative losses were measured at each stage in the post-production operations. Harvesting loss was determined using a 2 sq m sample frame. Following harvest, paddy was bundled and stacked and grain that had either fallen on the ground or remained unharvested within the sample area were handpicked and weighed. This process was replicated two or more times per plot depending on the total area involved in a given system. To measure stacking losses, harvested materials were placed on canvas sheets provided to farmer cooperators. Following the stacking operation, grain remaining on the sheets was weighed. Losses incurred using the traditional system of threshing were determined by weighing the paddy recovered by gleaners or "mambabarog" (people re-threshing the paddy). For mechanical threshing, canvas mats were used to recover and measure paddy discharged onto the ground.

Records were kept of the labor employed for each operation within individual systems, the costs incurred to perform each operation and the total and elapsed times required to complete an entire sequence of operations. In addition, the quantitative and qualitative measurements necessary to impute relative benefits and costs for each system were also compiled.

In addition to the field level operational trials, concurrent interviews are being conducted among sample farmer-members of associations in the three pilot areas of the Bicol Region. These interviews are designed to examine farmers' post-production practices, attitudes and preferences toward use of alternative milling and processing technologies, problems and suggested improvements and paddy production and disposal.

Acquisition of Equipment

The threshers and dryers used in the pilot trials were purchased through a project fund and sold to the farmers' assciation selected for the field trials. An Equipment Purchase Agreement was signed by the President of the Association, the Manager of the Area Marketing Cooperative (AMC) and a representative from the cooperating agency through which the project was being implemented. In the Central Luzon pilot trials, the project was implemented in cooperation with the Integrated Development Project for Nueva Ecija (IDP/NE). In the Bicol Region, the research is being done in cooperation with the Bicol River Basin Development Program (BRBDP). Under the terms of the purchase agreement, the government agency (IDP/NE in Nueva Ecija and BRBDP in Bicol) sells the equipment (one thresher and one twin-bed batch dryer) to the farmers' association. The machines are amortized over a period of not more than five years with 8 percent interest charged on the unpaid balance. Payment is obtained from fees charged from members and other users of the equipment. The agreement further states that 40 percent of the gross income from the equipment is to be used for yearly amortization and 60 percent is to be retained by the association to defray labor, fuel and maintenance costs.

Results and Discussion

Field trial were completed at four villages in Central Luzon during the 1975 wet season and were continued through the 1976 dry season. Four to six farmer-members of each village association were chosen to participate (**Table 1**). The association purchased and operated the axial-flow threshers and twin-bed batch dryers, kept records and acted as marketing agent. Another three villages are presently

Table 1. Characteristics of five villages included in the post-production pilot trials, Philippines, 1975-76.

Location	Season	Cooperators (no.)	Plots (no.)	Average area (sq m/plot)	Yield[a] (t/ha)	Variety
Soledad, Sta. Rosa, Nueva Ecija	Wet	5	80	771.4	3.3	I R20 I R26 I R1529 I R1561
Malapit, San Isidro, Nueva Ecija	Wet	6	46	1,423.2	3.6	I R26 I R30 I R579 I R1529 I R1561
Polilio, Cabanatuan, Nueva Ecija	Dry	4	42	1,242.3	3.1	I R26 I R30 C4-63G
Sta. Cruz, Zaragosa, Nueva Ecija	Dry	5	22	1,350.27	3.6	I R747 I R30 I R20
Poblacion, Libon, Albay	Wet	3	25	1,269.67	[b]	C4-63G B P I 76
Total/average		23	215	1,211.36	3.3	

[a] Final paddy weight after drying and adjusting for purity at 14% moisture.
[b] Still being analyzed.

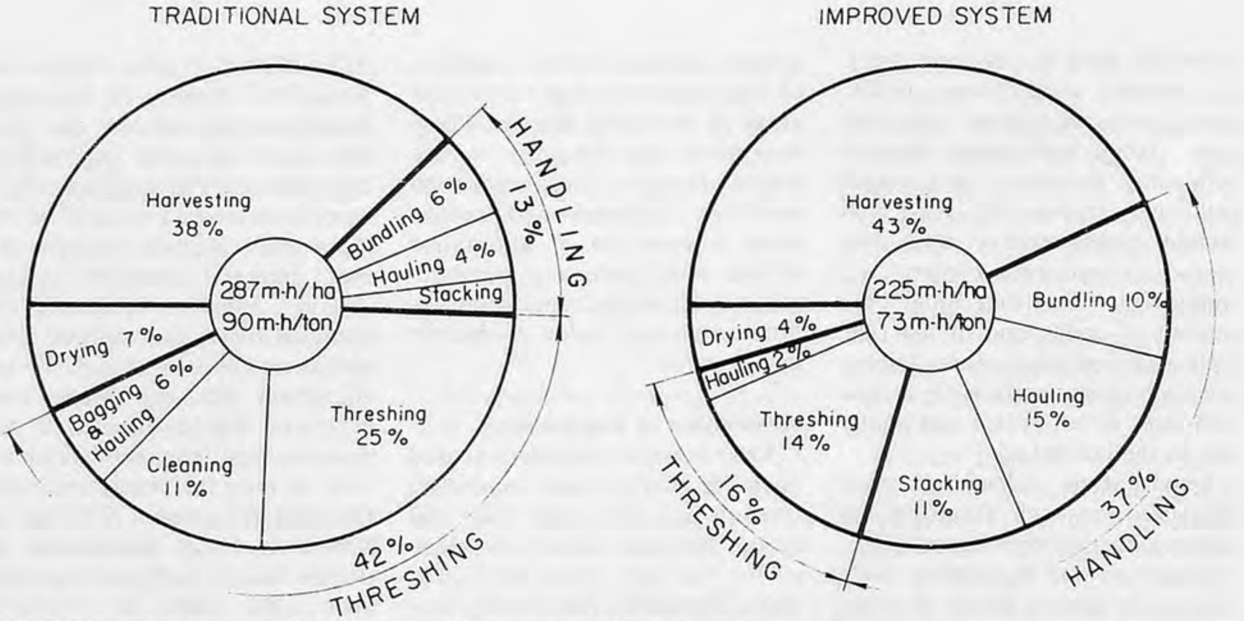


Fig.2. Comparative labor use for traditional and improved post-production system.

being evaluated in the Bicol Region.

Labor Requirements

Detailed labor records were kept of the man-hours used in each operation under each level of technology. Man-hour requirements refer to the net time devoted to each operation and exclude snack and rest periods.

Figure 2 shows the relative percent distribution of labor between traditional and improved systems by operation as well as for the total system.

Harvesting: Harvesting, which includes cutting, gathering, bundling, and stacking required the greatest manpower input. Harvesting was one of the major constraining operations in the post-production process as indicated by an earlier farm level survey.[1] The survey also indicated that a rapid harvest had little correlation with a farmer's desire to plant a subsequent crop. Generally, farmers in the area who harvest their paddy early tend to wait and plant with their neighbors to protect their crop from rat infestations and other pest problems. Timeliness in harvest operations reflects the farmer's awareness of the relationship between delays and increased losses.

In handling operations, the mechanical system required twice (2x) as much labor as the traditional system (**Table** 2). Examination of the data showed that paddy for mechanical threshing had to be moved to the dikes or roadside to make it accessible to the thresher. Moreover, large stacks were required to effectively utilize the equipment.

Threshing: Threshing is the separation of the grain from the stalk. In System I (tratitional), threshing also included cleaning or winnowing to separate the grain from immature kernels and foreign materials. The mechanical thresher reduced overall labor requirements by 70 percent on a per hectare basis. The reduction is slightly higher on a per ton basis because the thresher also tends to improve gain yields.

In addition to improved yields, farmers also appeared to prefer the mechanical thresher because of its high degree of availability (timeliness) and the ease of monitoring the threshing and distribution of the final product. In contrast to traditional methods which offer considerable opportunity for pilferage by those performing the threshing operation,

Table 2. Comparative labor requirement between alternative post-production systems by operation, Central Luzon, 1975-76.

Operation	Labor requirement (m-h)			
	Per hectare		Per ton	
	Traditional	Improved	Traditional	Improved
Harvesting	108	97	35	31
Handling	37	83	11	27
bundling	17	24	5	9
hauling	13	34	4	9
stacking	7	25	2	9
Threshing	122	36	39	11
threshing	72	31	23	10
cleaning	33		11	
bagging	9		3	
hauling	8	5	2	1
Drying	20	10	7	3
spreading	9		2	
stirring	1		1	
collecting/bagging	9		3	
weighing	1		1	
loading		2		1
unloading		4		1
weighing		4		1
All Operations	287	226	92	72

[1]Duff, B. and Z. Toquero, 1975. "Factors Affecting the Efficiency of Mechanization in Farm Level Post-Production Systems, IRRI Saturday Seminar Paper, August.

mechanized threshing effectively consolidates control of the threshing operation.

The machanical thresher used in the trials has the technical capability to thresh high moisture paddy, a feature which proved particularly useful when combined with mechanical drying. A major limitation of the thresher is its high initial cost and lack of field mobility during the wet season harvest. The machine did not eliminate the need for repeated intermediate handling, a major cause of grain loss.

Drying: The labor required for drying includes the handling of threshed paddy in preparation for drying, management of drying system and the collection and bagging of dried materials. Use of mechanical dryers reduced the amount of labor required for drying by 50 percent on both a per hectare and per ton basis. In contrast to the higher yields obtained with the introduction of the mechanical thresher, use of the mechanical dryer did not improve output compared to traditional methods, particulary when used in combination with traditional harvesting-threshing techniques. The dryer did, however, demonstrate an improvement in grain quality as measured by head rice recoveries. Dryer performance appears to be somewhat better when used in combination with the mechanical thresher. This is not a conclusive observation, however, since performance can partially be ascribed to the lower field losses from mechanical threshing rather than reduced drying losses.

Quantitative Grain Loss

Harvesting loss was based on the quantity of grain recovered during the interaval from harvesting up to stacking. The improved system incurred lower harvesting but higher stacking losses compared to the traditional system (**Table 3**). These differences were partially a result of stack size. Under the traditional system, paddy is stacked in small bundles in the field while paddy intended for mechanical threshing is immediately hauled and stacked in larger bundles along the levees or roadside to facilitate access to the thresher. This practice is especially prevalent during the wet season harvest when the field is soft and muddy making it impossible for the thresher to negotiate the field.

Data from the Central Luzon trials show that grain losses from manual threshing were three times (3x) greater than for those systems using the mechanical thresher. The results from Bicol gave a different pattern because manual threshing was performed on a cement threshing floor. All grain recovered after the threshing operation was considered part of the threshing yield. Moreover, traditional threshing in Bicol is a combination of treading and use of flail or stick. The threshing operation is somewhat more complete compared to the "hampasan" method (beating paddy against a threshing frame) practiced in Central Luzon.

Table 4 illustrates the relationship between elapsed time from harvest through drying and resulting grain yield.[1] In general, grain loss increased as the interval between the harvest and threshing operations lengthened. During this period, grain remains unthreshed or undried or both. More significant, however, are the yield differences observed between traditional systems and those using either one or both improved methods of threshing and drying. Using a dryer in System II increased grain yield by 12 percent over System I. Similar increases in yield were found in System III using the mechanical thresher. System IV which em-

[1]Analysis was based on samples from 51 fields.

Table 3. Grain loss incurred in harvesting and threshing operations, Central Luzon and Bicol Region, 1975-76.

Item	Harvesting[1]		Threshing[2]	Total
	Harvesting	Stacking		
	(percent)			
Central Luzon				
Traditional	3.16	0.12	6.82	10.10
Improved	2.14	0.14	2.07	4.35
Bicol[3]				
Traditional	3.75	[4]	0.93	4.68
Improved	2.03	1.85	2.18	6.06
Mean (ave. of 2 areas)				
Traditional	3.35	0.12	5.74	9.21
Improved	2.26	0.74	2.12	5.12

[1] Based on the amount of paddy recovered in the field immediately following harvest from 32 fields.
[2] Based on the quantity recovered by gleaners ("mambabarog") in the traditional system as reported by 10 farmers for 24 fields. For mechanical threshing, losses include blower loss and straw loss as reported by 13 farmers for 27 fields.
[3] Data was taken from results of completed field trial in Libon, Albay.
[4] No stacking loss was noted in the Bicol area because paddy was immediately threshed following harvest with no intermediate stacking operation.

Table 4. Relationships between elapsed time from harvesting to drying and grain yield for alternative post-production systems, Central Luzon, 1975-76.

Item	Post-production Systems			
	Manual thresh and sun dry	Manual thresh and mechanical dry	Mechanical thresh and sun dry	Mechanical thresh and dry
Elapsed time by operation (days)				
harvest to thresh	1	1	0	0
thresh to dry	1	0	2	2
harvest to dry	4	1	2	2
Yield per hectare (t/ha)				
harvesting	3.3	4.1	4.9	3.9
threshing	2.9	3.6	4.8	3.8
drying	2.5	3.6	4.2	3.5

ployed both the thresher and dryer in sequence, produced the greatest increase in output. A high degree of variability was observed from each system, largely because of the difficulty in controlling all factors that affect the performance of the systems. Rain after harvest but before threshing often damaged the grain that was stacked or bundled in the field. Subsequent operations could do little to rectify these effects. Better scheduling of operations for all systems would have reduced losses by cutting the time interval between harvesting and drying.

Qualitative Grain Loss

Differences in grain quality from each post-production system are shown in **Table 5.** Although overall milled rice recovery increased only 4 to 6 percent using the improved system, the percentage of broken, fermented, discolored and immature grains was significantly reduced, particularly in those systems using the grain dryer. An inverse relationship was also observed between elapsed time from harvest to final drying and percentage head rice recovery (compare **Tables** 4 and 5). A total elapsed time of 4 days from harvest to final drying resulted in a 77 percent head rice recovery (as exhibited by manual threshing and sun-drying). In contrast, systems with a total elapsed time of two days or less (mhchanical threshing and drying or a combination of mechanical threshing and sun-drying) gave a 90 to 91 percent head rice recovery. These results were obtained through laboratory milling analysis. Current milling tests include passing the output of field level systems through a number of alternative commercial milling systems.

Distribution System

An examination of the paddy marketing system following the field level post-production operations partially explains why mechanical dryers are not attractive to farmers. **Figure** 3 shows the distribution of paddy among recipients following harvest. Of the 60 percent retained by a tenant-operator, 25 percent is sold and 32 percent is stored for home consumption. **Figure** 4 pinpoints the location within the post-production distributive system where drying takes place. For tenant farmers, 52 percent of the paddy is sold or distributed before it is dried. The remainder is not sufficient inducement for an individual farmer to own and operate a dryer. While the bulk

Table 5. Quality characteristics for milled rice from alternative post-production systems, 51 paddy samples, 16 plots, Central Luzon, 1975.

System	Elapsed period (harvest to dry)	Quality characteristics			
		Head rice	Broken rice	Milling recovery Brown rice	Milled rice
	days	percent			
Manual thresh and sun dry	4	77.4	20.2	63.0	59.3
Manual thresh and mechanical dry	1	84.5	14.1	67.4	63.4
Mechanical thresh and sun dry	2	90.6	8.8	70.5	65.6
Mechanical thresh and dry	2	89.9	9.2	68.4	64.4

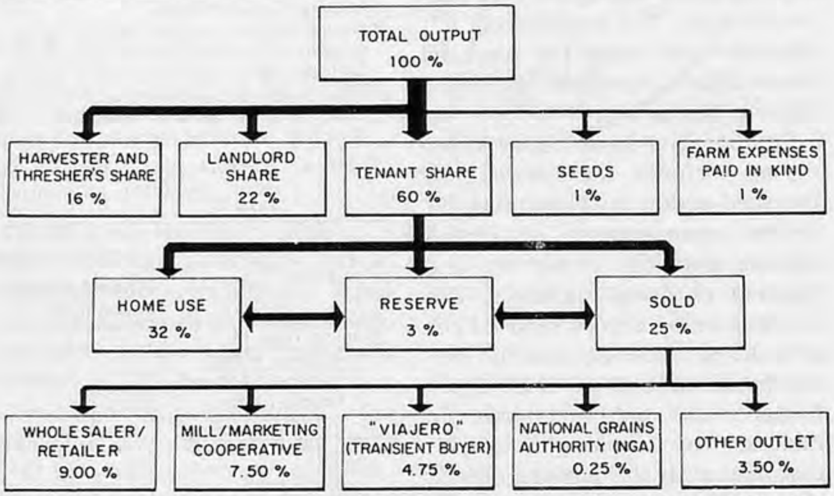


Fig.3. Production and disposal of paddy by a tenant-operator, Central Luzon, 1974-1975.

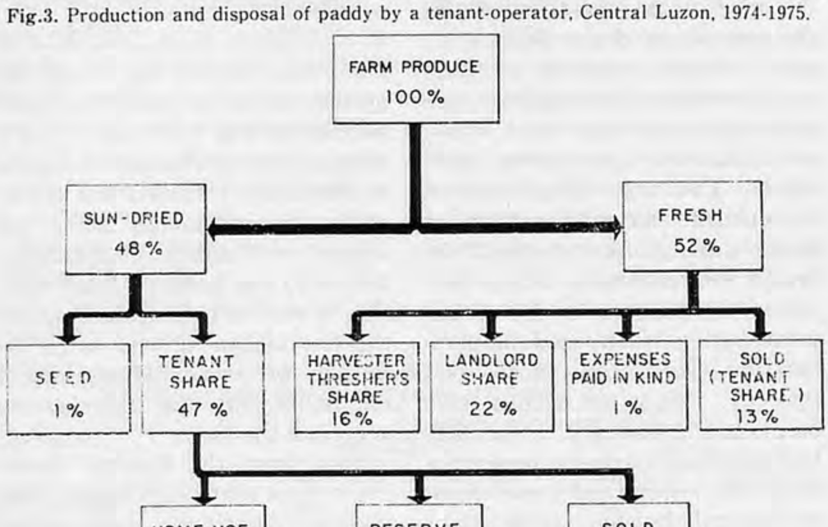


Fig.4. Flow of paddy harvest in fresh and dried form, Central Luzon, 1974-1975.

of paddy is sun-dried at the farm level and retained for household consumption, a significant share enters the market prior to drying and is dried at rice mills or warehouses.

Comparative Costs

A series of cost estimates for traditional and improved post-production systems were computed for each village included in the Central Luzon trials. Items included in the analysis were observed labor, fuel and maintenance, and fixed investment requirements. These are expressed in $/t to incorporate the loss differentials between alternate systems. No attempt was made to ascribe increased value to improvements in quality that resulted from use of the mechanical systems, although this would accentuate the differences.

Two methods of estimating costs were considered in the analysis. One was based on a contractual harvesting-threshing fee paid in kind. The second was calculated using an imputed wage rate of $0.14/h (₱1/h) for actual labor.

In the Central Luzon pilot trials, both harvesting and threshing activities utilized hired or exchange labor from the village itself or from neighboring communities. Compensation for labor is usually in kind and harvesting and threshing are considered a joint operation. It the cost estimate, the harvester-thresher's fee was 1/6 of the gross production.[1] For the traditional system, the harvesting-threshing fee amounted to $23.80/t (**Fig.** 5). With the axial-flow thresher (including the man-hour requirement for harvesting and threshing[2]), costs were reduced by 60 percent to $14.30/t.

Inspite of the high contractual fee for harvesting and threshing, farmers in the study area were still willing to pay the fee plus the added cost for using the thresher. According to the farmers, the harvester-thresher's fee ensures that the field is cleared immediately following harvest, a major problem under the traditional system where threshing was carried out in the field and straw disposal is a problem. With mechanical threshers, paddy is hauled and stacked along levees or roads where it is accessible to the equipment. Immediately following threshing, straw is either spread along the dike, scattered in the road or burned.

The improved drying system incurred a total cost of $4.40/t, $3.97 of which was for the opera-

[1]Average production was 77 bags per hectare or 3.85 tons.

[2]Harvesting utilized an average of 43 m-h/t and manual threshing, 40 m-h/t.

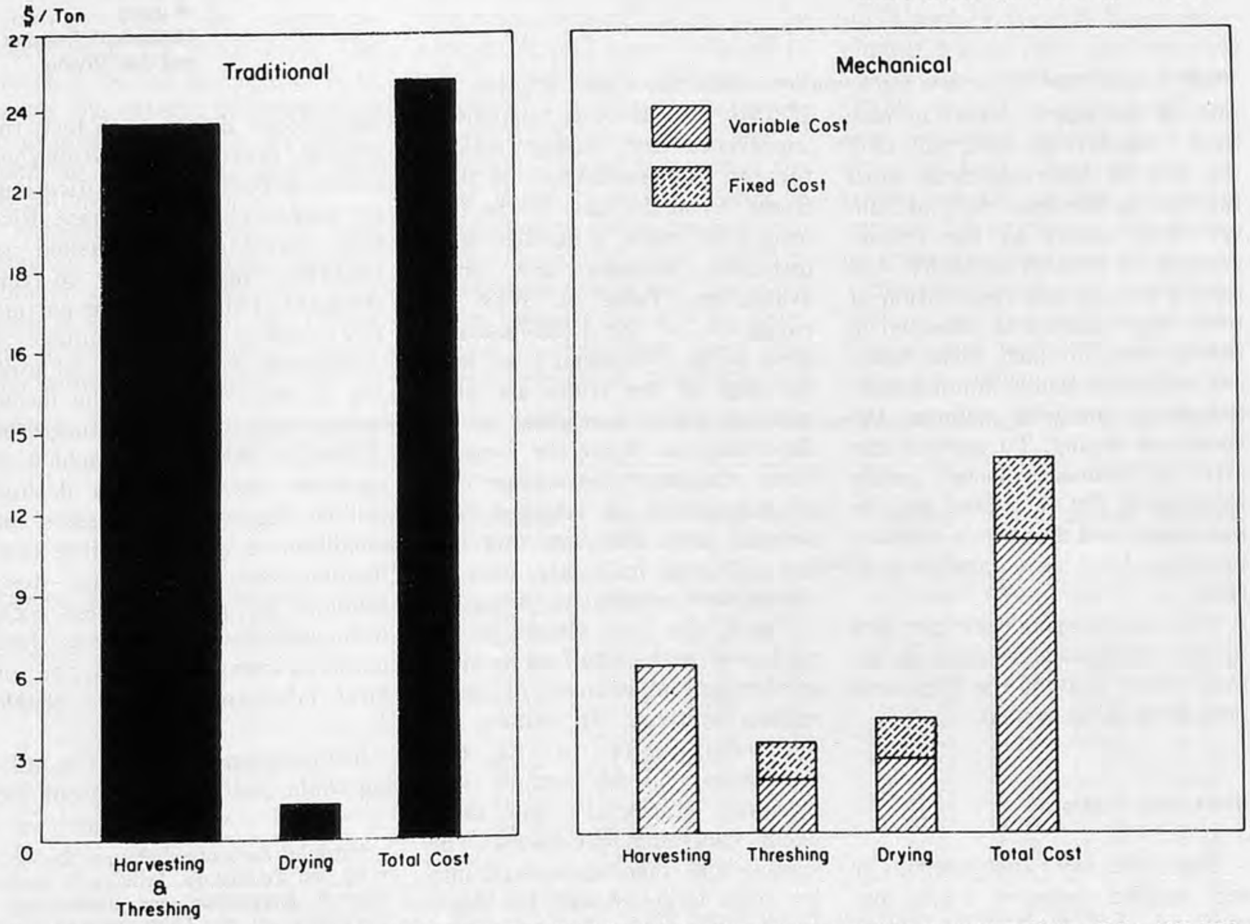


Fig.5a. Cost estimate (based on contractual harvesting and threshing fee) for alternate post-production systems, Nueva Ecija, 1975-1976.

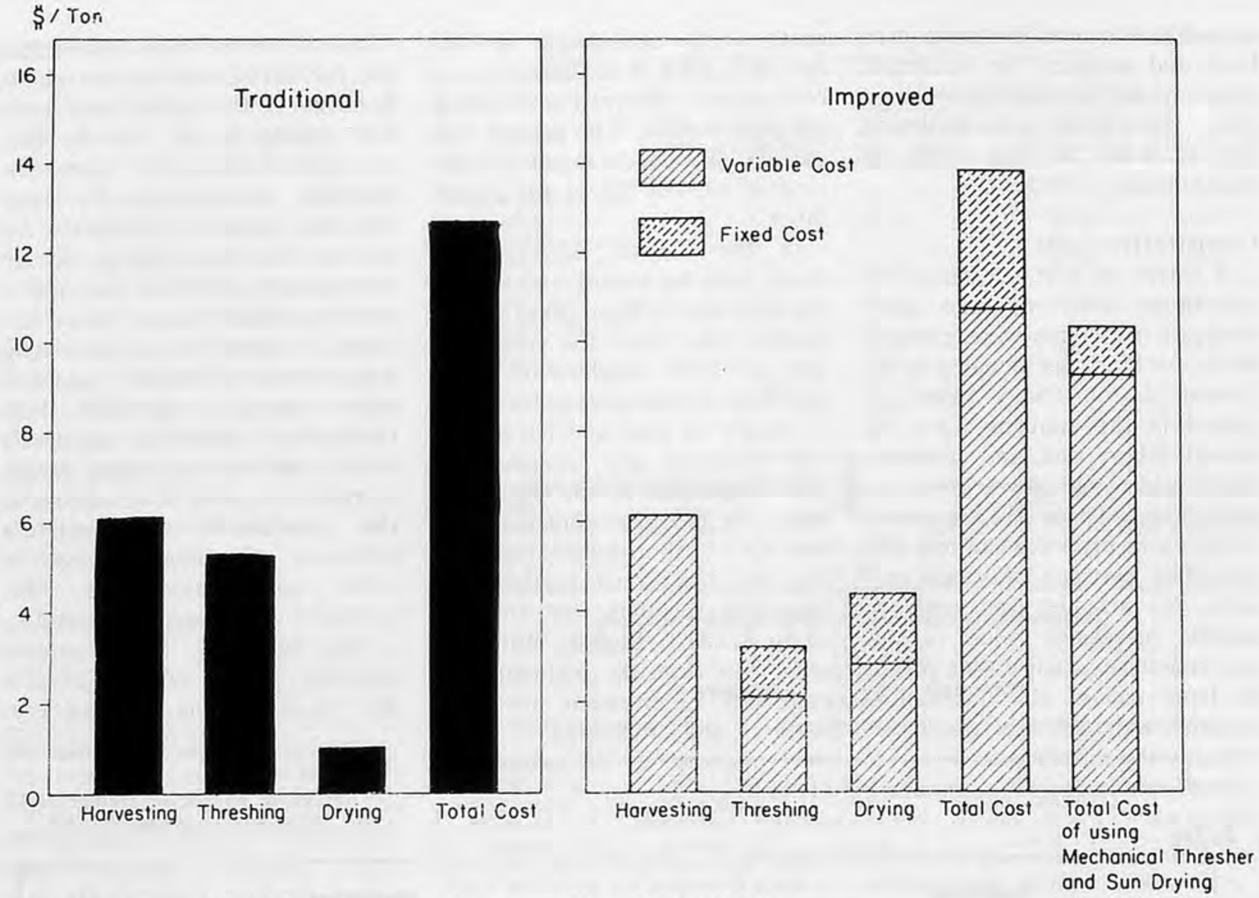


Fig.5b. Cost estimate for alternate post-production systems, Nueva Ecija, 1975-1976.

tion of the batch dryer. In contrast, sun-drying incurred only the cost of labor. Because most farmers in the area did not sun-dry their paddy to the recommended 14 percent moisture content, a serious underestimation of total labor hours was observed in this process. In fact, most farmers sell their paddy immediately following threshing without the benefit of drying. To prevent this error in future trials, all paddy included in the field trial will be purchased and dried to a uniform moisture level as a condition of sale.

The total expenditure per ton in the traditional system was almost twice that of the improved post-production system.

Mill Level Trials

The mill level demonstration and applied research trials are confined to the Bicol area. UPLB[1] is proving manpower, supervision and testing facilities for the implementation of these trials. As in the case of the field level pilot trials, a number of alternative systems are under evaluation (**Table 6**). With the exception of the IRRI-improved steel huller ("kiskisan"), all mills included in the trials are commercial units operating in the Bicol Region. While the focus of these studies is the village mill, an assessment of selected commercial level disc-cone and rubber roll-type mills are also included for comparative purposes.

There are four stages in the mill level trials. The first involves a technical assessment of seven milling systems. To reduce experimental error, a 35 ton, homogenous paddy sample was procured, threshed and dried under controlled conditions. The sample was then segregated into lot sizes large enough for replicated test runs through each milling system. Before each test, the milling degree was established using government specifications for second class milled rice. Rice mill operators were asked to calibrate their system to this standard. This procedure partially eliminates bias attributable to differences in the degree of milling. In the trial runs, the initial sample was used to: a) purge the system, b) charge the machine, c) calibrate the mill to a desired milling degree, and d) assess the condition of the mill before conducting the performance test. Samples of paddy, milled rice, bran and other by-products were gathered during each trial run for later laboratory analysis (**Table 7**).

In the second stage of the milling trials, paddy from each of the

[1]Dept. of Agricultural Process Engineering and Technology, Institute of Agricultural Engineering and Technology, University of the Philippines at Los Baños.

Table 6. Alternative milling systems.

Systems	Pre-cleaning	Hulling	Husk aspiration	Whitening	Refining
I[1]	None	Engelberg	Air trap	Engelberg	Leather polisher
II[2]	Scalper-sieve	Stone-disc	Air trap	Cone	Leather polisher
III[3]	Scalper-sieve	Rubber roll	Aspirator	Abrasive friction	Leather polisher
IV[4]	None	Rubber roll	Air trap	Kiskisan	None
V[5]	Sieve	Stone-disc	Air trap	Kiskisan	None
VI[6]	None	Rubber roll	Aspirator	Friction	None
VII[7]	None	Engelberg	Air trap	Engelberg	None

[1] One pass system (local Engelberg).
[2] Conventional cono type rice mill.
[3] Japanese multipass rice mill (Satake).
[4] Rubber roll huller-Engelberg whitener rice mill (BRBC proposed mill).
[5] Stone-disc huller-Engelberg whitener rice mill.
[6] One pass Japanese rice mill (Kyowa).
[7] IRRI improved Engelberg.

Table 7. Measurements performed in each milling system.

Operation	Measurements
Pre-cleaning	Moisture content, crack ratio, dockage, weight/1000 grains
Hulling	Brown rice, broken, dimensions, hardness
Husk aspiration	Loss in sound grains, loss in immature grains
Whitening	Head grains, broken grains, brewer's rice, dimensions, milling degree

field level systems mentioned earlier is subjected to a series of similar trials. These tests are confined to the disc-cone ("cono") and steel huller ("kiskisan") mills commonly used by farmer-co-operators in the study area. The objective of the latter tests is to assess the effects of pre-milling field level harvesting, threshing, handling and drying techniques on milling performance.

A third phase of the mill-level analysis is to monitor a selected number of operating rice mills over a one-year period. During this phase of the study, paddy and milled rice samples will be obtained periodically. Records indicating the volume of paddy procured and processed will also be maintained. Monitoring will be confined primarily to village level rice mills, although there will be a range of mill types included to permit comparative analysis.

Finally, a mill level survey involving 45 kiskisan mills and 12 cono mills located throughout the Bicol River Basin area will be undertaken to assess their technical, economic and social viability. In addition, users and non-users of the sample mills will be interviewed to determine their attitudes, preferences, problems and recommendations regarding improvements in milling and processing technologies.

Comparative Milling Tests

Because disc-cone and steel-huller mills are the two most popular milling technologies in the Bicol area, the evaluation team was able to assess four mills within each of these categories. However, because other milling techniques are not commonly used in the area, only one mill was tested for the five remaining milling systems (see **Table 6**).

Results from the commercial milling tests showed the highest total milling recoveries for mills using rubber-roll hullers. Disc-cone and steel hullers followed in that order. This finding is based on the mean performance of each mill type. Close examination of total milling recoveries for two cone-type units showed recoveries of 71 and 70 percent which were slightly higher than was obtained from the rubber-roll hullers (**Table 8**). A simillar condition was also noted for one steel huller which had a total milling recovery of 67 percent which is comparable to the output obtained from the cone-type mills.

Systems employing multipass milling (as exemplified by one Satake and the cone-type units) obtained higher head rice re-

Table 8. Preliminary results from commercial and laboratory milling tests for six alternative milling technologies in the Bicol River Basin Area, 1976.

Milling System	Commercial milling[1]					Laboratory milling			
	Actual capacity (kgs/hr)	Milling recovery	Head rice	Broken rice	Brewer's rice	Milling recovery	Head rice	Broken rice	Brewer's rice
		(percent)							
Rubber roll single pass (Kyowa)	225	69.75	60.55	38.50	0.95	72.65	82.94	14.97	2.09
Rubber roll multipass (Satake)	4,200	69.43	77.71	21.94	0.35	71.33	80.00	17.25	2.75
Rubber roll kiskisan combination	300	68.47	59.05	40.50	0.45	71.31	86.07	11.50	2.43
Cono (ave.)[2]	630	68.36	74.55	24.61	0.84	70.90	80.22	17.37	2.41
a. Libmanan RM	800	71.10	72.91	26.17	0.82	73.10	84.35	14.00	1.65
b. Concina RM	600	69.90	72.32	26.45	1.23	71.12	79.44	18.16	2.40
c. Gonzales RM	900	67.88	78.45	21.03	0.42	70.06	80.46	16.69	2.85
d. Nazarrea RM	225	64.56	74.52	24.78	0.70	69.33	76.62	20.63	2.75
Stone disc kiskisan combination	444	65.56	53.68	43.63	2.69	68.80	80.00	17.67	2.33
Kiskisan (ave)[2]	380	64.50	29.18	68.86	2.06	72.29	81.19	16.45	2.36
a. Torres RM	585	66.70	26.60	67.37	2.41	72.11	83.19	14.79	2.02
b. Olaño RM	270	65.09	38.23	77.00	1.67	70.87	82.32	15.42	2.26
c. Dycoco RM	410	63.26	21.75	60.08	1.25	72.12	80.70	16.45	2.88
d. Ruta RM	240	62.93	30.12	70.99	2.47	74.06	78.56	19.13	2.31

[1] Tests for each milling system were replicated four times (4x).
[2] These are mills selected within the pilot areas of the farm level demonstration and applied research trials.

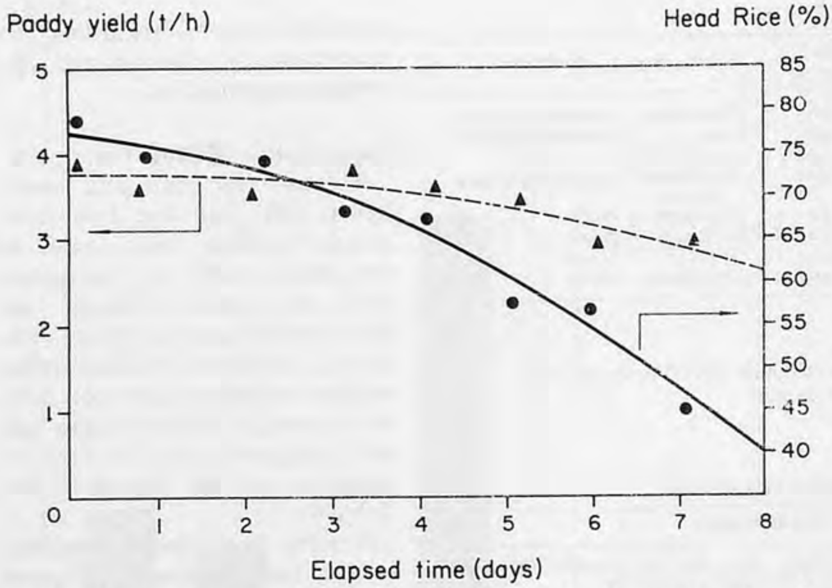


Fig.6. Qualitative and quantitative effects of timeliness in Post-harvest Operations. Average of 52 sites, Nueva Ecija, 1975 wet season.

coveries—ranging from 72 to 78 percent—compared to systems using pass milling (as exemplified by the steel huller and the stone disc-steel huller combination). The difference in hear rice recovery in multipass milling can be attributed to the fact that grains are subjected to less pressure during the whitening process and removal of the bran. In single-pass milling, the grain is under high pressure with concurrently higher temperatures which results in excessive breakage. Moreover, single-pass mills do not have paddy separators, allowing unhulled paddy to mix with brown rice during the whitening process. The mixture of unhulled paddy and brown rice increases frictional forces in the whitening process resulting in further breakage.

Among the six alternative milling technologies tested, the steel-huller mill gave the lower total and head rice recovery. However, when the steel-huller is used as a whitener in combination with a rubber-roll or stone-disc huller, significantly higher total and head rice recoveries were obtained.

To gauge the performance of the commercial mills included in the technical assessment stage of the trials, a series of laboratory milling tests were conducted on the same paddy samples used in the commercial milling tests. The preliminary results showed that the Satake rubber-roll huller produced milling rates comparable to those obtained in the laboratory.

Concluding Remarks

The major objectives of the field level trials appear to have been met. We have been able to estimate the degree and nature of grain loss in several components of the rice post-production system. There is need for further replication of the trials to verify the reliability of the methodology and to investigate factors other than technology which affect the efficiency of these operations. Considerably more work is required at the mill level to assess comparative milling performance and to quantify the utility of milling services by location, size and type of service provided.

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Increasing Insecticide Efficiency in Lowland Rice

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Abstract

Cooperative research among engineers and entomologists led to the development of an applicator for injecting insecticide into the root-zone of rice plants. Root-zone placed insecticides provided more effective insect control and higher profit than foliar sprays and broadcasting of granules, and was compatible with paddy fish culture.

The great scientific challenges that face the modern world will, in all probability be solved by teams of scientists from varied disciplines. It is common knowledge that man's efforts to visit the moon, explore it and return safely required the best efforts of many biological and physical scientists working in harmony. Similarly, controlling environmental pollution and solving the energy dilemma will require the best efforts of the world's scientists from many disciplines.

The formidable problem of feeding the growing population of the world is often considered a problem for the biological scientist; however, there are aspects of the problem that will require the help of engineers and social scientists. This paper deals with one aspect of the food shortage problem that is being worked on by a multi-disciplinary team of scientists at the International Rice Research Institute in the Philippines (IRRI).

There are 1.3 billion people that depend on rice for more than one half of their diet. This rapidly growing segment of the world population has been affected by past food shortages and it seems certain to be the hardest hit in the future unless really significant progress can be made in increasing rice yields in farmer's fields.

Various factors such as poor water and fertilizer management, inadequate land preparation, and pests and diseases prevent farmers from obtaining yields achieved at experiment stations. IRRI economists refer to the difference in potential yields and actual yields as the "yield gap." Experiments conducted in farmers' fields in Laguna, Province, Philippines indicate that insects are one of the major causes of the yield gap (IRRI, 1976) causing a yield decrease of about 1 ton/ha. Similar results would be expected throughout most of Tropical Asia.

There is little doubt that rice pests cause significant economic losses in the tropics, but, it is at times difficult to show a profit when applying insecticides, due to their high costs and inefficient utilization. Much of the insecticide applied to rice does not benefit the plants. Foliar sprays and broadcast application of granules are the most common methods of insecticide application in rice. Foliar sprays have been less than satisfactory because of

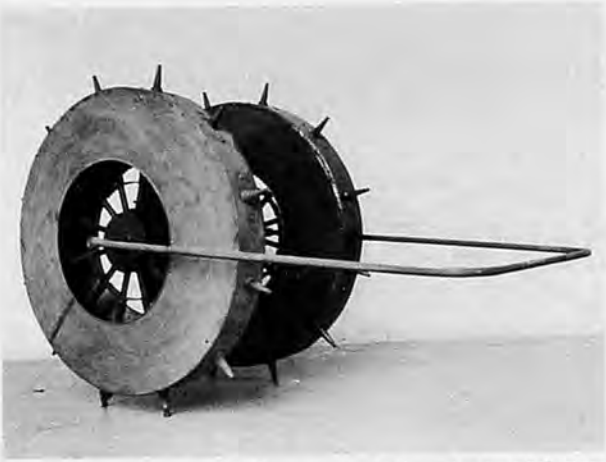

Fig.1. Slurry injector with the cam operated master type injectors.

Fig.2. Four-row peristaltic pump liquid injector.

the thick canopy which is not easily penetrated, effect of the environment, especially rains on the residual activity and the difficulty of controlling internal feeders such as the whorl maggot and stem borers which are protected inside the plant. Foliar sprays only provide protection for about 10 to 15 days. With the development of granular insecticides (Pathak, 1968) the duration of effediveness was increased to 20 or 30 days. However, insecticides placed in the paddy water were still subject to rapid degradation by sunlight and high temperature and susceptible to being diluted and washed out of the paddies during heavy rains.

In an attempt to maximize insecticide efficiency by lengthening the residual period and thus decreasing number of insecticide applications, the root zone concept of application was developed (Pathak et al., 1974). One application of insecticide in capsular form near the root-zone provided season-long protection of certain pests. Gas chromatographic analysis comparing root-zone application of capsules and a broadcast application indicated 220 times more insecticide in the leafblade at 20 days and 4 times as much as 80 days after treatment in the foot zone application than the broadcast application (Aquino and Pathak, 1976). The root zone application of insecticides in gelatin capsules has been tested in several countries and has been found to provide effective control of a number of different rice pests (van Halteren et al., 1974; Anon., 1974 and Choi et al., 1975). However, production of capsular formulations has been considered to be too costly and the manual placement of capsules into the root zone too laborious for general acceptance by farmers. Thus, the International Rice Research Institute has developed several machines to facilitate the application of insecticides into the root zone of rice plants grown under flooded condition. This paper reports on the results of field experiments conducted with a 2-row liquid band injector. The primary objective of these experiments was to compare the performance of that injector with conventional methods of application in relation to pest control effectiveness.

Several injector devices were developed prior to the one used in these experiments. In 1974 a slurry injector consisting of a series of cam operated piston type injectors was tried (**Fig. 1**). The prototype machine was heavy, complex and prone to service problems. This approach was abandoned in favor of a 4-row injector (**Fig. 2**) which used a tandem peristaltic pump arrangement mounted directly on a pair of ground wheels.

Four tubes connected to the feed tank were wound around a set of three rollers on the ground wheel axle and then connected to the injector nozzles. A tensioning device maintained sufficient tension on the tubes to give peristaltic pumping action as the rollers rotated with the axles. The pitch diameter of the rollers was adjustable to provide a means of adjusting the application rate. The injector nozzles were mounted on small skids to limit their depth of penetration to 10 cm. In experiments conducted by IRRI's Entomology Department, the performance of this device gave results almost comparable to that obtained with capsule placement methods; howerer, users did not like the machine's heavy weight and bulkiness and found it difficult to pull through the mud.

Fig.3. Manually operated granular chemical applicator.

A push-type deep-placement granular applicator patterned after a Japanese design was tried next (**Fig. 3**). This single row machine had a 6 kg capacity hopper with a fluted ground-driven roller in the hopper bottom. A metering plate under the fluted roller with predetermined hole sizes was used to regulate application rates. The hopper assembly was mounted on a small skid with a furrow opener beneath, through which granules fell to the furrow bottom. Two small furrow closers mounted on the tail of the skid sealed the granules in the mud. This machine was tested by the IRRI Entomology and Agronomy Departments for use in experimekts on insecticide and fertilizer placement. It worked fairly good on small experimental plots, especially with insecticides. Problems were encountered in farmers' fields with larger areas in which soil preparation was inadequate. The high humidity in lowland rice caused caking of hygroscopic chemicals, and some farmer's plots lacked water, causing hardening of the soil surface which made the applicator difficult to push. The granular applicator was more acceptable from a maneuverability standpoint than the more bulky applicators tried previously. Nevertheless, the problems encountered resulted in a decision to attempt developing a compact liquid injector. Using a liquid form, a chemical has several advantages over granular formulations:

1. Pushing effort needed to inject liquid in the root zone is less since the liquid applicator's furrow opener can be narrower than those for the granule applicator.
2. Placement of the chemical in liquid form can be more precise than granules which tend to scatter during placement.
3. The wetting of granules due to their hygroscopic nature is not a problem when using the liquid injection method.
4. Generally, the granular chemical formulations are more expensive than wettable powders or emulsifiable concentrates.

A 2-row liquid injector was developed which consists of two 3 mm diameter injectors attached to the tail end of small skid with narrow furrow openers. The injectors are connected to a back-pack-style, 10 liter chemical tank by a metal tube and plastic hose. The metal tube also acts as a structural member (**Fig. 4**). Liquid is fed from the tank to the nozzles by gravity. The skid is mounted to the metal tube in such a way that the skid angle can be adjusted for proper planning on the mud surface to keep the nozzle from penetrating too deeply. Application rate is controlled by inserting orifices in the tubes to the nozzles. To stop the flow of liquid when the operator reaches the end of a row, he simply raises the nozzles above the tank level. A stop cock is

Fig.4. Two-row liquid band applicator in operation at 3 days after transplanting.

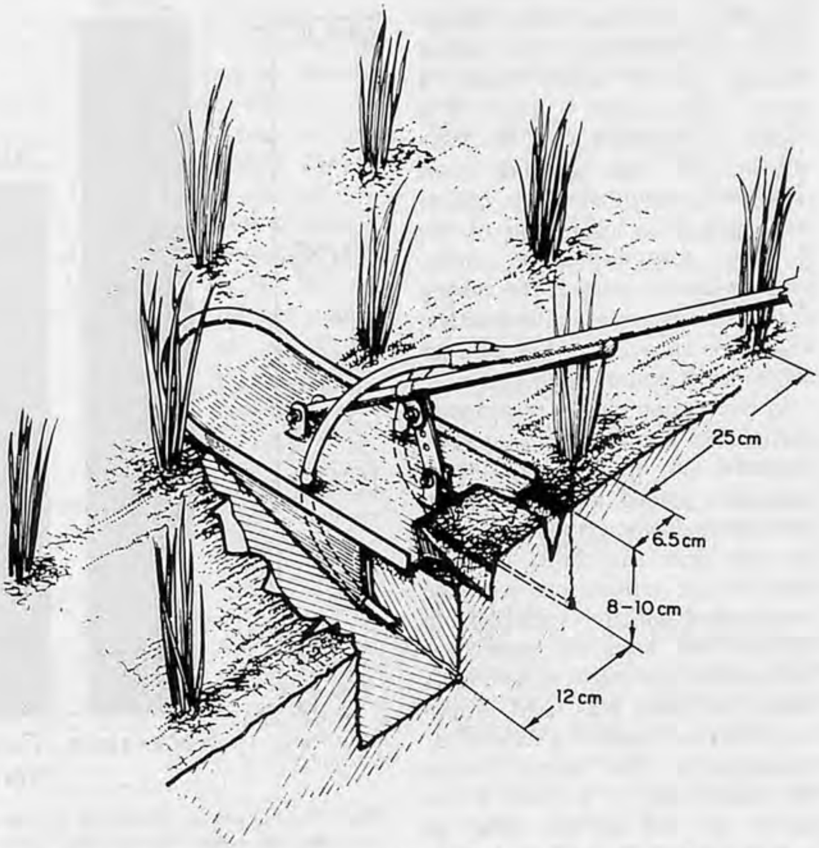

Fig.5. Four-row liquid injector skid assembly. Placement of liquid in relation to rice plants.

also provided on the tank.

Occasionally the nozzles clog due to the operator inadvertently puppling the injector backwards. A flow indicator was added so that a clogged condition of either nozzle could be detected during operation. Also several nozzle configurations were tried to minimize this problem.

Experiments were conducted on the IRRI farm and Central Luzon State University at Muñoz using this 2-row liquid injector. To determine the applicability and acceptance of the injector by farmers, tests were conducted in farmers' fields around Laguna de Bay near Los Baños. The injector was compared with several other application methods; capsules in the root-zone, root coat, broadcast application of granules and foliar sprays.

Field preparation and cultural practices were similar to that reported by Aquino and Pathak, 1976. For the gel root coat treatment, seedlings were dipped for a few minutes into heated mixture of 89 parts water, 6 parts gelatin and 5 parts of a flowable formulation of carbofuran. In the seedling soak treatment, seedlings were placed overnight in a suspension of the flowable formulation of carbofuran which covered the roots. Foliar sprays were applied with a knapsack sprayer at the rate of 300 liters of water per hectare.

In the root zone treatments carbofuran was placed in gelatin capsules and the capsules were manually placed about 2 cm to the side and below the surface of the soil near the roots. Dilution rate for the applications with the liquid band injector varied from 200 to 1000 liters of water per hectare but for most experiments about 300 liters was used. Applications were made 3-5 days after transplanting. The injector places the insecticide in a band 6 cm below the soil surface (**Fig. 5**) and within 7 cm of the roots in a 25 cm row width. Carbofuran was the insecticide chosen for the tests as it has proven to be most effective in root zone application (IRRI, 1974).

Results were obtained on the effectiveness of the root zone application of carobufran when applied with the liquid band injector against the major insects attacking rice in the Philippines. Results were also obtained on the simultaneous application of insecticide, fertilizer and herbicide and the compatibility of the root zone method with paddy fish culture.

Results

The initial experiment conducted during the wet season of 1975 indicated that one application with the injector shortly after transplanting provided insect control superior to that of one broadcast application, root coat, treatment and four foliar sprays. Yields in the root zone application were three times that of the broadcast treatment (**Fig. 6**). Due to heavy rains, the broadcast granules were washed out of the paddy and foliar sprays also failed to provide adequate residual protection.

Whorl maggot

Attack by the whorl maggot begins immediately after transplanting and lasts for about 40 days. There is no commercial variety with a high level of resistance to this pest. This pest has risen from a minor pest of no economic significance to a pest

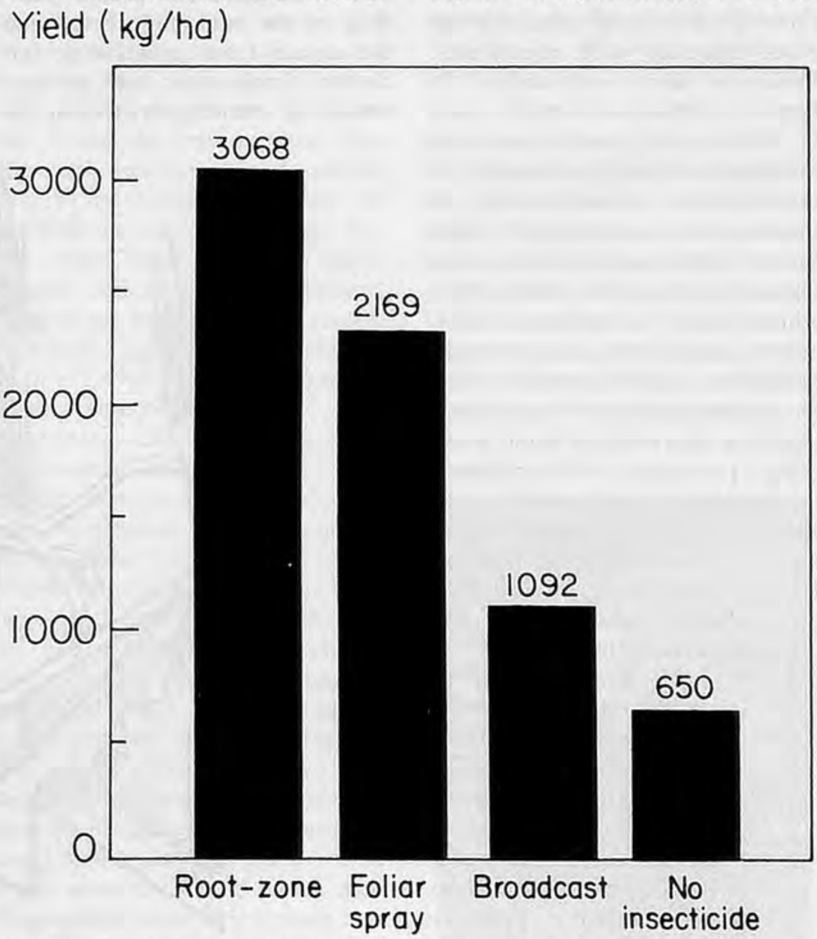

Fig.6. Yield of rice as affected by various methods of insecticide application. Carbofuran at 1 kg a.i./ha was applied 3 days after transplanting into root zone and as a broadcast treatment. Monocrotophos was applied four times at 20 day intervals as a foliar spray. At 0.75 kg a.i./ha. IRRI, 1975 wet season.

Table 1. Whorl maggot, Hydrellia philippina control with root-zone and broadcast applications of carbofuran. IRRI, 1976.

Method of insecticide placement	Rate (kg a.i. /ha)	Whorl maggot damage[a]
	Test 1	
Root zone (injector)	1	0
Broadcast	1	7
No insecticide		8
	Test 2	
Root zone		
Capsules	2	0
Injector	2	0
Capsules	0.5	0
Injector	0.5	3
No insecticide		9

[a]: Based on a scale of 0.9:
0 = no damage
9 = severe damage

causing economic losses in the Philippines. In a test of some of the latest IRRI varieties and breeding lines root-zone application provided excellent control while one broadcast application was not sufficient to provide protection for the entire period of whorl maggot attack (**Table 1**). In test 2, the injector was compared to the capsule treatment. At rates of 2 kg/ha both methods provided equal and excellent control. However, at the 0.5 kg/ha rate capsules were more effective.

Green leafhopper

The green leafhopper Nephotettix virescens feeds on rice from the seedling stage to harvest. It seldom builds up to sufficient numbers to cause direct feeding damage but is economically important because of its vector relationship with tungro virus. Tungro virus attack is most severe during the early tillering phase and protection for 45 days after transplanting is generally considered adequate. In a test comparing broadcast with root-zone application, one application in the root zone was superior to the one broadcast application, producing 1,790 kg more rice (**Table 2**). One root-zone application was equal to four broadcast applications. Due to a high population of the virus vector, there was no yield without insect protection. Despite the higher

Table 2. Control of the tungro virus vector the green leafhopper, Nephotettix virescens with carbofuran as broadcast and root-zone applications with a liquid band injector at 1 kg a.i./ha.[a] Variety IR22. IRRI, 1976 wet season.

Treatment[b]	Applications	Leafhoppers/10 sweeps 47 DT	Tungro virus (%) 97 DT	Yield (t/ha)	Income[d] (US$/ha)
Broadcast	1	25[c]	68[b]	1.302[b]	147
Broadcast	4[c]	9[ab]	33[a]	2.516[a]	222
Root-zone	1	3[a]	20[a]	3.092[a]	375
No insecticide		212[d]	100[c]	0[c]	0

[a]: In a column, all means followed by the same letter are not significantly different at the 5% level (Duncan's Multiple Range test).
[b]: All treatments applied 3 days after transplanting (DT).
[c]: The four broadcast applications were made at 20 days intervals.
[d]: Income = value of rice − cost of insecticide application. Cost of 1 kg granules used in broadcast = $30/kg a.i. and flowable formulation used in root zone = $46/kg a.i.

cost of the formulation used in the root-zone application, it was the most profitable treatment because of more effective control of tungro virus.

White-backed planthopper

Although much less important than the brown planthopper, Nilaparvata lugens, the white-backed planthopper, Sogatella furcifera, occurs throughout Asia and is capable of developing population numbers which can directly damage the plants causing "hopper burn". On the IRRI farm, high populations develop early but decrease towards the end of the tillering phase. In both tests conducted (**Table 3**), the liquid band injection into the root zone provided protection superior to that of the broadcast application. In test 2, the 0.5 kg rate had one-tenth the hopper population as the broadcast application at 1.0 kg.

Table 3. Control of the white-backed planthopper, Sogatella furcifera broadcast and root-zone liquid band injection applications of carbofuran.[a] IRRI, 1976.

Treatment[b]	Rate (kg a.i. /ha)	Number of Planthoppers[c]
	Test 1	
Root zone	1.0	3[a]
Broadcast	1.0	19[b]
No insecticide		34[b]
	Test 2	
Root zone	0.5	61[a]
Broadcast	1.0	664[b]
No insecticide		1,345[c]

[a]: In a column, means followed by a common letter are not significantly different at the 5% level (Duncan's multiple range test).
[b]: All treatments applied once at 3 days after transplanting.
[c]: Counts in test 1 taken 45 days after transplanting and in test 2 taken at 40 days.

Yellow stem borer

Populations of the yellow stem borer, Tryporyza incertulas have generally been to low on the IRRI farm to accurately assess the effectiveness of the injector. However, in an experiment conducted on a farmers' field near IRRI, applications of both 1 and 2 kg/ha provided control of the an early infestation of the yellow stem borer (**Table 4**). There was no significant difference between the 1 and 2 kg/ha rates.

Table 4. Control of yellow stem borer, Tryporyza incertulas, with root-zone application of carbofuran.[a] Variety IR1561. Cabuyao, Laguna, Philippines, 1976 dry season.

Treatments (kg a.i./ha)	Deadhearts (%) 30 DT	Deadhearts (%) 61 DT
1	0.6[a]	1.4[a]
2	0.3[a]	0.6[a]
No insecticide	8.1[b]	8.7[b]

[a]: In a column, means followed by a common letter are not significantly different at the 5% level (Duncan's Multiple Range test).
[b]: Insecticide applied with a liquid band injector at 10 days after transplanting (DT).

Leaffolder

Leaf folder Cnaphalocrosis medinalis usually occurs after flowering. Foliar sprays are most commonly used for control of this pest. However, one root-zone application shortly after transplanting is sufficient for season-long control even at low rates of 0.5 kg a.i./ha (**Table 5**). There

Table 5. Rice leaffolder, Cnaphalocrisis medinalis control with root-zone applications of carbofuran.[a] Variety IR29. Cabuyao, Laguna, Philippines, 1976 wet season.

Treatment	Leaves damaged (%) 71 DT[b]
Applied once at 10 DT[b]	
0.5kg	6 [b]
1.0kg	4 [ab]
Applied twice at 10 and 30 DT	
0.5kg	1 [a]
1.0kg	0 [a]
No insecticide	65 [c]

[a]: In a column, all means followed by a common letter are not significantly different at the 5% level (Duncan's multiple range test).
[b]: DT=days after transplanting.

was no significant advantage of split applications.

Brown planthopper

Within the last 4 years, the brown planthopper has become a major pest of rice in the Philippines, Vietnam, Thailand, Indonesia, Sri Lanka, and India. Due to its habit of feeding on the stem near the water surface, it is difficult to effectively penetrate the canopy with a foliar spray the contact the pest. In fact, we have found an excellent way to dramatically increase the hopper population is to apply foliar sprays of certain chemicals above the canopy.

To determine the effectiveness against the brown planthopper, applications at 2 and 0.5 kg with the liquid injector were compared with capsules (**Table 6**). At 36 days after treatment (DT) control at both rates in the capsule treatments and the 2 kg injector rate was equal to and greater than that of the 0.5 kg injector rate. However, control at the 0.5 kg injector rate was still satisfactory. At 45 DT, control provided by both rates in the capsule treatment was equal and superior to that of both injector rates.

Insecticide-fertilizer-herbicide mixtures

Fertilizer efficiency in root-zone applications has been shown to be much greater than that of broadcast applications (IRRI, 1976). It would be advantageous to apply urea simultaneously with insecticide to decrease cost of application. However, carbofuran is reported to be unstable in an alkaline media. Since urea is alkaline, we wanted to determine whether carbofuran deterioration would be manifested in poor insect control. Thus, an experiment was conducted to determine the compatibility of carbofuran, urea, and 2-4D when mixed with water and applied simultaneously to the root zone. Results indicated that neither the fertilizer nor the herbicide had an adverse effect on the insecticide as indicated by control of the tungro virus vector, the green leafhopper (**Table 7**). Weed control was more effective where 2-4D was broadcast than applied in the root zone.

Fish culture and insect control

The culturing of fish in rice paddies is one way of increasing farmers' income and at the same time providing much needed animal protein for the human diet. Since fish and rice are the

Table 6. Control of the brown planthopper, Nilaparvata lugens with root-zone applications of carbofuran as capsules and with a liquid band injector.[a] Variety IR20. IRRI, 1976.

Treatment[b]	Rate (kg a.i./ha)	Number/10 sweeps	
		36 DT[c]	45 DT[c]
Capsules	2.0	9 [a]	1 [a]
Injector	2.0	13 [ab]	34 [b]
Capsules	0.5	8 [a]	6 [a]
Injector	0.5	32 [b]	71 [b]
No insecticide		845 [c]	302 [c]

[a]: In a column, means followed by the same letter are not significantly differnt at the 5% level (Duncan's multiple range test).
[b]: Applied once at 5 days after transplanting.
[c]: DT=days after treatment.

Table 7. The effectiveness of root-zone applications of carbofuran against the green leafhopper, Nephotettix virescens when mixed with nitrogen fertilizer and herbicide applied simultaneously in the root zone or separately as a broadcast application.[a] Variety IR22. IRRI, 1976 dry season.

Treatment[b]	Green leafhopper/10 sweeps 41 DT	Virus (%) 113 DT	Weeds/m² 30 DT	Yield (t/ha)
Carbofuran (RZ)+Urea (RZ)	2[a]	8[a]	10 [cde]	4.006[a]
Carbofuran (RZ)+Urea (B)	2[a]	6[a]	22 [de]	3.865[a]
Carbofuran (RZ)+Urea (RZ) +2-4D (RZ)	0[a]	7[a]	4 [bcd]	4.112[a]
Carbofuran (RZ)+Urea (RZ) +2-4D (B)	1[a]	6[a]	0 [a]	4.025[a]
Control (Urea (RZ))	35[b]	62[b]	9 [bcde]	0.569[b]

[a]: In a column, all means followed by a common letter are not significantly different at the 5% level (Duncan's Multiple Range test).
[b]: All treatments root-zone (RZ) and broadcast (B) applied at 3 days after transplanting (DT). Carbofuran applied at 1 kg a.i./ha, urea at 60 kg N and 2-4D at 0.8 kg.

Table 8. Yields of IR34 rice and fish, Tilapia mosambica as affected by carbofuran root-zone and broadcast applications.[a] Central Luzon State University, 1976 dry season.

Method	Cost of insecticde application (US$/ha)	Rice yield (t/ha)	Fish[b]		
			Yield (kg/ha)	Value (US$/ha)	Income[c] (US$/ha)
Broadcast					
1 kg at 3 DT	30	4.919 [bc]	141	115	673
1 kg at 3, 23, 43, & 63 DT	120	4.935 [abc]	0	0	552
Root-zone					
1 kg at 3 DT	46	5.116 [ab]	166	136	786
2 kg at 3 DT	92	5.613 [a]	150	123	794

[a]: In a column, means followed by a common letter are not significantly different at the 5% level (Duncan's multiple range test).
[b]: Fish seeded 7 days after first insecticide application at the rate of 3000/ha.
[c]: Income=value of rice+fish minus insecticide and application costs. Based on price of rice at $0.82/kg.

Filipinos' main diet, research on fish culture in the rice paddies has been given a priority status in the Philippines. Experiments at the Freshwater Aquaculture Center at Central Luzon State University have indicated that application of pesticides is generally not compatible with fish culture. Previous studies (IRRI, 1974) have indicated that concentration of insecticides in water when applied in the root zone is much lower than with broadcast applications. Results of one experiment conducted at Central Luzon University indicated that fish seeded 7 days after either a root-zone application or a broadcast application did not cause fish mortality (**Table** 8). However, in the treatment with four broadcast applications, fish mortality occurred within minutes after the second application.

The experiment indicated that the root-zone method is compatible with fish culture while a broadcast application of carbofuran after fish are in the paddy, is not. Income in the 1 and 2 kg/ha root-zone treatment was more than US$100 higher than in all other treatments, due primarily to control of the whorl maggot and safety of the treatment to fish.

Discussion

Application of carbofuran into the root zone with the liquid band injector provided excellent control of most rice pests and provides a more efficient use of insecticides than the application methods now commonly practiced by farmers, but is less effective than placement of insecticide in capsules near the roots. More data is needed on the effectiveness of one application in the root zone at transplanting on control of late infestations of the brown planthopper and stem borers. It is doubtful that brown planthopper migrants from neighbouring fields will be controlled late in the crop season. However, it is expected that an increase in populations of brown planthoppers within a treated field will at least be delayed to late in the season if not prevented altogether.

Additional information is needed to determine the effect of root-zone applied insecticides on the complex of parasites and predators attacking rice pests.

The fact that fertilizers and insecticides can be applied simultaneously without any apparent degradation of either is of great interest. It was expected that carbofuran might degrade when mixed with urea because of the alkaline conditions but there was no evidence of this as based on insect control. With the continually increasing costs of these inputs, application methods must be developed to provide for more efficient use of pesticides and fertilizer.

The time required to cover a hectare is about 12 hours which is 2-3 times that required for one foliar application. IRRI is currently developing a 4-row applicator which will cut the time of application in about half.

In tests on farmers' fields, it became evident that proper land preparation is essential. The machine is easy to push in well-puddled soil but becomes difficult to push when colds and organic matter are in abundance which is often the case when animal draft power, rather than mechanical power is used. Occasional clogging of the nozzles resulted from failure to consistently push the machine farward. Certain soil types consolidate rapidly after tillage and it becomes difficult to push the machine through the soil if application was not done within a short time after transplanting.

Liquid band injectors have been provided scientists in several countries and numerous trials have been conducted by farmers in the Philippines. Tests are currently being conducted by several research stations, pesticide companies and in farmers' fields.

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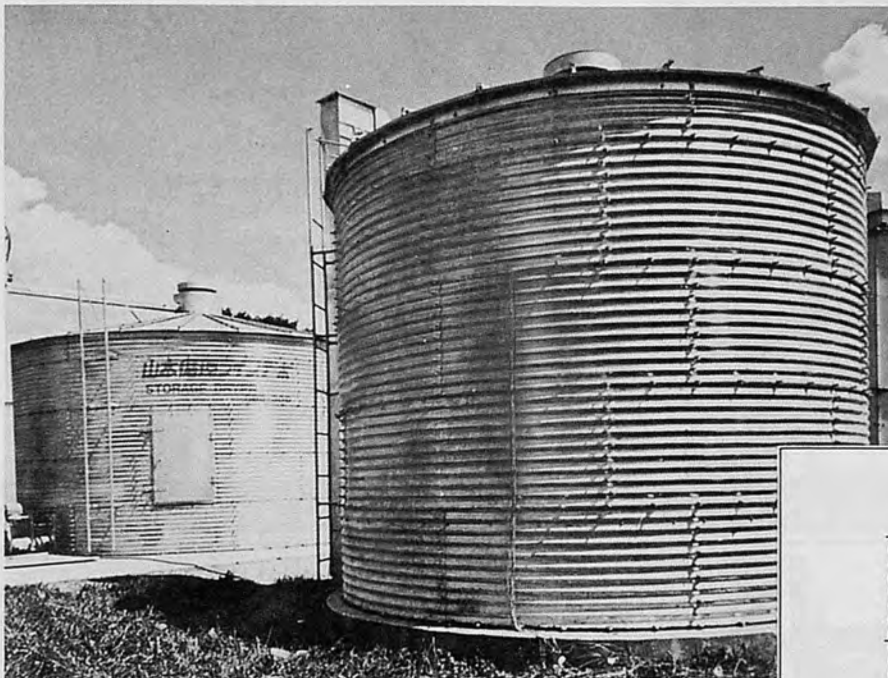

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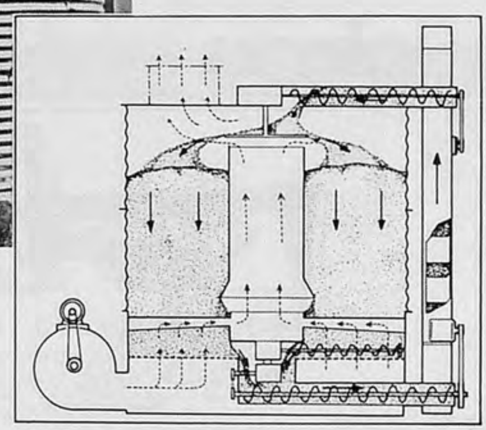

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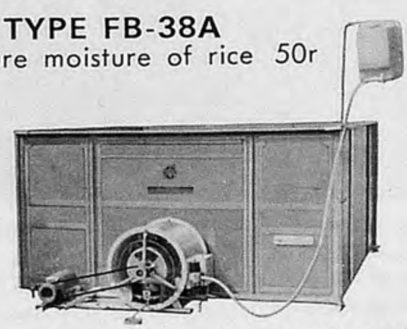

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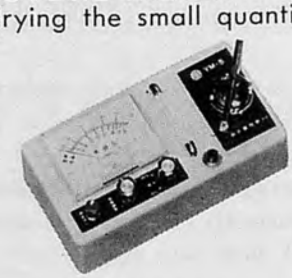

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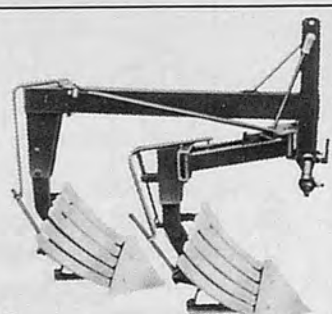

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Effect of Tractor Tire on Soil Compaction

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Introduction

The ultimate objective in designing a tractive device for Agricultural Implement is to provide the required traction without detrimental effect on soil structure. Soil compaction is defined as moving the soil particles close together thereby increasing soil bulk density by decreasing void ratio.

The direct effect of soil compaction such as resistance of the soil to root development and germinations of seed cannot be distinguished from indirect effects on soil and water, soil air and soil temperature relationship. Root growth in soil is dependent on temperature, moisture, pore space and mechanical resistance of the soil. All these parameters are changed in soil by compaction.

Causes of Soil Compaction

Causes of soil compaction are various, but the most important of them are (i) Rainfall (ii) Drying and weathering (iii) Movement of Farm Machineries over the soil and undue vibration associated to the machiners. The amount of soil compaction may be less for simple direct pressure than for a dynamic force caused by slippage of tractor tire. Amount of soil compaction is dependent on several soil properties (i) Moisture content of the soil (ii) Pore space (iii) Void ratio and also on the (iv) Type of soil. Gill and Miller (1956) pointed out that compaction results by thrust as well as vertical force. These actions give orientation of particles which may cause more compaction than one simple force.

Vomocil and Flocker (1961) indicated that an ideal root bed should have about 50 percent soil volume occupied by solids, 25 percent by water, and rest 25 percent by air when the soil has reached equilibrium by wetting. Experiments by him indicated that as soil are compacted prcductivity and plant growth decline rapidly when air space at field capacity are reduced to certain critical levels. Gill and Miller (1956) indicated that when the roots have to penetrate the compacted and hard soil mass, in order to maintain constant growth rate more oxygen are required because of increased metabolism. So compaction may retard the plant growth and development by restricting the oxgen diffusion to the root.

Mechanics of Compaction

Since compaction is brought about by the action of external forces action on the soil it is necessary to have a clear picture of the stress and strain distribution in the soil due to external forces under different conditions of loading. In eighty percent of the cases compaction is brought about by the action of Agricultural Machines on arable soil.

The pressure distribution under the tire, trailer of tractor depend of the amount of (i) load, (ii) size of contact area between the tire and the soil and (iii) the distribution of surface pressure within this contact area. The pressure distribution under the tire can be determined by considering the soil mas as a elastic semi infinite media of isotropic meterial under point loading. Frochlich inserted in the equations a correction factor 'V' that alters the distribution according to the factor. The concentration factor also takes into account varying soil strength.

$$\sigma_z = \frac{VP}{2\pi r^2} \operatorname{Cos}^{V} \phi \quad \cdots\cdots (1)$$

$$\sigma_n = \frac{VP}{2\pi r^2} \operatorname{Cos}^{V-2} \phi \operatorname{Sin} \phi \quad \cdots\cdots (2)$$

$$\sigma_t = 0 \quad \cdots\cdots (3)$$

$$\tau_n = \tau_z = \frac{VP}{2\pi r^2} \operatorname{Cos}^{V-1} \phi \operatorname{Sin} \phi \quad \cdots\cdots (4)$$

Different values of concentration factors 'V' are used for soils in various conditions such as hard, medium and soft soil. The concentration factors are used because of the fact that distribution of stress in isotropic medium and soil is not same. The compressive stress in a soil has a tendency to concentrate around the load axis. The tendency is more pronounced for plastic and less cohesive soil. According to Sohne (1958) the polar principal stress is more important for the compaction of soil. At the load axis $\sigma_r = \sigma_z$ and as ϕ increases σ_r becomes larger and larger.

It is also interesting to note from **Figure 1** that curves of equal principal stress in soils are circles for V=4 (hard soil) and becomes elliptical for increasing V.

Main drawback of the equation is that the tractor tire does not transfer load at point. Therefore 'P' in the equation should be replaced be PdA and the integration can be carried out numerically.

The tire tract in soil becomes deeper with increasing moisture content. The deeper the tire tract the larger is the contact area. For large smooth tire on hard surface uniform pressure distribution may assumed over the contact area. This is not true for plastic soils. These distributions are developed from load on a circle according to the formula:

$P = P\ max\ (1-(a/R)^{1/16})$

$P\ max = 1.125\ Pmean$

R = Radius of circular area

a = Distance of the point from the center of the circle.

For sandy clay soil fairly moist relatively dense. The distribution is fourth degree parabola.

$P = P\ max\ (1-(a/R)^4)$, $P\ max = 1.5\ Pmean$

For plastic flowing wet soil

$P = P\ max\ (1-a^2/R^2)$, $P\ max = 2\ P\ mean$.

However, tires have rubber lugs. The distribution is not exactly the same as shown. On hard soil entire load is carried by lugs and the soil is essentially compacted little. On more soft soil the pressure is distributed over the lugs and grooves.

Soehne (1958) carried out compaction tests in laboratory. The results indicated that change of porosity has a logarithmic relationship with pressure. The higher the moisture content the more pronounced is the change. But this happens upto certain moisture content the so called optimum moisture content at which the density of soil reaches a maximum for a given compaction efforts at this point all the pores are filled with water and the soil can not be compacted any more by the application of short temporary loads. Moisture content has pronounced effect on compaction.

It is interesting to note that the compaction under a tire is due to combination of tangential force due to draft and slippage and the vertical load. It was calculated that the total pressure on 11-38 tire was 1.3 psi due to draft and 11.00 psi due to load making total of 12.3 psi.

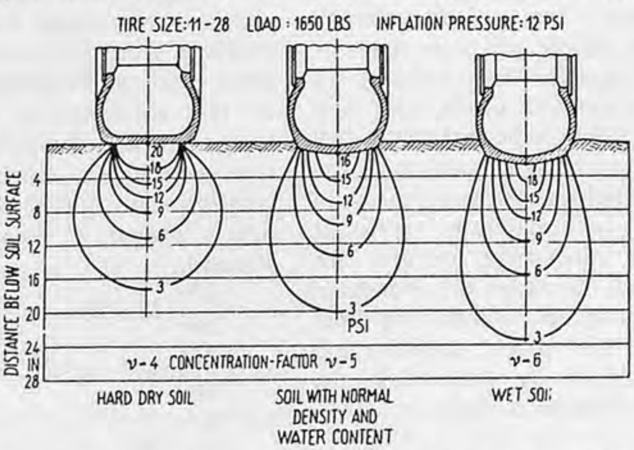

Fig. 1. Calculated curves of equal pressure of a tractor tire for different soil conditions

Conclusion

Soil compaction depends upon shear as well as pressure. Soil compaction results from horizontal forces caused by thrust as well as from vertical forces caused by loading from tractor. Polar principal stress is the most important single variable for the predicition of compaction. In every case it was found that moisture content of the soil increases the compaction considerably and maximum compaction takes place under the center line of the tire. Increased compaction of the soil is reflected in the increased bulk density of the soil, decreased infiltration, permeability, void ratio and porosity, and increase in the mechanical strength of the soil.

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Rice Post-Harvest Process in Japan

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Outline of Rice Cultivation and Rice Consumption in Japan

Japan grows about 15 million ton of paddy on about 2.7 million ha of farm land by about 3 million rice growing farm households.

This quantity of paddy production is sufficient to feed about 105 million population. The government is trying to control the production so that neither import nor export of rice is required.

Per capita rice consumption is steadily decreasing since 1962. In 1975, it became 88 kg per head per year.

Rice farmers occupy about 60% of total number of farmers. More than half of Japanese farmers are part-time farmers and their income from other industries exceed the income from agriculture.

The growing season of rice in Japan is between March to November, mostly once a year. All of the rice is transplanted half of which by use of machines. About a million transplanters are used.

All the rice grown in Japan is short, round grain. Parboil is never practised.

About 9 million ton of white rice is consumed as food, while one million ton is used for industrial use such as brewery, confectionery, etc. Glutinous rice occupies only less than 3% of the production.

The views and opinions expressed in the paper are those of the author and do not necessarily reflect those of the ESCAP Secretariat.

Rice Harvest and Post-Harvest Operations by Farmers

About 85% of paddy harvesting was done by machines and 15% by hand in 1975. 40% of the machine harvest was by small combine harvesters.

All of the threshing operation is done by use of about 3 million power threshers unless combine-harvested.

Paddy drying is done by the sun, individually owned dryers and the cooperative dryers. The ratio of the quantity of the dried paddy by these were 27, 63 and 7% respectively in 1975. The number of the individually-owned dryers and the cooperative drying facilities are about 1.7 million and 1,100 respectively.

Then almost all of paddy is dehusked into brown rice by farmers by use of their own small rubber-roll huskers whose number is estimated to be about one million.

Putting aside some of paddy for seeds and some of paddy or brown rice for their own consumption, they sell rest of brown rice either to the government at the fixed price according to its grades or to the authorized dealers with better price.

Farmers keep some paddy or brown rice for their consumption mostly in wooden boxes or in cans made of galvanized iron sheet. When required, they mill it by use of their own small rice whitening machines of 1/3 to HP.

Rice Procurement, Processing and Marketing

Almost all of the marketable rice is under government control. About 8—9 million ton of brown rice is inspected by the government officials and graded into the first to fifth grades. The average price of the government purchasing of brown rice was about US$

880 per ton in 1975.

The procured brown rice is stored in bag in the government warehouses or in the nominated ones. Total storage capacity is about 9 million ton whose 15% is low-temperature storage.

Brown rice procured by the government is sold to about 400 number of the licenced wholesalers at the subsidized price. The financial support for this exceeds US$ 2,300 million a year.

About half of the marketed brown rice is milled by some 500 large rice mills most of which are owned by the wholesalers, the capacities ranging from 3 to 30 ton per hour. The rest is milled by about 20,000 small rice mills belong to retailers, whose capacities being mostly less than 0.5 ton per hour.

The white rice is sold through some 60,000 licensed retailers with controlled price. Even though there still exist the legal provisions on rice rationing, limiting monthly allotment to 15 kg per head, these are practically nominal. Anybody is free to buy any amount of white rice.

On selling of white rice, it is packed in 2, 5 or 10 kg plastic bags indicating the quality, quantity, brands and names and addresses of distributors. The retail price was about US$ 0.7-0.85 per kg in 1975.

By-product Utilization

About a half million ton of bran, which is about half of the quantity of the produced bran in the country is collected from rice mills by the hand of oil extraction firms and 100 thousand ton of crude bran oil (70% of which is edible oil) and 400 thousand ton of bran cake are produced. Bran oil occupies the majority of domestic production of vegetable oil.

Husk produced in each farm household is not much quantity. This is used various minor purposes or disposed.

Hush produced in the cooperative paddy drying-husking facilities (so-called "Rice Centers" and "Country Elevators") reaches to much quantity in one place. The utilization are: the black or white ash for industries; soil texture improvement; culvert material; black ash for nursery beds; etc. At present much of husk is disposed.

Specific Features of Rice Post-Harvest Process in Japan

(I) Influence to Farmers

The most distinctive feature of the rice post-harvest process in Japan may be that the farmers do not sell paddy but sell brown rice.

This means that have to do the works which rice millers do in other countries, i.e. paddy drying and husking. It caused considerable effect both to the farmers themselves and to the development of rice processing technology.

The most remarkable effect to the farmers is that it made the strong stimulant for the improvement of their agricultural practice. As they produce brown rice, they can see not only the real quantity but also the quality of grain. If the quality is lower, the selling price is also lower. By looking at the existance of cracked, immature or chaulky grains in their own brown rice, they have to realize the causes: improper way of paddy drying, wrong timing of harvest, poor fertilization, etc. Feed-back from these lessons to their practice makes the impetus for their improvement of farming and post-harvest technology.

Even when they had been selling brown rice to the merchants before the war, Japanese farmers were less prone to be cheated due to the ready assessment of the quality. This considerably contributed to the improvement of their economic situations compared to South East Asian farmers.

Above that, such post-harvesting process, especially husking, by the hand of farmers make the foundation for their cooperated works. Unlike the case of farming, the function of machines are essential on husking, not from the view point of labour saving but for the effect of the work. In order to make use of the machine, the scale of the operation must be enlarged to justify it by their cooperation.

In 1933, there existed about 100,000 rubber-roll hushers in Japan, owned either by farmers cooperatedly or by custom-huskers. The custom-huskers also contributed for the introduction and development of engineering skills into the rural society. This circumstances partly paved the road for the explosive development of mechanization and the nation-wide establishment of agricultural cooperatives in the post-war period. Existing 1000 cooperative paddy drying-husking centers ("Rice Centers") and 100 cooperative paddy drying-storage-husking centers ("Country Elevator") in Japan are on the same production line. (These "Country Elevators" have paddy silos whose average storage capacity is 2,000 tons)

Such cooperation among farmers through the post-harvest operation would have widened their knowledge, developed their inventiveness and positive attitude and made them aware of the social implication of their work. These also diversified their interest and activities and eventually lead to the rural development.

Specific Features of Rice Post-Harvest Process in Japan
(2) Influence on Rice Milling and Storage Technology

Another essential result caused by the brown rice marketing in Japan was the remarkable advancement of the rice whitening technology. The brown rice marketing means that the brown rice must be free from defect. It must not contain any dirt, paddy, or half-polished grain. Much effort is paid to reduce cracked, immature or chaulky grain as much as possible as they lower the quality. Among these, half-polished or scarred grains are specifically rejected because they make the storage of brown rice difficult. As the consequence, the brown rice which the rice millers receive became of uniform, sound, and almost perfect quality.

As may be understood, high milling recovery can be attained only if the brown rice is uniform and not scarred at all. If some of the brown rice is already scarred, these grains are subjected to whitening process much faster than sound grain. It lower the milling recovery of the whole lot as the consequence, specifically in the case of friction type whitening process. This situation is observed on huller operation. Some of grains are already 100% whitened while the majority are still unwhitened at all.

Japanese rice millers could take the advantage of getting uniform brown rice without scarred grains in it. By use of such excellent material. they tried to attain the best results in various ways: serial use of 3 to 10 units of friction type whiteners; addition of calcium carbonate powder etc. to brown rice; application of moisture on starting whitening process; varied distribution of power and pressure to each machine; etc. Finally, they found that the following way is most advantageous; by use of abrasive type whitener at the initial stage for making uniform scar on each grain, then apply friction type whiteners successively. This minimizes brokens and maximize head and overall recovery with least power requirement. The same principle can be applied for the whitening of long, slender, indica rice or immature rice, simply by changing the ratio between abrasive type and friction type.

It must not be overlooked that the other factors than the brown rice marketing also contributed for the development of such techology.

One was technology used for the rice milling for sake brewery. For this purpose they had to develop ultra-low pressure abrasive type whiteners. This machine was successfully applied for the above process for the edible rice milling.

The other factor was the price control of brown rice and white rice by the government. Due to this fact, the rice millers had to improve the milling recovery in order to survive. The improvement of milling technology is the only source for their additional gain. This is the remarkably different point from other rice growing countries where the real paddy procurement prices are quite uncertain even though the nominal price might be fixed and they can expect extravagant profit if they are slightly smart on paddy quality assessment on their purchasing of paddy from farmers.

The brown rice marketing gave the much effect to the grain storage technology also. Brown rice is more susceptible to insect, mold or rodent attack than paddy. The generated heat by the respiration is much great as the density of brown rice is almost double to that of paddy. Then, all of the counter-measures have to be taken against to these dangers. Rejection of scarred grains in brown rice on the procurement is the first requirement. Storage buildings must be constructed more neatly. The ventilation, stacking of bags, dunnage, temperature control, fumigation, anti-rat device, etc. have to be well-considered. These requirements nourished careful attitude on grain storage among the concerned people. If the attention is deficient in some points, it will easily cause heavy damages to grain to which they cannot afford.

There can be much argument on whether the brown rice marketing is more advantageous than paddy marketing. It may be difficult to judge. The plain fact is that in Japan the brown rice marketing system has long been established and they have exploited some of the possible advantages from this. It made the considerable differences on the technological and social situations compared to other rice growing countries.

Post-Harvest Loss of Rice in Japan

Post-harvest loss of rice in Japan is estimated to be below 5% counting those of all of the process between the harvest and retailing. Estimated loss of each stage is as follows:

1) Loss on harvest:
   - —manual reaping; 2-3%
   - —binder; about 1%
   - —small combine harvester; 1-2% (below3%)
   - —large combine harvester; 5%

Considering the proportion of above methods of operation as below average loss is assumed to be about 2%.

Type of operation methods	% of harvested area (2.7 million ha)
Manual	15%
Binders (1.3 million machines)	51
Small combines (0.34 million machines)	34
Large combines (2,000 machines)	1

(Source: Min. of Agri. and Forest, 1975)

2) Loss on transportation of paddy:
Nil or negligible

3) Loss on threshing:
0.8-2.4%. Mostly about 1%

4) Loss on paddy drying:
Nil or negligible

5) Loss on paddy husking:
0.2-0.3%. Below 1% in any case.

6) Loss arising after the purchase of brown rice by the government until its arrival to rice mills, including the storage in between:
Below 0.3%
The reason for the estimation is as follows:
Each bag of brown rice purchased by the government is stored and then delivered to rice mills under assumption of 60 kg content. After delivery of the brown rice bags to the rice mills, if the deficiency of weight were found, the rice millers can claim the compensation to the government. Such cases happen very rarely. It proves that the additional input of average 200 g per 60kg bag (=0.3%) is enough to cover all of the possible losses during transportation, storage and handling.

7) Loss on handling in wholesalers: 0.1%

8) Loss on rice milling (whitening): 0.3%

9) Loss on retailing: 0.2%

Adding all of the losses of above 1) to 9), the sum is less than 5%. This figure might be split into two, i.e. 4% loss on farmers operations and 1% on marketing and circulations.

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Recent Advances in the Processing of Cocoa Beans

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Introduction

The cocoa (Theobroma cacao L.) crop is processed to a considerable extent at the farm after harvesting to produce the dry cocoa beans, which are used by the manu,acturers of chocolate or other secondary industries. Processing at the farm consists of pod-breaking, fermentation and drying followed by storage, along with some cleaning and grading during or after drying and storage. The equipment used for the farm processing may vary from the simple cutlass to a sophisticated automatic temperature regulator. The cocoa beans undergo a drastic change in their physical appearance and properties like shape, size, color, density and flavour during the processing, and they need to be handled with extreme care in order to retain the characteristic properties associated with good quality chocolate.

The basic operation of drying cocoa, the most difficult part of processing on the estate, is the reduction of moisture in the freshly fermented beans to such a level that micro-organisms cannot grow and the beans can be stored safely for a number of months (1). During drying a considerable reduction in weight and volume of the material takes place, along with certain chemical changes inside the bean which gives rise to the typical aroma or flavour associated with good quality chocolate. The freshly fermented beans, with a loose surface coating of mucilage, have a maximum initial moisture of approximately 55% (w/w) and are dried down to an average of 7% to ensure good keeping qualities during storage. However, the initial moisture content is subject to considerable variation (2) and can be as low as 39%. It depends to a large extent on the type of fermentation box used (number of holes in the wooden box to drain the mucilage), the amount of mucilage drained for preparing cocoa jelly as a byproduct before fermentation and the number of days necessary to complete the fermentation process. It is also affected by the rainfall in the area during the few days preceding the harvest of the cocoa pods.

The common method of drying cocoa beans in Brazil, a major world producer of cocoa, is by exposure to the sun in *barcaça* or a drying platform constructed above ground level, where the beans are spread out in a thin layer of 4-5cm and a sliding roof is provided over the platform to protect the beans during rain and also at night. The drying floor dimensions usually vary between 50 and 72 sq.m and the number of platforms in a farm between one and 16-20, depending mainly on the quantity of cocoa produced by the farm.

The sun-drying method for cocoa beans in Brazil has a great disadvantage in that frequent rain and showers are experienced during the processing season, which extends from April to January, when drying on the *barcaça* is either slowed down to a considerable extent or rendered impracticable. An alternative artificial drying system is therefore necessary to maintain the volume of production, and most *fazendas* or cocoa farms in Brazil have an artificial dryer in addition to sun-drying platforms or *barcaças*. The different types of artificial dryers commonly used for cocoa beans, along with their shortcomings, have been described elsewhere (3-6).

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Problems in Cocoa Drying

A large number of problems are associaqed with the drying of cocoa beans, after fermentation, at the farm level. These have been discussed in detail elsewhere (3—8) and summarized below:

1. Frequent rain and showers experienced during the processing season slows sun drying to an impracticable level, requiring up to 3—4 weeks at certain times of the year.
2. As the beans have to be spread out in a thin layer of 4—5cm for sun drying, a large number of *barcaças* are necessary if drying is carried out only by sun.
3. The cost of constructing a *baracaça* is rather high and its drying efficiency is low.
4. The labour requirements is sun drying is high as the beans have to be turned frequently on the drying floor.
5. During bad drying weather prolific amounts of mould quickly develop on the surface and also inside the bean, which may seriously affect its quality.
6. Good quality, cheap, dry firewood for artificial dryers in some cocoa-growing areas is already in short supply, while in other areas transport of the bulk firewood over rough or mountainous terrain is difficult and expensive.
7. The difficulty in maintaining the heat exchangers in a trouble-free condition for the wood-burning type of artificial dryers gives rise to a smoky flavour in dried beans.
8. With certain types of artificial dryers (*eg* Ferraz) the minimum amount of cocoa bean necessary for a satisfactory batch operation is sometimes too big even for a large producer except during the peak season.
9. Lumping and excessive breakage of beans during drying by mechanical dryers.
10. Too much separation of dried mucilage from the bean surface, which is lost as a dry powder due to excessive mechanical mixing in artificial dryers.
11. High capital cost of a mechanical dryer; also, the need for electrical energy (which may or may not be available at the farm) or an internal combustion engine to operate the driving mechanism.
12. The need for expert mechanical supervision for the operation and maintenance of the equipment.

Experimental Scope

A comprehensive study of the existing drying systems used for cocoa beans (1) clearly indicated that none of them were basically designed to meet the various specialized requirements of the crop; hence, it was considered that it would be easier to incorporate these requirements in a new design rather than try to modify and improve any one of the existing systems. In developing the new system, the following design parameters were laid down:

a. The dryer should be flexible in design, using a repeatable unit module, so that the requirements of any farm size can be easily met.

b. The dryper should be dual purpose, so that it can be used either as a solar dryer and/or as an artifical dryer, in order to economize on the construction and operational costs.

c. The physical effort required by the farm operators in drying the crop should be as little as possible. In the existing *barcaça* they have to stand over the bean on the drying floor and bend down to reach them; also, the operator's feet are affected by the acidic mucilage in the beans while the beans are contaminated by the dirty, usually bare, feet of the operator. An elevated drying platform at the normal working height would minimize the physical effort required by an operator and also avoid contamination of either his feet or the beans from each other.

d. The drying house should utilize as much as possible locally and easily available wood as a material of construction; also, the design should be simple for the farm carpenter to follow and execute.

e. The roof over the drying platform should be fixed and be built of a material which will easily allow the heating rays of the sun to pass through while praventing the rain or dew at night to come in contact with the beans.

f. Ventilation and circulation of air inside the dryer should be preferably by convection rather than mechanical, for simplicity in design and ease of operation.

g. The charging and discharging of the beans on and from the drying platform should be easy; a platform raised to the working height would achieve this objective.

h. A central passage with a drying platform on either side would facilitate the movement of both the operator and the material.

i. The height of the roof above the drying platform should be low to minimize the volume of air to be heated during solar drying, yet should be enough for operators to walk through the central passage; a roof sloping down on either side from the central passage would be desireable.

j. The plenum chamber for artificial heating should be located under the platform to facilitate passage of the heated air through the layer of drying beans.

k. The artifical heating system

Fig.1. Glass-roof dryer—inside view.

should preferably use a smokeless fuel, as contamination from smoke is one of the most objectionable aspects of practically all the existing artifical drying systems even when equipped with a heat exchanging device.

l. The heating fuel should be easily available at a reasonably low cost, even in the outlying cocoa farms which may or may not be connected by a road to the nearest highway.

A Solar-Cum-Artificial Dryer

A new type of sun drying platform was designed and developed by the author to meet the abovementioned design parameters at the Cocoa Research Center of Brazil (CEPEC), located at the heart of the Brazilian cocoa region at Itabuna in the State of Bahia. The prototype glass-roof dryer (**Figure** 1) is light in construction and is covered by a fixed glass-roof like a green house instead of a sliding roof used in a *barcaça,* which is expensive to build and heavy and cumbersome to operate. The prototype dryer has been described in detail in a recent paper (7); it basically consists of two parallel rows of drying platform (each 12 m long, 1.76 m wide and 0.8 m high) with a central passage 1 m wide for an operator to facilitate the loading of either platform with the beans for drying, turn during drying by a rake provided with a long handle and transfer the dried beans directly to sacks after cooling on the platform. The overall width of the drying house including the outer supporting pillars is just over 5 m, while the length can be made to suit the needs of the individual farm; for lengths more than 15-20 m it would be better, however, to construct a second, separate unit. The top of the platform is provided with a ridge 10 cm high along the edge and the drying surface is made of galvanized iron wire-mesh laid over wooden beams fixed across the platform at a pitch of 0.5 m, so that the heating rays from the artificial heaters (**Figure** 2) located underneath the platform can easily pass through the wire-mesh. A strong metal wire laid over the wooden beams and under the wire-mesh along the length of the platform at a pitch of 0.4 m provide additional strength to to the wire-mesh against sagging under load. A fixed glass roof (3 mm thick, commercial quality, 1 m x 1 m panel) above the drying platforms allow the heating rays of the sun inside the dryer but prevent the rains or the dew at night to come in contact with the beans. All surfaces inside the drying house are painted black to facilitate the absorption of heat from the sun.

For artificial heating, a plenum chamber is provided under and along the length of the drying platforms. Each platform is pro-

Fig.2. Gas burning infra-red heater (note : the write-mesh protective cover avoids incineration of falling cocoa particles.)

vided with three small doors opening out to the central passage for entry into the plenum chamber where infra-red heaters using low-cost commercially available gas are located in a central furrow on the floor. The equipment is fairly simple and there are no moving parts like fans or electric motors, as natural convection forces set up by cold air entering at the bottom of the plenum chamber through a vertical space of 12 cm at the lower edge of the platform wall force the heated air to rise through the layer of drying beans. The heat is available for drying immediately on starting the heaters without any elaborate or time-consuming preparations or smoke, as is the case for starting wood fires. For artificial drying, the adjustable shutters under the lower edge of the sloping glass roof are also closed, so that the flow of ambient air is routed through the plenum chamber.

Each heater is located 120cm below the platform, as at this distance a desirable maximum drying temperature of around 70°C can be maintained for the beans on the platform. The temperature at the platform can be easily regulated by a valve provided with each heater and also with the gas cylinder. By this configuration each heater can effectively heat an area of 2 sq. m of the drying platform, the total number of heaters used for a particular installation being dependent on the capacity needed. The system is therefore highly flexible and can equally serve the needs of the very small farm using only one or two heaters to the very large farm with 16-20 or more heaters. Approximately 75 kg of beans can be dried per batch for each square metre of the drying platform.

The gas is supplied in the cocoa-growing region of Brazil in cylinders of either 13 kg (household) or 45 kg (industrial) capacity, the cost of gas per kilogramme being the same in both cases. The smaller cylinders are generally preferred by the farmers, mainly due to their ease of handling and transport, which in some instances has to be by mules over rough terrain, and their interchangeability with existing household clyinders. The number of smaller cylinders used in a multiple-heater installation is equal to the number of heaters. They are located outside the plenum chamber in two groups, so that only half the number of cylinders are used at a time, while the other half is kept connected to the system in readiness for switching over instantly when required during a drying operation.

Results

Sun Drying

Experimental evidence obtained from continuous recording thermohygrographs (7) clearly illustrate the advantage of the glass-roof dryer over a common *barcaça*. The mean maximum temperature inside the dryer, at around mid-day, is approximately 20-25°C higher than ambient, while the mean minimum relative humidity at the same time of the day inside the dryer is around 15-20% lower than the ambient. A combination of these two factors produces a condition which is highly conducive to a faster drying rate for the cocoa beans.

The drying rate of cocoa beans inside the glass-roof dryer has also been compared with that in a common *barcaça*, located some 30 m from the dryer. The drying rate inside the dryer is consistently faster than that in the common *barcaça* (**Figure** 3), and the end point is reached in the glass-roof dryer one day before that in the common *barcaça*; the saving in time of 1 day in 8 days correspond to a saving of approximately 12%. Also, the initial moisture content of the cocoa beans after fermentation, at the start of drying, was higher for the beans in the glass-roof dryer than in the common *barcaça*. Such differences of moisture in cocoa beans during and after fermentation, carried out in batches, is attributable to a number of factors (2). Also, the beans in the dryer with a higher initial moisture content had proportionally larger amount of water to evaporate than those in the common *barcaça*, to dry the beans to the same level of moisture content, indicating a higher drying efficiency for the glass-roof dryer over the common *barcaça*.

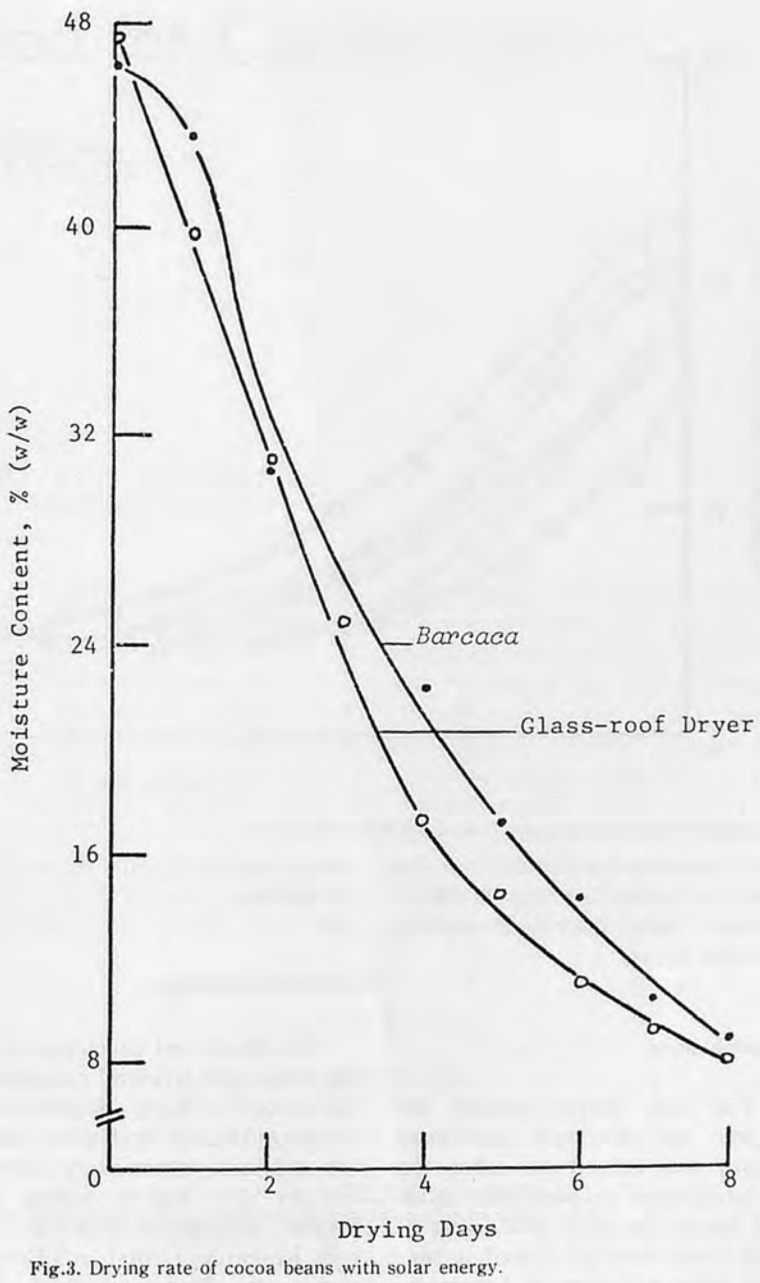

Fig.3. Drying rate of cocoa beans with solar energy.

Gas Drying

The maximum drying temperature for cocoa beans for gas drying maintained at around 70-75°C in the initial stages and is gradually lowered as the moistre content is reduced to around 15-12%. This is easily achieved by the simble but effective temperature control equipment described in a recent paper (1), where factors affecting the cost of gas drying along with the total drying cost has been considered in detail.

The main advantage of using the same installation for both solar and gas drying is in the possibility of switching from sun to gas drying or vice-versa instantly, in view of inclement weather, nightfall or daybreak before drying is complete. In the traditional system, a considerable amount of time and energy is needed for transferring the beans from the drying platform to the artificial dryer, the transfer usually being in one direction only, which also gives rise to the possibility of bean damage or breakage through mechanical handling during the transfer.

Experiments carried out with gas drying of beans initially dried by sun and/or with beans immediately after fermentation indicated that a highly satiscactory end product could be obtained without any loss in product quality. The characteristic drying rate obtained by using the infra-red heaters under the platform (**Figure** 4) indicate that the drying time varies from 18 to 34 hours, with the moistre content of the beans at the start of gas drying varying from 30 to 46% respectively. The typical falling rate curves obtained in **Figure** 4 closely resemble the theoritical drying rate of a vegetative material like cocoa beans (3).

The overall performance of the prototype dryer over a period of two seasons has been satisfactory, and a number of farm installations have since been carried out in the cocoa region of Brazil. Also, adaptation of the gas dry-

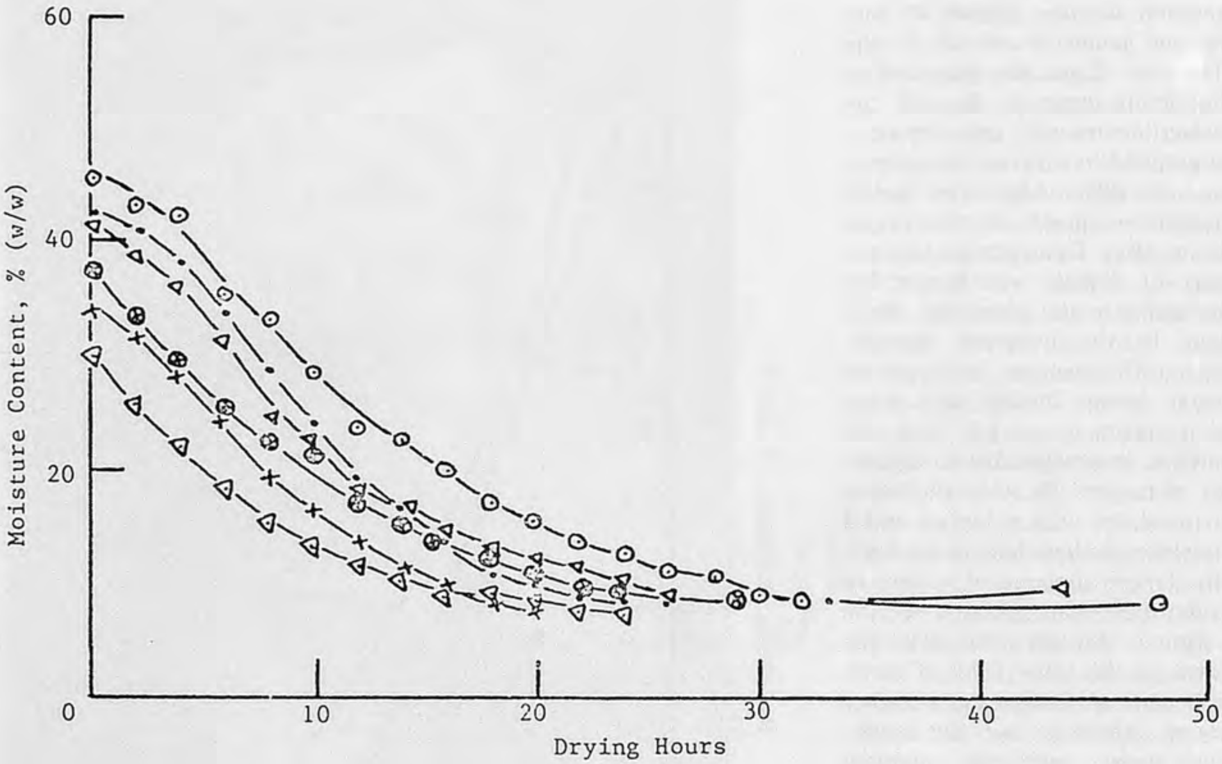

Fig.4. Drying rate of cocoa beans with infra-red heaters.

ing system to traditional *barcaças* and to wood burning artificial dryers have been successfully carried out (1).

Conclusions

The new drying system designed and developed for cocoa beans has helped to solve the most difficult problem encountered during the farm processing of the cocoa crop in Brazil, where the main requirement for maintaining quality of the end product is that drying should be a continuous operation without interruption or slowing down and that the crop is handled with extreme care to avoid bean damage.

The newly developed glass-roof dryer uses solar energy and/or artificial heat in the same installation to produce an excellent product. Also, the gas drying system can be used to adapt traditional *barcaças* and wood burning artificial dryers. Further, the dryer can be easily modified for drying practically any other crop on the farm.

Acknowledgement

The design and development of the solar-cum-artificial cocoa drying system and its adaptation to existing *barcaças* and wood burning artificial dryers were carried out by the author during his former assignment with the Cocoa Research Center of Brazil, under the Directorship of Dr. Paulo de T. Alvim.

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New Method for Conservation of Paddy Rice

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A storage method, which is based on the effect of a chemical, is basically independent of temperature and humidity of the environment. This is an essential difference from e.g. low temperature drying, which in many places may be considered as one of the most economical storage methods. In tropical and subtropical areas, grain drying is difficult and risky, while the chemical storage method seems to have a possibility to ensure the storage of grains in such areas.

Treatment of grains with propionic acid or its salt has been found to reduce infection by fungi during storage (Schroeder (1964)). In recent times, storage of grain for animal food with 0.5— 1.0% of propionic acid, weight basis, has been widely used (Fink (1970), Madsen et al. (1973)). Na- and Capropionate with dosage of 0.1 — 0.3% weight basis, have for a long time been used as preservative for bread. But, this chemical storage method has not yet been engineered to practical storage of rice for human consumption.

Minimization of dosage is a basic requirement for use of such a preservative for foodstuffs.

The principle of the chemical storage of grain is: the kernels

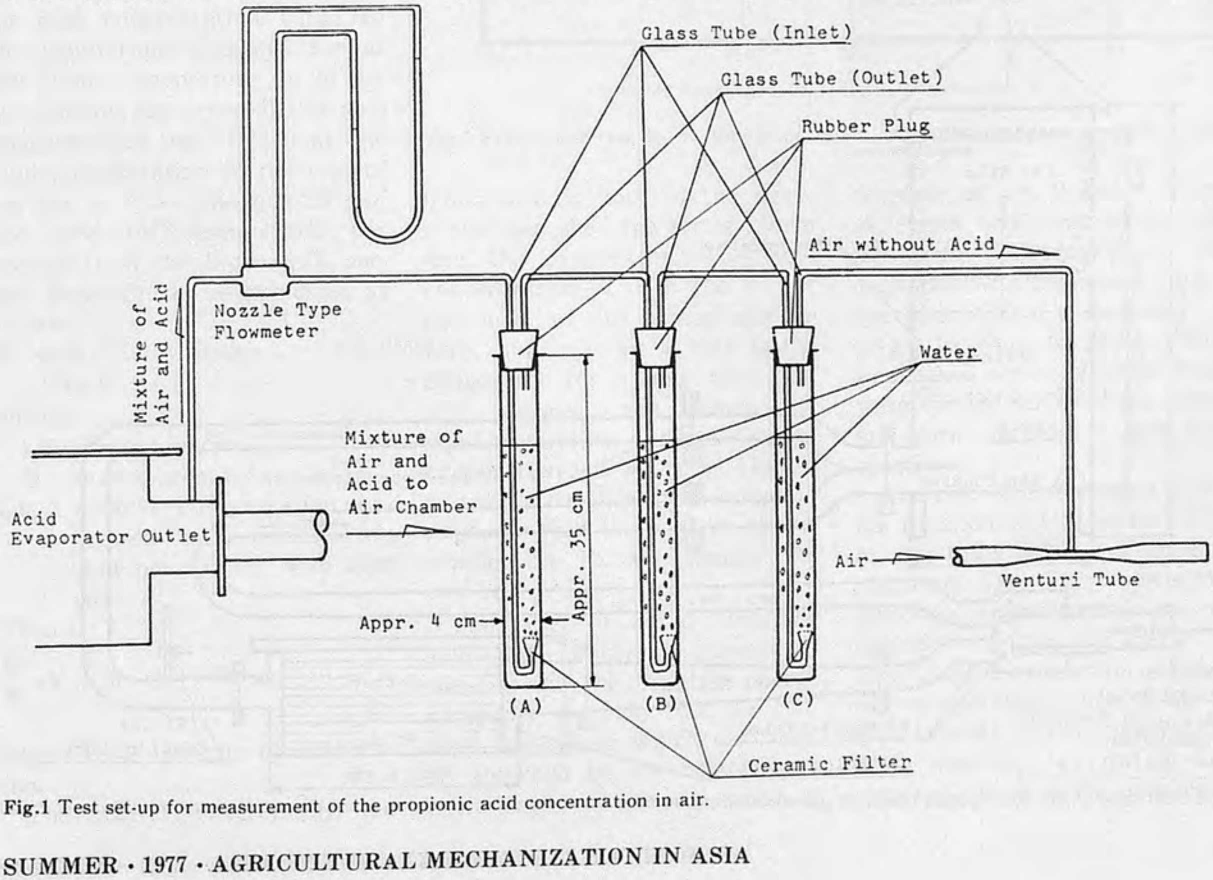

Fig.1 Test set-up for measurement of the propionic acid concentration in air.

are coated with preservative, as a result of which the mold growth on/in kernels is prevented. A perfect coating minimizes the amount of preservative to be dosed. Due to very low volume ratio of liquid propionic acid to grains, performance of perfect of grains with the acid is very difficult. To obtain high volume ratio, the volume of propionic acid must be increased by bringing it in the gas phase. If grains are exposed to propionic acid gas, the grains ad-/absorb the acid, thereby a perfect coating of grains with propionic acid is performed.

The research project described in this article aimed to:

1) Develope a pilot type of the dose system based on gassorption-priniciple.
2) Test the efficiency of the dose system performed with use of propionic acid.
3) Illustrate the feasibility of rice storage by means of chemical methods under tropical and subtropical conditions.

Materials and Methods

Propionic acid with concentration of 99% was used as preservative and the experiment was carried out with paddy seed, Honenwase, harvested in 1974 at Hasshiki, Japan. The rice was humified before it was used in the experiments.

A method was developed to determine the propionic acid gas concentration: The air containing acid is led into the water in the form of bubbles, so that the acid in the air is absorbed by the water. Analyse the water by means of titration with natrium hydroxide and determine the quantity of the acid present in the water. Measure the total quantity of the sampled air by help of a nozzle type flowmeter and a stopwatch. Thus the propionic acid gas concentration is given in the term of g acid per m^3 air. (Cf. **Fig. 1**).

The propionic acid content in the rice was determined by titrating with natrium hydroxide, which means initial acidity value of the rice plus the quantity of added acid by dosing.

Pilot Type of Dose System

A pilot type of dose system was developed, **Fig. 2**. The dose system consists of a fan, two air flow control valves, two flowmeters, an acid evaporator, an air chamber and a silo. The principle of dosing is as follows: The rice is exposed to the gaseous preservative, provided by a special designed evaporator, and the preservative is ad-/absorbed by the rice. As **Fig. 2** shows, the acid evaporator is composed of blotters, acid container and casing. The blotter is folded in such a way that they form crests and throughs to obtain a greater evaporation area. Some holes are made in the blotters so that a turbulent air flow is easily obtained, cf. **Fig. 3.** The acid gas concentration is controlled by means of mixing the acid gas with fresh air: The air blown by a fan is distributed

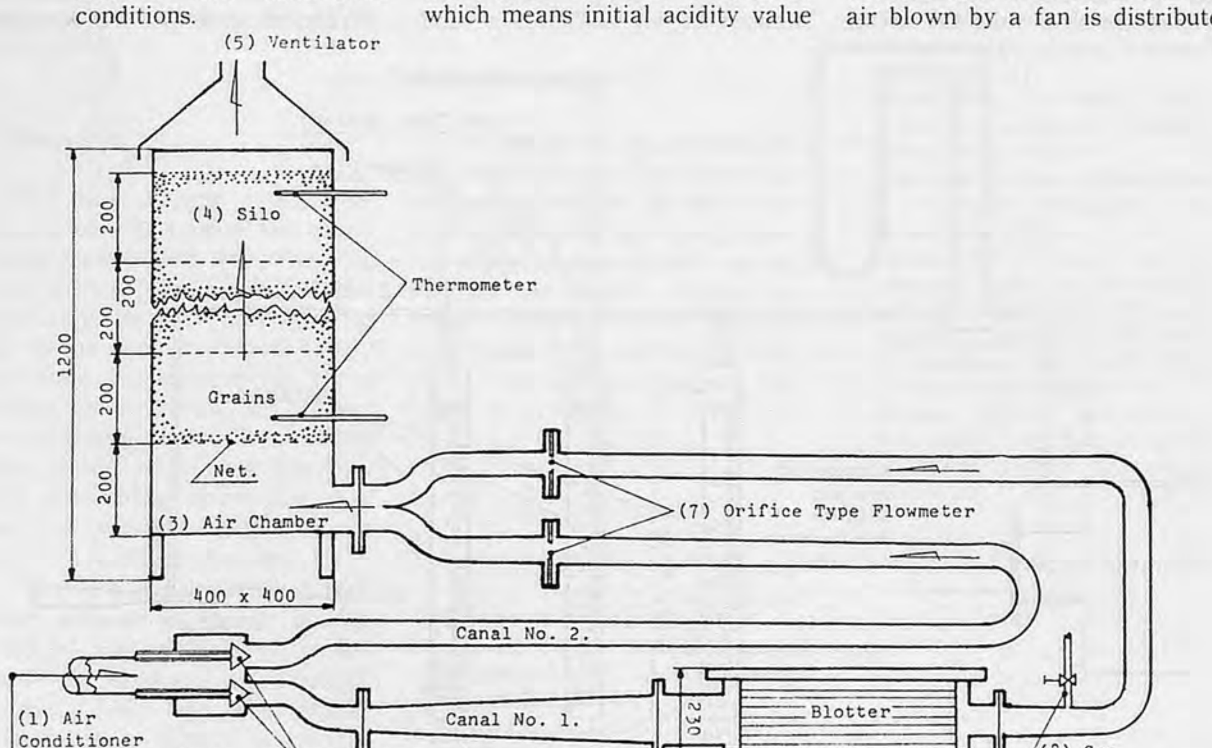

Fig.2 Pilot type of the dose system based on gas-sorption-principle

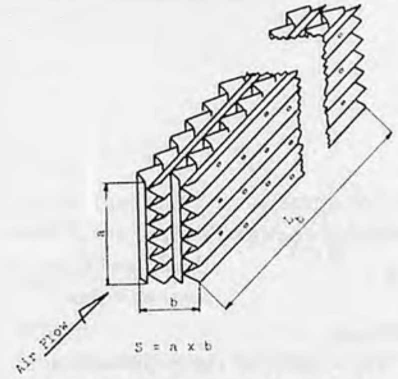

Fig.3 Blotters for the acid evaporator

into two canals, of which No. 1 is connected to the acid evaporator, and No. 2 functions as a bypass canal. The air flow capacity in each canal was controlled by help of needle valve and orifice type flowmeter. The acid gas concentration in canal No. 1 is measured, and according to the data obtained, mixing ratio of air containing acid and fresh air is adjusted in order to obtain the desired acid gas concentration in the air chamber.

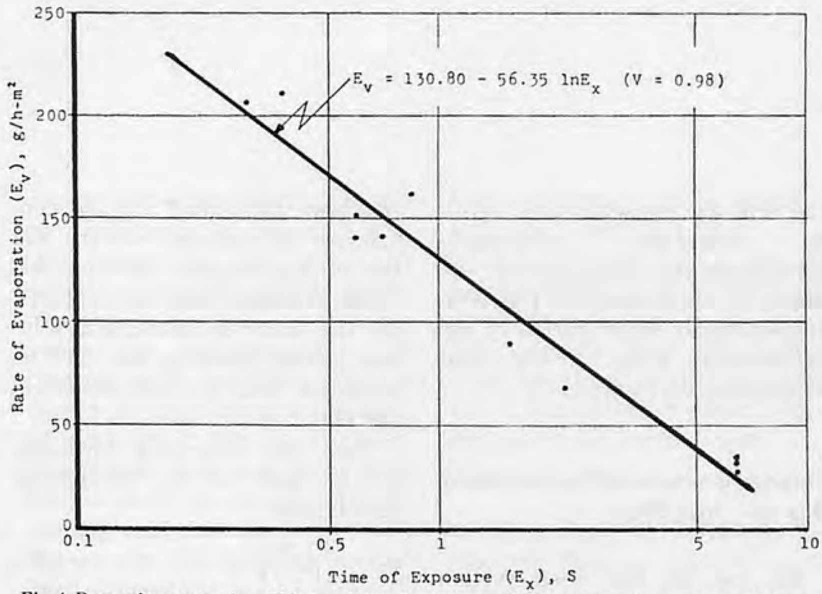

Fig.4 Rate of evaporation (E_v) vs. time of exposure (E_x) at time of operation (O_p) of between 3 and 36h., cf. fig. 6. 10.

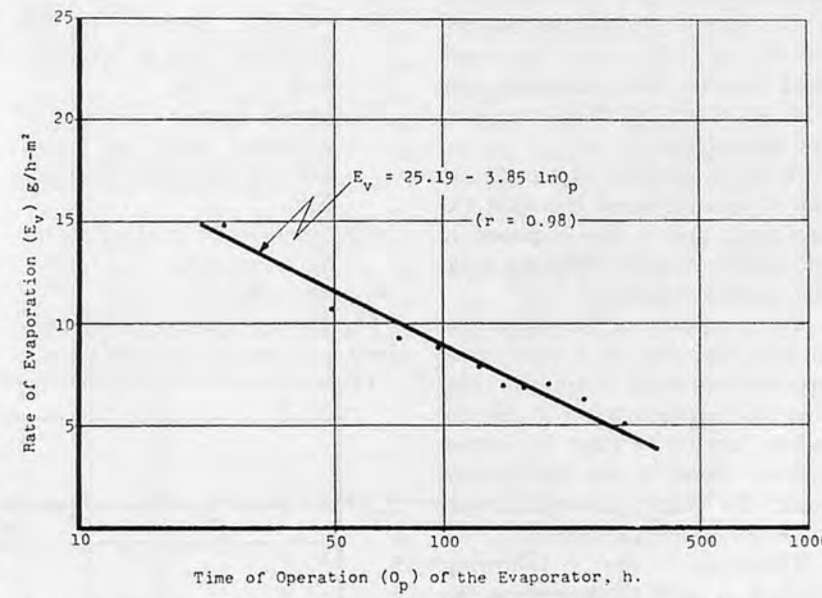

Fig.5 Evaporation rate (E_v) vs. time of operation (O_p) at time of exposure of 6.0 S, cf. fig. 6. 10.

Rate of Evaporation of the Propionic Acid in the Evaporator

The blotter is dipped partially in the liquid propionic acid in order to form a layer of acid on it. The air in the very close surrounding to this layer has always an acid concentration equal to the equilibrium concentration at the same temperature as in air surrounding the layer. If this acid concentration is "C_E" and the acid concentration in the rest of the air is "C_A", the quantity of the acid (M) evaporated per second from the layer with surface area (B) can be expressed as follows:

$$M = k \cdot B \cdot (C_E - C_A) \text{ kg/s} \quad (1)$$
$$(0 \leqq C_A \leqq C_E)$$

where:

k = constant, m/S

B = surface area, m²

C_E, C_A = acid concentration expressed in the terms of kg acid per m³ air with acid gas.

Then

$$\frac{M}{B} = k \cdot (C_E - C_A) = E_V \text{ kg/sec m}^2 \quad (2)$$

where E_V is the rate of evaporation.

The blotter covered by the liquid acid is kept in the evaporator and then the air is blown into the evaporator. The acid concentration (C_A) in the air at the inlet of the evaporator is zero, and if the air is kept in the evaporator for a long time, C_A will increase and reach the equilibrium (C_E), i.e. the rate of evaporation will be zero. That is to say C_A depends on the time of exposure (E_X) for acid to air-the smaller the E_X, the smaller C_A will be.

The layer of liquid propionic acid on the blotter is exposed to wet air, and the moisture is absorbed by the acid. The air contains some dust, which also may be absorbed by the acid. These extraneous substances cause a decrease of net transfer of acid molecules, and this means that the acid concentration (C_E) decreases with increasing time of operation (O_P) of evaporator.

On the basis of above discussions, two series of experiments were carried out, and the results are shown in **Fig. 4 and 5**, respectively.

The rate of evaporation (E_V) is the function of two factors, time of exposure (E_X) and time of operation (O_P). This means that the evaporation rate, i.e. the concentration of the acid gas at the outlet of the evaporator, changes during operation, even if the air flow velocity in the evaporator is held constant, i.e. E_X is held constant. With such evaporator the acid gas concentration has to be determined continually throughout the dosing period. To make the operation of the dose system easier, stabilization of the evaporation rate of the acid evaporator is required.

Sorption Isotherm of Propionic Acid Gas on-/into Rice

By use of the does system shown in **Fig. 2**, two experiments were carried out. In experiment 1, the rice with moisture content of 18.5 ± 1.5% (d.b.) was used. And the rice with moisture content of 28 ± 1% (d.b.) was used for experiment 2.

A layer of rice, about 20 cm thick, was prepared for each experiment, and it was exposed in the acid gas with different relative concentrations.

The sorption of the acid gas on-into the rice is a very slow process especially when the relative acid concentration in the air is low, but in 3-4 days it reaches a level close to the equilibrium state. To reach the equilibrium state takes several weeks.

Therefore the following method is used to determine the sorption isotherm curve:

1) Measure the acid contents in rice sampled each day in order to determine the change of the acid content.
2) If this change is less than 0.05% (w.b.) in two succeeding samples, the acid content in the rice is very close to its equilibrium state. The last measurement is used as the equilibrium acid content to make the sorption isotherm curve.

The rice used for the measurements were sampled from the surface of the pile.

Theoretical Calculation

Several assumptions were made: (1) The surface of wet rice, i.e. the rice with moisture content of above 15% (d.b.), can be considered as ordinary water, and the sorption occurs between this "surface water" and the acid gas. (2) The water-propionic-acid-solution follows Raoult's law. (3) The propionic acid gas follows Boyle and Gay-Lussac's law.

Then the following formulas can be used for the theoretical calculations:

$$m_P = \frac{P_P \cdot m_W}{(kP^0_P - P_P)} \quad (3)$$

(Raoult's law)

Where:

P^0_p = Vapour pressure of the propionic acid at temperature t°C, N/m²

P_p = partial vapour pressure of propionic acid in water solution at temperaturet°C, N/m²

M_W = number of mol of water in the solution

K = constant = 1

The partial pressure of the propionic acid gas (P'_p) in the air is

$$P'_P = \frac{G'_P}{M_P \cdot V} \cdot R \cdot T \ \ N/m^2 \quad (4)$$

(Boule and Gay-Lussac's law)

Where:

G'_p = mass of the propionic acid gas, kg

M_p = 74.08 (molecular weight of propionic acid)

V = volume of the gas, m³

R = 8314.4 N · m/K · Kmol (gas constant)

T = temperature, K

At the equilibrium state the partial vapour pressure of propionic acid (P_p) in water solution is equal to P'_p.

On the basis of the vapour pressures given in the reference books, the formula for the vapour pressure of propionic acid is found by help of least square method:

$$l_n P^0_P = 20.23151 - 5625.734/T - 1.211 \cdot 10^{-6} \cdot l_n T \quad (5)$$

Where:

T = temperature, K

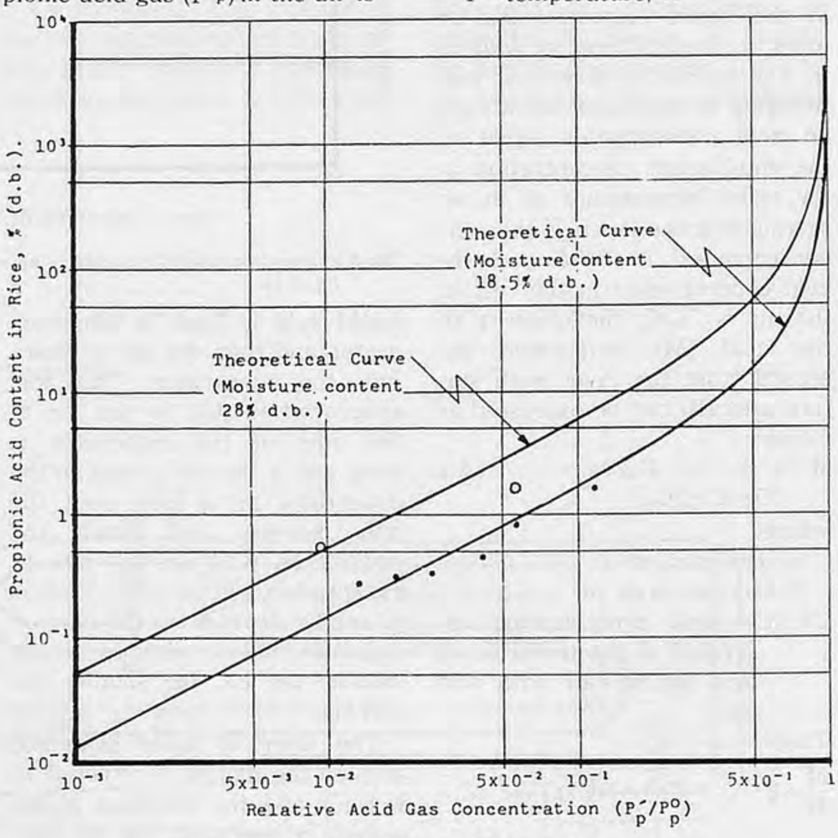

Fig.6 Sorption isotherm curves of the propionic acid gas on-/into rice.

On the basis of assumption 1 and 2, m_W can be found as follows:

$$m_W = \frac{G_W - 15}{M_W} \quad (6)$$

where:

G_W = moisture content in rice (d.b.), % or g H_2O/100g of dry matter

M_W = 18.02 (molecular weight of water)

Thus the number of mol of propionic acid (m_P) in the water on the surface of the rice kernel with a moistre content G_W% (d.b.) at equilibrium is given by formula (3).

Therefore the propionic acid content (G_P) in the rice is:

$G_P = M_P \cdot m_P$ % or g of acid/100g of dry matter.

The results of experiments and theoretical curves are shown in **Fig. 6.** The data obtained in experiment 1 have relatively large deviation, and it is likely systematical, which may be caused by unstable concentration of acid gas, difference of moisture content within the rice used, and deviation of acid content determination.

As the evaporation rate changes with operating time, it causes an unstable concentration of acid gas in the air chamber. Equilibrium moisture content in rice is likely to change with absorbing acid, and this may be the reason why the moisture content in the rice could not be held constant throughout the experiment. Stabilization of the acid evaporator, more understanding of the sorption phenomena within the acid-water-grain-system and improvement of the acid content determination is required to reduce above mentioned problems.

Only two different acid concentrations were tested in experiment 2. As shown in **Fig. 6,** the equilibrium acid content in the rice with high moisture content is higher than in the rice with low moisture content.

The data obtained in the experiments are placed reasonably close to the theoretical curve. This indicates that the assumptions made above aid in analyzing of sorption phenomena within the acid-water-grain system.

Sorption Rate of Propionic Acid Gas into Rice

By use of the dose system shown in **Fig. 2,** two experiments were carried out:

Experiment 1.

Rice with moisture content of 23.9% (w.b.) was stored in silo section 1, 2, 3 and 4, **Fig. 2.** Air with a relative acid concentration (P'_P/P^o_P) of about 0.05 was blown through the silo bottom into the pile. The apparent air-flow velocity in the silo was 0.0118—0.0243

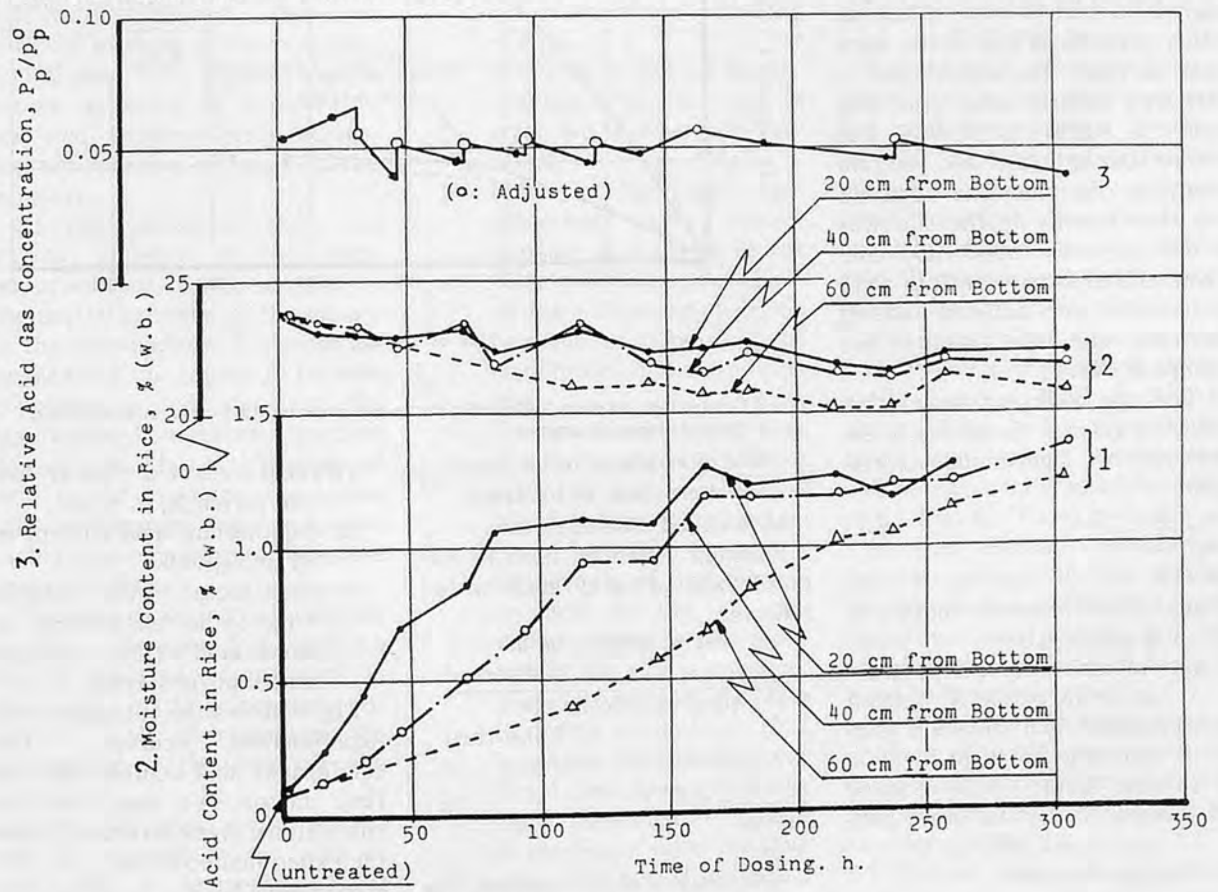

Fig.7 Dosing of propionic acid into thick layer of wet rice, experiment 1

m/s. Acid contents and moisture contents were determined at different dosing periods.

The results are shown in **Fig. 7**, and show that unstable acid concentration caused an unstable sorption process. It was observed that

1) Equilibrium moisture content in acid treated rice is high — more than 20% (w.b.) — and depends on location of the rice in silo.
2) Rate of acid sorption into rice depends on location of the rice in silo.
3) Equilibrium acid content in the rice is likely to depend on location of the rice in silo — the closer to the silo bottom, the higher is the acid content.

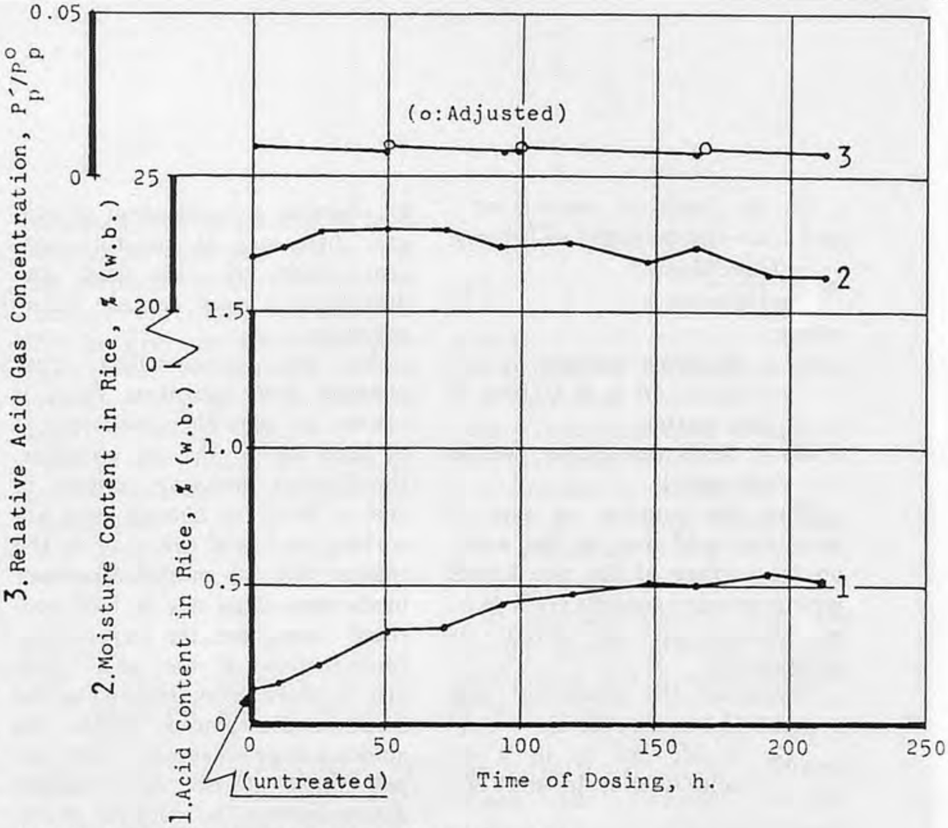

Fig.8 Rate of acid sorption on-/into wet rice, experiment 2

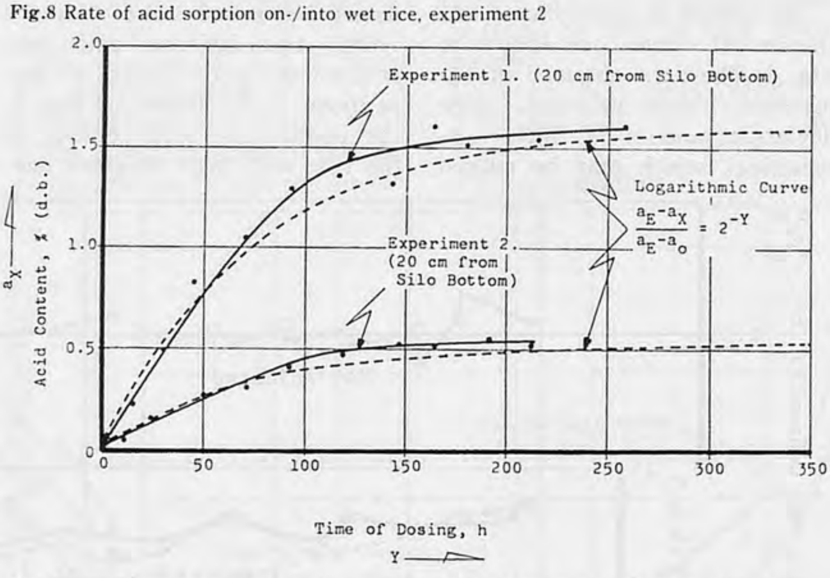

Fig.9 Comparison between logarithmic curve and experimented curve in acid content-time of dosing diagram

Experiment 2.

About 18 kg of rice with moisture content of 22% (w.b.) was stored in the section 1. The section 2, 3 and 4 were filled by other portions of rice in the same way as used for experiment 1. Air with relative acid concentration of 0.0095 ± 0.0005 was blown through the silo bottom into the rice pile. The apparent air flow veocity in the silo was 0.0287 – 0.0453 m/s. Acid contents and moisture contents were determined at different dosing periods, and the results are shown in **Fig. 8**.

The rate of drying a very thin layer of grain is theoretically expressed by logarithmic expression:

$$\frac{m_X - m_E}{m_0 - m_E} = 2^{-Y} \quad (7)$$

where:

m_O = initial moisture content in grain, %(d.b.)

m_X = moisture content in grain at drying period X, % (d.b.)

m_E = equilibrium moisture content in grain, % (d.b.)

Y = time factor (= the required time to dry the grain halfway to m_E from m^o).

Formula 7 means:

$$M = \frac{\text{rest of moisture to be dried}}{\text{total moisture to be dried}} = 2^{-Y}$$

M is called moisture ratio.

Formula 7 can be used to express rate of acid sorption as follows:

$$A = \frac{\text{rest of acid to be ad-/absorbed}}{\text{total acid to be ad-/absorbed}}$$

i · e ·

$$\frac{a_E - a_X}{a_E - a_0} = 2^{-Y} \quad (8)$$

Where

a_O = initial acid content in grain, %(d.b.)

a_X = acid content in rice at dosing period X, % (d.b.)

a_E = equilibrium acid content in grain, % (d.b.)

Y = time factor (= the required time to ad-/absorb half as much acid as the total acid to be ad-/absorbed).

Fig. 9 shows the calculated and experimented curves. The equilibrium acid content and the time factor (Y) used for the calculations were estimated from the experimented curve:

Experiment 1:

a_e = 1.6% (d.b.), 1 · Y = 52h, and

Experiment 2:

a_E=0.54% (d.b.), 1 · Y=58h.

As the figure shows, the curve obtained in the experiment is reasonably close to the calculated curve. This indicates that the sorption of propionic acid into rice in principle should be understood as the opposite process of drying.

When rice with high moisture content is exposed to air containing acid, two phenomena, sorption of the acid into rice and desorption of "water" from rice, occur at the same time.

Rice with a moisture content above 15% d.b. contains free moisture. The assumption was made that the properties of the free free moisture are the same as the properties of the ordinary water, and that the sorption of acid and the desorption of "water" occurs between the free moisture and the surroundings.

The vapour pressure of the acid-water-solution decreases with the increase of the mol-fraction of acid. This means that the vapour pressure of moisture in wet rice decreases with increasing mol-fraction of acid in the moisture.

At the equilibrium state, the vapour pressure of the acid--water-solution in rice is equal to the partial pressure of the vapour in the surroundings. If the partial pressure of the vapour in the surroundings is held constant, the equilibrium moisture content depends on the mol-fraction of acid in the moisture; the higher the mol-fraction of acid, the higher the equilibrium moisture content will be.

The rate of drying is a function of the difference (Δp) between vapour pressure of moisture in rice and partial pressure of vapour in the surroundings; the smaller the Δp, the lower the rate of drying.

Rice with high moisture content is exposed to air without acid gas: If temperature and R.H., i.e. partial pressure of vapour in air, is held constant, the rate of drying of rice will be constant until the moisture content reaches about 15% (d.b.), because the vapour pressure of free moisture is constant at constant temperature, i.e. no change in Δp.

If rice with high moisture content is exposed to air with a constant R.H. and a constant relative acid concentration (P'_P/P^o_P) at a constant temperature, then the moisture in wet rice absorbs acid from the air. This causes a decrease of vapour pressure of the moisture in rice, i.e. Δp decreases. In other words; the rate of drying decreases with increasing of the acid-mol-fraction of moisture.

Acid dosing under isothermal conditions may be described as follows:

1) Air with a constant relative humidity and a constant relative acid concentration is blown through the silo bottom into the rice pile.
2) The acid in the air is ad-/absorbed by the rice in layer No. I where the air enters.
3) Due to the acid ad-/absorbed, the vapour pressure of moisture in this layer will decrease. This causes a decrease of drying rate and an increase of the equilibrium moisture content.
4) The air which passed layer No. 1, i.e. the air without acid gas, passes rice layer No. 2, which is located on top of layer No. 1.
5) On account of that there is no acid in the air, the vapour pressure of moisture in the rice is constant. This means that the rate of drying within layer No.2 is greater than within layer No. 1, and causes a lowering of the moisture content in the rice of layer No. 2.
6) At a later period of dosing, the moisture and acid content in rice of layer No. 1 reached the equilibrium state and the air blowing into layer No. 2 now contains acid gas.
7) The moisture content in rice layer No. 2 is lower than the moisture content in rice layer No. 1. Rice with low moisture content has less capacity to absorb acid than rice with high moisture content, and therefore the equilibrium acid content in rice layer No. 2 becomes less than the one obtained in layer No. 1.
8) The results will be that the equilibrium moisture content and the equilibrium acid content will have gradient with the pile depth. Yet, this gradient will be zero above the level where the moisture content in rice equilibrates with the relative humidity of the air used, cf. **Fig. 10.**

For instance, air with relative humidity (R.H.) of 85% and relative acid concentration (P'_P/P^o_P) of 0.05 is blown through silo bottom into the pile of rice which initial moisture content is 24 (w.b.) in order to dose propionic acid. Temperature is held at 30°C throughout the dosing period.

The equilibrium moisture content in rice corresponding to air at 30°C and a R.H. of 85% is about 16.5% (w.b.). The equilibrium acid content in such rice will be about 0.7% (d.b.). or 0.6% (w.b.), **Fig. 6**, - Experiment 1.

If the obtained equilibrium moisture content in rice on the silo bottom is e.g. 22% (w.b.), the equilibrium acid content will be about 1.6% (d.b.) or 1.2% (w.b.), Fig. 6, - Experiment 2.

At the end of dosing, the gradient of equilibrium moisture content and equilibrium acid content with the depth of silo will be as shown in **Fig. 10.**

If the air flow velocity (V) is very high, the acid gas passes

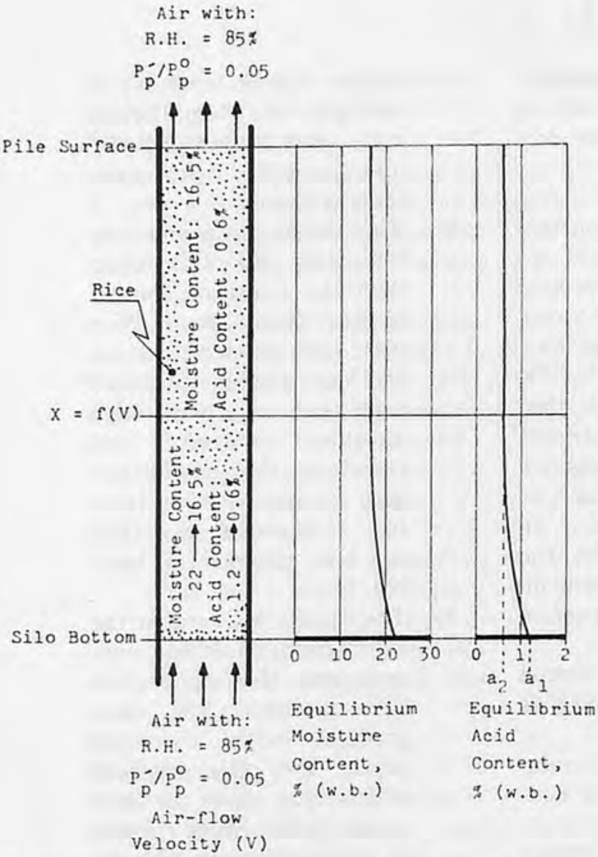

Fig.10 Moisture content and acid content within thick layer of wet rice at equilibrium state (Due to the acid absorbed by the moisture in rice, the equilibrium moisture content has gradient with pile depth. This causes an uneven acid content within the pile.)

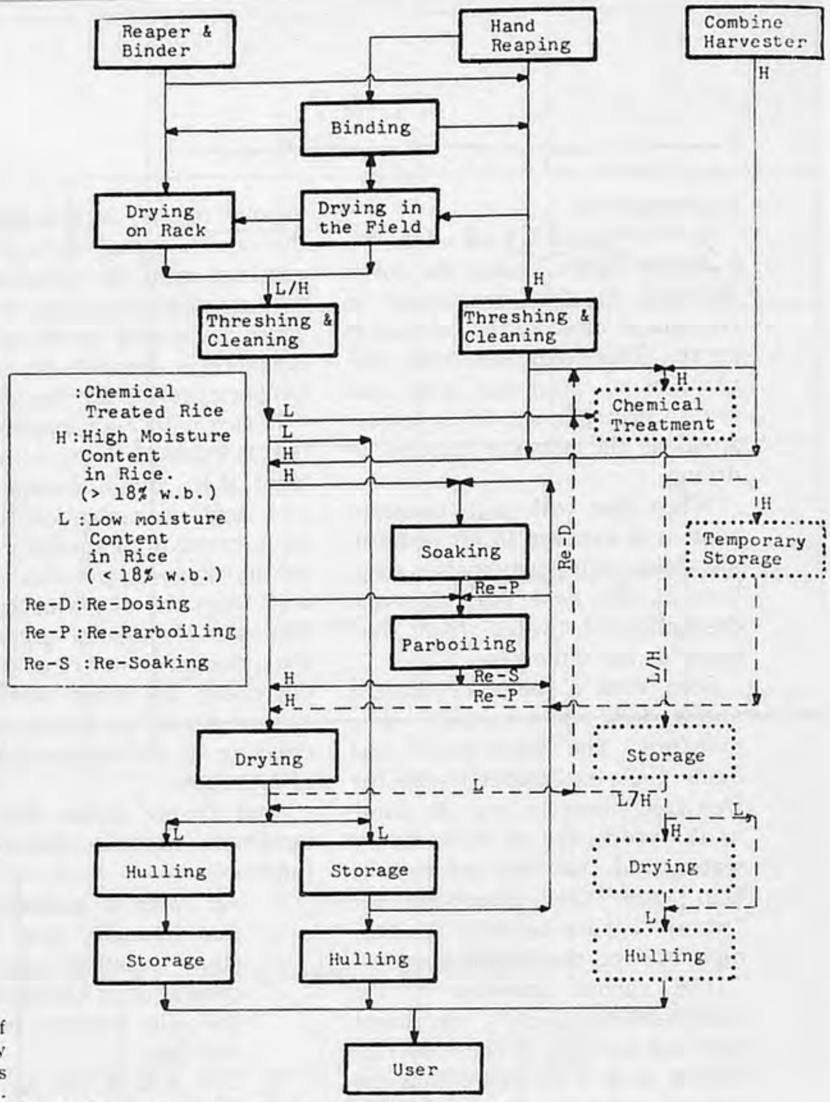

Fig.11 Harvesting and processing of paddy rice

through the pile, and the equilibrium moisture content, i.e. also equilibrium acid content, will have gradient throughout the pile. On the other hand, the acid will be ad-/absorbed by thin rice layer if V is very small, and the rice in most part of the silo is dried down to the moisture content which is in equilibrium with the R.H. of the air. That is to say, the level of X (cf. **Fig. 10**) is the function of V.

The difference between the highest equilibrium acid content (a_1) and the lowest equilibrium acid content (a_2) can be reduced by the following three different methods:

1) Blow the air containing acid into the pile with very high flow velocity. (A big amount of unutilized acid will pass through the pile. To use this method economically, a method for reuse of acid gas is required).
2) Dry the rice down to the moisture content which is in equilibrium with the relative humidity of the air used. (This method is only useful when there is some possibility to dry the rice, e.g. in the field, before the dosing).
3) Circulate the rice under the dosing process. (Some system to circulate the rice is required, and the mechanism for rice transport must be constructed of non-corrosive materials).

Practical Use of the Method

On basis of the background provided by the research carried out, the possibilities for improving harvesting, processing and storage of rice by utilizing chemical methods may be described as follows, cf. **Fig. 11**:

I. Drying of rice down to 17-18% (w.b.) can usually be carried out by natural drying utilizing sunshine and wind, while drying from this level down to safe storage moisture content of 14-15% requires artifically drying, unless the environment is very dry.

In stead of the latter part, following chemical storage system may be used:

1) Dry the rice down to app. 18% moisture content by means of sunshine, wind or both.
2) Thresh and clean the rice at app. 18, which is a very suitable moisture content for threshing.
3) Treat the rice with preservative-propionic acid-by using the dosing method described in the report. Since the moisture content in the rice in equilibrium

with the environment, it should be possible to obtain a very uniform distribution of the chemical throughout the rice pile.

4) Store the rice treated with preservative. Moisture content in rice will not change, because it is in equilibrium with the environment. But content of the chemical in the rice will descrease during storage.

5) Dry the rice if it is necessary for hulling. Hulling of rice with moisture content of 18% (w.b.) is usually not troublesome, but it depends on the variety.

II. Fermentation and mold growth will occur within few days after harvesting, if the moisture content of the rice and the temperature is high. This can be prevented by chemical treatment:

1) The rice harvested by combine and the rice harvested in inclement weather may contain much moist-moisture content can be be 30% (w.b.) or even more.

2) Treatment with preservative permits longer period of safe storage for new harvested rice. This should give possibility to improve the drying process and its economy.

III. In rainy season, parboiling is a way of saving rice from damage, because the drying process can be postponed by possibly further soaking and boiling. In this way rice can be kept 5 to 7 days, thereby increasing the chance of having suitable conditions for sun drying, (Andersen et al., 1974). Chemical treatment can provide temporary storage for parboiling. The rice with high moisture contents can be stored by chemical treatment until the weather changes to stuitable conditions for sun drying of the parboiled rice. This may solve several problems found in the indigneous method of parboiling, and gives the following advantages:

1) Risk for fermentation and germination of grains during soaking treatment will be reduced.

2) During the waiting period for fine weather, the rice can be stored by chemical treatment, thereby re-soaking and-boilding of the rice should not be necessary. This provides simplification of the parboiling process and improvement of its economy.

3) Since chemical treatment permits safe storage of wet rice, it is not necessary to parboil all the rice in the silo at the same time. This should give essential improvement in the economy of parboiling.

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B. K. S. Jain awarded ISAE Gold Medal

At the 15th Annual Convention of the Indian Society of Agricultural Engineers just concluded in Pune, President A.C. Pandya announced the nomination of Mr. B.K.S. Jain for the coveted ISAE Gold Medal for the year 1976-77.

Mr. Jain (photo) is a life member and the Vice President of the Society. During his 27 years of association with the agricultural engineering discipline, he has made significant contribution towards its development. He has been an active member of the Society's Executive Council since its inception. It has been due to sincere and devoted efforts of persons like him that the Society has come to its present level of operations. His reports on 'Assessment of Demand for Inputs to Farm Mechanization', 'Bottlenecks in the Farm Equipment Industry', 'Sprinkler Irrigation in India' and other such topics are regularly quoted as an authoritative reference.

Mr. Jain graduated in agricultural engineering from the Allahabad Agricultural Institute and later obtained his Master's Degree from the University of Melbourne under a Colombo Plan Fellowship. He is a chartered professional agricultural engineer and after 25 years of experience with the industry, has taken to consultancy in marketing, management and agro sectors. It is for the first time that professional technical consultancy services in the agricultural engineering discipline have been organized in the country to meet the domestic as well as the needs of other developing countries. It is befitting that Mr. Jain has been decorated with the profession's highest award.

Earlier, Mr. Jain had received at the hands of the Prime Minister Mrs. Indira Gandhi the FICCI Award 1969, the industry's highest award for his individual initiative in modernising agriculture.

The Convention was attended by over 300 delegates from all parts of the country, including observers from overseas. The theme of the convention was agricultural engineering technology to small and marginal farms. The items covered by about 200 papers presented at the Convention included Bullock Carts, Water Management Techniques Biogas plant and post harvest technology.

The next convention of the Society will be held in Kharagpur early in January 1978 and the theme will be 'Agricultural Engineering Technology for integrated rural development'.

IRRI made a Scientific Exchange with China

by the IRRI reporter 1/77, May 1977

World rice production will benefit from a series of exchanges between the People's Republic of China and the International Rice Research Institute (IRRI). The first formal exchange occurred in 1972 when seed of IR20 and other promising IRRI rice lines were presented to a Chinese trade delegation by President Ferdinand E. Marcos of the Philippines. The Chinese reciprocated by giving seed samples of several of their top rice varieties to IRRI's Director General N.C. Brady during his August 1974 visit to China, by sending a team of scientists and administrators to IRRI in March and April of 1976, and by inviting a team of IRRI scientists to China.

In a summary report of their 7-27 October 1976 visit to China the IRRI team suggested:

- sharing of genetic materials, including rice varieties and brreding materials, from the large collections held by Chinese researchers and by IRRI,
- exchange of rice production and protection technology, and
- exchange visits of scientists and other personnel for conferences, seminars, training sessions, and other purposes.

The report also suggests that the Chinese scientists are interested in IRRI's Genetic Evaluation and Utilization (GEU) program and the associated International Rice Testing Program (IRTP). Likewise, IRRI specialists could learn much from the Chinese experience with intensified cropping systems, as well as from advances in the use of biological control of rice pests.

The itinerary of the IRRI team took them to the area around Peking, the Yangtze River Valley in East Central China (around Nanking and Shanghai), and Kwangtung provice in the southern region. The team saw widely differing environments in several of the country's rice areas of "high and stable yield." Visits were also made to national and provincial agricultural research institutes, commune production brigades and production units, and universities.

Photo. 1 Workers spread compost at a commune near Peking. Farmyard manure is the main rice fertilizer.

Photo. 2 IRRI scientists and hosts go to the field. Annual production of paddy in the People's Republic of China is about 120 million t.

The IRRI team held formal and informal discussions with national, provincial, and commune officials, researchers, technologists, farmers, and workers; and saw rice field experiments and production plots, chemical plants, irrigation facilities, exhibits, laboratories, and communal agriculture. Among the things that particularly caught the interest of the IRRI scientists were:

- the intensive care that various crops receive,
- practical orientation of research and rapid transformation of research findings into field practice,
- careful conservation and exploitation of organic wastes,
- research on and use of biological controls for rice pests,
- rapid turnaround—aided by machinery and intensive labor—between the harvest of one crop and planting of the next,
- local manufacture of antibiotics, pesticides, and machinery.

Here is a summary of the IRRI team's impressions.

Rice breeding

The major thrust of the Chinese breeding program appears to be for higher annual yields. Since 1962, grain production has increased an average of 3.5% a year.

Chinese breeders seek rice varieties with a high yield potential and early maturity. Such varieties require less time between planting and harvesting, allowing additional crops to be grown in a year. Most of the work on yield potential focuses on the development of short-statured rices that do not lodge. In northern and central China, for instance, breeding of japonica rice types for shorter stature has produced varieties whose heights vary between 80 and 100 cm. Traditional tropical rice varieties stand about 160 cm. The development of short-season varieties (70 to 100 days from transplanting to harvest) has contributed greatly to the 20% expansion of rice plantings in 20 years.

There are other objectives that hold breeders' attention.

- Photoperiod sensitivity is important in the second crop of the two-crop pattern common in the summer season in the Yangtze River Valley. This second crop must mature early enough to permit the establishment of a winter crop, such as wheat, before cold weather.
- Threshability is important for areas affected by cold. Most indica rices, for instance, shatter badly when they mature under low temperatures.
- Tolerance for extreme temperatures becomes increasingly important as cropping patterns are intensified. Some crops must perform well with high temperatures, others with extremely low temperatures.

The Chinese scientists indicated they intend to give more emphasis in their breeding programs to the development of host resistance to insects and diseases and, in some areas, to tolerance for problem soils.

A high tillering rate does not appear to be too important to rice production in China. Chinese farmers use a large number of seedlings in each rice hill and thus reduce the need for profuse tillering.

Cropping patterns

The Chinese drive to achieve maximum yield from every hectare of arable land is expressed in their cropping patterns. Rice, the most important crop, grows on about 33.6 million hectares and gives a nationwide average yield of about 3.4 t/ha. Production in the communes visited (a commune may be thought of as a municipality encompassing a market center and a number of satellite villages) averaged about 10 t/ha each year for all crops, and about 4 to 5 t/ha for a single rice crop.

The use of irrigation is almost

the rule for any crop in the "high and stable yield" areas. But cropping patterns vary widely in response to temperature and other factors. Near Peking, in the northern region, a common pattern was a summer crop of corn, vegetables, millet, or rice and a winter crop of wheat or winter vegetables. In the south, two rice crops and one other crop have been usual, and experiments with three rice crops plus another crop are in progress. Four crops a year are currently being grown on about 50,000 ha in Kwangchow province, and the Chinese expect to increase the area to more than 600,000 ha by 1980.

Mechanization

A corollary to China's intensive cropping is mechanization. Most of the mechanized farm equipment is meant to help minimize the turnaround time between harvesting of one crop and planting of a succeeding crop. Much of the threshing and land preparation were mechanized in the communes that IRRI scientists visited; mechanical seedling-pullers and transplanters, developed by the Chinese, are said to be used on about 20% of the rice crops in central China and are high on the "want" lists of most communes.

The relationship between mechanization and labor was seen at a commune nar Peking, where land preparation between the harvest of the rice crop and the sowing of winter wheat was done mostly by tractors—some of them large, but most of them 12-hp power tillers. Labor was occupied chiefly with straw removal and the transport and spreading of compost. Mechanization did not reduce the need for labor, but it shortened the period between harvesting and planting to 1 or 2 days for a field and to about 2 weeks for the entire commune (2,000 to 4,000 ha).

At one brigade (a commune subunit) in the central region, the turnaround time was less than a day; the second rice crop was transplanted in the afternoon of the day on which the preceding rice crop was harvested.

Agricultural mechanization does not extend to activities for which time pressure is slight. Weeding and fertilizing, for instance, continue to consume considerable manual labor.

The IRRI team

The IRRI scientists who made the China visit were Dr. N. C. Brady, director general; Dr. M. D. Pathak, director for research coordination; and the following heads of IRRI research departments: Dr. S.H. Ou, plant pathology; Dr. G. S. Khush, plant breeding; Dr. S. Yoshida, plant physiology; Dr. S. K. De Datta, agronomy; and Dr. R. Barker, agricultural economics. *R. L. D.*

IDA Assists Agricultral Extension & Research in India

by World Bank (IDA News Release No. 77/38, March 24, 1977)

A credit of $12 million from the International Development Association (IDA), an affiliate of the World Bank, will help finance a project for the strengthening and expanding of agricultural extension services and upgrading of research facilities in India's West Bengal State. The purpose of the project is to help the state achieve early and sustained improvements in food grain production.

With a population of nearly 50 million, West Bengal is the second most densely populated State in India. It ranks fourth in India's food grain production (first in rice), and accounts for 60% of India's jute and 25% of its tea. Although production of rice and wheat has increased significantly over the past decade, these increases have come largely from irrigated crops. Yields from rainfed areas have largely remained stagnant. The project, through reorganization and improvements in agricultural extension, research and staff training seeks to provide the means for sustained increases in production from some 320,000 contact farmers and through them most of the four million farm families in West Bengal. This would be achieved by setting up a system of regular farm visits by trained village level workers who would encourage the adoption of improved agricultural practices.

The IDA credit to India is for a term of 50 years, including 10 years of grace. It is interest free, except for a service charge of 3/4 of 1%. The Government of India will channel the proceeds of the credit to the Government of West Bengal.

NOTE: Money figures are expressed in U.S. dollar equivalents.

Crop Protection Center Launched

A National Crop Protection Center (NCPC) has been established by the Philippine government to implement and coordinate a wide range of crop protection programs.

The Center, headquartered at the University of the Philippines Los Banos campus, has seven regional branches located throughout the country, as decreed by Philippine President Ferdinand E.

Marcos in May 1976.

NCPC is charged with planning and developing crop protection research, carrying out training programs, advising governmental officials regarding regulatory programs, undertaking information/extension activities, and establishing linkages between research and operational areas of crop protection.

NCPC director, Dr. Fernando F. Sanchez, has listed priorities for the Center's early activities. Integrated pest management for rice, corn, vegetables, and grain sorghum will be emphasized, along with training, field surveillance and research. Translating research results into practical information for use by small farmers also has high priority.

The IX International Congress of Agr. Engineering

July 8-13, 1979, Michigan State University, East Lansing, Michigan, USA

Sponsored by CIGR (Commission, Internationale de Genie Rural).

An International Agricultural Engineering Organization with administrative headquarters in Paris.

An International CIGR Congress is held at five-year intervals. First CIGR Congress to be held in USA.

CIGR membership is drawn from 31 countries.

Program : Three concurrent technical sessions during each of five one-half day sessions, plus mid-week IX International Congress sponsored technical tours to Michigan farms and agricultural industries.

Hosts : Michigan State University and American Society of agricultural Engineers (ASAE).

Participation : Leading world authorities present technical papers related to :

Soil and Water Sciences

Agricultural Structures and Equipment

Agricultural Machinery

Electricity distribution in rural areas and its agricultural applications in the general context of energy

Scientific Organization of Agricultural Work

Related Educational Benefits : Annual ASAE Summer Meeting June 24-27, 1979, with CSAE, Winnilpeg, Canada. Nearly 400 technical papers presented in three-day meeting.

Scheduled pre and post CIGR Congress Technical Tours of agriculture, agricultural institutions and related industries.

Tokyo Farm Machinery Show '77

Japan Agricultural Machinery Manufacturers' Association is going to hold TOKYO FARM MACHINERY SHOW '77 at the East Building (**Fig.**) of International Trade Center, Harumi, Tokyo, for one week from November 23 (Wedn.) to 29 (Tues.), 1977. Japan Agricultural Machinery Manufacturers' Association, the sponsor of this show is a national organization of farm machinery manufacturers and includes 143 companies.

Objective : The objective of this show is to report the results to users, dealers and experimental institutes concerned, in Japan, and secondly to ask them for advice regarding development and improvement especially in safety, in the case of export to foreign countries, and thirdly to promote the research and development of the machinery fitting the conditions of foreign countries, and to establish the basis of export.

Products : (1) farm prime mover (2) machinery for soil preparation (3) machinery for cultivating and managing (4) machinery for harvesting and preparating (5) machinery for livestock & dairy farming (6) machinery for cereal processing (7) machinery for forging. Almost all of the machinery manufacturered in Japan other than above things will be displayed at this show. The Japanese live on rice and 12-13 billion tons of rice is produced per year. The stress is placed especially on the machinery for rice cropping. Therefore, visitors can see many machinery for rice cropping there in a short period.

Incidentally, they are going to have a seminar on farm machinery safety problems, especially regarding exhibits on one day during this period.

For Foreign Visitors : Interpreters will show them around the exhibition and explain the machinery for them. In addition, foreigners are able to have opportunities to discuss the technical problems and others with the members.

Detail information will be obtained from :

Japan Agricultural Machinery Manucacturers' Association,
Room No. 312, Kikai Shinko Kaikan, 8-5-3, Shiba Koen, Minato-ku, Tokyo, Japan
Tel. Tokyo 03(433)0415-7 ■ ■

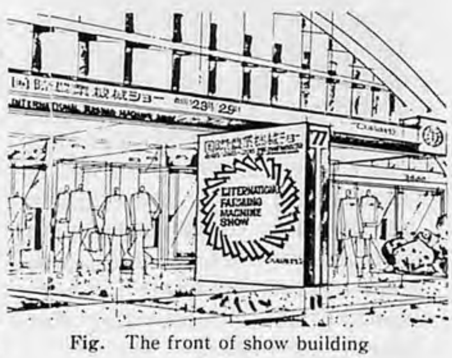


Fig. The front of show building

NEW PRODUCTS

Tractor

Hinomoto Best E-14··· (1) Special double universal joints used, the angle of the front wheel turning becomes up to 62°. So, the very small turning is possible. (2) The internal mechanism is covered so tightly and protected so well that you can use this tractor beyond its power. Especially it suits the works such as those in paddy fields in bad conditions. (3) You can connect and disconnect the attachment with a lever, while sitting on a seat. (4) 886 cc large displacement engine made by Toyosha which is the same power as the one of 16 hp. (5) You can move the attachment up and down with only one lever by three position control method. (6) A suspension seat which is usually adopted in only big tractors. (7) The largest size of high rag tyre (8-18) in this class. (8) 6 forward and 2 backward gear. You can choose any speed.

〔Specifications〕

Dimentions: L 2.150 (body only) 3,115 (including a rotary) x W 1,065 x H 1,790 (up to the top of the muffler) 1,270 mm (up to the handle), Weight: 675 kg, Road clearance: 235 mm, Engine: vortex pump water cooled engine 14 ps/2,300 rpm 886 cc, Clutch: diaphragm dry single plate, Gear: 6 forward 2 backward, Wheel: front 5-14 rear 8-18 high rag, Drive: 4-wheel drive, Pump: hydraulic gear pump, The radius of the smallest turning: 1,600 mm, Attachment control: three position control (automatic returning system), Rotary: side drive, Cutting width: 1,200 m

(Toyosha Co., Ltd.: 55-16, Joshoji-machi, Kadoma-shi, Osaka, Japan)

Tractor

International 576··· (1) This tractor is the first one to adopt 6 cylinder engine in this series. Revolution is smooth. Vibration and noise are very small. (2) Power steering adopted, you can easily do such a job as front loading or unleveled land works. (3) Because of the high power wet hydraulic disk brake, you only need to step into the pedal lightly. (4) Position draft control is easily regulated by up and down response system. (5) You can choose two revolution speeds for light work and heavy work because of the independent hydraulic PTO. So, you can do works very efficiently. (6) It is designed with stress on safety and efficiency for example; equipped several safety devices which fit to the Regulation in 1976.

〔Specifications〕

Dimentions: L 3,400 x W 640 x H 1,565 mm, Weight: 2,330 kg, Engine: vertical water cooling 4 cycle diesel 66ps/2,400 rpm 3,783 cc, Transmission: dry single plate system (8 forward and 4 backward gear), Radius of the smallest turning: 3,100 mm, Steering: hydraulic power steering, Brake: wet power disk brake, PTO revolution speed: standard shaft-624/2,400 rpm high speed shaft-1,021/2,400 rpm, Attachment elevator: position draft control (three point linkage category I, II)

(Komatsu International Mfg. Co., Ltd.: 3-2, Akasaka, Minato-ku, Tokyo Japan)

Tractor

Iseki T5000···This tractor has a powerful 48 hp diesel engine developed for a big powered tractor. The engine is a quite and less-vibrating water-cooled 4-cylindered engine.

The model has 20 speeds forward and 4 speeds backward in a transmission so that you can choose a right speed in accordance with working. It has wet disk brake built-in and exceeds in water-proof and mud-proof.

Driver's seat is comfortable and foot controls are conveniently positioned and easy-to operate.

A wide variety of attachments can be used because of 3-point linkage system.

〔Specifications〕

Dimensions: 3,400 x 1,700 x 2,300 mm (L x W x H), Wheel base: 2,000 mm, Engine output: 48 ps, Exhaust: 2,775 cc, PTO shaft speed: Independence 2 speeds, Brake: Wet disk brake, Lift system: 3-point linkage

(Iseki Agricultural Machinery Mfg. Co., Ltd.: 1-3, Nihonbashi 2-chome, Chuo-ku, Tokyo 103, Japan)

Tractor

Iseki T 6000··· T 6000, big powered tractor manufactured in Iseki's excellent technique, its compact design and high maneuverability making it ideal for every farm works. As its heart is a 65 hp water cooled 4-cylinder

diesel engine, smooth running and easy to start in all weathers.

This model has been designed specifically for the big-thinking farmer who wants faster cultivation and a higher PTO output.

The features of this model are as follows: (1) Wet disk brake built-in and exceeds in waterproof and mud-proof. (2) New designed protective frame cab gave a operator's safety and comfort careful consideration. (3) All hand and foot controls are conveniently positioned and easy-to-operate. (4) 20 forward/4 reverse/2 PTO speeds available for any work application.

[Specifications]
Dimensions: 3,630 x 1,750 x 2,350 mm (L x W x H), Wheel base: 2,150 mm, Engine output: 65 ps, Exhaust: 3,595 cc, PTO shaft speed: Independence 2 speeds, Brake: Wet disk brake, Lift system: 3-point linkage

(Iseki Agricultural Machinery Mfg. Co., Ltd.: 1-3, Nihonbashi 2-chome, Chuo-ku, Tokyo 103, Japan)

Tractor

Kubota L3001DT··· (1) This is DT type of 4-wheel drive. The bevel gear drive system of sharp angle is adopted at two front wheels. Small turning and a drive on the steep slope or sandy ground are possible. (2) The engine (4 cylinder vertical water cooling, 4 cycle diesel), is very silent and causes little vibration. The strong point of this tractor is to be able to do a heavy work easily such as works in muddy paddy fields. (3) There are two types, to one of which gauge attches in front and the other in the rear. (4) 16 forward and 4 backward gears. Special low speed (0.24 km) is possible. You can use this tractor as a trencher, a snow-plough, and as a planter which all need to move slowly. So, it is very convenient. (5) You can maintain the working position as you like with automatic position control system and even very small change of position is also possible. So, it suits cultivating or puddling works.

[Specifications]
Dimentions: L 2,890 x W 1,450 x H 1,925 (up to the top of the muffler) 1,445 mm (up to the handle), Weight: 1,225 kg (body only), W.B.: 1,765 mm, Road clearance: 340 mm, Engine: vertical water cooled 4 cycle diesel 4 cylinder 1,487 cc 30 ps/2,800 rpm (cell starter), Clutch: dry single plate, Speed change gear: 16 forward 4 backward, Brake: wet disk brake, Differential gear: bevel gear, Tread: front-1,100 rear-1,130-1,600 mm, Wheel: front-=8-16 rear=12.4/11-28, Hydraulic system: position draft control (three point linkage JIS (I)), Rotary cutting width: full cut-1,610 side drive-1,565 mm

(Kubota Ltd.: 22-2, Funade-cho, Naniwa-ku, Osaka, Japan)

Tractor

Satoh ELK···So lean and tough, it's carving out a place all its own, going places the big ones can't go. Doing things they can't do. Doing it all economically.

Elk gives you traction power. Pushing and pulling power. Hydraulic lift power. PTO power. There's a drawbar to low a wagon. A hydraulic, Category 1 • 3-point hitch to handle almost any implement.

You've got power at your fingertips to channel through that rugged Satoh transmission and power train. Plus an advanced-design, self-adjusting clutch. Eight speeds: 6 forward and 2 reverse.

[Specifications]
Dimensions: 2,627 x 1,169 x 1,310 mm (L x W x H), Weight: 649 kg, Ground clearance: 350 mm, Engine type: 4 cylinder water-cooled 4-cycle overhead-valve gasoline, Engine output: 19.5 hp/2,300 rpm, Speeds: Forward 6/reverse 2.

(Satoh Agricultural Machine Mfg. Co., Ltd.: Hibiya Kokusai Bldg. 2-3, 2-chome, Uchisaiwai-cho, Chiyoda-ku, Tokyo, Japan)

Tractor

Satoh Stallion···Consideration for the operator. Large, cushioned seat, easy on-and-off access, easy-to-reach controls, good visibility on all instruments, steering wheel at correct angle.

Designed for easy mounting of

attachments such as backhoes, loaders and mowers. Rugged main chassis and axle with strength to handle heavy loader work.

Sweptback front axle gives excellent turning radius yet is adjustable for row-crop work. Performs well in close quarters or in open field.

〔Specifications〕
Dimentions: 2,916 x 1,636 x 1,974 mm (L x W x H), Weight: 1,300 kg, Ground clearance: 413 mm, Engine type: 3-cylinder water-cooled 4-cycle overhead valve swirl chamber diesel, Engine output: 38 hp/2,500 rpm, Speeds: Forward 9/reverse 3.

(Satoh Agricultural Machine Mfg. Co., Ltd.: Hibiya Kokusai Bldg. 2-3, 2-chome, Uchisaiwai-cho, Chiyoda-ku, Tokyo, Japan)

Tractor

Shibaura SE8345··· (1) 83 hp, the biggest tractor made in Japan. It is 4-wheel drive and has the same power as the ones of 100 hp. (2) A large displacement engine 4,561 cc. It is silent and possible to work for a long time at a low speed or do a heavy work. (3) 16 forward and 4 backward gears and you can choose any speed you like according to your work. In addition, you can change gears, while driving at a high speed. (4) Independent gear system. You can switch on and off PTO, and the revolution of a rotary is separate from running speed of tractor. The speed of revolution can be changed by three step gear. You can also use ground PTO which revolves according to the running speed. (5) There are two hydraulic systems. One is hydraulic draft control which lifts up and down an attachment according to the soil. The other is hydraulic position control which regulates position exactly. (6) A power steering which is easy to handle. A comfortable air cushion seat in which you can drive for a long time without getting tired. In addition to these, you can change the angle of the handle according to your body.

〔Specifications〕
Dimentions: L 3,800 x W 2,020 x H 2,700 mm, Road clearance: 400 mm, Weight: 3,200 kg Engine: water cooled 4 cycle 4 cylinder 4,561 cc 83 ps/2,200 rpm, Gear: 16 forward 4 backward, Clutch: dry single plate, Brake: wet mule plate brake, Attachments elevator: hydraulic draft position control device, Linkage: three point linkage=JIS 2, PTO: revolution speed=540 · 750 · 1,000/ram, ground PTO, Wheel: front 11.2-/10-24, rear 14-34

(Ishikawajima-Shibaura Machinery Co., Ltd.: 8-6-1, Nishi-Shinjuku, Shinjuku-ku, Tokyo, Japan)

Tractor

Yanmar YM2210D···(1) Because of the high power shift which combines advantages of gear mission and hydraulic drive mission, you can move forword or backward, and change moving speeds with one lever without clutch. The working efficiency increased more than ever. (2) 15 forward and 5 backward gears make wide range operations possible for you. (3) With a large displacement diesel engine, it manages heavy tillage operation. (4) You can start with one time even in a very cold period. (5) Adopted 4-Wheel drive and high power shift mission, it has big traction power and suits works in muddy paddy fields. (6) With cross center drive system patented, there is no untilled land by this tractor in fields. (7) You can till every field with a special system with which you can put a tine to a forracre.

〔Specifications〕
Dimentions: L 2,785 (without rotary) x W 1,165 x H 1,865 mm (up to the top of the muffler), Weight: 945 kg, W.B.: 1,550 mm, Tread: front-880 mm rear-900 mm, Engine: 22 ps/2,600 rpm 1,145 cc cell starter, Wheel: front=4.00-15 (6-14), rear=9.5/9-24 high rag, Gear: 15 forward 5 backward PTO 4 change gear, Attachment elevator: hydraulic position control, Tillage method: center drive · side drive, Hitch: special three point hitch, Working width: 1,400 mm

(Yanmar Agricultural Equipment Co., Ltd.: 62, Chayamachi, Kita-ku, Osaka, Japan)

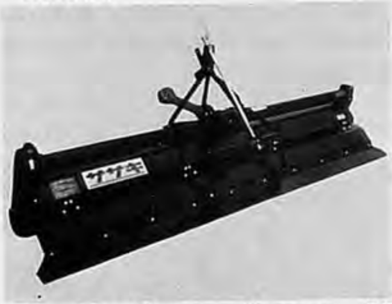
Plow (Bottom Plow)

Sasaki Plow PM···This model has following features:
(1) Economical plow with wide range of usage: Generally called bottom plows, are the ones for

ordinary plowing. But our Sasaki bottom plow can be used as a breaking one and also as an ordinary one.
(2) More durable and more beautiful: This plow of a brand-new design, made of materials in the best quality, has enough beam clearance. So, it will do the best work with draft power of tractors.
(3) Besides the above features, Sasaki bottom plow with a disk coulter offers you smooth operation and straight plowing. Also you can bury stalks and grasses deep in ground.
(4) We provide you with gauge wheels as attachments for easy operation.
〔Specifications〕
Mounting method: 3-point linkage, Dimensions: 1,150 x 830 x 1,000 mm (L x W x H), Weight: 86 kg, Working width: 305～356 mm, Efficiency: 10～18 a/h, Tractor output: 15～20 hp

(Sasaki Noki Co., Ltd.: 259-1, Satonosawa, Towada-shi, Aomori, Japan)

Harrow



Sasaki Power Harrow SR-280…The SR280 is designed only for the job of puddling, under any field condition. It promise you to do the smooth and the best job in fields with its high performance.

The lugs are attached with bolts to the rotor. You can exchange a lug which was broken in accident with a spare one. Power Harrow puddles well with a claw of the lugs on the rotor, and burys stalks deep in ground. With special lugs we developed, the problem of the tires' trace has solved completely.
〔Specifications〕
Dimensions: 830 x 3,100 x 1,050 mm (L x W x H), Weight: 300 kg, Rotor's dia.: 330 mm, Cutting width: 2,940 mm, Tractors: Over 25.

(Sasaki Noki Co., Ltd.: 259-1, Satonosawa, Towada-shi, Aomori, Japan)

Rice Transplanter

Kubota B5000X SPR600…(1) Speedy rice planting which is the same speed as a tractor. (2) The planting device is placed backward. So, it does not disarrange the ground or cause damage to nursery plants. (3) You can level planting bed, with 2 step land preparation system. With hydraulic brake and rolling system, the planting depth is constant. (4) When you plant on the edge of a field, you can plant rice in as few rows as you like with a nursery plant stopper. (5) It is easy to attach and take off the planting device. So, you can also use this as a tractor by exchanging tyres. (6) There is a shelf for 12 pieces of rice nursery bed. When the pieces on the shelf get few, the buzzer notifys you. So, you can do jobs by yourself. (7) You can regulate the intervals or depth of rice and exchange plants with a lever.
〔Specifications〕
Dimentions: (B) planting device-L 1,210 x W 2,090 x H 890 mm running device+planting device-L 2,980 x W 2,090 x H 1,800 mm, (C) planting device-L 1,210 x W 2,210 x H 890 mm • running device+planting device-L 2,980 x W 2,210 x H 1,800 mm, Weight: (B) planting device-110 kg • running device+planting device 530 kg (C) the same, Efficiency: 20-30 minutes/10 a, Running: 4-wheel float rag wheel, Gear: planting-2 step 6 forward 2 backward, Planting system: gold finger, Attachment linkage: two point linkage, Engine: 2,500 vertical water cooled 2 cylinder 4 cycle diesel engine 508 cc, maximum-9 ps-/3,000 rpm

(Kubota Ltd.: 22-2, Funadecho, Naniwa-ku Osaka, Japan)

Rice Transplanter

Mitsubishi "Suku Suku" MP-410…(1) Because of the planter of the new double action system Mitsubishi developed, it never causes damage to rice plants. (2) The front sight is good because the shelf for plants inclined backward. You can drive it straight and it is easy to operate it. (3) The driving on a rough road does not joggle because of the hydraulic automatic lifter system. (4) A planter clutch and a crank of body rolling are interlocked. So, this planter is excellent in turning and running. (5) When you switch off the planter clutch lever, in turning, the body is lifted up. So, it is easy for this planter to turn. (6) The diameter of wheels is wide, 650 mm, in order to make it easy for this planter to run on muddy or ultra muddy ground. In addition, a float prevents mud from being pushed forward and makes it easy for the planter itself to turn. (7) The planter stops automatically, in moving backward.

〔Specifications〕

Dimentions: L 2,350 x W 1,500 x H 950 mm, Weight: 150 kg, Engine: 4 cycle N25L cooled (electronic engine) • maximum-3.5 ps/1,800 rpm gasoline • recoil starter, Sort of rice plants: immature and mature rice, Planting efficiency: 30-40 minutes/10a, Planting method: planting claw and fork, Planting depth: 20 • 27 • 34 • 41 • 50mm, Planting rows: four, Running: automatic lifter, Gear: 1 forward 1 backward, Wheel: two wheels 650mm (diameter)

(Mitsubishi Kiki Hanbai, Ltd.: 3-2-2 Uchisaiwai-cho, Chiyoda-ku, Tokyo, Japan)

Broadcaster

Toyo Bradcaster TBB500…(1) Application Rate: The lever controlling the rate of feed operates over a scale marked from one to ten with two subdivisions. (2) Spread Width: Effective spread width have an effective working capacity. TBB500 has excellent performance and durability. (3) Stainless Steel Hopper: TBB500 is equipped with stainless steel hopper and stainless steel spread apparatus.

(Toyo Agricultural Machinery Mfg. Co., Ltd.: 14, Kita 1-chome, Nishi 22jo, Obihiro-shi, Hokkaido, Japan)

Combine Harvester

Yanmar TC1400… (1) When 4 bags get full, the buzzer will notify you. In addition, there are two more spare bags which can be changed with a lever. So, you can continue your job without pause. (2) With a new Y shape handling device, you can do easily the work of three rows at the same time, without extra power. (3) The pck-up time speed can be changed and you can easily reap falled crops. (4) With a high power shift, you can engage 9 forward and 3 backward gears, without clutch. You can choose any speed you like. (5) The surface of contact with ground is large and straw never gets entangled. This combine especially suits the work in muddy paddy fields. (6) All levers are concentrated on one place and a drivers's seat is comfortable. So, you never get tired after a long time working. (7) A straw rack adopted, it is excellent in grading and managing dust.

〔Specifications〕

Dimentions: L 3,180 x W 1,660 x H 1,800mm, Weight: 1,130kg, Engine: water cooled 4 cycle vertical 2 cylinder diesel engine 14ps/2,700rpm, Cutting width: 1,050mm, Threshing: upper threshing, Threshing cylinder: diameter 420 x width 650mm, Grading: shaking • air pressing and absorbing methods, Running: endless rubber crawler, Road clearance: 160mm, Gear: 9 forward 3 backward, Working efficiency: 11-16a/h

(Yanmar Agricultural Equipment Co., Ltd.: 62, Chaya-machi, Kita-ku, Ohsaka, Japan)

Beet Harvester

Toyo Beet Harvester TBH-2…The TBH-2 is used beet tops as green manure.

The main features of this harvester are as follows:

(1) Lifting depth is controlled by the hydraulic cylinder. After being lifted by the forks the beet go onto the cleaner conveyer.

(2) These clean the roots while conveying them to the elevator.

(3) The elevator carries the beets to a large capacity 2,000kg hopper which is situated over the wheels.

(4) The hopper has a moving floor and side elevator to give quick discharge.

(Toyo Agricultural Machinery Mfg. Co., Ltd.: 14, kita 1-chome, Nishi 22-jo, Obihiro-shi, Hokkaido, Japan)

Reaper

Irino L5-46B…This is handy and ideal grass-cutting machine even girls handle with ease in any kind of cutting work at a mountain or at a plain for it is light and small in size, equipped with superior safety-device and sibration-proof.

〔Specifications〕

Set Engine: 1.7 ps Kawasaki engine KT-17L or KT-17X, Driving system: Centrifugal clutch, Carrying method: Shoulders band, Length: 1,600mm, Weight: 6.1kg

(Irino Agricultural Machineries Selling Co., Ltd.: 4-24, 1-chome, Shimada-Honmachi, Okayama-city, Japan)

Bush Cutter

Seiko FD···Seiko cutter is setted Mitsubishi diaphram carbretor engine. It is so light as to perform swift and easy cutting. Its application ranges from household to field.

Outstanding features:

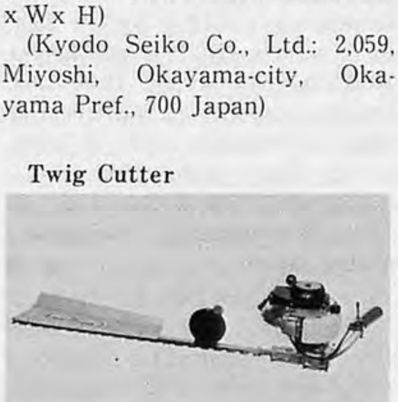
(1) "Point-less engine" is settable. (2) Compact size and light weight. (3) Available for any angles. (4) Complete prevention system for vibration. (5) high power. (6) Safety design.

[Specifications]

Driving system: Centrifugal clutch spiral bevel gear, Reduction ratio: 17 : 21, Rotating speed of blade: 4,950rpm, Rotating direction: Left, Weight: 5.3kg (excluding blade & handle) Dimensions: 1,860 x 540 x 400mm (L x W x H)

(Kyodo Seiko Co., Ltd.: 2,059, Miyoshi, Okayama-city, Okayama Pref., 700 Japan)

Twig Cutter



Ochiai Engine Twig Cutter 50-1···This cutter is a new type cutter for horticulture. It is so light as to perform swift and easy reaping of twig.

The features of this model are as follows:

(1) Compactly designed and little in weight, it can be manipulated easily by women and old men.
(2) The upper and lower blades moving as in an act of rubbing, it works with high efficiency.
(3) With the use of rubber clips, its efficiency is exceptional.
(4) Can be used at any place without difficulty; it always cuts well powerfully.

[Specifications]

Weight: 5.7kg, Source of power: engine (22.6cc, 1.2hp), Length of blade: 740mm, Length of machine: 1,100mm, Movement of blades: Crank type, both blades in rubbing motion, Number of revolutions: 7,000rpm

(Ochiai Hamono Kogyo Co., Ltd.: 38, Chokaiji, Kikugawa-cho, Ogasa-gun, Shizuoka-ken, Japan)

Twig Cutter

Ochiai EOP Twig Cutter D-6···This machine has been developed through the advanced technology of the specialist cutter manufacturer.

Outstanding features:

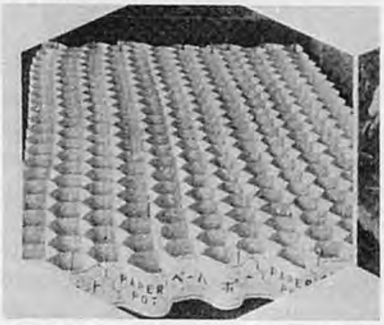
(1) Safe and rarely gets out of order, as a battery is used as a power source. (2) Easy to handle, it can be easily operated, even by women or old men, (3) Light and makes little noise, and only consumes minimum fuel.

[Specifications]

Length of blade (teeth bar): 415mm, Weight: 2.8kg, Source of power: Flat motor (DC24VD5W), Speed reduction: Flat gear system, Cutting method: Reciprocating type

(Ochiai Hamono Kogyo Co., Ltd.: 38, Chokaiji, Kikugawa-cho, Ogasa-gun, Shizuoka-ken, Japan)

Paper Pots



Nitten Paper Pot···Specially treated square or honey-comb-like hexagon shaped paper pots are of most convenience, because its size and weight are small and light. Being collapsible, the space saving device can be prepared for large quantities of ready-made pot planting, by unfolding it.

Special characteristics of paper pot are as follows:

(1) Easy handling of folded, light weight and compact paper pot.
(2) Since pots are connected to each other, it's space-saving.
(3) Healthy uniform plants are the result of good ventilation and good water seepage of the paper pot.
(4) The paper pot eliminates the danger of damage through transplanting and handling.
(5) Different sizes suits various types of seedlings and or plants.
(6) The price is reasonable.
(7) Labor-saving for transplanting and sapling-growing by this method.

(Uchida Corporation: AIU Akasaka Bldg. 1-2, Akasaka 3-chome, Minato-ku, Tokyo 107, Japan)

Cereal Moisture Tester

Kett PB-1K···This is a standard piece of equipment specified for use by the Food Agency. It

NEW PRODUCTS

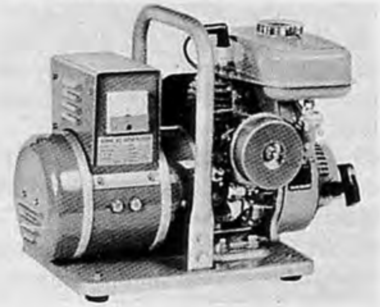
has gained wide acceptance not only in Japan, but also in many of the world's major rice-producing nations. Because of its high performance, it is employed by numerous inspection and research organizations.

[Specifications]

Measuring range: Rice-11～30% (barley, wheat, polished rice, rye, and miscellaneous cereals-10～20%), Accuracy: Within 0.5%, Power source: AC 100-220V・50 or 60 Hz, Dimensions: 16 x 28 x 21cm (H x W x D), Weight: 6.5kg

(Kett Electric Laboratory: 8-1 1-chome, Minami-Magome, Ota-ku, Tokyo 143, Japan)

Engine Generator



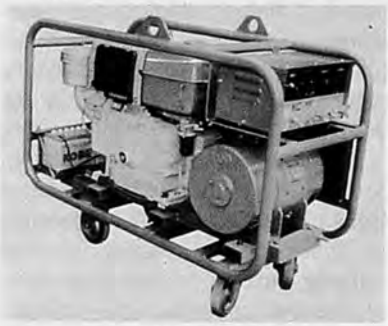
Sowa SG-650-1···"Sowa" generator is enjoying good reputation both in Japanese and many overseas markets for its sturdy and trouble-free mechanism and construction as well as its prominent features and performance together with their most advanced tecnique and long years' experience.

Main features of the generator are as follows:

(1) Compact & light weight (22kg): easy-to-handle, anywhere-to-carry. (2) Easy operation: just pull the recoil starter or rope, that's all. (3) Fine durability & rigid construction: trouble-free continuous operation. (4) Protection device: with protection fuse against excessive current. (5) Stable and powerful perfarmance: with highly improved engine (1.3ps).

(Sowa Electric Mfg. Co., Ltd.: Sayama-Kogyo-Danchi, 337, Kashiwabara, Sayama-shi, Saitama 350-13, Japan)

Welder



Sowa Diesel DC Welder···The welder has so many exclusive features to do better work, as follows:

(1) Increased efficiency of output power conversion: most stable output converted from minimum engine hp. (2) Minimized revolution: equipment failures reduced due to the minimized revolution speed. (3) Electric starting: quick start with a cell motor···electric starting with generator···possible use of electric tools. (4) Compact-light weight (205～420kg): connected with the diesel engine and the whole equipments mounted on the four wheels wagon. (5) Direct current welder: electric shock absorber needless.

(Sowa Electric Mfg. Co., Ltd.: Sayama-Kogyo-Danchi, 337, Kashiwabara, Sayama-shi, Saitama 350-13, Japan)

Outboard Motor

Tas Motor TOB-25···This motor is a small and light weight marine engine for leisure.

Its features are as follows:

(1) The main parts are made from anti-corrosive alminum alloy which provides excellent anti-crrosion properties from sea-water. (2) For safety, the fuel tank is designed away from the cylinder head of the engine.

(3) The reverse cruising lock is very convenient when cruising in narrow passages or for emergency use.

(4) For easy transporting, an auxiliary handle is designed on the power head to create a well balanced load.

[Specifications]

Dimensions: 14.17 x 9.65 x 35.43 in. (L x W x H), Transom height: 20.87 in., Dry weigh: 18.00 Lbs., Engine output: 2.5hp/6,000rpm (Max.), Propeller size: 3 blade. 7.17 in. Dia. x 5.39in. Pitch.

(Tanaka Kogyo Co., Ltd.: 7-1460 Yatsu-machi, Narashino, Chiba, Japan) ■ ■

Tools for Agriculture : A Buyer's Guide to Low-Cost Agricultural Implements

In 1973, the Intermediate Technology Development Group identified a need that existed in developing countries for a directory of commercially available small farm implements and agricultural equipment. As a consequence, they published the first *Guide To Hand-operated and Animal-Drawn Equipment* which proved to be an immediate success. It enabled would-be purchasers to locate their nearest supplier of the sort of equipment required, as well as providing information about the various implements available.

This directory identifies more than 250 manufacturers of various types of simple, low-cost agricultural implements all over the world, and this edition contains over 600 entries. The 14 sections of the book are classified by type of farming operation and in each case, a few notes are provided outlining the types of equipment available. The scope of this edition has been considerably widened to include not only far more manufacturers and implements, but also relevant equipment powered by small engines. It should be pointed out that the inclusion of an item of equipment in this book does not imply that it is recommended by I.T.D.G., but that it is simply information supplied by the manufacturers. Nevertheless, this directory, which contains a mine of carefully assembled material, should prove to be invaluable to farmers, agricultural colleges, extension officers and smallholders, providing information in a handy catalogue form, from which they can make their own judgements on the alternative equipment that is available and their best source of supply.

Net Price : £4.00 (US$10.00) Postpaid : £4.75 (US$11.50) Airmail : £6.25 (US$14.70)

Compiled by John Boyd (2nd Edition)

Intermediate Technology Publications Ltd. 9 King Street, London WC2E 8HN, England.

The Green Book
—1977 Edition—

So many new developments have been made among the range of tractors and equipment used in farming, forestry and horticulture that the Green Book has had 100 extra pages added in the past two years. Its Complete revision has entailed 350 changes in photographs and editorial matter, a task which has been in the capable hands of Harry Catling, Head of the Mechanisation Department of the Royal Agricultural College, Cirencester.

Section 2, Manufacturers' Names and Addresses, has been re-set in bolder type, new counties and telex numbers (where known) have been added; over 1400 names are now available in this section. Last year saw the return to hard covers and the current edition has continued with this improvement.

The Green Book has always been unique in its presentation-every tractor having a page to itself, with a photograph and specifications; every piece of equipment is illustrated and has accompanying editorial, with the name of the manufacturer or concessionaire.

Surprisingly, the price has not been increased, so the cost of £10.50, plus a small order charge of 70 pence, represents a good buy for everyone considering capital outlay for farming, horticultural or forestry equipment. A descriptive brochure with order form is svailable from:

Thomas Reed Industrial Press Ltd.,
36/37 Cock Lane, London ECIA 9 BY.

Four Language Trade Mark Guide of Dutch Agricultural, Horticultural and Forestry Machinery 1977

The Department of Mechanization of the IMAG (Instituut voor Mechanisatie, Arbeid en Gebouwen=Istitute of Agricultural Engineering), in conjunction with the Agricultural Machinery Federation, have compiled a new version of the official Dutch trade mark guide of agricultural machinery, to replace the previous edition which appeared in 1966.

Its wide coverage makes the guide a complete directory of suppliers of agricultural, horticultural and forestry machinery. It appears in the form of a classified catalogue of all the various kinds of machinery and tools available on the Dutch market, and where applicable also lists the trade marks and the names and addresses of the Dutch importers and manufacturers. At any rate as far as the forms of cultivation practised in the Netherlands are concerned, Dutch agricultural engineering can compete with the most modern forms of mechanization to be found anywhere in the world. Thus the systematic presentation in this guide may be regarded as representative of the present overally state of mechanization in agriculture, horticulture and forestry. As a result it makes a very real contribution to publicising and explaining modern machinery, and can thereby benefit the trade, research, information, education and users, in short everybody involved with agrarian mechanization.

In simple layout and also fully illustrated with about 1600 drawings of the various kinds of machines and tools, the 61 main groups, sub-divided into 1086 sub-sections, present a virtually complete picture of the entire range of technical farming aids available in Holland during the period 1966 to 1977. This convenient guide, containing about 450 pages, proviced a complete analysis of all the possibilities of the entire range of Dutch machinery, and also gives a clear picture of the market as a whole, both for Dutch and for foreign manufacturers.

It also acts as an excellent illustrated agricultural engineering dictionary in four languages, since in addition to the Dutch text, there is a complete translation into German, English and French; this will be of great help in many situations. Where alternative terms may be used, these are also given, so that the probability of misunderstandings can be reduced to a minimum.

Copies of this unique guide may be obtained by remitting fls. 40 to the giro account 3514771 of IMAG, Mansholtlaan 10—12, Wageningen (Netherlands), stating "Agricultural Trade mark guide".

New IRRI Publications

Recent IRRI publications include a new book, new editions of two previous books, two new periodicals, and the IRRI *Annual Report for 1975*.

Manual on Genetic Conservation of Rice Germ Plasm for Evaluation and Utilization is by T.T. Chang, IRRI geneticist and leader of its Genetic Resources program. Designed to help rice researchers to conserve, evaluate, and use existing gene pools, it complements the *Manual for Field Collectors of Rice* issued by IRRI in 1972.

The Flowering Response of the Rice Plant to Photoperiod: A Review of the Literature, by B.S. Vergara and T.T. Chang, is the third edition of a book published in 1969. It includes a new chapter on the flowring response of the rice plant under natural growing conditions. Dr. Vergara is an IRRI plant physiologist.

Training Manual for Rice Production is by Vo-Tong Xuan, a former research fellow in the IRRI Rice Production Training Program (RPTR), and V.E. Ross, former hear of RPTR. It updates a 1972 publication.

The International Rice Research Newsletter (IRRN), a bimonthly, carries concise summaries (one or two short paragraphs and a table, figure, or photograph) of significant rice research from workers and investigators throughout the world. It incorporates most of the functions of two earlier IRRI newsletters—*The Rice Entomology Newsletter* and *The Rice Pathology Newsletter*—and covers all other areas of rice research. The first 4 issues, 1/76, 2/76,1/77, and 2/77, have been distributed to more than 4,000 scientists, as well as libraries, across the rice-growing world.

The IRRI Research Paper Series is a vehicle for timely publication of research findings by IRRI senior staff and associated scientists that have significant value for researchers on rice and rice-based cropping systems. (See box for recent titles in the series.)

The IRRI Annual Report for 1975 is the 14th such report to be issued by the Institute. In words, pictures, table, and figures, its 479 pages describe the 1975 calendar-year results of IRRI's interdisciplinary teamwork on a wide variety of problems.

Manual on Genetic Conservation of Rice Germ Plasm for Evaluation and Utilization can be ordered for US$1.00 a copy by surface mail, US$3.00 by airmail, or ₱4.00 in the Philippines. *The Flowering Response of the Rice Plant to Photoperiod* can be obtained for US$1.00 surface mail, US$4.00 airmail, or ₱4.00 *Training Manual for Rice Production* is US$2.00 by surface mail, US$6.00 by airmail, or ₱7.00. The *Annual Report for 1975* costs US$6.50 by surface mail, US$20.00 by airmail, or ₱35.00. Subscription to IRRN is available without cost upon request. The *IRRI Research Paper Series* goes regularly only to libraries and certain other institutions. Individuals may request one or two selected titles. Address orders and inquiries about these and other IRRI publications to the Office of Information Services, IRRI.

Office of Information Services
The international Rice Research Instltute P.O. Box 933, Manila, Philippines

Four More UNIDO Guides to Information Sources

To help developing countries obtain rapid access to sectoral information and professional, trade and research organizations, the United Nations Industrial Development Organization (UNIDO) has compiled four more guides to selected branches of industry, bringing the total to 24. The latest publications deal with fertilizers, machine tools, dairy products and soaps/detergents. A revised edition on the meat-processing industry is also available.

Details provided include addresses of national bodies, regional and international organizations, sources of statistics, marketing and other economic data, textbooks and manuals dealing with technological information on various branches of industry, specialized journals, bibliographies, films and other potential sources of information such as consulting and engineering services, fairs and exhibitions, meetings and conferences, patents and licences and standards and specifications.

may be ordered from the Sales Section, United Nations, New York or Geneva, or from UN Sales Agents or major booksellers in all parts of the world. Price: $US 4.00 each (or equivalent in other currencies).

Review copies may be obtained from the Chief of the Public Information Service.

Employment and Technology Choice in Asian Agriculture

Given that agriculture is the major provider of employment and, ipso facto, of the personal income distribution in the developing world, it is essential to examine systematically the implications of alternative agricultural technologies for the major policy objectives: output, employment, and income distribution. This latter task necessitates the availability of reliable and representative data, which can be obtained only through a very painstaking process of assembling, evaluating, and presenting input-output estimates from a variety of micro-economic sources.

Researchers and planners should be thankful to Mr. Bartsch for having performed this task in an extremely thorough and careful fashion for cereals in Asia. Using a breakdown consisting of three levels of techniques--defined on the basis of the main source of power--from mechanized to labor-intensive---and technologies representing three levels of packages of biological and chemical inputs, from the more advanced (including high-yield varieties, fertilizer, and insecticides) to the traditional, he presents, both at the operations level and over the whole production cycle, the labor requirements per hectare and per unit of output for the nine possible combinations of technologies and techniques for a number of cereal crops in Asia.

This information should provide the essential raw material for the analysts and planners who want to plot the effects of alternative agricultural technologies on major policy objectives. This study thus could become an element in the formulation of more development-oriented agricultural strategies.

Edited by William H. Bartsch, economist on the regular staff of WEP.

Published in the United States of America in 1977 by Praeger Publishers, Inc., 200 Park Avenue, New York, N.Y. 10017, U.S.A.

Energy for World-Wide Agriculture

FAO/MSU Agricultural Development Paper

This statement is not intended to imply that the LDC's should or could follow the lead of the petroleum gobbling industrial nations. Because petroleum supplies are dwindling, other energy bases must be developed and exploited within the prevailing economic and political framework. The alternative is stagnation of the world economy and a reduced standard of living for mankind.

The purpose of this book is to put energy and the food system in perspective and to provide a manual for persons interested in maintaining or increasing world food supplies. Energy resources are tabulated and the principles, processes and efficiency of various conversion processes are considered along with detailed discussions of their applications in the food system.

In addition, a conceptual outline of the energy flow in the food system and the energy requirements for each operation in its production, processing and delivery are presented.

The energy implications of providing an adequate diet for the expanding world population as well as alternative energy sources for the future are discussed.

A major problem in preparing the manuscript was the lack of data from or relating to LDC's. Most of the information available comes from more advanced countries. More comprehensive data on energy flow in the food systems of LDC's must be collected before adequate alternatives for supplying food can be developed that are less dependent on expensive and possibly insecure petroleum supplies.

Every effort has been made to keep the presentation non-technical. However, definitions and technical terms which may be unfamiliar to you are included in the Appendix.

Edited by B.A. Stout, Professor, Agricultural Engineering Dept., Michigan State University, East Lansing, Michigan 48824, USA. in collaboration with C.A. Myers, A. Hurand and L.W. Faidley. ■ ■

BACK NUMBERS

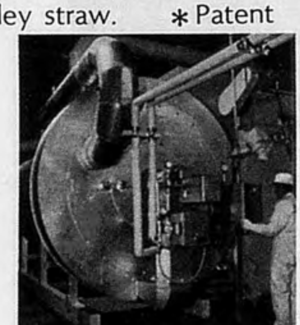
THINKING AND THINKING, MORE THAN 70 YEARS

When turn around ourselves, it was absorbed for the development and research since we established in 1901.

FROM NOW ON ......

We would like to pay our full effort for the development of the new tractor implement to meet various requirement and the plant for re-cycling of the resources such as surplus activate sludge treatment and*alkali treated high quality fodder from rice and barley straw. *Patent

●POWER HARROW



●RE-CYCLING PLANT

●BROADCASTER

SASAKI NOKI CO.,LTD.

HEAD OFFICE/
TOWADA AOMORI JAPAN TELEX 8255-70 SASAKI

TOKYO OFFICE/OVERSEAS DIV.
5F MATSUOKA BLDG.,5-5,YAESU,CHUO-KU,TOKYO 104 JAPAN
TEL 03 - 272 - 2831 TELEX : 2228129 SASAKI. J

TOKYO FARM MACHINERY SHOW '77

EXHIBITS : engine for agricultural use, power tiller and soil preparation machinery, weed control equipment, sprayer and duster, pumps and irrigation machinery, harvesting and processing machinery, food processing machinery, equipment for animal production and milk production, equipment and special vehicle for agricultural material handling and transportation, other machinery and facilities for agriculture and forestry, agricultural products.

DATES : November 22(Tues.) - 29(Tues.), 1977
PLACE : 5-chome Harumi chuo-ku Tokyo
Tokyo International Trade Center, East Building

Sponsored by the Japan Agricultural Machinery Manufacturers' Association
Supported by the Ministry of International Trade and Industry
the Ministry of Agriculture and Forestry

NewsLetter

INTERNATIONAL FARM MECHANIZATION RESEARCH SERVICE
c/o SHINNORIN-SHA 2–7 KANDA NISHIKI-CHO CHIYODA-KU,
TOKYO, JAPAN., TEL. 03–291–5718, 3674

Dear friends

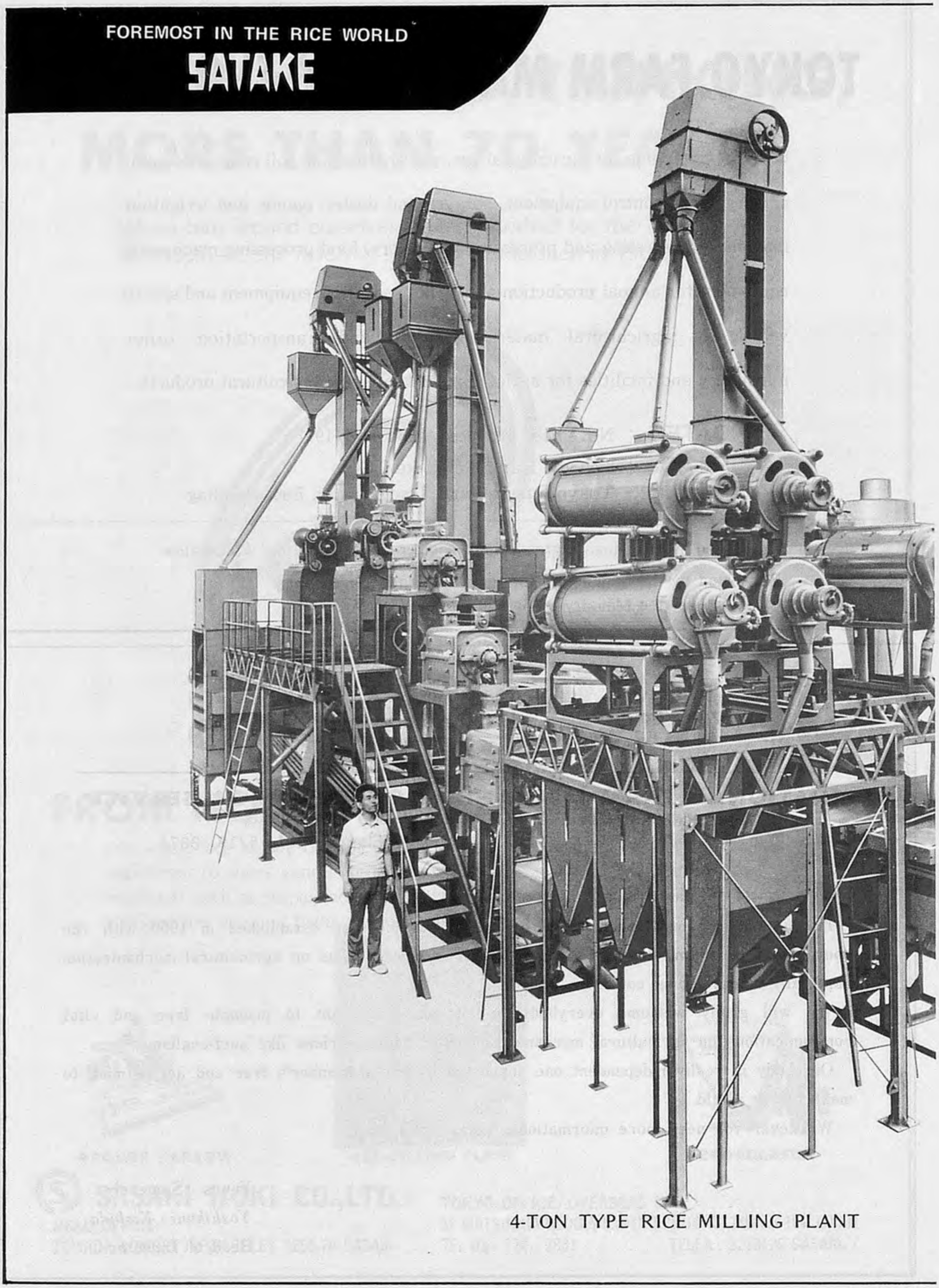
International Farm Mechanization Research Service was established in 1968 with the pourpose of promoting efective communications and researches on agricultural mechanization especially in developing countries.

We will gladly welcome everybody to join us who want to promote free and vital communications on agricultural mechanization over many barriers like sectionalism.

Our body is really independent one supported by every member's free and active mind to make better world.

Whenever you need more informations, pleas write me!

Yours Sincerely
Yoshikuni Kishida
Head of Directors



4-TON TYPE RICE MILLING PLANT