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KAOLIN AND BENTONITE CLAYS PARTICLE FILMS AS A NEW TREND FOR SUPPRESSION OF CHEWING AND SUCKING INSECTS OF COTTON PLANTS

[28]

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ABSTRACT

The effects of two particle films (kaolin and bentonite clays) on all developmental stages of the cotton leafworm, *S. littoralis*, as well as cotton aphids, *Aphis gossypii* were studied. There was a positive relationship between the concentration of tested agents and their antifeeding activity . Kaolin and bentonite showed highly significant and moderately antifeedant activities on the 3rd instar larvae of *S. littoralis*, respectively . Kaolin particle film was significantly more effective than bentonite on pupal weight and pupal formation . In case of kaolin ,the deformed pupae were larval-pupal intermediate , while, in case of bentonite treatment they appeared as pupal-adult intermediate. Kaolin treatment at 5 and 3 % concentrations possess both behavioural characteristies and post ingestive toxicity against, *S. littoralis* . Females oviposited fewer eggs on cotton plants covered with kaolin particle film with 78.9 % repellency, than on bentonite treatment or untreated cotton plants in free and no choice tests. The tested three day ages of *S.littoralis* egg masses were highly significantly affected by kaolin than bentonite particle film treatments. Nearly 70 % reduction and lack of nymph production in cotton aphid numbers occurred within 24 hrs period, when aphid adults were placed onto treated cotton seedling with bentonite . Bentonite completely prevent insect infestations by coating cotton plants with a white natural physical barrier that deters insect infestation , and impedes their movement, feeding, and egg laying.

Key words: Kaolin and bentonite particle films, Cotton leafworm, Cotton aphids, Repellency

INTRODUCTION

Particle film technology has emerged as a new method for controlling harmful arthropods pests and diseases of agricultural crops (*Glenn et al* 1999). Kaolin and bentonite particle films are sprayed on as a liquid, which evaporates, leaving a thin film on the plant or crop surface . Coating plants completely with the liquid is very important. The material sticks to plant leaves, stems and fruits, coating the

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plant with a white powdery film. According to the promotional literatures, insects do not recognize the tree or fruit as a host, because it's the wrong color ,and because the chemical sensors in their feet perceive clay, not leaves or fruit (**McKenzie 2000**).

The objective of such control are to create an inert mineral barrier on the plant surface. The particle agitate and repel insects. Affected insects will not feed, lay eggs, or settle on treated surfaces. Insects may die from starvation or desiccation. Based on these mode of action, particle films should be applied before insects infest orchards to keep pest problems from developing **(Puterka and Glenn 2001)**. Particle films prevent insect infestation by coating plants with a physical barrier that deterres insect infestation and impedes insect movement, feeding and egg laying while enhancing photosynthesis and yield of product (***Glenn et* al1999; Puterka *et al* 2000**). The non-abrasive kaolin formulation strongly deterred feeding and oviposition of adult of root weevil , *Diaprepes abbreviatus* and no insecticidal activity was detected after 14 days of exposure to kaolin-treated citrus leaves. **(Lapointe, 2001). Puterka *et al* (2000)** investigated particle film technology for control-ing key pests of pear. Insect damage fruit was generally low, which resulted in few significant differences among treatments. Particle film formulations significantly reduced plum curculio, *Conotrachelus renuphar* ovipositional scarring of the fruit compared with the untreated control. **Thomas (2000)** sprayed particle film onto leaves and fruit apples to form a protective barrier that controls or suppresses many insects and mites populations by repelling or irritating them. Beneficial insects such as lady beetles and honey bees that do not feed on the leaf or fruit remain unharmed. **Showler (2002)** examined a non-insecticidal tactic for suppressing boll-weevil damage to cotton. In cage assays, kaolin ,a reflective white mineral, applied to excised cotton squares or to the cotton foliage, *Gossypium hirsutum* ,initially resulted in lower levels of boll weevil injury to squares than nontreated squares. **Glenn *et al* (1999) and *Puterka et al* (2000)** reported that particle films suppressed many insects and mites, pear psylla, *Cacopsylla pyricola,* potato leafhopper *Empoasca fabae*, spirea aphid, *Aphis spiraecola,* pear rust mite, *Epitrimerus pyri* and spotted spider mite,*Tetranychus urticae.* This work leads to evaluate the biological effects of kaolin and bentonite particle films against chewing and sucking insects of cotton plants under laboratory and semifield conditions.

MATERIAL AND METHODS

The particle films used in this study were kaolin and bentonite clays. Kaolin particle film is a white nonabrasive fine-grained alumino silicate miniral ($Al_4 Si_4 O_{10} (OH)$) that has been purified and sized .Ben-tonite is a colloidal clay (hydrate alluminium silicate that has the property of forming viscous suspensions (gels) with water. Five concentrations (0.5, 1, 2, 3 and 5 %) of each tested particle film (kaolin and bentonite) were prepared (in percent of w/v) of particle film and mixed thoroughly with 2 drops of emulsifier and the appropriate amount of water to prepare (5 % conc.). A suspension of water and emulsifier was prepared as control.

Antifeedant activity (Free choice test)

Third instar larvae were taken from a standard colony maintained on cotton leaves at 28±2°C. Five larvae were starved for 3hrs. Then were offered a two cotton leaf discs (5 cm in diameter each) in each petri dish (15 cm in diameter) placed on moist filter paper. The first disc was sprayed with the desired concentration of the tested particle film while the other one (control) sprayed only with water and emulsifier as control (untreated set). Ten replicates for each concentration were used. After two days, the antifeeing activity % per each leaf disc was counted and estimated by using the following equation :

Antifeeding activity% $= (1 - T/C) X100$
(Lwande *et al* 1985)

Where: T and C represent the percentage of leaf area consumed per larva of the treated and control sets, respectively.

Ovicidal tests

Different concentrations of kaolin and bentonite particle films were tested against *S. littoralis* egg masses (24, 48, and 72 hrs old).

The egg masses were sprayed with each of the tested particle films.

Another three groups of eggs of the same age were sprayed with water and emulsifier as control. Five egg masses of each age were used for each treatment and the experiment was repeated for three times. After dryness ,the egg masses were transferred to petridishes and incubated at 28±2°C until hatching. The hatcibility (%) was recorded. Results were subjected to statistical analysis of variance (F-Test) and Duncan,s values were estimated **(Duncan, 1955).**

Biological and Biotic Potential Parameters

Twenty 2nd instar larvae of *S. littoralis* were left for 3 days on treated cotton leaves with the particle film emulsion at the desired concentration. Five replicates were used for each tested concentration. After feeding, larvae were kept in clean glass jars provided with untreated leaves . Survivors were retransferred to new jars and applied with fresh cotton leaves every 2 days until pupation. Records were taken daily for larval and pupal duration, % pupation, pupal weight and pupal malformation (%). The resulting moths from each concentration were kept in pairs in jars (1L.capacity), and fed on 10% honey. Eggs were laid on filter papers. The moth emergency, moth malformation and egg hatchability were determined .

Ovipositional inhibitory effects of particle films

Cotton plants, *Gossypium barbadense* var. Giza 78 (3 months old) sowned in pots were sprayed with the desired concentration of each tested particle films using a back pack sprayer. Controls were sprayed with water and emulsifier. One hour after spraying, leaves were placed in an ovipositional cage, into which a pair of newly emerged male and female moths taken from the stock culture was released. A 10% honey solution soaked in a cotton swab served as a feeding source. Each cage was considered as one replicate, 10 replicates were used for each conc. Egg masses were collected daily from each cage. Eggs laid per one female were counted and the egg hatchability (%) was determined in each case.

In another test, moths were given a choice of treated and untreated cotton plants in the ovipositional cages to select the favourable ovipositional site. The repellency value (%) [D]was calculated using the equation:

$$D = (1 - T/C) \times 100$$ (**Lwande *et al* 1985**),

Where: T and C represent the mean number of eggs oviposited per female of the treated and control sets, respectively.

Effect of particle films on cotton aphid (*Aphis gossypii*) survivors

In no choice test, continous films of each kaolin and bentonite at the desired concentrations were applied on leaves of cotton seedlings by camel hair brush. Then, the seedlings were artificially infested with adults (10 per each) and replicated ten times for each treatment. The experiment was repeated 5 times.The progeny of aphids on treated cotton seedlings were counted and compared with those on untreated control ones after different intervals of infestation (1, 2 and 3 days). The experiment was conducted in a controlled growth chamber maintained at 25°C.

RESULTS AND DISCUSSION

A- Effect of particle films on the biofeatures of the cotton leafworm (chewing mouth part insect)

1. Antifeeding effects of the tested particle films

Results in Table (1) indicated a positive relationship between the tested concentrations of kaolin or bentonite particle films and the antifeedant activity .When the larvae had an opportunity to select between treated and untreated leaves, the larvae were almost directed to the untreated ones . Kaolin, however, showed a strong deterrent activity against 3rd instar larvae of *S. littoralis* which reduced the total food consumption significantly. Kaolin at 5 and 3% concentrations demonstrates highly significant antifeedant figure on the third instar larvae. The percentage of deterrency was 73.34 and 55.13 %, respectively.

Table 1. Antifeedant activity of particle films against the 3rd larval instar of *Spodoptera littoralis*.

Concentration (%)	Bentonite	Kaolin
5	45.25 a	73.34 a
3	29.61ab	55.13 a
2	17.15bc	35.04 b
1	9.02 c	21.11bc
0.5	3.33 c	5.9 c

Means in columns with the same small letters are not significantly different at 0.05% level (Duncan,s multiple range test).

On the other hand, bentonite showed moderate antifeedant activity i.e, 45.25 and 29.61 %, respectively. **Knight *et al* (2000)** evaluated the effects of the kaolin-based particle film formulation M96-018 on the obliquebanded leafroller, *Choristoneura rosaceana* (Harris). In choice tests, larvae preferred to feed on untreated leaf surfaces of apple orchard. **Unruh *et al* (2000)** mentioned that fruit penetration rate by larvae of codling moth, *Cydia pomonella* on apple host plants coated with particle film (kaolin) were significantly lower than on host plants without particle film in laboratory assays. Fruit infestation figures were significantly reduced when particle films were used on treated apple and pear trees compared with untreated ones for both first and second generations of codling moth in field trials.

2. Influence of particle films on the developmental stages of *S. littoralis*

Data given in Tables (2 and 3) showed that kaolin and bentonite particle films were independent of concentrations and had no significant effects on larval duration after feeding 2nd instar larvae of *S. littoralis* on treated cotton leaves for 3 days . In case of (5% conc.) of kaolin , only 68 % of the larvae reached the pupal stage. The pupal stage showed a more concentration dependent reaction. There was a positive correlation between the concentration and the percentage of deformed pupae, pupal duration and adult malformation Table (2). On the other hand, when the correlation coefficient was estimated yielded negative r values between the concentration of the treated particle films and the corresponding pupal weight (mg), % pupation, % adult emergence and % egg hatchability. The effect was more pronounced at the higher tested concentrations. Kaolin particle film was significantly more effective than bentonite on pupal weight and deformed pupae. In case of bentonite, the deformed pupae were pupal-adult intermediate, while in case of kaolin treatment, were larval-pupal intermediate. These results were in harmony with the obtained results of Dodonia essential oil which disrupts the hormonal balance in the larvae of *S. littoralis*, when ingested with the diet, producing malformed pupae which fail to give rise to adults, or develop into intermediate larval-pupal forms. The adult abnormalities failed to expand their wings and to emerge from the pupae (**Zidan *et al* 1994**). Kaolin gave the lowest adult emergence 33 %, 49% at 5 and 3% concentrations, respectively, compared to (56 and 60%) and (95 and 94%) at bentonite and control treatments, respectively. Latent effect on egg hatchability was obvious, only, among Kaolin-treated group where 100% sterility of all deposited eggs was shown at (5% concentration). Egg hatchability (%) were significantly low (20 and 43%) at 3 and 2% concentrations of kaolin treatments compared with 100 % for the untreated one. Results indicated that kaolin particle film at 5 and 3% concentration. Possessed both behavioural effects and post ingestive toxicity. **Knight *et al* (2000)** mentioned that larval weight gain and pupal weight of obliquebanded leafroller were significantly reduced and larval mortality increased in no-choice feeding tests with kaolin (M98-018). **Showler (2002)** examined kaolin particle film for suppressing boll weevil, *Anthonomus grandis* (Boheman) damage to cotton,*Gossypium hirsutum L.* .In cage assays, kaolin applied to excised cotton squares or to the cotton foliage, initially resulted in lower levels of boll weevil injury to squares than nontreated squares. A laboratory assay and field trials suggested that boll weevils distinguished between cotton plots based on color differences caused by kaolin and this appeared to influence levels of damage to cotton squares.

Table 2. Latent biological effects of Kaolin particle film when (2 nd.instar *S.littoralis* larvae) fed on cotton treated leaves for (3days).

Kaolin conc. (%)	Larval duration (days)+S.E. (Range)	Pupation (%)	Pupal weight ±S.E.(mg) (range)	Pupal Duration (days) S.E. (Range)	Deformed Pupae (%)	Adult Emergency (%)	Adult Malformation (%)	Egg Hatchability (%)
5	18.8± 2.78a (16-23)	68	175.2±6.18 e (107-183)	9.86±0.5 d (9.8-10.5)	35 e pupal-larval intermediate	33	14.5	0.0
3	18.2±1.79a (16-20)	75	186.2±4.64 e (179-194)	9.84±0.75 d (8.9-10.7)	25.8 d	49	9.3	20
2	18.0±1.58a (16-20)	80	207.0±3.6 d (200-212)	8.74±0.76 c (7.7-9.5)	19 c	61	5.7	43
1	17.6±1.67a (15-19)	86	233.0±2.8 c (228-238)	7.98±0.94 b (6.9-9.2)	11.6 b	74	2.2	80
0.5	17.8±2.49a (14-21)	94	258.6±4.39ab (253-265)	7.14 ±0.83 a (6-8.2)	5 a	89	0.0	95
Control	17.6±2.30a (14-20)	95	279.0±3.81 a (274-284)	7.14±0.79 a (6-8)	1.4 a	94	0.0	100

Means in columns with the same small letters are not significantly different at 0.05% level (Duncan' s multiple range test).

Table 3. Latent biological effects of Bentonite particle film when (2nd instar *S.littoralis* larvae) fed on treated cotton leaves for (3 days).

Bentonite conc. (%)	Larval duration (days)+S.E. (Range)	Pupation (%)	Pupal weight ±S.E. (mg) (range)	Pupal Duration (days) S.E. (Range)	Deformed Pupae (%)	Adult Emergency (%)	Adult Malformation (%)	Egg Hatchability (%)
5	19.2±1.79 a (18-22)	80	200.04±4.278d (195-206)	9.94±0.58 e (9.3-10.7)	24 d Pupal-adult intermediate	56	21.2	100
3	19.0±1.22 a (19-20)	80	202.0±4.899 d (197-205)	9.58±0.44 d (9-10.2)	20 c	60	18.7	100
2	18.8±2.39 a (17-22)	85	227.2±4.32 c (221-232)	8.92±0.65 c (8.1-9.7)	13.8 b	71	13.0	100
1	18.8±1.92 a (16-21)	90	243.0±4.47 b (238-249)	8.74±0.51 b (8.1-9.4)	6 a	84	9.5	100
0.5	18.6±1.14 a (17-20)	93	251.4±3.51 ab 248-257)	8.52±0.23 b (8.0=9.0)	5.2 a	88	3.3	100
Control	18.4±0.89 a (17-19)	95	256.6±4.56 a (250-261)	7.98±0.66 a (7.1-8.7)	0.0 a	95	0.0	100

Means in columns with the same small letters are not significantly different at 0.05% level (Duncan' s multiple range test).

3. Ovipositional repellency of particle films

Data in Table (4) indicated that a positive relationship between the concentration and the ovipositional repellency of tested particle films (in free choice test). The number of eggs laid by a single female was more affected by kaolin than bentonite. Few eggs were deposited on cotton leaves previously treated with 5 and 3 % kaolin with 78.9 and 63.2 % repellency, respectively.

Table 4. Ovipositional inhibitory effects of spraying particle films against *S.littoralis* moths at semifield trial (free choice test).

Particle film	Concentration (%)	Mean No.of eggs/ female ±S.E. (Range)		Repellency (%)
		Treatment	Control	
Kaolin	5	426±60.66 (350-500)	2020±144 (1800-2300)	78.9
	3	680±80 (520-800)	1848±134.4 (1660-2000)	63.2
Bentonite	5	690±40.62 (640-750)	1200±40 (1100-1300)	42.5
	3	650±29.16 (610-690)	806±31.2 (740-870)	19.36

The corresponding figures in case of bentonite treatment, were 42.5 and 19.36% respectively. Repellency of Kaolin-treated cotton leaves was relatively higher those that for bentonite. In (no choice test) at 5% conc., Table (5), the number of eggs oviposited per female were 300 and 900 eggs / female on treated cotton leaves with kaolin and bentonite, respectively compared with 1680 eggs/ female on untreated ones. **Unruh *et al*** (2000) mentioned that codling moth females laid almost three times fewer eggs on kaolin-treated fruit (8.9) versus control fruit (31.2) and ~40% fewer eggs on kaolin- treated leaves (35.2 eggs per bouquet) compared with control leaves (60.3 eggs per bouquet) Kaolin particle film possessed maximum insect repellent potency followed by bentonite against *S. littoralis* moth. Spraying of 5% kaolin on cotton plants can minimize the number of eggs laid by female moths of *S. littoralis*. The viability of deposited eggs was not affected by treating of the ovipositing site with bentonite, all eggs hatched on the treated cotton leaves .On the contrary, the viability of eggs was significantly affected with kaolin treatment with 45 and 70% egg hatching

Table 5. Ovipositional inhibitory effects of particle films sprayed against *S.litoralis* adult under semifield condition (no choice)

Particle film	Concentration (%)	Mean No. of eggs / female±S.E. (Range)	Egg Hatchability (%)	Repellency (%)
Kaolin	5	300±19.24 c (240-360)	45	82.14
	3	780±17.61 b (720-830)	70	53.57
Bentonite	5	900±22.14 e (850-980)	100	40.0
	3	1250±28.11d (1160-1130)	100	16.67
Control		1680±28.11a (1600-1770)	100	

Means within column bearing the same small letters are not significantly different (according to Duncan's multiple range test

compared to 100% hatching in untreated set. **Unruh *et al*** (2000) reported that hatch rate of codling moth neonate larvae was unaffected by particle films sprayed on host plants either before or after oviposition. **Knight *et al*** (2000) mentioned that particle film treatments (kaolin-based particle film formulation M96-018) significantly reduced female longevity, mating susses and number of egg masses oviposited compared with moths on untreated apple leaves in sleeve-cage and screen-cage tests. **Unruh *et al*** (2000) reported that females of codling moth, *Cydia pomonella* oviposited less on host plants covered with a particle film residue (kaolin) than on untreated plants in laboratory choice and no-choice tests. Dust and liquid applications of particle films experimented against key pests of pear (**Puterka *et al*** 2000). The treatments obtained high levels of early-season pear psylla control and prevented pear rust mite damage .They also found that prior seasonal applications of particle films in 1997 can carry over into the 1998 season to suppress early season pear psylla oviposition.

4. Ovicidal activity of the tested particle films

Data (Table 6) concerning the ovicidal activities of the tested particle films indicated the important role played by age of eggs and particle films concentrations in determining the ovicidal activity against *S. littoralis* eggs .The results clarified that the percentage of egg hatching decreased by increasing the particle film concentrations and affected the embryonic development of eggs .The percentage of reductions in egg hachability were 47.37, 67.01 and 89.25% at 5% conc. of bentonite compared with 45.26 ,52.58and 59.14 % in bentonite treatment, in case of egg masses ages (24, 48 and 72 hrs old), respectively. This indicates that as eggs grow in age, they almost became much more susceptible to the particle films. This finding is in agreement to some extent with the results obtained by **Unruh *et al* (2000)** which reported that hatch rate of codling moth neonate larvae was unaffected by particle films sprayed on host plants (apple and pear orchards) either before or after oviposition. This may explained due to the inhibiting influence of the chemical agent on vital enzymes which had been directed at the late stage of embryonic development of eggs **(Smith and Salkeld, 1966).**

Based on these findings, it can be concluded that a spray of 5 % concentration of white particle film of kaolin on cotton plants can reduce the egg deposition as well as the viability of *S. littoralis* eggs and can protect the cotton plants from being attacked by *S. littoralis* with other means of integrated pest managements .

B. Effect of particle films on cotton aphids (as sucking insect)

Efficacy of kaolin and bentonite particle films on *Aphis gossypii* (G.) was conducted in Table (7). Nearly 70% reduction in cotton aphids numbers occurred within a 24 hrs period when cotton aphid adults were placed on treated cotton seedling with bentonite 5%. These populations remained static over 3- days period on particle film treated cotton leaves. Some adult aphids lost footing soon after being placed on leaf surfaces treated with bentonite which contributed to initial reduction in number. Lack of nymph production by those aphid adults that became established indicated that either the adults did not reproduce in this un-suitable environment or the new born aphid nymphs, also became coated with particle, lost footing and fell from the plants. On the other hand, treated cotton seedlings with kaolin 5% did not significantly affect cotton aphids survivors during tested intervals.

These results were in agreement with the findings obtained by **Glenn *et al* (1999)** who mentioned that nearly 50 % reduction in spirea aphid numbers, occurred within 24 hrs period when spirea aphid adults were placed uncaged on treated apple leaves with kaolin particle film. **Cottrell *et al* (2002)** tested the effect of kaolin-based particle film on host selection, adult mortality,and production of nymphs by black pecan aphid, *Melanocallis caryaefoliae (Davis)* on seedlings pecans in the laboratory. Adult mortality figures were high on treated foliage and led to an overall decrease in production potentiality of nymphs on those seedlings.

This particle film technology is unique trend, that represents the combined synthesis of knowledge of particle films, natural physical particle barriers and white reflective plant surfaces to suppress cotton pests (aphids and cotton leafworm) populations. Therefore, this concept offers an alternative pest management strategy and improved more safty parameters when compared to pesticide handlers and the overall environment and mainly for the bioorganic cultivations.

Table 6. Effect of different concentrations of Kaolin and Bentonite Particle films on viability percentages of *S. litoralis* egg masses.

Particle film	Concentration (%)	Egg age (in hours) 24	48	72
Kaolin	5	52 (45.26)	46 (52.58)	38 (59.14)
	3	68 (29.90)	60 (36.84)	57 (38.71)
	2	83 (14.43)	74 (22.11)	61 (34.41)
	1	90 (7.22)	80 (15.79)	88 (5.38)
	0.5	95 (2.06)	86 (9.47)	90 (3.23)
Bentonite	5	50 (67.01)	32 (47.37)	10 (89.25)
	3	68 (29.90)	58 (38.95)	21 (77.42)
	2	75 (22.68)	70 (26.32)	48 (48.39)
	1	85 (12.37)	80 (15.79)	76 (18.28)
	0.5	91 (6.19)	82 (13.68)	87 (6.45)
Control		97	95	93

Numbers between brackets represent decrease (%) (as compared with the corresponding control).

Table 7. Productivity of aphids after successive day-intervals on seedling cotton foliage treated with Kaolin and Bentonite particle films and untreated control in no-choice test

Treatment	Mean No.of aphids per cotton seedling at different Post treatment days 24 hrs	48 hrs	72 hrs
Kaolin (5% conc.)	9.6±0.25bA (9-10)	10.6±0.51bB (9-12)	12.4±0.25 bC (12-13)
Bentonite (5%conc.)	3.2±0.37aA (2-4)	2.8±0.58 aB (1-4)	2.0±0.32 aB (1-3)
Control	10.4±0.25 bA (10-11)	12.2±0.58 bB (11-14)	13.4±0.25 bC (12-14)

Means within rows bearing the same capital letters and within columns bearing the same small letters are not significantly different (according to Duncan,s multiple range test. (n = 10).

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استخدام الطبقة الرقيقة من طين الكاولين والبنتونيت كاتجاه حيوى جديد لتثبيط الاصابة بالحشرات القارضة والماصة لنباتات القطن

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شادية السيد عبد العزيز[١]

١- قسم آفات ووقاية النبات - المركز القومى للبحوث - الدقى - القاهرة - مصر

تم تقييم تاثير الطبقة الرقيقة لكل من طين الكاولين والبنتونيت على اليرقات والطور الكامل والبيض لدودة ورق القطن كحشرة قارضة وكذلك على الطور الكامل وانتاجية الحوريات لحشرة من القطن كحشرة ماصة.

وجد أن هناك علاقة موجبة بين تركيز كل من الطبقة الرقيقة لطين الكاولين والبنتونيت وخاصية المنع للتغذية ـ وكان الكاولين ذو خاصية عالية فى منع التغذية على الطور الثالث من يرقات دودة ورق القطن بينما البنتونيت كان تأثيره متوسطا.

وكان الكاولين أكثر تاثيراً من البنتونيت على وزن العذارى والعذارى المشوهه.

وفى حالة الكاولين كانت العذارى المشوهه فى طور وسط بين اليرقة والعذراء- بينما فى البنتونيت كانت فى طور وسط بين العذراء والطور الكامل. وكانت معاملات الكاولين عند تركيز ٣ ، ٥ % لها تأثير على كل من السلوك والتأثير المتأخر السام للطعام ضد دودة ورق القطن. وكانت الإناث أقل فى وضع البيض على نباتات القطن المغطاه بالكاولين مع نسبة طرد ٧٨,٩% عنه فى نباتات القطن المعاملة بالبنتونيت - وكذلك الغير معاملة فى اختبار (الاختيارية وعدم الاختيارية). كما تاثرت جميع كتل البيض الناتجة من الاعمار المختلفة لدودة ورق القطن بدرجة معنوية عالية فى معاملات الكاولين والبنتونيت.

وفى حالة حشرة المن ، أدى وضع الحشرات على بادرات القطن المعاملة بالبنتونيت الى خفض الاصابة ما يقرب من ٧٠ % وكذلك عدم القدرة على خروج الحوريات خلال ٢٤ ساعة.

وبذلك أدت معاملات الكاولين والبنتونيت إلى منع الإصابة بالحشرات نتيجة لتغطية سطح نباتات القطن بطبقة بيضاء (الكاولين او البنتونيت) كعائق وطارد للحشرات كما انها تعوق حركة الحشرات والتغذية ووضع البيض.

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