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Strategies adopted by maize farmers to minimize post-harvest losses in Delta State, Nigeria

Ovharhe, O. J.[1]*, Emaziye, P. O.[1], Okpara, O.[3], Agoda, S.[2] and Benson, C. O.[1]

[1]Department of Agricultural Economics and Extension, Delta State University, Asaba Campus, Asaba, Delta State, Nigeria; [2]Nigerian Stored Product Research Institute, Lagos State, Nigeria; [3]Department of Animal Science and Fisheries, Delta State University, Asaba Campus, Asaba, Delta State, Nigeria.

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Abstract The study assessed the strategies which is adopted by maize farmers to minimize post-harvest losses in Delta State, Nigeria. The results showed that major causes of post-harvest losses were inadequate awareness of modern storage facilities ($\bar{x}$ = 3.74). Respondents experienced post-harvest losses on a maximum level at storage structure ($\bar{x}$ = 3.64). It was noticed that there were poor extension activities and visits ($\bar{x}$ = 0 .26) and zero beneficiaries of incentives for storage activities from the government ($\bar{x}$ = 0.00). One of the most effective strategies adopted to minimize post-harvest losses was the use of bags for storage ($\bar{x}$ = 3.06). A high degree of mean constraints was the limited capacity of institutional support to post-harvest activities ($\bar{x}$ = 3.78) and the use of less efficient processing technology ($\bar{x}$ = 3.73). Results revealed that significant relationship ($p<0$) exit among marital status, education and age of respondents and perceived strategies to minimize post-harvest losses among maize farmers. It was concluded among other factors that poor extension activities affected post-harvest management and the sorting of grains was a better strategy adopted to minimize post-harvest losses.

Keywords: Extension, Maize, Post-harvest, Storage

Introduction

Maize (*Zea mays*) is well known as one of the key staple food crops grown in Nigeria. The crop offers the secured sources of income for farmers and the unemployed for contributing to food security issues among various households. In the field production and storage of maize, the major setbacks affecting maize production in Nigeria are lack of control measures against pests and diseases and poor storage facilities. (Abdulaleem *et al.,* 2017). The production of maize worldwide was reached to 785 million tons. The United

* **Corresponding Author**: Ovharhe, O. J.; **Email**: drovharhe.oghenero@gmail.com

States produced 42%; Africa produced 6.5% and Nigeria was the largest African producer close to 8 million tons, after that South Africa (IITA, 2018). The term "post-harvest" refers to the period of crop delivery from harvest time to consumption and location with the slightest loss, optimal efficiency, and expected returns for all stakeholders (Spurgeon, 1976 and Hodges *et al.*, 2011).

Post-harvest handling is a phase of crop production next to harvest, cleaning, selection, packaging and preservation. The moment a crop is harvested from the soil or detached from its parental stock, it commences deterioration. Bourne (1977) reported that post-harvest means after separation from medium and site of immediate growth or production of the food. It starts as soon as the phases of gathering or separating edible food from the farm site. According to Chukwunta (2014), post-harvest begins at the moment of separation of the edible commodity from the plant with the purpose of utilization. Post-harvest losses have been a major issue in the agricultural sector in Nigeria. The three main factors causing post-harvest losses, they are physiological, physical, and environmental factors. Major components of the environmental, physiological and physical factors causing post-harvest losses are high relative humidity and rain, uncontrolled fluctuating temperature, mechanical damage and crop adulteration causing by fungal and bacterial pathogens, inappropriate handling, attacking from birds, rodents, insect and other pests, storage and processing techniques leading to crop perishability (World Bank, 2011).

A considerable amount of work is being carried out in every country on food loss reduction, studies in a reflection of the general global concern over agricultural wastes are declared at the seventh special session of the UN General Assembly in 1975 in which every nation was called upon to strive for a 50% reduction in post-harvest losses by 1985 (FAO, 1975). Maize crop usually grows luxuriantly during the growing period, but it is always discovered that much of the crop does not get to the ultimate consumers probably because of losses they encountered at the post-harvest stage. Food and Agriculture Organization (FAO) and World Bank data revealed that post-harvest losses of cereal in sub-Saharan Africa ranged between 5 to 40 %, worth around $4 billion (Zorya *et al.,* 2011). According to the FAO, 30% of food-producing for human consumption is lost or useless along the supply chain every year. This is a whopping 1.3 billion metric ton of food that did not even reach to the consumers. Some reports have estimated that lost or wasted food could be fed to 1.6 billion people every year (Gustavsson *et al.,* 2011). Post-harvest losses are estimated to be up to 25% per annum in Nigeria (Odigboh, 2004). The major factor acting as a constraint to food and nutrition security is limited food preservation capacity for effective supply. Grolleaud (2004) postulated that

post-harvest loss is more than just food loss for instance when 20% of the harvest is a loss, the actual crop loss is just part of the problem, also waste is 20% of all the factors that contribute to producing the crop, 20% of the land use to grow the food and 20% of the irrigation water, human labour, fertilizers and everything else. In a nutshell, post-harvest losses are a waste of human, material and environmental resources. There are other broader factors such as poor storage amenities, infrastructure and lack of policies that have a direct impact on post-harvest issues.

Several authors have postulated that more supports should be given to post-harvest research and development efforts in developing countries (Bourne, 1983; Mukai, 1987; Okezie, 1998). Kader (2003) opined that support for research on post-harvest losses justifies and compensates the losses, Golleti and Wolff (1999) stated that "while research on the development of agricultural production has gotten substantial responsiveness and funding; until recently, post-harvest projects have not attracted much attention from international donors. They acknowledged the subsequent five reasons to substantiate incremental advancement in post-harvest research by concerned stakeholders: high internal rates of return, international public good character, the effect on poverty, effect on food security and health, and effect on sustainable use of resources. Golleti and Wolff (1999) concluded that: "As the significant contribution of post-harvest research to international visions such as food security and poverty reduction, post-harvest issues become better managed." Thus, embarking on this study, tend to enable farmers to acquire the appropriate skills and techniques for good post-harvest management strategies of crops thereby increasing the quality and quantity of stored crops, seeds viability and availability, and farmers' profits. It will contribute to poverty reduction by enhancing income-generating opportunities for poor people and interested stakeholders. It can also transform the role of the farmer into producer, processor and thus getting more dividends for hard labour.

The consumers will benefit from this study because there will be a supply of large quantity and quality food crops in the market at low prices, as a result of the farmers' improvement on post-harvest management techniques. Also, processed convenience foods will reduce the number of time consumers has to spend in preparing meals. Technologies and innovation have been developed to address the various causes of food losses. Some of these have either not reached the targeted user or have not had the desired result. This is partly because of little or no awareness level of beneficiaries; coupled with affordability due to high prices. It is on this premise that the study is posed to bridge identified gaps and access information on the current management post-

harvest strategies employed by maize farmers in Delta State and proffer interventional measures where necessary.

Maize varieties are primarily distinguished by the type of endosperm and grain colour (Anyanwu *et al.,* 1979), maize can be classified based on the endosperm characteristics as follows:

Dent Corn (*Z. mays indentata*): The most widely of colour, some are yellow or white in most commercial varieties. Dent type is high in lysine content with an essential amino acid. Flint Corn (*Z. mays indirata*): The endosperm is usually soft and starchy in the centre, but enclosed by a corneous out layer. It is widely grown in California. Floury Corn (*Z. mays anylacea*): This has a very thin pericarp and a large amount of white starchy endosperm which is soft. This type is very susceptible to weevil attack. Pop Corn (*Z. mays truricala*): The kernel is enclosed in a pod of husk. The typical podded ear will never have bred true. Sweet Corn (*Z. mays sacchorata*): In this case instead of all starch granules, we have sugary granules with very little starch granules, this type wrinkle on drying. In West Africa, various varieties that are resistant to maize rust and adaptable to local conditions. In Nigeria, such varieties include NSI, Harti, Tsola and various Mexican varieties (Anyanwu *et al.,* 1979).

Aside from various types of food, maize is useful as medicines and raw materials for industries. Medicinally, maize is an effective anti-oxidant that guides the body from harm by free radicals responsible for cellular damage. It has the ability to ameliorate pain and it possesses analgesic activity as well. Owoyele *et al.* (2010) confirm that maize helps produce and make good sex relate hormones for sexual health especially for men with erectile dysfunctions. Corn silk contains potassium majorly which helps to increase the rate of urine excretion (diuretic). Corn silk is also used to conquer urinary tract infections and kidney stones (Lans, 2006). Corn silk also helps to support liver functioning, producing bile as well as improve blood pressure. It helps to mollify ulcer, wound and swelling. In some cases, the extraction of corn silk and dried corn is extremely useful in nausea and vomiting. To ease stomach upset, maize roots, leaves, and corn silk as decoction are used. Also, the concoction of maize cob is used as a tea.

Economically, its starch is well recognized for its uses in the cosmetic and pharmaceutical industries as diluents. It contains oil-rich in the embryo which is used for the manufacture of soap and cooking. Corn seeds are utilitarian in making alcohol and stem fibers for the manufacture of paper. Maize contains some glutinous substance known as dextrin used for sealing envelopes and labels.

According to Atanda *et al.* (1998), post-harvest losses occur on plant produce or plant products at the moment of separation of the edible commodity

from the parent plant. This occurs during harvesting, processing, grading, packaging, transportation, and storage. Elements of a post-harvest system according to Grolleaud (2004) are: harvesting, preharvest drying, transport, post-harvest drying, threshing, processing and marketing. Harvest time is known by the level of maturity. World Resources Institute (1998) stated that post-harvest loss is measurable in either quality or quantity foodstuffs reduction.

Post-harvest losses are caused by diseases, insects, rodents, fire, floods, pilferage, spillage, floods, spoilage, shelling damage, rain and sun among others. Post-harvest losses are important as it affects the quantity, quality and toxicity of plant products. The strategies for reducing post-harvest losses otherwise known as post-harvest management techniques or technology. While developing post-harvest technologies, a multidimensional and interdisciplinary approach is needed which includes scientific creativity, technological innovations and commercial entrepreneurship and stakeholders' inputs Chukwunta (2014). To minimize post-harvest losses and enhance storability in homes there are needs for increased knowledge levels in preservation with low-cost technology, use of thermal processing, low temperature, drying, chemical and biological reactions couple with other preservation techniques should be applied to crops. Also to minimize mechanical or physical injury in grains such as bruises, punctures, scratches, harvesting should be carried out carefully and this should be done when the crop is in its mature green state Atanda *et al.* (2011). Ulysses *et al.* (1992) also postulated that handling of maize grain should be carefully carried out since mechanical injury provides sites for insect attack and increases physiological losses. Bruising renders products unsaleable to customers even if it has minor effects on the nutritional value.

In handling, farmers must transfer immediately harvested crops to a well-ventilated, clean and cool shed. It is essential that they clean, and sort out damaged grains from undamaged that is, the whole crop from bruised before transferring into transport containers. Vehicles that are well ventilated, clean and covered should be used for transportation and should be driven with care over a smooth road to minimize loss of crops harvested. The use of a storage facility is essential in minimizing post-harvest loss, but only crops or grains having high initial quality can be successfully stored. Only crops of high quality (undamaged and matured) must be stored. Shewfelt (1986). Nigerian Stored Product Research Institute (1982) stated that for domestic storage of grain, use hermetic (airtight) containers, store only dried grains and use plastic only in rodent-free areas. This allows all-year-round storage. Also for commercial purpose use Inert Atmosphere Silos, which is ideal for bulk storage of grains and strategic reserve and do not require the use of pesticides. The use

of Improved Ventilated Crib for storing un-threshed grain acts as a storage and drying chamber and prevents rodent entry through the type of material used. However, maize losses could be minimized by observing the following improved methods and practices; harvesting the grain when it attains maturity, using proper tools and equipment for harvesting. The main global post-harvest challenge is how to ensure food security for the world's ever-increasing population while ensuring long term sustainable development. Farmers experience a lot of challenges during post-harvest some of which are: lack of awareness and skill, limited infrastructures for production and post-harvest, inadequate transportation facilities, insufficient and ineffective storage facilities, use of less efficient processing technologies, inadequate market systems, lack of availability of improving technologies (awareness, availability and affordability), uncoordinated and fragmented efforts in research, education, and extension, limited and no institutional capacity in support of post-harvest activities.

In the management of post-harvest losses in maize production and ensuring the sustainability of maize farming, it is worthwhile to consider the processes leading the post-harvest losses in the business. The nexus of the field-to-store phenomenon in maize production and post-harvest management (Figure 1) reveals that good management practices tend to production increase; making available future planting materials and robust income profitability and *vice versa*. The study was guided by the following research questions: What are the socio-economic characteristic of maize farmers? Are there post-harvest losses in maize production? Then, what are the causes? How do we assess extension activities on post-harvest management? Which techniques are involved in post-harvest losses management and what are the Constraints of post-harvest losses management?

The study was set to achieve the following specific objectives to describe the socio-economic characteristic of maize farmers, identify the causes of post-harvest losses in maize production, ascertain the level of post-harvest losses, assess extension activities on post-harvest management, identify the perceived strategies to minimize post-harvest losses and determine the constraints of post-harvest losses management.

Materials and methods

The method employed to achieve the objectives of the study is discussed under the following headings: study area, method of data collection, sampling procedures, sample size, measurement of variables and the data analysis. The study was carried out in Ughelli North Local Government Area (LGA) of Delta

State. Ughelli North LGA constitutes one of the twenty-five (25) local government areas of Delta State. Its coordinates are 5°30'N 5°59'E / 5°500'N 5°983'E of the equator. Ughelli North LGA is physically located between Isoko North and Ughelli South Local Government Areas. This Local Government Area comprises various villages and towns which are divided into seven (7) clans namely, Ughelli, Agbarha, Ogor, Ewreni, Owheru Agbarho and Orogun clans. Major crops cultivated include maize, cassava, plantain, banana, vegetables and plantain.

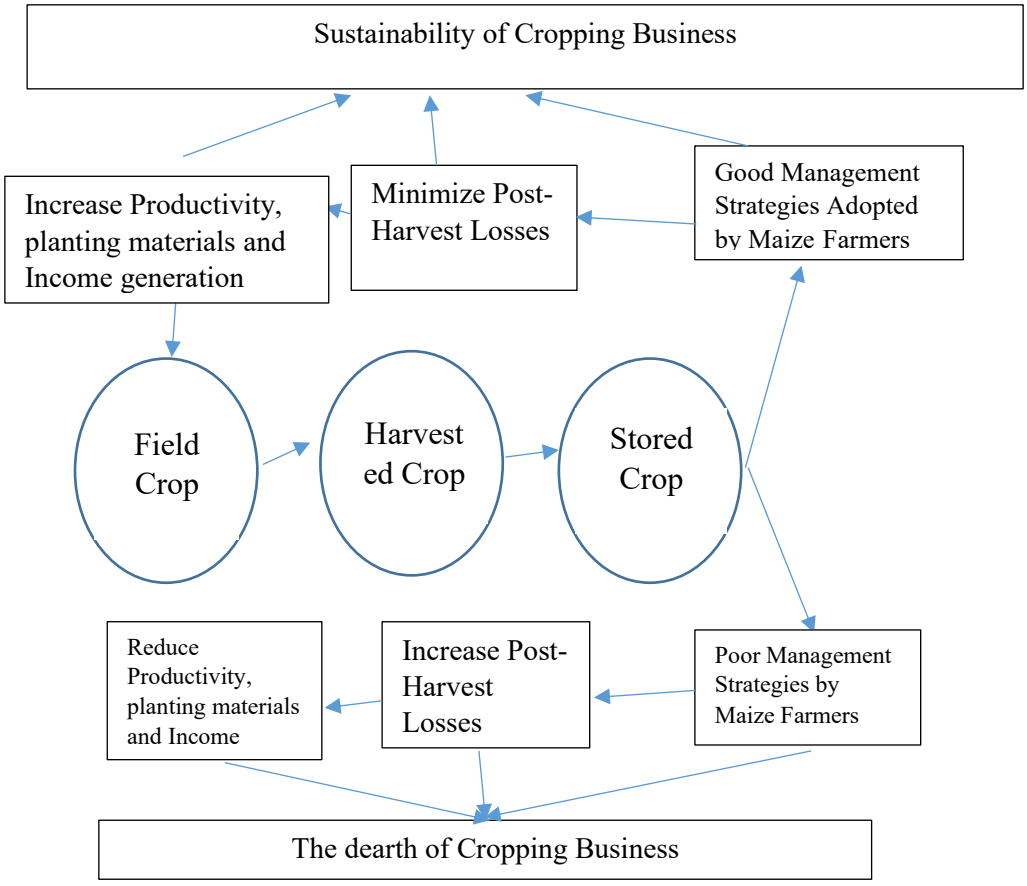

Figure 1. Perceived strategies by maize farmers post- harvest losses

A two-stage sampling procedure was used for sample size determination. The sample frame was gotten from the Delta Agricultural and Rural Development Authority (DARDA), formerly known as the Agricultural Development Project (ADP).

Stage 1: Simple random sampling of four (4) out of the seven (7) clans in the study area
Stage 2: Simple random sampling will be used in the selection of twenty (25) respondents from each of the selected four (4) clans. This brings the total number of useful respondents to eighty-five (85) respondents as sample size. Primary data and secondary data was used for this study. The primary data were collected using a structured questionnaire, containing the following sections:

a. Socioeconomic characteristics of respondents e.g. sex, age, marital status, household size, farming practice, farm size, cropping pattern, types of maize variety cultivated, sources of labour, source of finance, etc.
b. Causal factors of post-harvest loss
c. Level of post-harvest loss
d. Extension activities on post-harvest loss management
e. Challenges encountered during post-harvest
f. Management strategies adopted to minimize post-harvest losses and the level of improvement given by those management strategies.

While secondary information was collected from published articles, journals and books. The causes of post-harvest losses were measured using a rating scale. A Likert-type scale was used to measure the causes of post-harvest loss. Various statements indicating the causes of post-harvest loss were associated with the following responses: Strongly Agree (4), Agree (3), Strongly Disagree (2) and Disagree (1). The various statements indicating the various causes of post-harvest loss are shown in Table 1. With a cut-off point of 2.5 (4 + 3 + 2 + 1 = 10 and 10/4 = 2.5). Agricultural extension activities were measured by compiling a list of items to curb post-harvest losses and farmers were asked to indicate 'yes' or 'no' they have been beneficiaries of extension activities. A weight of zero (0) and one (1) was assigned to 'no' and 'yes' respondents respectively. Thus, having a cut-off value of 0.5 (0 + 1 = 1 and ½ = 0.5) for decision making. The perceived strategies to minimize post-harvest losses concerning the project objectives were measured using a Likert – type scale was used to measure the strategies used for reducing post-harvest loss. Various statements indicating the various strategies used for post-harvest loss reduction was associated with the following responses: Strongly Agree (4), Agree (3), Strongly Disagree, (2) Disagree (1). A cut-off point of 2.5 was generated to make a decision.

Major challenges of post-harvest losses management were measured using a Likert-type scale, to gauge each of the challenges, they are Lack of awareness and skill, limited infrastructures for production and post-harvest, inadequate transportation facilities, insufficient and ineffective storage facilities, use of less

efficient processing technologies, inadequate market systems, lack of availability of improving technologies (availability, affordability, awareness), uncoordinated and fragmented efforts in research, education, and extension, limited and no institutional capacity in support of post-harvest activities, the problem of logistic; a score of (4) most serious, (3) serious, (2) less serious, (1) not serious. Similarly, a cut-off point of 2.5 was produced for decision making. Data were analyzed using the Statistical Package for Social Sciences (SPSS). Both descriptive and inferential statistics were used for the analysis of the data generated. Descriptive statistics included frequency counts, means and percentages.

Hypothesis

The test of Hypothesis was done using chi-square

Ho: There is no relationship between perceived strategies to minimize post-harvest losses and some given socioeconomics characteristics of maize farmers. The model is shown as follows;

$$\chi^2 = \frac{\sum(Fo - Fe)^2}{fe}$$

Where;
Fo = Observed frequency
Fe = Expected frequency

$$Fe = \frac{RT \times GT}{GT}$$

Where;
RT = Row Total
CT = Column Total
GT = Grand Total

Results

Socio-economic characteristics of maize farmers

The socio-economic characteristics of maize farmers into processing and storage of maize were considered under the following subheadings: sex, marital status, age, religion, educational level, farming experience, household size, farm size, and the type of storage method used. The result (Table 1) revealed that all respondents were of age range 25-84years; this implies that the majority are adults who are in their economic active age group. The average age of respondents is 41.50years (about 42years). Most of the respondents were female (60%) implying that maize processing and storage were female-dominated in the study area and respondents were mostly married (85.9%). On

the educational level, it was found that the majority (34.1%) of respondents had secondary education, others 23.5% had ND/NCE, 21.2% had HND/BSc, 9.4% had primary education, 8.2% no formal education and 2.4% went through postgraduate level.

Table 1. Respondents according to socio - economics characteristics (n = 85)

Characteristics	Frequency	Percentage	Mean/Mode
Age(years)			
25 – 34	10	11.8	
35 – 44	47	55.3	
45 – 54	19	22.4	41.50
55 – 64	7	8.2	
65 – 74	1	1.2	
75 – 84	1	1.2	
Sex			
Male	34	40.00	
Female	51	60.00	Female
Marital status			
Single	5	5.9	
Married	73	85.9	Married
Single again	7	8.2	
Educational level			
No formal education	7	8.2	
Primary school	8	9.4	
Secondary	29	34.1	Secondary
ND/NCE	20	23.5	
HND/BSc	18	21.2	
Postgraduate	2	2.4	
Household size			
3.00	4	4.7	
4.00	11	12.9	
5.00	17	20.0	
6.00	27	31.8	6
7.00	18	21.2	
8.00	5	5.9	
9.00	2	2.4	
11.00	1	1.2	
Types of storage			
Traditional	80	94.1	Traditional
Modern	5	5.9	

Source: Field Survey, 2019

The mean farming experience was 11.5 years (about 12years), 2.2 ha was the mean farm size possessed by respondents. Again, the study clarified the fact that maize farmers constituted 68% of adult farmers' participation in typically grown arable crops of which (94.1%) practice the traditional storage method.

Causes of post-harvest losses

Result showed that the causes of post-harvest losses including inadequate awareness on modern storage facilities was recorded as the major cause ($\bar{x}$ = 3.74), lack of modern farm machineries infrastructure and equipment ($\bar{x}$ = 3.73), inadequate processing techniques was equally recorded ($\bar{x}$ = 3.67), inappropriate transportation facilities ($\bar{x}$ = 3.09), lack of storage facilities ($\bar{x}$ = 3.07), effects of government policies ($\bar{x}$ = 2.93), bumper harvest occurrence ($\bar{x}$ = 2.76), delayed harvest ($\bar{x}$ = 2.31), distance from farm to market ($\bar{x}$ = 2.21), daily harvest was recorded with the lowest mean of ($\bar{x}$ = 2.11) as shown in Table 2.

Table 2. Respondents according to causes of post-harvest losses (n = 85)

Causes	Strongly agree(4)	Agree (3)	Disagree (2)	Strongly disagree (1)	Mean
Inadequate awareness of modern storage facilities	72	7	3	3	3.74
Lack of modern farm machinery infrastructure and equipment	67	13	5	0	3.73
Inadequate processing techniques	64	18	1	2	3.69
Long-distance from farm to market	67	11	3	4	3.67
Inappropriate transportation facilities	11	71	3	0	3.09
Lack of storage facilities	9	74	1	1	3.07
Government policies also cause post-harvest loss resulting in food loss	7	69	5	4	2.93
Delayed harvest can cause post-harvest loss.	3	64	13	5	2.76
Daily harvest can cause post-harvest loss	1	11	69	4	2.11

Source: Field Survey, 2019. A cut-off point ≥ 2.5 implies a high level of causes.

Level of post-harvest losses

Result showed that the maize farmers experienced losses on a maximum level at storage structure ($\bar{x}$ = 3.64), during processing ($\bar{x}$ = 3.05), upon pest attack ($\bar{x}$ = 2.91) during transportation to the market ($\bar{x}$ = 2.88), at packaging ($\bar{x}$

= 2.85) and during harvesting ($\bar{x}$ = 2.81) respectively. On the contrary, maize farmers witnessed low losses as a result of Poaching ($\bar{x}$ = 2.11), fluctuation of stored room temperature/humidity ($\bar{x}$ = 1.95) and at flood incidence ($\bar{x}$ = 1.83) as shown in Table 3.

Table 3. Respondents according to the level of post-harvest losses (n = 85)

Level of Postharvest Losses	Very Often (4)	Often (3)	Not Often (2)	Not at all (1)	Mean
Losses at storage structure	64	13	7	1	3.64
Losses during processing	51	11	15	8	3.05
Losses upon pest attack	8	65	8	4	2.91
Losses at transportation to the market	4	70	8	3	2.88
Losses at packaging	2	70	11	2	2.85
Losses during harvesting	2	69	10	4	2.81
Losses upon Poaching	2	74	7	2	2.11
Losses at flood	5	8	40	32	1.83

Source: Field Survey, 2019. A cut-off point ≥ 2.5 implies a high level of losses.

Extension Activities on post-harvest loss management

Result showed that respondents experienced poor extension activities that were carried out on post-harvest losses management they range from extension visits ($\bar{x}$ = 0 .26), or Practical display of storage and processing techniques to farmers ($\bar{x}$ = 0.14) to ineffective as in the training of farmers on storage techniques ($\bar{x}$ = 0.04) as seen in Table 4. The most striking was that there was no beneficiary of incentives for storage activities from the government ($\bar{x}$ = 0.00).

Table 4. Respondents according to extension activities (n = 85)

Extension activities	Yes (1)	No (0)	Mean
Have you been visited by an extension agent?	22	63	0.26
Practical display of storage and processing techniques to farmers.	12	73	0.14
Proper information dissemination to farmers on post-harvest loss technologies.	11	74	0.13
Have you established a demo-plot before contact with the extension agent?	8	77	0.09
Were there conducts of project monitoring and evaluation in your locality?	6	79	0.07
Have you undergone any training in the storage of maize anywhere?	3	82	0.04
Have you been a beneficiary of incentives for storage activities from the government?	0	85	0.00

Source: Field Survey, 2019. A cut-off point ≥ 0.5 implies a high level of extension practices.

Perceived strategies adopted to minimize post-harvest losses

The perceived strategies that respondents adopted to minimize post-harvest losses concerning more effective strategies ($\bar{x} \geq 2.5$) including sorting of grains by separation of good from bad ones ($\bar{x}$ = 3.79), use of bags for storage ($\bar{x}$ = 3.06), farm house storage practice ($\bar{x}$ = 3.05), quick maize-grain processing ($\bar{x}$ = 3.00), carrying out harvesting to minimize mechanical injuries ($\bar{x}$ = 2.96), use of 'Okporo'[traditional earthen container] for storage ($\bar{x}$ = 2.89), conduct of sun-dry and store in cool places ($\bar{x}$ = 2.87) and conduct of smoke drying ($\bar{x}$ = 2.80) as shown in Table 5. Other less operative strategies ($\bar{x} < 2.5$) were use of metallic containers for storage ($\bar{x}$ = 2.35), well-designed vehicle for transporting maize grains ($\bar{x}$ = 2.04) use of improved ventilated crib for storage ($\bar{x}$ = 1.96) demonstration of best practices on post-harvest management ($\bar{x}$ = 1.65) fumigation before storage ($\bar{x}$ = 1.54) and use of modern silos for storage ($\bar{x}$ = 1.07).

Table 5. Respondents' perception of strategies adopted to minimize post-harvest losses

Strategies	Strongly agree (4)	Agree (3)	Disagree (2)	Strongly disagree (1)	Mean
Sorting of maize grains	71	11	2	1	3.79
Use of bags for storage	10	70	5	0	3.06
Farmhouse storage practice	13	65	5	2	3.05
Quick maize grain processing	12	63	8	2	3.00
Carrying out early harvesting to minimize mechanical injuries	5	73	6	1	2.96
Use of 'Okporo' for storage	9	61	12	3	2.89
Conduct of sun-dry and store in cool places	3	70	10	2	2.87
Conduct of smoke drying	2	70	7	6	2.80
Use of metallic containers for storage	6	19	59	1	2.35
Well-designed vehicle for transporting maize grains	7	8	51	19	2.04
Use of improved ventilated crib for storage	0	7	68	10	1.96
Demonstration of best practices on post-harvest management	8	15	1	61	1.65
Fumigation before storage	1	11	21	52	1.54
Use of modern silos for storage	0	0	6	79	1.07

Source: Field Survey, 2019. A cut-off point ≥ 2.5 implies a high level of strategies.

Constraints of post-harvest management by farmers

The constraints faced by maize farmers in post-harvest management in the study area as shown in Table 6. It was observed that a very high degree of mean constraint ($\bar{x} \geq 2.5$) existed in limited capacity of institutional support to post-harvest activities ($\bar{x}$ = 3.78), follow by use of less efficient processing technology ($\bar{x}$ = 3.73), deficiency of functional farmers association to encourage value addition ($\bar{x}$ = 3.73) poor awareness and skill in post-harvest technologies ($\bar{x}$ = 3.13) insufficient and ineffective storage facilities ($\bar{x}$ = 3.11) shortage of improve technologies ($\bar{x}$ = 3.09) availability of post-harvest technologies at an affordable prices ($\bar{x}$ = 3.02) and ignorance of policy to encourage value addition to agricultural produce ($\bar{x}$ = 2.96) accordingly. However, two situations ($\bar{x} < 2.5$) of inadequate marketing system ($\bar{x}$ = 1.56) and inadequate transportation facilities ($\bar{x}$ = 1.54) were seen as less serious constraints.

Table 6. Respondents according to constraints of post-harvest losses management (n = 85)

Constraints of Post-Harvest	Most Serious (4)	Serious (3)	Less Serious (2)	Not Serious (1)	Mean
The limited capacity of institutional support to post-harvest activities	73	7	3	2	3.78
Use of less efficient processing technologies	68	14	3	0	3.73
Deficiency of functional farmers association to encourage value addition	66	15	4	0	3.73
Poor awareness and skill in post-harvest technologies	12	72	1	0	3.13
Insufficient and ineffective storage facilities	15	66	2	2	3.11
Shortage of improving technologies	11	71	3	0	3.09
Availability of post-harvest technologies at affordable prices.	8	72	4	1	3.02
Ignorance of policy to encourage value addition to agricultural produce	6	71	7	1	2.96
Inadequate marketing system	5	14	5	61	1.56
Inadequate transportation facilities	7	10	5	63	1.54

Source: Field Survey, 2019. A cut-off point ≥ 2.5 implies a high level of constraints.

Test of hypothesis

For this study, the hypothesis stated that:

Ho: There is no relationship between perceived strategies to minimize post-harvest losses and some given socioeconomics characteristics of maize farmers.

The results of the hypothesis are displayed in Tables 7, 8 and 9. There were significant relationships between marital status and perceived strategies to minimize post-harvest losses among maize farmers where ($p<0.01$). This implies that married respondents carry out more strategies to minimize post-harvest losses in the practical display of sorting of maize (0.01) and quick grain processing (0.00). Similarly, it was observed that there were significant relationships between educational status and perceived strategies to minimize post-harvest losses among maize farmers where ($p<0.01$). This suggests that respondents with higher educational levels were exposed to carrying out early harvesting to minimize mechanical injuries (0.04) and demonstration of best practices on post-harvest management (0.00) perform better in storage management activities than other farmers. There were significant relationships between age and perceived strategies to minimize post-harvest losses among maize farmers where ($p<0.01$). This implies that adults who are in their economic active age group carry out more strategies to minimize post- harvest by quick processing of harvested maize grain (0.000). Other parameters which do not have positive significance with the age of farmers are the use of a well-designed vehicle for transporting maize grains (0.017), use of an improved ventilated crib for storage (0.022) and fumigation before storage (0.022).

Table 7. Relationship between perceived strategies to minimize post-harvest losses and marital status of the farmer

S/N	Parameter	Values	Df	Significant level
1	Sorting of maize grains	9.282	2	0.010*
2	Quick maize grain processing	18.500	2	0.000*
3	Use of improved ventilated crib for storage	9.079	2	0.011
4	Use of modern silos for storage	9.079	2	0.011

*Significant @ 1%

Table 8. Relationship between perceived strategies to minimize post-harvest losses and the educational status of the farmer

S/N	Parameter	Values	Df	Significant level
1	Carrying out early harvesting to minimize mechanical injuries	18.952	6	0.004*
2	Demonstration of best practices on post-harvest management	29.848	6	0.000*

*Significant @ 1%

Table 9. Relationship between perceived strategies to minimize post-harvest losses and age of a farmer

S/N	Parameter	Values	Df	Significant level
1	Well-designed vehicle for transporting maize grains	13.862	5	0.017
2	Use of improved ventilated crib for storage	13.124	5	0.022
3	Fumigation before storage	13.124	5	0.022
4	Quick maize grain processing	24.021	5	0.000*

*Significant @ 1%

Discussion

Socio-economic characteristics of respondents

On average age of respondents is in tandem with the findings of Agoda *et al.* (2011) who observed that women of 40 years on the average were major stakeholders in the provision of food. While on education and household size. Ovharhe (2017, 2019) asserted that the majority of farmers in the Niger Delta area of Nigeria attained secondary education level and attained approximately 5 persons per household which were in agreement with the findings of the study. Ovharhe (2016) ascertained that maize farmers in Delta State possessed an average of two hectares for farming with an average farming experience of ten years. The study confirmed the results of Ovharhe, Alakpa and Iteku (2018) that adult men and women are interested in maize farming. On storage techniques, Bamishaiye *et al.* (2011) and Agoda *et al.* (2011) remarked that most farmers practice traditional storage methods like storing maize over fireplaces, packing grains in containers, sacks and baskets. The implication is that the vast majority of farmers, in the study area, are not exposed to modern storage facilities and technologies. This is a setback factor for modern post-harvest techniques.

Causes and levels of post-harvest losses

The works of Agoda *et al.* (2011), Chukwunta (2014) and Olayemi *et al.* (2010) confirmed that improper drying, poor storage structure, improper handling during harvesting and processing, inappropriately designed and cracked storage material results in mechanical injuries which in turn causes deterioration in storage processes. While the levels of post-harvest losses were agreeable with the findings of Kitinijola and Gorny (2002), Ray and Ravi (2005), Watkins and Anubha (2007) that 40% to 50% of crops produced in developing countries are lost before they are consumed mainly because of the high rate of bruising, subsequent decay during handling. The story is not different from Delta State maize farmers.

Extension activities on post-harvest loss management

The poor government extension workers support for farmers on post-harvest management. However, the little assistance to the farmer on information dissemination concerning post-harvest loss technologies through extension service department of Nigerian stored product research institute (NSPRI) was documented according to the findings of Agoda (2005) and that they practically demonstrate storage techniques of maize to farmers and construction demonstration cribs to farmers. This is commendable.

Perceived strategies adopted to minimize post-harvest losses

Many techniques in handling post-harvest of maize as demonstrated by respondents revealed that some practices like sun- drying, storing in jars/tins, baskets, containers, grading and sorting before packing or preserving grains are by Bamishaiye *et al*. (2011) and Chukwunta (2014). Again, that farmers use the traditional method of storage such as storing over fireplaces, sacks and containers which they consider effective to manage post-harvest losses. This is also in conformity with Olayemi *et al.* (2010) in his research that says farmers use traditional basket and sacks as packaging material in conveying produce. The findings affirmed Ovharhe (2016) that the early processing of maize grains is one of the strategies to combat post-harvest losses in maize farming.

Constraints of post-harvest management by farmers

Some constraints of the findings were in accordance with the study of Olayemi *et al.* (2010) which shows that lack of efficient processing techniques,

ineffective storage facilities are the major constraints facing post-harvest management and consequently result in losses in crop production status. A Pearson Chi-square was used to analyze the hypothesis and it was revealed that there was no relationship between perceived strategies to minimize post-harvest losses and some given socioeconomics characteristics such as sex and household sizes hence they were thus not analyzed. However marital status, education and age of respondents provided some useful statistical information tending to a positive relationship. Some of these hypotheses results are following the findings of researchers such as demonstration of best practices on post-harvest management (Agoda, 2005), sorting of maize grains (Chukwunta, 2014), and quick maize grain processing (Ovharhe, 2016). They agreed that these practices have been adopted by farmers in the management of post-harvest losses in maize production.

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