ORIGINAL ARTICLE

Evaluation of Locally Available Botanicals Powder for the Management of Maize Weevil (*Sitophilus zeamais)*

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ABSTRACT

Maize is the second most widely grown cereal and gaining importance as highly nutritious crop in Ethiopia. However, evidences showed that maize is severely damaged by storage insects, mainly by Sitophilus sp. and need further research to minimize losses due to this pest in storage. In line with this, research was initiated to evaluate the efficacy of three botanical plants powders against Sitophilus sp. under laboratory conditions. Azadirachta indica L., Euphorbia trucalli and Calpurnia aurea powders were evaluated using completely randomized design (CRD) in three replications and at the rate of 1, 2 and 3g per 100g of grains and compared with untreated control. The effectiveness of the powders was evaluated on the basis of response variables like insect mortality, percentage of seed damage, weight loss, germination capacity, grain color and odor change. The obtained results showed that the powders caused 2.5 to 99% mortality at the different concentrations used with the highest concentration being most effective in killing the pests and reducing the grain damage and weight loss. Azadirachta indica and Euphorbia trucalli at 3g/100g were performed best in terms of mortality rate, reducing grain damage, weight loss and did not affect germination capacity. Moreover, there was no significant change in grain color and odor in comparison with untreated control. Based on the result, it was concluded that botanicals used in the present study have pesticidal properties to suppress S. zeamais in maize grain storage and could be used in protecting maize from weevil.

Key words: botanical plants, maize, storage and weevil

INTRODUCTION

Cereal crops are said to be the dominant source of nutrition for one-third of the world's population especially in developing nations of Sub-Saharan Africa (Macauley, 2015). Among cereals, Maize (*Zea mays L.*) is an important staple crop for most people in sub-Saharan Africa serving as source of food, feed and industrial raw material for production of fuel ethanol and starches (Nukenine *et al,* 2002; Ogunsina *et al*., 2011). FAO (2009) reported that maize is the most important cereal food crop in Africa particularly in eastern and southern parts of Africa accounting for 53% of the total area covered by cereals. It is also an important source of carbohydrate and forms about 90-95% of the total calories intake of the Sub-Saharan people (Emily and Sherry, 2010). In Ethiopia, food security and welfare of most farming population are dependent on the productive capacity of maize farmers (Wekesa *et al*., 2003). It is the staple food and one of the main sources of calories particularly in the major maize producing regions of the country (Girma *et al*., 2008).

In Ethiopia, the greater proportion of maize is produced by resource poor farmers in remote villages and they store maize to facilitate uniform supply of food throughout the year, to make available reserves for contingencies and to speculate on higher prices whether it is for local or export markets. During storage farmers are using poor post- harvest storage facilities, which often make them incur high post-harvest losses (Sori, 2014). Among biotic factors, storage insects are the primary causes of loss for maize grains in storage and constitute a great constraint to the realization of food security. In spite of the use of all available means of plant protection, the overall annual average damage caused by insect pests is estimated to be 10-40% worldwide (Satin, 1997; FAO, 1997) and 5 to 30% in Ethiopia (Abraham, 1991; Emana, 1999; Befikadu, 2014). Nearly one thousand species of insects have been found associated with stored products in various parts of the world. Among many stored insects weevils (*Sitophilus zeamais*), bruchids (*Calloso bruchus)*, larger grain borer and grain moth are the most well-known (Tefera *et al*., 2011). Maize weevils *(Sitophilus zeamais)* are one of the major and predominant pests among storage pests of maize and contribute to food insecurity and low farm incomes in Ethiopia (Keba and Sori, 2013). Therefore, in order to meet the food demand for the ever increasing world population, it is necessary to address the issue of maize grain loss to insect pest damage in storage.

Although satisfactory pest control has been obtained by use of synthetic pesticides, their adverse effects on environment and development of resistant weevil strains and residues in food crops have motivated different researcher to search for safer alternative methods. So far, different attempts have been made to come up with an appropriate maize insect pest control methods having promising results and safer for environment and human. For example, Bernard *et al.* (2013*)* evaluated the performance of basil powder as insecticide against maize weevil; Simbarashe *et al.* (2013) used *Eucalyptus tereticornis*, *Tagetes minuta* and *Carica papaya* as stored maize grain protectants against maize weevil. Longe (2016) used Cheesewood, Lemon-scented Gum, Ginger, Lime, Mint and Tobacco against Maize Weevil. Dekeba *et al,* (2016) used Ethanol extract of *A. indica, C. ambrosoides, M. lanceolata* and Diatomaceous earth. It has been shown that losses of grain due to weevil damage decrease with application of botanical plants. Money others researchers also used different botanical plants and predominately *A. indica* indicated promising result as grain protectant against maize weevils (Asmare, 2002; Issa *et al*., 2011; kifle *et al*., 2016; Tadele and Mulugeta, 2017).

However, subsistent farmers in Ethiopia treats maize grains with botanical plants available in their locality such as *Euphorbia tirucalli* and *Calpurnia aurea* commonly known as kincib and cheka respectively to protect grain from maize weevils on which scientific information is scarce. Therefore, the current study aimed to evaluate the efficacy of *Euphorbia tirucalli* and *Calpurnia aurea* in comparison with *A. indica* which is already indicated promising result in earlier report of different researcher as maize grain protectants in storage.

MATERIALS AND METHODS

Study Area

The study was conducted at University of Jimma in Post-harvest Management Laboratory, Located in southwestern part of Ethiopia at 356 km from Addis Ababa in between 2013 and 2014. The mean maximum and minimum temperature of the laboratory during the study period were 26.8^{0}C and 14.8^{0}C, respectively and the mean maximum and minimum relative humidity were 88.4% and 61.8% respectively.

Collection and preparation of test materials

Fresh leaves of *Azadirachta indica* A. Juss. (Meliaceae), *Calpurnia aurea (*Aiton) Benth. (Leguminosae) and steam of *Euphorbia trucalli* L. (Euphorbiaceae) (were collected from the natural habitat of Jimma zone of Oromia regional state and shed-dried naturally until they became crisp dry. The dried leaves and steam were crushed into powder using pestle and mortar and sieved using 80µm Laboratory sieve.

The initial generation of *S. zeamais* was obtained from Entomology laboratory of Jimma University and allowed to reproduce further at room temperature in Postharvest management laboratory. Adult weevils were introduced into one litre jars with maize grains and insects were allowed reproduce further for seven days after which they were sieved out with a sieve (2mm in diameter) to get similar aged weevils. The opening on the jars lids were covered with muslin net to firmly secures them to prevent possible escape from the jars. Finally similar aged and only newly emerged weevils were used for the experiment.

The common maize variety grown in the country and considered to be the most susceptible to storage insect infestation (BH-660) was used in the experiment ( ). It was thoroughly cleaned of broken kernels and debris and disinfested by keeping the grain in a cold for 12 hours to kill any introduced pests before storage.

Treatment application

The experiment was laid out in Completely Randomized Design (CRD) with ten replications. Twenty newly emerged *S. zeamais* were introduced into the plastic jar with perforated lids and containing 100g maize grains. Each botanical was weighed and added to the maize grain in plastic jars at rate of 3, 4 and 5g per 100g and shaken well for uniform coating before introducing the pests. One treatment was used as a control with no addition of any botanicals. The perforated lids of the jars were covered with muslin cloth to protect weevils from going out of the jars and secured with rubber bands as a ventilated lid

Data collection

The treated grains in the jar were kept for about 21 days and mortality rate assessments were performed regularly every 1, 3, 7, 14 and 21 days after exposure of botanical powders as indicated in Yankanchi and Gadache (2010). Briefly, the numbers of live and dead weevils were counted from each jar and the following formula was used to calculate the percentage weevil mortality:

$$Mortality\ (\%) = \frac{Dead\ weevils}{Total\ weevils} x100$$

Percentage of grain weight loss due to insect was carried out on treated and untreated grains by taking samples grains from each jar. Each treatment was separated into undamaged and insect-damaged grains and their numbers was counted, weighed and the percent weight loss of maize grains in storage was computed according to the methods described in Haines (1991) as follows:

$$Weight\ loss\ (\%) = \frac{UND - DN_U}{U(N_d + N_u)} *100$$

where UND = weight of undamaged grains, DNU = weight of insect damaged grains, Nu = number of undamaged grains Nd = number of insect damaged grains.

Percentage of seed damage was assessed by counting wholesome and bored or seed with insect emergent holes and expressed in percentage.

To carry out germination test, one hundred seeds randomly selected from the jar were placed in Petri dishes containing moistened soft paper and kept at 30^{o}C in an incubator (Model MJX-150B, China). The number of germinated seedlings from each Petri dish was counted and recorded from 7 to 9 days after planting. The percent germination was computed as described in Ogendo *et al.* (2004):

$$Ger\min ation\ (\%) = \frac{Number\ of\ seeds\ ger\min atetd}{Total\ number\ of\ seed} *100$$

Subjective evaluation was used for color and odour change of untreated and treated maize grain following the methods described in David and Francis, (1957). A total of 50 panelists were evaluated using a five point hedonic scale Where: 5. No detectable change, 4. Slight change, 3. Moderate change, 2. Great change, 1. highly significant change for color and 5. Odorless, 4. Little offensive odour, 3. Moderate offensive odor, 2. High offensive odour, 1. Very high offensive odor.

Data Analysis

All data were analyzed using one-way Analysis of Variance (ANOVA) using Minitab version 20 and displayed using graphs and table. Before data analysis, diagnostic tools like normal plot of residuals were tested and indicated that the residuals of all parameters are normally distributed. Mean separations were conducted using Tukey's Honestly Significant Difference (HSD) test at 5% level of significance

RESULTS AND DISCUSSIONS

Effect of Botanical plants on Weevil Mortality

The effectiveness of the botanicals on maize weevil mortality is shown in Table 1.There was a significant difference ($p<0.001$) in mortality rate of weevils due to botanical powders with *Azadirachta indica* and *Euphorbia trucalli* being most effective at 3g dosage compared to other treatments over all duration of storage. The mortality rate of weevils treated with *Azadirachta indica* and *Euphorbia trucalli* was high at 3 g dosage although similar mortality was attained using 2g at 7th, 14th and 21st days of storage. The lowest mortality was recorded from control treatment over all storage period followed by *Calpurnia aurea* at lowest concentration (1g/100g).

Azadirachta indica and *E. trucalli* powder significantly reduced the number of maize weevils by at least 93% at higher concentration. These results indicated that utilization of *A. indica* and *E. trucalli* at higher concentration (3g/100g) can be used to control *S. zeamais* in stored maize grain. In similar manner, utilization of different botanical products as stored crop grain protectants has been reported by different researcher (Sori, 2014; Dekeba *et al.,* 2016; Longe, 2016; Tadele and Mulugeta, 2017). Mortality of *S. zeamais* varied with the concentration used with highest mortality at application of high concentrations (3g/100g) for all botanicals over 21 day's period. This is consistent with the finding of Simbarashe *et al.* (2013) who reported that higher dosage of plant powders resulted lower number of live insects and stored grain damage and weight loss.

Table 1: Effect of botanical powder on the mortality of *S. zeamais* on treated maize

		Mean mortality (%) over days				
Treatment	Dosage/100g	1st day	3rd days	7th days	14th days	21st days
Control	-	0.00e	0.00e	0.00e	3.60e	4.30f
Azadirachta indica	1gram	9.15c	25.33c	38.35cd	47.50c	60.50cd
	2gram	14.70bc	38.33b	73.50ab	80.15ab	89.00ab
	3gram	32.50a	78.15a	87.50a	93.35a	96.65a
Euphorbia trucalli	1gram	5.83cd	24.85c	50.65c	56.5c	70.65c
	2gram	17.50b	41.35b	82.50ab	88.35ab	93.35a
	3gram	33.05a	79.15a	90.85a	95.00a	99.15a
Calpurnia aurea	1gram	2.50d	10.15d	24.65d	30.50d	38.00e
	2gram	5.83cd	24.00c	37.50cd	43.35cd	45.85de
	3gram	16.09b	37.50b	47.50c	50.85c	55.50d
CV (%)		1.34	1.40	1.20	1.71	3.45

Effect of Botanical plants on percentage of seed damage and weight loss

There was a significant difference among different doses applied on percentage of seed damage (Figure 3) and grain weight loss (Figure 4) caused by maize weevil in the storage. A maximum percentage of seed damage was obtained from the untreated control followed by *C. aurea* treated maize grains although there was no significant difference between three botanical powders.

Low percentage of seeds damage was recorded when higher concentrations of all botanicals were applied (Figure 3). This could be due to the fact that high concentration of botanical powders promoted higher insect mortality as a result of physical barriers effect. Bernard *et al.* (2013) also reported the highest dosage of the basil powder protected the maize grain against feeding by maize weevils which resulted in no noticeable feeding damage on seeds. In similar manner, Kifle *et al.* (2016) reported there are no grain holes when maize was treated with Neem seed and citrus peel powder at higher concentrations.

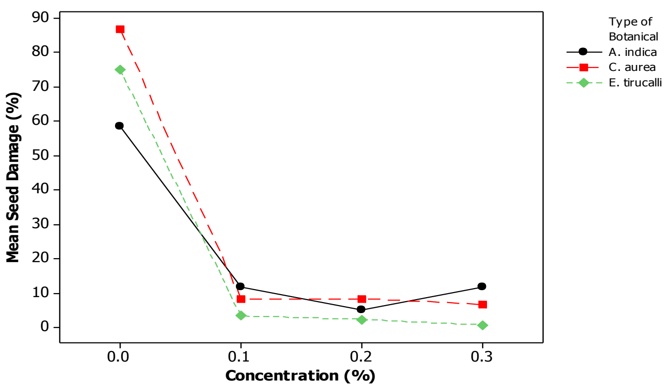

Figure 1: Effect of botanical powders at different concentration on percentage of maize seed damage

Similarly Parwada *et al.* (2012) reported that ground plant extracts may suffocate the weevil and reducing weevil movements and thus resulting in reduced grain damage and weight loss. In terms of grain weight loss, there was a significant difference ($p<0.001$) in grain weight loss among the different treatments (Figure 4). All treatments significantly reduced weight loss compared to the untreated grain. Among all treatments *A. indica* 3g resulted in the least grain weight loss due to weevil damage and untreated grain highly suffered with weight loss than other treatments followed by *C. aurea* treated maize grains (Figure 4). Similar finding was reported by Akhtar *et al.* (2004) on investigation of the growth inhibitory and anti-feedant effects of plant extracts and pure allelochemicals on four phytophagous insect species.

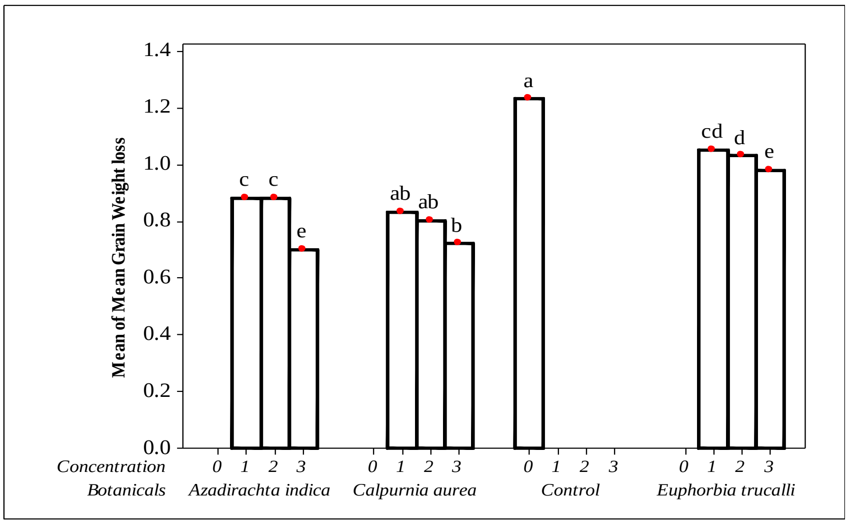

Figure 2: Effect of botanical plants at different concentration on percentage of maize grain weight loss in storage

Therefore, the present finding showed that powders of all three botanicals at higher doses effectively reduced the grain weigh loss compared with untreated control. Similar result was recorded by Bernard *et al,* (2013) who showed there was no significant weight loss in the grains treated with the highest dose of Basil Powder. Simbarashe *et al,* (2013) also indicated there is no weight loss at higher dosage when maize grains treated with *Eucalyptus tereticornis*, *Tagetes minuta* and *Carica papaya* powders.

Effect of Botanical plants on Germination capacity

The effect of botanical powders on seed viability (germination percentage) of maize seeds revealed that there was a significant difference (P<0.05) between untreated control and botanically treated grains (Figure 5). The result indicated that none of the botanical powders mixed with the grains adversely affected the germination of maize grains compared to the untreated controls. Minimum germination percentage of around 15% was recorded from the untreated control seeds while all treated grains recorded more than 80% of germination capacity.

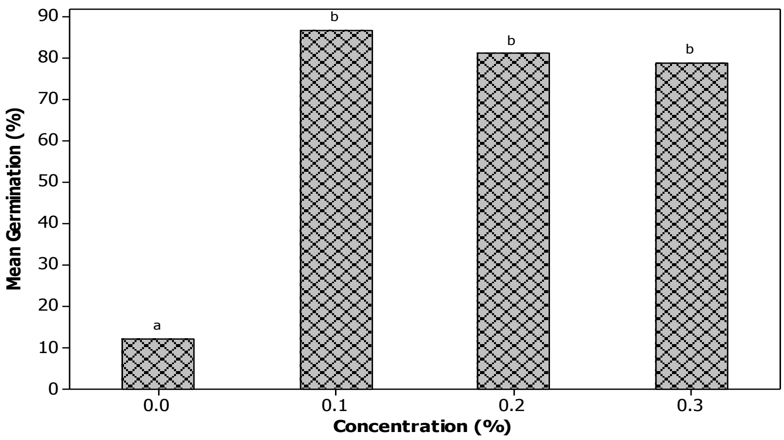

Figure 3: Effect of botanical plants at different concentration on percentage of maize germination capacity in storage

This is could be due strong and positive correlation between the percentages of grain damage and germination capacity in which damaged grains are low in germination capacity. Similar trends was reported by Dekeba *et al.* (2016) who reported that ethanol extract of selected botanicals and diatomaceous earth do not adversely affected germination capacity of maize grains.

Effect of Botanical plants on grain color and odor change

The result of subjective odor change evaluation showed that there was no significant difference (P>0.05) among the treatments. The lowest numerical odor change was recorded from untreated control and followed by maize treated with *C. aurea* (Table 2). On the other hand, the highest numerical odor change was observed on maize grains treated with *A. indica* followed by grain treated with *E. trucalli.*

Table 2: Effect of botanical plants at different concentration on maize grain odor and color change in storage

Treatment	Dosage/100g	Color	Odour
Control	-	5.00	5.00
	1gram	4.55	4.33
Azadirachta indica	2gram	4.50	4.33
	3gram	4.35	4.15
	1gram	4.43	4.85
Euphorbia trucalli	2gram	4.40	4.35
	3gram	4.05	4.15
	1gram	4.85	4.15
Calpurnia aurea	2gram	4.83	4.00
	3gram	4.59	4.50
CV (%)		1.34	1.40

CONCLUSION

The powders of botanical plants tested in the current study demonstrated great potential to be used as protectants against maize weevils in storage. Among the botanical plants powders, *A. indica* and *E. trucalli* were observed to be the highest potent botanicals and *C. aurea* revealed to be moderately toxic to the weevils. *A. indica* and *E. trucalli* powders at their highest concentration caused mortality ranging from 33-99% to *S.zeamais* over 21 days of exposures, reduced percentage of seed damage from 85% (untreated control) to at least 15%. With application of botanical powders, percentage weight loss decreased and did not affect the germination capacity. Therefore, Small holder farmers can use the powders as storage insect pest management options, but this may only be guaranteed at high levels of botanical concentration. It is recommended that studies be conducted to determine the efficacy of these powders against the maize weevil in large scale (in real farmer's store). Moreover further work is needed to find out active materials (bioactive compounds) of these plants to develop effective formulations, which can be commercialized in commercial industry for insect control.

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