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FULFILLING THE FARMERS' CORN SHELLING NEEDS: THE UPLB CORN SHELLER (A TECHNOLOGY AND MARKET DEVELOPMENT STUDY)

by
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Working Paper No. 2009-19

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February 2009

Fulfilling the Farmers' Corn Shelling Needs: The UPLB Corn Sheller (A Technology and Market Development Study)

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Introduction

The UPLB two-drum corn sheller and the AMDP manual corn sheller developed by the Agricultural Mechanization Development Program (AMDP) at U. P. Los Banos were identified as the technology alternatives most suitable to the current condition and needs of the corn producing areas of the country, specifically with respect to post-harvest technologies. Both the UPLB two-drum corn sheller and the AMDP manual corn sheller are being commercialized by few, selected AMDP manufacturer-cooperators in selected corn producing regions and provinces.

In a nutshell, the UPLB corn sheller is a non-crushing type of sheller wherein spent cobs remain whole after the kernels are removed. The shelling assembly is composed of two drums with rasp bars welded around its periphery and a cylindrical presser that keeps the corn ears pressed against the drum during shelling. It uses an oscillating sieve as a separator and an aspirating blower as a cleaner. The shelling capacity is about 0.8 to 1.0 ton per hour at 18-24 % kernel MC wet basis. Shelling efficiency is high at almost 99 % and it requires only 2-3 persons to operate. It also has a relatively low power requirement needing only a 7 to 8 horsepower engine.

Nature of the Study/ Research Conducted & Methodology

This is a technology and market development study which delves on the UPLB two-drum corn sheller using secondary data from references and materials provided by AMDP and AMTEC such as the Philippine Agricultural Mechanization Bulletin and the Philippine Journal of Agricultural and Biosystems Engineering; some completed masteral theses in agricultural power

and farm machineries; and through conduct of key informant interviews (KIIs) of key AMDP personnel engaged in technology development and market promotion of the UPLB two-drum corn sheller. Internet research on some related topics were also conducted.

The objectives of the study are as follows: a) to provide a brief background of corn production in the country; b) to assess the status of farm mechanization in the corn producing areas with particular focus on the post-harvest operations; c) to describe the technology development processes involved in the design and fabrication of the UPLB two-drum corn sheller and AMDP manual corn sheller; d) to assess the extension as well as the market promotion and development efforts of AMDP and selected manufacturer-cooperators; and e) to discuss the various potentials and barriers to commercialization of the UPLB technology.

Summary of Findings

Corn is one of the major staple food crops, particularly white corn which is being consumed by about 12 million Filipinos (20 % of the population). On the other hand, it

constitutes about 50 % of the feed ration for livestock and poultry production. Yellow corn alone accounts for about 70% of livestock mixed feeds. Essentially, every part of the corn plant can be transformed into various products utilized by human beings and animals either as food or feeds. Corn forage is also important as it is used as feedstuff for ruminants and is a major source of good quality roughage. Other known high value industrial products from corn are related to the production of corn starch, gluten, snack foods, corn oil, etc. (Robles, et. al.).

Likewise, corn is the second most important crop in the Philippines, next to palay. Both crops accounted for about 47.56 % of the total agricultural output. In 1999–2003, production ranged from 4.584M metric tons to 4.615M metric tons with an average annual growth rate of 0.14% (Table 1).

In 2007, the country's corn yield was 6.737M metric tons while estimated corn production in 2008 is about 7.962 metric tons. This is a reduction from the annual growth rate of 18 % to just about 10-15 % due to typhoon damage on crops; high costs of farm inputs (e.g. fertilizer, pesticides); and decrease in areas planted to corn.

Through the enactment of Republic Act No. 8435, otherwise known as, the Agriculture and Fisheries Modernization Act (AFMA) in 1997, concerted efforts and actions were pursued to achieve the desired modernization of the agriculture and fisheries sectors of the country to enhance their profitability and prepare the said sectors for globalization. The development and promotion of appropriate agricultural machinery and other agricultural mechanization technologies to enhance agricultural modernization in the countryside were given emphasis.

Appropriate adoption of production and processing mechanization technologies by corn farmers plays a significant role in the modernization of agriculture, contributing to the increases in productivity, added value to corn crop and enhanced income opportunities and thus, ensures food security, global competitiveness and sustainability at the village-level. To help realize the potentials and gains of AFMA, there are several government institutions that conduct R & D activities geared towards the design and development of farm machinery, equipment and tools for production, post-harvesting and processing. UP Los Baños, through the Agricultural Mechanization Development Program (AMDP), has been one of the institutions at the forefront of promotion of agricultural mechanization. The Program conducts research, development and extension of agricultural mechanization technologies and undertakes collaborative activities with other key institutions of the government like the Department of Agriculture and the Bureau of Post-Harvest Research and Extension (BPRE).

Status of Mechanization in Corn Farming

Among the crops planted in the country rice, corn and sugarcane are some of the major commodities where some mechanization technologies have been used extensively in the production and post production operations. Based on the national corn mechanization needs survey and analysis, mechanization of corn production operations in the Philippines is relatively low. Mechanized technology is only commonly used in land preparation, shelling, milling and transport operations (Franco, D. T. et. al., 2003). Only about 39 % of 1,310 survey respondents used 2- or 4-wheel tractors in primary and/or secondary tillage. The use of draft animals is still considered significant at greater than 60 % of power needs, most likely in rural areas. Next to the use of the power tiller, only the shelling operation is highly mechanized.

Table 1. Philippine Corn Production (MT), Area Harvested (ha) and Yield per Hectare (kg) (1999 - 2003)

PHILIPPINES	1999	2000	2001	2002	2003
PRODUCTION (MT)	4,584,593	4,511,104	4,771,522	4,319,262	4,615,625
White	1,823,834	1,889,338	2,071,480	1,796,929	2,052,684
Yellow	2,760,759	2,621,766	2,700,042	2,522,333	2,562,941
AREA HARVESTED (Ha)	2,642,208	2,510,342	2,613,398	2,395,456	2,409,828
White	1,607,755	1,573,408	1,633,322	1,503,118	1,564,943
Yellow	1,034,453	936,934	980,076	892,338	844,885
YIELD/HECTARE (MT)	1.75	1.80	1.83	1.80	1.92
White	1.13	1.20	1.27	1.20	1.31
Yellow	2.67	2.80	2.75	2.83	3.03

Source of data: Bureau of Agricultural Statistics

Village-level processing is an important post-production activity to increase profitability of the corn farm. Use of mechanical corn dryers, corn shellers, and corn mills add value and increase crop storage life, either for home consumption and/or for sale. However, the lack of such facilities bring serious problems to the corn farmers as they are forced to sell their produce to the middlemen or traders.

Only one percent of the total farmers owned 4-wheel tractors and about 3.6 % owned engine-driven corn shellers. However, widespread availability of custom-hired equipment and services for 2-wheel tractors and mechanical shellers compensated for low machine ownership. Still, it is recognized that operations such as plowing, furrowing, harvesting, shelling and drying can be further mechanized.

The above scenario, combined with other problems such as poor varieties, inadequate production costs, inefficient farm operations, production losses and poor market structure have not made corn farming an attractive and always viable enterprise. This has also contributed to the country's chronic problem of importing corn from other countries. In 1995–2001, average volume

of imported corn was about 296,631 MT from at least six (3) countries. USA accounted for at least 51.33% of total average imports. In 2001, about 100% of the imports came from the USA which is equivalent to 33,000 MT (Table 3). There has been no recorded importation in 1999. Corn imports reached 400,000 MT in 2007.

Table 2. World / ASEAN Corn Production, 1996-2000 (MT)

Production (MT)	Year					5-yr average	% of world's total	annual average growth rate
	1999	2000	2001	2002	2003			
World	467,829,788	461,626,036	470,998,492	458,693,785	489,425,253	464,727,912	95.50	1.18
USA	239,548,992	251,854,000	241,484,864	228,805,088	256,904,560	245,701,496	52.87	0.40
China	128,287,195	106,178,315	114,253,995	121,498,915	114,175,000	117,232,755	25.23	1.46
Brazil	32,037,600	31,879,392	41,955,264	35,932,960	47,809,300	31,958,496	6.88	8.44
Mexico	18,314,344	17,556,900	20,134,300	19,299,236	19,652,416	17,935,622	3.86	2.28
France	15,656,000	16,018,353	16,408,234	16,440,000	11,898,000	15,837,177	3.41	(5.77)
Argentina	13,500,000	16,781,400	15,365,047	15,000,000	15,040,000	15,140,700	3.26	(2.17)
							% of ASEAN's total	
ASEAN	20,485,657	21,357,676	21,396,788	21,717,586	23,945,977	20,921,667	100	2.31
Indonesia	9,204,036	9,677,000	9,347,200	9,654,105	10,910,104	9,440,518	45.12	2.43
Thailand	4,389,900	4,462,000	4,466,000	4,230,000	4,500,000	4,425,950	21.15	0.17
Philippines	**4,584,600**	**4,511,104**	**4,525,010**	**4,319,262**	**4,478,173**	**4,547,852**	**21.74**	**(0.15)**
Viet Nam	1,751,900	2,005,900	2,161,700	2,511,200	2,933,700	1,878,900	8.98	7.90
Myanmar	349,111	362,700	532,420	660,000	750,000	355,906	1.70	15.64
Laos	96,110	117,000	111,869	124,122	112,000	106,555	0.51	(0.87)
Cambodia	53,000	156,972	185,589	148,897	190,000	104,986	0.50	3.89
Malaysia	57,000	65,000	67,000	70,000	72,000	61,000	0.29	2.

Source of data: FAO, 2004

Table 3. NFA CORN IMPORTATION, MT (1995-2001)

Country	1995	1996	1997	1998	1999	2000	2001	Average
U.S.A.	156,411	429,706	53,397	187,375	-	53,750	33,000	**152,273**
ARGENTINA	50,175	128,425	-	80,787	-	-	-	**86,462**
CHINA	-	-	118,658	49,130	-	5,900	-	**57,896**
Total	**206,586**	**558,131**	**172,055**	**317,292**	**-**	**59,650**	**33,000**	**296,631**

Source of data: National Food Authority, May 2003

The Agriculture and Fisheries Modernization Act (AFMA)

Recognition of the above problems not only for corn, but for other major crop commodities, led to the enactment of Republic Act 8435, otherwise known as the Agriculture and Fisheries Modernization Act (AFMA). Under the Act, agricultural mechanization was adopted as a major strategy for agricultural modernization. For each major crop commodity, different programs were crafted to address problems in production and post-production operations where the use of mechanized technology was a major consideration.

For corn, the Ginintuang Masaganang Ani (GMA)-Corn was the flagship program, where one of the major component strategies was the clustering program. The program sought to introduce the concept of large scale production areas where mechanized technology would be utilized from production to post-production operations. Under the clustering program, prime corn production areas with a minimum of 200 hectares were clustered or consolidated into one integrated production module where a complete set of mechanized technology were loaned out to service the said module. Despite the huge promise of the concept, initial implementation of the clustering project has not enjoyed the projected success. The implementation of the scheme has suffered from a myriad of problems foremost of which is debt servicing for the loaned out machines.

The Agricultural Mechanization Development Program

UPLB, through the Agricultural Mechanization Development Program (AMDP), also addressed the inefficiencies in the different farming operations through it research, development and extension activities. Even before AFMA, the country through UPLB was a founding member of the Regional Network for Agricultural Machinery (RNAM), an ESCAP-UNIDO project that sought the cooperation and promotion of agricultural mechanization technology among member countries in Asia. Since its inception in 1978, the program has evolved in to the Regional Network for Agricultural Engineering and Machinery (RNAEM). AMDP has remained as the local counterpart member of the regional cooperative network.

Since its founding in 1979, AMDP has been in the forefront of the efforts to promote agricultural mechanization as a necessary strategy for agricultural modernization. Its numerous research, development and extension efforts have led to numerous contributions to the pool of developed mechanized technologies that have been used for different crop commodities.

Presently, corn is one of the major target commodities of AMDP in its various development efforts. While DA through BPRE is involved in the mechanization of large scale clustered areas, AMDP's focus is on the non-clustered corn areas which still account for a considerable percentage of the total areas planted to the crop. These include areas not covered by the clustering program including areas where corn remains as the staple food crop. Among the technologies developed and/or are in various stages of development by AMDP for corn are, the upland power tiller, seed jabber, animal drawn planters, fertilizer applicators, corn harvester, corn sheller, corn dryer, and corn mill.

Research, Development and Extension Strategies

AMDP prescribes a more specific approach in identifying machines for development and extension. The current strategies that the program employs have been developed from its years of experience in the research, development and extension of agricultural mechanization technology. Currently the program adheres to the "location specific and production process dependent" mechanization strategy wherein there is a more purposeful approach to identifying mechanization problems that exist within a certain target area. This is in contrast to existing formula-based strategies wherein a certain locality has to meet the requirements of a specific program for it to be benefited by mechanized technology.

A case in point is the extension of various mechanization technologies in a pilot area in Cebu, particularly the town of Argao. The project in Cebu is a collaborative project with the Farmer Scientist Training Program (FSTP) a DA-BAR funded project that recently has become a national program through E.O. 710.

The mechanization project in Cebu started with a rapid assessment of the mechanization needs and potentials of the area. Farmer interviews, ocular site inspection, and secondary research data were analyzed to come up with the area's specific mechanization needs. These needs were matched with the program's existing pool of developed technologies and at the same time new machines for development were identified. The initial rapid appraisal showed that within the area there was a potential to immediately mechanize land preparation and shelling operations. Other areas where potential machines could be developed were the application of organic fertilizer (chicken dung), planting/seeding, drying and corn milling.

UPLB Corn Sheller: Matching the Farmers' Needs for Corn Shelling

Areas where corn is a basic necessity had traditionally used hand shelling or native manual shellers to shell their produce. The produce is normally used as food, stored as seeds or sold to traders as shelled corn. Availing of shelling and milling services in corn milling centers entails considerable cost to the farmers. Transport cost per sack of corn averages about P 40.00 from the farm to the milling center and back to the farm. Thus, to avoid incurring such cost they shell their produce manually and just avail of the milling services.

Considering the above scenario, the UPLB Two-Drum Corn Sheller (Fig. 1 and 2) and the AMDP Manual Corn Sheller (Fig. 3) were identified as the technology alternatives most suitable to the current condition and need of the locality. The sheller is a non-crushing type sheller wherein spent cobs remain whole after the kernels are removed. The shelling assembly is composed of two drums with rasp bars welded around its periphery and a cylindrical presser that keeps the corn ears pressed against the drum during shelling. It uses an oscillating sieve as a separator and an aspirating blower as a cleaner. The shelling capacity is about 0.8 to 1.0 ton per hour at 18-24 % kernel MC wet basis. Shelling efficiency is high at almost 99 % and it requires

only 2-3 persons to operate. It also has a relatively low power requirement needing only a 7 to 8 horsepower engine.

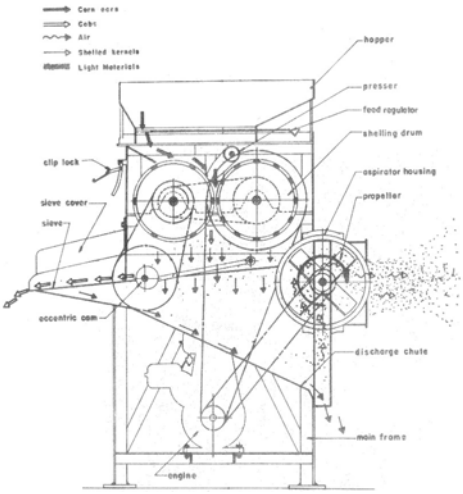

Figure 1. Schematic diagram of the UPLB Two-Drum Corn Sheller.

The shelled output from the sheller can be used both for milling and for seed purposes. The medium range capacity of 1 ton per hour is suitable for the current level of production of corn farms in the area. Since the area is basically rain-fed and traditional varieties have been planted, yield levels have been quite low averaging from 0.5 to 2 tons per hectare. Average landholding size of most of the farms range from 1 to 2 hectares. However, with the introduction of improved varieties by the FSTP, yield levels are expected to increase to 4 to 5 tons. With this future scenario the UPLB sheller would still be suitable for use since not all produce are shelled simultaneously.

Figure 2. The two-drum corn sheller in operation.

As an added benefit, since the spent cobs remain whole, there are possibilities to use these materials as biomass fuel for dryers or as raw materials for charcoal briquettes.

Although there are other shellers commercially available, most of these are the crushing type, high capacity shellers. However, in terms of suitability to the current conditions in the area, these shellers would be less suitable than the UPLB sheller. At the current yield levels of the farms these shellers would be underutilized due to its higher capacity. It would also be much more costly to operate since these machines require larger engines (12 to 16 horsepower) and thus use more fuel during operation. Considering the current cost of fossil fuels, recovery of costs would also be much harder since these are more expensive and would require a higher annual utilization for it to recover costs if it is to be used for custom hiring. These type of shellers are also not suitable for shelling corn ears to be used for seeding purposes due to the relatively higher degree of external and internal cracks of the shelled corn output.

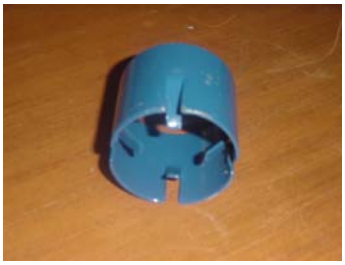

Figure 3. AMDP manual corn sheller.

Meanwhile, the AMDP manual sheller is a simple hand tool that can be used for manual shelling and eliminates the usual pain experienced when shelling by hand. The device is made of steel tubes with the shelling teeth bent inward. The design was based on a simple gadget used in Nigeria for the same purpose. The tool works by inserting the shelled ear into the tube and exposing the kernels to the shelling teeth. Shelling is effected when the tube is turned clockwise and counterclockwise alternately (Fig. 4).

Figure 4. The manual sheller in operation.

Technology Dissemination

Once the sheller was identified as a suitable technology, preliminary tests were made to further validate its performance using locally grown varieties. After this validation stage, the machine was demonstrated to a wider audience through the holding of field demonstrations coinciding with the field activities of the FSTP. During this stage, the AMDP Manual Corn Sheller was also demonstrated to create awareness among farmers' minds that mechanization also encompasses the use of hand tools to increase efficiency of operations.

The machine demonstrations elicited positive response among the farmers and created awareness on the benefits that can be derived from mechanization. From the initial

demonstration, several other demonstrations were held in other locations. Requests for training were also received by AMDP from farmer groups as well as the Regional Agricultural Engineering Groups. These training programs were conducted to create greater awareness and knowledge about mechanization especially with the proper use and choice of machines for the existing conditions of their respective localities.

Several other partners were tapped by AMDP and FSTP to provide assistance and support to the extension of the technologies. These included local schools like the Cebu State College of Science and Technology (CSCST), LGU's, Regional Agricultural Engineering Division (RAED) of the regional field units of DA and local manufacturers. The existence of these project partners provides a better chance of sustainability of the use of the technology as they will continue the extension efforts of AMDP. With the limited manpower and resources of AMDP, local partners will help ensure large-scale adoption of the mechanized technology in corn production in the province of Cebu.

The Commercialization Process

As an offshoot of the training programs and machinery demonstrations, the knowledge of the potential of using mechanized technology began to spread to a wider audience. Several LGUs and DA offices initially requested for numerous units of the hand sheller that they distributed to the farmers. In addition, a local manufacturer expressed interest in fabricating the two-drum sheller.

Wide scale dissemination of the hand sheller further created demand for the use of mechanized technology. To sustain awareness of such technology, a pilot area was established to allow a farmer cooperator to experience the full benefits of using mechanized technology. This allowed AMDP a continuous feedback mechanism and a showcase of the technology in actual farm use. For such pilot area, not only the shellers were in use but also the other technologies that were identified to be suitable for the conditions of the area. These included the upland power tiller and a prototype corn mill.

In response to the request of the manufacturer, AMDP tapped his company to be a cooperating partner. Since AMDP is not in the business of actually manufacturing and selling its designs, local manufacturers are tapped to do the fabrication and actual selling of the machine. To ensure that design standards are met, the manufacturers are provided continuous technical support. The initially fabricated unit is also subjected to field tests by AMDP. Once the performance standards are met, the manufacturer will be allowed to sell the machine. AMDP also requires constant feedback from the manufacturer with regards to comments and experiences of end users.

The role of the manufacturer is key to the commercialization of mechanized technologies like the sheller. The cooperative relationship between the manufacturer and AMDP needs to be managed properly. This will ensure that the machine will be fabricated according to specifications and fabricated units will perform according to acceptable standards. Without this cooperation, there is always the possibility that a manufacturer will duplicate a machine without the proper training and technical knowledge. In such cases, the machine may not perform according to standards. In the worst cases, AMDP may be blamed for the poor performance of the machine which would be unfair since in the first place the machine would not be an accurate prototype of the original design.

Wide-Scale Commercialization

Conducting demonstrations, training and identifying manufacturers to fabricate the machine designs is only the first step in the wide-scale commercialization process. The initial success of the demonstrations and training would have to be followed up with sustained extension efforts to make sure that mechanization would remain in the consciousness of the target market.

On the side of the farmers, there has to be a realization that the use of the corn sheller would indeed be beneficial for his farming enterprise. Since individual ownership is usually beyond the reach of corn farmers, ownership through cooperatives or farmer's groups would have to be pursued. A viable scheme would have to be made so that members would benefit from the use of the sheller at competitive costs. Custom hiring the machine to farmers who are not members of the cooperative will be a potential source of added income. In this case, the sheller should have an annual utilization rate that would make it viable to operate as a business venture.

For the manufacturer, a steady stream of clients would have to be found so that fabrication of the design would be a viable source of income. Thus, it is imperative that the machine will have enough market exposure through field demonstrations, trade fairs, the internet or his display shop to assure constant visibility and the possibility of additional orders.

For the RAED, awareness of the potentials of the use of the machine will allow them to locate other areas within the region that would be suitable for the use of the sheller. For its part AMDP works closely with the RAED to provide them a steady stream of technologies that would be suitable for use in the different localities in the region.

For the other partners, AMDP would have to be in constant communication with them so that any concerns about agricultural mechanization would have to be addressed properly.

The interplay of these different stakeholders and events will assure that the use of mechanized technology will always be a viable strategy for addressing the problems of agricultural productivity in the region.

The wide-scale commercialization of mechanized technology is usually a long and arduous process. Like the case of the International Rice Research Institute (IRRI) which came up with numerous machine designs, they can only count one or two technologies, particularly the axial flow thresher, that generated wide-scale use and proved to be a commercial success for many manufacturers.

Current Demand for the UPLB Corn Sheller

Word from the manufacturer in Cebu indicates that there is increasing demand for the corn sheller. For this current year, the DA-RFU is set to order four units of the sheller for distribution to different municipalities in the region. This will be followed by eight more units this year.

The RAED also informed AMDP that there were interested LGUs in Bohol that desired to use the sheller, thus a demonstration had held during the latter part of last year.

These are definite offshoots of the continuing efforts to introduce mechanized technology in one of the country's key corn-eating regions. The positive interplay of factors will surely lead to the probable wide-scale adoption of mechanized technology such as the corn sheller.

Potentials for Commercialization

The reduction of post harvest losses through primary processing is a concrete measure to help increase a farmer's income as well as generate new employment and means of livelihood in the rural sector. This is made possible through the adoption of local processing machines and facilities. Using farmer's cooperatives and custom-hire arrangements with private entrepreneurs, the farmers would easily gain access to these machines. These integrated or consolidated schemes are being implemented successfully in countries with small landholdings such as Japan, Korea, and Taiwan.

Through joint-venture arrangements, foreign and local manufacturers can jointly set-up manufacturing and assembly plants in the country that manufacture critical farm machines and machine parts.

The Department of Agriculture (DA) highly recommended the promotion and adoption of appropriate farm machinery technologies that would meet or satisfy the specific needs of the location and the kind of machines appropriate for the specific corn-growing areas. The use of commercially-available machines/implements for land preparation, planting/fertilizing, cultivating and spraying and agro-processing machines could be given priority while at the same time further developments on these implements could be done to come up with more efficient models. The study further recommended the use of smaller versions of commercially available technologies.

At the farm level, massive technical demonstrations and trainings on the operation of selected agricultural machinery at the farmer-operator's level must also be done to provide the farmers and operators with the basic knowhow of these farm mechanization technologies.

Local manufacturing of agricultural machinery can be promoted through training on village-level craftsmanship, manufacturing technology, operation, repair, and maintenance. Local manufacturers can be provided with technical assistance in the fabrication of machine prototypes.

Agricultural technicians (ATs) should have ample time and the needed depth to learn a technology before they can effectively teach the farmers. Some ATs even establish and manage their individual farms to test and adopt the technology right in their own fields**.** This will lend real credibility among the agricultural technicians, in terms of timely and quality extension efforts.

Through proper and effective training and exposure given to different manufacturers, agricultural officers as well as farmer leaders, the farmers will gradually shift from the traditional methods of corn farming in the Philippines. Hopefully, through the mechanization program, we can have a globally competitive corn industry.

Actual field demonstrations and loan-out of farm machine models or prototypes must be conducted right at the farmers' field or at pilot areas. Serious integration of traditional or indigenous agricultural knowledge into mechanization system and procedures would help overcome farmers' initial reluctance to accept and use the mechanization technology. Moreover, the more popularized versions of training and technical materials in the local dialects would promote better understanding of these materials.

The Philippines, through PCARRD-DOST, can developed a systematized and centralized information database for agricultural engineering, linking all vital information concerning farm mechanization that can be accessed by farmers, extension personnel, scientists, engineers, students, and policy makers. These special efforts would greatly contribute to the transfer of the technology.

With the formation of farmers' organizations, the farming community can be empowered with the knowledge and skills to identify its own needs and problems, harness its resources to deal with their current problems, and take action collectively. In order to obtain farmers' cooperation, technical support, facilitation of credit assistance, land clustering and consolidation, this can be facilitated through farmers' organizations which are considered as the "usual" entry point of developmental programs by government and non-government organizations (NGOs).

Land clustering and consolidation is a concrete means to transform the land and facilitate the adoption of larger-scale mechanization rather than attempting to fit the mechanization technologies to small farms. The DA-RFU II aggressively pursued the clustering of corn farms, a step toward full-scale land consolidation. This involves the removal of fences and other obstructions along farm property boundaries to form a contiguous land area that will increase the efficiency of operation of large machines to synchronize land preparation, planting, and harvesting; minimize turns at headlands and other interruptions; and reduce energy inputs. Land consolidation, on the other hand, improves land clustering by refining the layout of the fields in the clustered area without regard to property boundaries (Lantin 2003).

Many farmers would readily adopt a technology that other farmers have successfully and profitably utilized. This is the basis for the model farmer**,** a model farm strategy, as a sustainable working system being used by a farmer cooperator to enhance the acceptability and adoption of the desired mechanization technology.

Technology verification and assessment would permit evaluation for developing, modifying, or entirely stopping the development of a technology. For example, technology adoption assessment was conducted for the UPLB hand tractor and UPLB/AMDP corn sheller. The study established the potential of the technology and revealed possible modifications to further enhance its performance and acceptability. It also revealed that locally trained manufacturers lacked some knowledge in marketing strategies (Paras et al. 2004).

Development and utilization of agricultural machinery must adopt relevant policies on intellectual property and the Philippine Standards for Agricultural Engineering. Intellectual property laws are intended to protect and encourage the development of truly unique and functional farm machinery and equipment. Lack of understanding of these laws can be a hindrance to the collaborative efforts between technology-developing institutions and individuals. Legal impediments and protection inhibit researchers and scientists to reveal the exact nature and feature of mature technologies. Adoption of standards, on the other hand, would benefit farmers in terms of safety and reliability of their machinery.

The government must have a strong political will to control and make policies to halt the influx of imported, second-hand machinery in the market. This will protect not only the farmers but also the local manufacturers.

Conclusions and Recommendations

Through effective R&D initiatives, the pertinent problems and/or issues must be adequately addressed such as: 1) lack of coordination and integration of R&D activities among implementing agencies; 2) insufficient R&D facilities and funds; and 3) absence of extensive assessment of farmers' needs towards identification of viable and appropriate technologies. However, these government institutions and state universities act separately in identifying the gaps in agricultural engineering without the benefits of consultation and thus, duplication of research and extension work as well as resource wastage may occur.

The mechanization of the corn industry is one of the priorities of the national government through the corresponding LGUs in order to help the farmers increase their yield and improve their productivity. With high acquisition costs of farm machines, however, farmers could not avail of large-scale corn machineries.

Around 27 million Filipino farmers remain poor. About one-half of them live in the rural areas. Highest poverty incidence is found among corn farmers (41%); rice and corn workers (36%); sugarcane farm workers, coconut farm workers, forestry workers (33%); and fishermen (31%) (PCARRD 2003). These farmers have limited resources and are unable to readily embrace technology.

In short, farm machinery and equipment are too expensive that small farmers could hardly afford to own and use these. Even if credit is readily available, other contributory factors are high interest rate, long processing time and the requirement for collateral or a guarantor. Another factor that prevents farmers from mechanizing their farms was their low income due to lowfarm gate prices.

Other equally important barriers to commercialization of the UPLB two-drum corn sheller are as follows: a) lack of economies of scale of farmer-operators; b) reluctance, resistance to change and risk aversion of farmer-operators; c) lack of appropriate machinery, in terms of design and quality to meet specific end user needs; d) poor profitability of agricultural machinery manufacturers in the country due to the high costs of machines, the dumping and smuggling of imported agricultural machineries, and the uncontrolled entry of second-hand farm machinery and equipment; e) lack of training for extension personnel.

Some local government units (LGUs) do not prioritize agricultural development and farm mechanization needs and programs in their allocation of the local budget. If ever funds are sourced out to help implement the acquisition of farm machines and other useful technologies, “mismatching” of technologies occur, primarily due to the lack of technical background of the LGUs.

Various constraints were also identified in large-scale corn mechanization such as frequent expensive breakdowns and/or unavailability of spare parts; incompatibility of tractors; inappropriateness of some machines because of small landholdings; the incapability of machines to perform satisfactorily under some of the actual farm situations; insufficiency of machines during peak operations as well as high machine rental fees; and inability to do repairs and maintenance in the area for lack of necessary tools and/or skills.

Despite all these overwhelming barriers or obstacles to successful commercialization, bright prospects and potentials remain to be realized, particularly when benefits readily offset the tangible and intangible costs of mechanizing the farm, particularly the post-harvest operations. With appropriate farm mechanization technologies, corn farmers are assured of increased farming efficiency and reduction in crop losses. However, this requires proper identification of machines suitable to the conditions of the farms, sustained exposure and use of the technology, properly trained local manufacturers and profitable utilization and custom hiring schemes.

Areas for Further Research

An AMDP manufacturer-cooperators' survey (including key informant interviews of non-cooperators) may be conducted to assess the actual and potential market performance of the UPLB two-drum corn shellers. Considering relevant financial and economic variables, cost analysis may be computed, in terms of investments and operations so as to assess the viability and profitability of using the UPLB technology as well as engaging in custom hiring services.

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