ASSESSMENT OF THE YELLOW CORN HARVESTING AND SHELLING LOSSES IN PANGASINAN, ISABELA, BUKIDNON AND SOUTH COTABATO, PHILIPPINES

Amelita R. Salvador* and Gigi B. Calica
Socio-economics and Policy Research Division
Philippine Center for Postharvest and Mechanization (PHilMech), Philippines
*Corresponding author: seprd@philmech.gov.ph

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ABSTRACT

Reducing post production losses had been identified as a key component to increase the domestic supply of corn as well as increase farm incomes. This paper reviewed the current harvesting and shelling practices of yellow corn farmers, measured its corresponding losses and identified the factors influencing these losses. A total of 237 corn farmers were interviewed while losses were assessed from the cornfields of 24 farmer-cooperators. Four different harvesting and shelling practices were established namely (1) manual picking, piling and mechanical dehusking/shelling; (2) manual dehusking/picking, piling and mechanical shelling; (3) manual dehusking/picking, corn on cob sun drying and mechanical shelling, and (4) use of combine harvester. The combine harvester garnered the highest losses while manual dehusking/picking, corn on cob drying and mechanical shelling practices incurred the lowest losses. In spite of these losses, the combine harvester incurred the lowest cost per hectare. The presence of weeds, moisture content and planting distance influenced significantly harvesting losses. The adoption of corn planting distance of 65cm in between furrows and use of mechanical seeder for planting can lower the losses from combine harvester. Provision of mechanical seeders, in tandem with the corn combines being distributed by the government to the farmers' organization is highly recommended.

Key words: loss assessment, corn combine harvester, corn seeder, corn sheller Alphabetize

INTRODUCTION

Corn or maize (*Zea mays L.*) is the second major crop grown in the Philippines. Based on the 2018-2022 average corn production data, about 73 % of the country's production is yellow while 27 % is white (PSA 2023). Yellow corn is one of the major ingredients in the livestock mixed feeds in the country while white corn is the main staple food of about 14 million Filipinos (DA-MIMAROPA undated). Yellow corn is preferred for poultry feeds due to its high β-carotene which is a source of Vitamin A (Salazar et al. 2021). Feeding chickens with yellow corn manifests in the yellow color of the egg yolk.

Corn can be grouped according to its physical characteristics such as color, shape and size. Yellow hybrid corn grains have diverse hues of color from pale yellow to dark yellow or almost orange in color. When dried, the center portion of the grain develops a depression or an indentation. That is why others call it as dent type of corn. The degree of dent depends upon the corn variety (Darrah et al. 2019). The shape and size of corn grains vary depending on the variety as well as to the moisture content of the

grain. Handling of grains having different varieties and moisture content are considered when designing machines for proper adjustment of its components (Darfour et al. 2022).

Corn can be harvested manually or mechanically. A study on the value chain of yellow corn revealed that 86 % of corn is harvested manually while 14 % use mechanical harvesters, specifically corn combines (Salvador et al. 2020). As the machine name connotes, the corn combine harvester performs combination of harvesting (cutting of corn stalks and picking of the corn ears), dehusking (removal of the husks from the corn still on cob), shelling (separation of corn kernels from the cob), cleaning and conveying of the kernels into a holding bin. At the same time the machine discharges residues such as corn stalks and broken cobs onto the ground while in operation (BAFPS 2018). Users of corn combines are found mostly in Isabela and Pangasinan.

Corn is manually harvested by detaching the corn by hand from the mother plant with and without the husk (Dela Cruz and Calica 2016; Salvador 2012). A mechanical dehusker-sheller is used for harvested corn with husk while a mechanical sheller is used for unhusked harvested corn. Dehusker-sheller machine removes the husks then separates the grain from the cob. It is equipped with a blower to clean the shelled grains. The corn still on the cob is manually fed into the mechanical sheller to separate the grain from the cob. It is also equipped with a blower to winnow the shelled grains (Salvador et al. 2012; Singh 2014). In manual harvesting, laborers ranging from 12 to 25 persons or an average of 15 laborers are needed to complete harvesting a hectare of corn in a day, while only four laborers are required when using a combine harvester. For mechanical dehusker-shellers, around 6 to 12 laborers are needed to operate the unit (Salvador et al 2021).

About 20 % of the country's labor force is still employed in agricultural activities. Of the total labor inputs, 64 % are hired laborers, while 19 % are family and 17 % are machine operators (PSA 2019). Even for rice and corn, farm laborers are not enough to cater to the simultaneous harvesting, threshing and/or shelling operations during peak harvest. As evidenced from the study of PHilMech and UPLB (2016), 22 % of the surveyed rice and corn farms suffered from labor shortage during peak planting and harvest season. Seasonality of labor employment led to most of the rural farm laborers to migrate in other areas, thus, decreasing the present available farm laborers. With the dwindling availability of farm laborers, corn farmers are slowly shifting to the practice of using corn combine harvesters to harvest and shell their corn produce. Similar to other post production activities, utilization of combine harvesters has its corresponding losses.

An actual loss measurement study conducted in 2005-2006 revealed that around 7.18% of the yellow corn production was lost due to post production activities, that is, from corn manual harvesting, piling, mechanical shelling, sun drying up to storage (Salvador et al. 2012). Physical losses from manual harvesting, piling and mechanical shelling amounted to 1.57 % of the total production which is equivalent to 21.91 % share of the total losses. On the other hand, a loss perception study revealed that 8.59 % was lost from harvesting up to marketing, of which 6.46 % was due to harvesting, piling and shelling losses (Dela Cruz and Calica 2012). Losses from corn combine harvesters were reported at 2%-4% (Singh 2014) and 3.5% (Wang et al. 2021) of the volume harvested, in India and China respectively.

Inasmuch as use of combine harvesters in corn is gaining popularity in the Philippines, there is a need to assess its losses vis a vis the losses from the practice of manual harvesting, piling and mechanical shelling practices. In addition, factors causing or influencing these losses has to be identified. The study sought to review the current practices of harvesting and shelling of corn farmers in major corn producing provinces in the Philippines and measured the losses in each of the operations. The factors influencing these losses were identified. This information can help significantly in crafting future plans and programs of the government, geared towards reducing harvesting and shelling losses which can ultimately increase the volume of yellow corn available for domestic use.

METHODOLOGY

Location of study. The study covered four major yellow corn provinces in the country namely Isabela, Pangasinan, Bukidnon and South Cotabato. Forty-eight % (48%) of the country's total yellow corn production are coming from these provinces (PSA, 2017). Three municipalities with the greatest number of yellow corn production were selected in each of the provinces.

Sampling procedure. Key informants and at least thirty % (30%) of the yellow corn farmers were randomly selected as respondents from the identified municipalities. Face-to-face interviews of respondents were employed prior to the identification of the project cooperators and actual loss measurements. A total of 237 respondents were interviewed from September 2018 up to March 2019. Information such as area planted, number of croppings per year, corn varieties planted, production and postproduction practices, costs and machines used were gathered from the interview.

An inventory of the existing machines used by corn farmers was likewise conducted through a separate project. The machine model, brand, capacity, number of units, number of service areas (in hectares), number of hours utilized per day or per season among others were obtained from the machine owners and users (Salvador et al. 2021a).

Cooperators for the measurement of harvesting and shelling losses were selected through stratified random sampling. Due to budget constraints and only a month-long harvesting period per province per season, three corn farmers that adopted the corn combine harvesters and another three farmers that are using the current harvesting and shelling practices were selected as project cooperators per province. At the time of the assessment the cooperators have at least one hectare planted to corn and have planted the dominant corn varieties. Also, the corn combine cooperators used the dominant brand or model of corn combine harvester existing in the area.

Data collection and analysis. Secondary data gathered from published studies and databases were used in the study. The total annual yellow corn production, area planted and yield per hectare per province were sourced from the PSA database. The number and type of corn post harvest facilities present in the provincial sites were sourced out from the database of PHilMech. The list was validated with the provincial and municipal agriculture offices and barangays of the identified provincial sites.

Primary data such as the average area planted to yellow corn, typical/existing post production practices and the preferred/common yellow corn varieties planted by the growers were collected from the interviews.

The identified farmer-cooperators were interviewed prior to the postharvest loss measurements. Information such as area planted, variety planted, pests infestations, drought affected, production and postproduction practices, machines used were solicited. Only one dominant variety were planted by all the co-operators wherein the matured corn was harvested from 110-115 days after planting. The procedure on how to measure the potential yield, conduct of the field loss measurement at harvest and shelling operations were explained to the project cooperators.

The data were collected for two seasons from March to May 2019 representing the dry season, and from September 2019 to February 2020 for the wet season. The daily operations by the corn cooperators from harvesting up to shelling were observed/recorded. Losses in every operation were collected and recorded, as well as relevant information and factors that affect losses were documented.

Quantitative loss measurements. The harvesting and shelling losses were measured quantitatively. Loss measurement procedures for manual harvesting, piling and mechanical shelling were patterned from the procedures developed by Harris and Lindblad (1978) and by Maranan et al. (1996).

Potential Yield (PY) is the estimated yield per unit area usually expressed in kilograms per hectare or tons per hectare.

$$potential\ yield_{py} = \frac{ave.wt.of\ shelled\ corn\ from\ sample\ frames}{10m^2}\ x\ 10{,}000\ m^2/ha \qquad (1)$$

Harvesting Loss (HL) is comprised of unharvested, uncollected and scattered corn kernels.

$$harvesting\ loss_{HL} = \frac{ave\ wt\ of\ shelled\ samples\ x\ 10{,}000m^2/ha}{10m^2}\ x\ 10{,}000m^2/ha$$

$$harvesting\ loss\ (HL), \%_{\square} = \frac{harvesting\ losses,kg}{potential\ yield,kg}\ x\ 100 \qquad (2)$$

Shelling Loss (ShL) is comprised of separation loss, blower loss and scattering loss. Scattered grains are any corn grains thrown from the grain discharge, or from any section of the machine during the shelling operation.

a. Separation loss (SpL) is the corn grains that came out of the shelling chamber together with the cobs, and/or corn cobs with several grains that remained attached to the cobs.

$$SpL, \% = \frac{Separation\ loss,\ kg}{Clean\ shelled\ grain,\ kg + (sum\ of\ all\ shelling\ loss - handling\ loss,\ kg)}\ x\ 100 \qquad (3)$$

b. Blower loss (BL) is the grains blown with the cobs by the sheller fan.

$$BL, \% = \frac{Blower\ loss,\ kg}{Clean\ shelled\ grain,\ kg + (sum\ of\ all\ shelling\ loss - handling\ loss,\ kg)}\ x\ 100 \qquad (4)$$

c. Scattering loss (ScL) using the formula:

$$ScL, \% = \frac{Scattered\ loss,\ kg}{Clean\ shelled\ grain,\ kg + (sum\ of\ all\ shelling\ losses\ -\ handling\ loss,\ kg)}\ x\ 100 \qquad (5)$$

Total shelling losses (ShL_{total}), % = BL + Spl + Scl

Combine harvesting loss**.** The corn combine harvester mechanically cuts the stalks, picks and strips the corn ears from the plant before dehusking and separates the corn kernels from the cob. Shelled grains are mechanically conveyed to the holding bin/bagging area. However, grains are manually placed in sacks and sealed by the harvesting laborers. The formula in the computation of the combine harvester losses (unharvested, uncollected and scattered) and shelling losses followed the same formula used above. Therefore,

Total corn combine harvesting losses (CCHL) = Harvesting Loss + Total shelling loss

Data analysis. The harvesting and shelling losses were computed using the formulas above. These were further analysed through frequencies, percentage and averages. The significant factors affecting these losses were determined using t-test and ANOVA.

RESULTS AND DISCUSSION

On farm harvesting and shelling system of operation. Four systems of harvesting and shelling operations were identified for yellow corn. System 1, which follows the practice in Isabela, manually harvests or separates the corn still with husk from the mother plant. The unhusked corn is placed either in round bamboo basket or placed directly in animal drawn carts. Corn is then hauled in bulk and piled in a cleared area in the corn field. One to three large piles are prepared in the corn field. The piled corn is left in the field from 3 days up to 14 days. This practice hardens the grains thus reducing damage during shelling (BAPS 2018). A dehusker-sheller machine is used to shell the corn (Fig. 1).

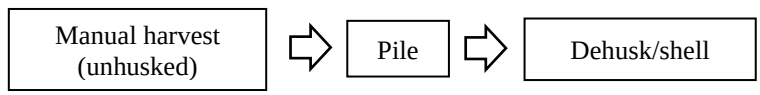

Figure 1. System 1 yellow corn harvesting and shelling practices

System 2 follows the common practice in the provinces of Bukidnon, South Cotabato and Pangasinan (wet season only) harvest. During harvesting, the corn husk is removed before detaching the corn still on cob from the mother plant. The corn on cobs (CoC) are temporarily piled on the ground without underlays. Afterwards, these are placed in sacks, hauled and piled in the shelling area. Shelling is done near the sun drying area. Shelling commences when the concrete drying pavements that will be used for sun drying is already available (Fig. 2).

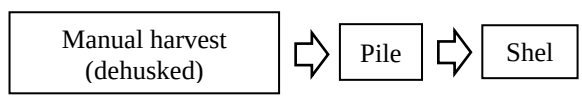

Figure 2. System 2 yellow corn harvesting and shelling practices

It takes 2-3 days to sun dry corn. During peak harvest, the drying pavements are always full thus farmers have to wait for their turn to use the sun drying facility. Corn farmers are aware that the quality of corn grains are maintained if corn are temporarily stored as CoC rather than storing the grains as shelled wet while waiting for the availability of the sun drying facility. (Salvador et al .2012; Salvador et al. 2021a; Salvador et al. 2021b).

Similar to System 2, System 3 manually dehusks the corn on cob during harvest. However, farmers field dry the corn still on cobs before shelling. Corn on cobs (CoC) are hauled and spread in a cleared corn field area, or in cemented pavement areas. CoCs are dried from 8 to 14 days before shelling. After shelling, the grains are placed in sacks, piled and picked up by the buyers. This system is practiced in Pangasinan during dry season harvest only (Fig. 3).

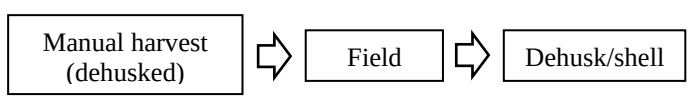

Figure 3. System 3 yellow corn harvesting and shelling practices

System 4 is with the use of a mechanical corn combine. Due to the dwindling availability of harvesting laborers coupled with simultaneous high demand for harvesters during peak harvest season, farmers resort to using combine harvesters in order to prevent over maturity of their produce. The combine harvester cuts the corn stalk, picks and dehusks the corn ears, then shells by detaching the corn grains from the cobs. The shelled corn grains are mechanically conveyed into the holding bin and then manually placed in sacks by two laborers. The laborers drop the closed sacks of grains in one place

and then pile them in the cornfield ready for hauling (Fig. 4). The combine harvesters can harvest three to four rows in one pass depending on the plant spacing in between rows. Corn combine harvesters can finish harvesting a hectare of corn in two to four hours.

Figure 4. Corn harvesting and shelling operation using combine harvester.

Harvesting and shelling losses by system. Figure 5 illustrates the comparison of losses per system. For both harvesting and shelling operations, harvesting loss contributed higher losses. System 4 exhibited the highest losses at 3.10 % and 3.52 % for the dry and wet seasons respectively, or an average of 3.36 % losses, while System 3 has the lowest losses at 0.65 %. System 1 loss is significantly higher during the wet season as compared to the dry season. For System 2, the difference in the losses per season is not significant. In both seasons, losses from Systems 1 and 2 are almost the same.

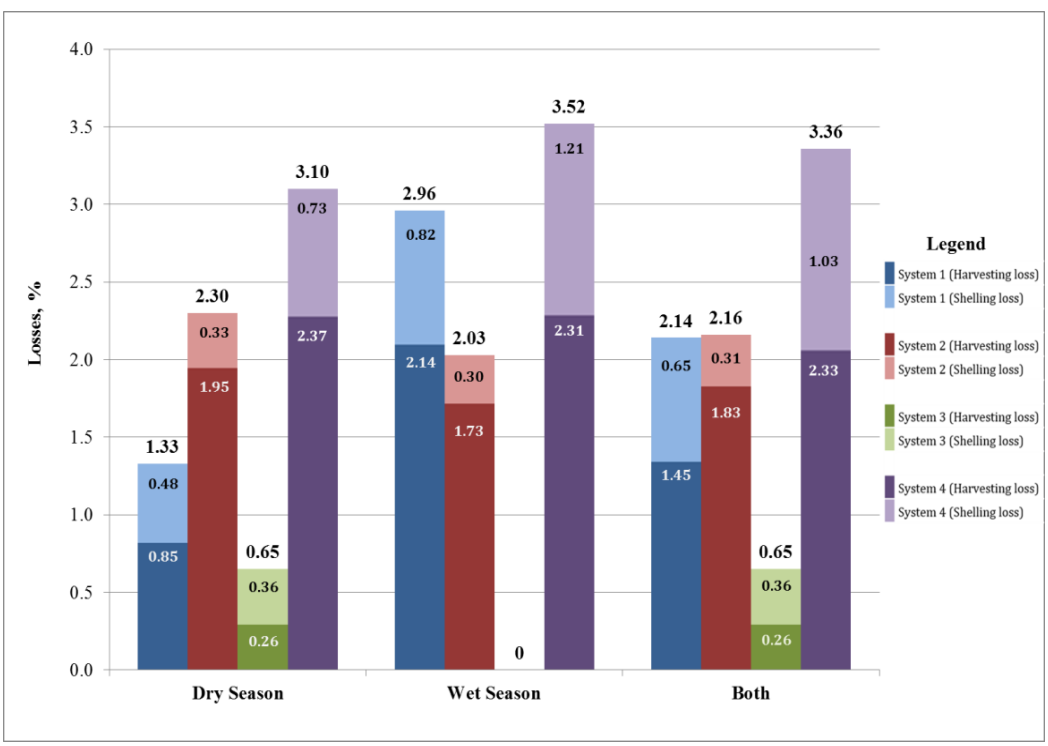

Figure 5. Harvesting and shelling losses by system per season, in %

Inspite of the combine harvester garnering the highest losses across the four systems, the resulting corn combine harvester loss figure is within the maximum allowable harvesting loss of three percent (3%), and maximum shelling losses of two percent (2%) as set by the Philippine National Standards and Bureau of Agriculture and Fishery Standards (BAFS 2018). Similar findings by Singh (2014) revealed that the highest maize losses were incurred for combine harvester (2-4%) as compared to the losses from the mechanical sheller (0.5-1.5%) and dehusker-sheller (1-2%). In China, harvesting losses using combine is around 3.5% of the average corn yield. Similarly, this % loss is acceptable as it falls below the Chinese loss standards for mechanical harvester set at ≤5% (Wang et al. 2021).

The presence of weeds contributed to the harvesting losses across all the four systems. Weed vines conceal some of the corn that is about to be harvested/detached from the mother plant. Corn that accidentally dropped to the ground are sometimes covered by the dried corn stalks and vines thus missed by the harvesting laborers.

Some of the corn plants produce two corn ears per plant of which one corn ear is smaller than the other. Most of the harvesting laborers in System 2 intentionally leave the unhusked smaller corn ear still attached to the plant. Harvesters are always in a hurry and do not even bother to dehusk the smaller corn ear to inspect whether the corn is still good or not. Harvesters assume it is rotten since the size is smaller as compared to the other corn ear.

For System 3, minimal harvesting loss was observed in Pangasinan dry season harvest. It was observed that the harvesters were careful in dehusking, picking and detaching the corn from the plant as compared to the harvesting laborers in Systems 1 and 2.

In System 4, the major source of harvesting loss is the high unharvested or unpicked corn ears. The combine harvester picks the corn ears from three to four rows at one time depending on plant spacing in between rows. At times when the combine harvester is harvesting three rows, the plants at the adjacent fourth row are swept accidentally by the machine, knocking down the corn plant. When the combine harvester is already harvesting that fourth row, the unhusked corn attached to the fallen corn plant cannot be picked by the combine harvester anymore. In some situations, unharvested corn ears are cut in the middle leaving the lower part of the corn ears still attached to the plant.

Corn plants with a high weed population clog the combine harvester header/cutting blade. Similar finding was observed in India wherein cornfield infested with weeds frequently chokes the combine harvester (Singh 2014). In addition, the weeds tend to conceal the unhusked corn ear thus the combine harvester operator cannot properly see the corn plant. This also results in many uncut/unharvested corn ears in the field.

Factors influencing harvesting losses. There were no significant factors identified which influenced harvesting losses for Systems 1 to 3. moisture content, presence of weeds and planting distance in between rows influenced harvesting losses for Systems 4 (Table 1). The optimum moisture content (MC) of corn at harvest is between 23-25% (Monsanto 2019). Based on the results, lower losses are recorded when the MC of grain is at its optimum. As supported by a study in China, mechanical harvesting loss at different grain MCs showed that harvesting loss rate increased sharply if MC falls below 20% (Hou et al.2021). As to planting distance, harvesting loss differ in corn plants with row spacing of 50 cm, 60 cm and 70 cm. Corn plants with row spacing of 50 cm revealed higher loss at 12.2%, as compared to 60 cm and 70cm distance with 7.5% and 7.9% harvesting loss, respectively (Wang et al. 2021; Zhang et al. 2009).

Table 1. Factors influencing harvesting losses, System 4, 2019-2020.

Factors	Harvesting loss, %					
	Dry Season		Wet Season		Both	
	Mean	Difference	Mean	Difference	Mean	Difference
Maturity						
Recommended days	1.84		2.61		2.34	
Otherwise	2.64	-0.80^{ns}	2.14	0.47^{ns}	2.33	0.01^{ns}
Moisture content						
Optimum (23-25%)	1.93		1.34		1.49	
Otherwise	2.42	-0.49^{ns}	2.54	-1.207^{ns}	2.50	-1.01*
Presence of weeds						
Yes	2.23		4.35		3.82	
No	2.39	0.16	1.83	-2.52**	2.05	-1.77*
Planting Method						
Manual	2.54		2.16		2.56	
Mechanical Seeder	1.78	0.76^{ns}	3.34	-1.18^{ns}	2.29	0.27^{ns}
Plant distance						
70 x 30 cm	3.97		-		3.97	
65 x 30 cm	2.17	1.80***	2.31	-	2.27	1.70***

***significant at 1% level
** significant at 5% level
* significant at 10% level
ns - not significant

Normally corn combine harvests three rows at a time. Corn plant distance between furrows range from 65cm to 70cm. The recommended distance of furrows is 65 cm apart for farms that use tractors during land preparation. The recommended furrow distance is between 65 cm to 70cm apart for animal drawn plow (CARRDEC 2007). The difference in the harvesting loss of the 65cm distance between furrows versus 70cm distance is highly significant at 1% level. Corn farms having a 65 cm distance between furrows have lower harvesting losses than 70 cm apart in between furrows. This is because the 70 cm furrow distance do not match the combine harvester's header width which measures less than 200 cm wide. Hence, while using a combine harvester at a 70 cm planting distance from each row (total of 210 cm at 3 rows per passing), some of the corn plants of the next or adjacent rows would be accidentally knocked down.

Some of the corn farmers in Isabela and South Cotabato experience delays in planting their crop due to the decreasing availability of planting laborers. As a consequence, farmers resort to using mechanical seeder in planting corn. The adoption of the mechanical corn seeder is gaining popularity in these areas. Harvesting losses of corn combine harvesters were compared in areas that used mechanical seeder as against manually planted corn. The results revealed that harvesting loss in mechanically direct seeded farms incur lower losses than manually planted corn. The use of mechanical seeder in Isabela and South Cotabato resulted in a significant reduction in harvesting loss of 1.20 % and 1.39 %, respectively (Table 2). A mechanical seeder regulates the number of seeds dropped per hill and provides a uniform spacing in between hills as well as distance in between rows (CARRDEC 2007). Thus, harvesting is easier for the corn combine harvester to locate, pick and cut the corn plants that are mechanically planted.

Table 2. Corn combine harvesting losses by planting method, Isabela and South Cotabato, 2019-2020.

Planting method	Harvesting losses, %			
	Isabela (dry season)		South Cotabato (wet season)	
	Mean	Difference	Mean	Difference
Manual	2.98		2.31	
Mechanical seeder	1.78	1.20*	0.92	1.39**

** significant at 5% level
* significant at 10% level
ns - not significant

Shelling loss. Similar to harvesting loss, shelling loss from using corn combine harvester (System 4) is higher than the three other systems. The shelling losses from using combine harvester ranged from 0.30 to 1.11%. The major source of shelling losses came from the separator and blower of the machine.

Statistical tests showed no significant factors were identified influencing shelling losses for Systems 1 to 3. For System 4 wet season, moisture content is a significant factor that influenced shelling loss in combine harvesters (Table 3). The initial moisture of the corn subjected to the corn combine harvester machines have moisture contents (MC) as high as 33%, while the corn subjected to mechanical shellers have MCs that fall within the recommended MC of 18% to 20%. Corn grains having 18% to 20% moisture content are already hard and can resist mechanical damage resulting in less damage to corn kernels during shelling (PCARRD 1990; PNS/BAFS 2018).

Table 3. Factors influencing shelling losses, System 4, 2019-2020.

Factors	Shelling loss, %					
	Dry Season		Wet Season		Both	
	Mean	Difference	Mean	Difference	Mean	Difference
Moisture content						
Optimum (18-20%)	0.60		0.50		0.59	
Otherwise	0.76	-0.16ns	1.33	0.83***	1.05	-0.46ns
Time of operation						
Machine age (new or old)			NOT SIGNIFICANT			
Operators' experience						

***significant at 1% level
** significant at 5% level
* significant at 10% level
ns - not significant

Cost comparison of losses per system. System 4 garnered the lowest expenses at Php9,250.00 per hectare while System 3 incurred the highest expenses at Php13,116.75 per hectare. Bulk of costs for System 3 are attributed to the costs of harvesting laborers which comprise 50% of the total costs. Shortage of laborers are evident in System 3 (4-7 harvesters per day) that is why harvesting days per hectare range from 5-9 days (Tables 4 and 5). The harvesting period maybe further prolonged during inclement weather conditions which may lead to an increase in the number of harvesting days and eventually increasing the harvesting costs. Harvesting operations using a combine harvester may take four hours or half of the day, at most, to finish harvesting a hectare of corn.

Table 4. Harvesting and shelling expenses of corn farmers per postproduction system, both seasons, 2019-2020.

Costs	Postproduction systems, Php/ha			
	System 1	**System 2**	**System 3**	**System 4**
Manual harvesting	4,500.00	5,937.75	6,570.00	-
Meals and snacks	750.00	625.00	1,175.00	200.00
Dehusking and/or shelling fee	3,575.00	1,859.00	1,716.00	-
Shelling laborer	-	1,000.00	-	-
Hauling	900.00	1,752.00	2,190.00	-
Sacks and twine	1,465.75	1,465.75	1,465.75	-
Combine harvester rental fee	-	-	-	8,000.00
Labor costs (picking of fallen CoC from combine)	-	-	-	800.00
Trailer fee (pick up & delivery of combine)	-	-	-	250.00
Total Costs	11,190.75	12,639.50	13,116.75	9,250.00

Average production, shelled wet – 7,126.91 kgs/ha (143 cavans @50kg/cavan)

Table 5. Information used in the computation of harvesting and shelling expenses

Particulars	**Costs (Php)**
Buying price, shelled wet, Php/cavan	10.15
Sacks and twines, Php/cavan	10.15
Meals and snacks, Php/laborer/day	25.00
System 1	
Harvesting, 15 laborers/day	300.00
Dehusking-shelling fee, Php/cavan	25.00
Hauling (farm to shelling area), 3 laborers, Php/laborer	300.00
System 2	
Harvesting, 1:12 bags @ 65 kgs/bag, Php/kg	10.15
Shelling fee, Php/cavan shelled wet	13.00
Shelling labor requirement (4 laborers), Php/laborer	250.00
Hauling (farm to shelling area), 219 cavans corn on cob, Php/cavan	8.00
System 3	
Harvesting, 219 cavans corn on cob, Php/cavan	30.00
Hauling (farm to field drying area), Php/cavan	10.00
Shelling, 143 cavans shelled wet, Php/cavan	12.00
System 4	
Combine harvester rental fee, Php/ha	8,000.00
Labor (picking of fallen corn on cobs), 4 laborers, Php/laborer	200.00
Trailer fee (pick up & delivery of combine)	250.00

Furthermore, the valuation of harvesting and shelling losses revealed that the use of combine harvester (System 4) garnered the highest value for losses. However, treating these losses as added costs to the harvesting and shelling operation showed that the use of combine harvesters is still relatively cheaper, even with the high losses, than the costs incurred by the other systems (Table 6).

Table 6. Value of losses per post production system of corn farmers, both seasons, 2019-2020.

Item	Postproduction Systems			
	System 1	**System 2**	**System 3**	**System 4**
Harvesting and shelling losses, % of total harvest	2.14	2.16	0.65	3.36
Volume of losses, kg/ha	155.85	157.34	46.63	247.79
Value of losses, Php/ha	1,581.89	1,597.00	473.27	2,515.07
Total cost plus losses, Php/ha*	12,772.64	14,236.50	13,590.02	11,765.07

*Total cost (Table 4) plus value of losses

CONCLUSION AND RECOMMENDATIONS

Four (4) harvesting and shelling systems of operation were identified for yellow corn. System 1 practices manual harvesting/picking of unhusked corn ears before mechanically dehusking-shelling the corn. System 2 manually dehusks the corn on cob before separating or cutting the corn on cob from the mother plant. Corn is shelled mechanically. For System 3, the corn is manually harvested similar to System 2. However, the corn on cobs are pre-dried in the field before shelling mechanically. System 4 is with the use of a combine harvester.

Among the four systems, the use of corn combines (System 4) in harvesting and shelling yellow corn produced the highest quantity of losses equivalent to 3.36% of the total harvest, while System 3 produced the lowest losses at 0.65%. Although the losses incurred from corn combine harvester fall within the range of losses set by BAFPS, there is a need for BAFPS to review the performance criteria set for corn combine harvester to be at par or lower than the losses incurred by the existing dehusker-shellers and shelling machines. The moisture content, presence of weeds and planting distance in between rows significantly influence the losses from corn combine. Adoption of a 65 x 30 cm distance in between rows and use of mechanical corn seeder in planting corn can reduce the corn combine harvesting loss.

Although high quantitative losses were revealed when using combine harvester (System 4), the total costs incurred, including the equivalent cost of the losses, are still lower compared to the other postproduction systems. With the high risk of having scarce availability of manual laborers and inclement weather condition during harvest season, the use of combine harvester is a better option in harvesting corn.

With the on-going distribution of corn post production equipment to organized farmers' cooperatives and association (FCA) by the Philippine government as part of modernizing agriculture, simultaneous provision of mechanical corn seeder, combine harvester and its corresponding accessories per FCA should be prioritized. This can greatly help reduce the harvesting and shelling losses, thereby increasing the volume of corn supply in the domestic market.

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