J. ISSAAS Vol. 17, No. 2:168-180 (2011)

STATUS OF ADOPTION OF UPLB FLATBED DRYER

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(Received: January 8, 2011; Accepted: October 27, 2011)

ABSTRACT

The status of adoption of the University of the Philippines Los Baños (UPLB) flatbed dryer, the earliest and simplest commercial drying technology of its kind, was determined in selected areas in the Philippines. The original 2-ton UPLB technology was introduced in the Philippine Post-harvest System in the 1970s and subsequently in the ASEAN, by IRRI and UPLB graduates. By 2000, the UPLB flatbed dryer had all but disappeared due to farmers' continued preference for sun drying. For traders/millers the entry of imported convection type models with thrice as much capacity and better space-saving design than the UPLB model were traced as leading reasons for low adoption. However, the Philippine Department of Agriculture (DA) disseminated 200 units of new flatbed dryers in 2007, with 500 more intended for 2008, which were esssentially improved versions of the UPLB design with much higher capacity (at least 6 tons). The new model called Maligaya Flatbed Dryer was jointly developed by the Philippine Rice Research Institute (PhilRice) and University of Agriculture and Forestry (UAF) of Vietnam. With drying costs accounting for up to 20% of current selling price of *palay (*Filipino for palay*)*, technology such as the UPLB Flatbed Dryer (UPLBFBD) holds promise as a profitability enhancing tool for rice farmers as well as traders. To facilitate adoption of homebred technologies like the UPLBFBD, the government needs to employ a participative approach to farm-level-problem solving such as Farmer Participatory Research. FPR can empower intended users of FBD make investment decisions regarding mass production of small machines for farm-level drying by individuals or small farmer-groups. Several farm-size dryers for a given *barangay* (village) will improve traders' drying and recovery rates which will ultimately redound to reduced drying costs that can translate to higher net incomes for farmers and traders.

Key words: sun drying, mechanical drying, moisture content

INTRODUCTION

The Bureau of Postharvest Research and Extension (BuPRE) in its 1996 report estimated that grain wastage from sun drying continues and can range from 0.7 to 8.7% (Hermida, 2008). Even as four decades earlier, in the 1970s, prompted by low wet-season *palay* yields from traditional sun drying practices and after the imported Louisiana State University dryers failed to address the problem, UPLB engineers developed what is considered the pioneer of all commercial dryers introduced in the ASEAN, the UPLB flatbed dryer. Scaled up versions of the flatbed dryers were later extensively used in Vietnam and in other neighboring countries (De Padua, 2008).

When the IR8, a high-yielding rice variety also called magic rice, was introduced in 1962, the volume of *palay* harvests far out distanced the stretch of road pavements and by-roads traditionally used as spreads for sun drying of dry-season *palay* harvested in March-May. This resulted in damaged grains and low recovery of milled rice. The situation was even worst for rainy season harvests in September-November. In response to the situation, the Philippine government with funding from the United States Agency for International Development (USAID) introduced centralized drying using 20-ton capacity convection type dryers. The drying problem was somehow relieved. However, the units had sophisticated controls that required a certain level of expertise to operate. Moreover, the set-up was later found inappropriate at the field level causing recipients to abandon it. The farmer-beneficiaries of the technology had small, fragmented farms and many were far from drying centers. Unable or unwilling to bring their harvest to the drying facility in their locality, the farmers minimized *palay* spoilage by immediately selling on cash-and-carry basis at the farm gate to middlemen/traders.

This situation worked against the very purpose of centralized drying, and made the use of centralized drying equipment impractical for farmers. This, therefore, presented a challenge to develop a low cost, simple to manufacture and operate, portable, and effective on-site grain drying equipment. The UPLB flatbed dryer was designed according to these attributes and the invention promised to facilitate proper farm-level drying of *palay* (De Padua, 2008).

Of the several persistent problems faced by the Philippine Post-harvest System, small farm size can be considered one of the leading reasons for waning adoption of the UPLB flatbed dryer (De Padua 2008). In Esperanza, Agusan del Sur for example, many of the farmers interviewed cultivated farms less than a hectare to two hectares in size. The largest chunk reported was only seven hectares, a rarity in the area. Clearly, in Esperanza, Agusan del Sur even consolidation of the small-sized farms would not be enough to justify acquisition of a mechanical dryer. Drying, the process that reduces grain moisture content to levels safe for storage, is the most critical operation after harvesting a rice crop (IRRI, 2009). A 14% moisture content (MC) is required for grains intended for milling and storage. In the Philippines, where both sun drying and mechanical drying are practiced, grain harvests typically range in moisture from 20 to 26 percent content on a wet basis (wb) which is too wet for milling and storage. Hence, drying must be done immediately to avoid losses.

Sun Drying

Sun drying is an age-old technique preferred by many Filipino farmers because it is the least costly and is usually done by family members. Sun drying involves spreading the grain on every available concrete surface including highways, and *barangay* and municipal roads. Aside from being a hazard to motorists, the conditions for sun drying cause deterioration in grain quality. Small stones and other contaminants are picked up with the grains and are carried through the milling process. Improper drying procedures or conditions are the primary causes of poor milling quality, such as low head rice yields. De Padua (1999) cited the quality standard for milled rice as long grained, white and crystalline, with a high percentage of head or whole grain, medium to soft in texture, and clean – free of contaminants such as stones, husk or bran, and weed seeds.

Previous studies revealed that farmers' failure to immediately dry *palay* harvested during the rainy months results in 35% average loss in yield and losses can rise to over 50% when the harvested grains darken due to delayed drying (Rodulfo, 1995). The probability of success of *palay* sun drying depends on the place and time of harvest (Gayanilo, 1988).

A year-round study in this regard was conducted in three representative sites, namely: Echague, Isabela; Munoz, Nueva Ecija; and Los Banos, Laguna (Table 1). The average rate of success in the dry season harvest (March-May) was 88.89% while harvest made in the wet season (September-November), averaged only 75.56%. The overall probability of success in the two seasons was generally around 82.22% while the year-round average was at 78.98%.

Table 1. Probability of success of palay sun drying (2 cm thickness) for any given harvest period in three representative sites

Month of Harvest	Echague, Isabela			Munoz, N. Ecija			Los Banos, Laguna		
	28	**24**	**20**	**28**	**24**	**20**	**28**	**24**	**20***
	Percent Probability								
March	80	90	90	90	90	90	90	90	90
April	90	90	90	90	90	90	90	90	90
May	90	90	90	80	90	90	80	90	90
June	90	90	90	70	80	90	70	70	90
July	80	80	90	70	80	90	70	80	90
August	60	70	90	50	60	80	70	80	90
September	80	80	90	60	70	80	70	80	90
October	70	70	90	80	80	90	70	70	90
November	30	40	70	80	90	90	70	70	90
December	30	30	60	80	80	90	60	70	80
January	20	30	60	90	90	90	60	70	90
February	80	80	90	90	90	90	90	90	90

Source: Gayanilo,1988
*Moisture Content (wet basis)

Mechanical Drying and the UPLB Flatbed Dryer

It has been established that a constant temperature of 110 deg F or 43.3 deg C prevents grain damage (De Padua, et al.,1976). In this regard, mechanical drying offers a distinct advantage over sun drying in its capability to provide uniform and controlled temperatures. Another advantage of mechanical drying is its relative convenience. It can be done any time of night or day, allowing increased capacity, thereby reducing to a great extent grain damage or totally eliminating spoilage caused by drying delays.

Envisioned to vastly improve rice farmers' incomes by accelerating drying and recovery rates for *palay,* the UPLB flatbed dryer was introduced in the 1970's. Under proper operating conditions and maintenance, the original UPLB unit could reportedly dry up to 72,000 cavans or 3,600 metric tons of palay over its entire useful life of approximately five years (De Padua, et al., 1976).

The machine was compact in design, making it readily portable to the farm gate. At 40-cavans capacity, each cavan weighing 50 kilograms, it could dry two metric tons of very wet *palay* for eight (8) hours during the wet season and only four (4) hours during the dry season. The dryer was easy to operate and needed only minor maintenance. It consisted of three components: (1) a bin to hold the grain on a perforated or lanced sheet metal floor above a plenum; (2) a fan to force the drying air from the plenum through the grains; and (3) a burner to heat the air. An optional cover for the unit may be improvised to prevent foreign particles from mixing with the grains.

Originally designed to dry rice grains, variants of the UPLB Flatbed Dryer have since been introduced by adopters of the technology. Today we encounter in the countryside the Maligaya flatbed dryer farmed out by DA-BPRE which has multi-crop capability and can also dry corn, coffee, legumes, banana and cassava chips.

UPLB Technology Revisited -2000 survey

The flatbed dryer was developed to address a critical post harvest problem – grain spoilage and income losses from improper drying of grains. The UPLB-developed drying technique was initially widely adopted but had since been almost forgotten. A number of farmers and traders/millers in Calauan and Bay, Laguna were interviewed to assess the extent of adoption as well as determine the reasons inhibiting sustained and material utilization of the UPLB-developed drying technology. The respondents were asked about their drying practices, perceived advantages in using the flatbed dryer as a post-harvest equipment, as well as the factors hindering them from actively using flatbed dryers (Pamplona, 2000).

Two groups of purposively selected respondents participated in the study: (1) farmers who are members of Hangan-II Development Cooperative and Lamot Multi-Purpose Cooperative (LMPC) both located in Calauan, Laguna; and (2) grains traders/millers from Bay and Calauan, Laguna. The five traders chosen to participate were users of the flatbed dryer while the forty farmers belonged to two cooperatives that were utilizing flatbed dryers as a post harvest mechanism.

Farmers' view on the flatbed dryer. The farmers reportedly came to know about the product through their membership in the cooperatives. Though the farmers were convinced of the usefulness of the product they were not willing to pay the cooperative custom-drying costs of PhP15.00 in the dry season and PhP20.00 in the wet season. For the farmers, sun drying was still the most viable during dry season. During wet season, instead of shelling out cash for drying, they generally preferred to sell their fresh harvests to traders/millers who willingly paid for the wet grains at rock-bottom prices (Pamplona, 2000).

Traders' view on the flatbed dryer. Traders had a more positive view on the use of mechanical dryers like the flatbed dryer. It is claimed that mechanical drying is superior to sun drying in achieving desired quality of milled rice. All the traders were convinced of the need for investing in a flatbed dryer but the UPLB model's two-ton capacity (equal to 40 cavans) per eight-hour shift was considered too low and therefore a problem for traders who handled large volumes of *palay* for drying during the rainy season. This limitation paved the opportunity for electric dryers with bigger capacities to invade the market, thereby contributing to the low utilization of the UPLB flatbed dryer (Pamplona, 2000).

Rebirth of the technology

The 2000 study revealed that there was already low adoption of flatbed dryer among members of two cooperatives identified in Laguna. In 2008, the featured cooperatives were no longer in operation and the units were nowhere to be found. However, to remedy the escalating problem of rice shortage, the DA through its various agencies once again began distributing flatbed dryers in the last quarter of 2007. This could be considered a rebirth of the technology. The new units named "Maligaya" flatbed dryer, was developed by PhilRice in collaboration with Vietnam's University of Agriculture and Forestry (PhilRice, 2008). These dryers were distributed for free to organized clusters of farmers, irrigators' associations and big cooperatives throughout the country. The technology dissemination program was implemented by BPRE. The Department of Agricultural and Bio-Process Division (DABPD) of UPLB tested two of these units and found them having the same functionality as the original UPLB flatbed dryer. At present, rice hull-fed 6-ton flatbed dryers are being distributed to rice clusters in the Philippines under the FIELDS (fertilizers, irrigation, extension, loans, dryers and postharvest facilities) program of the DA (Agri Business Week, 2009).

In their study of agricultural machinery adoption in Southeast Asia, Douthwaite and Gummert (2009) reported that in early 2007, the DA Secretary impressed with PhilRice-designed

"Maligaya" flatbed dryer when he observed at work in a farmers' cooperative, initiated a program to install roughly 1,000 units of the flatbed dryer nationwide. They noted that a few modifications had been made to the flatbed dryers' design over the years. The study in 2000 also revealed that the number of flatbed dryers used in the Philippines increased from 100 to 200 since the early 1990s. The rise in the adoption of the flatbed rice drying technology could be attributed primarily to the PhilRice engineers' efforts to provide technical assistance to interested farmers and cooperatives. It was noted that similar machinery programs in the past failed because farmers' groups were supplied with poorly-performing equipment due to lack of technical support from the implementing agency.

The principal objective of this study is to determine the reasons that account for waning adoption and/or almost nil utilization of the UPLB flatbed dryer. Specifically, the study presented the two most common drying practices in the areas covered by the study and compared the costs and returns of each drying method for the different stakeholders. Based on the gathered information, the study offered possible remedies to bring back the pioneering technology to the fore of Philippine agriculture and make a positive impact on the Philippine economy.

METHODOLOGY

Primary data were collected by means of key informant interviews (KIIs) with two technology developers, one fabricator/manufacturer, one rice trader/miller, and twelve farmers; focus group discussions (FGD) with four technology evaluators; and, site inspections in localities where the technology was adopted. The study area covered the Southern Luzon provinces of Batangas where a technology adopter continues to use a UPLB flatbed dryer, and Laguna where technology-developer UPLB is located; and Agusan del Sur, in Mindanao where the technology was unheard of. Secondary data were gathered from public documents on the IRRI website, published and unpublished materials in the UPLB Main and CEAT libraries, and other related references and publications from various sources including some of the interviewees' personal archives.

RESULTS AND DISCUSSION

2008 and 2010 Surveys

Eight years after the study of Pamplona (2000), it was discovered that the two cooperatives previously cited no longer exist. Moreover, key informant Mildred Mejino, a rice trader/miller from Calauan, Laguna indicated that when she did an industry study of rice milling business in Laguna in 2007, none of the twenty- three rice millers she interviewed still used flatbed dryers. The rice millers now use convection type, circulating dryers imported mostly from Taiwan. The flatbed dryers were totally abandoned by millers because newer models are more compact yet more efficient – occupy much smaller space despite bigger capacities (Mildred Mejino, personal communication).

The sample flatbed dryer on display at the DABPD, CEAT, UPLB appears exactly the same as the model introduced about forty years ago. Major change have not been made in the design of the product, although the bin had already undergone some repairs due to wearing out caused by the passage of time. As a minor improvement on the original design, the furnace used in heating the air could utilize agricultural wastes such as coconut husks and rice hull in lieu of kerosene (Engr. Edgardo V. Casas of DABPD, personal communication)

When asked about the current usage of the equipment, Engr. Casas said that the latest inquiry DABPD has received was in March 2008 from a grains trader in Calaca, Batangas. The trader was then referred to Mariñas Engineering, a dryer manufacturer/fabricator in Pila, Laguna. The one unit two-ton flatbed dryer was built for PhP80,000 but with plywood bin sidings. An all-steel bin would reportedly cost PhP110,000 excluding installation.

The above-mentioned unit installed in Calaca, Batangas is intended to dry corn grains supplied to corn snack manufacturers in Bulacan and animal feed processors in Batangas. This was purchased when the single unit in this area broke down. The unit was bought from Mariñas Engineering at Pila, Laguna for PhP80,000. The unit is rented out for a drying fee of PhP0.70 per kilogram. Fuel for the furnace is supplied by the clients who are also charged for electric power usage for blower at PhP0.50 per kilogram or a total of PhP1.20 per kilogram amounting to PhP60.00 per cavan. Drying time ranges from 3 to 8 hours depending on the moisture content of the grains. So far no repairs had been done on the unit since its installation in April 2008 though some minor inconveniences had been experienced. Coconut husk soot would sometimes go with the air blown and smoke is generated which discolors the grains.

Financial Analyses

Cost of operating a UPLB flatbed dryer

Assuming a two eight-hour shift operation for sixty days, the unit is estimated to process 120 batches during the wet season and 240 batches during the dry season. Each batch is for forty cavans or 2,000 kilograms of *palay*. Fuel requirements for blower are at 1.5 liters of gasoline per hour of operation while expenses for oil and lubricants are set at one-third of gasoline cost. Depreciation charge per batch is at PhP91.25 and PhP45.83 for wet season and dry season respectively, computed as follows:

Cost of flatbed dryer……………………………. PhP110,000.00
Divided by estimated useful life (5 years)
Annual depreciation………………………………PhP22,000.00
Divided by number of batches:
120 batches during wet season, and
240 batches during dry season
Depreciation charge per batch:
Wet season……………………………….PhP91.67
Dry season……………………………….PhP45.83

Annual maintenance overhead is provided at 10% of machine cost or PhP91.67 and PhP45.83 for wet and dry seasons, respectively. Based on the foregoing plus the cost of labor, total operating expenses per batch were estimated at PhP1,121.33 and PhP560.67 or PhP28.04 and PhP14.02 per cavan for wet and dry seasons, respectively (Table 2). These figures were computed under the assumption that rice hull or appropriate agricultural wastes are used as fuel to fire the furnace. Rice hull can be taken from rice mills free of charge.

Drying fees

Pamplona's study in 2000 reports drying fees of PhP20.00 in the wet season and PhP15.00 in the dry season. This indicates a mark-up of 36.5% and 100%, respectively, on wet and dry season costs in 2000. On the other hand, the operator in Calaca, Batangas had a fixed mark-up of PhP0.70 per kilogram or PhP35.00 per cavan. Financial analysis however, indicates that fixing the net income at PhP5.00 per cavan is reasonable since a project is acceptable if the payback period is not more than one half of the economic life of the project or investment. Thus, drying fees were arrived at PhP33.00 in wet season and PhP19.00 in dry season. Assuming that capacity utilization of the flatbed dryer averages 75% and the cost of capital is 14% per annum, projected returns would give a payback of 2.58 years which is about half the estimated useful life of the flatbed dryer.

Table 2. Estimated operating expenses per batch of forty cavans

Particulars Drying time*	Wet Season 8 hours	Dry Season 4 hours
Labor Cost (PhP250.00 per 8 hrs)	250.00	125.00
Energy cost:		
Gasoline	516.00	258.00
Oil and lubricant	172.00	86.00
Depreciation	91.67	45.83
Maintenance overhead	91.67	45.83
Total cost of drying per batch of 40 cavans (PhP)	1,121.34	560.66
Cost of drying per cavan (PhP)	**28.04**	**14.02**

Sources: 2008 and 2010 Field Surveys
* Assumed moisture content: 25% for wet season and 19% for dry season

Financial implications of operating flatbed dryer

Farmers. The sale of dried *palay* promises net advantages of 13.33% and 16.03% compared to selling fresh during dry season (Table 3). But concerns on stability of palay price (which may go lower the next day) and the unavailability of drying equipment near the farms hinder farmers from drying their harvest. Hence, it is understandable that farmers prefer to sell fresh palay to traders after setting aside a portion for home consumption which they would sun dry. In any case, if farmers want to earn a little more, they would still resort to sun drying because the net advantage of mechanical drying over sun-drying is still not convincing for them. While common sense dictates not to sun dry during the wet season, the use of mechanical dryers is still not justified since the net advantage in selling fresh remains more attractive and risk-free to farmers (Table 4). To avert losses and be immediately compensated for their harvest, farmers would rather go straight to traders than resort to mechanical drying.

The succeeding tables use data from various sources to estimate incomes per hectare for farmers and returns to traders during the dry and wet seasons.

The NSO using BAS data in 2005 reported increases in rice hectarage and volume outputs for the period 1997 to 2004. Area for *palay* production rose from 3,842.3 hectares (has.) in 1997 to 4,126.6 has. in 2004 and volumes of *palay* output rose from 11,269.0 metric tons (MT) to 14,496.8 MT over the same period. This places the average yield for 2004 at 70 cavans per hectare (Table 3). Given a two percent allowance for impurities (dockage) imputed by traders on fresh and dry *palay* purchases, the projected net saleable quantity of palay in the dry season would be 63.60 cavans for fresh, 61.23 cavans for sun dried, and 64.53 for mechanically-dried *palay*.

The net recovery rates were computed as follows:

	Dry Season MC=19%		Wet Season MC=25%
Computation of percent recovery (per 100 kgs.):	Sun dried	Mechanical	Mechanical
Weight loss due in cavans to drying @ 1.1643 kgs for every 1% moisture removed	4.08	4.08	8.97
Dockage (70 x 2%)	1.40	1.40	1.40
Losses from sun drying per BPRE @4.7%	3.29		
Total weight reduction in cavans	8.77	5.48	10.37
Recovery in percent	87.47%	92.18%	85.19%

The International Rice Research Institute (IRRI) has determined that price of dried *palay* must be at least 20% higher than that of wet *palay* to cover drying expenses (IRRI, 2009) thus, price per cavan of PhP500 for fresh and PhP600 for dried.

Operators. Custom drying seems to be lucrative for individuals who have money to invest in a mechanical dryer and offer drying services to farmers. Analysis shows that the investment is recoverable in a matter of three cropping periods or about 1.5 years (Table 5). However, the question that remains is whether or not farmers would use the facility. As pointed out earlier, mechanical drying is at the moment not a good option for small farmers.

Traders. It appears that mechanical drying has an edge over sun drying because of at least an average of five percent yield increment in mechanical drying and savings on labor realized due to large volume of palay processed (Table 6). It is also good to note that investment in a dryer could be easily recovered during the dry season. A net return on assets deployed of 11% in just sixty days at sixteen hours operation daily could already compete with alternative uses of capital. However, in the wet season, the net returns is down to only about 4% which could be easily wiped out even in a case of minor untoward incident.

Table 3. Projected income for farmers per hectare during the dry season.

Particulars	Fresh Form	Dried Form: Sun dried	Dried Form: Mechanical
Gross proceeds from sale of palay			
Average yield per hectare in cavans	70	70	70
Equivalent clean and dry weight percentage	98%	87.47%	92.18%
Net weight	68.60	61.23	64.53
Less: Deduction for moisture content (@18%-20% mc	5		
Net saleable weight in cavans	63.60	61.23	64.53
Price per cavan (PhP)	500	600	600
Gross proceeds from sale of palay (PhP)	31,800.00	36,738.00	38,718.00
Less: Drying and hauling expenses			
Labor cost for sun drying: PhP10 per cavan		700	
Drying fee charged by operator per cavan - PhP19.00			1,330.00
Hauling expenses from farm @ PhP7 per cavan			490
Total expenses (PhP)		700	1,820.00
Net proceeds (PhP)	**31,800.00**	**36,038.00**	**36,898.00**
Net benefit in selling in dried form over wet form (PhP)		**4, 238.00**	**5,098.00**
(in percent)		**13.33**	**16.03**

Sources: 2008 and 2010 Field Surveys

Table 4. Projected income for farmers per hectare during the wet season.

Particulars	Fresh Form	Dried Form	
		Sun dried	Mechanical
Gross proceeds from sale of palay			
Average yield per hectare in cavans	70	70	70
Equivalent clean and dry weight percentage	98.00%	75.56%	85.19%
Net weight	68.6	52.89	59.63
Less: Deduction for moisture content (@25% mc	10		
Net salable weight in cavans	58.6	52.89	59.63
Price per cavan (PhP)	500	600	600
Gross proceeds from sale of palay (PhP)	29,300.00	31,734.00	35,778.00
Less: Drying and hauling expenses			
Labor cost for sun drying: PhP10 per cavan		700.00	
Drying fee charged by operatorper cavan - PhP33.00			2,310.00
Hauling expenses from farm @ PhP7 per cavan			490.00
Total expenses (PhP)		700.00	2,800.00
Net proceeds (PhP)	29,300.00	31,034.00	32,978.00
Net benefit in selling in dried form over wet form (PhP)		1,734.00	3,678.00
in percentage		5.92%	12.55%

Sources: 2008 and 2010 Field Surveys

Table 5. Projections for flatbed dryer operators (custom drying operations only)

Particulars	Wet Season	Dry Season
Maximum volume (in cavans) of fresh palay processed in 60 days	4,800	9,600
Custom drying fee per cavan PhP	33.00	19.00
Gross income (PhP)	158,400	182,400
Less: Drying cost @ PhP28.04 and PhP14.02 per cavan, respectively	134,592	134,592
Net Income per season (PhP)	**23,808**	**47,808**
Return on Investment (net income / P110,000)	**22%**	**43%**

Sources: 2008 and 2010 Field Surveys

Table 6. Comparative income of traders from buy and sell of *palay* under two methods of drying

Particulars	Dry Season		Wet Season	
	Sun	Mechanical	Sun	Mechanical
Gross proceeds from selling palay				
Max. vol. (in cavans) fresh palay processed for 60 days	9,600	9,600	4,800	4,800
Equivalent clean and dry weight percentage	87.48%	92.18%	75.56%	85.19%
Net weight in cavans	8,398	8,849	3,627	4,089
Price per cavan (PhP)	600	600	600	600
Gross proceeds (PhP)	5,038,800	5,309,400	2,176,200	2,453,400
Less: Cost of Operation (for 60 days)				
Acquisition cost of palay:				
Max. vol. of palay purchased in cavans	9,600	9,600	4,800	4,800
Less:Deduction for MC (5kgs.,10kgs. per 100 kgs.)	480	480	480	480
Net weight paid in cavans	9,120	9,120	4,320	4,320
Cost of fresh palay per cavan	500	500	500	500
Total cost of palay	4,560,000	4,560,000	2,160,000	2,160,000
Hauling: PhP7 per cavan	67,200	67,200	33,600	33,600
Total acquisition cost of palay (PhP)	4,627,200	4,627,200	2,193,600	2,193,600
Drying expenses:				
Labor cost-Sun drying: PhP10 per cavan	96,000		48,000	
Labor cost-Mechanical drying: PhP250 x 2 x 60 days		30,000		30,000
Overhead Expenses:				
PhP14.02 x 9,600 cavans		134,592		
PhP28.04 x 4,800 cavans				134,592
Total drying expenses (PhP)	96,000	164,592	48,000	164,592
Total cost of operation (PhP)	4,723,200	4,791,792	2,241,600	2,358,192
Net Income (PhP)	315,600	517,608	-65,472	95,280
Net advantage in drying using Flatbed dryer (PhP)		202,008		160,752
Mark-up percentage on total cost of operation	6.68%	10.80%	-2.92%	4.04%
Return on Investment (net income per PhP110,000)		471%		87%

Sources: 2008 and 2010 Field Surveys

CONCLUSIONS AND RECOMMENDATIONS

The foregoing financial analyses indicate that for farmers, selling dried grains using the dryer does not pay well enough. There is not much advantage in using the product even during the wet season as the little differential it accords could be easily overcome with the risk in storing harvest even for just a day before drying. Thus, farmers would always prefer to immediately dispose of their harvest to traders.

For traders, buying wet grains and selling dried grains could be a lucrative business. However, a sizable amount of capital is needed to achieve safe margins. Moreover, capacity is a big challenge especially during the rainy days since harvest in one locality is done almost simultaneously. Under such situation, traders buying of fresh palay are limited to the daily capacity available. Traders in this case become mere conduits for millers and final processors as they would also sell to millers and other commercial entities in wet form to bypass drying. To those who have large capital, imported re-circulating dryers at a cost of around PhP450,000 but having a capacity of 6 tons were utilized.

Custom drying is a safe alternative for the risk averse. Though still the question remains whether farmers will resort to this alternative before disposing their produce and again the problem on capacity is a big challenge especially during wet season.

Dryers should come in different sizes depending on the need of the intended users. IRRI's version of the flatbed called "GC-7" with a capacity of one ton could complement UPLB's 2-ton model in serving the requirements of individual farmers or a group of small farmers at village level. The DA-BPRE and PhilRice 6-ton model is more suitable for millers and traders. Hence, a two-stage drying scheme should be seriously pursued where traders could play as extensions of millers. The UPLB unit would be used as pre-dyers at farm level to accommodate larger volumes during wet season while final drying would be undertaken at the millers' site or in centralized drying centers (De Padua, 2008).

Whether in the dry or wet season, there are constraints to farmers' adoption of the UPLB Flatbed Dryer technology. Proper education therefore on the usefulness of mechanical dryers is critical to increasing and sustaining technology adoption. A number of tested approaches can serve as models for government intervention in removing these constraints. IRRI's farmer's participatory research (FPR) approach involves encouraging farmers to engage in experiments in their own fields so that they can learn, adopt new technologies, and spread them to other farmers. With scientists acting as facilitators, farmers and scientists work closely together from initial design of the research project to data gathering, analysis, final conclusions, and follow-up action. This is currently being illustrated in Bangladesh where farmers' livelihoods are being improved by closing rice yield gaps by weeding out the weeds (Raju, 2004).

A Japanese model which had been very successful in Ogata, Akita involves establishing farmers into study groups that experiment with new technologies as way of solving common problems (Tozawa, 2004). The Tozawa study determined that economic incentive moved the farmers to technological innovation. In West Godavari District, known as the rice bowl of India, FPR empowered entrepreneurial farmers to adopt new techniques such as System of Rice Intensification (SRI) to combat the ill effects of stagnated rice yields after two decades of high-yielding hybrid use (Raju, 2004). In the Philippines, particularly in Agusan, where cooperation is still to be institutionalized, FPR may be a means to resolving common problems related to *palay* drying.

Flatbed dryers must be actually experienced by the intended users for them to appreciate the technology's future value to them. Hence, government extension activities must focus in on-site demos and lend to small groups of farmers for, say one harvest season, for testing. Furthermore, subsidizing the ultimate users' procurement costs would be a key to adoption of this technology.

The next area to be looked into is the hardware support. Recall that that grains dealer from Calaca, Batangas was at a loss where to buy a unit. Even the proponent of the technology when asked during his lecture at CEM did not have a ready answer where to procure one. This means that our local production of the product has not been formalized after all these years. Again, the government is in the best position to spur commercial production locally by giving its most valued orders to local entities. However, for this scheme to work, government initiative is indispensable.

First, there is a need to maximize the use of investment. Considering a two to three month usage of the dryer each harvest season would result to under utilization of at least six months every year. This could be another drawback in the acquisition of dryers. Therefore, an integrated drying system must be developed. Other grains or nuts could be included in the drying cycle to keep the investment in effective use year round so that the design of the dryer should be looked into for it to accommodate other produce in between rice harvest seasons.

Second, another scheme that maybe adapted is for the state universities, with UPLB at the forefront, to give support or take the lead role in implementing its own developed technology. State universities could set-up drying centers within their campuses for closer management of experts. The drying facility maybe offered for free or at a minimal fee for farmers. This may prove to be one of the universities' extension projects that have a national impact. Further, it may be utilized as an income generating project to augment university funds.

And third, but most importantly, it is critical to mass-produce Filipino technology already proven effective like the UPLB flatbed dryer. The government's drive towards self-sufficiency in rice hinges upon early and widespread adoption of homebred technologies such as this. Needless to say, research and development must be pursued aggressively and sustained by not only the government but also by institutions leading in agriculture like the UPLB.

Farmer participatory research can empower intended users of UPLBFBD make investment decisions regarding mass production of small machines for farm-level drying for individuals or small farmer-groups. Several farm-size dryers for a given *barangay* will improve drying rates and recovery of traders and ultimately redound to reduced drying cost which translates to higher net incomes for key players in rice production.

ACKNOWLEDGEMENT

This paper is a spin-off from Leila Pamplona's techno-managerial study of the UPLB flatbed dryer, a special problem in agribusiness management, CEM- UPLB in 2000. The author used personal funds for the conduct of the study and is indebted to many colleagues at the College of Economics and Management, University of the Philippines Los Baños, especially to Dean Flordeliza Lantican and Dr. Dinah Pura Depositario, Department of Agribusiness Management. Their support and valuable suggestions made the completion of this work possible. I also wish to acknowledge Dr. Dante de Padua, the technology proponent and the assistance of Ms. Laida Abarquez, University Researcher at the Department of Agribusiness Management for editorial work.

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