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EVALUATION OF SOME PLANT EXTRACTS AGAINST MAIZE WEEVIL, *Sitophilus zeamais* (COLEOPTERA: CURCULIONIDAE) UNDER LABORATORY CONDITIONS

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Laboratory studies were conducted to evaluate the insecticidal potential of extracts of eight plants viz. lemon grass *(Cymbopogon flexousus)*, turmeric *(Curcuma longa)*, basil *(Ocimum basilicum)*, harmal *(Peganum harmala)*, heeng *(Ferula assa-foetida)*, neem *(Azadirachta indica)*, tumma *(Citrullus colocynthis)* and mint *(Mentha arvensis)* against maize weevil, *Sitophilus zeamais* using three concentrations (5, 10 and 15%) at three time intervals (2, 4 and 6 days) in the laboratory. The results revealed that maize weevil mortality was increased with the increase in concentration and time interval. Maximum mortality (86.67%) of the pest was observed with the use *A. indica* extract at 15% concentration after 6 days of application followed by *C. colocynthis* extract (81.66%), *P. harmala* (76.66%), *C. longa* (71.67%), *O. basilicum* (66.66%), *F. assafoetida* (61.66%), *C. flexousus* (58.33%) and *M. arvensis* (53.33%). The lowest mortality (22.78%) was observed against lowest concentration of *C. flexousus.* Overall results show that mortality of the insect increased with the increase in concentration and exposure time.
Keywords: Stored grain insect pests, botanicals, stored maize, toxicity

INTRODUCTION

Maize is the highest yielding cereal crop in the world (Whitt *et al.*, 2002). It is of significant importance for countries like Pakistan, where rapid growing population has already out stripped the available food supplies (Khan *et al.*, 2014). Among cereal crops in Pakistan, maize holds 3rd position after wheat and rice (GOP., 2012). Its share in agriculture is 2.2% and 0.4% in GDP of Pakistan (MOF., 2013-14). During 2015-16 the area under cultivation was recorded 1144 thousand hectares and production was 2920 thousand tones (GOP, 2016). Also, the existence of low capacity stores, use of local mud bins for storage, un-cleaned and filthy store houses, improper ventilation, leaky and dampness in store houses, inconvenient storages (with broken walls, ceilings and floors) are some of the serious but less noticeable storage problems. The situation is further intensify when storage is done in open areas where insect pests, rodents and birds cause lots of damage (Tunio, 2012). It is estimated that 50% grain production is lost due to improper storage and attack of insects pests in tropical countries including Pakistan (Ahmad and Ahmad, 2002).

Different insect pests, attack on maize during storage and among these pests maize weevil, *Sitophilus zeamais* is the most destructive pest (Ebeling, 2002).This pest caused up to 50% losses in stored maize especially when humidity and temperature increase during summer season in the tropical countries (Maqsood *et al*., 1988; Irshad *et al*., 1988; Ahmad and Ahmad, 2002). In Pakistan heavy infestation may cause weight losses of as much as 30-40% of produce (CABI, 2005).

A number of management techniques are available to control stored products insect pests. The synthetic insecticides are commonly used to control pests in general and stored product pests in particular. However, indiscriminate use of many synthetic insecticides is associated with manifold health and environmental problems, like development of resistance in insect pests, residues in food product, pest resurgence and effect on non-target organisms (Kumar *et al*., 2007).

There are a number of local medicinal plants known for their insecticidal value (Gaselase and Getu, 2009). The application of plant based product for the management of stored product insects is a prehistoric exercise (Qi and Burkholder, 1981). According to Araya and Emana (2009), the insecticidal actions of the botanical powders are broad and variable. Various studies showed that plant extracts have growth inhibitory effects on insect development causing the reduction in larval, pupal and adult weight, extended larval and pupal duration, reduced pupal retrieval and reduced rate of adult emergence (Koul *et al*., 2008). Plant-derived materials are more readily biodegradable. Farmers can easily and cheaply produce these plant extracts for their use. The integration of insecticidal natural products from locally available plants appear to be quite safe and promising (Jillani *et al*., 1988; Hanif *et al.*, 2015). Keeping in view the current problems of chemical insecticides, present study was designed to evaluate the efficacy of different plant extracts against maize weevil.

MATERIALS AND METHODS

The experiment was conducted to evaluate the efficacy of eight plants viz. lemon grass (*Cymbopogon flexousus*), turmeric (*Curcuma longa*), basil (*Ocimum basilicum*), harmal (*Peganum harmala*), heeng (*Ferula assafoetida*), neem (*Azadirachta indica*), tumma (*Citrullus colocynthis*) and mint (*Mentha arvensis*) against maize weevil in the laboratory of Department of Entomology, Faculty of Agriculture, Gomal University, Dera Ismail Khan, Khyber Pakhtunkhwa (KPK), Pakistan.

The experiment was laid out in a completely randomized design using six replications. The experimental conditions were maintained at 27±3°C and 70±5% relative humidity (R.H.) and a photoperiod of 12:12 hours (L: D). Maize variety Azam was used in trial. Each treatment was consisting of 20g of sterilized maize seed treated with three concentrations (5, 10 and 15%) of plant extracts. The collected plant materials were prepared from the fresh leaves and seeds. The plant parts were cleaned by washing in water. After shade drying these were grinded in electrical grinder to make the powder form. Then 50 g of grinded sample was taken in a flask and 100 ml of water added into it as a solvent. Mouth of the flask was closed with aluminum foil. The flasks then placed in rotary shaker at 220 rpm for 24 h. After that, the extracts filtered with the help of filter paper and used to make stock solution. Further dilutions made according to application requirement.

The culture of adult maize weevils was maintained in transparent plastic jars on sterilized maize grains in jars covered with polyester mesh to ensure proper ventilation. Initial culture was obtained from the laboratory of Entomology Section, Agricultural Research Institute, Dera Ismail Khan, for its further multiplication. Insect culture was raised in the laboratory at controlled temperature of 27±3°C at 70±5% RH under 12:12 h day length (L: D).

The treated seeds were kept in petri dishes and vigorously shaken before release of weevils for complete mixing of plant extracts. Ten pairs of newly emerged (two days old) adult weevils were released in the tested arena. The weevils were starved for 24 hours before releasing in the tested arena. The data of insect mortality were recorded 2, 4 and 6 days after treatment and then converted to percent mortality. Mortality was corrected using Abbott's formula:

$$\text{Corrected mortality (\%)} = \frac{\text{MO}-\text{MC}}{100-\text{MC}} \times 100$$

Mo = % Mortality observed in treatment

Mc = % Mortality observed in control

Statistical analysis was based on a completely randomized design. Analysis of variance (ANOVA) was performed using GenStat-8 (GenStat, 2005. VSN International Ltd. Oxford, UK) and means were compared by applying Tukey's HSD test at 5% significance level.

RESULTS AND DISCUSSION

The results (Table 1) showed effectiveness of eight plant extracts with three concentrations (5, 10 and 15%) at different time intervals against maize weevil (*Sitophilus zeamais*). The results revealed that all the treatments showed significant difference (P > 0.05) in mean percent mortality of the maize weevil. At 5 % concentration, maximum mortality (54.17%) was recorded with *A. indica* extract followed by *C. colocynthis*, *P. harmala*, *C. longa*, *O. basilicum*, *F. assafoetida*, *C. flexousus* and *M. arvensis* extracts with 49.16,

Table 1. Comparative efficacy of different plant extracts by using them in three concentrations against *Sitophilus zeamais* (Motsh) after different time intervals.

Plant Extracts	5% Concentration			10% Concentration			15% Concentration			Means of plant extracts
	2 days	4 days	6 days	2 days	4 days	6 days	2 days	4 days	6 days	
Neem *(Azadirachta indica)*	37.50±1.12 hi	52.50±1.24 de	72.50±1.31 a	42.50±1.05 jk	61.67±1.23 de	77.50±1.36 a	47.50±1.12 jk	67.50±1.42 de	86.67±1.53 a	60.65
Basil *(Ocimum basilicum)*	17.50±1.17 mn	32.50±1.11 ij	52.50±1.20 de	22.50±0.83 q	41.66±1.05 kl	57.50±1.16 ef	27.50±0.83 op	47.50±1.11 jk	66.66±1.42 def	40.65
Heeng *(Ferula assafoetida)*	12.50±0.83 no	27.50±1.16 jk	47.50±1.13 ef	17.50±0.70 r	36.66±1.11 mn	52.50±1.22 gh	22.50±0.67 pq	42.50±1.19 kl	61.66±1.35 fg	35.65
Mint *(Mentha arvensis)*	5.83±0.79 p	20.83±0.83 lm	41.66±1.05 gh	9.16±0.64 s	30.83±0.85 op	45.83±1.05 jk	16.66±0.54 r	35.83±1.22 mn	53.33±1.32 hi	28.88
Tumma *(Citrullus colocynthis)*	32.50±1.12 ij	47.50±1.21 ef	67.50±1.11 ab	37.50±1.12l m	56.67±1.26 fg	72.50±1.34 b	42.50±1.05 kl	62.50±1.48 efg	81.66±1.94 ab	55.65
Turmeric *(Curcuma longa)*	22.50±1.08 klm	37.50±1.12 hi	57.50±1.08 cd	27.50±1.05 p	46.66±1.16 ij	62.50±1.19 d	32.50±0.78 no	52.50±1.16 ij	71.67±1.46 cd	45.65
Harmal *(Peganum harmala)*	27.50±1.11 jk	42.50±1.19 fgh	62.50±1.12 bc	32.50±1.14 no	51.67±1.08 H	67.50±1.27 C	37.50±1.11 lmn	57.50±1.32 ghi	76.66±1.52 bc	50.65
Lemongrass *(Cymbopogon flexousus)*	10.83±0.84 op	25.83±0.85 kl	46.67±1.06 fg	14.17±0.83 r	35.83±0.92 mn	50.83±1.12 hi	21.66±0.85 qr	40.83±1.05 lm	58.33±1.12 gh	33.89
Means of exp. time	20.83	35.83	56.04	25.42	45.21	60.83	31.04	50.83	69.58	
Means of Conc.		37.57			43.82			50.48		
LSD		5.0671			4.4568			5.0671		

Means sharing similar letter in columns are not significantly different by LSD test.

44.16, 39.17, 34.16, 29.17, 27.78and 22.78% mortality, respectively. Interaction effect showed that maximum mortality (72.50%) was recorded in *A. indica* extract after six days of application followed by *C. colocynthis* (67.50%) and these both were statistically at par with each other. The results showed that at 10% concentration, mean percent mortality of maize weevil ranged from 60.55 to 28.61 percent. Among them maximum mortality (60.55%) was recorded treated with *A. indica* extract followed by *C. colocynthis* (55.55%), *P. harmala* (50.56%), *C. longa* (45.55%), *O. basilicum* (40.56%), *F. assafoetida* (35.55%), *C. flexousus* (33.61%) and *M. arvensis* (28.61%) extract. Interaction effect showed that maximum mortality (77.50%) was recorded in *A. indica* extract after six days of application and minimum mortality (9.16%) was observed in *M. arvensis* after 2 days of application. With increase in concentration, mortality of maize weevil was also increased. The results showed that when different plant extracts were applied at the rate 15% concentration; mean percent mortality of maize weevil ranged from 67.22 to 35.28 percent. Among them maximum mortality was recorded in *A. indica* extract i.e. 67.22% followed by *C. colocynthis*, *P. harmala*, *C. longa*, *O. basilicum*, *F. assafoetida*, *C. flexousus* and *M. arvensis* extract with 62.22, 57.22, 52.22, 47.22, 42.22 and 35.28% mortality, respectively. Interaction effect showed that maximum mortality (86.67%) was recorded in *A. indica* extract after six days of application followed by *C. colocynthis* extract (81.66%) and were statistically at par with each other. While minimum mortality (16.66%) was observed in *M. arvensis* extract after 2 days of application. However, mortality rate was increased with the passage of time.

The Figure 1 indicates that mean mortality in maize weevil increased with the increase in concentration. Maximum mean mortality i.e., 67.22% was observed at 15% concentration of *A. indica*, followed by 10% (60.55% mean mortality) and 5% (54.17% mean mortality) concentrations. The effect of concentrations of *A. indica* against *S. zeamais* was in the following order 15%>10%>5%. *M. arvensis* at 5% concentration showed minimum mean (22.78%) mortality of *S. zeamais*.

In the current study, all the plant extracts showed significant results against maize weevil at all the tested concentrations (5, 10 and 15%) after different exposure time. However, *A. indica* extract proved to be most effective among them which gave maximum mortality against this pest. Azadirachtin is chemical present in the *A. indica* products inhibits or disrupts development of eggs, larvae, pupae, larval moulting, mating and adult maturation (Karnavar, 1987; Schmutterer, 1990; Mordue and Blackwell, 1993; Murugan *et al.*, 1999). The results of present study showed conformity with the previous studies (Iqbal *et al*., 2010; Singh, 2011) who reported that among different plant extracts *A. indica* extract was proved most effective against maize weevil.

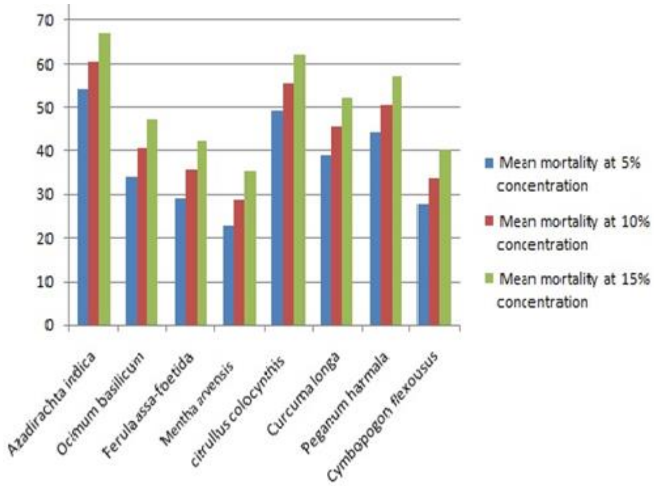

Figure 1. Mean mortality (%) of *Sitophilus zeamais* against eight plant extracts using three concentrations.

Nukenine *et al*. (2011) studied the efficacy of different plant extracts against maize weevil and concluded that among these *A. indica* was the most effective plant material which gave 90 to 100% mortality of maize weevil after 14 days of application. The results of present study are also confirmed by Danga *et al*. (2015), who evaluated the *A. indica* product (*A. indica* Pro®) and chemical insecticide against maize weevil and reported that *A. indica* Pro® completely killed the entire exposed maize weevil after 14 days of treatment. The results of current study revealed that *C. colocynthis* gave significant mortality after *A. indica* extract, these results showed conformity with Nadeem *et al*. (2012), they evaluated *A. indica* and *C. colocynthis* extracts against *Tribolium castaneum* (Hbst.) with four concentrations (2.5, 5, 7.5 and 10%), *A. indica* extract caused 35.93, 47.77, 55.92 and 64.44% mortality followed by *C. colocynthis* extract at 10% gave 44.07% mortality after 72 hours, respectively.

P. harmala and *C. longa* also proved effective against maize weevil, present findings also confirmed by previous studies (Saljoqi *et al*., 2006; Iqbal *et al*., 2010) who tested different plant extracts, among them *P. harmala* and *C. longa* caused more mortality of this pest as compared with other plant material. *O. basilicum*, *F. assafoetida*, *C. flexousus* and *M. arvensis* extracts also have potential to control this pest. In the current study these extracts caused mortality ranged from53.33 to 66.66% mortality at 15% concentration after 6 days of application, respectively. Mwangangi and Mutisya (2013) used *O. basilicum* extract against maize weevil and confirmed that *O. basilicum* extract has potential to control this pest effectively. Kerdchoechuen *et al*. (2010) reported that sweet *O. basilicum* oil extract can caused 96 to 100% mortality of maize weevil, 5 days after application. It is concluded from current study, plant extracts have a potential to control maize weevil without causing lethal effects on stored commodity and environment and safer for health.

***Conclusion*:** It is obvious from the present studies that four plant species, viz. *A. indica*, *C. colocynthis*, *P. harmala* and *C. longa* provided above 70% mortality of the pest at 15% concentration after 6 days of application. Hence, it is concluded that aqueous extract of these plant products can effectively be used as a major component for the management of *S. zeamais* during storage.

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