Asian Journal of Agricultural Sciences 6(3): 83-88, 2014
DOI:10.19026/ajas.6.5152
ISSN: 2041-3882; e-ISSN: 2041-3890

Submitted: March 29, 2014 Accepted: May 09, 2014 Published: May 15, 2014

Research Article

Evaluation of Certain Plant Leaf Powders and Aqueous Extracts against Maize Weevil, *Sitophilus zeamais* Motsch. (Coleoptera: Curculionidae)

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Abstract: Aim of the present study was to evaluate powders and aqueous extracts of *Melia azedarach*, *Mentha piperita*, *Phytolacca dodecandra*, *Schinus molle* and *Xanthium strumarium* leaves against maize weevil *Sitophilus zeamais*. Repellent activity of plant powders were evaluated by mixing 0.625, 1.25, 2.5, 5 and 10 g of powder per 100 g of clean uninfested maize seeds individually in separate plastic container. The numbers of insects moving outside the container were recorded at 24 h and 48 h post exposure period and percentage of repellent activity was calculated. The insect mortality was recorded at 5 days, 10 days and 15 days post exposure period and percentage of insect mortality was calculated. In addition, aqueous solutions were prepared by mixing 0.0625, 0.125, 0.25, 0.5 and 1 g of plant powder with 10 mL of water and tested for their insecticidal activity by topical application method. Total numbers of dead insects were counted for every 24 h up to 96 h post exposure period and percentage of insect mortality was calculated. Plant powders admixed with maize seed failed to show satisfactory level of repellent activity. Maize seed admixed with 10 g of *Mentha* leaf powder showed 93.3% mortality followed by *Schinus* (90%) and *Phytolacca* (90%) 5 days of post exposure period. After 15 days, 100% mortality recorded in *Mentha*, *Melia* and *Schinus* leaf powder mixed with 10/100 g of maize seeds followed by *Phytolacca* (90%) and *Xanthium* (86.6%). The topical application of aqueous extracts did not show insecticidal activity at satisfactory level. In general, application of *Melia*, *Mentha* and *Schinus* leaf powders proved to be effective against *Sitophilus zeamais*.

Keywords: Insecticidal activity, *Melia azedarach*, *Mentha piperita*, *Phytolacca dodecandra*, plant extracts, repellent activity, *Schinus molle*, *Sitophilus zeamais*, *Xanthium strumarium*

INTRODUCTION

One of the challenging tasks for developing countries is to prevent insect infestation in the storage to reduce grain damage in order to feed on growing population. The estimated global annual losses due to pest's activity in the field and storage are valued more than $100 billion. The quantitative and qualitative damage from insect pests ranged 20-30% in tropical zone and 5-10% in temperate zone (Jacobson, 1982; Ahmed and Grainge, 1986). In addition, induced changes in the storage environment provide suitable condition for the development of storage fungi that may further increased loss of stored grains (Rajashekar *et al*., 2012).

Maize is one of the important cereal grains widely cultivated and consumed in Africa due to rich in dietary carbohydrate (Rouanet, 1992; Onwueme and Sinha, 1991). In tropical countries, great constraint for maize storage is infestation caused by the pest *Sitophilus zeamais* (Bosque-Perez and Buddenhagen, 1992). The loss and quality deterioration caused by this pest is a major obstacle to achieve food security in developing countries (Rouanet, 1992). The development of insecticide based technologies for grain protection in traditional farm storage in Africa has been partially successful due to high cost of synthetic insecticides (Obeng-Ofori *et al*., 1997). The indiscriminate use of chemicals pave the way for developing resistant strains, toxic residue getting enter in to food of animal and man, workers safety and high cost of procurement (Sighamony *et al*., 1990). In this scenario, it is necessary to find out eco-friendly, economically viable alternative pest control methods which are affordable by resource poor farming communities. One of the alternative methods tried world wide is by using plant powders and their extracts (Cobbinah and Appiah-Kwarteng, 1989; Niber, 1994; Jembere *et al*., 1995; Lajide *et al*., 1998; Asawalam and Adesiyan, 2001). Talukder (2007) listed 43 plant species as insect repellents, 21 plants as insect feeding deterrents, 47 plants as insect toxicants, 37 plants as grain protectants, 27 plants as insect reproduction inhibitors and 7 plants as insect growth and development inhibitors.

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In Ethiopia, farmers are using dried leaves of *Datura stramonium*, *Phytolacca dodecandra*, *Tagetes minuta* and *Weinia longiflora* to protect their stored grains by believing pesticidal effect (Lynch *et al*., 1986). Ethiopian farmers believe that adding a layer of dried plant leaves over the seeds may produce stink and drive the insects away from stored grains (Abraham and Abate, 2002). Even though, rich floral diversity of Ethiopia is not well explored and documented for human welfare. Therefore, present work was aimed to find out repellent and insecticidal activities of leaf powder and aqueous extracts of *Melia azedarach*, *Mentha piperita*, *Phytolacca dodecandra*, *Schinus molle* and *Xanthium strumarium* against maize weevil *Sitophilus zeamais*.

MATERIALS AND METHODS

The experiment was conducted at the biology laboratory, College of Natural and Computational Sciences, University of Gondar, Gondar, Ethiopia from February 2013 to May 2013:

Insect culture establishment: Adult *Sitophilus zeamais* were collected from infested maize seeds at Arada market storage site, Gondar, Ethiopia. The infested seeds were brought to the laboratory and kept in 2 kg plastic container. To establish insect culture, cleaned, uninfested maize grains were added to the infested seeds and the culture was maintained throughout study period.

Plant materials collection and processing: The fresh leaves of *Melia azedarach, Phytolacca dodecandra* and *Xanthium strumarium* was collected from Tewodros campus and *Schinus molle* was collected from Maraki Campus, University of Gondar and *Mentha piperita* was collected from GTZ area, Samunaber, Gondar. The plant leaves were washed thoroughly with tap water to remove dirty material attached from the natural environment and dried under shade to prevent denaturation of chemical substances. After complete drying, powdered by using electric blender and fine powder was obtained by sieving through kitchen strainer. Those plant powders were used to prepare different concentration by weight by weight (w/w) basis.

Evaluation of repellent activity: Repellent activity of the plant powders were evaluated at five different concentrations by mixing at 0.625, 1.25, 2.5, 5 and 10 g per 100 g of clean uninfested maize seeds individually in separate plastic container. After adding the plant powder to the maize seeds, thoroughly mixed and introduced 10 healthy adult weevils for each container. From each container after 24 and 48 h post exposure period numbers of insects moving outside the seeds were recorded from three replications and percentage repellent activity was calculated.

Evaluation of insecticidal activity: Insecticidal activity of plant powders were recorded after 5, 10 and 15 days of the post exposure period from the same container as used for repellent activities. After the exposure period, numbers of dead insects were counted and removed from the container. Total numbers of dead insects were counted continuously up to 15 days with 5 days interval from three replications. The percentage of insecticidal activity of plant powder was calculated.

$$\text{Percentage insecticidal activity } \frac{\text{Number of dead insects}}{\text{Total number of insects introduced}} \times 100$$

Evaluation insecticidal activity by topical application method: Insecticidal activity of aqueous extract of plant powders were tested by topical application method. In this method aqueous solutions were prepared by mixing 0.0625, 0.125, 0.25, 0.5 and 1 g, respectively of plant powder with 10 mL of water individually in a clean test tube. After adding the powder, test tubes were shaken vigorously in subsequent period of time and allowed to stay for 24 h, then filtered by using muslin cloth and used for topical application. For topical application 10 healthy insects were selected randomly and the aqueous extracts applied directly to insect body by using fine brush and kept in a test tube. The test tube mouth was covered with cotton plug. The numbers of dead insects were recorded continuously for up to 96 h with every 24 h interval and the percentage of mortality was calculated.

$$\text{Percentage insecticidal activity} = \frac{\text{Number of dead insects}}{\text{Total number of insects treated}} \times 100$$

Statistical analysis: The data collected from each experiment were subjected to statistical analysis to calculate percentage mean and standard deviation. The statistical significant difference of plant materials and different concentrations were analyzed by two way analysis of variance (ANOVA) at 5% level by using Microsoft office excel 2003 program.

RESULTS

Repellent activity of various plant powder admixed with 100 g of maize seeds after 24 h exposure period were presented in Table 1. Among the plant powder tested, maximum percentage repellent activity of 26.6% was recorded in *Schinus* treatment followed by *Mentha* (23.3) at 10 g/100 g of maize seeds. Even though, plant powders are not showing satisfactory repellent activity, two way ANOVA results indicates that within the plant powders and within the concentration tested showed statistical significant at 5% level. The interaction among the samples were statistically not significant ($p>0.05$).

Table 1: Repellent activity of plant powders tested against *Sitophilus zeamais* after 24 h exposure period

	Plant powder admixed with the 100 g of seeds (g/100 gm)				
Plant powders tested	0.625	1.25	2.500	5.0	10
Melia	6.60±5.77	10.0±10.0	13.3±5.77	13.3±5.77	16.60±5.77
Schinus	10.0±0.00	13.3±5.77	6.60±5.77	16.6±5.77	26.60±5.77
Phytolacca	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.000±0.00
Mentha	20.0±10.0	16.6±5.77	16.6±5.77	20.0±10.00	23.30±11.54
Xanthium	0.00±0.00	0.00±0.00	0.00±0.00	6.60±5.77	10.00±10.00

Values are Mean ± Standard deviation of three replications

Table 2: Repellent activity of plant powders tested against *Sitophilus zeamais* after 48 h exposure period

	Plant powder admixed with the 100 g of seeds (g/100 gm)				
Plant powders tested	0.625	1.25	2.5	5.0	10
Melia	13.3±4.44	6.60±4.44	16.6±4.44	20.0±6.66	23.3±4.44
Schinus	13.3±4.44	16.6±4.44	16.6±8.88	23.3±4.44	26.6±4.44
Phytolacca	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
Mentha	23.3±4.44	26.6±8.88	30.0±6.66	30.0±6.66	33.3±4.44
Xanthium	0.00±0.00	0.00±0.00	0.00±0.00	13.3±4.44	16.6±4.44

Values are Mean ± Standard deviation of three replications

Table 3: Insecticidal activity of plant powders against *Sitophilus zeamais* after 5 days of exposure period

	Plant powder admixed with the 100 g of seeds (g/100 gm)				
Plant powders tested	0.625	1.25	2.5	5.0	10
Melia	36.6±5.77	50.0±10.00	76.6±5.77	83.3±5.77	86.6±5.77
Schinus	26.6±5.77	40.0±10.00	63.3±5.77	70.0±10.00	90.0±10.00
Phytolacca	60.0±10.0	66.6±5.77	73.3±5.77	83.3±5.77	90.0±10.00
Mentha	16.6±5.77	26.6±5.77	43.3±5.77	76.6±5.77	93.3±5.77
Xanthium	13.3±5.77	30.0±10.00	56.6±5.77	66.6±5.77	80.0±10.00

Values are Mean ± Standard deviation of three replications

After 48 h exposure period, maize seed mixed with 10 g of *Mentha* leaf powder showed 33.3% repellent activity followed by *Schinus* (26.6%). The seeds mixed with 5 g of plant powder only *Mentha* showed 30% repellent activity (Table 2). The two way ANOVA results indicates that within the plant powder tested and within the concentration showed statistical significant ($p<0.05$). The interaction among the samples were statistically not significant ($p>0.05$).

Insecticidal activity of plant powders tested against maize weevil after 5 days of exposure period was presented in Table 3. Maize seed admixed with 10 g of *Mentha* leaf powder was recorded 93.3% mortality followed by *Schinus* (90%) and *Phytolacca* (90%). The percentage mortality of insects in maize seeds admixed with 5g of *Phytolacca* and *Melia* was 83.3%. In general, maize seeds treated with *Phytolacca* Leaf powder insect mortality was more than 60%. At quantity of plant powder treated maize seeds i.e., 0.625/100 g of seeds and 1.25/100 g of seeds except for *Phytolacca* and *Melia* remaining all observed with less than 50% mortality. The two way ANOVA results revealed that within the plant powder tested, within the concentration and interaction among the samples were statistically significant ($p<0.05$).

After 10 days of exposure period, maize seed treated with 10 g of *Mentha* and *Schinus* leaf powder was recorded with 96.6% mortality followed by *Melia* (93.3%) and *Phytolacca* (90%). The insect mortality in seeds treated with 5 g of *Phytolacca* (83.3%) was on par with *Mentha* (83.3%) and *Melia* (83.3%). In general, maize seeds applied with *Phytolacca* plant powder, insect mortality was more than 60% (Table 4). The two way ANOVA results clearly demonstrates statistically significant ($p<0.05$) difference within the plant powder tested, within the concentration and interaction among the sample.

After 15 days of exposure period, maize seed admixed with 10 g of *Mentha*, *Melia* and *Schinus* leaf powder was recorded 100% insect mortality followed by *Phytolacca* (90%) and *Xanthium* (86.6%). The application of *Phytolacca* and *Mentha* leaf powder at 5/100 g of maize seeds recorded 86.6% insect mortality. At low quantity of plant powders mixed maize seeds i.e., 0.625/100 g of seeds and 1.25/100 g of seeds except for *Mentha* and *Xanthium* remaining all showed more than 50% mortality (Table 5). The two way ANOVA indicates that within the plant powder tested, within the concentration and interaction among the samples were statistically significant ($p<0.05$).

Insecticidal activity of aqueous extracts of plant powders applied topically on maize weevil after 24 h post exposure period was presented in Table 6. Maximum percentage mortality of 33.3% was recorded in *Mentha* followed by *Phytolacca* and *Melia* (26.6%) and *Schinus* and *Xanthium* (23.3%) at 1 g/10 mL treatment. The two way ANOVA results revealed that

Table 4: Insecticidal activity of plant powders against *Sitophilus zeamais* after 10 days of exposure period

	Plant powder admixed with the 100 g of seeds (g/100 gm)				
Plant powders tested	0.625	1.25	2.5	5.0	10
Melia	46.6±11.54	56.6±5.77	83.3±5.77	83.3±5.77	93.3±5.77
Schinus	53.3±11.54	50.0±10.00	66.6±5.77	80.0±10.00	96.6±5.77
Phytolacca	60.0±10.00	66.6±5.770	73.3±5.77	83.3±5.77	90.0±10.00
Mentha	23.3±5.77	30.0±10.00	50.0±10.00	83.3±5.77	96.6±5.77
Xanthium	13.3±5.77	33.3±5.770	60.0±10.00	70.0±10.00	83.3±5.77

Values are Mean ± Standard deviation of three replications.

Table 5: Insecticidal activity of plant powders against *Sitophilus zeamais* after 15 days of exposure period

	Plant powder admixed with the 100 g of seeds (g/100 gm)				
Plant powders tested	0.625	1.25	2.5	5.0	10
Melia	56.6±11.27	60.0±10.00	83.3±5.77	83.3±5.77	100.0±0.00
Schinus	53.3±11.54	50.0±10.00	76.6±5.770	80.0±10.00	100.0±0.00
Phytolacca	63.3±5.77	70.0±10.00	80.0±10.00	86.6±5.77	90.00±10.0
Mentha	23.3±5.77	43.3±15.27	56.6±15.27	86.6±5.77	100.0±0.00
Xanthium	30.0±10.00	36.6±5.77	63.3±5.77	70.0±10.00	86.60±5.77

Values are Mean ± Standard deviation of three replications

Table 6: Insecticidal activity of water extracts against *Sitophilus zeamais* after 24 h of exposure periods

	Concentration of plant powder (gm/10 mL of water)				
Plant extracts tested	0.0625	0.125	0.25	0.5	1.0
Melia	0.0±0.00	16.6±5.77	20.0±0.00	20.0± 10.00	26.6±5.77
Schinus	6.6±5.77	20.0±0.00	20.0±10.00	23.3±5.77	23.3±11.54
Phytolacca	6.6±5.77	10.0±0.00	13.3±5.77	16.6±5.77	26.6±5.77
Mentha	3.3±5.77	13.3±5.77	6.60±5.77	26.6±5.77	33.3±5.77
Xanthium	0.0±0.00	0.00±0.00	6.60±5.77	6.60±5.77	23.3±15.27

Values are Mean ± Standard deviation of three replications

Table 7: Insecticidal activity of water extracts against *Sitophilus zeamais* after 48 h of exposure period

	Concentration of plant powder (gm/10 mL of water)				
Plant extracts tested	0.0625	0.125	0.25	0.5	1.0
Melia	0.00±0.00	16.6±5.77	23.3±5.77	20.0±10.00	30.0±10.00
Schinus	7.00±5.190	23.3±5.77	23.3±5.77	26.6±5.77	26.6±5.77
Phytolacca	10.0±10.00	13.3±5.77	20.0±10.00	30.0±10.00	40.0±10.00
Mentha	6.60±5.77	16.6±5.77	13.3±5.77	26.6±5.77	36.6±5.77
Xanthium	0.00±0.000	3.33±5.77	6.60±5.77	10.0±0.000	30.0±10.00

Values are Mean ± Standard deviation of three replications

Table 8: Insecticidal activity of water extracts against *Sitophilus zeamais* after 72 h of exposure period

	Concentration of plant powder (gm/10 mL of water)				
Plant extracts tested	0.0625	0.125	0.25	0.5	1.0
Melia	0.00±0.00	20.0±0.00	23.3±5.77	20.0±10.00	33.3±5.77
Schinus	7.00±5.19	23.3±5.77	23.3±5.77	33.3±5.770	26.6±5.77
Phytolacca	13.3±5.77	10.0±10.00	26.6±5.77	30.0±10.00	46.6±5.77
Mentha	6.60±5.77	16.6±5.77	20.0±10.00	26.6±5.770	36.6±5.77
Xanthium	0.00±0.00	3.30±5.77	6.60±5.77	13.3±5.770	30.0±10.00

Values are Mean ± Standard deviation of three replications

within the plant tested, within the concentration tested showed statistically significant result ($p<0.05$). The interaction among the samples were statistically not significant ($p>0.05$).

After 48 h exposure period, 1g mixed with 10 mL of water recorded maximum mortality of 40% in *Phytolacca* followed by *Mentha* (36.6%) and *Melia* and *Xanthium* (30%) (Table 7). The two way ANOVA results demonstrates statistically significant differences within the plant extract tested, within the concentration ($p<0.05$). The interaction among the samples were statistically not significant ($p>0.05$).

After 72 h post exposure period, 1g plant powder mixed with 10 mL of water observed maximum mortality of 46.6% in *Phytolacca* followed by *Mentha* (36.6%), *Melia* (33.3%) and *Xanthium* (30%) (Table 8). The two way ANOVA results showed Statistically significant differences within the plant tested, within the concentrations of plant extracts ($p<0.05$). The interaction among the samples were statistically not significant ($p>0.05$).

After 96 h exposure period, 1g of plant powder mixed with 10 mL of water recorded maximum

Table 9: Insecticidal activity of water extracts against *Sitophilus zeamais* after 96 h of exposure period

	Concentration of plant powder (gm/10 mL of water)				
Plant extracts tested	0.0625	0.125	0.25	0.5	1.0
Melia	0.00±0.00	23.3±5.77	26.6±5.77	23.3±11.54	33.3±5.77
Schinus	7.00±5.19	23.3±5.77	23.3±5.77	36.6±5.77	33.3±5.77
Phytolacca	16.6±5.77	23.3±5.77	26.6±5.77	30.0±10.00	46.6±5.77
Mentha	6.60±5.77	20.0±0.00	23.3±11.54	26.6±5.77	36.6±5.77
Xanthium	0.00±0.00	6.60±5.77	10.0±10.00	16.6±5.77	30.0±10.00

Values are Mean ± Standard deviation of three replication

mortality of 46.6% in *Phytolacca* extract followed by *Mentha* (36.6%), *Melia* (33.3%), *Schinus* (33.3%) and *Xanthium* (30%) (Table 9). The two way ANOVA results demonstrates statistically significant differences within the plants tested, within the concentrations of plant extracts ($p<0.05$). The interaction among the samples were statistically not significant ($p>0.05$).

DISCUSSION

Plant products are used to control many pests in the field and also in storage since time immemorial. The utilization of plant materials was mainly by believing low toxicity to mammals, easily biodegradable in nature and highly suitable for small scale farming communities. Chemical pesticides are good candidate but its application to food commodities may leads to residual problems. Kouninki *et al*. (2007) pointed out synthetic chemical pesticides cannot be used in association with flour or sources of provender because of their direct consumption by human and animals. Hence, eco-friendly pest control strategies are very much essential to protect food grain in a safe way. Plant materials with insecticidal properties considered to be useful for post harvest practices particularly relevant for small scale farmers for their storage commodities.

In this study *Melia*, *Mentha*, *Phytolacca*, *Schinus* and *Xanthium* plant powders were tested for their repellent and insecticidal properties against maize weevil *Sitophilus zeamais*. The bio-potential of plant powder was mainly based on concentration and exposure period. After 24 h exposure period the plant powders were not effective. However, after 48 h exposure period higher amount of *Mentha* and *Schinus* plant powder mixed maize seeds repellent activity was maximum. This is because both plant leaves have oily substances in which odour was released due to this reason repellent activity may be increased. The low repellent activity of plant powders may be associated with the amount of chemical substances and mode of action on insect body. Present findings are corroborate with the works of Casey Sclar (1994) who has mentioned that repellent activity of *A. indica* was based on different mode of action such as repellent, insecticidal, antibacterial, antifungal, antifeedant, oviposition and growth inhibiting properties.

Insecticidal activity of plant extracts tested against maize weevil, 100% mortality was recorded in maize seeds treated with 10 g of *Mentha*, *Melia* and *Schinus* followed by *Phytolacca* and *Xanthium*. Generally percentage of mortality was increased at higher concentration and exposure period. After 15 days of exposure period *Mentha*, *Melia* and *Schinus* was proved to be effective. Mulungu *et al*. (2007) suggested that higher death of insects exposed in plant powders as a result of physical barrier effects. This is because plant powders have the tendency by blocking spiracles of the insects body thus impairing respiration leading to the death. If the respiratory system is arrested, that leads to affects metabolic activities which ultimately cause death.

Insecticidal activity of aqueous extracts by topical application varied greatly based on the concentration and period of exposure. Generally, mortality rate of insects was low in aqueous solution directly applied to the insect body. This may be due to hard exo-cuticle covering of the insect body may not allow the plant materials to enter inside. It is obvious that due to hard covering these insects have developed resistance to many commercial insecticides. Even though, at higher concentration maximum percentage mortality was observed in *Phytolacca* extracts treatment. The *Phytolocca* plants contain chemical component saponins that have molluscidial activity (Lemma *et al*., 1979). Higher mortality of insects in the present study may be associated with saponin. From the study, it is concluded that application of *Melia*, *Mentha* and *Schinus* plant leaf powders on maize seeds may control the damage caused by the maize weevil *Sitophilus zeamais*.

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