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Postharvest Practices among Grain Farmers in Oyo State, Nigeria

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ABSTRACT

The need for adequate postharvest crop management has come to the fore in sub-Saharan Africa. A survey was conducted in ten farm settlements in Oyo state, Nigeria, where 400 farmers were interviewed. Respondents were predominantly males (82%), and about 33% did not undergo any formal education. About 39% reported hardly ever seeing agricultural extension agents coming to train them on mitigation of postharvest losses, while 87% of the farmers agreed that they experience significant postharvest losses. Observations revealed a low level of postharvest mechanization, while storage structures and processing equipment installed at the inception of the settlements were in a state of disrepair. Maize threshers were found in all settlements however, blowers, dryers and modern storage facilities which would ensure that grains are processed and stored properly were unavailable. Inability to effectively stop insect damage to stored grains makes over 80% of the farmers to apply unapproved chemicals such as DD–Force (Dichlorvos as active ingredient) on harvested crops despite the threat to human health. Moreover, about 60% of the farmers surveyed were unaware of aflatoxin related issues. An obvious gap in information dissemination to farmers in hard-to-reach locations must be eradicated if sub-Saharan Africa will achieve food security.

Keywords: Farm settlement, postharvest losses, mechanization, aflatoxin, storage structures, Nigeria

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1 Introduction

Recent estimates indicate that food production will need to grow by 70% in order to feed the world population which is projected to reach about 9.725 billion by 2050 (Victor, 2014; FAOSTAT, 2015). However, postharvest losses constitute a threat to attaining global food security (Sawicka, 2019). These food losses refer to the decrease in edible food mass throughout the supply chain that specifically leads to reduction in available food for human consumption (Rockefeller Foundation, 2015). As the human population grows, food demand increases, and there is need for adequate, substantial and sustainable sources of food and practicable methods for food preservation (Adejumo, 2012).

Agriculture is a major sector of many economies including Nigeria where it contributes more than 30% of the total annual Gross Domestic Product (GDP) and over 70% of the non-oil exports (Olayemi et al., 2012). In Nigeria, cereals play an important role in the agricultural sector, accounting for 55–60% of subsistent farmers' output and it forms the main diet for individuals and families in rural and urban areas (Tahir, 2014). In Nigeria, about 6 million hectares is cultivated annually for maize production and a yield of about 1.7 metric tons per hectare is produced (FAOSTAT, 2015). In 2013, rice production in Nigeria accounted for about 1.1 million metric tons (Nwalieji et al., 2016) while Nigeria produces over 2.24 million metric tons of Sorghum in about 2.52 million hectares (Singh et al., 2013). Major reasons for food loss are ineffectiveness and inefficiencies of management practices in the food value chain (Tadesse et al., 2015). By making food supply chain efficient and effective, half of the food losses can be prevented thereby reducing the population of people without food (Kummu et al., 2012). A boost in grain availability may therefore be attained with diligent effort towards good handling practices across each stage of the postharvest value chain.

Postharvest loss is a measurable quantitative and qualitative loss of produce, occurring between the beginning and completion of harvesting, till the period of human consumption (FAO, 1994, Sawicka, 2019). Methodologies for estimating postharvest losses are focused at providing an estimate of the quantitative losses occurring after production (FAO, 1992, Verma *et. al*, 2019, Sugri *et. al*, 2021). Adejumo and Raji (2007) reported that these losses are experienced during postharvest activities mainly in crops such as maize, rice, sorghum, millet, cowpea, groundnut, soya beans, yam, cassava, plantain and fruits in many developing countries particularly in Africa. Proper postharvest handling operations have important roles to play in ensuring availability of grains and other crops since agricultural production is seasonal while the demand for agricultural commodities is daily (Adejumo, 2012, Manandhar *et. al*, 2018, Njoroge *et. al*, 2019).

Biological factors that cause substantial amount of losses to harvested produce are insects, rodents and birds as they consume grains directly at pre-harvest or postharvest periods (Igbeka, 2013). Their activities result in both quantitative and qualitative losses — through consumption, excreta deposits, webbing, frass and unpleasant odours that they impart to grains (Heike, 2013). Insect pest damage may occur due to cross infestation from neighboring habitats, migration from hiding places in stores, use of infested bags and introduction of infested commodity (Odeyemi and Daramola, 2000). Aside biological factors, temperature is one of the most important environmental factors to be considered in storage (Rajapaksha *et. al.*, 2021). It has a significant effect on insect growth and development as the optimum temperature for reproduction is about 26°C (Sergio, 2010). Dried grains need to be stored under conditions of low humidity in order to avoid absorbing moisture to the point where mold growth occurs. The social factor in grain loss is predominately caused by human tradition — individual attitudes and beliefs in a society, theft, improper handling and spillage (Igbeka, 2013).

At the storage stage, access to storage technology remains one of the most challenging issues throughout the postharvest value chain. Some engineering factors that affect postharvest losses include drying facilities and storage structures, types and efficiency of harvesting tools, and use of appropriate equipment and machines (Folayan, 2013). These factors can directly or indirectly result in increased vulnerability to infestation by pests, fungi and rodents leading to losses in grain quality. Devastating pests such as the large grain borer can cause up to 30% dry weight loss in about 6 months of storage (Boxall, 2002; Golob, 2002).

Tadessse et al. (2015) reported that there is no universally agreed method for food loss assessment that accurately illustrates measuring food losses for various food types in all situations. However, Hodges et al. (2011) reported that there are two major approaches to measure/estimate food losses. First, is the actual measurement of quantity or quality losses in food chains while the second is the use of questionnaires to indicate peoples subjective estimated losses based on their experiences within the food chain. Postharvest handling and practices associated with postharvest losses vary across different farm environments in Nigeria. Some of these practices pose significant threats to food security, human health and the environment. A first–hand information on how smallholder farmers carry out postharvest practices and operations necessitated the investigation into this study. This study therefore made use of questionnaires and field observation to investigate the postharvest practices among grain farmers in Oyo State, Nigeria**.**

2 Methodology

This study was designed to collect information from grain farmers in ten farm settlements in Oyo State, Nigeria in order to evaluate postharvest handling and practices.

2.1 Study Location

The ten farm settlements which were surveyed in nine local government areas (LGAs) were Akufo, Ido LGA (07º 27.73' N, 003º 49.35' E); Agunrege, Atisbo LGA (08º 17.49' N, 003º 24.94' E); Eruwa, Ibarapa East LGA (07º 30.44' N, 003º 26.12' E); Ijaye, Akinyele LGA (07º 42.13 N, 003º 44.10' E); Ilora, Afijio LGA (07º 44.40' N, 003º 48.21' E); Iresaadu, Ogbomosho North LGA (08º 02.12' N, 004º 12.21' E); Ipapo, Iseyin LGA (07º 57.47' N, 003º 32.18' E); Ogbomosho, Ogbomosho South LGA (04º 07.25' N, 08º 03.45' E) and Olosun, Akinyele LGA (07º 38.71' N, 003º 42.34' E) and Olowa, Ido LGA (07º 23.31' N, 03º 21.03' E) as shown in Fig. 1. The global positioning system (GPS) locations of the farm settlements were recorded using a "Garmin eTrex10" device. and the land mass of the farm settlements are shown in Table 1. Each settlement comprises 45–100 lead-farmers who employ other farmers and labourers. The survey covered the periods from July 2016 to September 2017. However, return visits were made to some of the settlements (*Akufo, Eruwa, Ijaye, Ilora* and *Olosun*) for additional data collection between January and March 2018.

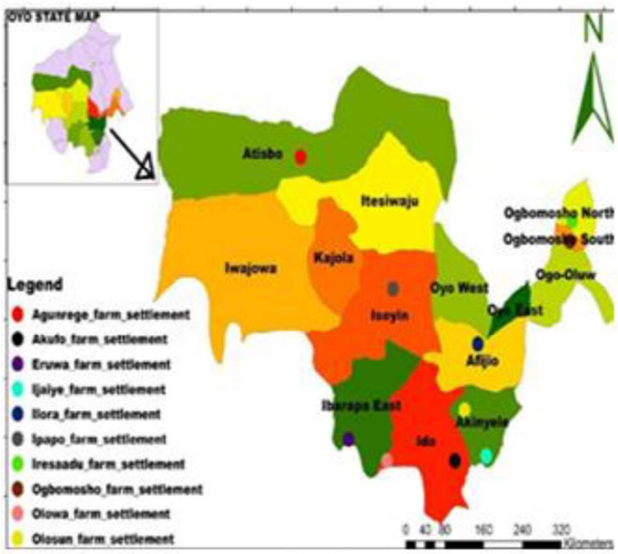

Figure 1. Map of Oyo State showing the location of the farm settlements

Table 1. Locations and land mass of the study areas in Oyo State

S/N	Farm settlement	Land mass (ha)
1	Akufo	820
2	Agunrege	3000
3	Eruwa	3067
4	Ijaye	5072
5	Ilora	3330
6	Iresaadu	262
7	Ipapo	2040
8	Ogbomosho	2428
9	Olosun	1236
10	Olowa	3306

2.2 Experimental Design

A questionnaire was designed to gather information like demographic data, farm environment, harvesting and drying activities, postharvest losses, sanitation and occupational safety, and operational challenges from farmers. The demographic data section contained information on age, marital status, education and years of farming experience. The farm environment section had information on crops grown, knowledge on farming practices and farming area. The harvesting and drying activities section included information on moisture determination methods, harvesting time of maize and length of drying time. The postharvest losses section collected information on type of grain storage structures, insect infestation and mycotoxin (aflatoxin) awareness. Sampling method employed in this study was a multi-stage sampling procedure and focused group discussions.

2.3 Data Collection and Analysis

Field trips were made to all farm settlements to facilitate the completion of questionnaires by 40 farmers chosen at random in each farm settlement — a total of 400 respondents from ten settlements who were identified as lead-farmers, were interviewed using well-structured self-reporting questionnaires administered during a focused group discussion. Most of the visits to survey, interview and discuss with the farmers in each settlement were conducted on their meeting day which was the last Wednesday of every month to facilitate the questionnaires administration and completion. Respondents who experienced challenges in reading or writing in English language were assisted by the enumerators. Approximately 45 minutes were required to complete each questionnaire. Data entry and analysis were conducted using SPSSv20 and Excel 2016, Google Earth and Arcgis10.2 were used to draw the maps while Sigmaplot13 was used to plot the bar charts. Data were analyzed to provide good understanding of postharvest practices among grain farmers in Oyo State, Nigeria. Descriptive statistics and cross–tabulation were summarized as percentages.

3 Results and Discussion

3.1 Demography

The socio-economic distribution of the 400 farmers across the ten settlements visited showed that majority of the respondents were predominantly males (Table 2) which is an indication that male farmers were more actively involved in the production phase of farming activities. Low participation of females can be attributed to the enormous amount of energy dissipated during farm work. Farming activities require a lot of energy to ensure the expected yield at harvest is achieved. Data showed that 92.8% of the respondent were married, 39.8% were well above 50 years while majority of the farmers were middle-aged with average of 45 years. These ageing farmers were observed to be indifferent in adopting new technologies during a group discussion but welcomed the idea of increased government input. Charles and Ruth (2007) reported that the conservative nature and risk aversion involved in new technologies can be attributed to the old age of farmers. The level of education of farmers varied from non-formal (33.3%) to Master of Science (M.Sc.) degree (1.5%), while 10.5% had other forms of education. Majority of the farmers have above 16 years of farming experience which makes them skillful and knowledgeable about farming activities using low-level technology. The level of education of farmers and trainings organized by extension agents give farmers the ability to adopt new ideas, learn, communicate effectively and also acquire additional skills.

Table 2: Distribution of Respondents according to their Socio-Economics Variables

Variable	**Response (%)**
Gender	
Male	82.3
Female	17.8
Age (in years)	
Less than 20	0.3
20–29	7.3
30–39	19.0
40–49	30.3
Above 50	39.8
Did not specify	3.5
Level of Education	
Primary	15.8
Secondary	22.0
National diploma (ND)	5.0
Higher national diploma (HND)	3.8
Bachelors of Science	7.3
Master of Science	1.5
Non–formal	33.3
Others	10.5
Did not specify	1.0
Marital status	
Single	5.3
Married	92.8
Widow	1.3
Divorced	0.3
Did not specify	0.5
Farming Experience (years)	
2–5	4.8
6–10	12.3
11–15	14.5
16–20	17.0
21–25	7.8
26–30	20.3
Above 30	20.0
Did not specify	3.5

3.2 Farming environment

Various crops are grown across the settlements such as maize, beans, cassava, vegetables, yam and other crops (Fig. 2). Maize cultivation alone accounts for 4.3% of crops grown while maize, cultivated alongside other crops accounted for 91%. Maize is the dominant grain crop cultivated in Oyo State. Over 70% of the respondents thresh maize on cobs using locally fabricated maize shellers which has no blower for winnowing or separating chaff from threshed grains (Fig. 3), while a few thresh using sticks — mostly for domestic consumption. Although maize threshers were found in all settlements visited, blowers, dryers, grain graders and other modern storage facilities which would ensure that grains are processed and stored properly were not available. The implication of this is that grains taken into storage are not sufficiently clean thereby making them susceptible to insect and rodent infestations.

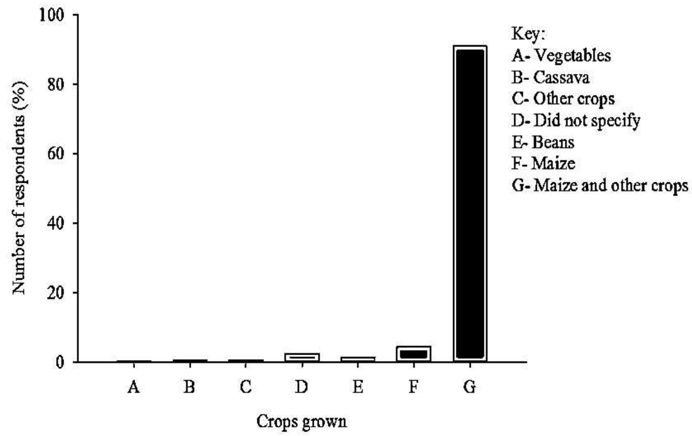

Figure 2: Crops grown across the study area

Figure 3a: Threshing operation at Ijaye Farm Settlement

Agricultural extension agents visited the farms regularly as noted by 58.5% of respondents. However, most visits by extension agents were described as being casual and training sessions for knowledge transfer are not common. Visits of extension agents did not change some of the postharvest practices of farmers because many of the farmers still use wrong methods to preserve and store grains, such as the indiscriminate use of approved chemicals, and the use of unapproved chemicals

Figure 3b. Winnowing operation at Ijaye Farm Settlement

Apart from extension agents, farmers typically acquire knowledge and training from other farmers, non-governmental organizations, farm input suppliers, mass media — radio, television and also by trial and error (Fig. 4). Information shared between farmers can be attributed mostly to the experiences acquired by older farmers. Significant difference was observed in the source of knowledge to the farmers on farming practices across the 10 farm settlements as shown in Tables 3 and 4. The information acquired through these sources influence their farming practices.

Proper sensitization and adequate knowledge transfer to the farmers in these settlements will impact positively on the way farming practices are carried out.

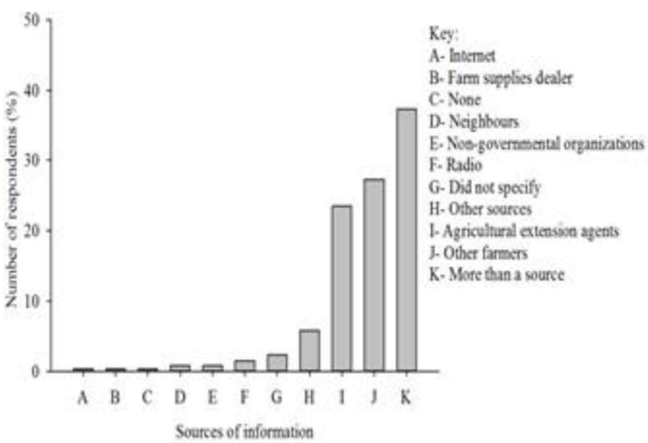

Figure 4. Farmer's sources of information across the farm settlements

Table 3: ANOVA for effect of farmers sources of knowledge on farming practices across the 10 farm settlements

Variable	Source	df	F	Sig.
Farm Settlements	Sources of information	9	4.65	.000

Table 4: Post Hoc Test (Turkey B.[a]) for the differences among the farm settlements

Farm Settlements	N	Sources of knowledge
Ipapo	40	4.03 ± 3.990^{a}
Iresa-Adu	40	4.03 ± 3.620^{a}
Ogbomosho	40	4.25 ± 3.774^{a}
Olosun	40	4.65 ± 4.549^{a}
Akufo	40	4.78 ± 4.067^{a}
Ilora	40	5.70 ± 4.189^{ab}
Agunrege	40	6.15 ± 4.288^{ab}
Ijaye	40	6.20 ± 4.262^{ab}
Olowa	40	6.73 ± 4.200^{ab}
Eruwa	40	8.25 ± 3.447^{b}

*Values in the same column with different superscript are significantly different ($p<0.05$)

3.3 Harvesting and drying activities

Observations revealed that harvesting by farmers take several days, depending on the size of farm land cultivated, method of harvesting which is predominantly by manual labour (94.3%) and number of participants. Harvest period requires substantial energy and time. Farmers experience drudgery as 67% admitted that they use hired labour by hand to harvest the maize crop. About half of the farmers mainly hire tractors (with trailers attached) as the major means of transporting large quantities of harvested maize from the field while about 27% make use of vehicles.

Figure 5. Sun drying near *Ilora, Afijio* local government area of Oyo state

Tractors are preferred for this purpose due to the bad state of farm roads. Sun drying of grains (Fig. 5) was the prevalent method for grain moisture reduction after threshing activities (Table 5).

Table 5. Maize drying methods, drying time and area cultivated by farmers

Variables	Response (%)
Maize drying method	
Open-air sun drying	75.5
Indoor air-drying	0.3
Dryer	2.0
Raised ventilated granaries	13.3
More than one method	0.5
Did not specify	8.5
Drying time of maize (days)	
1–2	1.5
3–7	17.6
8–14	17.0
15–21	8.5
22–28	1.0
29–30	14.8
Above 30	28.3
Did not specify	11.5
Area cultivated for maize alone (acres)	
< 1–2	14.5
3–10	48.8
11–20	29.0
21–30	3.3
31–40	0.8
41–50	1.0
51–60	0.3
71–100	0.3
Above 100	0.3
Did not specify	1.8

High presence of moisture in grains leads to mold formation and food contamination, hence resulting to food loss during storage. Deepak and Prasanta (2017) reported that drying is a vital activity after harvesting which help to preserve the quality of crops, limit losses during storage and decrease transportation cost. Several methods were used by farmers to determine the moisture content of harvested crops. Such practices include crude methods like biting kernels, sound test and visual observation (Table 6).

Table 6. Moisture content determination techniques by farmers across the study area

S/N	Moisture content determination	Response (%)
1	Kernel biting	16.5
2	Sound of kernel when shaking or turned in a can	6.8
3	Moisture meter	6.0
4	Visual observation	37.0
5	Number of days dried	4.0
6	*Others	1.5
7	**More than one method	24.8
8	Did not specify	3.5

*Other methods such as the salt test
**More than one method such as those listed in the table

The absence of dryers on all the settlements visited caused farmers to leave their maize on the stalk till they are dried for about 20–30 days or more after maturity and many farmers reportedly experienced insect infestation right from the field before harvest. Baloch (2010) reported that delay in harvesting matured crops results to crop exposure to attack by birds, insects and rodents while other losses may occur due to natural disasters. Although farmers ensure maize is dried to a level, they still experience challenges during drying activities as rodent attacks are a major threat (Fig. 6). The crops are then harvested and de-husked manually after which they are stored in cribs where they are further air-dried. Most farmers keep their harvest between 1–12 weeks before sale. General observations also revealed a low-level use of postharvest mechanization while storage facilities (most especially silos) and processing equipment installed at inception of the settlements were in disrepair. The poor state of storage structures at the settlements was attributed to poor maintenance culture and total dependence on government to repair and build new ones (Figure. 7).

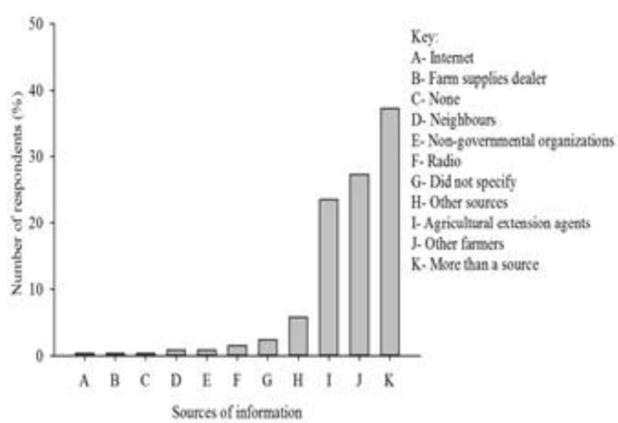

Figure 6. Challenges faced by farmers during drying of maize across the farm settlements

Figure 7A

Figure 7B

Figure 7C

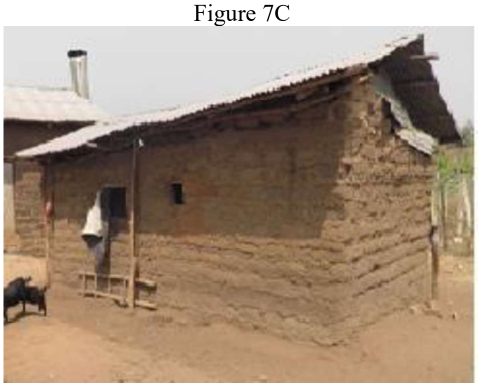

Figure 7D

Figure 7. Dilapidated and abandoned storage structures (maize cribs and warehouses) at the settlements of (A) Akufo, (B) Eruwa, (C) Ilora and a mud granary at (D) Ijaye settlement

3.4 Postharvest Losses

Farmers (87.3%) noted that they experienced substantial postharvest losses, up to a third of total harvest due to rodent, insect and mold damage. Losses experienced the most in postharvest operations were in de-husking and threshing operation as indicated by 19.3% of the respondents while winnowing and cleaning operations accounted for 12.3%. Losses encountered during threshing operations were due to the use of inefficient maize shelling machines while the complete absence of grain cleaning machines affected cleaning operations. Half of the farmers gave an estimation of about 10% grain loss from harvest to point of sale, while 29.5% had no idea of the quantity lost. It was observed that majority of the farmers practiced little or no book keeping and documentation of farming activities. Maize crib, store-room and earthen/mud-walled structures were found to be widely adopted by farmers in storing un-threshed crops.

More than half of the respondents were able to link a general lack of adequate storage facilities to losses which in turn affected their productivity and profitability. Similarly, an appreciable number of respondents opined that inadequate processing facilities influenced their postharvest losses arising from kernel damage or unnecessary delays in processing, while inadequate funding contributed to slow growth in productivity as shown in Table 7. The respondents (87.5%) observed insect infestation on the field, while about 80.5% of the respondents observed insect infestation during storage. An implication that farmers start experiencing losses even before harvest while some stored grains may have been infested right from the field. Rodent attack was identified as the main source damage during storage at the farm followed by insect infestation. A major effect of this attack is the reduction in quality of maize from food grade to feed grade.

Over 90% of the respondent unavoidably make use of rat poison in their stores, a practice which they acknowledged was dangerous as it has the tendency of contaminating the stored products, but which to them was unavoidable. Farmers opined that some factors have significant effect on grain quality, thereby reducing the market value of their grains and causing severe economic losses. Moreover, the high risk of losses due to stored product insect pests constrains 80.8% of the farmers to apply field pesticides on stored grains in cribs and stores despite the threat to human health. A common postharvest handling practice at *Ijaye* farm settlement during storage is to hang a plastic container with insecticide above and around unthreshed grains in a barn with the expectation that fumes from the chemical will be carried by air currents, which eventually will kill the insects (Fig. 8). Some of these practices are entrenched in cultural norms or a long history of practices that seems not to have been changed despite the level of education in this modern time.

Table 7. Constraints to farmer's productivity and factors affecting grain quality

Variables	Response (%)
Constraints to high productivity	
Inadequate processing facilities	91.3
Lack of finance	96.6
Inadequate storage facilities	92.6
Poor technical know-how	83.8
Poor power supply	88.6
Price of spare parts	82.8
Inefficient farm machines/equipment	90.0
Bad road networks	94.0
Factors affecting grain quality	
Presence of molds on field	68.8
Storing moist grains	69.3
Presence of molds during storage	70.1
Loading and unloading of grains	70.3
Winnowing	70.8
Usage of low-quality bags	73.1
Usage of inefficient threshing machines	78.8
Pesticide usage	80.8
Rainfall event	84.0
Transportation	85.0
Spoilage and damage of grains by animal or animals	85.0
Usage of inadequate storage facilities	86.0
Field insect infestation	89.6
Storage insect infestation	89.8

Figure 8. A plastic container filled with insecticide outside a maize crib at the *Ijaye* Farm Settlement

Victor (2014) reported that postharvest handling was recognized as one of the key areas that requires attention. About 61% of the farmers were unaware of molds which causes aflatoxin contamination or how to prevent infestation, while 50.5% were unaware of aflatoxin threat to humans and livestock. Consequently, moldy and infested grains were mostly fed to livestock. Emphasis on the causes, prevention and health implications of aflatoxin infested maize must be addressed for food security to be improved. Disposal of maize cobs was mostly by burning and burying. Inspection of stored maize by the respondents (37.5%) were done bi-weekly while majority clean grain storage facilities anytime. Dirty storage structures create a suitable environment for insects and rodents to thrive, and this leads to contamination and grade loss. Inspection and monitoring of stored grains are vital in increasing food security and preserving grain quality over time. The respondents (47.5%) reported the sale of about 2–30 bags of maize after threshing, while 34.4% keep a bag for home consumption. Farmers are conscious of their safety during farming operations as majority of them had never experienced any form of accidents(s) over the past years. However, 54.4% of them use some type of personal protective equipment (PPE) during postharvest operations.

4 Conclusions

The postharvest practices among grain farmers in Oyo State, Nigeria was investigated using well-structured questionnaires and field observation. In order to successfully train smallholder farmers to adopt good postharvest practices, a first-hand knowledge of their current practices is required. However, the existing extension training system and the services they ought to provide to smallholders on postharvest practices and mitigating postharvest losses are grossly inadequate. No significant difference was found in practices at all settlements visited. The obvious lack of information dissemination to farmers in hard–to–reach locations must be addressed if Africa is to achieve food security.

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