

Full Length Research Paper

Eco-friendly management of chickpea storage pest, *Callosobruchus chinensis* L. (Coleoptera; Bruchidae) under laboratory conditions in Eritrea

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Bruchid (*Callosobruchus chinensis* L) is the most important insect pest of pulses in store. Loss assessment study due to Bruchids in store on chickpea was conducted from October 2004 to March 2005 under laboratory conditions (25-27°C and 61% RH) in the College of Agriculture Asmara University. The treatments used were: Control, (with no treatment), mixture of sand, taff, ash, Malathox 1% and sesame oil. Monthly data were collected on number of damaged and undamaged grains, weight loss and germination percent. The highest mean grain damage was recorded in treatments of control, mixture of sand, and taff with a mean count of 16.97, 15.37 and 8.02 g respectively. The corresponding weight grain damage for mixtures of taff, sand and control were 5.46, 14.53 and 20.07 g, respectively. The most effective treatments were malathox, sesame oil and ash with a mean grain damage loss of 0.93, 0.11 and 0.21, respectively. The germination percentage of the damaged grains decreased with the increase population of the pest and period of storage.

Key words: *Callosobruchus chinensis*, storage, Ash, sand, taff, sesame oil, germination percent.

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is an ancient crop that has been grown in Asia, the Middle East and parts of Africa for many years (Tesfu, 2011; FAO, 2005). In Eritrea it is one of the major pulse crop cultivated in the highlands and mid altitudes with an area of 11,013 ha and total production of 8472 tones (MoA, 2013). It provides high quality protein and considered to be best food for vegetarian population in Asia and during the fasting periods in Eritrea (FAO, 2010; MoA, 2013). Chickpea is used in a range of different food preparations and has a good source of energy, that is, 416 calories/ 100 g

(Shrestha, 2001; Vance, 2001) along with protein (18-22%), and carbohydrate (52-70%) (Ali and Prasad, 2002; Bhalla et al., 2008). Furthermore, it plays a vital economic role to fix atmospheric nitrogen, thereby reducing agricultural cost through a reduction of fertilizer use and decreasing environmental contamination and enriches the soil fertility (Omeozor, 2005; Hauggaard-Nielsen et al., 2007; Kantar et al., 2007). According to Lale (2002), grain storage has often resulted in quantitative and qualitative losses due to physical, chemical, and most important biological factors such as pests which may be

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birds, rodents, fungi and insects of which storage insect pests are the most important. Apart from their direct losses by consumption of kernels, they accumulate frass, exuviae, webbing, and insect cadavers which may result in grain that is unfit for human consumption and/or induced changes in the storage environment warm, moist 'hot-spots' that are suitable for the development of storage fungi that cause further losses (FAO, 2005). Besides production constraints, post harvest loss of chickpea is very high in subsistence farmers' storage conditions. The major factor for heavy loss of the grain legumes in the storage is pulse beetle (*C. chinensis* L.). It is frequently, reported that worldwide in minimum of 10% of cereals and legumes are lost after harvest (Boxall et al., 2002). It is widely agreed that food losses after harvest can be substantial and are important in terms of quantity, quality, nutritional and economic value (Golob et al., 2002; Homan and Yubak Dhoj, 2011). *Callosobruchus chinensis* L. attacked chickpea are significantly affected not only in terms of quantitative and qualitative, but also these grains lose their germinating capacity completely as well (Ahmed et al., 2003; Ahmed and Din, 2009; Kumar et al., 2009). Reduction of insect damage in stored grains is mainly a serious problem in developing countries of the tropics due to favorable climatic conditions and poor storage structures. A warm and humid climate of the region is most conducive for losses of stored chickpeas by insects and storage moulds and the insect damage intensifies mould development (Kumar et al., 2009).

Until very recently, control of bruchid is heavily dependent on the use of chemical pesticides. 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 and the germination loss due to the attack of storage pests on cereals and pulse grains ranges from 3-37 and 4-88%, respectively (Adugna, 2007). Adugna (2006) reported that on-farm storage of grain damage in Eritrea is in a range of 4-14% in cereals and 8-27% in pulses and the damage is very less in small sized grains as compared to large seeded one such as of chickpea and faba bean. To reduce pest damage, farmers use different storage management practices that include mixing of ash, sand with grains to protect from storage pests. This showed that there is a need for more information on chickpea storage pests and their nature of damage in store in Eritrea.

Objectives

The main objective of the study was to understand the nature of damage and losses caused by the storage pests in chickpea in Eritrea.

The specific objectives of the study were:

1. To assess the grain damage losses caused by the

insect pests

2. To determine effectiveness of the treatments;
3. To estimate the weight loss of the grain by storage pests, and
4. To estimate the viability of damaged and undamaged grains.

MATERIALS AND METHODS

Storage pest study was conducted on chickpea in the laboratory of the college of agriculture, Paradiso campus, Asmara University at room temperature 25-27°C and relative humidity of 65%. The grain for the study was bought from market and filled into bags. Prior to the study, the grain was fumigated to avoid any insect pest infestation. Similarly, initial germination percent was evaluated using blotting paper method in Petri dish. At the time of experimentation, the moisture content of chickpea was 12.3% and the germination percent was 96%.

Twenty four bags were filled with chickpea grain each weighing five kilograms. The bags were arranged in Completely Randomized Design (CRD) in four replications. The treatments used were mixture of taff (*Eragrostis teff*), sand, ash, Malathox 1%, sesame oil and control without any treatment. The rate of treatments for taff, sand, and ash to grains was one to one ratio (1:1), malathox 1% was used at the rate of 15 ppm, and sesame oil was used at 10 ml per kg of grain. All the treatments were thoroughly mixed to assure that each seed was treated with the respective treatments.

All the bags both treated and untreated were inoculating 20 pairs of newly emerged adult *C. chinensis* L. (on the assumption of 1:1 male to female ratio) and stored for six months under room temperature.

Observation and data recoding

Data collection was done at the end of each month starting from October 2004 up to March 2005. At each count five hundred grain samples were taken from each bag. From each sampled gain the data collected were numbers of eggs/grain, number of hole/grain, number of beetles per sample grain, weight of damaged and undamaged grains (FAO, 1985).

All the data collected were transformed using the square root formula ($Z=Y+1/2$). Where Z = transformed data; Y = original data, because some of the data collected had zero counts. The counted grains were again recounted as damaged and undamaged grains.

Germination percent

In order to determine the viability of seeds, random sample of fifty grains each from the damaged and undamaged bags of each treatment and replication was taken. Each of the sampled grain was placed in blotting paper for germination test. The Petri dishes that contained the grains were put in germination cabinet at temperature of 10°C and relative humidity of 65% for 10 days to determine the germination percent. Finally, the germination percent was calculated using the following equation:

$$\text{Germination Percentage} = \frac{\text{number of germinated seeds} \times 100}{\text{Total number of seeds}}$$

Loss assessment

For the assessment of percent weight loss, 100-grain sample each

Table 1. Monthly mean number chickpea grain damage in store under Laboratory condition.

Treatment	Months					
	First	Second	Third	Fourth	Fifth	Sixth
Control (untreated check)	1.4	2.45	4.36	7.62	16.54	16.97
Chickpea+sand mixture	1.37	2.36	4.04	5.19	13.26	15.37
Chickpea+taff mixture	1.96	2.11	2.83	4.69	7.35	8.02
Chickpea+ash mixture	1.92	1.98	1.35	1.37	1.76	1.98
Chickpea+oil mixture	0.71	1.01	1.22	0.71	0.93	1.28
Chickpea+malathox 1%	0.71	1.21	1.35	0.71	0.84	0.93
LSD	1.19	1.38	1.49	2.66	3.42	2.86
S.E±	0.558	0.64	0.701	1.25	1.60	1.34

from damaged and undamaged grains were taken randomly from each bag monthly to determine weight loss with the help of electronic balance. The activity was done using the count and weight method as adopted by Joost et al. (1996). For this, the number and weight of damaged and undamaged grains of composite sample of 100 grains were taken from each experimental unit at final observation.

The percent weight loss was calculated using following equation (FAO, 1985):

$$\text{Percent loss in weight} = \frac{\text{Und} - \text{DNu} \times 100}{U (\text{Nd} - \text{Nu})}$$

Where U = weight of damaged grain; D = weight of undamaged grain; Nd = number of damaged grain; Nu = number of undamaged grain.

Data analysis

Data entry and analysis were done using Microsoft Excel and Gen Stat statistical package, respectively. Data were transformed using Arcsine transformation when necessary. To observe the effects of the treatment on number of grain damage, hole number, weight loss and germination percent one-way analysis of variance (ANOVA) was run. LSD and SE are given to show the difference between treatments.

RESULTS

The results of damaged chickpea grains are presented in Table 1. Count of the October infestation showed that there was no significant difference among the treatments used. However, there was a relatively more number of grain damage in the treatments of sand, taff, control and ash with mean number of grains of 1.37, 1.96, 1.40 and 1.92, respectively than in oil and chemical treatments.

Infestation counts of the second month (November) showed the same trend as of the first month, but with an increase mean number of grain damage in all the treatments. The mean number of grain damaged for chickpea for each treatment were 2.45, 2.36, 2.11, 1.98, 1.01 and 1.21 in control, sand, taff, ash, oil and chemical, respectively (Table 1).

In the third and fourth months, the infestation of the

grain increased. In parallel there was a significant difference in number of grain damage among the treatments. Control and sand treatments had significantly higher damaged grains than that of taff, ash, oil and chemical treatments. The mean number of grain damage for the different treatments during the third month count were 4.36, 4.04, 2.83, 1.35, 1.22 and 1.35 for control, sand, taff, ash, oil, chemical, respectively. Similarly there was a significant difference among the treatments in the fourth month. The highest damage count was obtained from the control treatment with a mean of 7.62 and the least damage was recorded in chemical treatments with mean value of 0.71 in each treatment.

There was a drastic change in number of grain damage among the treatments after 5 and 6 months of storage. Treatments of ash, oil and Malathox 1% had a significantly lower infestation than sand, taff and control. There was also a significant difference among the treatments of taff, sand and control. Control gave the highest number of grain damage followed by sand and taff (Table 1).

The result of the study in general showed that there was no significant difference in treatments of ash, oil and Malathox 1% across the months (from the first month to sixth month of storage). However, there was a significant difference in treatments of sand, taff and control across the months. The damage of the control increased from 1.4 in the first month to 17 in the sixth month (Table 1).

Grain weight loss in storage

It is a natural phenomenon to decrease the weight of grains in storage. This could be due to the increase of pest population with the progress of the storage period. So also during this study it has been observed that the damage of the grain has been increased in a weight loss. The result of weight loss in storage for chickpea grain is given in Table 2. The weight loss in storage after one and two months showed that control, sand and taff gave higher loss than ash, oil and insecticide. Control, sand and taff had weight loss of 0.08, 0.03 and 0.05% in

Table 2. Monthly mean weight losses of chickpea grain damage in store under laboratory condition in grams.

Treatment	Month					
	First	Second	Third	Fourth	Fifth	Sixth
Control (Untreated check)	0.08	0.95	1.91	8.54	19.54	20.07
Chickpea+sand mixture	0.03	0.87	1.64	4.82	11.96	14.53
Wheat+taff mixture	0.05	0.82	1.72	2.29	8.07	5.46
Chickpea+ash mixture	0.16	0.18	0.14	0.08	0.18	0.21
Chickpea+oil mixture	0.01	0.19	0.15	0.01	0.01	0.11
Chickpea+chemical	0.01	0.14	0.11	0.01	0.02	0.02
LSD	0.011	0.85	1.21	4.35	5.27	6.73
S.E	0.01	0.11	0.71	3.25	4.53	5.11

Table 3. Germination percentage of damaged chickpea grains under laboratory condition.

Treatment	Months					
	First	Second	Third	Fourth	Fifth	Sixth
Control (check)	100	53	32	25	22	17
Chickpea+sand mixture	66.6	66.7	24.3	23	22	22.3
Chickpea+taff mixture	80	43	33.3	27.9	14.4	11.4
Chickpea+Ash mixture	89.6	66.7	33	45.	57.5	42.1
Chickpea+oil	84	85	20	60	90	50
Chickpea+Malathox1%	87	85	16.7	25	30	20.5
LSD	35.61	45.23	21.38	18.72	32.12	19.35

the first month and 0.95, 0.87, and 0.82% in the second month respectively. Similar results were obtained in the third, fourth, fifth and sixth months of storage period. In all the months (third to sixth month), control, sand and taff gave the highest weight loss as compared to ash, oil and chemical treatments (Table 2). The loss in weight was higher in control and sand treatments followed by taff treatment with a loss of 20.07, 14.53, and 5.46%, respectively.

Damaged and undamaged germination percent of chickpea grains in storage

Table 3 shows damaged germination percentage of chickpea grains in storage. The germination percentages of all treatments except sand were high after one month of storage. However, the germination percent decreased as the storage period increased across the months. The reduction percent were from 100, 66.67, 80, 89.6, 84 and 87 after one month to 17, 22.3, 11.4, 19.50 and 20.5 after 6 months of storage for the treatments of control, sand, taff, ash, oil and chemical respectively (Table 3). Not only the damaged grains showed reduction in germination but also they showed poor seedling survival. The seedling survival of the undamaged grains was very strong and vigorous as compared with the damaged grains. The

damaged grains also had unpleasant smell.

The germination percentage of undamaged chickpea grains was very high in the range of 90 to 100% in all treatments throughout the study period (Table 4).

DISCUSSION

Chickpea grain storage study under laboratory showed that, there was no significant difference among the treatments after two months of storage. This was mainly due to the pest population build-up was very low during this period. However, after the third month the pest population started to build-up and hence it caused damage, which results in a significant difference among the treatments. Ash, oil and insecticide treated bags had significantly lower insect population than the other treatments. This lower number of grain damage count could be due to the treatments used had different effect on the bruchids as explained following.

Insecticide is a toxic substance, which is able to kill storage insect pests, and reduces grain damage. It affects storage pests by penetrating the insect body through cuticle and inhales through the respiratory system, which cause the insect to die and finally reduce the population build-up (Hall, 1978).

Vegetable oil acts as grain protectants against beetles

Table 4. Germination percentage of undamaged chickpea grain under laboratory condition.

Treatment	Months					
	First	Second	Third	Fourth	Fifth	Sixth
Control (check)	100	100	96.5	97.5	66.5	82.5
Chickpea+sand mixture	98.5	98.5	99.5	98.5	83.5	81.5
Chickpea+taff mixture	99	98.5	99	98	97.5	91
Chickpea+ash mixture	100	99.5	97.5	98.5	98	89
Chickpea+oil	99	100	99	100	99.5	98.5
Chickpea+malathox1%	100	99	99	99	99.5	99
LSD	3.13	3.54	1.13	1.57	12.76	11.39

in storage (Khaire, 1992). Oil is effective against storage pests because it has a slippery and/or oily property, which the eggs of the insects could not be attached or adhere to the grain surface. It could also have a repellent character where the insects cannot come in contact of the grain. The lower grain damage in oil treatment might be due to the decrease in number of adult emergence that results in less weight loss and kernel damage (Vijaya and Khader, 1999).

Ash is an inert dust that affects the respiratory system of the insect and may kill it by suffocation. Khaire (1992) reported that, mixing of ash with grain makes the entry of insects in grain a difficult task and cause physical and physiological injuries to the insects. Beside, ash is a fine powder, chemically inactive but with insecticidal property. The ash dusts that reduce the relative humidity of the storage condition could also dry the grain surface to cause less damage by the pest. Egg laying and larval development of the beetles could be hampered because ash dusts cover the grain seeds. It might also affect the insect movement to search their partners for mating. Aslam and Suleman (1999) in their studies of storage grain reported that friction of the dust particles with insect's cuticle leads to desiccation and hampers the development of the pest.

Adugna et al. (2003) in their survey of storage pests, reported farmers in Eritrea use mixture of small sized grain and fine sand gave good control of grain storage pests. According to the farmers' experience, these treatments lower the temperature of the storage condition. During these studies it was observed that the damage of the grain and weight loss was low for the first four months. However, in the fifth and sixth month's storage period, the damage increased that resulted in higher weight loss in all the studies. This could be due to these treatments had less air suffocation as compared to ash.

The germination percent for the control (untreated check), sand and taff decreased with the progress of the storage period that resulted in high grain damage by the pest. This was mainly due to these treatments were not effective to reduce or control the pest population. During the germination test it was observed that the damaged

seedlings were very weak and had unpleasant smell. The weakened seedling could be due to the depletion of the reserved food of the seed by the insect pests and the smell could be due to the rupture of eggs on the surface of the grain and mould development.

Conclusions

The mean number of grain damage and weight loss was not severe in the first two months in all the treatments. However, the severity of the damaged grains increased across months of the study period. The damage situation was very high and was severe in the fifth and sixth months of storage period. Treatments such as ash, insecticide and oil were found to be more effective in controlling of the pests in all the grains studied. The seed viability of damaged grains had also decreased across the storage period in the control, sand and taff treatments.

In general it can be concluded that the severity of the grain damage by the insect pests increased across the months that resulted in a significantly higher weight and germination loss in all the treatments.

Conflict of Interest

The authors have not declared any conflict of interest.

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