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Research Paper

Management of *Sitophilus zeamais* Motshulsky (Coleoptera: Ciurculionidae) and *Sitotroga cerealella* (Olivier) (Lepidoptera: Gelechidae) using locally available agricultural wastes in Southern Ethiopia

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Abstract. Locally available agricultural wastes including sawdust, coffee husk and wood ash were evaluated at different proportions against *Sitophilus zeamais* and *Sitotrog cerealella* in 2002 in Awassa National Maize Project entomology laboratory. The experiment was laid out in completely randomized design (CRD) in three replications. The insect pests were reared at laboratory condition before introducing into each treatment to obtain the same age group. Maize grain was disinfected to eliminate undiserable field infestation in refrigerator at –2°C before using for experimental purpose. The treatments were 10% (w/w), 15% (w/w), 20% (w/w) and 30% (w/w) of coffee husk, 10% (w/w), 15% (w/w), 20% (w/w) and 30% (w/w) of saw dust, 10%(w/w), 15% (w/w), 20% (w/w) and 30% (w/w) of wood ash and 2% (w/w) of Pirimiphos-methyl as standard check and untreated control. The efficacy of each treatment was evaluated with respect to F1 progeny emergence of the pests, mean number of damaged kernels and germination percentage of maize kernels. Coffee husk and wood ash at all dosages were found to be effective in controlling *S. zeamais* and *S. cerealella*. Wood ash in all proportions gave the best control of the pests during the study period. Wood ash and coffee husk at higher rates were more effective in controlling the pests. Sawdust at all dosages was not different from the untreated control in controlling *S. zeamais*. However, sawdust at some dosages showed superior performance against *S. cerealella*.

Keywords: Agricultural waste, coffee husk, *Sitotroga cerealella*, *Sitophilus zeamais.*

INTRODUCTION

Maize (*Zea mays* L.) is the most important food crop grown in Africa and is capable of giving high yield (Assefa, 1981). Ethiopia produces more of maize than any other crop. The total area under maize cultivation in 2009/2010 was 1.69 hectares from which 37.8 million quintals of maize were produced which was higher than that of any other cereal crop (CSA, 2010), which also was more than 27% of the country's total grain production. Maize is the major food crop of the southern region of Ethiopia.

Despite its importance to the country, numerous coleopterous and lepidopterous pests attack maize in storage in Ethiopia (Emana, 1993; Firdissa and Abraham, 1999). Emana (1993) recorded eight insect species belonging to four orders and seven families on stored maize grain in Sidama administrative region namely: *Sitotroga cerealella* (Olivier), *Sitophilus zeamais* Motschulsky, *Ephestia cautella* (Walker*), Tribolium castaneum (*Herbst*), Tribolium confusum* Jaluelin de val*, Plodia interpunctella (*Hubner*)*, *Rhizopertha dominica* (F.) and *Liposcelis* sp*.,* of which *S. cerealella* and *S. zeamais* are the most important primary pests.

In the store, maize insect pests cause losses ranging from 20 to 30% in Ethiopia (Abraham, 1991; Emana, 1993). In *Bako* area, farmers reported 25 to 33% maize grain losses within six months of storage period. In Sidama administrative zone, southern Ethiopia, 30 to 90% losses could occur to maize grain stored for five to seven months by *S. cerealella* and *S. zeamais* (Emana, 1993). A number of experiments have been done on the management of storage pests at the farm storage level (Emana, 1999). Chemical control of insect pests has been the most efficient and effective means of protection of stored product (Emana, 1999). However, with the increasing cost of chemicals and their hazards to the environment, alternative control strategies are being exploited. Use of locally available agricultural wastes can be considered as one of the alternative control strategies for resource poor farmers of the region. Agricultural wastes such as wood ash and similar fine substances are used in the control of storage pests by filling the space between maize kernels (Emana, 1993; Gwinner et al., 1996). This means that newly hatched insect pests are denied in their activities. They experience more difficulty in finding partners and as result are forced to deposit their entire stock of eggs on relatively few maize kernels. In general, identifying useful locally available agricultural wastes against *S. zeamais* and *S. cerealella,* the most important primary pests, may provide important component of storage pest management in maize grain in Southern Ethiopia. Therefore, the objective of this study was to evaluate the efficacy of locally available agricultural wastes including coffee husk for the control of *S. zeamais* and *S. cerealella* in Southern Ethiopia.

MATERIALS AND METHODS

Establishment of culture of *S. zeamais* and *S. cerealella*

S. zeamais

Adult *S. zeamais* of known age were produced in a sufficient number for the experiment following the rearing procedures of Strong and Subur (1968). About 25 kg of maize variety BH540 was cleaned to remove kernels with visible damage symptom and stored in a freezer at 0 to -2°C for one month to further clean the kernels from possible internal infestation (Strong et al., 1967). Grain moisture content was measured by moisture tester. Low moisture level was adjusted to 12.5% by adding water, while high moisture level was adjusted to 12.5% by allowing it to dry slowly (Wright et al., 1989).

Unsexed *S. zeamais* adults were collected from grain store of Awassa Agricultural Research Center and Debub University, the then Awassa College of Agriculture, and cultured on cleaned and disinfested maize in four replications. In each replication, 800 *S. zeamais* adults per 400 g of grain were put in glass jar of 3-L capacity and covered with muslin cloth and fixed by rubber band. After seven days of oviposition period, all parent *S. zeamais* adults were removed from each replication and placed on another set of grain in the same condition. Such removal of parent *S. zeamais* adults and placement on a fresh grain medium was made three times, so that sufficient number of laboratory reared *S. zeamais* adults of known age, about 3000, were made available.

After the third transfer, parent *S. zeamais* adults were discarded. Then each grain lot where *S. zeamais* adults oviposited for seven days was kept for progeny emergence. Starting from 34 days after infestation of the maize grain in the different batches, counts of emerged adults were recorded daily until the 45th day and those emerged on the same day were transferred to a glass jar of one liter capacity, so that each jar will contain *S. zeamais* adults of the same age. For the experiments *S. zeamais* adults of known age were used.

S. cerealella

A new culture of *S. cerealella* was established by using maize kernels with 300 *S. cerealella* pupae as moths, which were collected from Debub University, the then called Awassa College of Agriculture, and put in three liters capacity jar containing 1.5 kg disinfected maize kernels (Emana, 1993, 1999). A total of four jars were used for culture establishment. After disinfesting maize kernels at 0 to -2°C, it was stored in the laboratory under room temperature in a clean 3-L capacity jar. Then, maize with 300 *S. cerealella* pupae were introduced to lay eggs on the disinfected kernels. After nineteen days of introduction, all live and dead moths were removed from the jar. The jars were inspected on daily bases for recording emergence of F1 moths. Then, maize kernels with *S. cerealella* pupae, which emerged as F1 moth, were used for experimental purpose.

Use of locally available agricultural wastes

S. zeamais

The local materials tested against *S. zeamais* include coffee husk, wood ash and sawdust. Before using all agri-cultural wastes for experimental purposes for experimenttal purposes, moisture contents were adjusted for 12.5%. Low moisture level was adjusted to 12.5% by adding water, while high moisture level was adjusted to 12.5% by allowing it to dry slowly (Wright et al., 1989). Coffee husk was brought from coffee processing factory of sidama zone, Southern Ethiopia, 42 km far away from Research Center, wood ash was collected from kitchen of the Researh Center and sawdust was collected from nearby wood product processing factory. For each treatment, five hundred disinfested sound kernels were used in 3 L capacity plastic bag and admixed at different proportions with different materials. Primiphos-methyl 2% w/w dust at the rate of 10 ppm, as a standard check and the untreated control were included in the experiment for comparison.

Fourteen sexed and ten-to-fourteen-day-old *S. zeamais* adults were introduced into each treatment. Then plastic bags were pin-holed to ensure adequate aeration and folded and stapled from top to prevent escape of *S. zeamais* adults. The experiment was done under ambient laboratory conditions.

Parent *S. zeamais* adults' mortality was assessed after one, two, three, and four weeks after treatment application and dead adult insects were counted and removed during each assessment. At 28^{th} day after the infestation, the remaining *S. zeamais* adults (dead and alive) were counted and removed together. The assessment periods were selected based on the earlier report by Dobie (1974).

After removing dead and live *S. zeamais* adults, the treatment remained under the same conditions to assess F1 progenies emergence. The F1 progeny of *S. zeamais* adults were removed and counted as soon as emerged. This was continued up to 76 days according to Dobie (1974), Evans (1985) and Hodges and Meik (1986). At the end, weight loss of grain and number of damaged kernels were recorded by separating the admixture by winnowing in each treatment. Germination percentage of the grain was assessed by randomly picking one hundred kernels from each treatment and placing it on moist filter paper and kept for seven days. The experiment was laid out in Completely Randomized Design (CRD) in three replications.

S. cerealella

The local materials tested against *S. cerealella* include different proportions of coffee husk, wood ash and sawdust. For each treatment, five hundred disinfested sound kernels were used in 3 L capacity plastic bag and admixed at different proportions with different materials. Primiphos-methyl 2% w/w dust at the rate of 10 ppm as a standard check and the untreated control were included in the experiment for comparison. Twenty maize kernels with unsexed 20 pupae of *S. cerealella* were introduced into each treatment. Then, plastic bags were pin-holed to ensure adequate aeration and folded and stapled from top to prevent escape of moths. The experiment was done under ambient condition.

Parent adult moths' mortality was assessed after one, two and three weeks after treatment application and the remaining dead and live moths were discarded together from the treatment at 21^{st} day. Then, the treatment was kept under similar conditions to F1 progenies assessment. The F1 progeny of moths were counted and removed as soon as they were emerged. This continued up to 3 months. At the end, weight loss of grain and number of damaged kernels were recorded by separating the admixture by winnowing. Germination percentage of the kerenels was assessed by randomly picking one hundred kernels from each treatment and placing it on moist filter paper and kept for seven days.

The experiment was laid out in Completely Randomized Design (CRD) in three replications.

Percent grain weight loss for all of the above experiments was calculated using Anon (1969) method. At the end of each experiment, maize kernels were separated into two categories (undamaged and damaged) from each treatment. Grains in each category were counted and weighed separately and subjected to the following equation:

$$\% \text{ Weight loss} = \frac{(W_u \times N_d) - (W_d \times N_u)}{W_u \times (N_d + N_u)} \times 100$$

Where, W_u = Weight of undamaged grains
N_u = Number of undamaged grains
W_d = Weight of damaged grains
N_d = Number of damaged grains

Statistical analysis

Data on number of F1 emerged *S. zeamais* and *S. cerealella* adults, number of damaged maize kernels and weight loss of grain were square root transformed in order to stabilize variances before being subjected to statistical analysis. The data obtained were subjected to analysis of variance (ANOVA) using MSTATC computer program, and means were separated using Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

S. zeamais

The effects of agricultural wastes in the control of *S. zeamais* are presented in Table 1. Among agricultural wastes tested against the pest, wood ash at all dosages showed superior performance in all parameters compared to the untreated check. Sawdust at four dosages was not better than the untreated control in all

Table 1. F1 progeny of *S. zeamais*, number of damaged maize kernels and weight loss as influenced by coffee husk agricultural wastes, 2002.

Treatments	Number of F1 progeny emerged	Number of damaged Kernels/500 kernels	% Weight loss
10% Coffee husk	107.00^{b-d}	114.33^{ed}	1.59^{b-e}
15% Coffee husk	109.33^{cd}	128.00^{b-d}	1.79^{b-e}
20% Coffee husk	65.67^{d-f}	80.00^{d-f}	1.12^{de}
30% Coffee husk	96.67^{c-e}	107.67^{c-e}	1.45^{c-e}
10% Sawdust	121.00^{b-d}	130.67^{b-d}	3.38^{a-d}
15% Sawdust	174.33^{a-c}	189.00^{a-c}	4.38^{a-c}
20% Saw dust	247.33^{a}	244.33^{a}	4.40^{a-c}
30% Sawdust	215.00^{ab}	227.67^{ab}	4.81^{a}
10% Wood ash	19.00^{fg}	27.33^{fg}	0.55^{e}
15% Wood ash	8.00^{g}	15.00^{g}	0.24^{e}
20% Wood ash	20.00^{fg}	29.33^{fg}	0.51^{e}
30% Wood ash	8.33^{g}	18.33^{g}	0.29^{e}
2% Pirimiphos-methyl	7.67^{g}	14.33^{g}	0.61^{e}
Untreated control	153.67^{a-d}	165.67^{a-d}	4.21^{ab}
SE (±)	2.28	0.90	0.24
CV%	23.22	7.96	27.37

All means followed by the same letter(s) within a column are not significantly different from each other at 5% (DMRT). Statistical tests were made with transformed values. SD = saw dust, WA = wood ash, CH = Coffee husk.

parameters. Very few F1 progeny emerged from kernels treated with all dosages of wood ash. However, higher dosages of wood ash were found to be more effective in suppressing development of F1 progeny. Lowest number of F1 progeny emerged from maize kernels treated with 15% w/w wood ash, while highest F1 progeny emerged from kernels treated with sawdust at 20% w/w. Coffee husk relatively at higher dosages, 20 and 30% w/w was found to be more effective in impending the development of F1 progeny compared to the untreated control.

There were significant differences in germination capacity of maize kernels treated with different agricultural wastes and the untreated control. The highest germination percentage was recorded from kernels treated with wood ash 30% w/w, while the lowest percentage was obtained from kernels treated with sawdust 30% w/w (Figure 1).

The results of the present study agree with reports of previous workers. Achiano et al. (1999) indicated that mixing wood ash with maize kernels before it is stored resulted in 100% *S. zeamais* adult mortality after 20 days of treatment. Moreover, a progressive increase in mortality with wood ash concentration was observed after 20 days. If added in sufficient quantity, wood ash can effectively protects grain stored in small lots on traditional Africa farmers (Golob et al., 1982). They indicated that the quantity must be as much as 20% or more, in order to submerge the grain almost completely. Moreover, the abrasive properties of the materials may play some part in preventing the development of pests; it is more likely that the dust inhibit insect behavior, affecting movement and reproduction by blocking air and space between grains.

Locally available dusts will continue to play an important role as grain protectants in farm stores in African and other developing countries because they are readily available (Golob and Hanks, 1999; Emana, 1993). However, such practice will remain viable for small-scale use only, particularly for the preservation of small quantities of seed grains, because of excessive quantities of dust required and the implication of some quality problems.

S. cerealella

The effects of agricultural wastes in the control of *S. cerealella* are presented in Table 2. Among agricultural wastes used coffee husk at the rate of 20% w/w followed by wood ash 15 and 30% highly restricted the development of F1 progeny of *S. cerealella* compared to the untreated control. Saw dust was not better than the untreated control in all parameters except germination capacity. However, relatively lower number of F1 progeny and mean number of damaged kernels were recorded from higher rates of sawdust compared to the untreated control. All agricultural wastes tested against the pest had a significant effect with regards to germination capacity of the maize kernels compared to the untreated control (Figure 2). The highest germination percentage was recorded from kernels treated with wood ash 10% w/w, while lowest germination percentage is ash 10% w/w, while

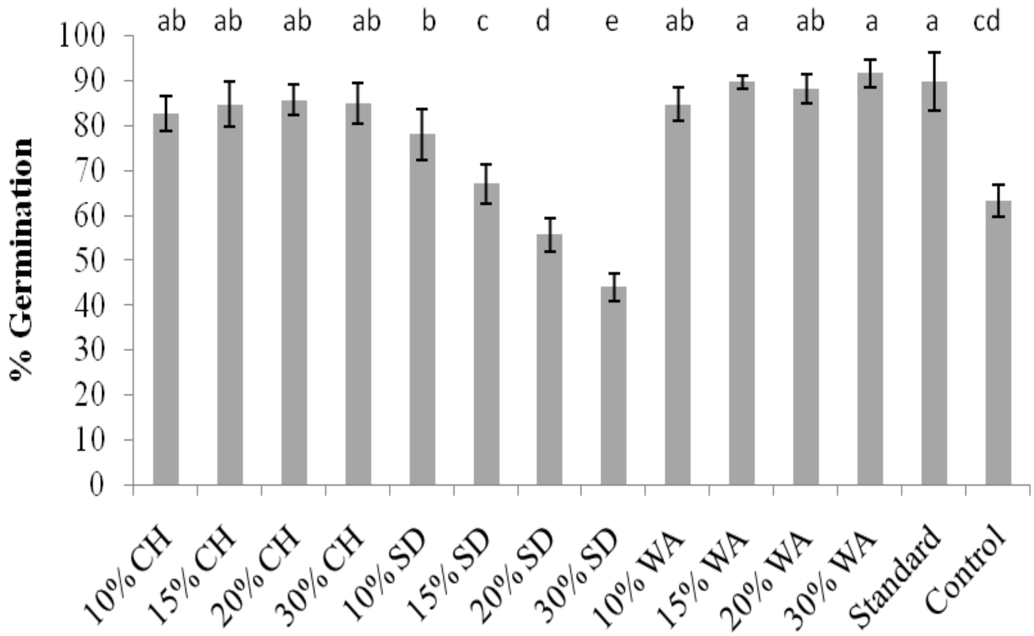

Figure 1. Effect of different rates of agricultural wasres on maize seed germination due to *Sitophilus zeamais* damage after six months of storage. Bars on the graph are standard errors of the means.

Table 2. Effect of coffee husk and agricultural wastes on F1 progeny of *S. cerealella,* number of damaged maize kernels and weight loss, 2002.

Treatments	Number of F1 progeny emerged	Number of damaged kernels/500 seeds	% Weight loss
10% Coffee husk	66.67^{a-c}	70.00^{a-d}	0.95^{b-e}
15% Coffee husk	108.00^{ab}	114.67^{a-c}	1.92^{b-e}
20% Coffee husk	33.33^{cd}	36.00^{de}	0.54^{de}
30% Coffee husk	82.67^{a-c}	84.33^{a-d}	1.65^{c-e}
10% Sawdust	73.33^{a-c}	75.67^{a-d}	1.80^{a-d}
15% Sawdust	69.33^{a-c}	71.00^{a-d}	1.23^{a-c}
20% Saw dust	109.00^{ab}	110.00^{ab}	2.04^{a-c}
30% Sawdust	48.67^{a-d}	52.67^{a-d}	1.05^{a}
10% Wood ash	71.00^{a-c}	77.33^{a-d}	1.00^{e}
15% Wood ash	47.00^{b-d}	48.00^{b-c}	1.12^{e}
20% Wood ash	75.67^{a-c}	77.67^{a-d}	1.46^{e}
30% Wood ash	35.67^{b-d}	36.00^{c-e}	0.53^{e}
2% Pirimiphos-methyl	7.33^{d}	7.67^{e}	0.08^{e}
Untreated control	133.67^{a}	140.67^{a}	4.12^{ab}
SE (±)	1.35	1.37	0.17
CV%	30.08	29.75	22.64

All means followed by the same letter(s) within a column are not significantly different from each other at 5% (DMRT). Statistical tests were made with transformed values.

lowest germination percentage is recorded from untreated control.

There was significant difference among agricultural wastes and pirimiphos-methyl treatments in all parameters. Sawdust in four dosages showed significantly inferior performance with regards to mean number of damaged kernels, germination capacity of the kernels and F1 progeny emergence. However, the highest dosage, 30% w/w of wood ash was not different from pirimiphos-methy treatment. In suppressing the development of F1 progeny emergence of the pest, coffee husk at 20% w/w and wood ash at 15 and 30% w/w showed similar performance with that of pirimiphos-methyl. These rates of indicated agricultural wastes also showed similar performance with

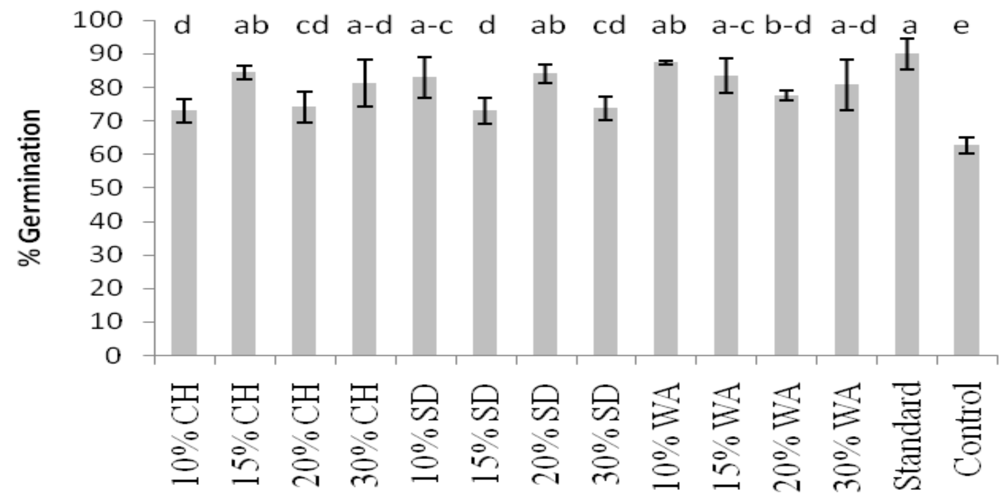

Figure 2. Effect of different rates of agricultural wastes on maize seed gfermination due to *Sitotroga cerealella* damage after six months of storage. Bars on the graphs are standard errors of means.

regards to mean number of damaged kernels. Except sawdust at the rate of 10% w/w, coffee husk at 10% w/w and wood ash at the rate of 20% w/w all dosages of agricultural wastes were not significantly different from pirimiphos-methyl treatment with regard to germination. In general, lowest F1 progeny and mean numbers of damaged kernels were recorded from kernels treated with Pirimiphos-methyl. The best performance of pirimiphos-methyl in restricting development of F1 progeny as compared to almost all agricultural wastes evaluated in this study agrees with reports of previous researchers. Emana (1993) reported that the highest dose of the local materials such as, wood ash and tobacco dust was better than the lowest dose in controlling *S. cerealella* except sawdust.

CONCLUSION

Locally available agricultural wastes including sawdust, coffee husk and wood ash were evaluated at different proportions against *S. zeamais* and *S. cerealella.* The efficacy of each treatment was evaluated with respect to F1 progeny emergence of the pests, mean number of damaged and germination percentage of maize seed. Coffee husk and wood ash at all dosages were found to be effective in controlling *S. zeamais* and *S. cerealella*. Wood ash at all proportions gave the best control of the pests during the study period. Wood ash and coffee husk at higher rates were more effective in controlling the pests. Sawdust at all dosages was not different from the untreated control in controlling *S. zeamais*. However, sawdust at some dosages showed superior performance against *S. cerealella*. Newly evaluated inert material like coffee husk should be re-tested to confirm the current result and sawdust, which showed inferior performance to the untreated control, should be tested at different environmental condition to confirm the result of the current study. In Ethiopia, where study was conducted especially high dosage of saw dust applied treatments increased the F1 progeny emergence of weevil. This might be due to the increased temperature of the micro-envirment of the treatments as observed during execution of the experiment.

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