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INSECTICIDAL ACTION OF FIVE PLANTS AGAINST MAIZE WEEVIL, *Sitophilus Zeamais* Motsch. (COLEOPTERA: CURCULIONIDAE)

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ABSTRACT

A study was conducted to evaluate the insecticidal action of five locally available plants namely: *Azadirachta indica* (Neem), *Cymbopogon citratus* (Lemon Grass), *Lantana camara* (Lantana), *Ocimum basilicum* (Basil) and *Tagetes erecta* (African marigold) against maize weevil, *Sitophilus zeamais* Motsch. following the repellency, adult mortality and antioviposition and growth inhibition tests. Results revealed that all test materials exhibited repellency action against maize weevil. Powdered leaves of neem and lantana were noted to be highly repellant while powdered leaves of lemon grass, basil and African marigold were observed to be moderately repellant against maize weevil within 96 hours of exposure. Corn grains treated with powdered leaves of lemon grass and basil exhibited a low mortality of 5.33% and 0.66%, respectively, at 24 DAII. Other test plants revealed zero adult mortality. None among the test plants manifested anti-ovipositional and growth inhibitory action against maize weevil. All examined corn grains except for carbaryl - treated corn grains showed larval tunnel. The total development period of the maize weevils emerged from both treated and untreated corn grains was the same (39 days) and 100% insect survival was noted indicating zero percent of insects that reached larval or pupal stages only. The adult body weight was comparable among treatments.

KEYWORDS: Maize weevil**,** *Sitophilus zeamais,* Coleoptera: curculionidae*, Azadirachta indica* (Neem), *Cymbopogon citrates, Lantana camara* (Lantana), *Ocimum basilicum* (Basil)*, Tagetes erecta*

1. INTRODUCTION

Corn, *Zea mays* L., belongs to the family Poaceae or Gramineae. It is a cereal grass related to wheat, rice, oat and barley; ranking second after wheat and is followed by third-ranking rice in order of world grain production. This plant is regarded as versatile and with many uses since it can thrive in diverse climates; hence, it is grown in many countries than any other crop. Aside from being one of the major sources of food for both human and animals, it is also processed into various food and industrial products including starches, sweeteners, oil, beverage, industrial alcohol and fuel ethanol. Moreover, thousands of foods and other everyday items such as toothpaste,

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cosmetics, adhesives, shoe polish, ceramics, explosives, construction materials, metal molds, paints, paper goods and textiles contain corn components. In addition, corn products are rapidly replacing petroleum in many industrial applications. Polylactide (PLA), a biodegradable polymer made from corn is being used successfully in the manufacture of a wide variety of everyday items such as clothing, packaging, carpeting, recreational equipment and food utensils of renewable resource [1].

Cereal pests may infest the corn grain during storage and transport. Among which is the maize weevil (*Sitophilus zeamais* Motschulsky), a ¼ inch long, reddish brown to black snout weevil. In maize or sorghum, attack may start in the mature crop when the moisture content (MC) of the grain has fallen to 18-20%. Subsequent infestations in store result from the transfer of infested grain into store or from the pest flying into storage facilities, probably attracted by the odor of the stored grain. In stored maize, heavy infestation of this pest may cause weight losses of as much as 30-40%, although losses are commonly 4-5% [2]. The chewing damage caused by the insect brings about increased respiration in the cereal (hot spots), which promotes evolution of heat and moisture and in turn provides favorable living condition for molds leading to production of aflatoxin. Subsequently, at very high moisture levels, bacterial growth is favored which ultimately gives rise to depreciation and finally total loss [3].

Controlling stored pests is not an easy job although synthetic chemicals are apparently available for use. Effective pest control is no longer a matter of heavy application of pesticides, partly because of rising cost of petroleum – derived products but largely because excessive use of pesticide promotes faster evolution of resistant form of pests, destroys natural enemies, turns formerly innocuous species into pests, harms other non-target species and contaminates food. There is, thus, an urgent need for control agents, which are less toxic to man and more readily degradable. Among which is the use of botanical pesticides with low mammalian toxicity and can effectively prevent and/or suppress insect pests especially in storage [4].

The use of botanical pesticides to protect plants from pests is very promising because of several distinct advantages. Pesticidal plants are generally much safer than conventionally used synthetic pesticides. Pesticidal plants have been in nature as its component for millions of years without any ill or adverse effect on the ecosystem. In addition, plant-based pesticides are renewable in nature and cheaper. Also, some plants have more than one chemical as an active principle responsible for their biological properties. These may be either for one particular biological effect or may have diverse ecological effects. The chances of developing quick resistance to different chemicals are highly unlikely [5].

Plant-derived pesticides can be transferred into practical applications in natural crop protection, which can help the small-scale farmers [6]. The use of natural and easily biodegradable crop protection inputs like azadirachtin can be a useful component of an IPM strategy since the compound is known for its low toxicity against beneficial insects [7].

Insect pests commonly attack stored grains like maize. They cause severe damage to the commodity resulting in losses in weight, seed viability, and nutritive quality of foodstuffs. The use of synthetic chemicals as a method of controlling pests is effective yet expensive, dangerous to human health and may create other problems in post harvest industry, thus, the use of botanical pesticides which are indigenous, effective and with low mammalian toxicity favors the industry by providing safe, environment-friendly and cheap source of preventive measures for stored product pests like the maize weevil, S. *zeamais* Motsch.

Five locally available plants including *Azadirachta indica* (neem), *Cymbopogon citratus* (Lemon grass), *Lantana camara* (Lantana*)*, *Ocimum basilicum* (basil) *and Tagetes erecta* (African marigold) were evaluated to determine their nature as grain protectant against *Sitophilus zeamais*. These plants are known for their insecticidal property against other insects including some stored product insect pests, thus, this study was conducted.

This study specifically aimed to determine the insecticidal action (adult mortality, repellency, anti-ovipositional and growth inhibitory affect) of powdered leaves of *A. indica, C. citratus, L. camara, O. basilicum and T. erecta* against maize weevil, *S. zeamais* Motsch.

2. MATERIALS AND METHODS

This study focused on the effectivity of powdered leaves of *A. indica, C. citratus, L. camara, O. basilicum and T. erecta* as protectants of stored maize grains against attack by *S. zeamais*. Effectivity was based on the repellency, antioviposition/growth inhibitory and adult mortality tests under laboratory conditions. The experiment was conducted at the Biological Control Division Laboratory, Bureau of Postharvest Research and Extension (BPHRE), Science City of Muñoz, Nueva Ecija from December 2005 to February 2006.

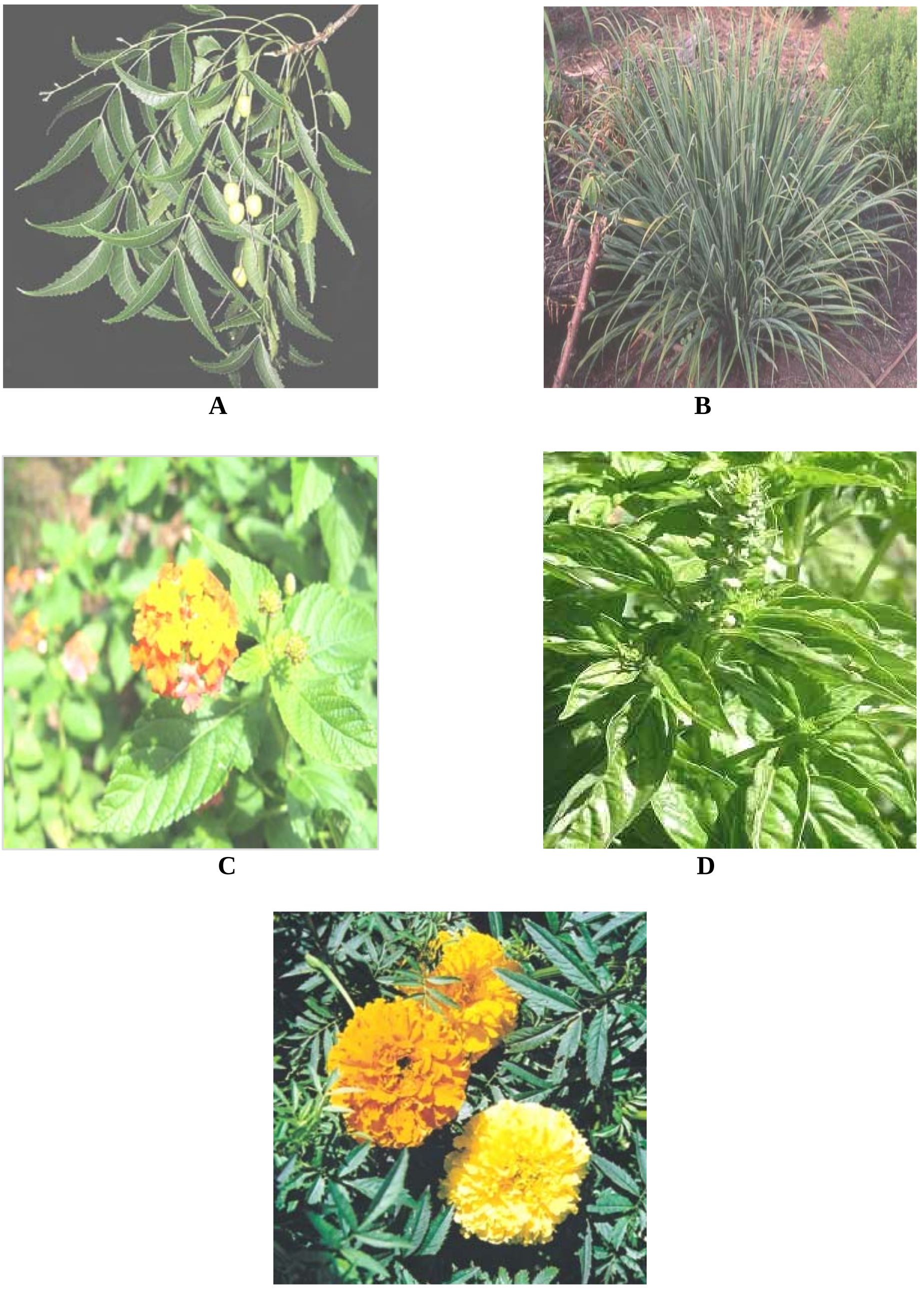
2.1 Collection and preparation of test materials

Fresh and matured leaf blades of *Cymbopogon citratus* and fresh, matured mixture of mid and lower leaves of *Lantana camara, Tagetes erecta, Azadirachta indica* and *Ocimum basilicum* (Figure 1) were gathered and brought immediately to the laboratory.

L. camara, T. erecta and *C. citratus* were harvested from Calabalabaan, Science City of Muñoz, while *A. indica* and *O. basilicum* were gathered from the College of Agriculture, Central Luzon State University, Nueva Ecija. The leaves were air dried in the laboratory until crispy. The dried leaves were pulverized using a micropulverizer and were sieved through a 0.5 mm size mesh to obtain uniform particle size. The resulting powders (Figure 2) were kept separately in glass containers with screw cap and stored at room temperature prior to use.

2.2 Mass rearing of *Sitophilus zeamais* Motsch.

Materials such as corn seeds, 12 cm high x 6.5 cm diameter glass jars, filter paper, funnel and mesh sieve used to culture corn weevils were thoroughly cleaned and exposed in an oven at $600^{o}C$ for 6 to 8 hours to ensure the absence of insects, mites or disease-causing microorganisms. The sealed glass jars were allowed to equilibrate to the ambient temperature before they were opened to avoid excessive loss or gain of moisture.



A B C D E

Figure 1 The plants used in the experiment: A) *Azadirachta indica*, B) *Cymbopogon citrates*, C) *Lantana camara*, D) *Ocimum basilicum* and E) *Tagetes erecta*

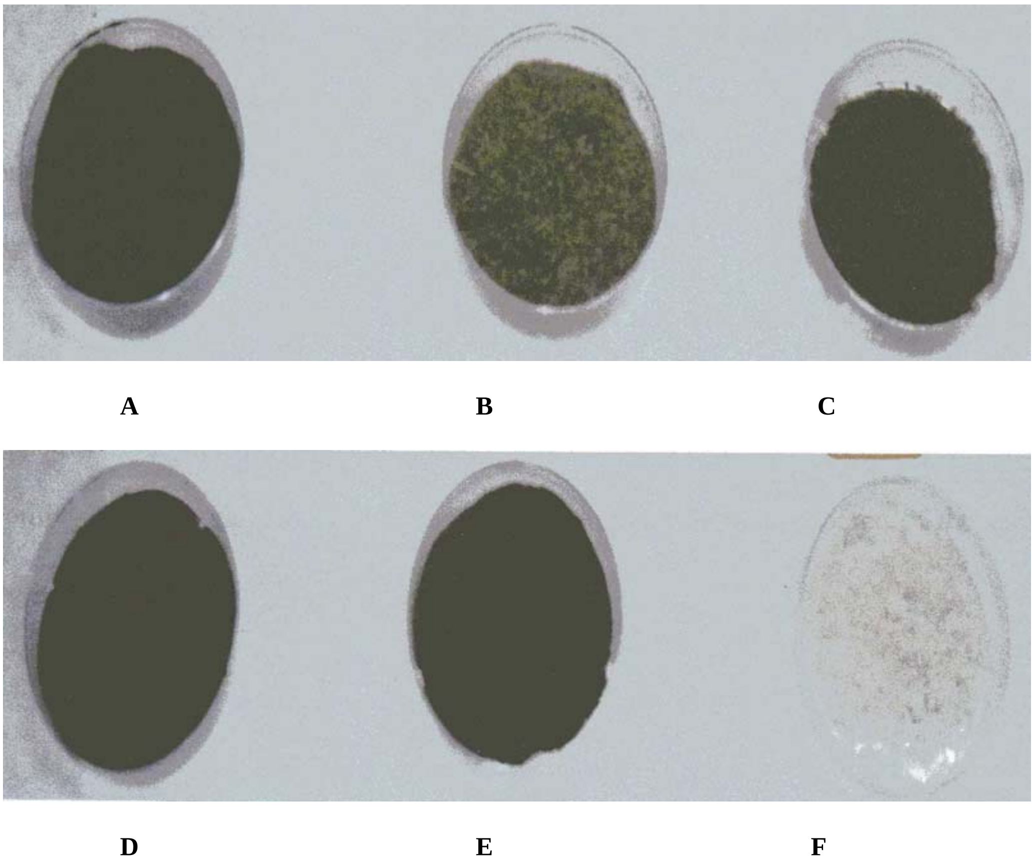


Figure 2 Samples of powdered test materials: A) *Azadirachta indica* (Neem), B) *Cymbopogon citrates* (Lemon grass), C) *Lantana camara* (Lantana), D) *Ocimum basilicum*, (Basil), E) *Tagetes erecta* (African marigold) and F) Carbaryl (chemical check, control)

Corn grains were adjusted to 14% moisture content (MC) prior to use. Four hundred grams corn grains were placed in each glass jar and the medium was conditioned to fit the temperature and RH at which the insects were cultured. Mixture of two hundred 1- week old male and female adult corn weevils secured from the Biological Control Division, BPHRE were introduced in each jar. After introduction of the insects in the medium, the top of the jar was covered with filter paper and sealed with molten wax to keep the insects inside the jar and also prevent the entry of mites and other insects and to allow exchange of gases in and out of the container. The jars were arranged 3 cm apart in a shallow tray with light oil to prevent attack of ants and left undisturbed at 28˚C for oviposition. Thereafter, all adults were removed thru sieving and each jar was left undisturbed for another 35 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.

2.3 Bioassay procedure

A.) Repellency test

The method employed by Garcia [1] on his work on some botanical materials against *Callosobruchus maculatus* Fab. with some modifications were followed. Transparent plastic tubings, 13 cm long x 1.3 cm diameter as test cylinders were used in the experiment. Each test cylinder was plugged at one end with fine mesh tulle containing 0.2 gram of powder made from the leaves of the test materials while the other end was plugged with clean cotton ball which served as control (Figure 3).

Mixture of ten 3-day old male and female weevils were introduced at the middle of each test cylinder through a hole at the middle portion of the cylinder. The hole was covered with nylon tulle mesh to keep the insects inside the cylinder. The cylinders were grouped accordingly to represent the treatments and replications. A total of 105 test cylinders were used in the experiment. Each treatment consisted of five cylinders and replicated three times.

Figure 3 General view of experimental set-up for repellency test

The cylinders were left undisturbed and the number of weevils that moved towards the untreated halves of the cylinders were counted and rated every hour for the first five hours and at 24, 48 and 96 hours thereafter. Repellency rating was calculated following the formula:

$$\text{Repellency rating} = \frac{n\,(1) + n\,(3) + n\,(5) + n\,(7)}{N}$$

Where:

n = number of insects stayed 0, 1-2, 3-4 and 5-6 cm from the center of the cylinder towards the untreated cotton plug, respectively

1, 3, 5 and 7 = rating scale on the reaction of the insects on different test materials.

N= Total number of insects introduced per cylinder

The degree of repellency of each test material was based on the following scale (Table 1).

Table 1 Scale for the determination of the degree of repellency of the test materials

Rating	Distance (cm) from the center of the cylinder towards the untreated plug	Description
1	0	Ineffective
3	1 – 2	Slightly Repellant (SR)
5	3 – 4	Moderately Repellant (MR)
7	5 – 6	Highly Repellant (HR)

Data were analyzed using ANOVA in Completely Randomized Design (CRD). Means were compared using the Duncan's Multiple Range Test (DMRT) at 5% level of significance.

B.) Anti-oviposition/ growth inhibition test

One hundred grams of corn grains adjusted to 14% MC were placed in 12 cm high x 6.5 cm diameter glass jars. Five grams of the powdered leaves of each of the test materials was thoroughly mixed with the grains in each jar. Three replicates were provided for each treatment. Treated seeds were placed separately in glass jar. Mixture of fifty 7-day old newly collected male and female maize weevils were introduced in each jar which was covered with filter paper and sealed with molten wax. The female adults were allowed to oviposit on the seeds for 48 hours, afterwhich, they were discarded.

After 5 days, when the adults were removed from each jar, thirty grains were secured from each jar for examination and further observation. Direct examination of the grains was done with the aid of a dissecting microscope. Since the eggs cannot be determined, the presence of larval tunnels (Figure 4) was used as a basis for counting the number of deposited eggs. A larval tunnel indicates egg deposition. A tunnel was formed inside the grain when the deposited egg hatched and the larva started feeding. Absence of larval tunnel means no egg was deposited, hence, this was the basis for anti-oviposition effect of the test materials. The examined grains were kept separately in properly labeled and covered 12 cm high x 6.5 cm diameter glass jars for adult emergence. The total development period (TDP), percent insect survival, weight of adult insects and number of insects that reached larval and pupal stages only were gathered to determine the growth inhibitory action of the test materials.

Figure 4 Corn grains showing tunnel made by maize weevil larva

The total development period of the test insects was gathered by counting the number of days when the egg was laid up (a day after removal of parent weevils from the jar) to adult emergence. Percent insect survival was determined by counting the number of insects that emerged into adult stage divided by the total number of eggs oviposited (represented by the total number of grain with larval tunnel (as mentioned earlier) multiplied by 100. Weight of the adult insects was determined with the use of a 1 g capacity top loading weighing scale. The number of insects that reached larval and pupal stages only was determined by dissecting the corn grains within the day after the emergence of the weevils from the untreated grains. All data gathered were analyzed using ANOVA following Completely Randomized Design (CRD). Means were compared using the Duncan's Multiple Range Test (DMRT) at 5% level of significance.

C.) Adult mortality test

One hundred grams of corn grains adjusted to 14% MC was admixed with 5 g powdered leaves of each of the test materials, respectively, in 12 cm high x 6.5 cm diameter glass jars. The admixtures were shaken manually for 5 minutes and then tumbled for 15 minutes in a mechanical tumbler. The treated corn grains were left undisturbed for an hour. Thereafter, mixture of fifty 3-day old male and female maize weevils were introduced per treatment. The glass jars were covered with filter paper and sealed with molten wax to keep the insects (Figure 5). Untreated corn grains served as control and seeds mixed with recommended rate of carbaryl served as chemical check (control). Each treatment was replicated three times.

Adult mortality was monitored at 3, 7, 14 and 24 days after exposure to the treatment. Percent adult mortality was determined by counting the number of dead insects divided by the total number of insects introduced multiplied by 100. Data were analyzed following the Completely Randomized Design (CRD). Duncan Multiple Range Test was used to compare the means at 5% level of significance.

Figure 5 experimental set-up for adult mortality test

3. RESULTS AND DISCUSSION

3.1 Repellency test

The repellency action of the test materials is shown in Table 2. Analysis of variance disclosed a highly significant repellency effect of the treatments on this parameter.

After the first hour of exposure, all the test materials except *O. basilicum* showed comparable repellency among each other but gave a significantly higher repellency over the untreated control. At two hours after insect exposure, all treatments showed highly significant repellency compared to the untreated control. Most of the weevils in the test cylinders were observed moving away from the treated plugs and stayed in the untreated cotton plugs, rated 7.00 (HR).

Each of the powdered *A. indica, L. camara* and *C. citratus* revealed highly significant results compared to other treatments with ratings of 7.00, 7.00 and 6.73, respectively. These are comparable to carbaryl, which served as the chemical control. On the other hand, powdered *O. basilicum* and *T. erecta,* recorded a similar result from each other on the third hour of insect exposure to the treatments. The repellency action of some of the test materials at four hours of exposure decreased. However, powdered *A. indica, L. camara*, and carbaryl retained their repellency rating of 7.00 (HR) while powdered *C. citratus*, *O. basilicum* and *T. erecta* recorded repellency ratings of 6.33, 5.93 and 5.66, respectively, which are lower compared to third hour of exposure. In addition, after 4 hours of insect exposure, it was noted that A.*indica*, L. *camara* and carbaryl obtained comparable repellency rating. However, they gave a significantly higher repellency over C. *citratus* , O. *basilicum* and *T. erecta*.

Table 2 Repellency rating of the different treatments to maize weevil at different exposure periods

TREATMENTS	Exposure Duration (hours)								
	1	**2**	**3**	**4**	**5**	**24**	**48**	**96**	**Mean**
Azadirachta indica	7.00[a]	7.00[a]	7.00[a]	7.00[a]	7.00[a]	7.00[a]	5.93[b]	3.53[b]	6.43[ab]
Cymbopogon citratus	7.00[a]	7.00[a]	6.73[a]	6.33[b]	6.06[c]	5.80[c]	1.53[c]	1.26[c]	5.21[ab]
Lantana camara	7.00[a]	7.00[a]	7.00[a]	7.00[a]	6.46[b]	6.33[b]	5.53[b]	3.53[b]	6.23[ab]
Ocimum basilicum	6.20[b]	6.73[a]	6.33[b]	5.93[bc]	5.80[c]	5.93[bc]	1.80[c]	1.13[c]	4.98[b]
Tagetes erecta	6.90[a]	7.00[a]	6.06[b]	5.66[c]	5.93[c]	5.26[d]	1.13[c]	1.13[c]	4.88[b]
Carbaryl	7.00[a]	7.00[a]	7.00[a]	7.00[a]	7.00[a]	7.00[a]	7.00[a]	7.00[a]	7.00[a]
Untreated	1.00[c]	1.00[b]	1.00[c]	1.00[d]	1.00[d]	1.00[e]	1.00[c]	1.00[c]	1.00[a]

In a column, means followed by a common letter are not significantly different at 5% level by DMRT.

Significantly highest repellency rating during the fifth hour of exposure was noted from the powdered *A. indica* (7.00) which gave a similar repellency with the treated control. These effects were significantly different over powdered *L. camara* (6.46), *C. citratus* (6.06), *T. erecta* (5.93) and *O. basilicum* (5.80).

At twenty-four hours of exposure, ratings of 7.00 (HR) were recorded in powdered *A. indica* and carbaryl. The repellency rating of powdered *L. camara* was significantly higher compared to powdered *C. citratus* and *T. erecta.* However, *L. camara* had comparable result to insects exposed to powdered *O. basilicum* at 24 hours of exposure.

Repellency rating of powdered *A. indica* decreased to 5.93, which is comparable to *L. camara* (5.53) after 48 hours of exposure. Powdered *O. basilicum*, *C. citratus* and *T. erecta* resulted in comparable results with untreated control (1.00), thus, considered ineffective as repellant against maize having mean ratings of 1.8, 1.53 and 1.13, respectively.

Repellency action of carbaryl did not vary even after 96 hours of exposure with 7.00 rating. Powdered leaves of *A. indica* (3.53) and *L. camara* (3.53) still showed a significant repellency rating compared to other test plants like *C. citratus* (1.26), *O. basilicum* (1.13) and *T. erecta* (1.13), which recorded the lowest repellency rating, thus, makes them ineffective against maize weevil because most of the weevils moved towards the treated plugs and was able to tolerate the odor of the test material.

Repellency test results indicated that powdered leaves of A. *indica* and L. *camara* were noted to be highly repellant while powdered leaves of C. *citratus*, O. *basilicum* and T. *erecta* showed moderate repellency action against maize weevil within 96 hours of exposure.

Results of the repellency test conform to the findings of earlier workers. Casey Sclar [2] mentioned the different modes of action of *A. indica* such as repellant, insecticidal, antibacterial, antifungal, antifeedant, oviposition and growth inhibiting, and crop and grain protectant. Furthermore, *A. indica* is the most promising source of bio-pesticide. Its azadirachtin content, being the most potent of its insecticidal compounds, was found effective against more than 200 pests of agricultural, horticultural, vegetable crops and household pests [3]. *A. indica* leaves, seed coat and bark contain these compounds though in smaller amounts. Kernels of neem are the richest source of meliacins and contain 0.2 to 0.3 % azadirachtin and 30 to 40% oil.

Powder from crushed *A. indica* kernels, when mixed with the grain at various concentrations, provides protection from many insect pests including weevils, *Sitophilus* spp; Khapra beetles, *Trogoderma granarium* and Lesser grain borer, *Rhizopertha dominica*. [4-5].

The repellency action of the test plants also corroborates with several research findings. Binggeli [6] cited that ground plants of *L. camara* and other *L. camara* spp. when mixed with the produce or placed in between the produce as protective layers (Sandwich method) can protect grain legumes against bruchids and potato tuber moth (*Phthorimaea operculella*) for about 6 months by acting as repellant. Furthermore, powdered leaves of *L. camara* mixed with 2.5 kg of maize grains contained in jute bags at the rate of 50 grams were found effective against *S. zeamais*. However, lower dosage of the powder had been reported not effective [7].

Lemon grass essential oil was found effective in deterring a wide variety of insects while *O. basilicum* was particularly effective in discouraging flies [8]. In addition, volatile oils of *C. citratus* and *O. basilicum* were found effective as repellant against cowpea beetle, *Callosobruchus maculatus* Fab. [9].

The decrease in the repellency action of powdered test plants as the exposure duration lengthens might be because the chemical compounds present in the powdered leaves possibly volatilized in air and the weevils had adjusted with the odor. Furthermore, leaves of *A. indica* contain lesser amount of the major active ingredient, azadirachtin, than neem kernels [10].

Marigold, lantana, garlic, chili, lemongrass and basil, among others, repel insects thus, farmers use these as companion crops to food crops because in some cases their smell acts as repellant and in other cases the scent of marigold and *O. basilicum* attract the insects feeding on food plants [11].

3.2 Adult mortality test

Percent adult mortality at 24 days after the introduction of weevils on treated grains is shown in Table 3. Three, 7 and 14 days after insect introduction (DAII) revealed that very small differences among means and figure transformation was not feasible, thus, analysis of variance cannot be done (Estolano, *pers. comm*.).

Analysis of variance showed that adult mortality was significantly different among treatments at 24 DAII. Results showed that corn grains treated with carbaryl significantly obtained the highest mortality. On the other hand, *C. citratus* gave a higher adult mortality (5.33%) compared to the other test plants.

Table 3 Percent mortality of adult maize weevil at 24 days after insect introduction (DAII)

TREATMENTS	24 Days after Insect Introduction (DAII)
Azadirachta indica	0.00[c]
Cymbopogon citratus	5.33[b]
Lantana camara	0.00[c]
Ocimum basilicum	0.66[c]
Tagetes erecta	0.00[c]
Carbaryl	100.00[a]
Untreated	0.00[c]

In a column, means followed by a common letter are not significantly different at 5% level by DMRT.

Results revealed that at 14 days after insect introduction (DAII), only *C. citratus* and *O. basilicum* gave a lower mortality of 3.33% and 0.66%, respectively, compared to carbaryl while other treatments resulted to zero mortality.

The above results corroborated with the findings of Varma and Dubey (1998), who found that essential oil of *C. citratus* showed its *in vitro* fumigant activity in the management of storage fungi and insects of some cereals without exhibiting mammalian toxicity in albino rats. The essential oils of *O. basilicum* showed its insecticidal activity against *S. oryzae, Stegobium panicum, T. castaneum* and *C. chinensis*.

3.3 Anti-oviposition and growth inhibition test

All test plants did not indicate anti-ovipositional action as shown in Table 4. Only larval tunnels were observed in all corn grains examined under this test. Deposition of eggs was not observed on the grains. This coincides with the work of Smith [12] and Fava and Springhetti [13], who found that *Sitophilus* females do not mark the grain where they lay their eggs and the careful sealing in of an egg with a protein plug helps to hide the oviposition puncture, therefore, they were unable to recognize the presence of eggs.

Table 4 Biological parameters as affected by the different treatments

TREATMENTS	Number of corn grains with larval tunnel	% Insect Survival	Total Development Period (days)	Adult body weight (mg)
Azadirachta indica	30	100	39	27.8[a]
Cymbopogon citratus	30	100	39	27.8[a]
Lantana camara	30	100	39	28.7[a]
Ocimum basilicum	30	100	39	28.0[a]
Tagetes erecta	30	100	39	28.3[a]
Carbaryl	0	0	0	0.00[b]
Untreated	30	100	39	28.8[a]

In a column, means followed by a common letter are not significantly different at 5% level by DMRT.

The method developed by Frankenfeld [14] on the determination of the deposited egg on maize grains by dipping in acid fuchsin to stain the egg plug was not employed in this study because the grains were treated with powders, which might be lost during the staining process and probably affect the result of the experiment. Therefore, a larval tunnel was used as an indication for oviposited egg since a tunnel will only form inside the grain when the deposited egg hatches. The absence of larval tunnel means no egg deposition, therefore, antioviposition action of the test materials is assumed.

A 100 % insect survival was also recorded in all treatments except for grains treated with carbaryl having 0% insect survival. The introduced adult maize weevils were not able to lay their eggs on the corn grains because a day after insect introduction, all insects died due to contact toxicity of carbaryl.

Caswell [15] stated that carbaryl contains methyl, the organic alkyl radical of methanol, a colorless, poisonous liquid that contributed to its toxic characteristics. In addition, mungbean treated with carbaryl at the rate of 0.5g/500g of grains revealed 100% adult bean weevil mortality 3 DAII [16].

The recorded TDP of the maize weevil that emerged both in treated and untreated corn grains except for carbaryl-treated grains were 39 days. This means that the powdered test plants did not affect the growth and development of maize weevil inside the grain.

Based on the result of the study, powdered form of the test plants might not be effective in inhibiting growth maybe because the active compound of the plants with insecticidal characteristics could not penetrate well inside the grains, thus, did not affect the development of the weevil.

Crop Protection Compendium [17] cited that maize weevil is an internal feeder. Thus, the different life stages developed successfully inside the grain. The growth and development of the weevils from the untreated corn grains and those insects from grains treated with powdered test plants had similar number of days of development, therefore, it could be assumed that the test plants did not affect the insect development. The body weight of the insects from both treated and untreated maize grains did not show significant differences among treatments.

4. CONCLUSIONS

A study was conducted to evaluate the repellency, adult mortality, antiovipositional and growth inhibitory action of five plant species, namely: *A. indica*, *C. citratus*, *L. camara*, *O. basilicum* and *T. erecta* against maize weevil, *Sitophilus zeamais* Motsch.

Results of the study revealed that all powdered test plants exhibited repellency action against maize weevil. Powdered leaves of *A. indica* and *L. camara* provided the highest repellency ratings against the maize weevil from the first hour until 96 hours of exposure. The rest of the test materials also showed repellency action but only to a shorter period of exposure.

Low mortality of adult maize weevils was observed from corn grains treated with *C. citratus* (5.53%) and *O. basilicum* (0.66%) 24 days after insect introduction while the other test plants disclosed zero adult mortality. Although eggs were not actually seen, oviposition of the maize weevils was not deterred as indicated by the presence of larval tunnels.

The powdered test plants as shown by 100% insect survival did not further affect growth of the maize weevils. The same total development period (TDP) of 39 days was noted among maize weevils that emerged from corn grains treated with powdered test plants and weevils from untreated corn grains. The body weight of the adult maize weevils was not affected by the test plants as shown by the body weight of insects from untreated control.

The above-mentioned findings revealed that powdered *A. indica* and *L. camara* could be used as grain protectant against maize weevil by acting as repellant.

It is recommended therefore that a similar study be conducted by using separately the other parts of the test plants like roots, flowers or even the whole plant to further evaluate their efficacy against maize weevil and other important stored product pests. In addition, the use of leaf extract of the test plants is also recommended to further determine their potential as insecticide against maize weevil.

REFFERENCES

[1] Garcia, J.R. **1990** Bioassay of Five Botanical Materials Against the Bean Weevil, *Callosobruchus chinensis* (L.) on Mungbean (*Vigna radiata* L.), Unpublished master's thesis. University of the Philippines at Los Baños, College, Laguna.

[2] Casey Sclar D. **1994** Neem: Mode of Action of Compounds Present in Extracts and Formulations of *Azadirachta indica* Seeds and their Efficacy to Pests of Ornamental Plants and to Non-target Species. Retrieved October 12, 2005 from http://www. colostate.edu /Depts /Entomology/Courses/en570/Papers_1994/sclar.html.

[3] Dahiya, S. **1999** Alternatives to Chemical Pesticides. Retrieved October 12, 2005 from http:// wwwtribuneindia.com/1999/99 Jul 26/agrohtm # 2.

[4] Golob, P. and D.J. Webley. **1980** The Use of Plants and Minerals as Traditional Protectants of Stored Products. Tropical Products Institute G138. Now Post Harvest Pest and Qquality Section, Natural Resources Institute, Chatham, United Kingdom.

[5] Saxena, R.C., Jilani G. and Kareem A.A., **1989** Effects of Neem on Stored Grain Insects in Jacobson (ed.) Forum on Phytochemical Pesticides. Volume I. The neem tree. Boca Raton, Florida: CRC Press.

[6] Binggeli, P. **1999** *Lantana camara* L. (Verbenaceae). Retrieved October 12, 2005 from http//www.memberslycos.co.uk/woodyPlant Ecology/docs/web_spd.htm.

[7] Koona, P. and Njoya, J. **2004** Effectiveness of Soybean Oil and Powder from Leaves of *Lantana camara* Linn. (Verbenaceae) as Protectants of Stored Maize against Infestation by *Sitophilus zeamais* Motsch. (Coleoptera: Curculionidae), Asia Network for Scientific Information.

[8] Mc Gowan, M. **1999** Herbal Pest Control. Retrieved October 12, 2005 from http//www.consciouschoice.com/1999/cc1208/herbs1208.html.

[9] Boeke, S., Barnaud, C. Van Loon, J. Kossou, D. Vanhuis, A. and Dicke, M. **2004** Efficacy of Plant Extracts Against the Cowpea Beetle, *Callosobruchus maculates*, *International Journal of Plant Management*, 50*(4)*, 251-258.

[10] Busungu, D.G. and Mushobozy, D.M.K. **1991** The Efficacy of Various Protectants against *Zabrotes subfasciatus* (Boh) Coleoptera, Bruchidae in Common Beans, *Bean Research*, *6*, 62-67.

[11] Sallam, M.N. **2004** Chapter II Insect Damage: Damage on Post-harvest Retrieved October 12, 2005 from http;//www.fao.org/inpho/content/compend/text/ch02-03.htm.

[12] Smith, R.H. **1986** Oviposition, Competition and Population Dynamics in Storage Insects. Poceedings of the 4th International Working Conference on Stored Product Protection, Tel Aviv, Israel. September. pp. 427-433.

[13] Fava, A. and Springhetti, A. **1991** Egg Distribution of *Sitophilus granaries* L. (Coleoptera:Curculionidae) in *Triticum aestivum caryopses*, *Journal of Applied Entomology*, *111*, 406-411.

[14] Frankenfeld, J.C. **1948** Staining Methods for Detecting Weevil Infestation in Grain. USDA Bulletin of Entomology R Q. E-T. Series 256, 1-4.

[15] Caswell, G.H. **1970** Storage of Cowpea in the Northern States of Nigeria. Samaru Res. Bull. 120. Institute for Agric Res., Samaru, Ahmadu Bello Univ. Zaria, Nigeria. pp. 510.

[16] Luciano, M.P. **1998** Efficacy of Powdered Mahogany Seeds in Vegetable Cooking Oil against Bean Weevil (*Callosobruchus maculatus* Fab.; COLEOPTERA: BRUCHIDAE), Unpublished undergraduate thesis Central Luzon State University, Muñoz, Nueva Ecija.

[17] Crop Protection Compendium. **2004** (CD-ROM). Compendium on Pests and Diseases. CAB International Publishing, Wallingford, United Kingdom.