USE OF BOTANICALS FOR MANAGEMENT OF WEEVIL (*Sitophilus zeamais* motschulky) IN MAIZE STORAGE

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ABSTRACT

A laboratory study was conducted with the aim of evaluating efficacy of different botanical insecticides against weevil in storage with four replication in completely randomized design. Seven plant materials; Acorus calamus Linn.*, Piper nigrum* Linn.*, Zanthoxylum armatum* DC.*, Azedarachta indica* A. Juss.*, Melia azedarach* Linn.*, Justicia adhatoda* Linn.*, and Artemisia vulgaris* Linn. *were compared along with control. Maize samples were infested with S. zeamais at the rate of 4 pair adults/50 g. At 120 days of treatment, the highest and lowest number of weevil progeny (19.75 and 0.70), and grain damage% (19.50% and 0.21%) was recorded in control and A. calamus. Similarly, weight loss% was the highest on control (7.03%) and lowest on A. calamus (1.80%), followed by A. indica (2.79%) and P. nigrum (3.13%), respectively.100% weevil mortality was observed in A. calamus and P. nigrum treated grains within 14 and 21 days. A. calamus was found more effective for weevil management in storage.*

Keywords: Botanicals, maize, maize weevil, mortality

INTRODUCTION

Maize (*Zea mays* Linn.) is one of the important staple food source in Nepal after rice. The productivity of maize is 2.84 t/ha. It occupies around 27.72% area of the total cereal cultivation and 25.39% of total cereal production (SINA, 2018/19). It is the world's biggest supplier of calorie (19.5%) for body growth followed by rice (16.5%) and wheat (15%) (FAO, 2019). However, losses in maize is significantly high in storage condition (Neupane *et al*. 1991). Approximately 10-100% loss is recorded in maize due to storage pests depending upon storage structure and physical environment (Shivakoti and Manandhar, 2000). Maize weevil (*Sitophilus zeamais* Motsch.) is the most important storage pest of maize in Nepal (Manandar and Mainali, 2001). Appropriate management practices against weevils are deficient in storehouse in Nepal. Deleterious chemical compounds like aluminum phosphide, malathion, ethyl formate etc., are being practiced by farmers for its control and management (Joshi *et al*. 1991). In fact, use of celphos (aluminum phosphide) is the common practices in Nepal (Tiwari *et al*. 2018). But the haphazard use of these synthetic pesticides is being great threat to the environment and human health due to residual property (El-Salam and Ahmed, 2010). So, it is necessary to replace harmful chemical compounds with better alternatives for healthy environment and good health. Use of botanicals

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with insecticidal properties could be the best possible alternative as they are biodegradable in environment with no residue effects. Many literatures have emphasized the use of insect repellent botanical pesticides like *A. calamus* (rhizome powder), *A indica* (leaf dust, oil, seed powder), *A. vulgaris* (leaf dust), *M. azedarach* (leaf dust), *Z. armatum* (fruit powder) etc., against the storage pest (Thapa, 1996; Iieke and Oni, 2011; Iieke and Ogungbite, 2014; Bhandari *et al*. 2015; Paneru and Thapa, 2018). These plant materials have the potentiality to act as repellent against storage pest due its various chemical constituent (Neupane, 2009). Considering this fact, the research was conducted in the laboratory of National Entomology Research Centre, Khumaltar from November 2020 to May 2021 using locally available plant material with insecticidal properties against maize weevil. Hence, the main objective of this research was to find out the effective botanical against maize weevil management in storage.

METHOD0LOGY

MAINTENANCE OF PURE CULTURE OF MAIZE WEEVIL

Pure culture of S. *zeamais* for the experiment was prepared at the laboratory of National Entomology Research Centre, Nepal Agriculture Research Council (NARC). The susceptible maize variety, Manakamana- 4 was oven dried at 60˚C for 4 hrs to make them free from possible insect pests and excess moisture (CABI, 2007). The moisture content of maize was maintained at 14% as per method described by Cecilia *et al*. (1990). Grain moisture content was determined using WILE 65 -Moisture meter. Maize grains (200g) were kept in glass jar of 500g capacity and 50 pairs of S. *zeamais* were introduced after sexing as described by Hidayat *et al*. (1996) and left for oviposition. The set up was replicated three times in completely randomized design and samples were observed daily until emergence of F1 progenies. The mouth of the glass bottles were covered with a black muslin cloth on the top. The average temperatures and relative humidity of laboratory was recorded 26.9 ± 1.76 ºC and 35.6 ± 7.32 % by temperature hygrometer (HTC-1, Instrumentics, India) respectively. The culture so maintained was used for further research.

COLLECTION, PREPARATION AND DETAILS OF BOTANICALS

Seven botanicals with insecticidal properties such as of *A. calamus, A. indica, A. vulgaris, M. azedarach, J. adhatoda, Z. armatum, P. nigrum* and control was taken for the study (Table 1). The selection of these specific plant materials and their doses were based on the recommendation in literatures (Paneru *et al*. 1996; Sharma, 2014; Sharma *et al*. 2016; Tiwari *et al*. 2018; Sitaula *et al*. 2020). Leaves (with small twigs) of *A. indica, A. vulgaris, M. azedarach* and *J. adhatoda* were collected from Kawasoti, Nawalparasi. Fruit of *Z. armatum* and *P. nigrum* were procured from the market (Asan, Kathmandu). Rhizome of *A. calamus* was collected from the garden of National Entomology Research Centre, Khumaltar, Lalitpur. They were properly washed and cleaned using distilled water. Afterward, leaves of *A. indica, A. vulgaris,* *M. azedarach* and *J. adhatoda* and rhizome of *A. calamus* were dried on shade for 4-5 days. Whereas, fruits of *Z. armatum,* and *P. nigrum* were dried on sun (4-5 hrs.) for 3-4 days. The dried plant materials were grinded in mixer grinder (IS 4250, Saiji, India) to bring them into powder/dust form. Then they were kept separately in airtight plastic bags in the laboratory.

The experiment was conducted in completely randomized design (CRD) with 4 replications and 8 treatments during November 2020 to May 2021.

Table 1. List of botanicals as treatments with parts used and its doses in experimental study of maize weevil management

S.N.	Treatments	Common Name	Nepali Name	Parts used	Doses	References
1	*Acorus calamus* Linn.	Sweet flag	Bojho	Rhizome powder	@10 g/kg	Tiwari *et al*. 2018
2	*Piper nigrum* Llinn.	Black pepper	Marich	Fruit powder	@10 g/kg	Sitaula *et al*. 2020
3	*Zanthoxylum armatum* DC.	Prickly ash	Timur	Fruit powder	@10 g/kg	Sharma *et al*. 2016
4	*Azedarachta indica* A. Juss.	Margosa tree	Neem	Leaf dust	@10 g/kg	Tiwari *et al*. 2018
5	*Melia azedarach* Linn.	Chinaberry tree	Bakaino	Leaf dust	@10 g/kg	Tiwari *et al*. 2018
6	*Justicia adhatoda* Linn.	Malabar nut	Ashuro	Leaf dust	@10 g/kg	Tiwari *et al*. 2018
7	*Artemisia vulgaris* Linn.	Mugwort	Titepati	Leaf dust	@10 g/kg	Sharma *et al*. 2016
8	Control	-	-	-	-	

EXPERIMENTAL PROCEDURE

Manakamana-4 variety of maize obtained from Agriculture Botany Division (ABD) was used for the study. They were sterilized (oven dried at 60^0C for 4 hrs) to eliminate insect pests and to minimize excess moisture. The grain moisture content (GMC) of oven dried maize samples were determined by using a WILE-65 Moisture meter (Farmcorp, Finland) and then adjusted to 14% GMC as per method explained by Cecilia *et al*. (1990).

Then, 50 g of maize grains were measured and separately, treated with the powder form of botanicals at the rate of 10 g/kg. They were kept in plastic bottle of 100g capacity and each bottle was infested with 4 pairs of freshly emerged sexed weevils. Holes of around 1.5—2 cm diameter was made in the lid of each bottle and then they were covered with black muslin clothes. The untreated maize grains served as a control in the experiment. Data was taken 3 times at 30 days interval. The observed parameters were parent's weevil mortality percentage, progeny emergence and grain damage percentage (weight basis). With the help of digital weighing balance, grain damage percentage was calculated whereas, parent's weevil mortality percentage and progeny emergence were found out by sieving followed by a visionary basis.

DATA ENTRY AND ANALYSIS

Data were entered using MS-excel and were analyzed using GENSTAT statistical package. Means were separated by using Duncan's Multiple Range Test (DMRT) at 5 % level of significance. The variance heterogeneity within the treatments were reduced by transforming percentage data into angular (Arc sine) value (Snodecor and Cookran, 1967) and numerical data into square root system using the formula (x+0.5) as suggested in the book of Gomez and Gomez (1984).

RESULTS AND DISCUSSIONS

PARENT'S WEEVIL MORTALITY

Among various tested botanicals, *A. calamus* was found to be most effective following *P. nigrum* in weevil mortality. The highest weevil mortality (100%) was recorded in *A. calamus* within 14 days of treatment ($P<.001$). 75% mortality was obtained within a week and remaining 25% was recorded in following week. In case of *P. nigrum,* 100% mortality of weevil was obtained in 21 DAT. 71.88% mortality was obtained within a week, 21.9% mortality was obtained in a second week and the remaining 6. 25% was obtained in third week. In case of control, weevil mortality was not found till the end of the experiment. After control the least mortality was recorded in *A. vulgaris* (31.26%). This result follows the findings of Sitaula *et al.* (2020), with high efficacy of *P. nigrum* and *A. calamus* in weevil mortality. Khanal *et al.* (2019) also reported 100% weevil mortality in *A. calamus* treated maize grains within 6 days of treatment. Similarly, Paneru *et al.* (1996) recorded high weevil mortality in *A. calamus* treated seeds.

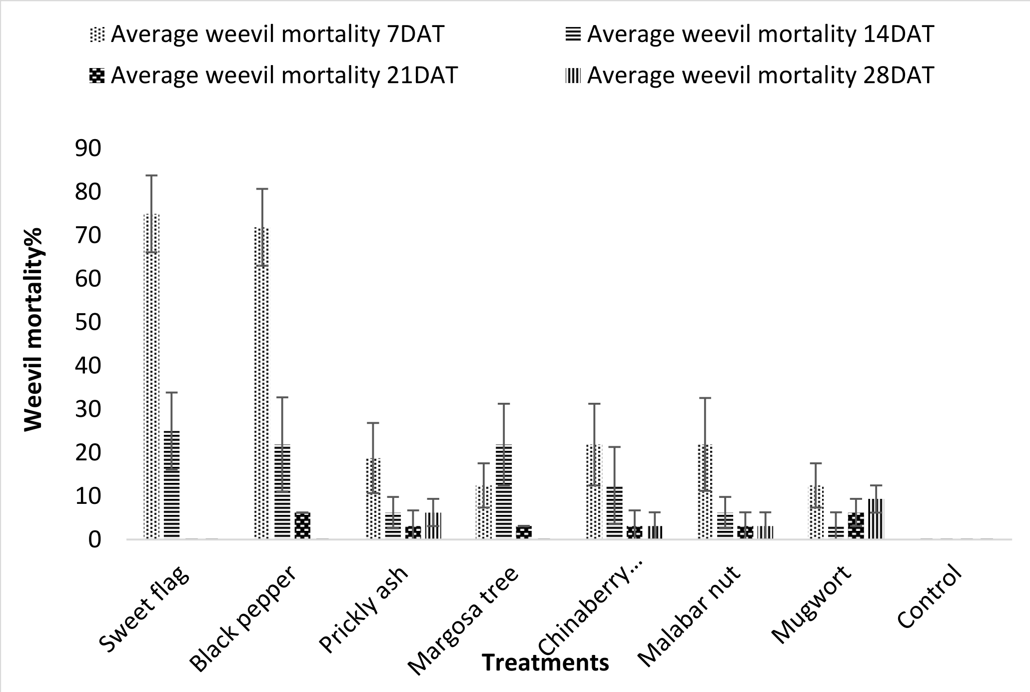

Figure 1: Effect of different treatments on weevil mortality (%) at days after treatment at storage with Standard Error of Mean (SEM). (Khumaltar, 2021)

PROGENY EMERGENCE

The progeny emergences at different date were found to be highly significant at 5% level of significance (P<.001) under various management practices (Table 2). In 60 days, highest progeny emergence was observed in control (5.00) followed by seeds treated with *A. vulgaris* (3.00) and *J. adhatada* (2.75), respectively (P<.001, F 6.09). Not a single progeny was observed in seeds treated with *A. calamus* during entire study period showing its effectiveness against maize weevil. *P. nigrum*s showed up least number of progeny emergence after *A. calamus*. All remaining treatments were found be statistically non-significant with each other. More or less similar trend was observed at 90 days of observation where the highest progeny was observed in untreated seeds (19.50) followed by seeds treated with *A. vulgaris* (13) and *J. adhatada* (11.75), respectively (P<.001, F 16.89). In 120 days, highest progeny emergence was observed in Control (19.75) followed by seeds treated with *J. adhatada* (15.00) and *A. vulgaris* (12.25), respectively. Seeds treated with *A. calamus, P. nigrum* and *A. indica* were statistically at par with lowest number of progeny emergence ((P<.001, F 18.95).

This result is supported from findings of Regmi *et al.* (2012) where fewer emergence of weevil progeny was recorded in the *A. calamus* treated seeds in the storehouse.

Similarly, Paneru *et al.* (1996) reported reduced new weevil generation in *A. calamus* treated seeds. Less weevil population was recorded in wheat seeds treated with *A. calamus* (Panthee, 1997) which follows similar result obtained in this study.

Table 2. Mean number of *S. zeamais* progeny emergence in different management practices at Khumaltar, Lalitpur, 2021

S.N.	Treatments	No. of exit holes after indicated days of treatments		
		60	90	120
1	*A. calamus* (rhizome powder)	0.00 (0.70) [c]	0.00 (0.70) [e]	0.00 (0.70) [c]
2	*P. nigrum*(fruit powder)	1.00 (1.22) [bc]	0.75 (1.05) [e]	0.25 (0.83) [c]
3	*Z. armatum* (fruit powder)	2.00 (1.53) [b]	5.75 (2.42) [cd]	7.00 (2.71) [b]
4	*A. indica* (leaf dust)	1.25 (1.31) [b]	2.25 (1.51) [de]	2.75 (1.60) [c]
5	*M. azedarach* (leaf dust)	2.25 (1.61) [b]	9.25 (3.10) [bc]	7.50 (2.83) [b]
6	*J. adhatada* (leaf dust)	2.75 (1.75) [ab]	11.75 (3.38) [bc]	15.00 (3.85) [a]
7	*A. vulgaris* (leaf dust)	3.00 (1.78) [ab]	13.00 (3.62) [ab]	12.25 (3.50) [ab]
8	Control	5.00 (2.32) [a]	19.50 (4.43) [a]	19.75 (4.46) [a]
	Grand Mean	1.53	2.53	2.57
	F-test (P value)	<.001	<.001	<.001
	LSD	0.56	0.94	0.93
	CV (%)	25.1	25.6	25

Values are means of four replications; means followed by the same letters within a column are not significantly different by DMRT at <0.05 level; CV: coefficient of variation; LSD: least significant differences. Figures in parentheses are the sq. root of (x + 0.5) transformed value of the original value.

GRAIN DAMAGE % (NUMBER BASIS)

Statistically significant differences were observed among various tested botanicals for grain damage made by weevils (Table 3). In 60 days of observation, the highest percent loss was recorded in the control seeds (4.95%) followed by seeds treated with *J. adhatada* (3.63%), *M. azedarach* (2.93%) and *A. vulgaris* (2.51%), respectively. The lowest grain damage was observed in seeds treated with *A. calamus* (0.00%) followed by *P. nigrum* (0.97%) and *A. indica* (1.81%) (P<.001, F 6.30).

More or less similar trend was observed in 90 and 120 days of observation. The highest percent loss was observed in untreated seeds (11.29%) followed by *J. adhatada* (8.41%) and *A. vulgaris* (6.85%). Seeds treated with *Z. armatum* (6.30%) and *M. azedarach* (4.47%) were statistically at par. The lowest grain damage was observed in A. calamus (0.00%) followed by seeds treated with *P. nigrum* (0.13%) and *A. indica* (1.53%) (P<.001, F 18.54). This result is supported by Regmi *et al.* (2012) where grain damage percentage was very much lower or almost negligible in *A. calamus* treated seeds in storehouse. Tiwari *et al.* (2018) also reported lowest grain damage on *A. calamus* (1.43%) and highest on control (18.02%). G.C. (2006) concluded the use of *A. calamus* (50g/kg) as effective control measure against maize weevil with minimum grain damage.

Table 3. Grain damage % (number basis) by *S. zeamais* in different management practices at Khumaltar, Lalitpur, 2021

S.N.	Treatments	Percent grain damage (no. basis) days after treatments		
		60	90	120
1	*A. calamus* (rhizome powder)	0.00 (0.21) [c]	0.00 (0.21) [e]	0.00 (0.21) [d]
2	*P. nigrum* (fruit powder)	0.97 (5.62) [b]	0.56 (3.04) [de]	0.13 (1.23) [cd]
3	*Z. armatum* (fruit powder)	2.24 (8.28) [ab]	4.06 (11.28) [c]	6.30 (14.15) [b]
4	*A. indica* (leaf dust)	1.81 (7.64) [b]	1.53 (5.78) [d]	1.53 (5.69) [c]
5	*M. azedarach* (leaf dust)	2.93 (9.62) [ab]	7.42 (15.48) [bc]	4.47 (12.04) [b]
6	*J. adhatada* (leaf dust)	3.63 (9.90) [ab]	11.07 (18.95) [ab]	8.41 (16.49) [ab]
7	*A. vulgaris* (leaf dust)	2.51 (8.50) [ab]	8.11 (16.33) [abc]	6.85 (14.90) [ab]
8	Control	4.95 (12.72) [a]	13.67 (21.63) [a]	11.29 (19.50) [a]
	Grand Mean	7.81	11.61	10.47
	F-test (P-value)	<.001	<.001	<.001
	LSD	4.28	5.31	4.94
	CV (%)	37.6	31.3	32.3
	Sem ±	1.46	1.82	1.69

Values are means of four replications; means followed by the same letters within a column are not significantly different by DMRT at <0.05 level; CV: coefficient of variation; LSD: least significant differences. Figures in parentheses are the angular transformed value of the original value.

WEIGHT LOSS %

There were variations and the significant differences were observed in botanical treated maize samples as compared to control for weight loss percent after 120 days of observation (Table 4). The lowest weight loss was recorded in *A. calamus* treated seeds (1.80%) followed by *A. indica* treated seeds (2.79%) and *P. nigrum* treated seeds (3.13%). The highest loss was found in Control (7.03%). However, seeds treated with *A. vulgaris* (6.20%) and *J. adhatada* (6.21%) were statistically at par with control (P<.001). Minimum weight loss was reported in the *A. calamus* treated seeds in the storehouse (Regmi *et al.* 2012). Tiwari *et al.* (2018) also reported lowest weight loss in *A. calamus* (1.5%) treated maize grains and highest in control (57.3%). Likewise, maize grains treated with *A. calamus* (10g/kg) was found to be superior over maize grains treated with *Z. armatum* (3g/kg), *A. indica* (10g/kg), A. vulgaris (10g/kg) and control in case of grain weight loss as reported by Sharma *et al.* (2016).

Table 4. Weight loss (%) by *S. zeamais* in different management practices after 120 days of storage at Khumaltar, Lalitpur, 2021

Selected genotypes	Weight loss by maize weevil after 120 days
A. calamus (rhizome powder)	1.80 (7.70) [e]
P. nigrum (fruit powder)	3.13 (10.06) [bd]
Z. armatum (fruit powder)	4.36 (12.03) [bc]
A. indica (leaf dust)	2.79 (9.37) [de]
M. azedarach (leaf dust)	4.37 (12.03) [b]
J. adhatada (leaf dust)	6.21 (14.42) [a]
A. vulgaris (leaf dust)	6.20 (14.41) [a]
Control	7.03 (15.37) [a]
Grand Mean	11.93
F- test	<.001
LSD	1.94
CV (%)	11.2
Sem ±	0.66

CONCLUSIONS

All the selected botanicals were effective for management of maize weevil in storage over control. Considering weevil mortality and other economic parameters like progeny emergence, grain damage and weight loss, *A. calamus* showed effective management against maize weevil than other tested botanicals. *P. nigrum* and *A. indica*, had showed the positive results after *A. calamus* against maize weevil. This finding is important for developing an eco-friendly approach of maize weevil management in storage to escape the risk of health hazard and environment pollution from the use of deleterious chemical compounds. However, similar kinds of study need to be conducted time to time for further validation and acceptance.

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