Effects of Cultural Methods in Controlling Maize Weevil (*Sitophilus zeamais* Motsch)

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Abstract

An alternative to pesticide use in the storage ecosystem is the re-adoption of traditional crop protection measures, which have gradually been ignored and replaced by chemical insecticides. Experiments were conducted to determine the efficacy of some traditional insect pest control practices against the maize weevil, *Sitophilus zeamais* Motsch. at Bako Research Center between 1996 and 1998. One to one and half kg of BH-140 maize hybrid seeds were placed in cloth bags and infested with 100 adult maize weevils in the laboratory and left for natural infestation in the storehouse. Different cultural insect pest control methods were applied in the experiments that were arranged in a completely randomized design with four replications. Among the cultural methods, heating maize grain at 70-80°C in an oven for 1hr, maize plus dockage, the mixture of chemically treated maize with untreated maize and exposure to the sun showed comparable results to the standard insecticide primiphos-methyl at 10 ppm in protecting maize grain from the maize weevil. These cultural methods could be recommended for use as part of an integrated pest management in stored maize particularly with low levels of pest infestation and small volume of produce.

Introduction

Post harvest losses of grain to stored product insects remain among the most serious problems faced by small farmers throughout the tropics, accounting for substantial losses in less-developed countries (CIMMYT 1970-1971). The primary aims of storing food commodities are to effect a uniform supply of food throughout the year, to make available reserve for contingencies and to speculate on higher prices whether it is for local or export markets. For one or more of the above reasons, maize grain is often stored in Ethiopia for more than six months (Emana 1999), as a result of which storage loss due to insect pests ranging from 20 to 30 % is very common (Abraham 1991, Emana 1999). Hence, the farmers are unable to store food grains for extended periods of time which deprives families of food and tend to depress market prices as the entire harvest must be sold in a relatively short period of time in order to escape from storage losses due to insect pests (Beyene et al. 1997).

Current survey works by the senior author on storage insect pests of maize revealed that farmers have come to depend solely on chemical insecticides for the control of storage pests. However, it must be recognized that small farm conditions for storage are often very poor, and because grain is intended for human consumption, pesticide use should be avoided (Dobie 1977). Moreover, such insecticides are rarely available and are not cost effective to small-scale farmers.

An alternative to pesticide use in storage is the re-adoption of traditional crop protection measures, which have gradually been ignored to an extent that farmer's indigenous knowledge is almost forgotten and replaced by chemical insecticides. However, in Ethiopia, there is little or no scientific documentation available as to the efficacy of these methods. Besides, keeping in view of the political and economic background of the crop protection problems, one cannot lose sight of the fact that there is a need to look for long lasting and reliable solutions that consider the requirements of man and environment. The current work is made to validate some of these cultural techniques so that they can be technically supported, and thus small-scale farmers will be receptive to methods of storage grain protection that lie within their technical and financial means. Therefore, the trials were conducted with the objective of determining the efficacy of using different cultural methods for the control of maize weevil, *Sitophilus zeamais* Motsch. (Coleoptera: Curculionidae) at Bako Research Center, West Ethiopia.

Materials and Methods

Experiments were conducted for three consecutive years (1996-1998) in two separate sets: one under natural infestation in a storehouse and the other under artificial infestation in the laboratory. Maize hybrid BH-140 susceptible to weevils was cleaned and disinfested by keeping in a refrigerator for about 2-3 weeks. The disinfested maize was then acclimatized to the experimental condition for a few days before the commencement of the experiments. One and a half (1996 and 1997) and one (1998) kilograms of the disinfested maize with a moisture content of 11-13% was placed in each of nine cloth bags (30x40 cm.) for both sets of the experiments and subjected to the following treatments:

- Clean maize (untreated check)
- Unclean maize (maize + dockage)
- Maize + tef (50% by weight)
- Maize treated with primiphos-methyl (10 ppm) (standard check)
- Smoking over fire (only for the storehouse experiment)
- Frequent tumbling (two times/day for three months)
- Exposure to the sun, every two weeks
- Heating maize at 70-80°c in an oven for 1hr
- Mixture of maize treated with recommended rate of primiphos-methyl and
- untreated maize (50% by weight)

Most of these treatments were selected based on various reports indicating that farmers in some localities of Ethiopia have been using them for a very long time.

Each of the experiments was laid out in a completely randomized design and replicated four times. For the laboratory experiment, 100 adult weevils of two weeks age, randomly picked from the Bako Research Center farm-store (to simulate with the natural infestation of the storehouse experiment), were introduced into each bag. After one month, dead and live adult weevils were removed and counted. For the storehouse experiment, the cloth bags with grain were left open in the farm-store for about a month to allow natural infestation, and at the end of the month, dead and live weevils from each bag were removed and counted. For both experiments, bags were kept tied at the time of progeny emergence.

Tumbling and exposure to the sun treatments (between March and May each year) were started a week after the start of the experiments. For the tumbling treatment, bags tied firmly at the top were flipped over forwards and backwards. For the smoking treatment, the bags were hung in the Bako Research Center's Social Club kitchen. Samples of 100gm of grain were withdrawn from each bag of each set of the experiments for analysis of insects starting from one month after the commencement of the experiment and continued at 15 days interval for more than two months. Data on the number of adult and progeny weevils dead and alive and damaged and undamaged grain were recorded at each sampling.

Results

Laboratory experiment

In the 1996 experiment, there were significant differences among the different treatments. Table 1 summarizes the mean number of adult and progeny weevils (dead and live) after being exposed to the different cultural methods. Significantly higher numbers of dead weevils (43.3, 39, 34.8 and 34.5) were recorded in treatments: primiphos methyl at 10 ppm, clean maize, maize plus dockage and the mixture of treated/ untreated maize, respectively. In contrast, frequent tumbling and maize mixed with tef treatments resulted in lower weevil mortality. On the other hand, exposure to the sun and heating maize grain at 70-80°c for 1hr in oven treatments were compared with the recommended insecticide. The lowest number of live weevils was recorded in maize treated with primiphos-methyl (13.3) and mixture of treated/ untreated maize (28.5), while the highest was recorded in maize plus dockage (100.8).

In the 1997 experiment (Table 1) maize treated with pirimiphos-methyl, the mixture of treated/ untreated maize and clean maize treatments gave comparable results in terms of percentage weevil mortality and grain damage. However, non-significant difference was detected among treatments such as maize plus dockage, exposure to sun, heating maize grain at 70-80°C for 1hr in oven, treated maize and the mixture of treated/ untreated maize for grain damage percentage. Low weevil mortality (11.3%) and high grain damage (24.7%) were recorded in maize plus tef treatment, where as high weevil mortality (84.5%) and least grain damage (2.5%) were recorded in maize treated with pirimiphos methyl.

Table 1. Mean number of adult weevils (dead and alive) and per cent damaged grain (laboratory experiment)

Treatments	1996		1997	
	Mean number of dead weevils	Mean number of live weevils	Adult weevil mortality (%)	Grain damaged (%)
Clean maize	39.00a	83.25ab	49.91 (7.065ab)	5.334 (2.362bc)
Clean maize + Dockage	34.75a	100.75a	35.84 (5.987bc)	7.738 (2.801bc)
Maize + Tef (50:50%)	17.50bc	70.50ab	11.3 (3.362d)	24.666 (4.951a)
Primiphos-methyl (10 ppm)	43.25a	13.25d	84.51 (9.193a)	2.520 (1.669c)
Frequent tumbling	16.25bc	72.25ab	21.53 (4.640cd)	10.599 (3.200b)
Exposure to the sun	27.00ab	58.00bc	28.56 (5.344bcd)	7.288 (2.718bc)
Heating maize at 70-80°c for 1hr	27.5ab	76.25ab	24.75 (4.975bcd)	5.764 (2.465bc)
Mixture of treated/ untreated maize	34.50a	28.50cd	77.35 (8.795a)	3.453 (1.939c)
S.E. (±)	5.26	10.53	0.7143	0.3722
CV (%)	38.86	37.33	22.73	27.14

- Means followed by the same letter(s) within a column are not significantly different from each other at 5% level of significance (DMRT).
- Values in parentheses are square root transformed values.

In the 1998 experiment, no significant difference was observed among treatments for weevil mortality but maize treated with pirimiphos-methyl resulted in relatively higher (30%) weevil mortality as compared to the other treatments (Table 3). However, significant differences for percentage grain damage were observed among treatments. Pirimiphos methyl (2.5%) and the mixture of treated/ untreated maize (1.4%) treatments resulted in lower percentage of damaged grains as compared to maize plus tef (20.8%), frequent tumbling (20.6%), clean maize (18%) and heating maize grain at 70-80°c for 1hr in oven (14.2%) treatments.

Table 2. Mean number of adult weevils (dead and alive) and per cent damaged grain (storehouse experiment)

Treatments	1996		1997	
	Mean number of weevils dead	Mean number of weevils alive	Adult weevil mortality (%)	Grain damaged (%)
Clean maize	11.5 b	17.8	14.92 (3.927bc)	6.81(2.703bc)
Clean maize + Dockage	12.5 b	17.3	19.19 (4.437b)	5.63 (2.475bc)
Maize + Tef (50:50%)Primiphos	9.0 b	20.0	14.39 (3.859bc)	18.57 (4.367a)
methyl (10 ppm)	22.75 a	16.5	55.87 (7.508a)	3.10 (1.897c)
Smoking over fire	0.75 c	4.3	1.63 (1.46d)	3.60 (2.025bc)
Frequent tumbling	8.25 b	13.8	14.24 (3.839bc)	5.21 (2.389bc)
Exposure to the sun	11.8 b	22.5	12.88 (3.658bc)	7.80 (2.881b)
Heating maize at 70-80°c for 1hr	12.3 b	19.0	3.06 (1.886cd)	3.53 (2.008bc)
Mixture of treated/ untreated maize	11.3 b	13.5	45.37 (6.773a)	2.89 (1.842c)
S.E (±)	2.35	VNs	0.6852	0.2761
CV (%)	42.3		33.02	22.01

Means followed by the same letter(s) within a column are not significantly different from each other at 5% level of significance (DMRT). Values in parentheses are square root transformed values. [V] Non significant

Storehouse experiment

The results of the storehouse experiment of the 1996 are presented in Table 2. Differences among treatments for mean number of dead weevils were not significant except for maize treated with pirimiphos methyl and maize smoked over fire. The highest mean number of dead weevils was recorded in maize treated with pirimiphos methyl (22.8) and the lowest was recorded in maize smoked over fire (0.8). However, statistically significant differences were not observed for live weevils recorded among treatments.

Significant difference was observed among the treatments in all parameters considered during 1997(Table 2). Primiphos-methyl treated maize and the mixture of treated/ untreated maize showed higher weevil mortality of 55.9% and 45.4%, respectively, while lower mortality (1.6%) was recorded for smoked maize. Per cent grain damage in clean maize, maize plus dockage, smoked maize, frequent tumbling and heating maize grain at 70-80°C for 1hr in oven treatments were comparable with that of pirimiphos methyl. Highest damage was inflicted to the maize plus tef followed by exposure to the sun treatments.

In the 1998 storehouse test (Table 3), significant differences among treatments in percentage of damaged grain were observed although no significant difference was detected in percentage of weevil mortality. Higher grain damage was recorded in maize plus tef (60.3%) and exposure to sun (60.6%), and lower in maize treated with primiphos-methyl (35.1%) and treated/ untreated maize mixture (23.5%). Maize plus dockage, frequent tumbling and heating maize grain at 70-80°C for 1hr in oven treatments were not statistically different from pirimiphos methyl treatment.

Table 3. Percentage of adult weevil mortality and damaged grain (1998)

Treatments	Laboratory		Storehouse	
	Mortality of adult weevils (%)	Grains damaged (%)	Mortality of adult weevils (%)	Grains damaged(%)
Clean maize	0.61 (0.959)	17.97 (4.239a)	17.775 (4.246)	56.528 (7.516a)
Clean maize + Dockage	4.792 (2.30)	8.96 (2.993ab)	21.195 (4.194)	50.541 (7.063ab)
Maize + Tef (50:50%)	0.0 (0.707)	20.79 (4.560a)	14.583 (3.070)	60.332 (7.760a)
Primiphos-methyl (10 ppm)	30.0 (5.52)	2.54 (1.594b)	15.147 (3.516)	35.116 (5.911bc)
Frequent tumbling	0.0 (0.707)	20.55 (4.533a)	0.000 (0.707)	50.279 (7.018ab)
Exposure to the sun	0.0 (0.707)	9.97 (3.158ab)	11.685 (3.130)	60.637 (7.758a)
Heating maize at 70-80°c for 1hr	2.083 (1.61)	14.24 (3.774a)	19.471 (3.977)	42.063 (6.436ab)
Mixture of treated/ untreated maize	0.0 (0.707)	1.36 (1.165b)	9.402 (2.847)	23.508 (4.752c)
S.E. (±)	[v]Ns	0.6682	[v]Ns	0.4090
CV (%)		41.09		12.07

- Means followed by the same letter(s) within a column are not significantly different from each other at 5% level of significance (DMRT).
- Values in parentheses are square root transformed values.
[v] - Non significant.

Discussion

Most resource poor farmers with adequate indigenous knowledge are unable to afford synthetic chemicals, and have still been fighting crop pests using their own methods. Through long experience, they have empirically evolved various useful cultural pest control techniques compatible with their biophysical and socioeconomic circumstances (Girma et al. 1999).

The results obtained in this work indicate that some of the cultural methods gave comparable results to the treatment with standard insecticide, primiphos methyl at 10 ppm. The mixture of treated/ untreated maize was found to be as effective as the recommended dose of primiphos methyl in both laboratory and storehouse experiments. Some farmers in the Bako area were reported to mix insecticide-treated maize with untreated maize for storage (Abraham 1997). Arthur (1992) found out that corn treated with chlorpyrifos methyl and stored for six months and subsequently mixed with untreated corn in a 2:3 ratio controlled maize weevils for six months. This suggests that resource poor farmers, who produce the bulk of grain but could not afford to purchase insecticides, can still have the chance to store their produce without much insect attack for a considerable length of time. Moreover, effectiveness of lower rates of the insecticide has to be studied for efficient utilization under farmers' conditions.

In addition, heating maize grain at 70-80°C for 1hr in oven, exposure to the sun, maize plus dockage and using clean maize treatments gave similar promising results as the standard insecticide treatment in both sets of experiment though they sometimes lack consistency over the test periods. Exposure to the sun is a very good and simple way of controlling storage pests because high temperature due to direct solar radiation may kill the developing larvae in the seed. All eggs and adult weevils were killed when infested grain was heated at 60°C for 2hr and 70°C and 80°C for 1hr (Abraham & Firdissa 1998). Firdissa & Abraham (1999) also reported that slight roasting caused more than 56% mortality of adult weevils seven days after treatment.

Contrary to the reports of Abraham (1991) and Abraham & Firdissa (1998), maize smoked over fire did not lower weevil damage. This might be attributed to the texture of cloth bags that did not allow the smoke to penetrate sufficiently to reach the grain inside. van Huis (1991) reported that the development of the insect pest is retarded and re-infestation by migration prevented, because of the heat and smoke as these accelerate the drying of the harvested product.

Tef plus maize treatments in both sets of experiments and frequent tumbling in the laboratory experiment were found ineffective when compared with all other treatments. This contradicts the findings of Facknath (1993) who reported that regular tumbling of beans (*Phaseolus vulgaris*) and rice caused 90-97% mortality of the important pests *Acanthoscelides obtectus, Sitophilus* spp., *Oryzaephilus surinamensis* and *Cryptolestes ferrugineus*, without significant breakage of the grains.

Conclusion

Cultural methods are simple, cheap, easily available and safe methods of controlling stored grains insect pests. Some of the cultural methods tested in this study may be recommended for practical use as part of the integrated pest management in stored maize. However, they may not give effective control when used singly and under heavy infestations with large quantities of produce. It is also suggested that further tests with these and other promising traditional methods must be made before making conclusive recommendations.

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