Arthropod Pests of Stored Maize in Sidama Zone: Economic Importance and Management Practices

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Abstract

We conducted surveys of stored maize grain arthropod pests and their natural enemies in four *weredas* of Sidama Zone, southern Ethiopia, in 1992 and 1993. We set out to determine the extent of losses due to these pests and explore farmers' management practices against stored maize grain insect pests. Results of the survey revealed a total of 14 arthropods in the groups of primary pests, secondary pests and parasitoids. Of the primary pests, the Angoumois grain moth (*Sitotroga cerealella*) and the maize weevils (*Sitophilus* spp) were found to be the most common and important, where they accounted for 77 to 95 percent of the total insect numbers counted. *Sitotroga cerealella* alone caused 11.2 to 13.5 percent weight loss while all other pests together caused 5.6 to 6.4 percent weight loss. As part of integrated management of stored maize grain insect pests, locally available materials were evaluated in the laboratory against *S. cerealella* in 1992 and 1993 at Awassa Research Centre. Of the local materials tested, tobacco dust, followed by wood ash-tobacco dust-saw dust-sand mixture gave the best control of the pest.

Introduction

In Ethiopia maize is one of the five cereal crops mainly grown for human consumption. Among the cereals, maize ranks first in total production and productivity (CSA 1995). Approximately 1.7 million metric tonnes of maize grains are produced yearly in the country on more than one million hectares of land (Benti et al. 1992).

In southern Ethiopia maize is grown by small scale farmers. Sidama Zone is one of the zones where maize is extensively grown in the southern region. In this zone the area coverage of maize is estimated to be 0.11 million ha which accounts for 32 percent of the cultivable land (Sidama Zone Bureau of Agriculture, unpublished data). Maize grain production capacity of individual farmers in the zone ranges from one tonne to four tonnes (Emana 1993a,b). The grain suffers from heavy losses from insect pests in the store in this area. Farmers estimate the loss in the range of 50 to 75 percent within nine months of storage. Experts of the Bureau of Agriculture claim the loss to be 20 to 30 percent within six months of storage (Assaye Lemma, personal communication). Emana (1993a) also reported 50 percent grain infestation by stored grain insect pests on maize grain stored for six months from the same zone.

Currently, maize production in Sidama Zone is increasing by 2-4 fold. However, farmers complain about the damage caused by stored maize grain insect pests. There is little information with regard to the types of insect pests involved, the amount of loss caused, and the coping mechanisms farmers are practise against storage pests in the zone. Research results on the management of stored maize grain insect pests under Ethiopian condition are also very few. Our work was therefore initiated to determine the pest complex, their economic importance, and to explore and test farmers' management practices.

Materials and Methods

Survey

Surveys of stored maize grain insect pests were conducted in four *weredas* (administrative unit equivalent to a county) of Sidama Zone in 1992 and 1993 (Fig. 1). The *weredas* included Awassa Zuria, Shebedino, Dale and Aletawendo. These were selected because they are the main growers of maize in the zone. From each *wereda* four localities were taken using a stratified random sampling technique. In 1992, four stores and in 1993, 10 stores from each locality were randomly assessed. Both shelled and unshelled grains were sampled during the survey. Samples were drawn from top, middle and bottom of each storage structure. Samples were evaluated twice in the laboratory - immediately after survey and one month later. As some of the important pests such as the Angoumois grain moth (*S. cerealella)* and the maize weevil (*Sitophilus* spp) are internal feeders data used to calculate percent weight loss were obtained from the assessment of the one month later. Percent weight loss was calculated using the count and weigh method by the following formula:

$$\%\ weight\ loss = \frac{(Wu \times Nd) - (Wd \times Nu)}{Wu(Nd+Nu)} \times 100$$

Where: Wu = Weight of undamaged grains
Nu = Number of undamaged grains
Wd = Weight of damaged grains
Nd = Number of damaged grains

Grain samples from each locality were mixed after one month. Then healthy kernels were collected and disinfested at -16°C for 10 days in deep freeze. Then germination test of samples from each locality was done for healthy and infested kernels. Percent germination reduction was then calculated using the germination percentage of healthy kernels as 100%.

Moreover, insects found in the samples were counted and preserved for identification purpose. Different insect identification tools such as insect key, standard pictures from the literature and examination under a dissecting microscope were employed. All specimens were sent to International Institute of Entomology (IIE) London for confirmation.

The grain samples were evaluated as number and weight of damaged kernels by *S. cerealella* and other insects. We did this because it is only the feeding mark of *S. cerealella* that can be distinctly differentiated from other insects feeding marks. For example, the feeding marks of *Sitophilus* spp, *Rhizopertha dominica*, *Tribolium* spp and others are difficult to tell apart. Thus, kernels damaged by these groups of insects were grouped together under the "other insects" category. Along with grain sample collection, the owner of each visited store and other farmers of the locality were presented with a questionnaire containing pieces of information on status of stored maize grain insect pests, types of insects involved, loss incurred within a given period of storage time, size of produce per farmer, and farmers' management practices.

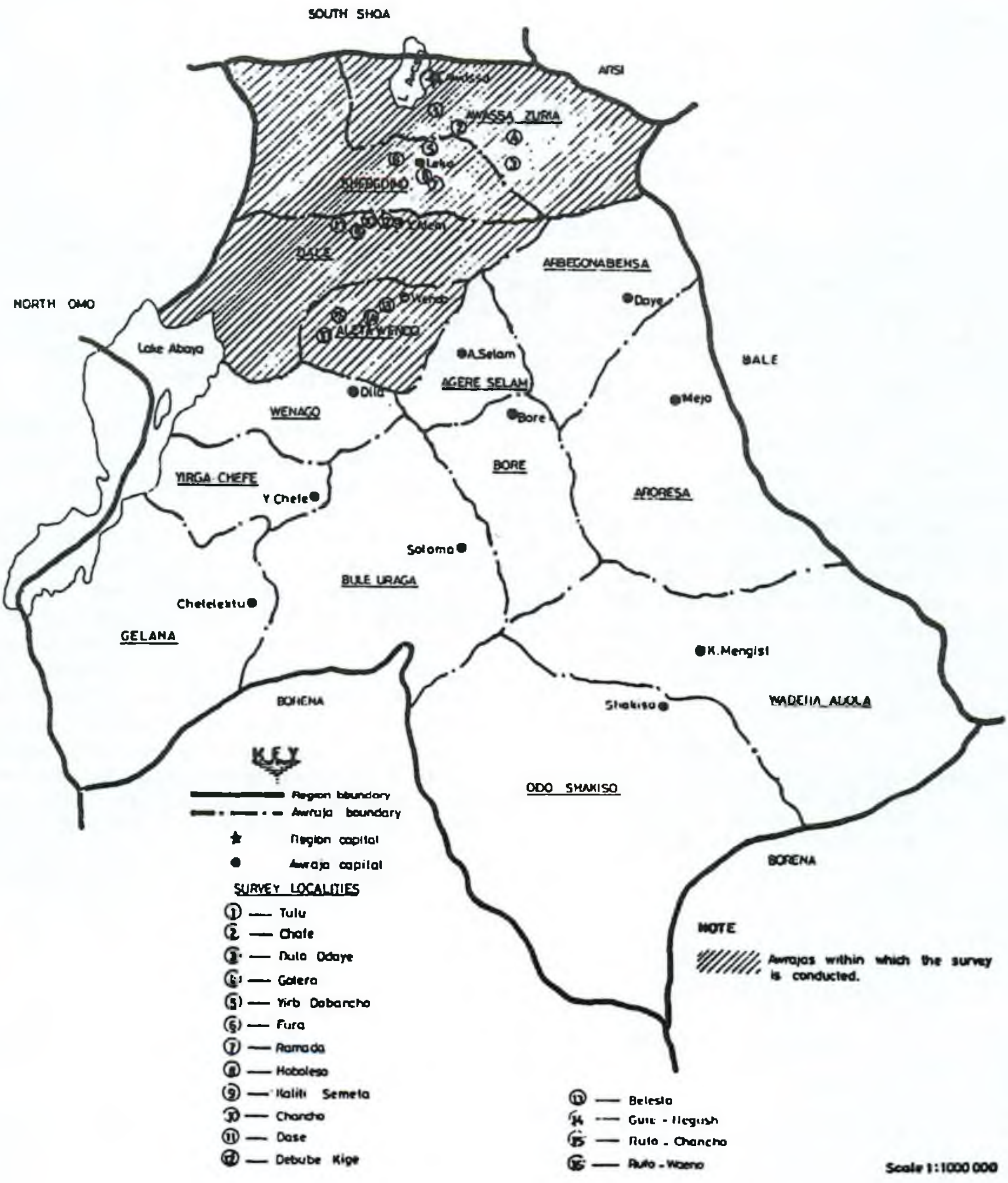

Fig. 1. **Sites covered in the survey of s. cerealella in Sidamo**

Source: Sidamo Regional Planning Office

Management of *S. cerealella* Using Locally Available Materials

The local materials tested were 20, 30 and 40 percent each of wood ash, tobacco dust, sand and sawdust, respectively, and 40 percent of the mixtures of wood ash, tobacco dust, sand and sawdust. These were compared with 2% w/w neem seed, two rates of pirimiphos-methyl (4 and 8 ppm), shelled and unshelled untreated checks. A maize variety 'A-511' commonly grown in Sidama Zone was used for the experiment. Seeds of this variety were disinfested in deep freeze at -16°C for 1 month. After that period, damaged and undamaged kernels were separated. The undamaged seeds were admixed with different locally available materials used by the farmers. The admixtures were infested with 0-4 hr old 20 *S. cerealella* moths and stored in the laboratory. The sex ratio was found to be 1:0.8 (female:male). The experiment was designed in a completely randomized design, replicated three times. Six months after storage, the kernels were separated from admixtures and evaluated by taking samples of 2000 kernels per replication. This was converted to percentage for statistical analysis. Besides this, 100 kernels were randomly picked and tested for germination. The experiment was conducted for 2 years, in 1992 and 1993.

Results

Survey results are summarised in Tables 1-4. The tables summarise insect species recorded , percent weight loss and farmers' practices to control stored maize grain insect pests in Sidama Zone. Table 1 indicates percent samples containing each species and proportion of each species in relation to total insect population collected from the samples. *Sitotroga cerealella* was recorded from 96% to 98% of the samples (Table 1). Nearly 50% of the insects collected from the samples consisted of *S. cerealela* with *Sitophilus zeamais* being next to *S. cerealella* in importance in Sidama Zone as it was recorded from 87% of the samples and also comprised nearly 36% of the total insect population. In 1992, 10 insect species, and in 1993, 13 insect species and one mite species were recorded. Insects listed in Table 1 consist of primary pests (*Sitotroga cerealella*, *Sitophilus zeamais*, *Sitophilus oryzae*, *Rhizopertha dominica*), secondary pests (*Ephestia cautella, Tribolium castaneum, Tribolium confusum, Plodia interpunctella, Liposcelis sp, Oryzaephilus surinamensis, Cryptolestes ferrugineus*) and parasitoids (*Anisptermalus calandrae, Trichogramma spp*). The mite (*Acarus siro*) is also a secondary pest.

In Table 2 percent weight loss due to *S. cerealella* and other insect/mite pests together are presented as estimated using the "count and weigh" method. According to the table, *S. cerealella* alone caused yield losses ranging from 11 to 13 percent. The other pests together caused yield losses ranging from 5.6 to 6.4 percent. Table 2 also shows that *S. cerealella* is widely distributed between 1600 and 1980 m above sea level as it caused economic losses within the indicated range of elevation. Though the loss incurred at higher altitudes is quite large, the importance of *S. cerealella* tended to decline at higher elevations.

In Table 3, it is indicated that insect infestation could result in germination reduction ranging from 25.5 to 26.6 percent. Relatively lower percent germination reduction was observed at higher elevations.

Farmers of Sidama Zone have a number of century-old coping mechanisms against stored maize grain insect pests as shown in Table 4. According to the table, 78 percent of farmers interviewed use different mechanisms to control stored maize grain insect pests. These mechanisms include physical, chemical, cultural, the use of botanical and inert materials such as wood ash and sand.

Table 1. Arthropods recorded from stored maize grain in Sidama Zone, southern Ethiopia.

Species	Samples containing each species (%)		Proportion of species (%)	
	1992	1993	1992	1993
Sitotroga cerealella (Olivier)	96.4	97.5	57.4	41.6
Sitophilus zeamais Motsch.	83.0	90.0	37.5	34.6
Ephestia cautella (Walker)	24.0	52.5	1.4	2.9
Tribolium castaneum (Herbst)	15.3	25.0	1.2	6.2
Plodia interpunctella (Hubner)	5.7	38.1	0.1	1.3
Tribolium confusum Jacqualin Duval	12.0	22.5	0.4	3.9
Liposcelis sp	4.6	11.5	0.1	1.2
Sitophilus oryzae (L.)	-	13.8	-	1.1
Oryzaephilus surinamensis (L.)	-	9.4	-	0.3
Cryptolestes ferrugineus (Stephens)	-	8.1	-	0.4
Rhyzopertha dominica (Fab.)	0.6	5.6	0.4	1.7
Acarus siro (L.)	-	11.3	-	1.7
Anisopteromalus calandrae (Howard)	5.3	9.4	0.2	1.5
Trichogramma spp	3.5	13.1	1.5	1.0

Table 2. Percent weight loss in stored maize grain due to *Sitotroga cerealella* and other arthropods in Sidama Zone, southern Ethiopia.

Locality	Altitude (m)	Losses due to *S. cerealella*		Losses due to other insects	
		1992	1993	1992	1993
Kaliti Semeta	1600	17.6	20.4	7.3	11.1
Chancho	1630	14.8	14.5	4.5	9.4
Debube Kige	1635	16.9	12.4	10.5	7.8
Dase	1640	22.5	12.5	9.8	8.5
Gotera	1700	12.7	11.8	7.6	9.0
Tulu	1710	10.5	9.2	6.5	4.5
Chafe	1730	11.6	10.2	9.8	7.0
Rufo-Chancho	1730	14.8	12.5	11.5	4.0
Dato-Odye	1740	15.4	10.5	4.5	7.5
Fura	1810	12.6	9.1	5.5	1.9
Hawlso	1810	13.5	11.2	6.5	3.5
Gure-Waeno	1815	11.7	12.3	4.5	2.9
Gure- Negash	1850	12.5	10.4	3.0	4.4
Weyebi-Bulesto	1870	13.3	6.8	3.2	3.6
Ramada	1900	8.6	8.9	2.5	1.9
Yerba-dobancho	1980	7.5	6.5	4.5	1.9
Mean	-	13.5	11.2	6.4	5.6
S.E.		0.9	0.8	0.7	0.8

Table 3. The effect of insect damage on germination of stored maize in Sidama Zone, southern Ethiopia.

Locality	Percent germination reduction		
	1992	1993	Mean
Kaliti Semeta	35.6	42.6	39.2
Dase	42.4	28.4	35.4
Debube Kige	33.5	26.5	29.9
Rufo-Chancho	36.8	22.4	29.6
Dato-Odye	27.4	31.5	29.5
Chancho	26.5	32.3	29.4
Gotera	28.0	24.3	26.2
Chafe	28.5	23.6	26.1
Hawlso	26.5	24.8	25.7
Gure-Waeno	22.4	26.3	24.4
Fura	24.3	22.8	23.6
Gure-Negash	19.4	24.5	21.9
Tulu	21.2	19.5	20.4
Weyebi-Bulesto	20.6	19.3	19.9
Ramada	15.5	21.8	18.7
Yerba-Dobancho	17.3	16.5	16.9
Mean	22.6	25.5	24.9
SE	1.9	1.6	-
CV(%)	28.0	24.5	-

Table 4. Proportion of farmers practising different methods of pest control on stored maize grains in Sidama Zone, southern Ethiopia.

Practices	No of farmers interviewed	Percent farmers using practice
No control	118	23.0
Insecticide treatment	117	23.0
Fire smoke	67	13.2
Shell grain	58	11.3
out door storage	57	11.1
Sunning	33	6.4
Periodic winnowing	23	4.5
use of wood ash	23	4.5
use of Eucalyptus leaves	17	3.3

Management of *S. cerealella* Using Locally Available Materials

The effect of locally available materials in the control of *S. cerealella* is shown in Tables 5 and 6. According to the tables, tobacco dust, followed by the wood ash-tobacco dust-sand-saw

Table 5. The effect of local pest control materials on percent damage by *Sitotroga cerealella* and germination of maize in the laboratory*

Materials	Mean percent *S. cerealella* damaged kernels		Mean percent germinated kernels
	1992	1993	1992
20% tobacco dust	11.3ab	6.5a	80.4abc
30% tobacco dust	1.7a	9.8a	83.4abc
40% tobacco dust	1.1a	5.2a	87.2ab
10%wa+td+10%s+10%sd (mixture)**	10.3ab	13.2a	92.4a
2% pirimiphos methyl 4 ppm	14.6abc	0.6a	64.9cd
2% pirimiphos- methyl 8 ppm	10.7ab	7.5a	66.9cd
20% sawdust	8.0ab	15.5a	68.0cd
30% sawdust	12.5abc	17.6a	56.6de
40% sawdust	25.2bcd	19.9a	63.3cd
20% wood ash	18.2bcd	33.7ab	71.4cd
30% wood ash	22.6cd	23.6ab	72.7bcd
40% wood ash	19.1bcd	27.0ab	72.3abd
2% neem seed w/w	25.3bcd	23.6ab	77.4abcd
20% sand	22.7bcd	29.1ab	58.9cd
30% sand	35.7cd	18.5a	71.8bcd
40% sand	18.3bc	28.8ab	63.3cd
untreated healthy	-	-	88.9ab
untreated shelled	44.63d	40.2ab	57.2de
untreated unshelled	69.63e	50.4b	41.3e
CV(%)	25.5	34.9	12.3

*Means within a column followed by the same letters are not significantly different from each other (P<0.05) using Duncan's multiple range test (DMRT); **wa=wood ash, td=tobacco dust, s=sand, sd=sawdust*

Table 6. Percent pooled data indicating the effect of various admixtures on mean number of kernels damaged by *S. cerealella**

Admixtures	1992	1993
Tobacco dust	3.1a	4.0a
Mixture	10.9ab	8.5a
Primiphos methyl	12.5ab	9.5ab
Sawdust	15.1bc	17.5b
Wood ash	16.9bc	13.5ab
Neem seed	24.9cd	27.6c
Sand	33.6cd	29.0d
Untreated shelled kernels	44.6d	57.5de
Untreated unshelled kernels	69.9e	23.5e
CV(%)	18.5	22.5

Means within a column followed by the same letters are not significantly different from each other (P<0.05) (DMRT) dust mixture gave the best control of *S. cerealella* consistently in both years. Untreated, unshelled kernels were infested more than the untreated shelled kernels. Kernels treated with pirimiphos-methyl, sawdust, wood ash, neem seed and sand were less infested when compared with the untreated checks. As shown in Table 5, all the treatments had no negative effect on seed germination. The germination percentage of seeds treated with tobacco dust and the mixture was comparable with that of the untreated healthy check.

Discussion

Farmers of Sidama Zone store their maize grain on cob by removing the husk in a storage structure locally known as the "gotera" which is constructed from maize stalks. Arbogast and Mullen (1987) indicated that *S. cerealella* and *Sitophilus zeamais* are the major worldwide pests of stored cereal grains, which occur in any stored cereal ecosystem together with other primary and secondary pests associated with parasitoids. Wengo and Pedersen (1990) put *S. cerealella* and *Sitophilus oryzae* as the major insect pests of stored cereal grains, with *S. cerealella* being more important on maize stored on cob and sorghum stored unthreshed than *S. zeamais* and *S. oryzae*. However, when maize is shelled and sorghum is threshed the importance is reversed. This agrees with our current findings that *S. cerealella* is more important under the Sidama Zone farmers storage system which is unshelled de-husked. Abraham (1991) recorded the same pests of Sidama Zone on stored maize grain in the vicinity of Bako. But, he found the dominant species around Bako to be *Sitophilus* spp, followed by *S. cerealella*, because of variations in the forms of maize stored. In parts of that country farmers store shelled maize.

As shown in Table 1, two genera of parasitoids (*A. calandrae* and *Trichogramma* spp) were recorded which indicate pest-natural enemies interaction in stored maize grain ecosystem under Sidama Zone condition. *Anisopteromalus calandrae* is a well known cosmopolitan parasitoid of Coleoptera and Lepidoptera (IIE 1992). Morrison (1988) indicated that *Trichogramma pretiosum* parastises 43-82% of the eggs of *S. cerealella*. Thus, in the future the potential of parasitoids in the biological control of stored maize grain insect pests in Sidama Zone could be considered as one component of IPM of stored maize grain pest control. *Sitotroga cerealella* is widely distributed in altitudes ranging from 1600 to 1980 m. The loss incurred across the elevation due to this insect is high, ranging from 7-18 percent, with the higher loss being incurred at lower elevations (Table 2). Shazali and Smith (1985) studied the ecology of *S. cerealella* and found that temperature, grain moisture content and relative humidity (RH) are the major factors which limit the survival of *S. cerealella*. At temperatures of 25-30°C, 60-80% RH, and 12-16% grain moisture content *S. cerealella* efficiently feed, perform mating and lay eggs. These conditions seem optimum for *S. cerealella* in all surveyed localities of Sidama Zone. Sampled maize and sorghum seeds in different climatic zones of Nigeria indicated that the relative incidence of the insect pests was related to moisture availability reflected in grain moisture content (Ayertey & Ibiotye 1987).

In addition to weight loss, infestation by stored insect pests such as *Sitotroga, Sitophilus* and others which mainly feed on the embryo of the seed, results in germination loss. In the presence of these two insects in uninfested seed with 95 percent germination potential. Santos et al. (1990) observed reduction in germination with increasing developmental stages in which *S. zeamais* and *S. cerealella* accounted for 13 and 10 percent, respectively. As shown in Table 3, insect pests which are listed in Table 1 resulted in germination reductions ranging from 16 to 43 percent. If farmers happen to use these grains for seed purpose they should plant with additional 16 to 43 percent grain which incurs either cost of seed on farmers or drains family's food. Farmers of Sidama Zone have a variety of traditional control options against stored maize grain insect pests (Table 4). Some of the practices, such as the use of wood ash, fire smoke, periodic winnowing, outdoor storage, sunning and the use of eucalyptus leaves have been practised by farmers for centuries. The use of insecticides is a very recent phenomenon. Relatively higher proportion of farmers do not practise any pest control methods. However, when they see infestation symptoms in their stored grains they sell without considering the price. Though farmers try to control stored grain insect pests, still the loss incurred both in terms of weight and germination is very high.

Pirimiphos-methyl, which is effective against stored grain pests under experimental and commercial conditions, did not achieve good result under farmers' conditions, may be due to poor application techniques. Farmers' storage structures are not also suitable for chemical treatment. Shelling of grain may reduce the problem of *S. cerealella*, but it increases the problem of *S. zeamais*. In all cases, the indigenous technologies farmers are using have a significant contribution to the integrated management of stored maize grain insect pests.

Use of sawdust, wood ash and sand in the control of stored maize grain insect pests has been demonstrated in many parts of the world. Shahjahan (1975) indicated that there was no pest attack when rice was covered with a layer of 22.8 percent of sawdust. Gwinner et al. (1990), and Golob and Ngulube (1982) reported that wood ash, sand and sawdust were the best locally available materials used on stored grain insect pests control under resource-poor farmers. Ash, sand, sawdust and similar inert materials easily fill in the space between grains. This narrowed space will not favour free movement of newly hatched larvae. This situation further creates a problem for the adult insect to find its partner or forces the female to deposit its entire stock of eggs on relatively fewer grains. Consequently, an explosive population build-up will be curtailed which leads to limited grain losses. Moreover, the admixtures of mineral substances to the harvested crops cause invisible injury to the protective wax layer of stored pests, leading to dehydration. The admixtures also cause respiration difficulties on the insect population because of the lack of space for air movement within the stored grains. Materials like neem, tobacco dust and pirimiphos-methyl have knock down and repellent effects on stored insect pests.

The use of locally available materials also has some disadvantages. Gwinner (1990) described the disadvantages of using wood ash in terms of taste and quantity of materials needed. Experience of the senior author indicated that 300-400 g of wood ash is recommended per kg of stored produce. When sand and sawdust are used, the amounts required are around 200-1000 g per kg of seed. Thus, the use of local materials should certainly be encouraged wherever it is practicable, such as in farm seed storage. The tested local materials had no negative impact on germination of seeds (Table 5); however, farmers face considerable amount of germination loss due to storage pests in Sidam Zone. Thus, these local materials should then be used for the protection of seed stock and grains of small quantities.

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