The Palawan Scientist
Vol. 4, No. 1. pp. 70-81, 2008.

ISSN No. 1656-4707

Biology of Diamondback Moth (*Plutella xylostella* Linn) Reared on Cabbage Treated with Ginseng and Mint Extract

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ABSTRACT

The study compared the biology of diamondback moth reared on cabbage treated with ginseng and mint leaves extracts and compared the effect of different concentrations of ginseng and mint leaves extracts on the biology of diamondback moth. There were seven treatments and three replications used in the study: T_1- control ; T_2 – 30% ginseng extract; T_3 – 60% ginseng extract; T_4 – 100% ginseng extract; T_5 -30% mint extract; T_6 – 60% mint extract and T_7-100% mint extract.

Results of the study showed significant differences among the treatment means on the pupal duration, adult longevity, total lifespan, number of eggs laid per female adult, duration of egg laying, larval mortality, growth inhibitory effect (percentage pupal and adult survival) and antifeedant effect of ginseng and mint leaves extracts based on the percentage leaf disc eaten by the diamondback moth larvae 24 hours after introduction in the choice and no choice test. However, the differences on the incubation period, larval duration, total lifespan, % hatchability and repellant effect based on the number of larvae that visited the treated and untreated cabbage leaf discs in the choice and no choice test were insignificant.

Keywords: biology, diamondback moth, Plutella xylostella, antifeedant

INTRODUCTION

Diamondback moth (DBM) or "tarsan", *Plutella xylostella* L. is the most destructive pest of crucifer crops in the Philippines. The DBM larvae feed on and destroys the foliage of the plant from seedling stage until it is ready for harvest. About 100% yield loss is incurred if DBM infestation will not be controlled (AVNET, 1991).

Mint (Mentha) is a very aromatic perennial plant from prostrate rootstocks. Leaves are ovate to oblong-ovate. The flowers are small, arranged in whorls in the

axillary and terminal spikes, the calyx which are five-toothed are companulate or tubular. The corolla is subsequently four- lobed. Stamens are equal and erect. The nutlets are smooth to reticulate (Merill, 1984). According to Sangatanan and Sangatanan (2000), this plant is effective against all chewing insect pests attacking cashew plants in combination with green onion and hot pepper.

Ginseng (*Panax ginseng*) is erect, branching, perennial plants ranging from 2 to 3 feet tall with square, purplish-green stems. Leaves are opposite, serrate, oblanceolate with acuminate apex and base with a length of 2 to 5 inches, flowers are small, irregular and unsymmetrical, maneuvers are clustered, 6 flowers per cluster, arranged in terminal. The calyx is green, gamosepalous, corolla is whitish violet, gamopetalous; stamens are polyandrous (4 to 5 stamens per flower), white, 1 to 2 inches filament and violet, oval shaped anther. The pistil is wanting (absent). This plant was reported to have many medicinal uses. Some people use it to boost resistance to viral infection as well as ii prevents human disease (Web MD, 1995).

To control DBM infestation, the farmers commonly use strong chemicals. However, the high dosage and continuous applications of insecticides do not totally control DBM, rather, make DBM resistance to practically all insecticides used. The costly insecticide adds up the cost of production and further aggravates hazards to human health and the environment. It is with this premise that the researchers pursued this study to search for biodegradable and environment friendly alternatives to insecticide in controlling diamondback moth. Specifically this study aims to compare the biology of diamondback moth reared in cabbage treated with ginseng and mint leaves extract, and the effect of varying concentration of ginseng and mint leaves extract on the biology of diamondback moth.

METHODOLOGY

The study was laid out in Completely Randomized Design (CRD) with seven treatments, three replications and 30 samples per treatment. The treatments used were: Treatment 1 – control (untreated); Treatment 2-30% ginseng extract (30ml plant extract +70 ml water); Treatment 3- 60% ginseng extract (60 ml plant extract + 40 ml water); Treatment 4- 100% ginseng extract (100 ml plant extract); Treatment 5-30% mint extract (30 ml plant extract + 70 ml water); Treatment 6-60% mint extract (60 ml plant extract + 40 ml water) and Treatment 7-100% mint extract (100 ml plant extract).

Raising Host Plant

Cabbage seeds were sown in a seedbox (40 cm x 30 cm x 10 cm) containing sterilized mixtures of sand, compost and garden soil (1:1:1 ratio). Emerged seedlings (first three leaves begin to appear) were pricked using plastic cups to provide ample room for development. After two weeks, the seedlings were transplanted in 50(8" x 11") polyethylene bags filled with soil and compost or animal manure. The plants were watered daily to avoid wilting. Ten one month old bagged cabbage plants were allowed to be infested with diamondback moth while the rest were protected with net to avoid insect infestation of cabbage intended for rearing the insect.

Rearing Test Insect

Last instar larvae and pupae of diamondback moth collected from the infested cabbage were placed inside the insect cage (oviposition cage) with a dimension of 2" x 2" x 4". These were allowed to become adults. White polypropylene sheets were hanged inside the oviposition cage and were sprayed with 20% honey solution which served as food for DBM adults. Four bagged cabbage plants were placed inside the cage for overnight oviposition. Ovipositioned cabbage plants were transferred in a rearing cage (1.5" x 2" x 2") after 24 hours and were replaced with another unovipositioned plant as source of stock.

Extraction of Ginseng and Mint Leaves Juice

Ginseng (500 g) and mint (500 g) leaves were harvested and pounded with mortar and pestle. Pounded leaves were squeezed using a piece of cheesecloth to extract the juice.

Life cycle study

Two hundred ten (210) first instar larvae that hatched at the same time were placed individually in a Petri plate and were fed with excised cabbage leaf treated with the different concentrations of ginseng and mint leaves extracts. Food was changed daily until the larvae pupate. Change in the larvae appearance, their development stages and mortality cases were recorded.

Newly emerged adults were collected, sexed and paired (female and male per pair). Two pairs per replication were used in the observation of fecundity and longevity of adults. Each pair was placed in an insect cage and fed with 20%

honey sprayed in hanged white polypropylene sheet. One and one half months old cabbage plants were placed inside the cage for oviposition where each pair was reared until they die. Cabbage plants laid with eggs were excised or cut and placed in Petri plates with moist tissue paper. Incubation period and percentage hatchability were noted. The hatched larvae were used in the second generation test.

Bioassay

A total of 210 first instar diamondback moth larvae were used in studying the growth inhibitory effects of diamondback moth larvae. Twenty one (21) Petri dishes were lined with moistened tissue paper. Cabbage leaf discs were cut according to the size of the Petri dish, dipped for 10 minutes to the different concentrations of crude extract of ginseng and mint and air dried for 4 hours. After air drying, it was placed inside the Petri dishes. Ten first instar larvae were introduced into each Petri dish with three replications. Pupae and adult survival percentages and abnormalities in each stage were recorded.

Repellant and Antifeedant Effects

This was studied using choice and no choice test. Cubed cabbage leaf treated with varying concentrations of ginseng and mint extract was arranged in a circular fashion inside a circular container or pan. For the choice test, third instar larvae were released at the center of the pan. his was done in 3 replications with 20 insects per replication for treated and control (untreated) cabbage leaf discs.

For the no choice test, the larvae were placed directly on the surface of the cabbage leaf discs. Only treated leaf discs were exposed to the test insects.

The number of insects that visited each disc was observed for two days at different time intervals (30 minutes, one hour and two hours after introduction and every two hours thereafter, up to the twelve hours and 24 hours). Each portion of the leaf discs were used as evidence for the repellant and antifeedant effects of the different treatments.

The data gathered were diamondback moths' biology (incubation period, larval and pupal duration, adult longevity, total life cycle and lifespan, fecundity (number of laid eggs per female adult), percentage hatchability, mortality, growth inhibitory effects (developmental abnormalities of the different stages), and treatments' repellant and antifeedant effects (number of insect visiting and initially

feeding on the diet at different time intervals in the choice and no choice test and % eaten/damage portion of the leaf disc).

Data collected were analyzed using Analysis of Variance (ANOVA) and Duncan's Multiple Range Test (DMRT).

RESULT AND DISCUSSIONS

Biology of Diamondback Moth Reared on Cabbage Treated with Ginseng and Mint Leaves Extract

The biology of diamondback moth reared on cabbage applied with varying concentrations of ginseng and mint extract is shown in Table 1. The incubation period of the cabbage reared DBM treated with 30% mint extract (T_5) obtained a mean of 2.30 days, followed by those reared on cabbage treated with 60%(T_6) and 100% (T_7) with the same means of 2.27 days. Incubation period of DBM reared on cabbage treated with 30 % (T_2), 60 % (T_3) and 100% (T_4) ginseng extracts had the same means of 2.23 days while the untreated or control incubated for 2.20 days.

Table 1. The mean incubation period, larval duration, pupal duration, adult longevity, total life cycle and life cycle of diamondback moth reared on cabbage treated with varying concentrations of ginseng and mint extract.

Treatment	Mean incu-bation period (days)	Mean larval duration (days)	Mean pupal duration (days)	Mean adult longevity (days)	Mean total life cycle (days)	Mean total life-span (days)
T_1-control	2.20	12.00	4.83^{ab}	9.73^{c}	19.03	28.77^{abc}
T_2-30% ginseng extract	2.23	14.17	5.57^{c}	8.30^{bc}	21.97	30.03^{bc}
T_3-60% ginseng extract	2.23	12.40	5.27^{ab}	9.10^{bc}	19.90	29.00^{bc}
T_4-100% ginseng extract	2.23	14.23	4.67^{a}	9.80^{c}	21.13	30.93^{c}
T_5-30% mint extract	2.30	12.33	5.47^{bc}	7.90^{ab}	20.10	28.00^{ab}
T_6-60% mint extract	2.27	12.43	5.50^{bc}	6.67^{a}	20.20	26.87^{a}
T_7-100% mint extract	2.27	13.23	5.17^{abc}	6.60^{a}	20.67	27.27^{a}
F-value	0.833^{ns}	2.31^{ns}	2.928*	8.640**	1.816^{ns}	3.114*

Note: Means having the same letter as superscript are not significantly different at 0.1 level based on DMRT.
ns – not significant
* - significant
** - highly significant

ANOVA revealed insignificant differences among the treatment means. This implies that the incubation period of diamondback moth was not affected by the varying concentrations of mint and ginseng leaves extracts thus, all treatments had statistically the same incubation period.

The larval duration of DBM reared on cabbage treated with 100% ginseng extract (T_4) obtained a mean of 14.23 days, followed by those reared on cabbage treated with 30% ginseng extract (T_2) with a mean of 14.17 days. Those reared on cabbage treated with 100% mint leaves extract (T_7) had a mean larval duration of 13.23 days while those reared on 60% mint extract (T_6), 60% ginseng extract (T_3), 30% mint extract (T_5) and the untreated or control (T_1) had mean larval durations of 12.43, 12.40, 12.33 and 12.00 days, respectively. ANOVA revealed that there were no significant differences among the treatment means which implies that feeding the DBM with varying concentrations of mint and ginseng extract did not affect their larval duration. In comparison to the larval duration reported in literature cited, the result is higher than the larval duration of 3 to 4 days (HYPP Zoology Homepage) and 5 to 11 days (AVNET, 1991) but lower than the larval duration of 9 to 30 days (Waterhouse and Norris, 1987).

The longest pupal duration of DBM was obtained from T_2 (30% ginseng extract) with a mean of 5.57 days, followed by T_6 (60% mint extract) and T_5 (30% mint extract) with means of 5.50 and 5.47, respectively. On the other hand, T_3 (60% ginseng extract), T_7 (100% mint extract) and T_1 (untreated or control) had mean pupal durations of 5.27, 5.17 and 4.83 days, respectively. Treatment 4(30% mint extract) had the shortest DBM pupal duration with a mean of 4.67 days. ANOVA revealed significant differences among the treatment means. DMRT showed that cabbage treated with 30% ginseng extract (T_2) had significantly longer pupal duration than those reared on cabbage treated with 60% and 100% ginseng extract (T_3 and T_4) and the untreated or control (T_1). However, it did not significantly differ from the rest of the treatments(T_5 to T_7). Moreover, all treatments are comparable to control except T_2. This implies that 30% ginseng extract can affect the life cycle of DBM by prolonging the pupal duration.

The longest DBM adult longevity was obtained in T_4 (100% ginseng extract) with a mean of 9.80 days followed by Treatment 1 (control or untreated) with a mean of 9.73 days. Those reared in T_3 (60% ginseng extract), T_2 (30% ginseng extract), T_5 (30% mint extract) and T_6 (60% mint extract) had mean adult longevity days of 9.10, 8.30 and 7.90, respectively. The shortest DBM adult longevity was obtained in T_7 (100% mint extract) with a mean of 6.60 days. ANOVA showed highly significant differences among treatment means. DMRT

revealed that T_6 (60% mint extract) and T_7 (100% mint extract) were highly significant over T_4 (100% ginseng extract), T_1 (control), T_3 (60% ginseng extract) and T_2 (30% ginseng extract). However, it is not significantly different from T_5 (30% mint extract). This implies that the use of mint extract shortens the longevity of adult DBM. Furthermore, as mint extract concentration increases, the higher the toxicity of the substance thus, DBM adult longevity decreases. The substance toxic to diamondback moth but not to human could be the menthol that is present in the plant (Lewis, 1998).

The total life cycle of DBM reared on 30% ginseng extract (T_2) obtained a mean of 21.97 days, followed by the 100% ginseng extract (T_4) with a mean of 21.13 days. Those reared on 100 %(T_7), 60%(T_6) and 30%(T_5) mint extracts had mean life cycles of 20.67, 20.20 and 20.10 days, respectively. The control or untreated DBM obtained a mean life cycle of 19.03 days. ANOVA showed insignificant differences among the treatment means. This implies that rearing DBM in cabbage plants treated with different concentrations of ginseng and mint extracts had no effect on their total life cycle of DBM.

Treatment 6 (60% mint extract) obtained the shortest total lifespan of DBM with a mean of 26.87 days, followed by T_7 (100% mint extract) with a mean of 27.27 days. Treatment 5 (30% mint extract), T_1 (control), T_3 (60% ginseng extract) and T_2 (30% ginseng extract) obtained the means of 28.00, 28.77, 29.00 and 30.03 days, respectively. The longest total lifespan of DBM was obtained from T_4 (100% ginseng extract) with a mean of 30.93 days. ANOVA revealed significant differences among treatment means. DMRT showed that T_6 and T_7 were significantly different from T_2 and T_4. However, it is not significantly different from T_5, T_1 and T_3. This implies that although T_6 and T_7 significantly differed from T_2 and T_4, the use of mint and ginseng extracts has no effect on the total lifespan of DBM since it was not significant different from the control (T_1).

Fecundity

Fecundity of diamondback moth reared on cabbage leaf discs treated with various levels of ginseng and mint extracts is shown in Table 2. In terms of the number of eggs laid per female adult DBM. Treatment 6 (60% mint extract) obtained the lowest number of eggs laid per female adult DBM with a mean of 82.67 eggs. This was followed by T_5 (30% mint extract),T_7 (100% mint extract),T_3 (60% ginseng extract),T_2 (30% ginseng extract)and T_4 (30% mint extract) with mean eggs of 85.67, 86.33, 96.67, 99.33 and 99.67 eggs, respectively. Treatment 1 (control and untreated) obtained the highest number of eggs laid with a mean of 110.00 eggs. ANOVA revealed highly significant differences among treatment

means. DMRT showed that T_6 (60% mint extract) was significantly lower than T_3 (60% ginseng extract), T_2 (30% ginseng extract), T_4 (100% ginseng extract), T_7(100% min extract) and T_1 (control). However, it is not significantly different from T5 (30% mint extract). This implies that 30 % and 60 % mint can reduce the oviposition capacity of female adult DBM thus, it may pose anti ovipository material against diamondback moth or this could be attributed to the shorter adult longevity of diamondback moth.

Table 2. The mean number of eggs laid, egg laying duration and percent hatchability of eggs of adult female DBM.

Treatment	Mean number of eggs laid	Mean egg laying duration(days)	Percent hatchability of eggs
T_1-control	110.00^{d}	10.00^{c}	100
T_2-30% ginseng extract	99.33^{cd}	8.67^{b}	100
T_3-60% ginseng extract	96.67^{bcd}	8.67^{b}	100
T_4-100% ginseng extract	99.67^{cd}	8.67^{b}	100
T_5-30% mint extract	85.67^{ab}	8.50^{b}	100
T_6-60% mint extract	82.67^{a}	7.50^{a}	100
T_7-100% mint extract	86.33^{b}	8.50^{b}	100
F-value	3.396*	8.933**	

Note: Means having the same letter as superscript are not significantly different at 0.1 level based on DMRT.
** - highly significant

The shortest duration of egg laying was obtained by the DBM reared on 60% mint extract (T_6) with a mean of 7.50 days, followed by those female reared in 30% (T5) and 100%(T_7) mint extracts with the same mean egg laying durations of 8.50 days. Those female reared on 30 % (T_2), 60% (T_3) and 100% (T_4) of ginseng extracts also had the same mean durations of egg laying of 8.67 days. The longest egg laying duration was obtained by female adult DBM reared on untreated cabbage (T_1) with a mean of 10 days. ANOVA showed highly significant differences among treatment means. DMRT revealed that duration of adult female DBM reared on 60% mint extract (T_6) differed significantly from those reared on all treatments. This implies that 60% mint extract can shorten the duration of egg laying of DBM. Moreover, the result was lower than the result cited by Poelking (1991) wherein a female DBM can lay eggs for 12 days.

On the percent hatchability of DBM eggs. All treatments had 100% DBM eggs hatchability which implies that the hatching of DBM eggs was not affected by the various concentrations of ginseng and mint extracts.

Mortality

The highest number of dead DBM larvae was obtained by T_6 (60% mint extract) with a mean of 7.33 larvae, followed by T_5 (30% mint extract) and T_7 (100% mint extract) with the same means of 6.00 larvae mortalities. Likewise, T_4 (100% ginseng extract) and T_3 (60% ginseng extract) had the same mean mortalities of 3.33 larvae. Treatment 1 obtained zero mortality (Table 3). ANOVA showed significant differences among treatment means. DMRT revealed that T_6 differed significantly over T_1, T_2 and T_3. However, it did not differ significantly from T_4, T_5 and T_7. This implies that 100% ginseng extract and 30%, 60% and 100% mint extract are deterrent to DBM larvae thus, greater DBM larval mortality was observed on these treatments.

Table 3. Mean number of dead DBM larvae and mean percentages of DBM pupal and adult survival.

Treatment	Mean number of dead DBM larvae	Mean percentage DBM pupal survival	Mean percentage DBM adult survival
T_1-control	0^{a}	100.00^{a}	100.00^{a}
T_2-30% ginseng extract	3.33^{ab}	66.67^{ab}	66.67^{ab}
T_3-60% ginseng extract	3.33^{ab}	73.33^{ab}	73.33^{ab}
T_4-100% ginseng extract	5.33^{bc}	66.67^{ab}	33.33^{c}
T_5-30% mint extract	6.00^{bc}	60.00^{ab}	53.33^{bc}
T_6-60% mint extract	7.33^{c}	40.00^{b}	20.00^{c}
T_7-100% mint extract	6.00^{bc}	60.00^{ab}	30.00^{c}
F-value	4.318*	28.35**	41.49**

Note: Means having the same letter as superscript are not significantly different at 0.1 level based on DMRT.
** - highly significant

Growth inhibitory effects

Larvae reared on cabbage treated with varying concentrations of ginseng and mint leaves extracts showed developmental abnormalities on the larval, pupal and adult stages. Some larvae survived to meet the next instar showed no apparent increase in size and body shrinkage after sometime, larvae survived to pupae are smaller compared to those reared on untreated plants. Pupae that survived resulted to smaller adults with deformed wings compared to DBM reared in untreated cabbage. This indicates that ginseng and mint extracts had growth inhibitory effect to diamondback moth.

In terms of percent pupal survival. Diamondback moth reared in untreated cabbage leaf disc (T_1) got the highest percentage of pupal survival with a mean of

100%, followed by those reared on cabbage leaf discs treated with 60% ginseng extract (T_3) with a mean of 73.33%. Those reared on 30% ginseng extract (T_2) and 100% ginseng extract (T_4) had equal mean pupal survival of 66.67%. Likewise, diamondback moth in T_5 (30% mint extract) and T_7 (100% mint extract) had the same mean survival of pupae of 60%. The lowest percentage of pupal survival was obtained on the cabbage leaf discs treated with 60% mint extract with a mean of 40% (Table 3). ANOVA revealed highly significant differences among the treatment means. Mean of T_6 (60% mint extract) differed significantly from the mean of T_1 (untreated) but it was not significantly from the rest of the treatment means. Furthermore, the rest of the treatments except T_6 was comparable to T_1 (control or untreated). This implies that 60% mint extract seem to posses insecticidal property that hinders or inhibits the DBM pupae from surviving into adults. It further implies that with greater larval mortality on the said treatment, the lesser pupae survive.

Diamondback moth reared on the untreated cabbage leaf disc (T_1) had the highest percentage adult survival with a mean of 100%. This was followed by those reared on cabbage leaf discs treated with 60% ginseng extract (T_3) 30% ginseng extract (T_2),30% mint extract (T_5),100% ginseng (T_4)and 100% mint extract (T_7) with a mean adult survival of 73.33, 66.67, 53.33% and 33.33%, respectively. DBM reared on 60% mint extract (T_6) got the lowest percentage adult survival with a mean of 20% (Table 3). ANOVA revealed significant differences among treatment means. Treatment 6 is significantly the same with T_7 (100% mint extract), T_4 (100% ginseng extract) and T_5 (30% mint extract) in terms of DBM adult survival but all these treatments were significantly lower than T_1 (control or untreated). The result implies that 100% ginseng extract and 30%, 60% and 100% mint extracts seem to possess insecticidal property that further inhibit adult DBM from surviving. It further implies that with greater larval mortality and lesser number that have pupated on these treatments, the lesser number of adults that survive.

Repellant and antifeedant effects

The choice test indicated that there were no significant differences among the treatment means in all time intervals. This implies that the varying concentrations of ginseng and mint extract have no repellant effect on diamondback larvae thus, the larvae in the untreated and treated cabbage leaf disc were statistically the same (Table 4a).

Likewise, no significant differences were observed among treatment means in all time intervals under the no choice test which imply that the different

concentrations of ginseng and mint extracts have no repellant effect on diamondback larvae (Table 4b).

Table 4a. Mean number of diamondback moth larvae that visited cabbage leaf discs treated with ginseng and mint extracts at different time intervals (Choice test).

Time Interval	Treatments						
	T_1	T_2	T_3	T_4	T_5	T_6	T_7
30 min^{ns}	4.33	2.00	3.33	2.33	2.33	2.00	2.67
1 hr^{ns}	5.00	2.33	2.67	2.67	2.33	2.67	2.33
2 hrs^{ns}	5.00	2.33	2.67	2.33	3.67	2.33	3.33
4 hrs^{ns}	4.33	2.33	4.00	2.67	3.00	3.33	3.67
6 hrs^{ns}	4.00	2.67	3.00	3.33	3.67	3.67	3.67
8 hrs^{ns}	5.67	2.33	3.00	4.67	3.67	4.00	3.00
10 hrs^{ns}	4.67	3.67	2.67	3.00	3.00	4.33	2.67
12 hrs^{ns}	4.00	3.00	3.00	3.67	2.67	3.67	3.33
24 hrs^{ns}	3.33	1.33	3.33	2.67	1.67	1.00	2.67

ns – not significant

Table 4b. Mean number of diamondback moth larvae that visited cabbage leaf discs treated with ginseng and mint extracts at different time intervals (No choice test).

Time Interval	Treatments					
	T2	T3	T4	T5	T6	T7
30 min^{ns}	1.33	1.33	1.67	2.33	1.67	2.33
1 hr^{ns}	1.67	2.33	1.33	2.67	1.67	2.00
2 hrs^{ns}	2.33	3.67	1.00	3.67	3.00	3.00
4 hrs^{ns}	1.67	2.67	1.33	3.00	3.00	2.67
6 hrs^{ns}	2.33	1.67	2.67	1.67	2.67	2.33
8 hrs^{ns}	3.33	2.33	2.33	3.33	2.67	2.33
10 hrs^{ns}	2.33	1.67	2.33	2.33	2.33	2.67
12 hrs^{ns}	1.33	4.00	2.67	2.67	2.33	1.00
24 hrs^{ns}	3.33	3.67	2.33	2.67	2.33	2.00

Conclusion

On the basis of the result of the study, it can be concluded that 30% ginseng extract prolongs pupal duration of diamondback moth while 60% mint extract was effective in reducing the egg laying capacity and inhibiting the growth of diamondback moth. Moreover, 100% ginseng extract and 30%, 60% and 100% mint extracts have deterrent and antifeedant effect on diamondback moth. However, the varying concentrations of mint and ginseng extracts have no effect

on diamondback moths' incubation period, larval duration, total life cycle and on the hatchability of adult female eggs.

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