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**Research Article**

# Assessing Storage Insect Pests and Post-Harvest Loss of Grain Sorghum in Ethiopia

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**ABSTRACT**

Ethiopia is the second largest sorghum producer in Africa, after Sudan and is a sixth global producer. The survey was conducted for three years in 2018 to 2020 cropping seasons, to identify insect pests and post-harvest loss of grain sorghum in Ethiopia. Stratified random sampling methods were used for farmers selection from each of the three regions, Amhara, Oromia and Benishangul Gumuz. The assessment was covered a total of 191 farmers field and the samples were taken for the analysis of weight loss, grains damaged and germination percentage. *Sitophilus zeamais* and *Tribolium castaneum* was recorded with high mean number 154 and 135 in the samples collected from west Hararghe. Almost, all 80% of the surveyed sorghum farmers areas were used underground pits storage. Maximum mean 89.33% of germination was recorded in the sample collected from Asosa. High mean value 19.39% of damaged grains was recorded in the sample taken from west Hararghe and the lower mean 8.00% was form west Wollega. From this survey, it can be concluded that most of the farmers used underground pits in bare soils, stored their grains sorghum either shelled or unshelled wrapped with polypropylene sheet, heap with head in the field and/or in gotera for a long period. The storage pits are regularly dug when opening and it is laboure's because of unloading for consumption, check for weevils damaged. Repeated uses of insecticides have a harmful effect on the environment and human health. Therefore, uses of hermetic storage technology can be suggested to the farmers for reducing germination losses, grains damage, use of insecticides and providing appropriate grains quality.

**Key words:** Grains Damaged, Sorghum, Underground Pits, Weight Loss

## INTRODUCTION

Sorghum, (*Sorghum bicolor* L.) Moench is avital cereal crop grown worldwide for food and feed purposes. It is typically cultivated in semi-arid tropics where water is a deficit and drought are frequent (Beshir, 2011). The second largest sorghum producer is Ethiopia after Sudan in Africa (Demeke and Marcantonio, 2013) and is a sixth global producer with a share of 7% of the total global sorghum production (FAO, 2013). Sorghum is one of the major commodity crops grown in different low land plains of Ethiopia. According to FAO, its production has meaningfully increased from 1.7 million tons in 2004/05 to nearly 4.0 million in 2013 (130%) (FAOSTAT, 2015). Although, the production reduced by 2.77% from 2013 to 2014. The production is a periodic and farmers have to store some of their produce to guarantee constant food supply for their family and when desirable, to sell grains to reimbursement for another household needs until the next season. The extent and types of postharvest losses in sorghum are attributed to many factors including the nature of the crop, the environmental condition during production and succeeding handling after harvest. Insect pests damage to stored grains results in reduced quantity, quality, nutritive and viability of stored cereals like sorghum, maize, wheat and rice (Abbas *et al.*, 2014). Among the factors insect pests have been the main challenges of agriculture in the tropics for long as favorable conditions exist for the pest and improper post-harvest handling services which results in considerable waste of foodstuffs and hereafter, extensive losses to the economy (Sori, 2014; Karthikeyan *et al.*, 2009). Utono (2013) reported that storage losses due to insect pest infestations have been a problem of major concern among smallholder farmers who use traditional storage structures. Type of technology and level of production determine the amount of grain to be stored for a given period. There are optimum conditions that could extend the shelf life and reduce the loss of produces in terms of quantity and quality (FAO, 2017). Thus, grain storage plays an important role in the livelihood

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of small-scale farmers. Unfortunately, stored grain losses due to insect pests represent a threat to farmers in realizing this benefit (Mvumi and Stather, 2003). Therefore, the objective is: to assess postharvest insect pests and to identify associated loss factors in stored sorghum.

## MATERIALS AND METHODS

### Survey Areas and Methods of Sample Collection

The research design used included observation, assessment and laboratory examination. Maize producing farmers in the regions, zones, woredas and kebele's were selected based on their potential in the production of sorghum together with woreda agricultural experts and interacted with to understand their views on the quality of maize stored in traditional storage structures and traditional storage practices used. Structured questionnaires were administered through personal interviews to obtain primary and other information from farmers. A total of 191respondents were questioned for the reasons of post-harvest losses of stored sorghum. The sample was collected from each of the agroecological areas through the administered questionaries. Formal and local languages that were understood by the farmers were used. Questions asked included demographics, target crop production and storage practices, storage structures, loss incurred after storage, use of stored maize and marketing of the maize. 250 gm of sorghum grain was sampled for each sampling areas. The necessary data (GPS reading, temperature, RH, storage duration, storage method and pest conditions) was collected together with samples (Fig. 1).

### Data to Be Collected

### Storage Temperature and Relative Humidity

The temperature and relative humdity of the internal and external environment of the storage was measured by using portable digital thermo-hygrometer (Hanna, HI8564) and measurement was done in the afternoon 3.00 p.m. in the day (to reduce variations) and at the time three data was taken and its average was recorded. Measurements were taken from the center, side, and top portion of the storage according to Befikadu *et al.* (2012).

### Insect Pest Identification and Estimation of Loss

Insects were separated from grains using sieves and their numbers and identities at each locality was recorded. Insect samples was kept in sealed containers and taken to the laboratory. The insects were then observed under microscope, hand lens for species identification, according to method used by Dobie *et al.* (1991). The grains were separated into undamaged and insect damaged categories. These were counted and the percentage of damaged grain computed. Each category was weighed and percentage weight loss was determined by using the count and weigh method formula as shown by Boxall (1998):

$$\text{Grain damaged (\%)} = \frac{\text{Number of insect-damaged grain}}{\text{Total number of grain}} \times 100$$

$$\text{Weight loss (\%)} = \frac{(\text{Wu X Nd}) - (\text{WD X Nu})}{\text{Wu (Nd + Nu)}} \times 100$$

Where, Wu = weight of undamaged grains, Nd = number of damaged grains, Wd = weight of damaged grains and Nu = number of undamaged grains. Percent grain damage and weight loss data will enter into Microsoft Office Excel 2007, coded and analysed using appropriate statistical software.

### Germination Test

Standard germination tests were carried out according to the procedures used by ISTA (2005) to evaluate the seed germination capacity. The seeds were kept in petri-dishes lined on filter paper moistened with distilled water until it was moistened and done in their replications (25 seeds per petri-dishes) and incubated at room temperature (25ºc) for 5 to 7 days. The germinated seeds were counted visually up on appearance of radicle and/or plumule and percentage germination was calculated as follows:

$$\text{Germination (\%)} = \frac{\text{No. of germinated seeds}}{\text{Total No. of seeds soaked in each petri} - \text{dish}} \text{X } 100$$

### Data Analysis

Descriptive statistics such as frequency distribution and percentages analysis were used. All the collected data were computed using Microsoft excel 2010 and SPSS statistical software (Version 26) for the differences among the mean values of weight loss, grains damage and germination percentage.

## RESULTS

### Demography of The Respondent

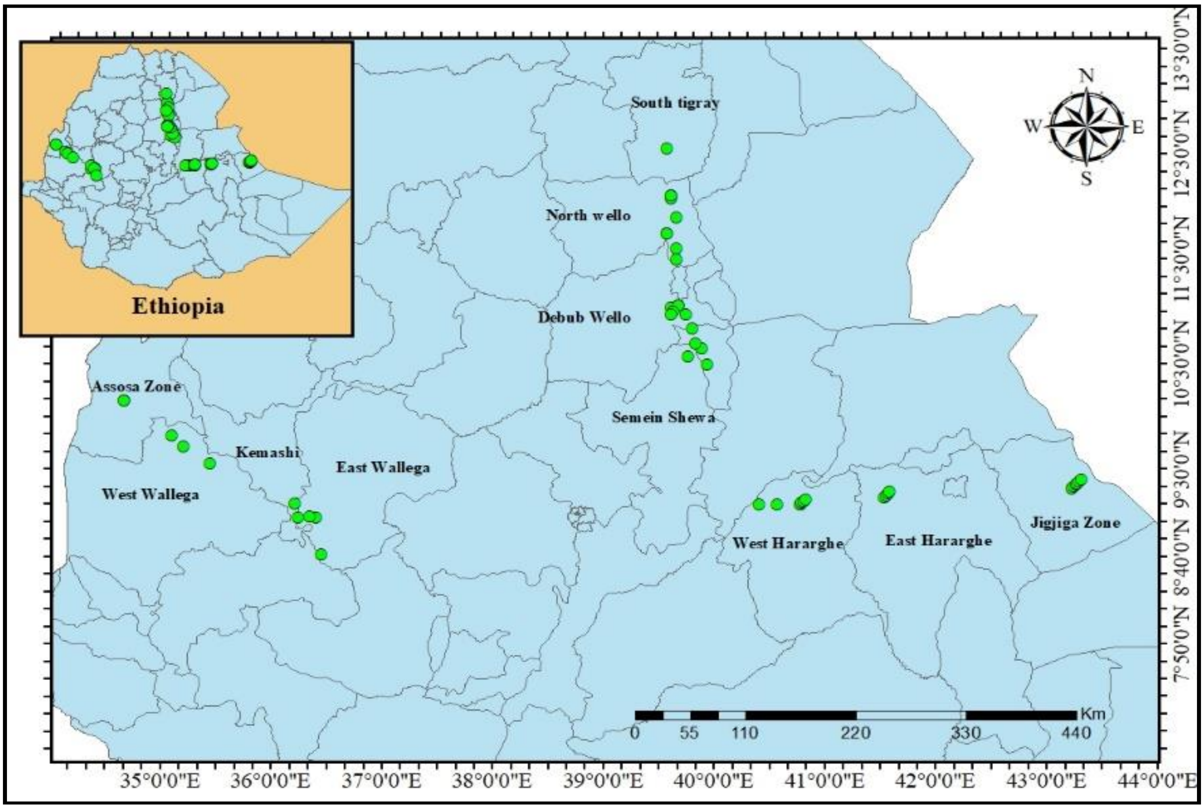
The majority of the respondent farmers were male (84.64%) and 15.36% (n = 191) were female. Among the responded farmers 30% and 20% had primary school and secondary school, respectively. None of the respondents had received a diploma. 50% of the interviewed farmers said that they had no education.

### Production of Target Crops and Threshing/Shelling Methods of Farmers

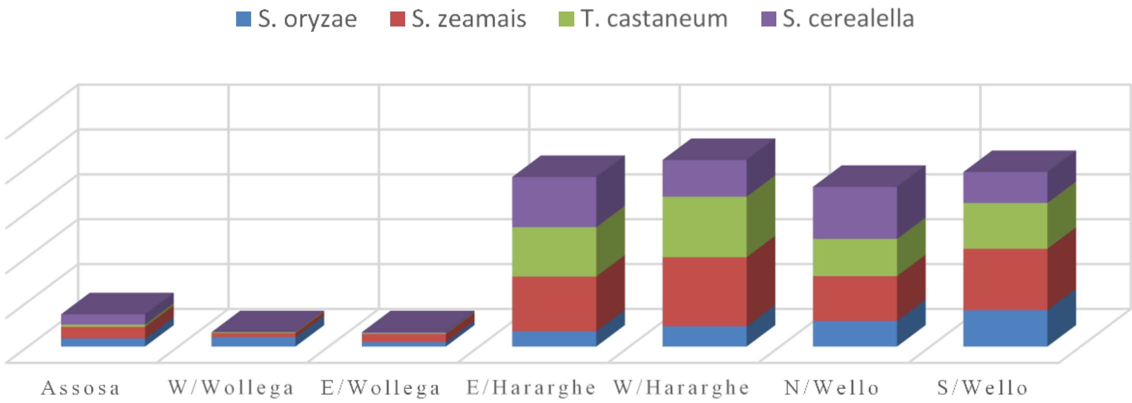
The farming practice of the responded farmers were mostly focus on the production of the target crops. The respondent farmers had highest farming practices of sorghum, maize, coffee, faba bean, pigeon pea, haricot bean, groundnut, sesame, nug and millet, respectively. The usual methods of threshing under small-scale farmers' condition were: (1) manually by beating with sticks. (2) few farmers use combiners and (3) at times drubbing with mortar and pestle, such traditional practices cause much loss to the grain's physical quality, smattering of grains out of the threshing ground, and contamination with a waste of chaff and broken seeds.

### Assessment of Cause Postharvest Losses

Factors that cause postharvest loss of stored grains in the production system are biotic and abiotic. Biotic factors encompass all losses due to pests of any sort that are capable of offensive undamaged grain (key pests) as well as damaged grain (minor pests). Insects, mites, rodents, thief, monkey and birds are the major ones. Post-harvest losses that are caused by insect pests can be qualitative and quantitative nature, as food is consumed, damaged, or contaminated, especially during the storage period. Abiotic factors: High relative humidity and temperatures of the area can made initiation to a change of certain biochemical processes that can lead to a deterioration of the grain in storage (Fig. 4 C). Grain temperature is greater in all the surveyed areas than that of the external temperature (Table 1).



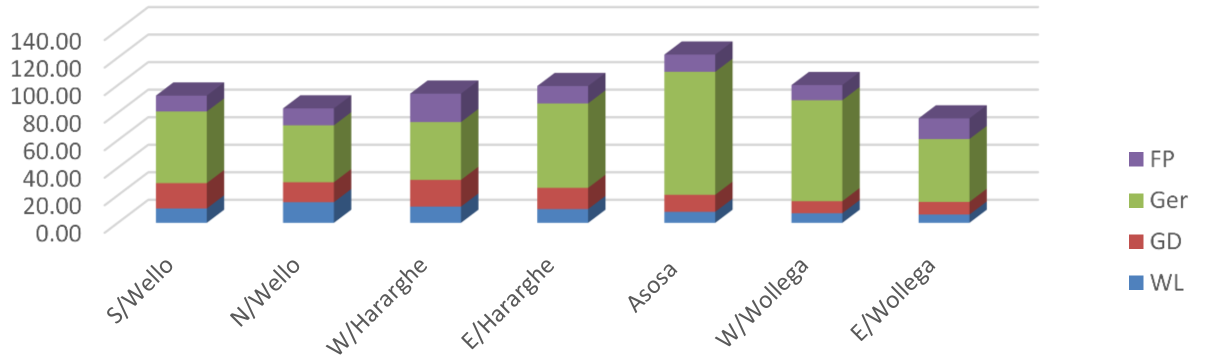

**Map 1:** Sorghum post-harvest loss assessment area of Ethiopia




Authors calculation using insect indentification parameters from Dobie *et al*. (1991) and Boxall (1998)
**N.B.** Bars shows mean numbers of storage weevils

**Fig 2:** Mean weevil species identified form the surveyed samples


**Fig 3:** (A) pit storage only and (B) shelled sorghum wrapped with polypropylene sheet & stored in pits, (C) infested grain sorghum




*Authors calculation using loss parameters from Dobie *et al.* (1991); Boxall, 1998; Fufa *et al.*, 2020
**N.B.** Bars shows percentage weight loss, grains damaged & germination

**Fig 4:** Percentage of weight loss, damaged grains and farmer's perception of lossess

**Table 1:** Overall average summary of environmental conditions of the surveyed areas

| Survey zone | Grain Temperature | Environmental Temperature | Environmental relative humidity |
|---|---|---|---|
| Asosa | 29.92 | 31.20 | 57.20 |
| W/Wollega | 26.33 | 29.20 | 58.50 |
| E/Wollega | 28.52 | 33.55 | 63.60 |
| B/Bedele | 29.00 | 36.00 | 57.50 |
| N/Wello | 28.04 | 33.43 | 56.40 |
| S/Wello | 29.26 | 33.00 | 58.00 |
| E/Hararghe | 32.30 | 37.55 | 59.20 |
| W/Hararghe | 33.00 | 38.81 | 56.32 |

Maximum grain temperature 38.81, 37.55 and 36.00 *°C were recorded in west Hararghe, east* Hararghe and Buno Bedele survey areas, respectively. Almost all of the surveyed areas relative humidity related since it is low land.

### Insect Pest Identification

From the surveyed samples four (4) weevils, *Sitophilus oryzae, Sitophilus zeamais, Tribolium castaneum* and *Sitotroga cerealella* were identified. Among the species identified, *S. zeamais* and *T. castaneum* was occurred with high mean number 154 and 135 in the samples collected from west Hararghe (Fig. 2 & 3). This is due to most of the farmers in these areas were kept their sorghum in pits with polypropylene wrapped (Fig. 3 B). Also, the reason for the proliferation of the insect in these areas were due to the storage periods that the samples was taken in the eight months of storage than that of Asosa, East and West Welloga which the sample was taken earlier of the storage periods.

### Sorghum Storage in Ethiopia

Most of the farmers 70 to 80% (n= 191) of in east and west Hararghe, north and south Wello stored shelled grains sorghum in underground pits. Almost, all of the farmers surveyed in east and west Hararghe areas stored grains sorghum in wrapped with polythene sheet & put in pits (Fig. 3 B). But the farmers in east and west Wollega and Asosa stored shelled or unshelled sorghum in wooden made gotera, sack for shelled, head sorghum in stalk made, bamboo baskets to mud structures, gunny bags and woven sack. The same authors stated that awesome majority of farmers (more than 70%) in Hararghe store their sorghum, and sometimes even maize, in the flask-shaped traditional underground storage pits of variable dimensions until it is consumed or sold when the grain market improves.

### Assessment of Grains Damaged, Weight Loss and Germination

The assessment was conducted from 2018 to 2020 cropping season to assess grains damaged and weight loss and germination percentage and it was done in three regions, Amhara, Oromia and Benishangul Gumuz and seven zones, Asosa, East and West Wollega, East and West Hararghe, North and South Wello, respectively. The assessment was covered a total of (n=191) farmers field. Maximum mean 89.33% of germination was recorded in the sample collected from Asosa. Highest mean 15.00% of weight loss was recorded in the sample collected from North Wello whereas, the lowest mean 6% of weight loss was observed in the sample taken from west wollega (Fig. 4). Regarding of grain damaged higher mean 19.39% of was recorded in the sample taken from west Hararghe and the lower mean 8.00% west wollega. In Wello and Hararghe zone the farmers used pits storage which favors the development of temperature, moisture form due to the respiration between the grains and the weevils. Additionally, in the two Hararghe zones the farmers were used polypropylene sheet in the pits and wrap it with the grains which increased temperature and moisture development in the storage. These all factors cause highest post-harvest losses of sorghum in quantity and quality. Regarding to the respondent's perceived losses up to 20% were due to storage insect pests and the damage reached up to 100% if the farmer not used insecticides.

## DISCUSSION

Four (4) weevils, *Sitophilus oryzae, Sitophilus zeamais, Tribolium castaneum* and *Sitotroga cerealella* were identified. Similarly, Antoine *et al.* (2019) identifies four insect species in the stored grains, namely *Rhizopertha dominica*, *S. zeamais* Motschulsky (Coleoptera: Curculionidae), *T. castateum* Herbst. (Coleoptera: Tenebrionidae) and *Oryzeaphilus Mercator* Fauvel (Coleoptera: Silvanidae) from the assessment data. Tefera *et al.* (2011) reported that in Ethiopia the major postharvest pests of cereal grains include the maize weevil (*S. zeamais*), the Angoumois grain moth (*S. cereallela*) and the lesser grain weevil (S. oryzae), and *Callosobruchus* spp. for grain legumes. furthermore, Karta *et al.* (2019) identified granary weevil, *Sitophilus granarius*, *Sitophilus* spp., and the Angoumois grain moth, *S. cerealella*, *Tribolium* spp., the India meal moth, Plodia interpunctella, and Liposcelis spp. from the surveyed samples. Among the species identified, *S. zeamais* and *T. castaneum* was occurred with high mean number 154 and 135 in the samples collected from west Hararghe (Fig. 2 & 3). According to Kadi *et al.* (2013), the survey data indicated that *S. cerealella* and *T. castaneum* adults with largest means number of 8.8 and 7.3, respectively. This is due to most of the farmers in these areas were kept their sorghum in pits with polypropylene wrapped (Fig. 3 B). Also, the reason for the proliferation of the insect in these areas were due to the storage periods that the samples was taken in the eight months of storage than that of Asosa, East and West Welloga which the sample was taken earlier of the storage periods.

Almost, all of the farmers surveyed in east and west Hararghe areas stored grains sorghum in wrapped with polythene sheet & put in pits (Fig. 3 B). But the farmers in east and west Wollega and Asosa stored shelled or unshelled sorghum in wooden made gotera, sack for shelled, head sorghum in stalk made, bamboo baskets to mud structures, gunny bags and woven sack. Similarly, Boxall (1974) survey data indicated that in Hararghe area about 70-75% of the farmers used underground storage pits exclusively and 8-12% used it in combination with other storage methods. However, Dejene (2004) indicate most peasants in Hararghe store their sorghum and sometimes maize in traditional underground pits. The investigation conducted in Jijiga area selected that only pits and bags were used as storage containers. The same authors stated that awesome majority of farmers (more than 70%) in Hararghe store their sorghum, and sometimes even maize, in the flask-shaped traditional underground storage pits of variable dimensions until it is consumed or sold when the grain market improves. While, Mahai *et al.* (2015) observed that some farmers in Nigerian store their sorghum in non-threshed form, tied in bundles or untied, while some keep threshed grains in structures such as thatched rhumbus, mud rhumbus and underground pits. Furthermore, Waongo *et al.* (2013) estimated that 60 to 70% of sorghum produced in Nigeria are stored at home level in indigenous structure ranging from bamboo baskets to mud structures, gunny bags and modern bins. The finding of Mahai *et al.* (2015) revealed that, in Burkina Faso, the farmers stored their sorghum traditionally as panicles in straw or mud granaries. Maximum mean 89.33% of germination was recorded in the sample collected from Asosa. Similarly, Adugna (2006) reported that cereals and pulse grains germination loss was ranged from 3-37 and 4-88% due to the damage of storage pests. Highest mean 15.00% of weight loss was recorded in the sample collected from North Wello whereas, the lowest mean 6% of weight loss was observed in the sample taken from west wollega (Fig. 4). The findings reported by Suleiman and Rugumamu (2017), showed that weight loss up to 13.12% of the threshed sorghum and weight loss of 8.34% of the unthreshed sorghum was caused by insect pests. According to according to Waktole and Amsalu (2012), weight losses up to 41-80% of maize and sorghum stored grains was caused by substantial infestation S. zeamais under traditional storage. While, Adugna *et al.* (2003) explained that the weight loss of stored grain sorghum ranged up to 9-29% for cereals and pulses, respectively. Regarding of grain damaged higher mean 19.39% of was recorded in the sample taken from west Hararghe and the lower mean 8.00% west wollega. FAOSTAT (2016) reported that the total post-harvest loss in sorghum estimated between 26.50% and 33.00 % with the average being 29.75% in west Armacho woreda of the Amhara regional state. The same reports of FAO indicated that total postharvest loss in sorghum ranged between 28.8% and 42.75 %, based on the FGD, KII and field observations. The average total sorghum loss is 35.7%.in Alamata Woreda of Tigray Regional State. The critical loss points of sorghum in Alamata Woreda are storage, threshing and harvesting stages. In Wello and Hararghe zone the farmers used pits storage which favors the development of temperature, moisture form due to the respiration between the grains and the weevils. Additionally, in the two Hararghe zones the farmers were used polypropylene sheet in the pits and wrap it with the grains which increased temperature and moisture development in the storage. These all factors cause highest post-harvest losses of sorghum in quantity and quality. Regarding to the respondent's perceived losses up to 20% were due to storage insect pests and the damage reached up to 100% if the farmer not used insecticides.

## Conclusion

Four weevil's species are identified from the surveyed samples. Among the weevil species observed *S. zeamais* and *T. castaneum* were occurred with heavy infestation. More than 70 to 80% the farmers stored their grains sorghum in underground pits. Farmers especially in east and west Hararghe areas used underground pits for more a decade without any uses of modern storage methods which made favorable for insect infestation and moulds development due to many factors. While, using of underground pits requires low cost it was too Laboure's because of regularly dug or opening the pits for consumption, for the check of the weevils damaged and for selling to earn cash. The mean number of weevil species, percentage of weight loss and grains damage shows increasing trends as the storage periods increased. Post-harvest losses of stored grains sorghum in the bottom, side and the top of the underground pits were high due to the grains contaminated with soil, moisture and grains temperature development as contact with the soils. The farmers used insecticides for a prolonged time which have a residual effect on the grains and causes health effect on human. Therefore, uses of hermetic storage technology can be advised to the farmers for reducing germination losses, grains damage, providing appropriate grains quality and reduces uses of insecticides. Multidisciplinary works is required in order to reduce post-harvest losses of grains and training the farmers on uses of storage technology is the most advised. Additional work is encouraged to examine the effect of the underground pits the grain stored for more than one year for healthy aspect of the farmers due to mycotoxin contamination.

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