USE OF BOTANICALS FOR WEEVIL MANAGEMENT: A INTEGRATED APPROACH OF MAIZE WEEVIL (*Sitophilus zeamais*) MANAGEMENT IN A STORAGE CONDITION

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ABSTRACT

A study was conducted at Entomology Laboratory of Agriculture and Forestry University with the aim of evaluating the efficacy of potential plant materials to manage the maize weevil; *Sitophilus zeamais* Mots. (Coleoptera: Curculionidae) from April to October 2015. The mean temperature and RH of storeroom during the experiment period was 29.37^{0}C and 71.91% RH. A completely randomized design (CRD) was laid out with three replicates. Seven plant materials such as *Acorus calamus* (rhizome powder) @ 10gm kg^{-1}, *Azadirachta indica* (seed powder) @ 10gm kg^{-1}, *Artemisia vulgaris* (leaf dust) @ 10gm kg^{-1}, *Zanthoxylum alatum* (fruit powder) @ 4gm kg^{-1}, *Melia azadirach* (seed powder) @ 10gm kg^{-1}, *Justicia adhatoda* (leaf dust) @ 10gm kg^{-1} and control were used as treatments. After six months, the lowest percentage maize weight loss (1.5) and lowest grain damage (1.43%) was observed in *Acorus calamus* treated grains. However, the highest grain damage percentage (18.02%) and weight loss (57.30%) was recorded in control treatment. Similarly, the lowest number of exit holes (3.30) was observed in *Acorus calamus* treated grains but highest (47.00) were recorded in control. Significantly more numbers of weevil were emerged (57.00) in control treatment whereas only a few (2.70) were recorded in *Acorus calamus* treated grains. Hence, it is concluded that maize weevil showed less preference to *Acorus calamus* treated grains with minimum weight loss and less grain damage as compared to other botanicals. This finding is important for promoting locally available botanical materials to manage maize weevil in Nepal.

Keywords: *Zea mays, Sitophilus zeamais, Acorus calamus,* botanicals

INTRODUCTION

Maize (*Zea mays* L.) is the major cereal crops produced worldwide (Ranum, Peña-Rosas, & Garcia-Casal, 2014) which is the second most important crop after rice in Nepal (MoAD, 2015/2016). The total annual production is about 23-thousands metric tons with a yield of 2458 mt/ha (MoAD, 2014). It covers about 78% of the total cultivated areas in hilly areas and 26.9% of the total cereal crop cultivated (AICC, 2016/017). These crops are susceptible by a wide range of insect pests both in field and storage condition (Neupane *et al.,* 1991). Out of them, maize weevil (*Sitophilus zeamais* Mots.) is the most important pest in a storehouse in Nepal (Sherpa *et al*., 1997). This pest damages the harvested maize by making holes and feeds the inner starch which causes weight loss and reduced the quality (Trematerra, Ianiro, Athanassiou, & Kavallieratos, 2013). The average loss by *S. zeamais* is estimated about 20-80% in tropical countries (Pingali and Pandey, 2001) however, the losses have been recorded up to 18-40% in Chitwan condition of Nepal (Sharma & Tiwari, 2016).

A considerable amount of grain weight losses including a loss in quality have been observed in the storehouse. The appropriate and safe weevil management practices are lacking in storehouse in Nepal. However, use of celphos (alumunium phosphide) is the common practices all over the Nepal. The current pesticide management practices deteriorate the health and environment and caused many complex health problems (Talukder & Howse, 1994). Further, pesticide management is an expensive and non-easy method for smallholding farmers (Iloba & Ekrakene, 2006). Hence, an alternative and safe method of weevil management has been realized for their integrated management. Nepal is rich in biodiversity especially with a diverse family group of plant materials. These plant materials have the potentiality to repel the storage pest from the storehouse (Neupane, 2009). The common plants and their parts such sweet flag stolen, *Azadirachta indica* oil, *Azadirachta indica* seed powder, *Zanthoxylum alatum* seed powder, *Artemisia vulgaris* leaf etc have been used to manage the diverse categories of storage (Sharma *et al.,* 2016; Paneru *et al*., 1997; Anonymous, 1988). Realizing the insufficient study of botanical materials to control weevil in storage conditions and to minimize the effect of hazardous chemical materials, an intensive study was conducted in Rampur, Chitwan, Nepal. The study is important to evaluate the potential botanical materials and promote these locally available resources for integrated management of weevil in storehouse. This study has a significant impact to promote the non-insecticidal pest management and safe production.

MATERIALS AND METHODS

The study was conducted at the Entomology Department of Agriculture and Forestry University of Nepal. Three kilograms of maize seeds cv. Manakamana-3 were used for each treatment and they were kept inside the air-proof plastic bag. Seven different treatments (botanicals) such as *Acorus calamus* (rhizome powder) @ 10gm kg-1, *Azadirachta indica* (seed powder) @ 10gm kg-1, *Artemisia vulgaris* (leaf dust) @ 10gm kg-1, *Zanthoxylum alatum* (fruit powder) @ 4gm kg-1, *Melia azadirach* (seed powder) @ 10gm kg-1, *Justicia adhatoda* (leaf dust) @ 10gm kg-1 and control was taken for the study. The experiment was laid out into the completely randomized design (CRD) with three replicates. The study was conducted at a normal room temperature. The temperature and humidity of the study room were taken daily from the onset of the experiment to the end. The data was recorded before the experiment set up and every two-month interval for three times (2-months, 4-months and 6-months). The following parameters such as total numbers of grain damage, total weevils emerged, total numbers of exit holes, initial and final weight of grains and weather parameters such as temperature and humidity of the room were recorded. All data were subjected to Gene-Stat for statistical analysis. Data were subjected to one-way (treatments) analysis of variance (ANOVA) and means were separated by unprotected least significance difference (LSD) at $P < 0.05$ (Saville, 2015).

RESULTS AND DISCUSSION

Grain damage

All the botanicals used for the weevil management had a significant effect ($P < 0.05$) on grain damage over control. The highest percentage grain damage was found under control (18.02%) and lowest was on *Acorus calamus* (1.43%) (Table 1).

Table 1: Grain damage by maize weevil (*Sitophilus zeamais*) using different botanicals in 2015

Botanicals	Grain Damage		
	2-months	4-months	6-months
Acorus calamus (rhizome powder)	0.93a	0.83a	1.43a
Azadirachta indica (seed powder)	2.28a	3.43a	12.68b
Justicia adhatoda (leaf dust)	2.17a	3.99a	13.86b
Zanthoxylum alatum (seed powder)	2.73a	3.56a	17.08b
Artemisia vulgaris (leaf dust)	1.70a	3.77a	13.76b
Melia azadirach (seed powder)	1.82a	2.80a	7.82a
Control	4.92b	5.60b	18.02b
P-value	0.027	0.014	0.003
CV%	21.1	13.8	17.9
$LSD_{0.05}$	2.037	2.097	6.826
SEM	0.661	0.681	2.215

Means within a column with no letters in common are significantly different (Unprotected LSD; P < 0.05). Each treatment was differentiated each other on the basis of Least Significant Difference and SEM represents standard error of the mean, CV represents the coefficient of variation and probability value (P-value) was designed on the basis of Unprotected LSD P <0.05.

G.C. (2006) also found *Acorus calamus* (50gm/kg) was most effective against maize weevil with least damage for the nine-month period. This result also follows the findings of Paneru and Thapa (2018), with high efficacy of *Acorus calamus* rhizome dust against weevils with lowest grain damage in the storehouse.

Number of exit holes per 100 grams of maize

The effect of different botanical treatment had a significant effect on the number of exit holes made by the weevil (P < 0.05). The exit holes made by the weevils at the end of the experiment were highest (47) in control whereas lowest was recorded on *Acorus calamus* treated seeds (3.3) (Table 2). A similar finding was demonstrated by Shrestha (2006) and reported that negligible exit holes in maize grains were recorded on *Acorus calamus* (rhizome powder) treated seeds.

Table 2: Exit hole numbers caused by maize weevil (*Sitophilus zeamais*) under different botanical treatments in maize seeds in 2015

Botanicals	No. of exit holes per 100-gram maize seeds		
	2-months	4-months	6-months
Acorus calamus (rhizome powder)	0.88a	2.00ac	3.30ac
Azadirachta indica (seed powder)	1.72a	3.67a	18.00c
Justicia adhatoda (leaf dust)	1.56a	5.33a	32.00b
Zanthoxylum alatum (seed powder)	1.77a	6.67a	36.00b
Artemisia vulgaris (leaf dust)	1.57a	3.33a	23.70b
Melia azadirach (seed powder)	1.46a	3.00a	12.70a
Control	2.53b	12.00b	47.00b
P-value	0.018	0.001	0.003
CV%	11.1	12.7	24
$LSD_{0.05}$	0.7466	2.652	17.890
SEM	0.242	0.861	5.810

Means within a column with no letters in common are significantly different (Unprotected LSD; P < 0.05). Each treatment was differentiated each other on the basis of Least Significant Difference and SEM represents standard error of the mean, CV represents the coefficient of variation and probability value (P-value) was designed on the basis of Unprotected LSD P < 0.05.

Weevil population

The effect of *Acorus calamus* (rhizome powder) and *Azadirachta indica* (seed powder) treated maize seeds had a significant effect on the weevil population as compared to other treatments (P < 0.05). The lowest number of weevil was found in *Acorus calamus* treated seeds (2.7) whereas highest (57) was recorded in control (Table 3). Β-arsanone found in *Acorus calamus* powder found to cause mortality in weevils thus reducing new live weevil generation (Paneru *et al.,* 1997) which follows the same result received in this study. Similarly, Panthee (1997) reported that less weevil population was recorded in *Acorus calamus* treated wheat seeds.

Table 3: Number of weevils in different botanically treated maize seeds in 2015

Botanicals	Weevil population		
	2-months	4-months	6-months
Acorus calamus rhizome powder	0.88a	0.71c	2.70c
Azadirachta indica (seed powder)	1.17a	1.05a	19.70c
Justicia adhatoda (leaf dust)	1.34a	1.47a	47.30b
Zanthoxylum alatum (seed powder)	1.26a	1.54a	55.30b
Artemisia vulgaris (leaf dust)	1.35a	2.18d	28.30b
Melia azadirach (seed powder)	1.38a	0.88c	6.30c
Control	2.53b	3.11b	57.00b
P-value	0.011	<.001	0.008
CV%	20.9	16.6	30.7
$LSD_{0.05}$	0.740	0.813	30.670
SEM	0.2403	0.2639	9.950

Means within a column with no letters in common are significantly different (Unprotected LSD; P < 0.05). Each treatment was differentiated each other on the basis of Least Significant Difference and SEM represents standard error of the mean, CV represents the coefficient of variation and probability value (P-value) was designed on the basis of Unprotected LSD P <0.05.

Weight loss

A significant weight loss has been observed in botanicals treated grains as compared to control (P < 0.05). The lowest weight loss was found in *Acorus calamus* treated maize grains (1.5) and highest loss was observed in control (57.3). *Acorus calamus* (30 gm/kg) in maize grains caused the lowest damage in low and mid hills of Nepal and also caused significant lowest weight loss (Sah, 1999). Regmi *et al.,* (2012) also concluded the same result and reported that *Acorus calamus* treated seed demonstrated low weight loss in storehouse.

Table 4: Percentage weight loss by maize weevil (*Sitophilus zeamais*) after six months under different botanical treatments in maize in 2015

Botanicals	Weight loss (kg) after six months of treatment used		
	Initial wt.	Final wt.	% Wt. loss
Acorus calamus (rhizome powder)	3.00	2.95a	1.50c
Azadirachta indica (seed powder)	3.00	2.80a	6.40c
Justicia adhatoda (leaf dust)	3.00	1.94c	35.20a
Zanthoxylum alatum (seed powder)	3.00	2.75a	8.30c
Artemisia vulgaris (leaf dust)	3.00	1.97c	34.10a
Melia azadirach (seed powder)	3.00	2.04a	32.00a
Control	3.00	1.28b	57.30b
P-value	-	0.001	0.001
CV%	-	6.9	10.7
$LSD_{0.05}$		0.277	9.240
SEM	-	0.0899	3.000

Means within a column with no letters in common are significantly different (Unprotected LSD; $P < 0.05$). Each treatment was differentiated each other on the basis of Least Significant Difference and SEM represents standard error of the mean, CV represents the coefficient of variation and probability value (P-value) was designed on the basis of Unprotected LSD $P < 0.05$.

CONCLUSION

Maize is an important staple food in Nepal and extensively used for human consumption and animal feed. In Nepal, maize has been growing in the mid-hills and inner-terai regions. The production of maize has been limited by several biotic and abiotic factors. Pre-harvest and post-harvest loss caused by insect pest recorded up to15-20%. However, maize grain loss in storehouse is comparatively higher than field conditions. Maize weevil is one of the devastating pests in the storehouse and their loss recorded up to 20% in normal situations. Use of highly hazardous pesticide such as aluminium phosphide (celphos) and malathion powder are the common weevil management practices in the storehouse. The current use of such pesticide negatively influenced the human health and environment. Hence, a locally available repelling plant materials were tested for the eco-friendly management of weevil. Out of the several tested plant materials, *Acorus calamus* (rhizome powder) has significantly reduced the weevil population. The weight loss, number of grains damage, number of exit holes and weevil population were significantly lower in *Acorus calamus* treated sample than control and other tested treatments. The other two tested materials such as *Melia azadirach* (seed powder) *Azadirachta indica* (seed powder) possess more positive results after *Acorus*. This finding is important for developing integrated weevil management model in storehouse which can be socially adaptable, economically viable and environmentally friendly approach in a rural part of Nepal.

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