# Effect of Altitudes/Ecology on Storage Pests Population and their Damage in Eritrea

Adugna Haile*

*Hamelmalo Agricultural College, P.O. Box 397, Keren, Eritrea*

**Abstract:** On-farm wheat grain storage study was conducted in three different altitudes of wheat growing areas of Eritrea in 2005/2006. The objective of the study was to assess the loss caused by storage pests in farmers' traditional store. The treatments used to control the pests were sand, small grain (taff, *Eragrostis tef*), ash, chemical (Malathox 1%) and control (no treatment). The trial was conducted for seven moths and data was collected on grain damage, weight loss and germination percent of the damaged and undamaged grains. The data was collected every month. The major storage pests recorded were weevils (*Sitophilus* spp.), Angoumois grain moth (*Sitotroga cerealella*) and flour beetle (*Tribolium* spp). The results of the study showed that higher altitude and cooler temperature had a suppressing effect on pest population build-up thus resulting in lower grain damage and loss. Sand and small grain reduced storage pest damage up to three months and then there was no difference with the control. Ash and Malathox 1% gave significantly lower percent of infestation, damage and weight loss throughout the study period. Ash is non toxic and has no side effects on the grain and human health and is therefore be recommended to small scale farmer for treatment of grain storage.

**Keywords:** Wheat, storage, pest, sand, small grains, ash, damage, weight loss.

## INTRODUCTION

On-farm storage studies in Eritrea showed that staple grains of cereals and pulses produced by small farmers in Eritrea are attacked by different storage pest. The germination loss due to the attack of storage pests on cereals and pulse grains ranges from 3-37 to 4-88 %, respectively. The weight loss for these grains also ranges from 4.4-14 to 9-29% for cereals and pulses respectively [1]. Preliminary storage pest studies in Adi Tekelezan, and Segeneiti showed that weevils and bruchids of various species attack cereals and pulses in store and cause a loss of 10-15% with a germination percentage loss for damaged seeds ranging from 50-92% (Tedros and Kebrom, Unpublished).

Storage studies undertaken in Central and West Africa to estimate food losses at the farm level have shown that levels of loss are generally high. About 15 % of maize grains harvested in Ghana are lost annually due to the maize weevil (*Sitophilus zeamis*) [2]. In Uganda, maize stored in traditional stores at 12.5 % per cent relative humidity for six months may lose 8-9 % of its weight due to attack by grain weevils [3]. Ogunlane [4], in Nigeria, reported maize stored in cribs for four months had 28% weight loses due to insect damage. Wheatley [5], pointed out that for maize direct and indirect farm losses in tropical countries vary from 23 to 35 % leading to an overall loss of about 2 million tons annually in developing countries. Dicheter [6] estimates that in Sub-Saharan regions of Africa, the loss of food grain during storage at farm or village level amounts to 25–40 % of the harvest crop.

FAO [7, 8] estimated that the world storage losses for cereals, pulses and oil seeds resulting from attacks by insects, mites, rodents, and moulds were of the order of 10 %. For cereals alone this is equivalent to storage losses of more than 100 million tons of grain [10]. According to Hall [11], the annual stored grain loss due to insect pests is 130 million tons. One of the main problems in storage in Eritrea is management of the store and the availability of a continuous source of infestation in the stored areas. Farmers in most areas keep old and new harvested grains in the same vicinity, which causes an easy migration or infestation of the new grains from the old grains. In addition, the location of the store is near a fire place, which increases the temperature of the store and finally speeds up pest population build-up.

Farmers in Eritrea use different pest control methods for storage pests; some use internationally banned chemicals like DDT, chemicals that leave residue others use kerosene. Some farmers use different traditional methods such as mixing of grain with ash, sand, chilly pepper, and smoke and plant materials.

There is a great loss of grains due to storage pests in Eritrea. Since over 75% of the Eritrean population relies on farming activities, their main source of food is the grain, not only as a supply of food, but also as seeds for the next year.

*Address correspondence to this author at the Hamelmalo Agricultural College, P.O. Box 397, Keren, Eritrea; Tel: 291 1 222279; E-mail: Ahailef@gmail.com

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Therefore, at least to minimize the losses caused by storage pests, it is highly desirable to understand loses caused by storage pests which can then be used as a guide to extension workers with respect to storage management.

## OBJECTIVES

- To study the effect of a mixture of different crops, ash, sand, and chemical on storage pests;
- To study the loss of stored grain due to storage pests; and
- To use the study as training for farmers.

## MATERIALS AND METHODS

On-farm wheat storage loss assessment studies were conducted in farmers' traditional store in three different altitudes of wheat growing areas of Eritrea. The studies were done in Teraemini, Tikul and Woki with altitudes of 1950, 2120 and 2400 meters above sea level, respectively. The grains for the study were bought from the market and they were fumigated prior to the study to avoid any pre-pest infestation. At each site fifteen bags filled with wheat grain weighting each 50 kilograms were used for the study. The treatments used were a mixture of wheat and taff, wheat and sand, wheat and ash, wheat treated with insecticide (Malathox 1% at the rate of 15 ppm), and untreated control. The rate of sand and taff were at the ratio of one to one i.e. for each 50 kg grain of wheat 50 kg of sand, ash or taff was used. Data were collected every month for seven months, starting from October 2005 up to April 2006. At each sampling date 200 gm of grain samples were taken at random from each bag at each location. From each collected samples 1000 grains were taken at random and were counted as damaged and undamaged and their weight was taken. From each damaged and undamaged grains samples 100 grains were taken and placed in Petri dishes, put in a germination cabinet to determine the germination percent. Data on the number of eggs, larvae, adult insect and damaged holes were counted and recorded. The data collected were transformed using the square root formula;

(Z = Y+ ½ where Z=transformed data, Y= original data) and then subjected to statistical analysis using a randomized complete block design. The assessment for percent weight loss due to insect damage was calculated using the following formula:

Percent loss in weight =Und-DNu_100/U (Nd-Nu)

Where: U = weight of undamaged grain, D = weight of damaged grain

Nd = number of damaged grain, Nu = number of undamaged grain

The germination percentage was calculated as follows:

Germination percentage =number of germinated seeds X 100/Total number of seeds.

## RESULTS

The damage on wheat ranged from 5.89 to over 15.30% during the seven months of wheat grain storage under farmer's traditional storage (Tables **1-3**). The major storage pests that were observed during the storage period were Angoumois grain moth (*Sitotroga cerealella*), weevils (*Sitophilus* spp) and confused flour beetle (*Tribolium* spp). Among these, Angoumois grain moth was the dominant pest followed by weevils. Confused flour beetle was observed after five months of grain storage and its population was quite low. The source of the infestation for the different pests could be from the crop residue or from the structure of the storage. Angoumois grain moth (*Sitotroga cerealella*) is a major pest of stored grains, causing weight loss to grain by hollowing them out. Its impact is greater in the products stored in lower altitudes of Teraemini and Tikul (Tables **1** and **2**).

### Wheat Grain Damage

Results of wheat grain damage in the three sites are given in Tables **1-3**. There was high grain damage in Teraemini followed by Tikul. The lowest grain damage was recorded in the higher altitude of Woki (2400). The highest grain damage for the three sites was observed in the control, 15.30, 10.35 and 5.89 percent, respectively. In all the sites the percent of infestation and damage of grain were lower in the first one to two months and then gradually increased in the following months (Tables **1** to **3**). The control check had significantly higher grain damage than other treatments in the first to three months. The damage of grain in sand and taff treatments was significantly lower in the first three months of storage than the control check in all the study sites. There was no significant damage difference in percent of wheat grain damage among the treatments in the first two months of storages in the higher altitude of Woki. In all the sites there were no significant difference among the wheat grain treatments

**Table 1: Monthly Percent of Wheat Grain Damage in on-Farm Storage in Teraemini, 2006**

| Treatment | 1st month | 2nd month | 3rd month | 4th month | 5th month | 6th month |
|---|---|---|---|---|---|---|
| Untreated control | 0.75 | 2.63 | 6.54 | 8.25 | 12.57 | 15.30 |
| Wheat and sand | 0.23 | 1.06 | 5.34 | 7.96 | 11.41 | 14.84 |
| Wheat and taff | 0.27 | 1.27 | 5.21 | 7.84 | 11.79 | 14.24 |
| Wheat and ash | 0.07 | 0.52 | 0.45 | 0.57 | 0.82 | 0.75 |
| Wheat and insecticide | 0.09 | 0.43 | 0.37 | 0.61 | 0.89 | 0.63 |
| LSDs | 0.28 | 0.78 | 1.75 | 1.50 | 1.89 | 1.63 |
| CV % | 15 | 19 | 12 | 14 | 15 | 17 |

**Table 2: Monthly Percent of Wheat Grain Damage in on-Farm Storage in Tikul, 2006**

| Treatments | Months | | | | | | |
|---|---|---|---|---|---|---|---|
| | First | second | third | fourth | fifth | sixth | seventh |
| Untreated control | 0.63 | 1.21 | 4.85 | 6.21 | 9.25 | 9.69 | 10.35 |
| Wheat and sand | 0.15 | 0.54 | 2.95 | 6.05 | 9.35 | 9.87 | 10.12 |
| Wheat and taff | 0.05 | 0.35 | 2.45 | 5.35 | 8.95 | 9.12 | 9.78 |
| Wheat and ash | 0.0 | 0.01 | 0.15 | 0.21 | 0.25 | 0.23 | 0.25 |
| Wheat and insecticide | 0.0 | 0.0 | 0.0 | 0.12 | 0.17 | 0.21 | 0.25 |
| Mean | 0.24 | 0.42 | 2.08 | 3.59 | 5.70 | 5.82 | 6.15 |
| LSD | 0.402 | 0.058 | 2.78 | 3.59 | 5.89 | 6.02 | 6.35 |

**Table 3: Monthly Percent of Wheat Grain Damage in on-Farm Storage in Woki, 2006**

| Treatments | Months | | | | | | |
|---|---|---|---|---|---|---|---|
| | First | Second | Third | Fourth | Fifth | Sixth | Seventh |
| Untreated control | 0.0 | 0.12 | 0.67 | 2.62 | 4.37 | 5.08 | 5.89 |
| Wheat and sand | 0.0 | 0.0 | 0.23 | 3.04 | 4.67 | 4.89 | 4.98 |
| Wheat and taff | 0.0 | 0.0 | 0.17 | 2.31 | 4.25 | 4.09 | 5.13 |
| Wheat and ash | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.01 | 0.015 |
| Wheat and insecticide | 0.0 | 0.0 | 0.01 | 0.03 | 0.07 | 0.06 | 0.013 |
| Mean | 0.0 | 0.02 | 0.22 | 1.67 | 2.67 | 2.83 | 3.21 |
| LSD | 0.0 | 0.0 | 0.131 | 0.821 | 2.234 | 2.355 | 2.752 |

of taff, sand and untreated control after four months of storage. Wheat grain treated with ash and insecticides showed significantly lower percent of grain damage throughout the study period during the storage period in all the locations (Tables **1** to **3**). In general the result of the seven month storage studies in all the sites showed that the grain damage in the control, sand and taff increases with the progress of the storage period. Ash and chemical gave good control of pest with lower grain damage.

### Wheat Grain Weight Loss

Similar to the grain damage, the results of the weight loss showed that Teraemini had the highest grain loss followed by Tikul and Woki with 6.35, 4.85 and 1.12 percent respectively (Tables **4** to **6**). In all the sites the weight losses in the first three months were very low. During this period the untreated control had significantly higher weight loss in all the study areas. Weight loss increased with the increase of the storage

period. Higher weight losses were recorded in the sixth and seven months of storage period. The highest weight losses were recorded in the untreated control, sand and taff treatments in all the locations. Ash and insecticide treatments gave significantly lower weight loss throughout the study period in all the sites (Tables **4** to **6**).

## Germination

Tables **7** and **8** showed mean germination percentage of damaged wheat grain in Teraemini and Tikul. The germination percent loss in the first two months was very low in all the treatments and sites. There was no significance difference in germination percent one month after storage. The germination in the untreated control, sand and taff significantly decreased in the second month than ash and insecticide treatments in Teraemini. The germination percent decreased with the increase of the storage period. Highest decreases were recorded in fifth and sixth month storage period. There was no statistical difference among the control, sand and taff treatments

**Table 4: Monthly Wheat Grain Weight Loss (%) in on-Farm Storage in Teraemini, 2006**

| Treatments | Months | | | | | | |
|---|---|---|---|---|---|---|---|
| | First | second | third | fourth | fifth | sixth | seventh |
| Untreated control | 0.56 | 1.17 | 1.39 | 2.55 | 3.25 | 5.89 | 6.35 |
| Wheat and Sand | 0.08 | 0.41 | 0.87 | 1.95 | 2.50 | 5.52 | 5.98 |
| Wheat and Taff | 0.06 | 0.36 | 0.97 | 1.87 | 2.46 | 5.05 | 5.85 |
| Wheat and Ash | 0.0 | 0.17 | 0.21 | 0.30 | 0.31 | 0.29 | 0.31 |
| Wheat and insecticide | 0.0 | 0.12 | 0.19 | 0.15 | 0.20 | 0.25 | 0.25 |
| Mean | 0.14 | 0.24 | 0.73 | 0.98 | 1.74 | 3.4 | 3.75 |
| LSD | 0.11 | 0.352 | 0.48 | 1.13 | 1.706 | 2.98 | 1.573 |

**Table 5: Monthly Wheat Grain Weight Loss (%) in on-Farm Storage in Tikul, 2006**

| Treatments | Months | | | | | | |
|---|---|---|---|---|---|---|---|
| | first | second | third | fourth | fifth | sixth | seventh |
| Untreated control | 0.27 | 0.63 | 1.13 | 1.75 | 2.13 | 3.59 | 4.85 |
| Wheat and Sand | 0.02 | 0.15 | 0.32 | 1.23 | 1.95 | 2.15 | 3.35 |
| Wheat and Taff | 0.09 | 0.24 | 0.55 | 1.09 | 1.73 | 2.37 | 3.54 |
| Wheat and Ash | 0.0 | 0.0 | 0.12 | 0.18 | 0.21 | 0.23 | 0.25 |
| Wheat and insecticide | 0.0 | 0.0 | 0.0 | 0.11 | 0.17 | 0.19 | 0.20 |
| Mean | 0.07 | 0.20 | 0.42 | 0.87 | 1.24 | 1.71 | 2.44 |
| LSD | 0.131 | 0.201 | 0.511 | 0.707 | 0.452 | 1.539 | 2.605 |

**Table 6: Monthly Wheat Grain Weight Loss (%) in on-Farm Storage in Woki, 2006**

| Treatments | Months | | | | | | |
|---|---|---|---|---|---|---|---|
| | first | second | third | fourth | fifth | sixth | seventh |
| Untreated control | 0.0 | 0.12 | 0.45 | 0.53 | 0.98 | 1.05 | 1.12 |
| Wheat and Sand | 0.0 | 0.05 | 0.15 | 0.45 | 0.75 | 0.95 | 1.03 |
| Wheat and Taff | 0.0 | 0.03 | 0.11 | 0.49 | 0.83 | 0.98 | 1.11 |
| Wheat and Ash | 0.0 | 0.0 | 0.0 | 0.0 | 0.12 | 0.15 | 0.14 |
| Wheat and insecticide | 0.0 | 0.0 | 0.0 | 0.0 | 0.09 | 0.15 | 0.15 |
| Mean | 0.0 | 0.04 | 0.11 | 0.29 | 0.55 | 0.24 | 0.71 |
| LSD | 0.0 | 0.032 | 0.231 | 0.223 | 0.393 | 0.457 | 0.325 |

**Table 7: Germination Percentage of Damaged Wheat Grain in on-Farm Storage in Teraemini, 2006**

| Treatment | Months | | | | | |
|---|---|---|---|---|---|---|
| | 1st month | 2nd month | 3rd month | 4th month | 5th month | 6th month |
| Untreated control | 97.3 | 93.2 | 87.1 | 78.8 | 65.2 | 59.2 |
| Wheat and sand | 95.4 | 92.3 | 85.2 | 82.3 | 67.3 | 58.5 |
| Wheat and taff | 94.5 | 90.5 | 85.3 | 80,8 | 66.4 | 61.3 |
| Wheat and ash | 95.7 | 95.8 | 95.1 | 94.2 | 93.3 | 95.1 |
| Wheat and Chemical | 96.3 | 96.2 | 95.1 | 95.4 | 94.3 | 94.2 |
| Mean | 95.84 | 93.60 | 89.56 | 86.30 | 77.30 | 73.66 |
| LSD | 2.21 | 1.32 | 1.01 | 1.53 | 1.04 | 2.758 |

**Table 8: Germination Percentage of Damaged Wheat Grain in on-Farm Storage in Tikul, 2006**

| Treatment | Months | | | | | |
|---|---|---|---|---|---|---|
| | 1st month | 2nd month | 3rd month | 4th month | 5th month | 6th month |
| Untreated control | 95.3 | 93.5 | 87.2 | 82.7 | 79.3 | 73.2 |
| Wheat and sand | 96.1 | 94.5 | 90.5 | 85.3 | 81.2 | 71.5 |
| Wheat and taff | 94.5 | 92.5 | 88.3 | 84.7 | 81.3 | 72.5 |
| Wheat and ash | 95.6 | 93.5 | 94.5 | 93.8 | 92.5 | 95.1 |
| Wheat and Chemical | 94.7 | 93.5 | 94.1 | 93.5 | 92.1 | 93.5 |
| Mean | 95.24 | 93.50 | 90.86 | 88.00 | 85.28 | 81.16 |
| LSD | 1.12 | 1.32 | 1.52 | 1.43 | 1.42 | 1.55 |

in the last two moths of storage. Ash and insecticide treatments had significantly higher germination percent in all the sites during the study period (Tables **7** and **8**).

### Gain Hole

The mean percent of grain hole was very low in all the treatments one month after germination (Table **9**). The percentage of gain holes increases with the increase of the storage period in control, sand and taff treatments. There was no a significance difference among these treatments in the percentage of grain hole. Ash and insecticide treatment had significantly lower percent of grain holes than all the treatments.

## DISCUSSION

The on-farm grain storage studies showed that there were no significant differences in all the trials and their respective treatments up to two months of storage period. This was mainly due to the fact that the pest population was very low in all the trials. However, after

**Table 9: Mean Percent of Wheat Grain Holes in on-Farm Storage in Teraemini, 2006**

| Treatment | Months | | | | | |
|---|---|---|---|---|---|---|
| | 1st month | 2nd month | 3rd month | 4th month | 5th month | 6th month |
| Untreated control | 0.23 | 1.53 | 4.57 | 5.63 | 7.25 | 9.38 |
| Wheat and sand | 0.13 | 1.73 | 3.98 | 6.78 | 8.12 | 9.25 |
| Wheat and taff | 0.17 | 1.23 | 4.68 | 5.98 | 7.45 | 8.97 |
| Wheat and ash | 0.0 | 0.0 | 0.15 | 0.37 | 0.75 | 0.58 |
| Wheat and insecticide | 0.0 | 0.0 | 0.15 | 0.25 | 0.55 | 0.53 |
| Mean | 0.11 | 1.144 | 2.69 | 3.80 | 4.82 | 5.74 |
| LSD | 0.21 | 0.45 | 1.53 | 1.45 | 1.75 | 1.68 |

the third month and onwards the pest population gradually increased causing more grain damage. There was a significance difference in storage pest infestation and damage among the three sites. The highest infestation and damage count were recorded in Teraemini followed by Tikul. The results of the Woki storage study showed a very low pest infestation and percent grain damage in all the treatments throughout the study period. Very low grain damage was recorded in the fifth to seventh months after storage. The main reason for this low infestation and low damage could be due to the high altitude (2400 m a.s.l.) of the site and windy in most parts of the year and cold temperature. The farmer's house where the trial was conducted was on top of a hill where it was windy and cold. Good aeration and low or cold temperature preserves grain from deterioration, insect population and mold development in store. The highest damage in all the trials was observed in the six and seventh month after storage. In all the trials, untreated control had a significantly higher percent of grain damage, weight loss and lower percent of grain germination followed by sand-grain and taff-grain mixture treatments. Sand-grain and taff-grain mixtures had a lower grain damage and weight loss up to four months of storage and there after increased grain damage and losses. On the other hand ash and insecticide treated grains had a significantly lower insect population with lower grain damage and germination loss than the other treatments. Similar results were obtained in ash and chemically treated grains of sorghum after two months of storage. This lower number of grain damage count could be due to these treatments having different inhibiting factors against the storage pests. Insecticides are toxic substances which are able to kill insects, and reduce grain damage. They affect storage pests by contact action or penetrate the insect's body through cuticle and are inhaled through the respiratory system, which causes the insect to die and finally reduce the population build-up [11]. Many insecticides such as Malathox and acetlic (Cypermethrin) 1% dust and fumigants are used to protect grains under storage conditions; however, grains for food consumption should not be treated with chemicals that have residue, as these chemicals would have an effect on the human being or animals. Grains that are stored for food should be controlled using fumigants, the most effective and convenient one being phosphine.

Ash has been used in storage pest control in most developing nations of Africa and Asia. Farmers in Eritrea and other developing nations mix field pea or chickpea grains with ash. This method is still recommended as a cheap and safe control method. To be efficient, one should use at least 5 % of ash [12]. Ash is an inert dust that affects the respiratory system of the insect and may kill it by suffocation. Khaire [13] reported that mixing ash with grain makes the entry of insects in grain a difficult task and causes physical and physiological injuries to the insects. Besides, ash is a fine powder chemically inactive but with insecticidal power such as silica that wears out of the mandible. The ash dust that reduces the relative humidity of the storage condition could also dry the grain surface. Egg laying and larval development of the beetles could be hampered because ash dust covers the grain seeds. It might also affect the insect movement to search for mating partners. Aslam and Suleman [14], in their studies of storage grain, reported that friction of the dust particles with the insect's cuticle leads to desiccation and hampers the development of the pests. Adugna reported in their survey that farmers in Eritrea use a mixture of small sized grain and fine sand which gave good control of grain storage pests. According to the farmers' experience, these treatments lower the temperature of the storage condition. During their studies, it was observed that the damage of the grain and weight loss was low in the sand and taff mixed stores for the first four to five months and then damage increased resulting in higher weight loss of grains in all the studies. This could be due to the fact that these treatments had less air suffocation as compared to ash. It might be also due to the rough surface of sand particles that can scratch the eggs of the insects laid on the surface of the grain and hence reduce the viability of the egg to hatch. The other reason could be that sand and taff are smaller than grain size and settle down to the bottom of the bags which makes the grain remain on top of the containers alone in due time. This could give a chance for the pests to build-up their population and cause damage on the upper part of the storage container. This leads the insect to disseminate all over the grains, and particularly in the upper part of the grain storage container. The germination percent for the control (untreated control), sand and taff in all the trials decreases with the increasing storage period. This was mainly due to the fact that these treatments were not effective to reduce or control the pest population. During the germination test it was observed that all the damaged seedlings were very weak; this could be due to the depletion of the reserved food of the grain by the pests.

## CONCLUSIONS AND RECOMMENDATIONS

It is a natural phenomenon to decrease the weights of the grains as the storage period progresses. This is mainly due to the insect pest population increased with

the progress of the storage period and hence the damage to the grain increased in due times causing a sever loss in weight of the stored grain. The grain damage was very higher in the lower altitudes study areas and in treatments of untreated control followed by sand-grain and taff-grain mixtures. Storage in higher altitude and cold areas had lower pest damage mainly due to the build up of the pest population is affected or suppressed by low temperature and good aeration in the storage area. Ash and Malathox 1% treatments were found to be more effective in controlling the storage pest in all the trials. Ash and had low or no storage pest problems in all the study sites; ash is easily available to farmers and is environmental friend. The use of these treatments should be popularized to farmers for control of storage pests. Ash is used in a high amount or volume; it is very difficult to use it when the amount of grain to be stored is in high quantity. Hence, its use is best for seed and small quantity food grain storage systems.

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