EVALUATION OF PARTICLE FILMS FOR CONTROLLING MELON LADYBIRD, *HENOSEPILACHNA ELATERII* (ROSS.) ON CANTALOUPE PLANTS (COLEOPTERA: COCCINELLIDAE)

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INTRODUCTION

Family Coccinellidae is very important economically, since it includes (about 90%) beneficial insects (carnivorous). The rest are phytophagous on crops or fungivorous. The feeding habits of larvae and adults are similar (Iperti 1999). *Epilachna spp*, both adults and larvae feed on the leaves and fruits of Cucurbits and other crop plants (Hill, 1975).

In Egypt, plants of the family Cucurbitaceae are the only host plants of *Epilachna chrysomelina* (Willcoks, 1922, Klemm 1929, Ghabn 1951 and Abd El-Moniem, 2000). Larvae and adults generally feed on the underside of leaves, eating all the leaf tissue leaving only a semitransparent thin of the upper epidermis. This damage, called "window-paning" gives the leaves a lacelike or skeletonized appearance. The remaining leaf tissue turns brown in few days, giving the plants a burnt appearance. New pods and stems are often attacked, and severely damaged plants may die prematurely (Hill, 1975). This insect was previously named *Epilachna chrysomelina* (F.), but it is now referred to the new genus; *Henosepilachna* which include two species: *H. elaterii* (Ross.) of the Mediterranean region and *H.capensis* (Thumb) of SouthAfrica (Hill, 1975).

The physical environment of the pest can be modified in such a way that the insects no longer pose a threat to the agricultural crops. Many physical control methods (physiological and behavioural) and grouped under two classes: passive and active were used. Particle films considered as a passive physical control one (Vincent *et al*; 2003).

The recent development of sprayable formulations of Kaolin under the generic name "Particle film Technology" (Glenn *et al*; 1999) showed good insecticidal activity. Several mechanisms are at play. Pear psylla, *Cacopsylla pyricola*, adults confined on a treated surface became coated with tiny particles that interfere with visual cues (Puterka *et al*; 2000). Kaolin clay presents a unique form of pest control: a non–toxic particle film that places a barrier between the pest and its host plant. It is an edible mineral and appears to has no mammalian toxicity or any danger to the environment, (Glenn *et al*; 1999). The use of sodium silicate, seaweed, bentonite and other natural, biological plant protecting agents against insect pests and diseases shows good results in organic and biodynamic vineyards, (Hofmann 2000). Kaolin clay had antifeedant properties, behavioural effects and post ingestive toxicity, repellency and ovicidal effects against larvae, adult and egg masses of the cotton leafworm , *Spodoptera littoralis* . Bentonite clay gave 70% reduction and lack of nymph production in the cotton aphids, *Aphis gossypii* attacking cotton seedlings. Adults were also disrupted and were unable to feed (Abd El-Aziz 2003). Hydrophobic Pf also deterred feeding and oviposition of the citrus root weevil, *Diaprepes abbreviatus* (Lapointe 2000), oviposition by female codling moth (Unruh *et al.*, 2000) and oblique banded leaf roller, *Christoneura rosaceana* (Knight *et al*; 2000). Surround (Kaolin, naturally occurring clay) is labeled for use on cucurbits, onions, tomatoes, eggplants and peppers for the suppression of several pest insect (Weinzierl, 2000).

This work aims to investigate the effect of particle films of Kaolin and bentonite clay on feeding, oviposition, settling response and mortality of larvae and adult of the melon ladybird beetle, *Henosepilachna elaterii* on Cantaloupe plants.

MATERIAL AND METHODS

A standard laboratory culture of *H. elaterii* was maintained on cantaloupe leaves, *Cucumis melon* under controlled laboratory conditions at 28 ± 5 C^0 and 65 ± 5 % R.H. Particle films (PF), Kaolin and Bentonite clays were used in this study. Three concentrations (1%, 3% and 5%) were prepared according to Abd El-Aziz (2003). Cantaloupe leaves were sprayed and air dried before being offered to beetles. Untreated leaves were sprayed with water and emulsifier and then allowed to dry and used in the control.

Feeding reduction (no choice and two – way choice tests)

Experiments were conducted using 3^{rd} instar larvae and adults starved for 4 hrs. At no–choice test, larvae or adults were provided with cantaloupe leaf discs (4 cm in diameter) sprayed with particle films (Kaolin or Bentonite) at desired concentrations. Leaf discs were left to dry and then placed in a Petri dish (arena) over moist filter papers to avoid desiccation. Twenty replicates (arena) were used for each concentration. For two-way-choice test, larvae or adults were offered a choice of two cantaloupe leaf discs in each Petri dish (arena). The first one was sprayed with the desired concentration of tested PF and the other was sprayed with water and emulsifier as untreated control and ten replicates (arena) were used for each treatment. Each test was repeated five times. All two-way-choice test were conducted with groups of 20 arenas per treatment. In no-choice test groups of 10 arenas for each treatment and ten replicates for untreated,were tested . After 48 hrs of feeding, consumed areas were measured according to Esconbas *et al;* (1993) with a computer interforces scanner. Percent of feeding reduction was calculated for each arena using to the following equation (Bentley *et al;* 1984):

$$\text{Feeding reduction (\%)} = \left(1 - \frac{\text{treated consumption}}{\text{untreated consumption}}\right) \text{X}100$$

Ovicidal activities

The particle films (Kaolin and Bentonite clays) at desired concentrations were tested on *H. elaterii* eggs (prior to hatch). Twenty eggs were used for each treatment and the experiment was repeated five times. Eggs were sprayed with each of the tested particle films. For untreated control, 100 eggs were sprayed with water and emulsifier and left to dry. Eggs were transferred to Petri dishes and incubated at (30 $\pm$ 3 C°) and (75 $\pm$ 5 % R.H.) until hatching.The hatchability (%) was recorded. The sterility (%) was calculated according to (Toppozada *et al*; 1966) as follows:

$$\text{Sterility (\%)} = 100 - \left(\frac{a \times b}{A \times B} \text{ X } 100\right) \quad \text{where:}$$

a = number of eggs / female in treatment. b = % hatchability in treatment.

A = number of eggs / female in control. B = % hatchability in control.

Ovipositing deterrence effects (two-way choice test)

Adults of *H. elaterii* were released in wirescreened cages, where cantaloupe plants in pots were sprayed with each tested particle films at desired concentrations to evaluate the effect on oviposition and site of ovipositing. Ten adult beetles (5 females and 5 males) were placed in 4 cages containing 2 pots of treated or untreated cantaloupe plants arranged as two-way-choice test. Beetles were given a choice of treated and untreated cantaloupe plants in the ovipositional cages.The ovipositing deterrence were estimated using the following equation (Lawande *et al;* 1985):
Deterrence (%) = (1 – T /C) X 100. Where T and C represent the mean number of eggs oviposited per female beetle on treated and untreated plants, respectively.

Insecticidal effects of particle films

The insecticidal effects of tested particle films (Kaolin and Bentonite clays) were studied on 2nd instar larvae and adult stages of *H..elaterii.* Cantaloupe leaves were sprayed with desired concentration of each tested particle films. The treated leaves were artificially infested with five larvae or five adults starved for 4 hrs and left to feed for 3 days on the treated leaves. Each concentration was replicated five times. Another group of leaves sprayed with water and emulsifier served as control. Mortality counts were recorded after 2, 4, 6 and 8 days for larvae and after 2, 6, 10 and 14 days for adults as accumulative mortality. Twenty replicates for each concentration were used.

All results were subjected to analysis of variance (ANOVA) and transformed means were compared by Duncan's multiple range test (Duncan, 1955).

Adult settling Response

Choice test: Beetles were given a choice of treated and untreated plants. Cantaloupe plants in pots were sprayed with water and emulsifier as control and particle films at desired concentrations.Treated and untreated pots were randomly placed in screencage. Three treated pots and three control pots were arranged alternatively equidistant from the cage. Fifty adult *H. elaterii* beetles starved for 24 hrs. , were released at the center of each cage. After 48 hrs, numbers of beetles on the plants were counted. Percentage of beetles settled on or under treated and untreated leaves were calculated as 100 T / (T + C) (Musabyimana *et al* ; 2001) where T and C were the number of beetles settled on treated and untreated cantaloupe leaves, respectively.

Multi-choice test: In this test *H. elaterii* were likewise given a free choice of three pots, each treated with Kaolin and Bentonite at desired concentration and control. Beetles settling response was calculated as described above. Both the one-choice and multi-choice tests were repeated 5 times.

RESULTS AND DISCUTION

Feeding reduction

Both larvae and adults of *H. elaterii* were deterred from feeding on cantaloupe leaves treated with Kaolin and Bentonite particle films at tested concentrations (Tables 1 and 2). The no-choice test was more sensitive than the two-way-choice test. Feeding consumption of treated leaf discs showed a progressive decrease with increase in the concentration. There were no significant differences between Kaolin and Bentonite treatments at all concentrations in case of larval treatment (no-choice test). Alford and Cullen (1987) studied the antifeedant activity of Limonin against the Colorado potato beetle. They suggested that the higher levels of antifeedant activity demonstrated in the no-choice situation were directly related to the greater amounts of limonin ingested and to the relationship of that amount to the overall feeding activity of the exposed larvae. The opposite is true in *H. .elaterii* adult treatment (Table 2). The amount of food consumed was inversely proportional to the concentration of particle films. The consumed untreated discs were 9.0 and 5.0 times greater than that of discs treated with 5% concentration of Kaolin in case of 3rd instar larvae and adults of *H. elaterii*, respectively.

TABLE (I)

Consumption of treated cantaloupe leaf discs sprayed with particle films in no choice and two-way choice tests by 3rd instar larvae of *H.elaterii*

Conc %	Particle film	No choice test	Two-way choice test		
		Feeding reduction %	X Consumption ± (S.E)of treated discs(cm2/arena) (range)	X Consumption ± (S.E)of untreated diuscs(cm2/arena) (range)	Feeding reduction %
1	Kaolin	38 a	15.2 ± 6.86 (11 - 19)	29.4 ± 1.6 (24 - 33)	48.30 b
	Bentonite	30 a	11.4 ± 1.29 (7 - 14)	18.6 ± 1.25 (14 - 21)	37.36 a
3	Kaolin	69 a	4.4 ± 0.51 (2 - 7)	21.4 ± 1.03 (19 - 25)	79.44 b
	Bentonite	55 a	8.6 ± 0.87 (6 - 11)	22.0 ± 1.41 (19 - 27)	60.91 a
5	Kaolin	78 a	2.2 ± 0.64 (0 - 5)	19.8 ± 1.28 (16 - 23)	88.89 a
	Bentonite	70 a	11.0 ± 1.65 (6 - 15)	45.2 ± 1.77 (40 - 50)	75.56 a

Means of particle films in horizontal columns under each concentration marked with the same small letters had no significant difference ($p < 0.05$).

The leaf consumed areas per larvae were (19.8 ± 1.28 cm^2) in untreated discs compared with (2.2 ± 0.64 cm^2) in discs treated with Kaolin at 5% concentration and percentage of feeding reduction was 88.89 %. Regarding to other concentrations, a limiting feeding activity was observed in comparison with the control.

From the previous results it can be concluded that 3% and 5 % concentration of Kaolin Pf had a strong and significant feeding reduction against *H. elaterii* larvae and adults. Govindachari *et al.*(1999) evaluated the antifeedant activity of 6 diterpenes against 4th instar larvae and adult of *Henosepilachna* *vigintioctopunctata.* Caryoptin was the most effective antifeedant while 3-epicaryoptin didn't deter feeding by adults. Lapointe (2000) tested the hydrophilic formulation of the inert silicate Kaolin in a screenhouse for its effect on the behaviour of the root weevil, *Diaprepes abbreviatus* (L.). Feeding of adults on treated citrus foliage was reduced by 68 – 84 % compared with adults fed on untreated foliage. However, twice as much untreated foliage was offered in untreated no-choice cages as in choice cages, untreated leaf area consumed in choice cages was approximately half of that consumed in no-choice cages. Kaolin clay had highly significant antifeedant properties on the 3rd instar larvae of *Spodoptera littoralis*, while bentonite had a moderate antifeedant activity, (Abd El-Aziz, 2003).

TABLE (II)

Consumption of treated cantaloupe leaf discs sprayed with particle films in no-choice and two-way choice tests by adult of *H. elaterii.*

Conc %	Particle film	No-choice test	Two-way choice test		
		Feeding reduction %	consumption ± (S.E) of treated discs(cm^2/arena) (range)	consumption ± (S.E)of treated discs(cm^2/arena) (range)	Feeding reduction %
1	Kaolin	29 b	21.4 ± 1.4 (18 - 26)	35.2 ± 1.72 (31 - 40)	39.21 b
	Bentonite	22 a	9.8 ± 0.97 (7 - 13)	13.8 ± 1.068 (11 - 17)	28.99 a
3	Kaolin	68 b	11.6 ± 1.63 (7 - 16)	48.6 ± 1.33 (44 - 52)	76.13 b
	Bentonite	43 a	9.4 ± 0.93 (7 - 12)	19.4 ± 1.50 (15 - 24)	51.55 a
5	Kaolin	80 a	6.4 ± 1.29 (5 - 12)	47.0 ± 1.31 (44 - 51)	86.38 a
	Bentonite	71 a	7.4 ± 1.08 (4 - 10)	34.0 ± 1.90 (28 - 38)	78.24 a

Means of particle films in horizontal columns under each concentration marked with the same small letters had no significant difference ($p<0.05$).

Ovicidal activity of Particle films

The results in Table 3 show that the percentage of egg hatching decreased as the particle film concentration increased and affected the embryo inside the egg. There was highly significant difference in percentage of egg hatchability between Kaolin and bentonite treatments and untreated ones. Kaolin had a high sterility effect on egg viability. They gave 93.9, 68.29 and 32.93 %sterility at1%, 3% and 5 %) concentration, respectively. While, bentonite had moderate ovicidal effect on eggs of *H. elaterii*. The sterility (%) was 14.63%, 51.22% and 71.95 % at 1, 3 and 5 %concentration, respectively.

TABLE (III)

Ovicidal activities of particle films against *H .elaterii* eggs (prior to hatch).

Effect on	Particle film	Particle film conc. (%)		
		1	3	5
Egg Hatchability%	Kaolin	55.00 a	26.00 a	5.00 a
	Bentonite	70.00 b	40.00 b	23.00 b
	Untreated	82.00 c	82.00 c	82.00 c
Sterility%	Kaolin	32.93 b	68.29 b	93.90 b
	Bentonite	14.63 a	51.22 a	71.95 a

Means of particle films in horizontal columns under each effect marked with the same small letters had no significantly difference ($p<0.05$).

This finding is in agreement to some extent with the results obtained by Abd El-Aziz (2003) who reported that the percentage of reductions in egg hatchability of *S. littoralis* were 47.37%, 67.01% and 89.25 % at 5 % concentration of Kaolin compared with 45.26%, 52.58% and 59.14 % in bentonite treatment in case of egg masses 24, 48 and 72 hrs old, respectively. Unruh *et al* (2000) reported that hatching rate of codling moth neonate larvae was unaffected by particle films sprayed on host plants (apple and pear orchards) either before or after oviposition.

Ovipositing deterrence effects (two-way-choice test)

Data in Table (4) show that longevity of exposed male and females of *H. elaterii* was considerably affected by the tested Kaolin and Bentonite PF. Beetles longevity was more affected by Kaolin than Bentonite. There was a negative correlation between PF concentrations and longevity reduction.

Females usually avoided treated leaves for oviposition. Eggs laid on leaves treated with Bentonite were relatively higher than those laid on leaves treated with Kaolin. The adult longevity and mean number of eggs laid per female were drastically affected by 5 % concentration of Kaolin. Knight *et al;* (2000) mentioned that Kaolin Particle film formulation (M96-018) significantly reduced longevity of oblique–leafroller female, mating succes and number of egg masses oviposited compared with untreated apple leaves in sleeve-cage and screen-cage tests.

Adult longevity was 7.4 $\pm$ 0.93 days and 9.2 $\pm$ 0.86 days in case of females and males, respectively. While mean number of egg/female on cantaloupe leaves treated with Kaolin was 6.2 $\pm$1.07eggs and only 36 % of eggs hatched compared with 40.8 $\pm$1.43 eggs /female and 85 % egg hatching in the control. Lapointe

(2000) reported that weevil of *D. abbreviatus* exposed to Kaolin in cages where they had a choice between untreated and Kaolin treated citrus leaves oviposited fewer eggs than weevils in cages containing only untreated leaves.

TABLE (IV)

Effects of particle films against the adult stage of *H. elaterii* in semifield trial (two-way choice test) .

Conc %	Particle film	Adult longevity (day) ± S.E (range)		Mean No. of eggs/female. (range) S.E±		Egg hatchability %	Deterrency %
		Female	Male	Treated	Untreated		
1	Kaolin	20.8±0.88 (18 - 23)	19.8± 0.69 (18- 22)	29.8± 0.86 (27- 32)	46 ± 1.0 (43- 49)	73 a	35.21b
	Bentonite	25.0±1.16 (23 -29)	26.8± 0.66 (25- 29)	33.4± 1.97 (29- 40)	40.6 ± .44 (37- 45)	85b	17.73a
3	Kaolin	13.4±0.51 (12 - 15)	14.6± 0.51 (13- 16)	14.8± 1.24 (12- 19)	58.2 ± .45 (48- 56)	54 a	71.65b
	Bentonite	18.8±0.66 (17 - 21)	20.2± 0.58 (19- 22)	22.8± 1.86 (18- 28)	33 ± 1.095 (29- 35)	72 b	30.91a
5	Kaolin	7.4 ± 0.93 (5 - 10)	9.2 ± 0.86 (7- 12)	6.2 ± 1.07 (3- 9)	40.8 ±1.43 (37- 45)	36 a	84.80b
	Bentonite	14.2± 1.72 (12 - 17)	17.0± 0.71 (15- 19)	12.6± 1.76 (15- 25)	45.8 ± .56 (41- 50)	60 b	57.21a
Untreated		41.2± 1.18 (38 - 45)	45.4± 0.81 (43- 48)	------	-------	85	-------

Means of particle films in horizontal columns under each concentration marked with the same small letters had no significantly difference ($p<0.05$).

The viability of the deposited eggs was moderately affected by Bentonite treatment at all tested concentrations. On the contray, it was significantly affected by treatment of ovipositing site with Kaolin at 5% and 3 % concentrations. Kaolin Particle film had a great deterrent effect on *H. elaterii* adult at 3% and 5 % concentration (71.65 % and 84.80 %), respectively. While Bentonite had a moderate deterrent effect (57.21 %) on adult beetles at 5 % concentration only.

Abd El-Aziz, (2003) found that Kaolin Particle film possessed maximum insect deterrent potency followed by bentonite against *S. littoralis* moths. The viability of deposited eggs was not affected by treating the ovipositing site with bentonite, all eggs hatched on the treated cotton leaves. On the contrary, tha viability of eggs was significantly affected with Kaolin treatment with 45% and 70 % egg hatching compared to 100 % hatching in untreated site.Unruh *et al* (2000) reported that females of the codling moth, *Cydia pomonella* oviposited less eggs on host plants covered with Kaolin. Hatching rate of codling moth neonate larvae was unaffected by Particle films sprayed on host plants either before or after oviposition. Rjendran (1999) mentioned that the steam distillate extract of *Solanum aethiopicum* on eggplants reduced egg hatchability of *E. vigintioctopunctata* from 84 % in the untreated control to 62 % intreated one.

Insecticidal effects of Particle films

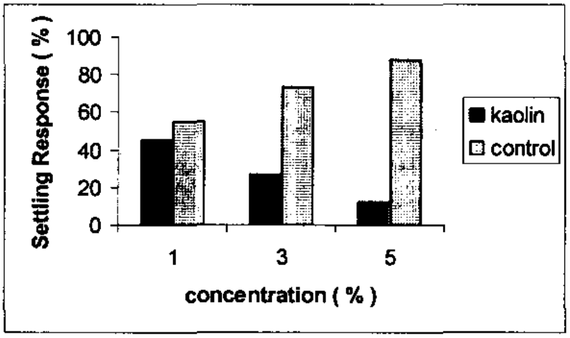
Data illustrated in (Figs 1&2 A, B & C) show the role of post treatment period as accumulative mortality (%) of Particle films against the 2[nd] instar larvae and adults of *H.elaterii*. The insecticidal activity didn't decrease by longer post-treatment period (time independent).There was a negative correlation between concentrations and accumulative mortality percent. Larvae were more susceptible to Particle films application than adults of *H. elaterii* . Kaolin clay was more effective than Bentonite against larvae and adult. In case of larvae, Kaolin caused 21%, 42% and 59 % accumulative mortality at 1%, 3% and 5 % concentration, respectively compared with 4.5 % accumulative mortality in the untreated test. Lapointe (2000) mentioned that after 28days, mortality of *D. abbreviatus* (L.) weevils caged on citrus leaves treated with Kaolin was 63.3 $\pm$ 14.5 % which was significantly greater than that of weevils caged on untreated leaves (4.7 $\pm$ 4.7 %).

In this study, Kaolin strongly deterred feeding and oviposition with moderate mortality compared with the control. This is an apparently new mechanism of activity possibly related to interference with tactile perception of the host plant (Puterka, 2000). The fine clay particles irritate insects and prefer to avoid it. Insects have sensory receptors on their feet which help them to identify the surface they are on by touch and taste. The clay particles which build up on their feet cause them to be: blinded, disoriented and agitated (Glenn 1999).

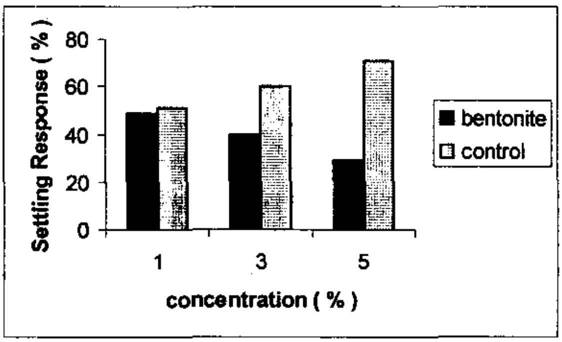
Settling Response

The repellent effect was dose dependent, the higher the concentration of Particle films, the stronger was repellency (% of settling response). Kaolin was more effective than bentonite. In choice test, settling percent for treated cantaloupe plants with Kaolin (Fig.3a) and bentonite (Fig.3b) was reduced by 18%, 63% and 86 % and 3.9%, 33% and 59% at 1%, 3 %and 5 %conc., respectively compared with untreated leaves. While in multi-choice test (Fig. 3c), the settling (%) on treated cantaloupe plants with Kaolin and bentonite was reduced by 14% and 8 %), 63 % and 26 % and 92% and 69% at 1%, 3% and 5% conc., respectively.

According to the literature, insects don't recognize a tree or fruit as a host, because they have the wrong color after treatment, and the chemical sensors in their feet perceive clay, not leaves or fruit (Mc Kenzie, 2000). When beetles did alight on treated foliage, however, particle films may serve as a physical repellent or may prevent tactile recognition of the hosts and stimulated some beetles to leave. Glenn *et al*; (1999) observed that *Cacopsylla pyricola* (Foe.) became coated with Kaolin particles and that adult *C. pyricola* were preoccupied with removing the particles from body parts.



(A)



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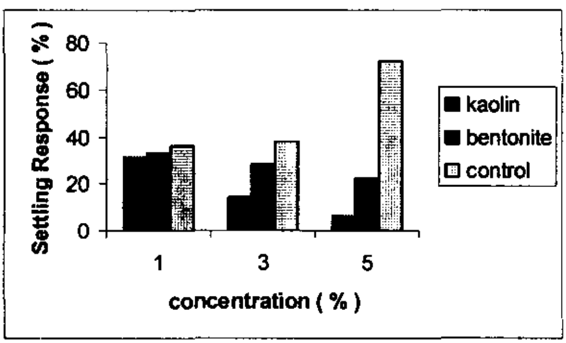

(C)

Fig. (3): Setting response of *H. elaterii* adults when given a choice (A & B) and multi - choice (C) tests of particle films.

In agreement, binocular observations of *H. elaterii* beetles from treated cantaloupe revealed an accumulation of film particles, especially on tarsi. Klingauf (1987) stated that plant shape contrast and other optical characters specifically the intensity of illumination are important for inducing alightment during flight. Cottrell *et al.*; (2002) found that more light was reflected from pecan foliage treated with particle film interfered with visual host-finding by *Melanocallis caryaefoliae* aphids.

These data indicate that Kaolin is a potential feeding deterrent and a good barrier that suppress oviposition and settling on cantaloupe plants and may prove to be an economically sound component of an integrated approach to the control of *H. elaterii.*

SUMMARY

Both larvae and adults of *Henosepilachna elaterii* (Ross.) were deterred from feeding on cantaloupe leaves treated with Kaolin and Bentonite particle films, in no-choice and two-way choice tests. The consumed discs were 9.0 and 5.0 times greater than that of discs treated with 5 % concentration of Kaolin in case of 3^{rd} instar larvae and adults, respectively.

Kaolin had a high sterile effect on egg viability giving 32.93%, 68.29% and 93.9 % sterility at 1%, 3% and 5% concentration, respectively. The beetle longevity was more affected by Kaolin than bentonite. There was a negative correlation between PF concentrations and longevity reduction. Females usually avoided treated leaves for oviposition. Adult longevity was 7.4 $\pm$ 0.93 days and 9.2 $\pm$ 0.86 days in case of females and males, respectively. The mean number of eggs/female on Kaolin treated cantaloupe leaves was 6.2 $\pm$ 1.07eggs and 36% egg hatch compared with 40.8 $\pm$ 1.43 eggs / female and 85% egg hatch in the control. Kaolin proved to have a great deterrence effect on *H. elaterii* at 3% and 5% concentration (71.65 and 84.80%, respectively).While Bentonite had moderate deterrence effect (57.21% for adult beetles at 5% concentration only).

Kaolin was more effective than bentonite on larval and adult accumulative mortality. Larvae were more susceptible to particle films application than adults. In case of larvae, Kaolin caused 21%, 42% and 59% accumulative mortality at 1%, 3% and 5% concentration, respectively compared with 4.5% accumulative mortality in the control. In choice test, settling response % on plants treated with kaolin and bentonite was reduced by 18%, 63 %and 86% and 3.9%, 33 %and 59% at 1%, 3 %and 5% conc., respectively compared with untreated plants. While in multi-choice

test ,the reduction in settling % for kaolin and bentonite was (14 % and 8 %) ,(63% and 26%) and (92% and 69%) at 1% , 3% and 5 % conc. , respectively .

These data indicate that Kaolin is a potential feeding deterrant and a good barrier for inhibiting oviposition in cantaloupe plants and may prove to be an economically sound component of an integrated approach for the control of *H. elaterii.*

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