# Efficacy of botanical plant extracts against Maize Weevil, *Sitophilus zeamais* (Coleoptera: Curculionidae).

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## Abstract

**Background:The maize weevil, *S. zeamais* Motschulsky is considered as the most notorious pest of stored grains. It is an internal feeder of grains and a female of maize weevil, that damages the grain by making a hole in the grain and laying eggs inside. The studies were conducted to investigate the biological activities of aqueous extracts of five botanicals viz. Hareer (*Terminalia chebula*), Ajwain (*Trachyspermum ammi*), Tobacco (*Nicotiana tabacum*), Paneer (*Withania coagulans*), and Dhamasa (*Fagonia indica*) against maize weevil under laboratory conditions. For the evaluation of biological activities, the data were recorded on the days to adult emergence, total adult emergence, percent infestation, weight loss, adult longevity, and adult sex ratio.**

**Results: The results revealed that the maximum number of 35.00 days to adult emergence of maize weevil was recorded when it was reared on maize grain treated with *N. tabacum* extracts which were statistically non-significant (32.00 days) on maize grains with *T. ammi* extracts. A maximum number of 25.66 days to adult emergence were recorded on untreated maize grains. The maximum number of 50.00 total adult emergence were recorded on maize grains treated with *T. ammi* aqueous extracts. The maximum (26.00) percent infestation were recorded when maize grains were treated with *T. chebula* aqueous extracts. The minimum (11.00%) weight loss was recorded in maize grains treated with *N. tabacum* extracts whereas; the maximum (16.00%) weight loss was recorded on maize grains treated with *T. chebula* aqueous extracts.**

**Conclusion: Overall, maximum adult longevity was recorded when weevils were reared on untreated maize grains. The plant aqueous extracts of *N. tabacum* and *W. coagluans* at 3% concentration should be used for the safer control of maize weevil.**

**Keywords**: Maize weevil, Plant extracts, Stored grains, Efficacy, Biological effects.

## Background

Maize (*Zea mays L.*) is considered as the queen of cereal crops and it is the only crop that is consumed from flower to flour [1]. It is the 3rd most important cereal crop around the globe after wheat and rice [2]. It is an important source of calories and used as a staple food in many countries [3], an item of animal feed, biofuel, and used as raw material for many vital industries. Maize is a valuable crop due to the fact that every part of like leaves, stalk, tassel and cob has monetary value and is used for the manufacturing of non-food items [4]. It was originally grown as a subsistence crop and has progressively become a critical crop as it has risen to a business crop as many vital industries depend on it [5]. Besides this, it's also used for the manufacturing of industrial starch and in the preparation of drugs as maltose, dextrose, ethanol and corn oil [6].

In Pakistan, maize crop is grown in all provinces in which the bulk of 97% of the total grain production comes from two major maize-producing provinces of Punjab and Khyber Pakhtunkhwa. Being warm weather plant, maize is grown in Pakistan from sea level to 3000 meters' altitude. The post-harvest losses caused by insect pests and molds is considered as a huge challenge for scientist around the globe [7]. These losses can occur in both conditions i.e. before harvesting and during storage; which leads to losses of food grain, inferior quality and financial losses [8]. It is estimated that in developing countries, every year 14-50% grain is damaged by insect pests and 1-2% grain damage is reported in developed countries [9].

The main cause of these post-harvest grain losses is the large prevalence of insect pests such as maize weevil. The maize weevil, *Sitophilus zeamais* Motschulsky is considered as the

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***Received:** 25-May-2022, Manuscript No. AAASCB-22-* 64838*; **Editor assigned:** 27-May-2022, PreQC No. AAASCB-22-* 64838*(PQ); **Reviewed:** 16-Jun-2022, QC No. AAASCB-22-* 64838*; **Published:** 30-May-2022, DOI:10.35841/2591-7897-6.6.126*

***Citation:** Ali H, Rashid MM. Efficacy of botanical plant extracts against Maize Weevil, Sitophilus zeamais (Coleoptera: Curculionidae). J Agric Sci Bot. 2022;6(6):126*

most notorious pest of stored grains. It is an internal feeder of grains and female damages the grain by making a hole in the grain and lays eggs inside [10]. The larvae feed internally making the grain unfit for human consumption. The feeding damage caused by weevil results in nutritive and qualitative losses, reduction in grain viability [11]. The infestation of insect pests leads to increased temperature and humidity of grains which facilitates development of molds including different toxigenic species like *Aspergillus flavus* [12]. Due to increasing environmental and health problems it is necessary to find out alternate control measures which are safe, sustainable and economical. Synthetic pesticides are continuously used aiming to prevent grain damage caused by insect pests. However, the increasing problems of resistance development and higher costs, concerns about toxicity of chemicals during application and toxic residues on the food items and environment have limited their use [13,14].

The usage of toxic chemicals to control weevils has mostly led to development of insecticides resistance, Excessive and acute toxicity, long duration of degradation, ill effects on the environment and carcinogenic issues are some of the problems related to synthetic chemicals used to minimize postharvest losses. The non-stop application of insecticides causes resistant development and accumulation of poisonous residues on grains stored for human intake leading to fitness worries [15]. Interest is developing on using plant based herbal compounds for the protection of stored grains due to the fact that they are biodegradable, frequently have low toxicity and as a consequence pose low risk to surroundings if utilized in small quantities [16,17]. The usage of plant derived insecticides is notably less expensive and ecologically more tolerable compared to chemical pesticides are being endorsed among resource-based farmers in developing countries [18,19]. Inert dusts together with diatomaceous earth ash and plant powders possess great potential for insect pests' control [20].

Current studies were conducted aiming to investigate the pesticidal efficacy and to explore some eco-friendly aqueous extracts of six different plants viz. Hareer (*Terminalia chebula*), Ajwain (*Trachyspermum ammi*), Tobacco (*Nicotiana tabacum*), Paneer (*Withania coagulans*) and Dsshamasa (*Fagonia indica*) at three different concentrations, for controlling maize weevil.

## Methods

Biological effects of plant aqueous extracts against maize weevil, *S. zeamais* (Coleoptera: Curculionidae), an experiment was conducted in the laboratory of the Department of Entomology, Faculty of Agriculture, Gomal University, Dera Ismail Khan, to investigate the effect of plant powders on the biology of maize weevil. The studies were carried out under controlled conditions of 27 ± 3oC and 65 ± 5% R.H. and12:12 hours (L: D). The maize grains were sterilized in a Gallenkamp oven for three hours at 60°C in order to eliminate the chances of prior invasion. The 20g disinfected seeds were treated with plant aqueous extracts and then kept in transparent plastic jars of 200ml capacity. The plant aqueous extracts were used at three different concentrations of 1, 2 and 3%, respectively. After an hour of the treatment of grains, 10 pairs of freshly emerged (24 hour starved) adult maize weevil were caged in the tested arena. After introduction of weevils, the jars were enclosed with fine mesh cloth to minimize the chances of escape of weevils and to facilitate the ventilation. The jars were fastened with rubber band. The weevils remained in the treated jars for ten days to ensure copulating and oviposition. After 10 days of the introduction, the weevils were removed from the tested arena. The jars were observed for adult emergence on daily basis upto 45 days. The botanicals (*T. chebula, T. ammi, N. tabacum, W. coagulans, F. indica*) used for the investigations, were obtained from the local farmers and market and were brought to the laboratory. The plant materials were carefully washed with tap water to remove dust and dirt particles. The collected materials were shade dried until complete dryness. The powered materials were grinded with the help of electric grinder (KINEMATICA AG, PX –MFC 90 D) to get fine powders. The resultant powders were sieved through a mesh sieve of 2mm. The aqueous extracts were prepared by adding 1, 2, 3 grams of fine powder of each plant powder in 100ml of distilled water. The mixture was shaken well on an electric shaker (Digital Orbital Shaker OS 10 B) at 153 rpm for 2 hours and was filtered using Whatman No.1 (9cm) blotting paper. The resultant aqueous extracts were stored in plastic container after tagging and were stored in refrigerator until used for experiments.

## Statistical Analysis

The data was noted on duration to adult emergence, Total adults emerged, Infestation (%) of grains, Percent weight loss, Sex ratio and adult life cycle of weevils (Male and Female). The collected data were analyzed using statistical percentage Statistix Ver. 8.1. The treatment means were separated using Least Significant Difference (LSD) test at α 0.05.

## Results

Biological effects of plant aqueous extracts against maize weevil, *S. zeamais* (Coleoptera: Curculionidae)

### *Days to Adult emergence*

Table 1 shows significant differences among the treatments regarding emergence of new progeny. At 1% concentration, the maximum (34.00) days to emergence of adults was noted when the tested insects were cultured on *N. tabacum* aqueous extracts applied grains having significant difference from all other tested extracts. Among the treatments, least (26.66) days to production of new progeny were recorded on *T. chebula* extracts. At 2% concentration, the maximum (34.33) days to production of new progeny were documented when it was cultured on maize grains treated with *N. tabacum* aqueous extracts which was statistically non-significant from 33.33 days when cultured on seeds having *W. coagulans* aqueous extracts. The minimum (27.33) days to emergence of new progeny were noted on maize grains having T. chebula aqueous extracts.

***Table 1.*** *Effect of plant's aqueous extracts used at different rates on duration(days) to emergence of maize weevil adults.*

| Treatments | Concentrations (%) | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| *Terminalia chebula* | 26.66 ± 3.76 d | 27.33 ± 3.54 c | 28.00 ± 3.54 c |
| *Trachyspermum ammi* | 30.33 ± 4.35 c | 30.66 ± 3.32 b | 32.00 ± 4.21 b |
| *Nicotiana tabacum* | 34.00 ± 3.32 a | 34.33 ± 3.87 a | 35.00 ± 4.76 a |
| *Withania coagulans* | 31.66 ± 4.23 b | 33.33 ± 4.76 a | 34.66 ± 3.00 a |
| *Fagonia indica* | 30.66 ± 3.32 c | 31.00 ± 3.98 b | 33.00 ± 3.87 b |
| Control | 25.66 ± 5.65 e | 25.66 ± 4.65 d | 25.33 ± 4.54 d |
| LSD Value | 0.93 | 1.18 | 1.56 |

**Means in a column followed by similar letters are not significantly different.*

At 3% concentration, the maximum number of 35.00 days for the emergence of adult generation was documented when it was cultured on maize grain having *N. tabacum* extracts which was statistically non significance from 32.00 days when cultured on seeds with *T. ammi* extracts. Overall, maximum number of 25.66 days required for the production of new progeny was documented on grains having zero percent plant extracts.

### *Total Adult emergence*

Major dissimilarities were observed among the treatments regarding total adult emergence of maize weevil (Table 2). At 1% concentration, the maximum number of 63.00 total adult emergence was documented when weevils were cultured on maize grains having *T. chebula* aqueous extracts which was statistically similar to 61.66 adult emergence in *T. ammi* treated maize seeds. The least (27.33) adult emergence as noted in grains having application of *N. tabacum* aqueous extracts which was statistically significant from rest of all treatments. At 2% concentration, the maximum number of 59.66 total adult emergence were recorded when it was cultured on grains having application of *T. chebula* aqueous extracts which was statistically non significance from 57.00 adult emergence in maize grains having application of *T. ammi* aqueous extracts. At 3% concentration, the maximum number of 50.00 total adult emergence were documented on seeds having application of *T. ammi* aqueous extracts which was statistically non significance from 43.33 adult emergence in maize grains treated with *T. chebula* aqueous extracts. Overall, maximum number of 82.00 total fresh progeny was documented on grains having zero percent application of plant extracts.

### *Percent Infestation*

The treatment of grains with selected botanical extracts, show significance differences among the treatments regarding percent infestation by maize weevil. At 1% concentration, the maximum infestation of 34.38% was documented in grains having application of *T. chebula* aqueous extracts which was different from all other tested extracts (Table 3).

At 2% concentration, the maximum number of 29.33 percent infestation was documented on grains having application of *T. chebula* extract which was statistically similar to 28.03 percent infestation in maize grains treated with *T. ammi* aqueous extracts. The minimum infestation of 17.34 percent was documented in grains having application of *N. tabacum* extracts. At 3% concentration, the maximum number of 26.00 total percent infestation were documented on grains having application of *T. chebula* aqueous extracts. Overall, maximum percent infestation of 38.66%, were documented on untreated maize grains.

### *Weight Loss*

Treatment of maize grains with selected botanical extracts showed significant variations among treatments regarding percent weight loss. At 1% concentration, the maximum weight loss percentage (20.00) caused by maize weevil was documented in grains having application of *T. chebula* aqueous extracts which was found statistically different from all other extracts. Among the treatments, the least (13.00) percent weight loss were documented in maize grains having application of *N. tabacum* extracts. At 2% concentration, the maximum (17.00%) weight loss were recorded on maize grain treated with *T. chebula* extract which was statistically non significance from 16.33 and 16.29 percent infestation in maize grains having application of *T. ammi* and *F. indica* aqueous extracts. The minimum (11.00%) weight loss was documented in grains having application of *N. tabacum* extracts. At 3% concentration, the maximum (16.00%) weight loss was recorded in maize grains treated with T. chebula aqueous extract which was statistically non significance from 15.00 percent weight loss on grains having application of *T. ammi* aqueous extracts. Overall, maximum (26.00) percent weight loss were noted in untreated maize grains (Table 4).

### *Adult Longevity*

The data show significant variation regarding adult longevity of maize weevil (Table 5). At 1% concentration, regarding the effect of treatments, maximum life span of 52.00 days was documented on grains having application of *T. chebula* extracts. The least (43.00 days) adult longevity was documented when maize grains were treated with *N. tabacum* aqueous extracts (Table 5). At 2% concentration, the maximum life span of adults (56.33 days) was observed on grains having application of *T. chebula* aqueous extracts whereas; lowest life span of adults (44.00 days) was documented on *N. tabacum* treated grains which differed non-significantly from 45.66 days on *W. coagluans* extracts applied grains. At 3% concentration, the maximum (50.66 days) life span of adults was documented

***Table 2**. Effect of plant's aqueous extracts used at different rates on progeny emergence of maize weevil.*

| Treatments | Concentrations (%) | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| *Terminalia chebula* | 63.00 ± 5.65 b | 59.66 ± 4.98 b | 43.33 ± 4.35 c |
| *Trachyspermum ammi* | 61.66 ± 5.76 bc | 57.00 ± 3.76 b | 50.00 ± 5.43 b |
| *Nicotiana tabacum* | 27.00 ± 3.23 e | 23.00 ± 3.09 d | 19.33 ± 2.98 f |
| *Withania coagulans* | 53.33 ± 4.40 d | 47.33 ± 4.01 c | 30.00 ± 4.06 e |
| *Fagonia indica* | 58.66 ± 4.76 c | 46.66 ± 4.22 c | 35.00 ± 3.00 d |
| *Control* | 82.00 ± 5.34 a | 79.00 ± 5.87 a | 77.66 ± 5.65 a |
| *LSD Value* | 3.84 | 2.81 | 2.91 |

**Means in a column followed by similar letters are not significantly different.*

***Table 3.** Effect of plant's aqueous extracts used at different rates on (%) infestation of seeds caused by maize weevil.*

| Treatments | Concentrations (%) | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| *Terminalia chebula* | 34.38 ± 3.00 b | 29.33 ± 3.00 b | 26.00 ± 3.48 b |
| *Trachyspermum ammi* | 32.45 ± 3.45 c | 28.03 ± 3.65 bc | 23.00 ± 2.04 c |
| *Nicotiana tabacum* | 19.63 ± 2.03 e | 17.34 ± 2.34 e | 14.00 ± 2.45 f |
| *Withania coagulans* | 26.80 ± 3.54 d | 19.68 ± 2.09 d | 16.33 ± 2.67 e |
| *Fagonia indica* | 32.18 ± 3.20 c | 26.92 ± 3.07 c | 21.20 ± 3.52 d |
| Control | 38.66 ± 4.09 a | 37.66 ± 3.32 a | 36.66 ± 3.00 a |
| LSD Value | 1.22 | 1.48 | 1.48 |

**Means in a column followed by similar letters are not significantly different.*

***Table 4**. Effect of plant's aqueous extracts used at different rates on percent grain weight loss.*

| Treatments | Concentrations (%) | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| *Terminalia chebula* | 20.0 ± 2.03 b | 17.00 ± 2.25 b | 16.00 ± 2.01 b |
| *Trachyspermum ammi* | 18.00 ± 2.00 c | 16.33 ± 2.09 b | 15.00 ± 2.03 b |
| *Nicotiana tabacum* | 13.00 ± 1.02 e | 12.00 ± 2.00 d | 11.00 ± 2.01 d |
| *Withania coagulans* | 15.00 ± 1.00 d | 14.33 ± 2.01 c | 13.00 ± 1.00 c |
| *Fagonia indica* | 16.66 ± 2.09 cd | 16.29 ± 2.24 b | 14.84 ± 2.07 b |
| Control | 25.33 ± 4.00 a | 26.00 ± 3.34 a | 25.66 ± 4.23 a |
| LSD Value | 1.87 | 1.76 | 1.83 |

**Means in a column followed by similar letters are not significantly different.*

***Table 5**. Effect of plant's aqueous extracts used at different rates on adult longevity cultured on maize seeds.*

| Treatments | Concentrations (%) | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| *Terminalia chebula* | 52.00 ± 4.97 b | 56.33 ± 4.09 b | 50.66 ± 4.56 b |
| *Trachyspermum ammi* | 48.66 ± 3.67 c | 52.66 ± 4.07 c | 49.66 ± 5.43 b |
| *Nicotiana tabacum* | 43.00 ± 4.47 d | 44.00 ± 4.35 e | 40.66 ± 4.40 d |
| *Withania coagulans* | 47.00 ± 5.76 c | 45.66 ± 5.56 e | 45.00 ± 5.67 c |
| *Fagonia indica* | 47.66 ± 5.76 c | 49.00 ± 4.31 d | 44.00 ± 3.76 c |
| Control | 59.66 ± 5.90 a | 59.00 ± 4.76 a | 59.66 ± 5.02 a |
| LSD Value | 2.29 | 1.921 | 1.966 |

**Means in a column followed by similar letters are not significantly different.*

on grains having application of *T. chebula* aqueous extract which was statistically similar to 49.66 days adult longevity on maize grain treated with *T. ammi* aqueous extract. Overall, maximum life span of adults (59.66 days) was documented on grains having zero percent application of extracts.

## *Sex Ratio*

The selected extracts had no significant influence on the sex ratio of maize weevil when it was cultured on grains pre-treated with various rates of botanical extracts (Table 6). The mean sex ratio presented as number of adult males emerged per 50 female show that always less number of adult males emerged in comparison to females in all the selected botanicals' extracts. Similarly, the effect of all concentrations on the tested botanical's extracts was found non-significantly different.

***Table 6.*** *Effect of plant's aqueous extracts used at different rates on sex ratio of maize weevil (males/50 females).*

| Treatments | Concentrations (%) | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| *Terminalia chebula* | 46.89 ± 4.07 NS | 47.14 ± 4.76 NS | 46.50 ± 4.30 NS |
| *Trachyspermum ammi* | 46.52 ± 4.65 | 46.36 ± 4.65 | 46.18 ± 4.32 |
| *Nicotiana tabacum* | 46.18 ± 4.43 | 46.29 ± 4.32 | 45.78 ± 3.25 |
| *Withania coagulans* | 45.87 ± 3.32 | 46.18 ± 4.09 | 45.56 ± 4.40 |
| *Fagonia indica* | 45.49 ± 4.65 | 46.18 ± 4.65 | 45.56 ± 4.75 |
| Control | 45.45 ± 4.08 | 45.97 ± 4.78 | 44.96 ± 4.32 |
| LSD Value | 3.29 | 3.15 | 3.05 |

**Means in a column followed by similar letters are not significantly different.*

*N.S. Non-significant*

## Discussion

A large variety of plants have been reported to carry insecticidal properties against insect pests of field crops and stored grains. These plants have been extensively investigated carrying insect repellent, anti-feedant, growth inhibiting and progeny inhibiting characteristics. In the current investigations, a dose dependent response of selected botanicals aqueous extracts was found. Among the selected extracts, the aqueous extracts of *N. tabacum* and *W. coagluans* prolonged the growth of maize weevil and inhibited the fresh progeny of adults from grains having application of botanicals. It is evident from the present results that aqueous extracts of *N. tabacum* and *W. coagluans* had pronounced influences on the survival of weevils which lead to prolongation of immature development and inhibition of adult emergence. *N. tabacum* extracts are easy to prepare and apply in the field conditions. The *N. tabacum* extracts possesses repellent properties and can work as Nerve or stomach poison against pest insects [21-23].

Similar findings have been reported by previous studies where extracts prepared from *N. tabacum* seeds have been reported to carry entomocidal properties against *C. maculatus* infesting stored cowpea [24]. The n-hexane, pet-ether and aqueous extracts prepared from *N. tabacum* seeds were found most effective, causing 100% mortality of adult beetles after 96 hours exposure period. The treatment of grains with pet-ether and n-hexane extracts drastically affected the beetles and no adult emergence was recorded. Sarkar & Lim (2018) reported that *N. tabacum* extracts at 2mg/ml, caused significant (92%) mortality of Oriental fruit moth, *Grapholita molesta* (Busck). The secondary metabolites present in plant derived insecticides have been reported to effect growth and survival of immature stages [25,26]. Similarly, lowest infestation percentage and weight loss of infested grains was documented in grains which were treated with highest (3%) concentration of *N. tabacum* aqueous extract which is attributed to the immature mortality and inability to infest the treated grains [24] found *N. tabacum* extracts to be effective in reducing seed damage and effective in controlling *C. maculatus* infesting stored cowpea.

## Conclusion

The plant aqueous extracts of *N. tabacum* and *W. coagluans* at 3% concentration should be used for the safer control of maize weevil.

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***Citation:*** *Ali H, Rashid MM. Efficacy of botanical plant extracts against Maize Weevil, Sitophilus zeamais (Coleoptera: Curculionidae). J Agric Sci Bot. 2022;6(6):126*

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