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Development of rice combines in Viet Nam[#]

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ABSTRACT

Rice combine development in Viet Nam, especially in the Mekong Delta in the South, has been a slow process. Mechanized farm equipment is accepted only if it matches local agricultural conditions technically and economically. Earlier attempts at bringing in or developing combines by Central research institutes, Provincial factories, and farmer-mechanics were unsuccessful at actual scale operation. Three main problems were encountered over the past 20 years:

(1) Machines working in soft paddy fields bog down, especially heavy Western-style combines.
(2) Reliability at lowest cost is critical; delays caused by machine breakdowns result in significant lost income during the harvest, and unreliability discourages users from adopting new technology.
(3) Harvesting severely lodged rice crops is challenging, not so much as an engineering problem as it is a matter of plant breeding and varietal selection to improve lodging resistance.

Nevertheless there has been intensive development in the past 5 years by as many as 15 small-scale Vietnamese manufacturers. One mini-combine manufacturers has lately sold 90 units to private farmers across the country. In 2006 a combine contest was organized by the Vietnamese National Testing Agency. Three designs were given "accredited recognition awards", meaning recognition for future promotion through the governmental Extension system. The recent development of mini-combines follows.

Keywords: *Combine, Rice Harvesting, Mechanization*

INTRODUCTION

Viet Nam is an agricultural country with 82 millions (M) inhabitants in 2005, of which 61 M are in rural households. Rice is the most important crop, cultivated on 80 % of the total farm area, and rice accounts for 85 % of the country's food grain output. In 2003 , Viet Nam produced 35 M ton of paddy on 4.2 M ha of rice land. This total production was four times more than that of 1976. Viet Nam is the world's third largest rice exporter. For the past 10 years, the export of rice has been 3 – 4 M tonnes a year.

The Mekong Delta in Southern Viet Nam , with 2.7 M ha of rice land, is producing about 50 % of Viet Nam total rice output. With only 17 % of the total population, this region has accounted for more than 90 % of Vietnamese rice export in the past decade. Average farm size is about 1

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ha per household, although in some newly-reclaimed districts, 3 - 10 ha per household is not uncommon.

Rice harvesting in the Mekong Delta of Viet Nam is still mostly done manually, but threshing was completely mechanized. Over the past 20 years, effort to introduce rice harvest equipment in this region have been attempted by different government agencies as well as the private sector, from central research institutes to skilled village mechanics. Different alternatives have been tried, i.e. the reaper or the combine, but these either failed or were only half-way solutions to the problem.

This paper describes the slow process of combine development in the Mekong Delta, identifies affecting factors and related problems. Details of the work on a mini-combine, including wheel systems for wet soils, and promotion to the industry for manufacturing are presented.

CURRENT STATUS OF RICE HARVESTING AND PROBLEMS

In the Mekong Delta of Viet Nam, as in various parts of South-East Asia, rice harvesting is mechanized to varying degrees beyond traditional manual methods. Three types of mechanized harvesting are:

1) Manual harvesting + mechanical threshing. More than 95% of rice is threshed mechanically by the axial-flow thresher (Phan H. Hien 1991). However, due to lack of technically suitable and economically viable methods of mechanically cutting rice plants, local people continue to harvest rice manually with a sickle.

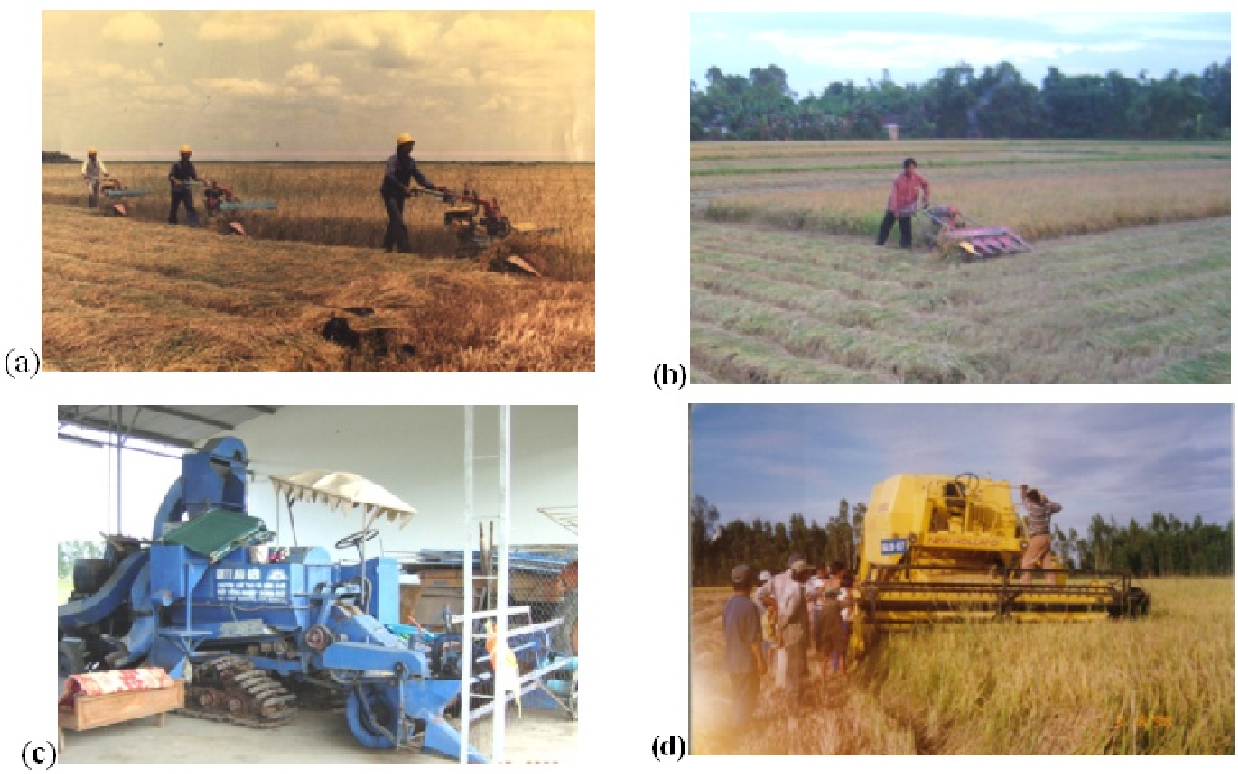


Figure 1: (a) Rice reaper, made by Long-An Mechanical Factory in 1985...
(b) ... and one from 3 major reaper manufacturers remaining in 2004;
(c) A combine made by a farmer-mechanics in Dong-Thap Province;
(d) An imported combine under test in 1998.

2) Mechanical reaper + mechanical threshing. The Chinese windrower reaper was introduced to South-East Asia through the International Rice Research Institute (IRRI) way back in the 1980's. The IRRI-designed reaper was introduced to Viet Nam in 1984 by the University of Agriculture and Forestry (now renamed Nong-Lam University **NLU**). Commercialization of the reaper (Figure 1a) peaked in around 1988 with about 15 manufacturers but there remain only three manufacturers producing 100-200 units per year each in the year 2000. (Figure 1b) Reaper adoption did not expand rapidly because it was only a partial solution. Manual gathering of the cut windrows still cost about 2/3 of the traditional hand cutting-gathering. Besides, the long-length cut of the plants is less suited to mechanical threshing, unlike manually harvested crops.
3) Combine. (See Next Section)

COMBINE DEVELOPMENT

Unlike Thailand, the only country in South-East Asia with some success in adapting the combine (with about 8000 units of Western-style Thai-made units in use), the introduction of such large combines have encountered three major problems in Viet Nam:

(1) *Soft soils*. Most local combine weights 1.2– 2 tonnes while imported models weigh 4– 11 tonnes. Such heavy machines easily bog down in soft soils. Even during the dry-season harvest, a seemingly dry field with a localized soft spot can render a heavy combine helpless in areas which may not have access roads for a rescue vehicle (Fig.1c and 1d). This is the main reason that has failed many researchers and engineers; one researcher has even concluded that there is no "dry soil" in the Mekong Delta as far as the combine is concerned. Many people now maintain that, for a large combine-harvester to work, the field must be well irrigated and drained, and should be large enough for the machine to easily maneuver. This sounds logical, except that the investment to implement such requirement for combine operation is too big to be drawn from the agriculture itself, a condition for a sustainable progress of a developing country.

(2) *Frequent break-downs*. Quality is often lacking in one-off manufacture by village mechanics, and such combines breakdown. Each break-down cost hours or days to repair; a week's repair time means significant lost income during the harvest season. Unreliability discouraged users from adopting new technologies. Thus, reliability at lowest cost is critical. The frequent breakdown of combines can be addressed through improved manufacturing and continuous design improvement with due consideration to added costs. A workable initial design, competent local manufacturer, close monitoring of field operation, and after-sales service support are all essential for the realization of a new technology.

(3) *Lodged crops*. Rice lodging is often caused by extreme climatic conditions such as typhoons or floods and attempts to develop a combine that can harvest severely lodged crops have been unsuccessful. Plant breeders and agronomists need to improve lodging resistance of rice varieties. However, a partially-lodged field area, say 10 % lodged, means that 90 % of the field is still available for combine harvesting, particularly if the combine is small enough to circumvent severely lodged spots that can be manually harvested.

These are the three reasons why combine development in the Mekong Delta of Vietnam has been slow over the past 20 years. Things are changing however in the last 5 years.

1980- 1999

Between 1980 and 1999, several combines were developed by Central research institutes, Provincial factories, and even farmer-mechanics. Attention was focused in 1997 when the Vietnamese Ministry of Agriculture organized a combine contest in Can-Tho Province, the heart of the Mekong Delta. Seven models participated, several locally made combine that were heavier than 2 tonnes, and one 5-tonne European combine. All bogged down in soft soils, except for a second-hand Japanese head-fed combine that weighed around 1 tonne. All bogged down in soft soils, except one second-hand Japanese head-fed combine weighing around 1 ton. About ten of these "light weight" combines were later sold by some trading companies. But these second-hand units quickly broke down in the first harvest season; spare parts were not available as they had been no longer fabricated in Japan; so these combines were junked. Among "best" locally made combines, the manufacturer was able to sell a few units; but again after one harvest season, buyers returned the machine to the manufacturer because of frequent breakdowns; each time requiring a severak critical days for repair. A one-week downtime meant that half of the peak harvest season was missed in the area. That meant significant lost harvest income as rice quality deteriorates when not harvested at the optimal time (Quick, 2003).

2000- Present

Since 2000, the Vietnamese economy has demonstrated rapid growth, and as a consequence harvest labor has become a serious problem. Rural people prefer higher-paying jobs at construction sites or other industrial jobs. This has motiovated researchers and manufacturers to renew efforts at promoting combines, this time with experience learnt from the earlier efforts. From 2000, about 15 small-scale combine manufacturers have tried their products. A combine contest was organized in 2006 by the Vietnamese National Testing Agency (Fig. 2). Eight local models and one Chinese imported model presented. Unlike the previous contest, these machines had been used by the manufacturers for harvesting their own rice or else extensively tested. Some manufacturers had sold up to a dozen units before entering the contest. From the contest, three designs were given "accredited recognition awards", meaning recognition and future promotion through the governmental Extension system. Two winners were the local Chin-Nghia 1500-kg combine, and a 2300-kg Chinese imported combine. The third was a 600-kg "mini-combine" with several distinctive features, which are described in the following Section.

Figure 2: Combines at the contest in Can-Tho Province, 2006.

THE MINI-COMBINE

Design

The NLU Center for Agricultural Energy and Machinery (CAEM) was established in 2001 and began research to improve rice harvesting methods and conditions in Viet Nam. Different surveys resulted in a database, including hundreds of pictures. In 2003, the Philippine Rice Research Institute (PhilRice) shared a design of a light-weight 600 kg mini-combine, to continue a long tradition of cooperation between NLU and the Institute in the area of Agricultural Engineering. The mini-combine project was sponsored by Briggs & Stratton Corporation, a U.S leading gasoline manufacturer.

The initial design came from China. In 2003, PhilRice re-designed and improved key functions adding significant improvements to the prototypes, which were then transferred to NLU for testing in Viet Nam. This is based on a tricycle undercarriage, and uses a Western-style combine open front gathering head (Fig. 2a), to feed a conveyor that brings the cut plants towards an axial-flow thresher. The cleaning of paddy is done beneath the thresher concave by an oscillating screen and a fan, similar to the IRRI axial-flow threshers (Quick, 1998), before the paddy grain is conveyed upwards for bagging (Bautista &Schmidley 2004). The combine is powered by a 16-HP B&S gasoline engine that weighs 40 kg.

In Viet Nam, design adaptation by the NLU included: *a*) identifying areas for strengthening and optimizing design performance and reliability; and *b*) comparing different traction wheel designs for wet soft soils. The NLU believes problems of combine harvesting in Viet Nam are "of the earth, and not of the air", that is to say, they are more concerned about soil and wheel interactions rather than the working principles and components which are already common knowledge.

After evaluation and further "fine-tuning" of the prototype, the design was transferred to the Viet Nam Agricultural Power Company (VINAPPRO), a leading manufacturer of diesel engines and other machinery, who then fabricated two units for local field testing and evaluation, before deciding to go on with mass production.

Testing

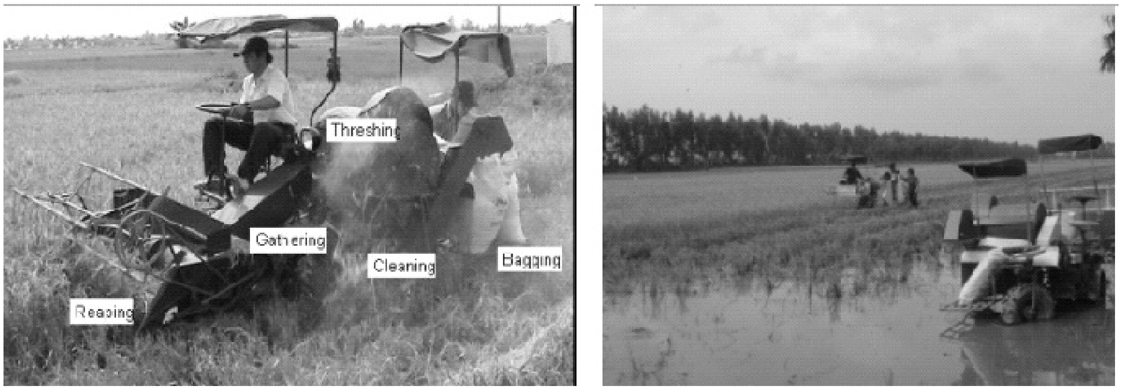
In 2004, the mini-combines were tested in different provinces, first for exploring the working capabilities of the PhilRice unit (Fig.3a), then for measuring the performance of the Vinappro units in wet conditions (Fig.3b), and for durability evaluation

Seven different traction types and variants were tested for trafficability (Figures 4), namely: *1)*rubber tyres, *2)*dual rubber tyres, *3)*steel cage wheels, *4)*original pyramid-shaped lug wheels with 10 lugs/wheel, *5)*pyramid-shaped lug wheels with12 lugs/wheel, *6)*wider pyramid-shaped lug wheels with 12 lugs/wheel, and *7)*retractable lugs mounted next to rubber tyre.

Standard test instruments and a penetrometer (ASAE 1994) to measure the hardness of soil, were used in the tests.

Results

The **performance** and specifications of the combine are summarized in Table 1 (Tran V. Khanh et.al 2004); the field tests were conducted under different soil and crop conditions. Average harvest was one hectare per day. The total losses ranged at 1.0 – 1.4 per cent, and never exceeded 2 per cent.



(a) (b)

Figure 3: a) The 600-kg mini-combine prototype from PhilRice (Tran V. Khanh et.al 2004).
b) Mini-combines in DongThap; both units are made in Viet Nam by Vinappro.

Table 1: Mini- combine performance and specifications

Working width :	1.2 m maximum
Working speed :	1.5 – 2.1 km/hr
Idle travel speed :	2.0 – 5.0 km/hr
Working time utilization efficiency :	70 – 80 %
Field capacity :	1 ha /day (0.9 – 1.3)
Cutting height :	Adjustable 0.1 – 0.4 m
Combined losses (shattering, un-threshed and separating) :	< 2.0 %
Power requirement :	16-HP B&S gasoline engine
Fuel consumption :	15 Liter/ ha
Labor requirement :	5: one driver, one bagger, and three haulers of grain bags to levees.
Traction: Semi-dry soil : Soft, wet soil :	Rubber tyres 6.00 x 12 Pyramid-shaped lug wheel, or Retractable lugs + rubber tyre
Overall dimensions (L x W x H) :	3.5 m * 1.5 m * 1.5m
Net weight:	600 kg

Trafficability Tests, among the 7 types of wheels:

The tests indicated that, on dry soils, the rubber tyres were most suitable in terms of both traction and vibration of the machine. However, in soft and wet soils, the pyramid-shaped lug wheels (Fig. 3a) could manage soft soils with penetration resistance of more than 0.4 MPa. The retractable lugs mounted to rubber tyres proved to be the most useful in soft soil. Rubber tyres provided floatation, while the lugs provided both traction and flotation (Fig.3b).

On soft soils, the light weight of the combine proved to be an critical advantage. If the machine was about to sink, the bag laborer in the rear seat could jump off temporarily to reduce machine load, to allow the mini-combine to pass through soft spots while maintaining operation. In extremely soft conditions where there was occasional bogging down, the problem was overcome within minutes by seven people, who simply lifted and pulled the combine out of the trouble spot (Fig. 3f). No other combines could be managed that way!

As for **reliability**, the mini-combine was operated on 15 hectares, before transferring the design to industrial production. During the tests, breakdowns and troubles occurred, such as shear of cotter pin of the steering wheel, failure of the rear U-fork..., but these were considered minor and were immediately fixed in the field or by small village mechanics. Nevertheless, this indicates more attention is needed during local manufacturing.

Figure 4: (a) The pyramid-shaped lug wheel; (b) Retractable lugs mounted adjacent to rubber tyre; (c) Dual tyre blocked with clay; (d) The cage wheel; (e) The combine is easily lifted for changing wheels; (f) Bogged-down combine on soft soil was simply pulled out by 7 people. (Tran V. Khanh et.al 2004).

Mini-combine commercialization

The VINAPPRO Company produced a total of 90 units between 2005-2006. Apart from a few units that went to state agencies for extension, the majority of these combines were bought by private farmer-contractors with their own money. Four users placed repeat orders, each for a second unit after the first unit had harvested some hundreds of hectares. All these are positive indicators that the mini-combine is following the well-known mechanization pattern in the Mekong Delta, where the machine is owned by the service provider. A small farmer owning only 1 ha buys an 80-HP tractor, plows his field for one day or less, and next plows for 100 other farmers on a contract basis. In the same way, the contractors harvest, thresh and dry paddy.

Cost calculations

In 2006, the sale price of a mini-combine from the production line was US$ 2900 [###]. Other data and assumptions are listed in Table 2 for estimating the cost of machine use.

Table 2: Data and assumptions for estimating the cost of machine use (Tran V. Khanh et.al 2004).

Purchase price :	US$ 2900 (≈ 46 000 000 VND)
Life :	3000 hours / 6 years (#*1*)
Interest rate :	10 % / year
Working capacity :	1.0 ha /day
Fuel consumption (gasoline) :	15 Liter /ha
Fuel price	US$ 0.63 / liter
Lubricants and filters… (as % fuel cost):	15 % fuel
Labor: Driver: (Number) * Daily wage:	(1) * US$ 2.2
Bagger &Hauling laborer: (Number) * Daily wage:	(4) * US$ 1.6
Total Repair & M. cost (as % Purchase price):	40 %

Note: (#*1*) 3000-hr life ≈ 6 yrs * 3 crop seasons/ year * 17 days/ season * 10 hrs/ day.

Based on the above data, cost of using the mini-combine is calculated and summarized in Table 3 and Figure 5.

For the convenience of overseas readers, all monetary numbers in Vietnamese Dong are converted to US$, with the conversion rate in 2006: 1 US$ ≈ 16 000 VND

Table 3: Cost of use for the mini-combine

Cost	US$ /ha
Depreciation	5.3
Interest	1.6
Gasoline	11.8
Labor	7.2
Repair	2.1
Total US$ per hectare	27.6 **≈ 28**

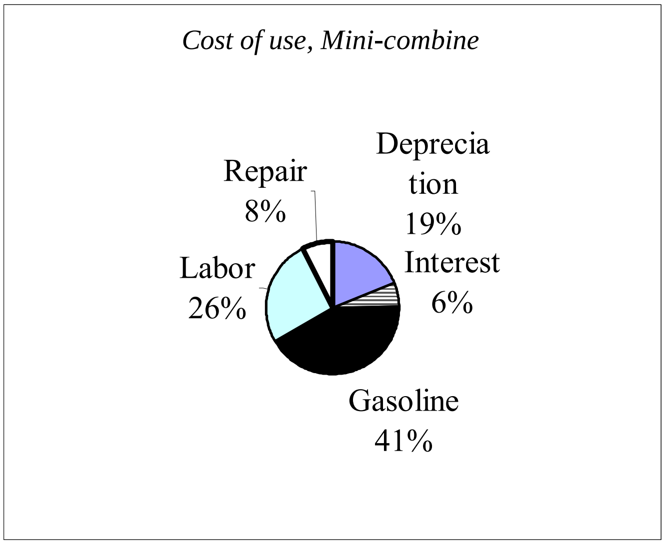


Figure 5: Distribution of utilization cost (Total = US$ 27.6)

Comparing Costs with current harvesting methods

The most common harvesting method in the Mekong Delta of Viet Nam is manual harvesting + mechanical threshing. Depending on the province, rice yield, and cropping season (dry or wet harvest), the total cost in 2004 of existing methods ranged from US$ 45 to 60 per hectare, with about 60% representing cutting and gathering costs and 40% for threshing costs.

Thus the total cost of US$ 28 /ha for the mini-combine represents a substantial cost reduction of 38 to 53 percent, compared to current practices. This is significant, considering that this saving alone is the equivalent of 15% of the profit from a typical hectare of rice.

Moreover, the labor requirement is appreciably reduced by the combine. The current harvesting and threshing system normally requires dozens of laborers and up to 150 man-hours per hectare, against five people and 40 man-hours per hectare with the combine.

CONCLUSIONS

Rice combine development in the Mekong Delta of Viet Nam over the past 20 years has been a slow process, following the introduction of axial threshers and reapers. Three problems affect the combine adoption: *(a)* soft soils; *(b)* machine reliability, and *(c)* lodged rice crops. Early attempts in the 1980's and 1990's by different agencies and the private sector were unsuccessful at actual scale operation. Since 2000's severe labor shortage for rice harvesting has prompted intensive development by several small-scale combine manufacturers. Three combine brands gained the "accredited recognition awards" during a combine contest in 2006; these 3 companies have commercialized their combines. Particularly, the Vinappro Company has sold 90 mini-combines. This 600-kg combine was adapted from an initial design from China, with modifications of the cleaning system by PhilRice. Durability testing and improvement of the wheels for soft soils were made by NLU in Viet Nam before transferring the design to industry. The combine represents a good step forward in Viet Nam.

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