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Repellent Responses of Maize Weevil, *Sitophilus zeamais* Motsch (Coleoptera:Curculionidae) towards Entomocidal Plant Products

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Abstract. Laboratory studies were conducted to investigate the repellency effect of six plant species (*Azadirachta indica, Caralluma fimbriata, Allium sativum, Curcuma longa, Citrullus colocynthis* and *Calotropis procera*) against *Sitophilus zeamais* reared on maize grains (Cv. Azam White) in the Laboratory of Entomology Department, Gomal University, Dera Ismail Khan, Pakistan. Six concentrations viz. 5000, 10000, 15000, 20000, 25000 and 30000 ppm of each plant powder were applied to 20 g of sterilized maize grains under constant conditions of 27 ± 1°C and 65 ± 5% relative humidity. Twenty newly emerged adult maize weevil were introduced into glass petri dishes and percent repellency of plant powders was determined. *A. indica* seed powder at 30,000 concentration showed 100% repellency against maize weevil followed by *C. longa* (76%) after 72 h exposure period whereas *C. procera* was found least effective showing only 39% repellency of the test insects compared to control. The powders of *A. sativum*, *C. fimbriata* were found moderately repellent against the test insects. During the observations, it was also noted that repellency of the tested plant powders was dose dependent, the higher the concentration of the tested powders, the higher was the repellency and vice versa. The findings of this study indicated that the selected plant products could be used for a safer control of maize weevil.

Keywords: plant powders, insect repellency, *Sitophilus zeamais,* maize grain

Introduction

Maize weevil (*Sitophilus zeamais*) (Motschulsky) (Coleoptera:Curculionidae), is one of the most damaging pests of stored cereals (Nakakita *et al.,* 1991). Whole grains are attacked by weevil adults and larvae inscrutably feed and develop within the grains (Ileleji *et al.,* 2007). Infestation by this weevil commences in the field (Ileke *et al.*, 2014.) but mostly damage occurs during storage. Damaged grains resulted reduction in germination, weight, nutritional and commercial values (Yuya *et al.,* 2009).

In recent decades, the use of synthetic insecticides has gained paramount importance as a means of controlling such insect pests. Nevertheless, its promiscuous usage as preservative is being discouraged due to a range of adverse effects. Various biological, environmental, and economic consequences associated with its usage are bringing them into disrepute (Park *et al*., 2003). According to Nishi *et al.* (2004), methyl bromide fumigation has been officially forbidden in developed countries since 2005 and was banned in developing countries in 2015 because it encounters human health and destroys ozone. The need for an alternative and effective preservative during storage is now essential. The use of botanical base insecticides is one of the several methods being given attention. Plant materials have played a major role in search towards controlling insect pest of the farm.

Stored product insects like most phytophagous insects use chemical cues (semiochemical) to find hosts. However, certain plants have evolved counter strategies as part of their defensive mechanism against insects. One such defense is the emission of repellent or deterrent volatile organic compounds. Natural chemicals that are easily bio-degradable, effective and non-toxic to human could be exploited for protection of stored grains from insect damage (Donald *et al.,* 2010). The use of natural products is more prevalent in the control of insect pests in storage systems. Farmers can grow them and they can also be locally available, cheaper and easier to use than the synthetic insecticides (Govindann *et al.,* 2010). Udo (2005) pointed that poor farmers in developing countries use different plant materials to protect grains against pest infestation by mixing grains with protectants made up of plant products. Many plant powders were evaluated and found effective in the management of *Sitophilus zeamais* attacking maize grains in the stores (Suleiman *et al.,* 2011; Danjumma *et al.,* 2009). This

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study describes laboratory investigations to evaluate the efficacies of local plant powders viz. *Azadirachta indica, Caralluma fimbriata, Allium sativum, Curcuma longa, Citrullus colocynthis* and *Calotropis procera* in modifying the behavior of maize weevil in storage condition. The outcome of this study can prove to be a mile stone for development of environmental friendly, sustainable and economically viable option for control of this obnoxious insect.

Materials and Methods

Insect cultures. Maize seeds (Cv. Azam White), plastic jars (5L), muslin cloth, funnel and mesh sieves used to culture corn weevils were thoroughly cleaned. Maize grains having 12-14% moisture content (MC) were used to culture the insects. Five hundred grams maize grains were placed in each glass jar. Initial culture of *S. zeamais* was obtained from the laboratory of Entomology Section, Agricultural Research Institute, Dera Ismail Khan, Pakistan for further multiplication. The maize grains were sterilized by using a Gallenkamp oven at 60 °C for three hours to remove the chances of previous infestation in the grains (Isah *et al*., 2012). Insect culture was raised in the laboratory maintained at controlled temperature of 27 ± 3 °C and 65 ± 5% relative humidity with 12:12 hour day length (L:D). Mixture of two hundred, one week old male and female, adult maize weevils were introduced in each jar. After introduction of the insects, the top of the jars was covered with muslin cloth and tighten by rubber band in order to prevent the insects from escaping and to allow exchange of gases in and out of the jars. The jars were then placed in an incubator at controlled temperature for ten days. After ten days the parent insects were removed through sieving and introduced to another jars in order to multiply the culture of the insects. The jars containing infested maize grains were left undisturbed for twenty days. Emerging adult insects were collected and were kept in separate jars according to their age. Adults that emerged on same day were considered of the same age and were used for the experimental purpose.

Plant powder preparation. The plant materials were collected from the local farmers and brought to laboratory. The collected plant materials were thoroughly washed with tap water to clean the dust and dirt. The plant material of *Azadirachta indica, Caralluma fimbriata, Allium sativum, Curcuma longa, Citrullus colocynthis* and *Calotropis procera*, was dried in an oven at 45 °C temperature until reaching constant weight. Later, it was pulverized in an electric mill and was sieved to have a fine and homogenous powder (Table 1). Powders were then stored at room temperature in nylon bags after due tagging (Sayonara *et al.,* 2009).

Repellent response of plant materials against maize weevil. The repellent effect of all the plant materials used against maize weevil was evaluated using the area preference method. Six concentrations 5000ppm, 10000ppm, 15000ppm, 20000ppm, 25000ppm and 30000ppm of powder were prepared from the stock solution by using calculated amount of distilled water following the standard method described by Musabyimana *et al.* (2001). Whatman No.1 filter paper was cut into two equal halves (8 cm), one half of each filter paper was treated with plant materials as uniform as possible by using micropipette and the other half of the filter paper was treated with distilled water and used as a control. The plant material treated and water treated filter paper halves were then air dried for 30 min to get solvent evaporated completely. Then these two halves (plant materials treated and water treated) were attached length wise, edge-to-edge with adhesive tape and were placed at the bottom in glass petri dish having 16 cm diameter. Ten pairs of newly emerged weevils were released at the centre of the glass petri dishes and were offered with a choice of dispersing on to either treated or untreated maize grains. The petri dishes were then subsequently covered and kept in an incubator at 27± 1 °C and 65±5% relative humidity. The experiment was laid out in a completely randomized design having 5 repeats. The number of insects settled on treated and untreated halves were counted after 1, 2, 3, 6, 24, 48 and 72 h, respectively.

Percent repellency (PR) was calculated as follows:
PR = [(Nc-Nt)/Nc] 100%

Table 1. Detail of plant materials evaluated for insecticidal activities against *S. zeamais*.

Common names	Technical names	Parts used
Neem	*Azadirachta indica*	Seed
Succulent cactus	*Caralluma fimbriata*	Fruits
Garlic	*Allium sativum*	Bulbs
Turmeric	*Curcuma longa*	Rhizomes
Bitter Apple	*Citrullus colocynthis*	Fruit
Aak	*Calotropis procera*	Leaves

where:

Nc= Number of insects present in control
Nt= Number of insects present in treated filter paper

Statistical analysis. The recorded data were subjected to analysis of variance (ANOVA) and means were separated by applying the Least Significant Difference (LSD) test at 5% probability level. All statistical analyses were carried out using computer software STATISTIX version 8.1.

Results and Discussion

Repellent response of plant materials against maize weevil. The settling response of *S. zeamais* differed significantly (P<0.05) under different treatments (Table 2-8). The adults of *S. zeamais* preferred the untreated maize grains as compared to treated grains and settled significantly more on untreated grains. The settling response of the test insect decreased significantly (P<0.05) with the increase in the concentrations of tested plant powders.

Among the tested powders, *Azadirachta indica* seed powder was found more effective as compared to other treatments, whereas; *Calotropis procera* and *Citrullus colocynthis* were found least effective (Table 2-8). *A. indica* seed powder at highest concentration repelled 100% test insects followed by *C. longa* (76%) after 72 h exposure period from the treated grains whereas; *C. procera* was found least effective showing only 39% repellency of the test insect. The extracts of *A. sativum* also produced good results at all the evaluated concentrations compared to control. From the results obtained it is clear that all the tested plant powders have significant (p<0.05) effect on the repellency of adult *S. zeamais*. Arannilewa *et al.* (2006) reported that 1.5 g of *A. sativum* applied to 25 g of maize grains caused mortality of 85% in adult *S. Zeamais,* 14 days after application. Similarly, Sayonara *et al.* (2009) concluded that the powders from the stalks, seeds, and leaves of the plant 49-1-XIV, applied as powders at 1% concentration have anti-insect effects against *S. zeamais* showing mortality, decrease of the emergence of adults,

Table 2. Mean percent (± SE) repellency of *S. zeamais* on maize grains treated with different concentrations of plant powders after 1 hour exposure period

	Concentrations (ppm)					
Treatments	5000	10000	15000	20000	25000	30000
Azadirachta indica	64.00 ± 4.18 a	66.00 ± 6.52 a	65.00 ± 4.18 a	67.00 ± 5.70 a	76.00 ± 2.23 a	80.00 ± 3.54 a
Caralluma fimbriata	25.12 ± 5.70 d	31.11 ± 6.52 d	32.45 ± 6.52 c	27.00 ± 6.52 c	32.00 ± 7.58 d	32.00 ± 4.18 d
Allium sativum	39.00 ± 5.70 c	44.00 ± 4.47 c	51.00 ± 3.54 b	52.00 ± 7.91 b	56.00 ± 6.52 c	57.00 ± 5.00 c
Curcuma longa	51.00 ± 2.24 b	56.00 ± 2.24 b	60.00 ± 2.74 a	63.00 ± 2.74 a	66.00 ± 2.24 b	68.00 ± 2.74 b
Citrullus colocynthis	25.00 ± 5.00 d	23.00 ± 2.74 e	29.00 ± 2.24 c	33.00 ± 2.74 c	33.00 ± 2.74 d	35.00 ± 3.54 d
Calotropis procera	17.00 ± 2.74 e	15.00 ± 3.54 f	20.00 ± 2.74 d	21.00 ± 2.24 d	26.00 ± 2.24 e	31.00 ± 4.18 d
LSD Value	5.83	5.77	8.08	6.68	5.89	5.46

Each value is a mean ± standard error of five replications. Means followed by the same letters along the column are not significantly different at (P>0.05) using LSD Test.

Table 3. Mean percent (± SE) repellency of *S. zeamais* on maize grains treated with different concentrations of plant powders after 2 hours exposure period

	Concentrations (ppm)					
Treatments	5000	10000	15000	20000	25000	30000
Azadirachta indica	65.00 ± 5.00 a	69.00 ± 6.52 a	68.00 ± 3.54 a	69.00 ± 2.23 a	80.00 ± 3.54 a	80.00 ±3.54 a
Caralluma fimbriata	29.00 ± 3.54 cd	30.00 ± 4.18 d	33.00 ± 7.07 c	35.00 ± 4.18 c	35.00 ± 2.24 d	37.00 ± 5.70 d
Allium sativum	40.00 ± 4.47 c	44.00 ± 5.70 c	51.00 ± 7.91 b	52.00 ± 5.70 b	58.00 ± 5.70 c	59.00 ± 5.70 c
Curcuma longa	51.00 ± 4.18 b	58.00 ± 5.70 b	63.00 ± 7.91 a	63.00 ± 7.58 a	68.00 ± 9.75 b	69.00 ± 6.52 b
Citrullus colocynthis	26.00 ± 7.42 de	28.00 ± 5.70 d	28.00 ± 4.18 cd	33.00 ± 5.70 c	38.00 ± 5.70 d	36.00 ± 4.18 d
Calotropis procera	18.00 ± 5.70 e	17.00 ± 5.70 e	23.00 ± 6.12 d	21.00 ± 6.52 d	27.00 ± 5.70 e	33.00 ± 2.74 d
LSD Value	10.04	5.77	6.47	9.23	7.72	6.13

Each value is a mean ± standard error of five replications. Means followed by the same letters along the column are not significantly different at (P>0.05) using LSD Test.

Table 4. Mean percent (± SE) repellency of *S. zeamais* on maize grains treated with different concentrations of plant powders after 3 hours exposure period

	Concentrations (ppm)					
Treatments	5000	10000	15000	20000	25000	30000
Azadirachta indica	65.00 ± 7.91 a	67.00 ± 5.70 a	70.00 ± 5.70 a	71.00 ± 6.52 a	78.00 ± 5.7 a	90.000 ± 3.54 a
Caralluma fimbriata	31.00 ± 2.73 d	34.00 ± 2.23 d	34.50 ± 5.48 c	36.00 ± 2.74 c	37.00 ± 2.74 d	37.50 ± 5.70 d
Allium sativum	43.00 ± 10.36 c	50.00 ± 6.51 c	52.00 ± 7.91 b	49.00 ± 7.91 b	55.00 ± 4.18 c	56.00 ± 7.42 c
Curcuma longa	56.00 ± 2.23 b	58.00 ± 2.74 b	65.00 ± 2.74 a	70.00 ± 3.54 a	70.00 ± 5.00 b	73.00 ± 2.74 b
Citrullus colocynthis	25.00 ± 5.00 de	26.00 ± 5.48 e	33.00 ± 2.74 cd	35.00 ± 5.00 c	40.00 ± 3.54 d	36.00 ±2.24 d
Calotropis procera	18.00 ± 2.73 e	20.00 ± 2.24 f	27.00 ± 2.74 d	28.00 ± 2.74 c	29.00 ± 4.18 e	35.00 ± 3.54 d
LSD Value	7.81	5.77	7.48	9.15	5.95	5.32

Each value is a mean ± standard error of five replications. Means followed by the same letters along the column are not Significantly different at (P>0.05) using LSD Test.

Table 5. Mean percent (± SE) repellency of *S. zeamais* on maize grains treated with different concentrations of plant powders after 6 hours exposure period

	Concentrations (ppm)					
Treatments	5000	10000	15000	20000	25000	30000
Azadirachta indica	68.00 ± 4.47 a	76.00 ± 6.52 a	70.00 ± 5.00 a	73.00 ± 8.37 a	85.00 ± 7.91 a	96.00 ± 4.18 a
Caralluma fimbriata	31.00 ± 2.74 d	33.00 ± 8.94 d	35.00 ± 7.91 c	37.00 ± 9.62 c	39.00 ± 4.18 d	38.00 ± 6.52 d
Allium sativum	43.00 ± 5.70 c	49.00 ± 9.62 c	53.00 ± 4.47 b	56.00 ± 7.42 b	56.00 ± 8.94 c	59.00 ± 6.52 c
Curcuma longa	62.00 ± 2.74 b	65.00 ± 3.54 b	66.00 ± 3.54 a	67.00 ± 5.70 a	68.00 ± 5.70 b	68.00 ± 5.70 b
Citrullus colocynthis	25.00 ± 5.00 e	30.00 ± 2.24 d	27.00 ± 2.74 d	40.00 ± 3.54 c	43.00 ± 2.74 d	40.00 ± 3.54 d
Calotropis procera	16.00 ± 2.24 f	20.00 ± 1.03 e	25.00 ± 2.74 d	26.00 ± 2.24 d	31.00 ± 2.24 e	36.00 ± 2.24 d
LSD Value	5.26	7.81	7.29	8.50	7.62	6.30

Each value is a mean ± standard error of five replications. Means followed by the same letters along the column are not significantly different at (P>0.05) using LSD Test.

Table 6. Mean percent (± SE) repellency of *S. zeamais* on maize grains treated with different concentrations of plant powders after 24 hours exposure period

	Concentrations (ppm)					
Treatments	5000	10000	15000	20000	25000	30000
Azadirachta indica	68.00 ± 5.70 a	77.00 ± 2.74 a	74.00 ± 7.91 a	78.00 ± 7.58 a	91.00 ± 6.52 a	97.00 ± 4.47 a
Caralluma fimbriata	29.00 ± 6.52 d	34.50 ± 7.91 d	36.00 ± 6.52 c	37.00 ± 5.70 d	39.00 ± 6.12 d	44.00 ± 7.91 d
Allium sativum	46.00 ± 2.74 c	48.00 ± 6.52 c	56.00 ± 5.71 b	59.00 ± 5.70 c	60.00 ± 6.519 c	61.00 ± 7.91 c
Curcuma longa	61.00 ± 5.48 b	65.00 ± 3.54 b	66.00 ± 2.24 a	68.00 ± 6.71 b	68.00 ± 5.70 b	72.00 ± 4.47 b
Citrullus colocynthis	25.00 ± 5.00 d	28.00 ± 2.74 e	32.00 ± 6.71 cd	38.00 ± 2.74 d	43.00 ± 2.74 d	42.00 ± 6.71de
Calotropis procera	18.00 ± 2.74 e	18.00 ± 2.74 f	27.00 ± 2.23 d	28.00 ± 2.74 e	31.00 ± 2.24 e	36.00 ± 2.24 e
LSD Value	6.41	6.01	8.08	7.90	7.62	7.81

Each value is a mean ± standard error of five replications. Means followed by the same letters along the column are not significantly different at (P>0.05) using LSD Test.

negative effect on the settling response, lower weight loss of the grain, and had no effect on the germination of the treated seeds. In our study the use of *A. indica* seed powder might have exerted a toxic effect by disrupting normal respiratory process of the weevils as already reported by Fekadu *et al.* (2012). The ability of tested plant powders to cause repellency against *S. zeamais* adults on the maize grains might be attributed to the contact toxicity of powders on the weevil. The findings of this study also revealed that the selected plant products applied at varying amounts were effective in reducing maize grain damage caused by *S. zeamais*.

Table 7. Mean percent (± SE) repellency of *S. zeamais* on maize grains treated with different concentrations of plant powders after 48 hours exposure period

	Concentrations (ppm)					
Treatments	5000	10000	15000	20000	25000	30000
Azadirachta indica	68.00 ± 5.70 a	79.00 ± 6.52 a	79.00 ± 8.22 a	82.00 ± 5.70 a	98.00 ± 4.47 a	100.00 ± 00 A
Caralluma fimbriata	30.00 ± 4.18 c	34.00 ± 4.18 d	39.00 ± 4.18 d	39.00 ± 6.12 d	40.00 ± 4.18 de	43.00 ± 5.70 de
Allium sativum	47.00 ± 5.70 b	51.00 ± 7.91c	56.00 ± 9.35 c	59.00 ± 6.52 c	63.00 ± 7.58 c	65.00 ± 6.52 c
Curcuma longa	63.00 ± 2.74 a	66.00 ± 7.42 b	68. 00 ± 2.24 b	69.00 ± 6.52 b	74.00 ± 4.18 b	76.00 ± 4.18 b
Citrullus colocynthis	25.00 ± 6.12 cd	29.00 ± 7.42 d	36.00 ± 4.47 de	38.00 ± 5.70 de	44.00 ± 5.48 d	47.00 ± 5.70 d
Calotropis procera	18.00 ± 5.70 d	20.00 ± 6.12 e	30.00 ± 5.70 e	31.00 ± 4.18 e	35.00 ± 7.91 e	38.00 ± 2.74 e
LSD Value	8.16	8.75	8.99	7.62	7.62	6.13

Each value is a mean ± standard error of five replications. Means followed by the same letters along the column are not significantly different at (P>0.05) using LSD Test.

Table 8. Mean percent (± SE) repellency of *S. zeamais* on maize grains treated with different concentrations of plant powders after 72 hours exposure period

	Concentrations (ppm)					
Treatments	5000	10000	15000	20000	25000	30000
Azadirachta indica	68.00 ± 5.70 a	81.00 ±4.18 a	81.00 ± 5.48 a	83.00 ± 5.71 a	100.00 ± 0.00 a	100.00 ± 0.00 a
Caralluma fimbriata	32.00 ± 2.74 c	35.00 ± 4.18 d	36.00 ± 4.18 d	43.00 ± 2.24 d	44.00 ± 2.24 d	47.00 ± 2.24 d
Allium sativum	49.00 ± 2.74 b	51.00 ± 7.91 c	50.00 ± 9.35 c	62.00 ± 7.07 c	66.00 ± 7.91 c	67.00 ± 7.91 c
Curcuma longa	65.00 ± 7.91 a	67.00 ± 5.70b	67.00 ± 5.70 b	73.00 ± 2.74 b	77.00 ± 5.70 b	76.00 ± 4.18 b
Citrullus colocynthis	26.00 ± 9.62 c	31.00 ± 6.52 d	31.00 ± 7.42 d	38.00 ± 5.70 d	45.00 ± 5.00 d	50.00 ± 7.91 d
Calotropis proceran	24.00 ± 9.62 c	22.00 ± 8.37 e	22.00 ± 7.91 e	28.00 ± 5.70 e	36.00 ± 4.18 e	39.00 ± 4.18 e
LSD Value	9.15	8.29	8.29	6.74	7.14	6.84

Each value is a mean ± standard error of five replications. Means followed by the same letters along the column are not significantly different at (P>0.05) using LSD Test.

This agrees with the findings of Arienilmar *et al.* (2005) who reported 2.81% grain damage of maize when 1.5% of *A. sativum* was applied. This is due to the strong aroma of the powder which might have served as feeding deterrent to the weevils. The reduction in grain damage was observed to be directly proportional to the amount of the applied plant materials. Similar results on the efficacy of *A. indica* derivatives against various insect pests have been reported by various scientists (Ashamo *et al*., 2013; Cosmas *et al.,* 2012; Edelduok *et al.,* 2012; Mamoon-ur-Rashid *et al*., 2012; Abiodun *et al.,* 2010). The results from our laboratory based experiment suggest that *A. indica*, and *C. longa*, powders can be used as insect repellent for the safer management of *S. zeamais* on stored maize.

Conclusion

Overall, *Azadirachta indica* and *Cureuma longa* powders were found more effective to control maize weevil *Sitophilus zeamais* at all the post treatment intervals whereas; *Calotropis procera* powder was found least effective.

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