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Ecofriendly management of storage insect pests of maize in Jimma Zone

Sisay Kidanu Demmirew[1], Tariku Tesfaye Edosa[2], Efrem Asfaw Gutema[3]
[1, 3] Jimma Research Center, P. O. Box 192, Jimma, Ethiopia
[2] Ambo Plant Protection Research Center, P. O. Box 37, Ambo, Ethiopia
[2] Chonnam National University, Kwangju, Republic of Korea

Abstract
The research was aimed to study the efficacy of botanicals and physical methods to manage storage insect pests of maize. The efficacy of two botanicals abeyi seed (*Maesa lanceolata*) and bekenisa leaf (*Croton macrostachyus*), both at 5% (w/w), teff (*Eragrostis teff*) admixture 50% (w/w), exposing maize grain to sun heat by black polyethylene sheet were evaluated to manage maize storage insect pests. The exposure of grain to sun heat using black polyethylene sheet caused the highest mortality of both maize weevil and Angoumois moth. Teff admixture constantly caused mortality of weevils and Angoumois moth through the experimental period. During the early stage, the botanicals were also equally performed mortality. All treatments reduced the grain damage and weight loss compared to the untreated check thereby, improved the seed germination compared the untreated check. However, the highest seed germination was recorded under the grain treated by teff admixture and the black polyethylene sheet. Finally, we concluded that solar heat, teff admixture as well as botanical plants are the potential and safe management options to control of maize storage insect pests, suggesting further investigation to extract the potential compound from these botanicals and test their efficacy for the future formulation of safe pesticides.

Keywords: maize weevil, insect mortality, grain damage, grain weight, progeny emergence

1. Introduction

In Ethiopia, particularly in Jimma zone, maize ranks first in production and productivity since the release of hybrid maize varieties. Yet, these hybrid varieties are reported to be highly susceptible to insect pest attacks both in the field and storage [1]. Hence, farmers are not as such the beneficiaries of this increased production and productivity potential of new varieties because of storage insect pests. Maize weevil (*Sitophilus zeamais*), Angoumois grain moth (*Sitotroga cerealella),* rice weevil (*S. oryzae)* and flour beetle (*Tribolium confusum)* insects, in order are the major pests of stored maize and widespread, abundant and causing major grain damage and loss in the zone. The two former insects showed greater mean 69.98 and 11.26 per 100gram of seed respectively while and an average of 64.5 grain damage associated with losses of up to 80% caused by the pests within three to six months of storage in Jimma zone [2]. In Ethiopia, due to maize weevil about 20% storage losses and 25% price reduction for the damaged grains were reported for maize, resulting in large income losses with value ratio not greater than one [3]. To reduce these losses, farmers intensively used synthetic insecticides in storage. However, synthetic insecticides have many deleterious effect to human and environments. Alternatively, farmers traditionally have been using various cultural practices and herbal products for the control of post-harvest insect pests [4]. However, because of various reasons, for example, lack of knowledge about the side effect of synthetic insecticides, less demonstration of safe and locally available pesticidal plants and immediate action of chemicals, farmers are still intensively using synthetic insecticides to manage storage insect pests. Therefore, the objectives of this farmers’ participatory research was to study the efficacy of available pesticidal plants and farmers’ indigenous practices against maize storage insect pests and adaptation of these safe management options among the farmers. At the end, we found all tested treatment have achieved good control compared with the untreated grain. Therefore, suggested to incorporate in IPM program further investigating the extraction of potential compound from the tested botanicals.

2. Materials and Methods

2.1 Description of the study area

Jimma zone is one of the 18 zones within Oromia regional states and divided in to 13 districts with population of over 2.2 million. It lies between 7^{0}15’ – 8^{0}45’N and 35^{0}30’-37^{0}30’E and the elevation ranges from 880 to 3360m above sea level. Kersa is one of the weredas in the Jimma zone of Ethiopia and is located at a distance of 346 km southwest of Addis Ababa, capital city of Ethiopia. It is situated at an altitude ranging from 1450-2550 meters above sea level and it is bordered by Limmu and Tiro-Afeta districts in the north, in the south by Dedo, Omo Nada in the East and Jimma town in the west. The area receives an average annual rainfall ranging from about 1400 to 1587mm. the minimum and maximum daily temperatures of the area are 100c and 320c, respectively. An agro-ecological setting of the district comprised of highlands (10%), midland (75%) and lowlands (15%). Seka Chokorsa is located at a distance of 364 km, south west of Addis Ababa. It is bordered by Gomma and Manna districts in the north, Gera district in the south, Dedo district and Jimma town in the east and Shebesombo district in the west. Seka Chokorsa is situated at an altitude ranging from 1480 – 2560 m.a.s.l. An agro-ecological setting of the district comprised of highlands (15%), midlands (67%) and lowland (18%) and the districts receives rainfall ranging from 1200 – 2800mm per annual [5].

2.2 Farmers selection

Three potential maize production and well-constructed Farmers Training Center (FTC) districts were purposively selected based on secondary data obtained from Jimma zone agricultural office. Totally thirty model farmers, which means, ten farmers from each area were randomly selected as participatory farmers. Seven male and three females were selected from each area. Traditional experiences of the farmers' practice to manage storage insect pests of maize were collected.

2.3 Botanicals collection and Preparation

Pesticidal plants (*Maesa lanceolata (*local name Abeyi*)* seeds and *Croton macrostachyus (l*ocal name bekanisa*)* collected from Tikurbalto (Kersa), Shashemane (Seka Chokorsa) and Ofiledawe (Dedo) districts together with FRG members. The leaves and seed of collected plants were dried under shade for a month in Jimma Agricultural Research Center Entomology laboratory. The dried botanicals were grinded in to fine powder using local mortar. Finally, 5% w/w (2.5kg of seeds or leaves /50kg of maize) botanicals powder was prepared for the experiment based on the previous preliminary research [6].

2.4 Treatment application

The prepared botanical powders and teff grain were thoroughly mixed with 50 Kg of the released maize varieties (BH660) each at the ration of 5% w/w and 50% w/w respectively. The Sacks containing maize were pilled upward separately side by side on wooden bench, 14cm above the ground. Sun exposure by black polyethylene sheet treatment was done for 3 hours during the hottest time of the day (11:30 AM – 2: 30 PM) on the first insect infestation, three months' post storage, during first progeny emergence and six months after storage. The experiment was replicated three times. Untreated maize was included as negative control and Ethiolathion was applied as positive control.

2.5 Data collection

Insect mortality, progeny emergence, Grain damage and grain weight loss were assessed by ten days' interval. 500g of grain sample was taken from the top, middle and bottom of the sacks from each treatment and the samples were composited according to the treatments. From each composite sample, 500g of grain was taken and insect mortality, progeny emergence, grain damage and grain weight loss percentage were calculated. Damaged and undamaged grains were separated using hand lens for the presence of holes. Grain damage and grain weight loss percentage were calculated using the formula of [7, 8].

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

Where "Wu" is weight of an undamaged grain, "Nd" is number of damaged grain, "Wd" is weight of a damaged grain, and "Nu" is number of undamaged grain.

$$\text{Damaged grain (\%)} = \frac{(NDG)}{(TNG)} \times 100$$

NDG: number of damaged grains TNG: total number of sampled grains

$$\text{Mortality (\%)} = \frac{(Dead)}{(Dead+alive)} \times 100$$

$$\text{Reduction of progeny emergence (\%)} = \frac{(NUT)-(NT)}{NUT} \times 100$$

NUT: Number of emerged progeny in untreated, NT: Number of emerged progeny in treated.

2.6 Data Analysis

All data were subjected to appropriate statistical software, Analysis of variance (ANOVA) using Statistical Analysis System (SAS) 2002 version at 5% ($p<0.05$) for experimental data (percent of mortality percent and progeny emergence percent, grain damage and weight loss). Least significance difference was used to check for significance difference.

3. Results and Discussion

3.1 Insect mortality and progeny emergence

During the study, two types of storage insect pests of maize (*Sitotroga cerealella* and *Sitophilus zeamais)* were observed from all experimental site (Fig.1. A and B). The statistical analysis shows that there is significant difference among treatments in causing mortality during the experimental period (Fig.2. A and B). During the experimental period, all treatments were caused significant mortality of both present insects compared with the untreated check. At the early stage (one month after storage), there were no significant different between the botanicals, teff admixture and black polyethylene sheet in causing mortality. Three, four and six months' post storage, black polyethylene sheet and Ethiolathion resulted in the highest mortality of maize weevils followed by teff admixture and both botanicals. On the other hand, efficacy of botanicals slightly decreased overtime. In case of the Angoumois moth, highest mortality was recorded when maize grain was exposed to sun. The others treatments were also significantly resulted higher mortality compared to the untreated control. Teff admixture caused consistent mortality of Angoumois moth through the experimental period. *Croton macrostachyus* caused the highest mortality of this insect during the early infestation and 1st progeny emergence. The report showed that 23% of the interviewed farmers uses teff admixture as the control of post-harvest insect pests [9]. Similarly, teff admixture with maize provided effective protection of maize grain from insect pests in storage [9]. This protection is from the small size of the teff grain and fill micro pores between the maize grain and thus hinder the movement of insects as well as cause shortage of air movement in the container.

Taken together, exposure of grain to sun using black polyethylene sheet caused the highest mortality of both maize weevil and Angoumois moth. Alternatively, teff admixture constantly caused mortality of weevils and Angoumois moth through the experimental period. During early stage, the botanicals were also equally performed mortality. This shows that the efficacy of botanicals against storage insect pests is high during the early application and probably decreased with time pass. This may be due to the chemical degradation of botanicals pesticides during longtime storage.

Three months after storage, all insects in the grain were removed by sieving and restored to check the emergence of progeny. Accordingly, significant differences were observed among the treatments in weevil and Angoumois grain moth progeny emergence. Interestingly, the two botanicals and teff admixture caused significantly less progeny emergence of maize weevils compared to the other treatments (Fig. 3). *Maesa lanceolate*, *Croton macrostachyus* and teff admixture reduced the weevils' progeny emergence by 59.7, 83.58 and 73.1% respectively. In case of Angoumois grain moth, *Maesa lenceolata* reduced the progeny emergence (70.1%), whereas, *Croton macrostachyus,* teff admixture and black polyethylene sheet resulted in the reduction of emergence by 44.7, 47.7 and 52.2 %, respectively. One of the fundamental characteristics of an effective grain protectant is its ability to reduce progeny production of insects in the treated grains [10]. *M. lanceolate* reduced the progeny emergence of maize weevils by 40% in laboratory study [11]. However, in our study, *M. lanceolate* caused higher percent reduction of progeny emergence. Similarly, the Mexican tea powder significantly reduced progeny emergence of maize weevil from the re- infestation and there by grain damage and weight loss [12].

Solar heating of *C. maculates* infested pea pigeon seeds in polyethylene bags trapped maximum temperature of 65ºC [13]. This resulted in complete death of the adult without laying eggs in all the solar-heated bags while considerable egg laying had taken place when the control treatment was examined five weeks after the treatment. Our current result agrees with this report in case of the highest mortality under solar heat; however, specially, the progeny emergence of maize weevils in our study was comparatively higher in the maize grain treated by solar heat. This emergence difference is probably due to the maize weevils lays eggs inside the grain and the solar heat does not enough to penetrate the grain seed coat to kill the eggs inside

Fig 1: Insect identified during the study. A) Angoumois grain moth (*Sitotroga cerealella)* B) maize weevil (*Sitophilus zeamais*)

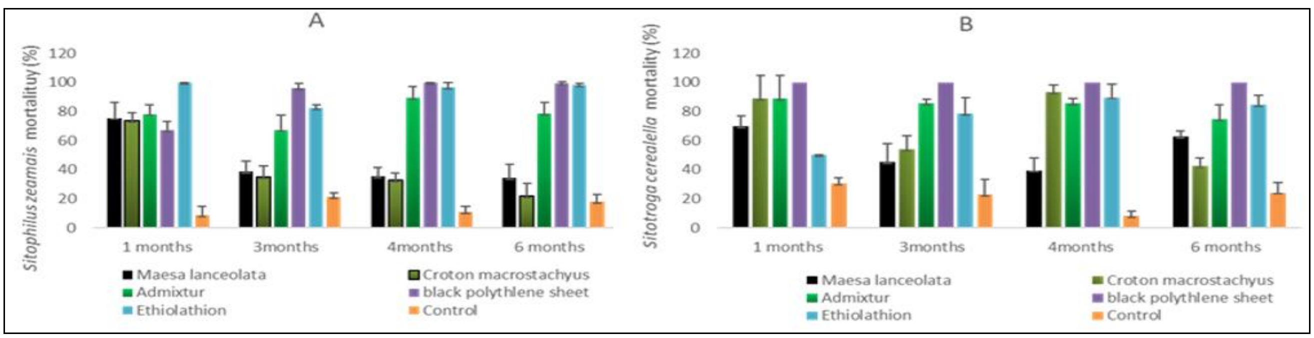

Fig 2: Percent mortality of insects due to treatments during the six months' storage. A) *Sitophilus zeamais* percent mortality; B) *Sitotroga cerealella* percent mortality. Months were counted from the first date of maize storage. 3 months' data was the average mortality of 2nd and 3rd months. 4th months was the first progeny mortality (During the 3rd month, all insects were removed from the storage by sieving and restored). 6th month is the average mortality of 5th and 6th months.

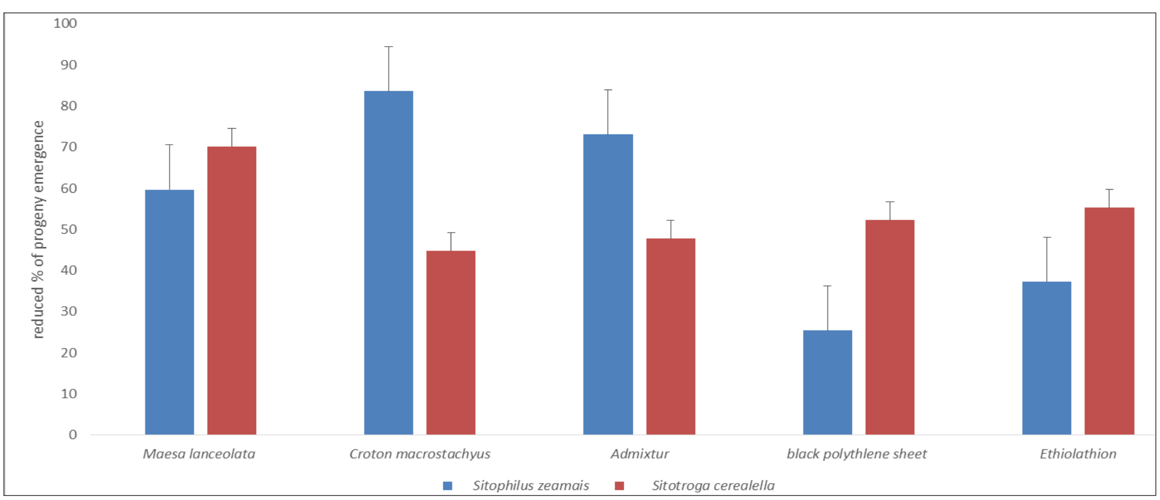

Fig 3: Mean number of progeny emerged after re-storage. Reduction percentage was calculated based the on the insect emergence under the untreated maize grain.

3.2 Grain damage, weight loss and germination percentage

Significant grain damage and grain weight loss were observed among the treatments compared to the untreated check six months' post storage (Fig. 4). All treatments reduced the grain damage and weight loss compared to the untreated check. Black polyethylene sheet and teff admixture were showed less percent of grain damage and weight loss as standard check. The report from Ethiopia showed that mean percentage of grain damage and weight losses by the pests under traditional storage practices were 64.50 and 58.85%, respectively and the maximum damage and weight loss was caused by *S. zeamais*, grain damage ranged from 54 to 75% between three to six months of storage whereas the weight loss varied from 41 to 80% [2]. To check the effect of the treatments on the seed germination, we tested the germination percentage at the end of the experiment (6months after storage). *M. lanceolate*, *C. macrostachyus*, admixture, and black polyethylene sheet increased the seed germination by 60, 60, 65, 63 %, respectively, over the untreated check. However, the significantly highest seed germination was recorded under the grain treated by teff admixture (90 %) and black polyethylene sheet (84 %).

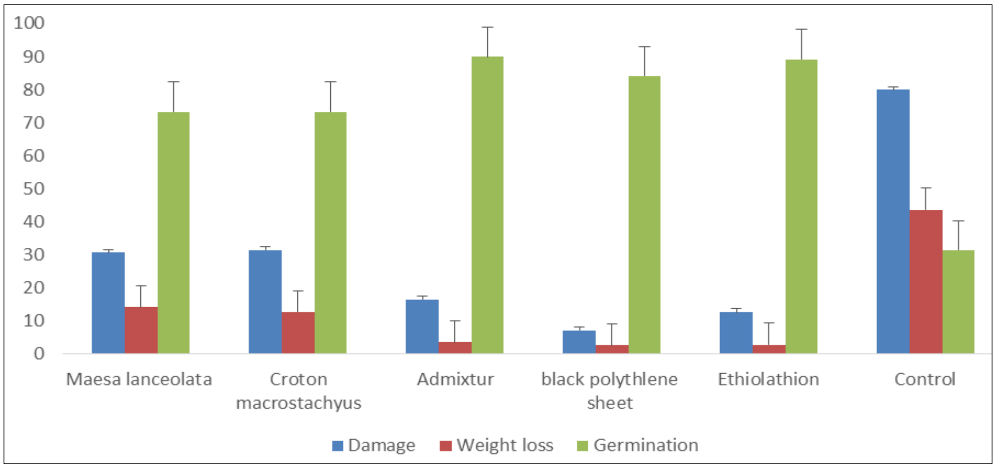

Fig 4: Percent of grain damage, grain weight loss and germination six months after storage

4. Conclusions

In conclusion, the efficacy of the two botanicals, black polyethylene sheet and teff admixture against maize weevils and Angoumois grain moth were studied using different parametries such as insect mortality percentage, progeny emergence, grain damage and weight loss percentage and seed germination percentage. Taken all together, botanicals performed well in causing mortality during the early application and the efficacy was decreased through time pass. Surprisingly, the progeny of maize weevils was low under botanicals compared to others treatments. All tested treatments reduced the grain damage and weight loss at the end of the experiment thereby, increased the seed germination percentage. In general, the results indicated the potential of using the solar energy and teff admixture as well as botanical plants for the control of maize storage insect pests. Further investigation should be initiated to extract the potential compound from these botanicals and test their efficacy for the future formulation of safe pesticides.

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7. Conflict of Interest Statement

The authors declare that they have no conflict of interest**.**

8. Author Contribution

Tariku Tesfaye Edosa, Sisay Kidanu Demmirew generated the idea and developed the experimental plan. Tariku Tesfaye Edosa, Sisay Kidanu Demmirew and Efrem Asfaw Gutema conducted the experiment. Tariku Tesfaye Edosa and Sisay Kidanu Demmirew wrote the manuscript. All authors read and approved the manuscript

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