Small-Mechanization Technologies for rice farmers
## Rice Technology Bulletin Series

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## Foreword

As technological innovations drastically arise, it made living easier and more productive. Same goes with rice production. Development of farm machinery made farming easier and faster enabling farmers to harvest more bountiful.

From land preparation to harvesting, even for some processing related to rice, Philrice has constantly developing farm equipment most suitable for Filipino farmers.

However, only few farmers have actually seen or used the newer technologies generated from the past decades of research work.

This issue of Rice Technology Bulletin presents different engineering technologies which can be used for the field and even with postharvest operations in rice. This can serve as guide on what kind of equipment to use in different stages of rice production, when and where it is best operated, advantages and disadvantages.

RONILO A. BERONIO  
Executive Director
Land Preparation

PART 1. PRODUCTION MACHINERY

Hand tractor

- the use of hand tractor for preparing the field prior to transplanting or seeding is now common in the irrigated and some rice rainfed areas.

- commonly powered by a small gasoline engine (9-16 hp) or a diesel engine (6-8 hp).

- Most popular in Asia as “farmers’ car”, hand tractors once put with riding attachments require extra power from the engine to pull an additional load coming from the operator.

Hand tractors’ Common attachments:

1. disc or moldboard plow for plowing
2. a pair of cagewheels (for soft fields, these are replaced with spiral plow for plowing)
3. comb harrow for harrowing
4. puddling trailer for transport purposes

Floating Hand Tractors

- For very soft soil conditions with deep hardpan
- useful in ordinary wet fields for puddling as a faster alternative to the hand tractor with cagewheel and harrow.
- have better capability to prepare deep and soft fields where animal or the hand tractor could not easily work properly.
- In South China, boat tillers (riding type) are also common in deep submerged areas.
- could not transport on its own in the road because of the fast rotation of the wheel.
- few design alternatives have been presented by several manufacturers of floating tillers but it is still common to transport it using other vehicles.
Rotavators attached to hand tractors are also used but most of these are surplus equipment imported from Japan or Taiwan.

Recently, the availability in Southeast Asia of cheap, reconditioned four wheel tractors with 15-25hp from Japan and Korea has encouraged adoption mainly due to its low cost (25% of original cost of brand new units) and durability (compared with locally manufactured hand tractors).

allows tillage in semi-dry fields for upland crops such as corn, tobacco and vegetables as well as large cage-wheels or steel-lugged wheels for wet, soft fields.

big four-wheel tractors with rotovators

**Factors that influence the use and adoption of mechanized land preparation equipment includes the following:**

- socioeconomic factors such as investment cost, presence of custom service potential in the area, and other perceived benefits such as income generation potential, etc.
- technical aspects such as capacity, soil hardness and depth of hardpan
- other uses such as transport of farm products, irrigation, etc.

**Crop Establishment**

**Mechanical Transplanter**

IRRI manually-operated rice transplanter introduced in the 1980s in several countries like the Philippines, Myanmar and Sri Lanka. It uses especially prepared mat-type seedlings. The operator walks backward while actuating the handle when pulling the transplanter and, by subsequently pushing the handle for every step, seedlings are picked from the tray and planted into the soil as the handle is pushed downward. Difficulty to prepare mat seedlings, the high skill required in its operation, and low field capacity (1/5 to 1/4 ha/d) contributes to its low popularity.
Mechanical transplanting technologies

For developed countries like Japan, Taiwan and South Korea, walk-behind or riding transplanters are common. Similar planting mechanisms are also adopted in East Asia and China. However, transplanting and direct seeding in most developing countries in Asia remains as a manual operation due to high machine costs and abundant supply of labor.

Drum seeder

• a simple, low-cost drum seeder developed to seed 24h-soaked and 24h-incubated rice seeds in neat rows.
  • Seeding rate is controlled at 40 to 80 kg/ha while seeding can be completed in 6-8 h/ha with two operators.
  • A furrow opener can be incorporated in the design to allow some soil cover and less rainfall displacement during rainy season.
  • A plastic version of a drum seeder is becoming popular in the Philippines, Vietnam, India and Bangladesh where hand broadcasting of about 150-200 kg of seed/ha is common.

Factors being considered in the adoption of mechanized planting techniques:

• cost of the machines, especially for transplanting machines which are often imported from neighboring countries
• availability of skilled technicians and spare parts for servicing defective equipment
• related farmers’ practices such as row spacing, number of seedlings per hill, etc.

Factors being considered in using direct seeding equipment:

• depth and hardness of paddy soil
• the ability to control seed rates (recommended is from 40 to 80 kg/ha)
• competitiveness of the seeder in comparison with manual broadcasting (field capacity of 6-8 h/ha compared to 3-4 h/ha for manual broadcast).
Crop Care
Knapsack or powered sprayers

The use of pesticides to control insect pests is currently being minimized in Asia because it’s hazardous to human and environment. Moreover, it reduces or eliminates the friendly predators within the ecosystem and increase production costs.

A strong international program is being pursued to encourage no early spraying. Alternatives like synchronous planting, changing of varieties, have been proven effective and is becoming popular.

Precautionary measures:
• Avoid physical contact with leaking tank or joints’ chemicals
• Use protectors like mask to prevent inhalation during use.

Irrigation
Centrifugal Pump

Centrifugal pumps installed in different ways (for shallow tube wells) and axial flow pumps (for low-lift application like canals, rivers, reservoirs) and farm reservoirs are common in the rainfed and upland areas.

• powered by a small gasoline or diesel engine and installed next to open- or closed-cased shallow wells.
• installed above the wells when water is sufficient
• could be installed also below the open well to lower head and to maximize water output.
• For low lifting requirements with open water surfaces like rivers, irrigation canals, or small water impoundments, pumps like the axial-flow type are sufficient and proven as more efficient (in terms of volume) than centrifugal pumps at heads of 6 meter or less.
• Countries like Vietnam, Thailand, and the Philippines have adopted this pump for low-lift application.

Weeders

mechanical weeder
rotary weeders
(inset is a cono weeder)
Harvesting

Mechanical Reapers

- 1-meter wide reaper can finish 1-2 ha/day with one person walking behind the reaper
- wider (up to 1.6 meter cutting width) or a riding version of a reaper has faster capacity (2-3 ha/d) but has slightly more shattering losses because of the speed of windrowing
- harvested plants are laid out in neat windrows at one side of the machine, ready for picking and bundling by other laborers.

Stripper Gatherer

- allows harvesting of grains and panicles with the plant still intact on the ground
- has a capacity of 0.7-1.0 ha/day and is normally coupled with a thresher in order to clean and rethresh the stripped materials on the same day.

Advantages of stripper over reaper:

- handling and other in-field losses are kept to the minimum since harvesting and threshing are done simultaneously
- it uses less labor since gathering of harvested materials is done by the stripper while the stripped materials are simultaneously threshed with a separate thresher so that the grains are bagged on the same day of harvesting
- And it has better ability to handle semi-lodged plants compared to the reaper

Combine Harvester

Combines harvesting, threshing, cleaning and bagging paddy grains in one operation and are ideal for large farms or for custom harvesting.

Sizes: 1.2, 1.7, 2, 3 and up to 6 meters

Models: Wheel-types with rubber or steel tracks

Types: Thai model (patterned after the Western combines) head-fed combines (patterned after Japanese designs)

A small lightweight combine that also utilizes axial flow thresher design is now being introduced in the Philippines and Vietnam. Their use and popularity depend on their suitability to Asian paddy fields having small sizes with soft, wet fields during wet season and on their cost.
types of combine harvester:

Japanese model

Thai design

minicombine (designed for small plots)

**Constraints to the wide adoption of mechanical harvesters:**

- expensive (especially the imported models)
- Only big combines can handle completely lodged crop
- require good soil conditions
- Consider machine weight and plot size
- availability of skilled technicians to operate the machine
- Hard to operate, repair and maintain
- local availability of spare parts
- the labor-displacement of harvester usage

**Factors to consider in selecting thresher:**

- the prevailing practices in the area, including the intended use of rice straw (for rice farming systems)
- farm size and competition, or the number of threshers operating in the area for custom hiring against the amount of area serviceable with such custom hired thresher
- economics, or the amount of investment compared with the time required to pay back the investment
- the features and performance of the thresher make compared with other models, particularly losses, weight, price, mobility, etc.

**Powered Threshers**

Models of Axial flow threshers common in Southeast Asia

- The simplest design is the hold-on powered pedal thresher (with a small electric motor or gasoline engine, 80 cav/d capacity with 2-3 men)
- the most sophisticated design is the old McCormick thresher
  - big thresher is powered by four-wheel tractor PTO, requiring 8 men to operate, having 2-4 t/h capacity but with more losses (6-11%) than the more modern axial-flow designs (0.14-1.57% loss)
Cleaning
Grain Cleaner

mechanical winnowing with engine power

• Mechanical cleaner (99% purity, good for seed purposes) equipped with a 3/4-HP electric motor or a small engine
• capacity of about 15-20 cav/h
• separates weed seeds (which is important in rice seed certification) through a set of screens, a winnowing fan and an optional blast fan

Drying
Flat bed dryers

• can dry 0.5 tons/batch to 200 cav/4-8 h depending on the initial moisture content of the paddy
• uses heated air from a kerosene burner or a rice hull furnace and forced by a fan powered separately by an electric motor or a diesel engine into a bed of wet paddy suspended above a plenum through a false floor within a wood, metal or concrete bin
• Air that has moved through the paddy comes out more humid at the top of the bed
• Drying temperature could be regulated up to 430°C for seed purposes but could reach a maximum of 600°C for commercial drying

types of flatbed dryers:

A flatbed dryer for seed drying (1 ton/batch) commercial paddy (3-10 tons) heated with rice husk furnace.

Recirculating batch dryer
Continuous-flow dryer

• dries paddy using high air temperature of 60-80°C using diesel or kerosene fuel (some recent circulating dryers use as high as 120°C)
• Lately, some of these dryers are fitted with local rice hull-fed furnaces
• can dry 4-6 tons of wet paddy per load through a centrifugal fan which forces the heated air into the vertical drying chamber
• Wet paddy is fed into the hopper of a bucket-type conveyor and is carried up at the top. It drops into that drying section with flow control section that controls the paddy flow through the dryer, where heated air is blown through the paddy.
• paddy is re-circulated within the dryer throughout the entire drying process before unloading at the bottom
• Normally have large holding or tempering bins on top with a small drying section at the bottom
• Recirculation is done by a small auger across the bottom to collect the paddy and a bucket elevator to lift the paddy back to the top. After drying, paddy is lifted to the top by the same elevator and discharged
Recirculating dryers schematic set-up, an imported model coupled with a rice hull furnace and a local version.

**Constraints** in using recirculating dryers:

- high investment cost
- high operating cost due to use of kerosene or diesel fuel. Rice hull furnaces such as shown in fig.
- automatic furnaces (with self-feeding and ash discharges) are also expensive due to heat exchangers that may also reduce the efficiency of the furnace itself

**Constraints** to the adoption of mechanical dryers:

- high investment and operating cost compared with sundrying (estimated to be about 6-10% of paddy with kerosene-fired heaters and 2-3% with rice hull-fired furnaces)
- high maintenance cost for the imported recirculating dryers
- must do custom drying to be economically feasible with its high investment cost
- perceived as useful only when unfavorable weather conditions do not permit sundrying, i.e. during rainy periods
- limited capacity (for small capacity dryers, i.e. 1-2 tons/batch) especially during peak harvest season
- lack of information to its advantages, operation, and availability

**Milling**

**Single pass kiskisan-type rice mill**

Engelberg steel/stone hulled

- combines dehusking and polishing
- Paddy is fed into the hopper and is forced to move around the milling cylinder toward the outlet end by the rotational direction of ribs on the rotating rotor
- Friction between grains and the perforated screen wrapped below the rotor causing the husk and bran to be scraped off the grain
- The husk, bran and some broken grains are ground and are pushed through the screen. Some husk and bran are discharged with the polished output and requires further sieving.
- accessible
- it can mill small paddy quantities
- produces more rice bran than other types (an important by-product for animal feed in rural areas)
- simple to operate and maintain
**Disadvantages in using single pass kiskisan-type rice mill:**

- prone to manipulation by mill operators and owners to suit their purposes
- has low milling recovery (<60% MR in general) while quality of milled rice is poor (about 30-40% head rice) compared with more recent designs.

**Micromill**

- was designed as an improvement of the kiskisan with slightly higher milling and head rice recoveries than the kiskisan
- capacity of 50 to 200 kg/h (depending on the model: household or village), suited for small farmers in remote areas.

**Rubber roll rice mill**

**mini/baby cono**

- better designed than the steel huller and has higher milling (64-68%) and head rice recoveries (60-80%)
- Capacities ranges from 0.5, 1 and 2 tons/hr depending on the size of rubber roll dehusker
- In countries where sundrying along concrete pavements are common, these mills are commonly equipped with a destoner that separates stones picked from drying from milled rice output

**Disadvantages in using rubber roll rice mill:**

- it is expensive
- requires high skill in operation and maintenance
- produces maximum of 10% rice bran only

**types of rubber roll rice mill:**

- mobile mill model
- multi-pass mills

**mill components:**

- paddy pre-cleaner
- whitener (friction- or abrasive-types)
- polisher (leather- or mist-types)
- grader that may include a rotary or oscillating sieve or indented cylinder
- Destoner
- paddy separator

(all these are linked by conveyors with separate power from small electric motors)

To attain capacity, it is common that millers adopt one or more dehuskers to compensate for capacity. Some millers in developed Asian countries also use electronic color sorters to separate discolored grains from the milled rice output.
Factors affecting the milling technology adoption:

- the amount of investment of milling equipment and associated facilities (i.e. land and shed) as well as maintenance cost
- the intended use of milled rice product (for home consumption or commercial use)
- the amount and use of by-products, i.e. rice bran
- the availability of trained personnel to operate and maintain it
- accessibility of the mill to the user

Storage

The most important factors for good storage are the paddy’s moisture content and cleanliness prior to storage and good housekeeping in the storage room or container. For milling purposes, the paddy should be dried to about 13-14%.

For seed purposes, paddy should be dried to the following moisture content depending on the length of storage period:

- 1-3 mo. storage: 13% MC
- 4-6 mo. storage: 12% MC
- 7-12 mo. storage: 11% MC

Storage Techniques

- aeration in the warehouse could be provided with small stacks (up to 20 bags high) on wood or plastic dunnage (paleta) and with adequate walking space around each stack to prevent moisture migration and permit good sanitation practices
- control rats, mice and birds by rat and bird proofing
- control insects with thorough sanitation and by spraying insecticides and fumigants during storage
- insects multiply slowly when temperature is below 15.6°C

- developed in Israel
- introduced in the humid countries in the tropics such as Philippines, India and Thailand is the hermetic bags which is actually a special plastic that hermetically seals grains stored in paddy bags in the warehouse or even in the outside environment
- isolates the grains from the outside environment
- allows fumigation and zero oxygen inside the hermetic bag, thus, discouraging insect and microorganism growth and multiplication
- Grains can stay for 6 months and longer without spoilage from humid air, insects and microorganisms
PART 3. OTHER RELATED TECHNOLOGIES

• IRRI is introducing “super bags” that hermetically seals one bag of seeds from the environment using a double layer of plastic with a ___ layer in between
  • It is known to safeguard the seeds from insects and the ambient air while maintaining zero level of oxygen inside, enough to kill any insects on the paddy before storage

Flour mill

Most flour mills in the market use wet process method that could lead to early spoilage of the product and ease of contamination. A flour mill that converts rice into dry milled flour was developed to allow flour storage for longer periods, i.e. up to six months. The mill is based on impact milling by throwing grains repeatedly at the periphery of the milling chamber until the particle is fine enough to pass through a milling screen. The fine flour particles then go through a cyclone to separate air from the particles before the flour drops into the container. The flour fineness ranges from mesh #60 to #120. It can mill other crops such as cassava, banana, squash, sweet potato, chili, pepper, ginger, garlic, saluyot, etc. with the change of milling screen to attain the desired fineness. Three models have been developed: a household model with 10 kg/h capacity, a village model with 50-80 kg/h capacity and a plant model with 150-200 kg/h capacity.

Flour mill that process dried rice, corn, cassava, squash, yam, condiments and other farm products for cakes and special purposes.

Malgaya Rice hull cookstove

• Designed for rural women that utilizes rice hull for domestic cooking
• a low-cost alternative to wood- or oil-based fuel
• an adaptation of the Vietnamese and Indonesian models and developed to utilize rice hull for cooking
• Efficient, almost smokeless, and easy to ignite and operate
• raw rice hull to generate a bluish flame that can boil water in less than five minutes
• simple, cheap and easy to fabricate.
Three-wheel hand tractor for transport

- single wheel in front for steering and powered by a small internal combustion engine
- has a car transmission complete with forward and reverse gears connected into a car differential
- The concept found its way outside the IRRI compound in Laguna for farm transport of coconuts, cavans of paddy, and farmers.
- In Isabela, one manufacturer produces this vehicle for transport of people in and out of farm

Rice hull carbonizer

- open-type carbonizers for rice hull was developed in PhilRice
- uses inverted cylinder with a long tubular extension welded on its middle top for smoke outlet
- smoke escapes on the 1-inch diameter hole at the side of the vertical tube

steps in using carbonized rice hull:

- Raw rice hull is first ignited around the cylinder and stacked slowly until the cylinder is totally covered by rice hull (estimated at 10 bags)
- the hull is stirred to encourage the uncarbonized hulls at the surface to get buried
- carbonized output looks like charcoal
- carbonized rice hull is cooled by water spraying

Soil Auger

- Designed as an optional attachment to the hand tractor
- drills holes at a rate of 1000 holes per day
- auger’s diameter dictates the size of the hole, from 4 inches for posts to as wide as 8 to 12 inches diameter holes for tree seedlings, watermelon, banana and other rice-based crops
- The hole depths can vary from 4 to 12-inches depending on the operator lowering the auger with the hand tractor handle
- It is attached in front of the hand tractor
- driven by the engine through a belt and pulley into a surplus car differential to drive the auger vertically when an idler pulley is activated by the operator
- After digging, the tractor handle is raised and the idler clutch for the hand tractor is activated to move to the tractor to next hole
Rice Hull Gasifier

- Designed to tap the producer gas generated from controlled combustion of rice hull or other farm wastes that can be used to power a stationary farm engine
- It is common that some gasifiers based on rice hull would employ a series of filters to ensure that the gas entering the engine carburetor is already clean to safeguard the engine.
- Others, such as those using charcoal, employ simpler arrangements since the gas is practically clean when gasified.
- The producer gas powers the engine for stationary tasks such as irrigation, milling, and drying
- Any residual heat generated by the gasifier may also be directed to dryers for direct use

**downdraft gasifier components:**

- reactor where combustion takes place
- scrubber which cool the gas before it enters a filter (also comprised of raw rice hull) that screens the gas from impurities and tar before it enters the carburetor of the internal combustion engine

Flame Thrower
for controlling rats

- Developed by Laguna blacksmiths to help eradicate burrows from rats
- Uses diesel ignited at the end of a nozzle
- Earlier models uses kerosene but this poses hazard to the operator
- pressure tank contains fuel which is manually pumped similar to manual knapsack sprayers
- After a certain pressure is generated, the nozzle is ignited upon release of the fuel and the end of the nozzle is inserted on rat burrows in the field
- One or two helpers watch over other holes with stick, ready to hit rats as rats get out of the burrow through other holes due to heat and smoke generated by the flame thrower
- A latest model uses LPG dispensed through a standard 5-kg tank

Shredders
For organic composting.

- Shredder-chippers for organic composting of biodegradable farm wastes.
• To allow faster decomposition of biodegradable farm wastes, farmers often employ shredders that cut into pieces and beats the backyard and farm wastes like leaves, straws, small branches, rotten vegetables and fruits, dried animal manure, etc. into smaller form ready for composting.
• Some shredder models even have chippers at the side that does extra cutting of small tree limbs and branches to generate materials ready for mulching.
• Organic farmers find the shredded materials easier to decompose especially when added with decomposting enzymes or microorganisms.

PART 4.
FACTORS INFLUENCING THE CHOICE OF FARM MACHINERY

• The technology answers farmer’s needs and has market demand. It solves a particular needs of the farming system, which could be in the form of cost reduction (with less labor or other inputs), drudgery reduction, faster completion of tasks, better product output, value adding, income-generation potential, or the combination of any of these factors.
• The technology can be mass-produced with reliability, with less cost, with less complexity, with greater profits for the stakeholders (in this case, the manufacturer, those involved in bringing it to the market, and other players).
• The technology, although it improves the farming system process, does not require too much change for the adoptor (farmer, manufacturer) in order to successfully implement and adopt it in the farmer’s field. In this case, technologies such as transplanters which require total change to the farmer in seedling preparation, fertilizer applicators, as well as labor-intensive and time-intensive operations such as chemical application may have less chance of acceptance compared to equipment such as harvesters and threshers unless major breakthroughs that will simplify field operations and farmers’ tasks come up.
• Well-thought of strategies for promotion of a particular technology pays off. However, promotion or marketing strategy for one machine may not be true for another. His is especially important for similar technologies that have not been accepted in the past, such as dryers, reapers, and transplanters. Close attention to field demonstrations, after-sales services, economics of use, as well as demand from the public sector have always contributed to the marketing of a new technology. Machinery loans or credit for the purchase of the equipment is also a major marketing strategy.
• The presence of skilled service technicians accessible to farmers needing service and maintenance and the ready availability of spare parts that reduces time loss of defective equipment are both important, especially when introducing a new innovation.
• Income generation potential. In most cases, small farmers could not afford to buy their own equipment but resort to hiring farm machinery at a certain fee or percentage of their farm output. The owners of these custom machinery generates extra income from such operation aside from using these equipment at their own farms. This is usually true for land preparation, harvesting and threshing machinery and is also applied for drying equipment.
Farm mechanization has to be appropriate to maximize its intended benefits.

<table>
<thead>
<tr>
<th>CRITERIA FOR APPROPRIATE MECHANIZATION</th>
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<tbody>
<tr>
<td>Investment cost</td>
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<tr>
<td>Income generation potential</td>
</tr>
<tr>
<td>Labor displacement</td>
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<tr>
<td>Adaptability to local conditions</td>
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<tr>
<td>conditions like crop, soil, etc.</td>
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<tr>
<td>Other socio-cultural system</td>
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<tr>
<td>Reduced drudgery</td>
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<tr>
<td>Less labor/cost of operation</td>
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<tr>
<td>Timeliness of operation</td>
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<tr>
<td>Better product output or work quality</td>
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<tr>
<td>R&amp;D support system</td>
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</tbody>
</table>

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We accomplish this mission through research, development, and extension (RD&E) through our central and branch stations coordinating with a network that includes 57 agencies and 70 seed centers strategically located nationwide.

Our R&D structure for 2006-2010 includes four programs and 19 major projects. Our interdisciplinary programs are favorable environment, unfavorable environment, impact and policy research, and knowledge management and promotion. With these programs, we aim to develop and promote technologies that are ecosystem-based, location- and problem-specific, and profitable to the Filipino farmers.

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