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Full Length Research Paper

On-farm storage studies on sorghum and chickpea in Eritrea

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On-farm storage studies were conducted in Teraemini, Ashera and Hamelmalo sub-zones in Eritrea during 2004/2005, with the objective of finding the damages caused by storage pests under farmers' situations. The studies were conducted on chickpea and sorghum and the treatments used were sand, small grain (taff, *Eragrostis tef*), vegetable oil and chemical (Malathox 1%). Data were collected every month on the number of eggs, number of holes, grain damage, weight loss and germination of the grains. The major storage pests observed during the studies were bruchids (*Callosobruchus chinensis* L.) on chickpea. Sorghum was attacked in storage by Angoumois grain moth (*Sitotroga cerealella*), weevils (*Sitophilus* spp), confused flour beetles (*Tribolium* spp), saw toothed grain beetles and mites. The populations of these pests were very low in the first three months. However, after three months of storage the population of the pests in all grains and locations increased very fast and caused high damage. The highest grain damages were recorded in the untreated control (check), sand and taff treatments. The weight loss for sorghum and chickpea in the untreated control (check) were 9.17 and 27.51%, respectively. Ash, oil and chemical treatments significantly lowered grain damage and weight loss in all the studies and locations. Ash and edible oils-treated grains had low or no storage pest problems in all the study sites.

Key words: Sorghum, chickpea, storage, sand, ash, taff, bruchids, weevils, storage and germination loss.

INTRODUCTION

On-farm storage studies made in Eritrea under the Drylands Coordination Group showed that staple grains of cereals and pulses produced by small farmers in Eritrea are attacked by different storage pest species of insects, rodents and birds. The germination loss due to the attack of storage pests on cereals and pulse grains ranges from 3-37 and 4-88%, respectively. The weight loss for these grains also ranges from 4.4-14 and 9-29% for cereals and pulses, respectively (Adugna et. al., 2003). 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 loss for damaged seeds in these areas ranging from 50-92% (Tedros and Kebrom, Unpublished). Farmers in the highlands and lowlands and ethnic groups in Eritrea have traditional storage types that consist of short and long term stores. The short-term storage types are highly variable from area to area and even within the same ethnic group. They differ in shape, size and are made out of different materials. They are mainly used for short-term storage and have a size of 0.3 to 0.4 tons. The long-term type of storage types also varies from area to area. Koffo is the main storage type in the highland, Wia or Suga in the western lowland, Gufet in Barka and Anseba regions; these are the main storage types in the country.

Detailed studies undertaken in other countries 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*) (Hall 1990). 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 of grain weevils (Youdeowei, 1983). Ogunlane (1976) in Nigeria reported that maize stored in cribs for four months loses about 28% due to insect damage. Wheatley (1973) 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.

Ditcher (1978) 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.

Insects damage grain directly by feeding on kernels and indirectly by contaminating the grain with their wastes, webbing and body parts. Common stored grain insects may be separated into four groups according to their feeding habits. Internal feeders enter the kernel as very young larvae and spend most of their life cycle inside the kernel. These insects cause an obvious hole in damaged kernels where the adult insect exits the kernel to mate and begin the next generation. Examples of internal feeders are the rice weevil, maize weevil and Angoumois grain moth. Both larvae and adult insects can usually be found in the grain, Bruchids (*Callosobruchus* spp.) cause a potential loss in legume by feeding on the protein content of the grain and their damage ranges from 12-30% in developing countries (Tsedeke, 1985; FAO, 1994). *Callosobruchus chinensis* caused 35% grain legume losses in Central America and Africa (Singh, 1990). FAO 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 (Leakey and Wills, 1977). According to Hall (1990), 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 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 the western lowlands of Eritrea, Wia (grain storage) remains open for a long period until the rainy season so that it is easy to take out grains when needed. This makes it easy for pest infestation. Similarly, in the highlands of Eritrea farmers keep grain in Koffos from one harvest to the next for seed or as food security and the Koffos most of the time remains open for a prolonged period. This helps the pests migrate from old grains to new ones. 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; some use internationally banned chemicals like DDT, chemicals that leave residue, kerosene, and different traditional methods such as mixed cropping, ash, sand, chilli, pepper, smoke and plant materials. However, some of these traditional methods need further investigation to study the proportion of mixing small grain with large grains, and the ratio of ash or sand with grain. After harvest, grain often contains small amounts of straw, weed seeds and dirt. These unwanted materials decrease the value of the crop if they remain in the grain. They also cause the grain to deteriorate during storage. Dirt holds moisture, insects and molds. Dirt also keeps air from moving well through the grain (Wilfred, 1994). If moist seeds are stored without air moving through them, the grain becomes hot, respires/breathe more quickly and gives off more heat and moisture. The grain is damaged if the heat content is too high, i.e. heat builds up more quickly, molds form rapidly, insects multiply faster and the grain can germinate (sprout) while in storage (Youdeowei et al., 1983).

The objectives of this work is to (1) study the effect of crops, ash, sand, and chemical on storage pests, and (2) study the loss of stored grain due to storage pests using different traditional, treatments such as ash, sand, edible oil and others.

MATERIALS AND METHODS

On-farm storage loss assessment studies were conducted on sorghum and chickpea in farmers' traditional store in Teraemini, Hamelmalo and Asheray (Hagaz). The grains for the study were bought from the market and they were fumigated prior to the study to avoid any pre-pest infestation. Sorghum on-farm storage studies were conducted in Hagaz and Hamelmalo with an altitude of 1100 and 900 m, respectively. At each site twenty bags filled with sorghum grain weighting each 50 kg were used for the study. The treatments used were taff (*Eragrostis tef*), sand, ash and chemical control (Malathox 1% at the rate of 15 ppm). A chickpea storage study was conducted in Teraemini with similar treatments to sorghum plus one additional treatment of edible oil used at a rate of 10 ml per kg of grain. The rate of sand and taff were at 1:1, i.e. for each 50 kg of grain (sorghum or chickpea) 50 kg of sand or taff was used.

Data were collected every month for seven months, starting from October 2004 up to April 2005. At each sampling date 250 g 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) were taken and placed in Petri dishes, put in a germination cabinet to determine the germination (%). Data on the number of eggs, larvae, adult insect and damaged holes were counted and recorded.

RESULTS

Chickpea

The bruchids beetle (*Callosobruchus chinensis*) was the only storage pest of chickpea recorded during the study period. The source of infestation could be from the stored grain residue of the previous year or the structure of the store. The Bruchids beetle (*Callosobruchus chinensis)* is a major pest of chickpeas, lentils, green gram, broad beans, soybeans and cow peas in various tropical regions. Adult *Callosobruchus* beetles do not feed on stored produce, and are very short-lived, usually no more than 12 days under optimum conditions. During this time the females lay many eggs. As the eggs are laid, they are firmly glued to the surface of the host seed. Eggs hatch within 5-6 days of the oviposition. Upon hatching, the larva bites through the testa of the seed and into the cotyledons. Bruchids cause damage to grain in store in one of the following ways: Attack on the endosperm resu-

Table 1. Monthly chickpea grain damage (%) in one farm storage in Teraemini, 2005.

Treatment	Months						
	1st	2nd	3rd	4th	5th	6th	7th
Control	0.37	0.98	3.9	12.8	17.5	25.9	31.75
Ash	0.0	0.0	0.12	0.15	0.4	0.73	0.5
Taff	0.21	1.01	1.65	4.65	13.45	21.51	25.57
Sand	0.18	0.89	3.51	6.2	16.52	23.45	27.24
Oil	0.0	0.0	0.15	0.71	0.96	0.95	1.38
Malathox (1%)	0.0	0.0	0.13	1.02	1.16	0.78	0.89
L.SD	0.12	0.34	0.61	1.13	2.49	3.78	3.52
CV%	19.6	22.8	23.6	20.5	22.3	22.4	18.0

Table 2. Monthly chickpea grain weight loss (%) in on-farm storage in Teraemini, 2005.

Treatment	Months						
	1st	2nd	3rd	4th	5th	6th	7th
Control	0.23	1.47	3.25	9.85	19.2	20.21	27.51
Ash	0.00	0	0.15	0.24	0.31	1.2	1.52
Taff	0.45	0.55	1.34	3. 63	7.34	8.15	10.52
Sand	0.32	0.46	2.85	4.82	11.9	14.53	17.35
Oil	0.00	0.12	0.22	0.71	0.93	1.28	1.08
Malathox (1%)	0.00	0.11	0.73	0.71	0.84	0.93	0.85
L.SD	0.31	0.35	0.51	2.39	3.85	2.78	4.56
CV%	16.51	23.3	21.3	14.15	16.8	23.4	17.3

Table 3. Germination (%) of damaged chickpea grain under on-farm storage in Teraemini, 2005.

Treatment	Months					
	1st	2nd	3rd	4th	5th	6th
Control	96.3	53.0	32.0	27.9	22.3	13.0
Ash	95.6	87.5	78.9	80.5	82.1	80.3
Taff	90.5	75.4	45.3	37.8	14.4	11.4
Sand	89.5	66.7	33.0	26.7	37 .5	19.0
Oil	85.7	85.0	87.0	89.1	85.0	83.5
Malathox (1%)	87.5	85.0	89.0	85.5	87.3	83.6

lts in a loss of weight and in a reduction in nutrients and quality. Germ damage causes a reduction in the seed's ability to germinate and ultimately the specific gravity of the grain decreases which finally lowers the market value of the product. Sometimes bruchids produce additional moisture and heat in the environment (store) through respiration, which results in a rapid multiplication of insect pests in the store. This leads to increased respiration and heating of the grain causing rapid growth of fungi and bacteria which spoil the grain and produce aflatoxins, which is poisonous to human beings.

Grain damage

The results of chickpea grain on-farm storage studies are given in Tables 1-5. The study showed that there was an increase in grain damage in all treatments as the period of storage months extends. Low grain damage counts were recoded in the first month of storage; the infestation during this month showed that there were no significant differences among the treatments used. However, there was relatively higher grain damage in the treatments with sand, taff, and control with means of 0.37, 0.21, and

Table 4. Number of chickpea grain holes in on-farm storage in Teraemini, 2005.

Treatment	Months						
	1st	2nd	3rd	4th	5th	6th	7th
Control	1.75	4.93	25.3	67.8	30.45	125.7	45.0
Ash	0.71	0.35	0.45	0.75	0.51	0.25	0.8
Taff	5.25	0.25	10.8	31.3	85.25	69.31	56.2
Sand	1.75	4.50	22.3	31.5	18.45	89.95	70.3
Oil	0.00	0.00	0.51	0.31	0.20	0.25	0.3
Malathox (1%)	0.00	1.25	1.50	0.00	0.75	0.25	0.0
L.SD	1.19	1.12	1.58	2.64	3.4	1.25	3.89
CV%	27.0	25.3	21.3	25.7	28.3	22.3	13.6

0.18%, respectively. Ash, oil and chemical treatments had the lowest grain damage during this count (Table 1). The number of grain damage counts during the second and third months (November and December) showed a higher infestation than the first month count. In the second month count, control, taff and sand treatments had a higher grain damage ranging from 0.89% in the sand treatment to 1.01% in the taff-chickpea treatment. Ash, oil and Malathox (1%) treatments had significantly lower infestation (Table 1). In the fourth months count, damage of the grain increased. The highest damage was recorded on control followed by taff and sand treatments with 12.8, 4.65 and 6.2%, respectively. In parallel there was a significant increase in grain damage during the fifth to seventh months after storage. The highest grain damage was counted on control with 31.75% followed by sand and taff treatments with 27.24 and 25.67%, respectively (Table 1). Throughout the study period, ash, oil and Malathox (1%) treatments had significantly lower grain damage (Table 1).

Weight loss

It is a natural phenomenon to decrease in the weight of grains in storage. It was also observed during this study that the damage increased as the period of storage extends (Table 2). Bruchids cause chickpea damage and affect grain weight loss (Table 2). There was no significant difference in weight loss among the treatments, one and two months after storage. Light weight loss of grain was recorded in control, sand and taff treatments. The weight loss in storage in the third month showed that control, sand and taff treatments had a significantly higher loss with 3.25, 2.85 and 1.34%, respectively, than ash, oil and Malathox 1% (Table 2). The highest grain weight losses were obtained from control, sand and taff treatments during 4 to 7 months of storage. These treatments had a significantly higher grain weight loss. The highest weight losses for the untreated check were 9.87. 19.96, 20.21 and 27.25% for 4, 5, 6 and 7 month storage period, respectively (Table 2). Ash, oil and Malathox gave a significantly lower loss of grain throughout the study period.

Germination

Table 3 shows the germination of chickpea grains in storage. The germination of all treatments were high in the first month count ranging from 86 to over 96%. However, the germination for control, sand and taff treatments decreased as the storage period extended, with 13, 19.4and 11% germination in the 7th month, respectively. The damaged grains showed reduced germination and the sprouting of these seeds was very weak and could not stay alive for a few days after germination i.e. they die immediately in the germination cabinet. The germination for ash, oil and Malathox treated grains did not change much throughout the study period (Table 3).

Grain hole

Storage pests such as bruchids cause grain damage by making holes in the grain. These holes in return affect the weight and germination of the grain. The number of the holes on the grain also increased with the extension of the storage time of the grain in store. Table 4 showed the number of holes on chickpea in the different treatments. In all the treatments there is damage on the grain. However, control, sand and taff treatments had significantly higher number of holes than ash, oil and Malathox treatments (Table 4).

Egg count

The number of egg counts in the different treatments was highly variable. Control, sand and taff treatments had significantly higher egg counts throughout the study period than ash, oil and Malathox. The number of egg counts increased as the storage time of the grain extends and reached maximum in the fifth month of storage. The number of the eggs for control, sand and taff treatments during the fifth month of storage was 166.5, 199.8 and

Table 5. Number of eggs on chickpea grain in on-farm storage in Teraemini, 2005.

Treatments	Months						
	1st	2nd	3rd	4th	5th	6th	7th
Control	9.0	18.75	21.4	25.9	166.5	135.7	169
Ash	0.0	0.0	0.0	0.15	1.25	0.23	0.15
Taff	10.3	17.5	21.3	24.3	170.56	165.6	154.2
Sand	14.3	25.8	28.3	31.2	199.8	167.5	178.5
Oil	0.0	2.5	0.15	0.15	0.15	0.12	0.13
Malathox (1%)	0.0	0.0	0.15	0.21	0.12	0.12	0.15
L.SD	1.38	1.1	0.01	0.89	3.39	2.44	0.93
CV%	14.6	21.5	19.7	16.3	24.3	15.7	9.9

Table 6. Monthly sorghum grain damage (%) in on-farm storage in Hamelmalo, 2005.

Treatment	Months						
	1st	2nd	3rd	4th	5th	6th	7th
Control	0.15	0.89	2.58	3.35	7.21	9.83	12.45
Ash	0.0	0	0.13	0.25	0.23	0.0	0.5
Taff	0.12	0.55	1.23	3.04	6.78	7.06	9.21
Sand	0.13	0.73	1.31	2.98	7.01	8.95	13.52
Malathox (1%)	0.0	0.0	0.0	0.12	0.21	32	0.5
L.SD	0.11	0.45	1.12	1.32	2.32	2.27	3.23
CV%	15.1	14.3	15.3	25.1	13.4	16.8	22

Table 7. Monthly sorghum grain damage (%) in on-farm storage in Asheray, 2005.

Treatment	Months						
	1st	2nd	3rd	4th	5th	6th	7th
Control	0.35	2.6	2.98	4.58	5.25	7.52	7.98
Ash	0.0	0.0	0.0	0.23	0.35	0.5	0.75
Taff	0.5	0.8	4.15	6.2	8.25	15.2	8.15
Sand	0.54	1.4	2.14	3.2	4.28	7.75	8.87
Malathox (1%)	0.0	0.0	0.0	0.0	0.2	0.25	0.35
L.SD	0.13	0.76	1.04	1.19	0.56	2.3	6.03
CV%	11.3	9.31	11.2	19.3	13.3	22.5	21.03

170.56 eggs, respectively, which thereafter declined in the 6th and 7th months of storage (Table 5).

Sorghum

Angoumois grain moth, weevils, confused beetle, saw-toothed grain beetle and mites were the main storage pests of sorghum. Angoumois grain moth was the major storage pest followed by weevils in both storage sites in Asheray and Hamelmalo. Saw-toothed grain beetle and mites were recorded in Hamelmalo, while the confused grain beetle was observed only in Asheray. In both sites the damage of sorghum grain by storage pests was very high.

Grain damage

The sorghum grain damage in the first and second months after storage was very low in all treatments at both sites (Tables 6 and 7). However, the grain damage increased with the extension of the storage period in the treatments of control, sand and taff treatments. In both sites the highest grain damage was recorded in the sixth and seventh months after storage. In Hamelmalo, control and sand treatment had the highest grain damage with 12.45 and 13.52%, respectively. In Asheray, there was no significant grain damage among control, sand and taff treatments. Throughout the study period ash and chemical treatments had significantly lower grain damage in both locations (Tables 6 and 7).

Table 8. Monthly sorghum grain weight loss (%) in on-farm storage in Hamelmalo, 2005.

Treatment	Months						
	1st	2nd	3rd	4th	5th	6th	7th
Control	0.12	0.56	1.85	4.35	6.28	7.53	9.15
Ash	0.0	0.0	0.0	0.0	0.13	0.25	0.5
Taff	0.21	0.47	2.35	4.52	5.57	6.85	6.83
Sand	0.15	0.43	2.57	5.52	5.72	7.85	9.75
Malathox (1%)	0.0	0.0	0.0	0.0	0.08	0.1	0.25
L.SD	0.01	0.23	1.03	0.56	1.11	1.09	2.11
CV%	11.3	16.5	10.3	12.3	21.5	18.9	15.9

Table 9. Monthly sorghum grain weight loss (%) in on-farm storage in Asheray, 2005.

Treatment	Months						
	1st	2nd	3rd	4th	5th	6th	7th
Control	0.12	1.2	3.1	5.2	5.51	6.63	8.75
Ash	0.0	0.0	0.12	0.25	0.24	0.27	0.5
Taff	0.25	0.68	2.83	3.89	4.81	5.23	6.98
Sand	0.23	0.83	1.87	4.25	4.57	6.63	8.92
Malathox (1%)	0.0	0.0	0.0	0.0	0.25	0.25	0.3
L.SD	0.21	0.88	0.63	1.14	0.48	1.27	2.57
CV%	7.56	10.2	9.85	12.3	12.6	21.3	26.6

Table 10. Germination (%) of damaged sorghum grain in on-farm storage in Hamelmalo, 2005.

Treatment	Months						
	1st	2nd	3rd	4th	5th	6th	7th
Control	95.2	92.3	75.2	65.13	55.1	48.7	45.6
Ash	93.3	94.21	87.4	90.1	88.7	90.2	85.12
Taff	94.2	95.7	78.3	71.7	65.2	56.3	52.32
Sand	92.1	89.4	81.2	68.2	61.01	52.2	43.57
Malathox (1%)	93.5	94.1	86.4	89.6	91.1	84.3	85.3
L.SD	2.31	1.27	2.51	1.42	3.41	1.78	1.27
CV%	9.52	21.5	12.5	51.1	8.52	13.5	22.3

Weight loss

The weight losses of sorghum under storage were the same in both sites. Like the grain damage, the weight losses of sorghum due to storage pests were low in the first and second month after storage in all the treatments. The sorghum losses were significantly higher in the treatments of control, sand and taff treatments and the losses in these treatments increased with the length of the storage period. The highest weight losses were recorded in the sixth and seventh months after storage (Tables 8 and 9). The weight losses in the taff treatment range from 6.83 to 9.75% in both sites. The weight loss for ash and chemical control were significantly lower than the other treatments (Tables 8 and 9).

Germination

There was no significant difference in germination in the damaged grain during the first and second month after storage, where all the treatments had high germination. The germination for control, sand and taff treatments decreased as the period of storage increased. The lowest germination for Hamelmalo and Asheray were recorded from the treatments of sand treatment and control with 43.57 and 43.51%, respectively (Table 10). The germination for ash and chemical control were high in all the months.

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 the third month and onwards the pest population gradually increased causing more grain damage. The highest damage in all the trials was observed in the 6th and 7th month after storage. In all the trials, untreated check (control) had a significantly higher grain damage, weight loss and lower grain germination followed by sand and taff treatments. Sand and taff treatments had a lower grain damage and weight loss up to four months of storage and thereafter increased grain damage and losses. On the other hand ash, oil and insecticide treated grains of chickpea 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 (Hall, 1990). Many insecticides such as Malathox and Actelic (Cypermethrin) 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.

Vegetable oil was used in chickpea control studies. It acts as a grain protection against beetles in storage (Khaire, 1992). Oil is effective against storage pests because it has a slippery and/or oily property in which the eggs of the insect could not be attached to the grain surface. It could also have a repellent character whereby the insect cannot come in contact of the grain. The low grain damage in oil treatments might be due to the decrease in number of adult emergence that results in less weight loss and less kernel damage (Vijaya and Khader, 1990). Ash has been used in storage pest control in most developing nations of Africa and Asia. Farmers in developing nations mix cowpea 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 (Tsedeke, 1985). Ash is an inert dust that affects the respiratory system of the insect and may kill it by suffocation. Khaire (1992) 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. 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 (1999), 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 et al. (2003) 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. The other reason could be that sand and taff are smaller in 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 for the control (untreated check), 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, all the damaged seedlings were very weak; this could be due to the depletion of the reserved food of the grain by the pests. It was observed that the damaged grains had a bad smell which could be due to the rupture of eggs on the surface of the grain and development of mould on the grain.

In conclusion, the monthly grain damage, weight and germination losses increased with the extension of the storage period. The highest grain damage, weight and germination losses were recorded in the untreated control sorghum and chickpea trials followed by sand and taff treatments. Ash, edible oil and Malathox (1%) treatments were found to be more effective in controlling the storage pest in all the trials. Ash and edible oils had low or no storage pest problems in all the study sites; these materials are easily available to farmers and are environmentally friendly. 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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