NOVEL MECHANICAL PESTICIDES FOR TOBACCO THRIPS, *FRANKLINIELA FUSCA*, CONTROL IN COTTON

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Abstract

Tobacco thrips are a pest of cotton and other plants, and the traditional most effective method for the control of these insects has been the use of chemical pesticides. Currently, there is no commercially available transgenic approach to control thrips. Research is presented of a mechanical insecticide with a particle size in the low micrometer range of varying structures, water and oil absorption rates, and inorganic composition effective in laboratory filter paper bioassays in killing tobacco thrips adults. Some of these compound are derived from nature and functionalized by different methods or can be manufactured. Three numbered compounds were examined for their insecticidal activity under low (27 ºC, 35% relative humidity (RH)) and high (32 ºC, 80% RH) environmental conditions by exposing adult thrips to a treated surface and examining mortality at different time durations post application (in mins). All three compounds had a LT_{50} (time for 50% mortality) of about 1 h and a LT_{80} of about 2 h under both low and high environmental conditions. The mode of action for the technology is not clear. There are a number of advantages of the technology over chemical methods which are discussed, but include low environmental impact, no known animal toxicity, and qualification as an organic insect control method.

Introduction

Thrips are slender, micro-sized insects with fringed wings. Even though they are difficult to see with the naked eye, these small insects infest cotton, *Gossypium hirsutum*, and many other crops in the United States and has been a pest for many years. Plant injuries from both adult and larvae of thrips can affect growth and development of roots (Brown et al. 2008, Cook et al. 2011). This may result in reductions in plant height (Burris et al., 1995) and the size of the leaf area (Roberts and Rechel, 1996). Extensive feeding by thrips may delay production of fruiting forms (Race 1961, Davis et al. 1966, Leser 1985, Lentz and Austin 1994), eventually delaying crop maturity and causing a late harvest. Thrips not only are responsible for the stunted growth of crop plants but also vector many tospoviruses.

Tobacco thrips, *Frankliniella fusca*, are a vector of Tomato Spotted Wilt Virus (TSWV) which is responsible for approximately 1 billion dollars in damage worldwide (Prins and Goldbach, 1998). The transmission of TSWV from thrips feeding results in cosmetic damage, making the fruit unmarketable and undesirable. Therefore, thrips management is crucial for cotton and other leafy vegetable production. Cultural management has only a limited impact on thrips populations because of their ability to rapidly disperse from native vegetation, weeds and crops. There are a few natural enemies of thrips including predators, parasitoids and pathogens (Butt and Brownbridge 1997, Loomans et al. 1997, Sabelis and Van Rijin 1997) but the use of classical biological control is difficult, because of the small size of thrips and their rapid reproduction (Cook et al., 2011). Biological control also requires frequent releases of biological control agents which is not feasible for field crops. Therefore, controlling thrips with chemical insecticides is the only viable alternative. The current widely adopted chemical method of controlling thrips on cotton seedlings is using of a prophylactic at-planting. Cotton seed coats are treated with an insecticide such as acephate, imidacloprid or thiamethoxam. Since the damage can occur soon after seedling emergence, an addition at-plant application of granular or liquid insecticides such as aldicarb or acephate in furrows with the seeds can also be used (Cook et al. 2011, Herbert 2010, Pollet et al. 2010, Reed et al. 2010). Recently, the western flower thrips, *Frankliniella occidentalis*, developed resistance to spinosyn and neonicotinoid insecticides (Gao et al., 2012). There are reports that the tobacco thrips populations in several states in the Southeastern US have developed resistance to neonicotinoids (Gao et al., 2012). This is astonishing, because the spinosyns and neonicotinoid insecticides have provided very high levels of efficacy against thrips for decades. Besides the resistance problem, many chemical insecticides are being considered for deregistered because of public concerns about their safety to the environment and non-targets like honey bees. Developments in thrips resistance towards chemical insecticides warrant the discovery and development of non-chemical insecticides for thrips control which in addition to being a new management tool, might also be more acceptable to the public.

In this study, we investigated a mechanical insecticide with a particle size in the low micrometer range of varying structures, water and oil absorption rates, and inorganic composition. These compounds were derived from nature or were manufactured to specific functionalities. Three numbered compounds were tested in low (27 ºC @ 35% RH) and high (32 ºC @ 80% RH) environmental conditions by exposing adult thrips to a treated surface on filter paper and examining mortality at different times post application (in mins).

Materials and Methods

Tobacco thrips were reared on organic cabbage at 27 ºC, 14:10 LD @ 40% RH. The insects used to start our colony were provided by Dr. George Kennedy in the Department of Entomology at NC State University (Raleigh, NC) which were originally collected from Clayton, NC. The bioassays were conducted in plastic Petri plates (8.6 cm in diameter and 1.4 cm in height) with the bottom covered with Whatman No. 1 white filter paper. The filter paper inserted into the bottom plate was treated by puffing approximately 0.25g of ND086, ND087 or ND088 provided by the company, Imerys (Roswell, GA). Immediately after the treatment, 25 adult tobacco thrips (1-5 days old) were transferred to the surface of the filter paper, the top half of the plate applied to the bottom plate, and percentage mortality recorded thereafter in min. Mortality was defined as no insect movement when the plate was disturbed. Three replicates were conducted per compound and under two conditions: (i) low environmental conditions of 27 ºC and 35% RH and (ii) high environmental conditions of 32 ºC and 80% RH. Probit models were developed for the time-morality data (Finney 1971, Steel et al. 1980, Preisler and Robertson 1982, Young et al. 2003) for each test compound and environmental condition. No mortality was observed in the controls.

Compounds tested

The compounds tested were provided by the company Imerys and used as provided. The physical properties for ND086, ND087 and ND088 were the following:

COMPOUNDS TESTED AND PARTICLE PROPERTIES

	ND086	ND087	ND088
Shape	variable	variable	variable
Oil Adsorption (g/100g)	400	150	120
Water adsorption (g/100g)	530	280	140
D-50 (µm)	19	14	14
Quartz content (%)	0.05	0.2	0.2
Inorganic chemical make up	delta1	delta2	delta3

Results and Discussion

Time-mortality response for low environmental conditions for test compounds

Fig. 1 shows the time versus mortality for ND086, ND087 and ND088 under low environmental conditions. Table 1 provides the probit models and the time to 50 and 80% mortality. No significant differences under low conditions were found at the 95% confidence intervals between compounds at the LT_{50} (Table 1).

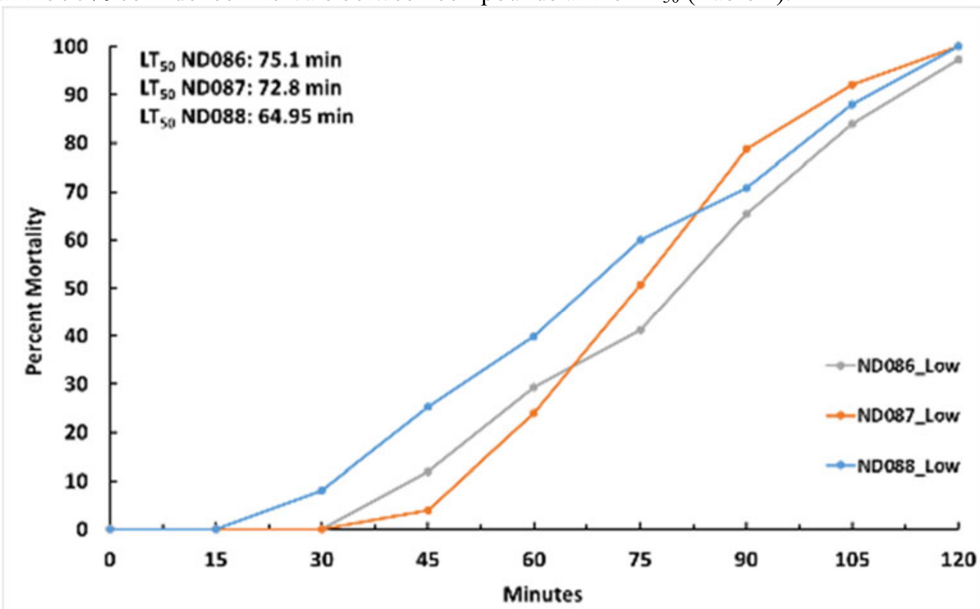

Figure 1. Effect of the different types of the mechanical insecticides ND086, ND087 and ND088 on mortality of *Frankliniella fusca* at low envionmmental conditions (27 ºC and 35% RH).

Table 1. Time to 50 and 80% mortality of adult *Frankliniella fusca* after exposure to different mechanical insecticides under low environmental conditions (27° C and 35% RH).

Type of mechanical insecticide	N	LT_{50}[a] (Treatment mins)	95 % CI[b]	LT_{80} (Treatment mins)	95 % CI	Chi-square	Slope ± SE
ND086	75	75.1A	60.65-93.8	105.69	85.32-140.15	1.532	5.68±0.58
ND087	75	72.77A	69.1-76.7	91.33	86.54-96.62	0.213	8.53±0.22
ND088	75	64.95A	50.96-81.1	97.88	77.88-128.59	0.909	4.81±0.52

[a]LT, Lethal Time-time to 50 or 80% mortality; LT_{50} followed by the same capital letter is not significantly different based on the 95% confidence interval.
[b]CI, confidence interval.

Time-mortality response for high environmental conditions for test compounds

Fig. 2 shows the time versus mortality for ND086, ND087 and ND088 under high environmental conditions. Table 2 provides the probit models and the time to 50 and 80% mortality. No significant differences were found between compounds at the LT_{50} under high conditions based on 95% confidence intervals (Table 2).

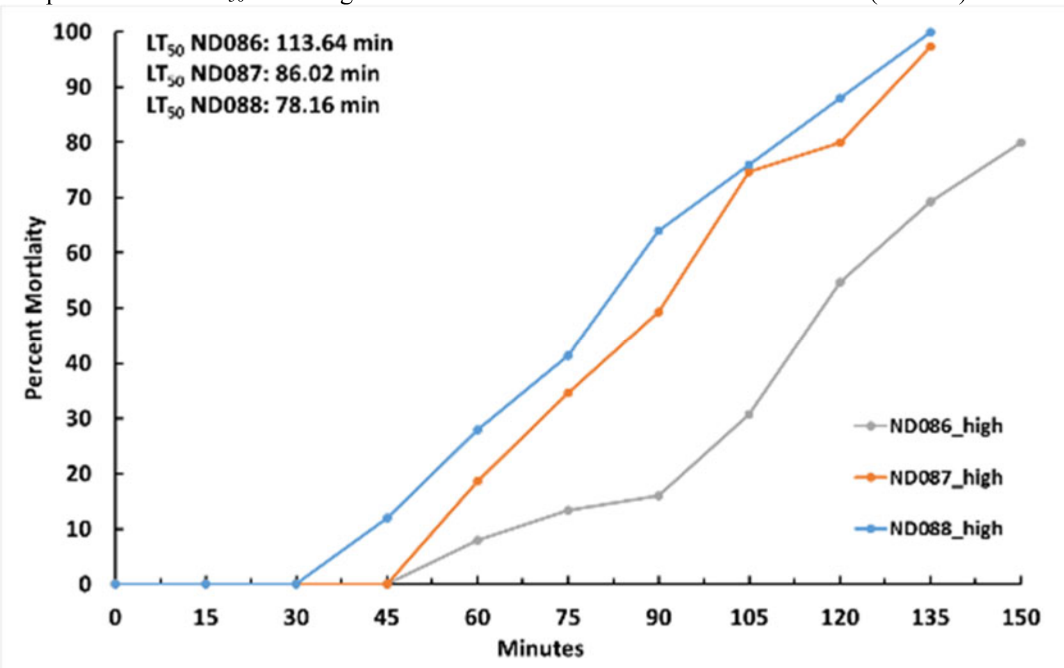

Figure 2. Effect of different mechanical insecticides on mortality of *Frankliniella fusca* under high environmental conditions (32 ºC and 80% RH).

Table 2. Time to 50 and 80% mortality of adult *Frankliniella fusca* after exposure to different mechanical insecticides under high environmental conditions (32° C and 80% RH).

Type of mechanical insecticide	N	LT_{50}[a] (Treatment mins)	95 % CI[b]	LT_{80} (Treatment mins)	95 % CI	Chi-square	Slope ± SE
ND086	75	113.64A	79.95-166.41	158.15	113.28-260.24	5.03	5.86±0.87
ND087	75	86.02A	74.34-99.39	118.77	102.64-142.4	0.77	6.01±0.51
ND088	75	78.16A	68.42-88.40	108.64	95.91-125.45	0.70	5.88±0.44

[a]LT, Lethal Time, time to 50 and 80% mortality; LT_{50} followed by the same capital letter is not significantly different based on the 95% confidence interval.
[b]CI, confidence interval.

Comparison of ND086 between low and high environmental conditions

Fig. 3 shows the time versus mortality for ND086 between high and low environmental conditions. Table 3 provides the probit models and the time to 50 and 80% mortality. No significant differences were found between low and high conditions at the LT_{50} based on 95% confidence intervals (Table 3).

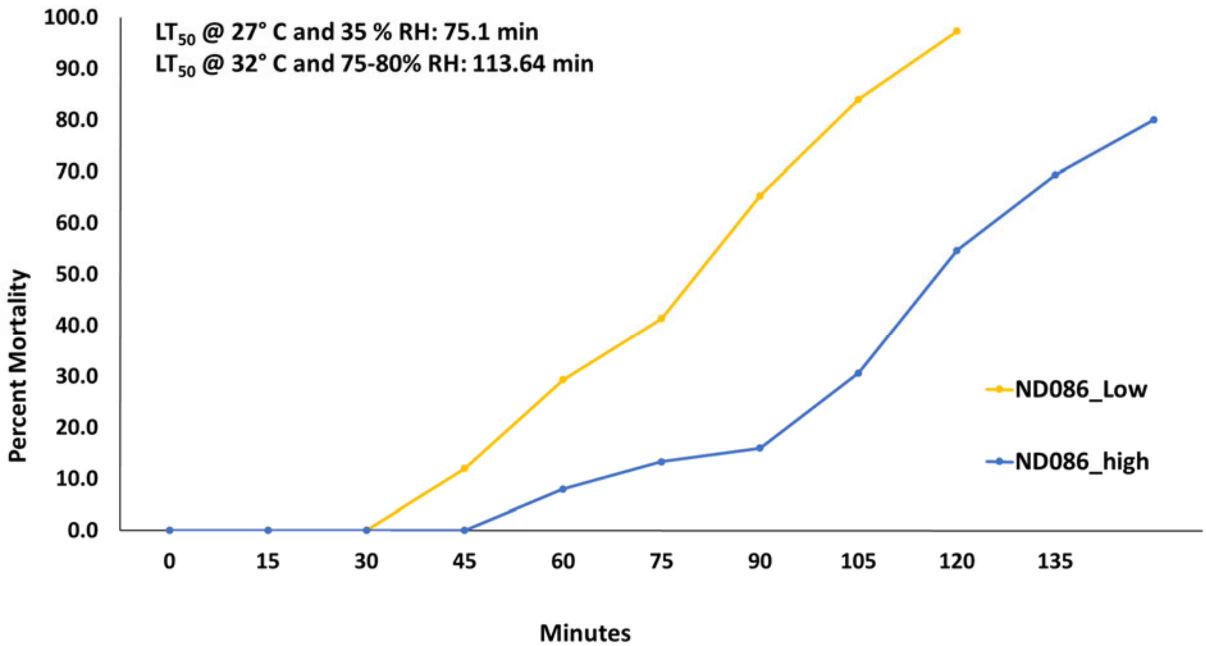

Figure 3. Effect of the mechanical insecticide ND086 on mortality of *Frankliniella fusca* under low (27 ºC and 35% RH) versus high (32 ºC and 80% RH) environmental conditions.

Table 3. Time to 50 and 80% mortality of adult *Frankliniella fusca* exposed to the ND086 mechanical insecticide under low (27 ºC and 35% RH) versus high (32 ºC and 80% RH) environmental conditions.

Type of mechanical insecticide	N	LT_{50}[a] (Treatment mins)	95 % CI[b]	LT_{80} (Treatment mins)	95 % CI	Chi-square	Slope ± SE
ND086 (Temp. & RH: 27°C & 35%)	75	75.1A	60.65-93.8	105.69	85.32-140.15	1.53	5.68±0.58
ND086 (Temp. & RH: 32°C & 75-80%)	75	113.64A	79.95-166.41	158.15	113.28-260.24	5.03	5.86±0.87

[a]LT, Lethal Time-time to 50 and 80% mortality; LT_{50} followed by the same capital letter is not significantly different based on the 95% confidence interval.
[b]CI, confidence interval.

Comparison of ND087 between low and high environmental conditions

Fig. 4 shows the time versus mortality for ND087 between high and low environmental conditions. Table 4 provides the probit models and the time to 50 and 80% mortality. No significant differences were found between low and high conditions at the LT_{50} based on 95% confidence intervals (Table 4).

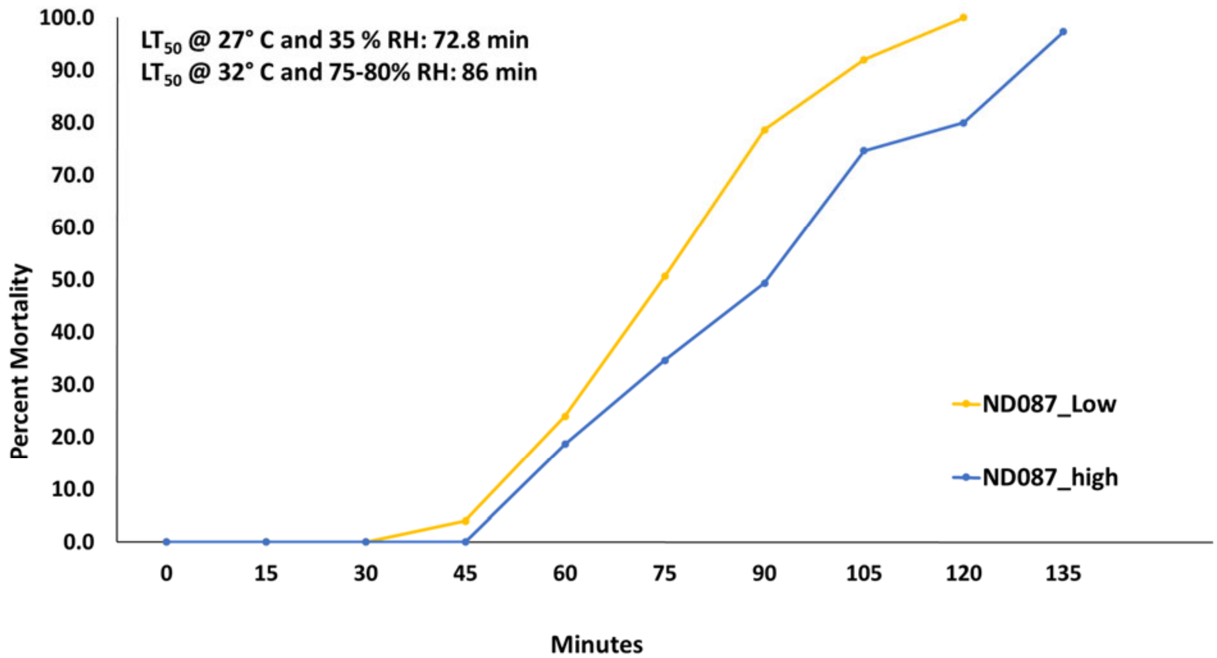

Figure 4. Effect of the mechanical insecticide ND087 on mortality of *Frankliniella fusca* under low (27 ºC and 35% RH) and high (32 ºC and 80% RH) environmental conditions.

Table 4. Time to 50 and 80% mortality of adult *Frankliniella fusca* after exposed to the mechanical insecticide ND087 under low (27 ºC and 35% RH) versus high (32 ºC and 80% RH) environmental conditions.

Type of mechanical insecticide	N	LT_{50}[a] (Treatment mins)	95 % CI[b]	LT_{80} (Treatment mins)	95 % CI	Chi-square	Slope ± SE
ND087 (Temp. & RH: 27°C & 35%)	75	72.77A	69.1-76.7	91.33	86.54-96.62	0.213	8.53±0.22
ND087 (Temp. & RH: 32°C & 75-80%)	75	86.02A	74.34-99.39	118.77	102.64-142.4	0.77	6.01±0.51

[a]LT, Lethal Time-time to 50 and 80% mortality; LT_{50} followed by the same capital letter is not significantly different based on the 95% confidence interval.
[b]CI, confidence interval.

Comparison of ND088 between low and high environmental conditions

Fig. 5 shows the time versus mortality for ND088 between high and low environmental conditions. Table 5 provides the probit models and the time to 50 and 80% mortality. No significant differences were found between low and high conditions at the LT_{50} based on 95% confidence intervals (Table 5).

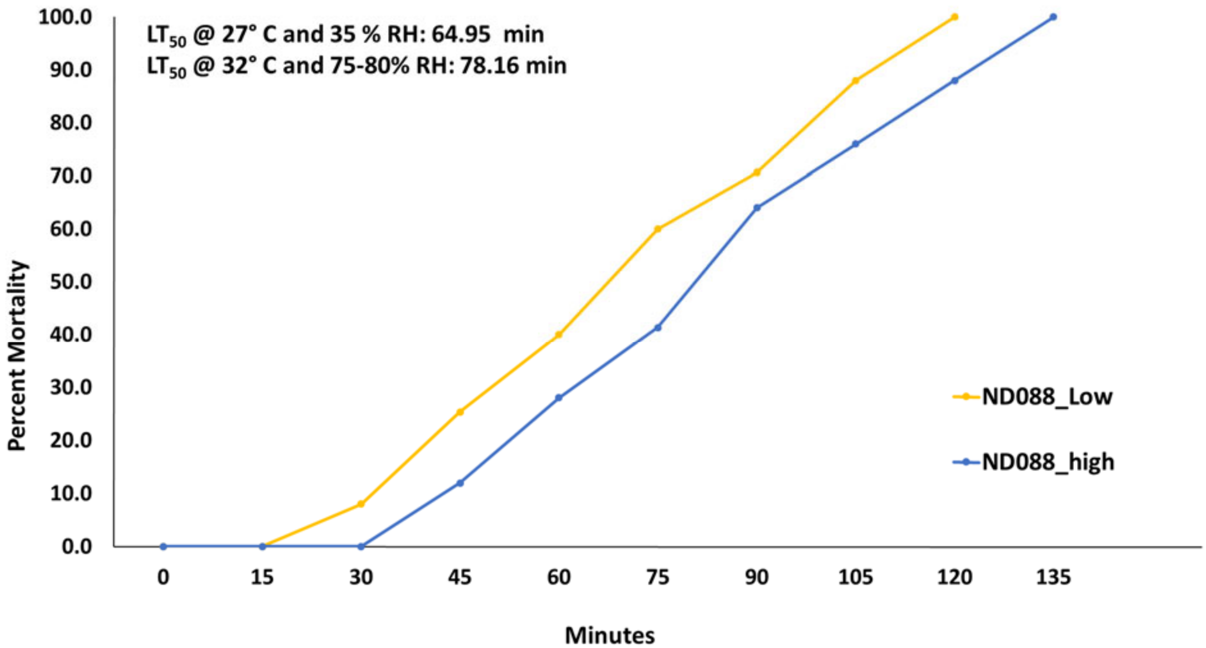

Figure 5. Effect of the mechanical insecticide ND088 on mortality of *Frankliniella fusca* under low (27 ºC and 35% RH) and high (32 ºC and 80% RH) environmental conditions.

Table 5. Time to 50 and 80% mortality of adult *Frankliniella fusca* after exposure to the mechanical insecticide ND088 under low (27 ºC and 35% RH) versus high (32 ºC and 80% RH) enviornmental conditions.

Type of mechanical insecticide	N	LT_{50}[a] (Treatment hours)	95 % CI[b]	LT_{80} (Treatment hours)	95 % CI	Chi-square	Slope ± SE
ND088 (Temp. & RH: 27°C & 35%)	75	64.95A	50.96-81.14	97.88	77.88-128.59	0.909	4.81±0.52
ND088 (Temp. & RH: 32°C & 75-80%)	75	78.16A	68.42-88.40	108.64	95.91-125.45	0.70	5.88±0.44

[a]LT, Lethal Time-time to 50 and 80% mortality; LT_{50} followed by the same capital letter is not significantly different based on the 95% confidence interval.
[b]CI, confidence interval.

Discussion

The numbered compounds provided by the company Imerys with a mechanical mechanism of action under the conditions of the filter paper bioassay conducted in our studies demonstrated insecticidal activity against adult tobacco thrips. The time to 50% mortality was approximately 60 min, and there was no differences at the 95% confidence intervals between the three compounds tested under low environmental conditions (27 ºC, 35% RH) and under high environmental conditions (32 ºC, 80% RH). Also there were no differences for each compound under low versus high environmental conditions. Additional work is needed to optimize the technology in at least the following areas: (i) dose-response studies, (ii) activity against different stages of the tobacco thrips, (iii) its activity against other cotton pests, (iv) its activity on plants, (v) development of application methods, and (vi) a better understanding of mode of action. The work conducted was a proof of concept study, and proof of concept was demonstrated.

There are a number of potential advantages of the technology listed in Fig. 6.

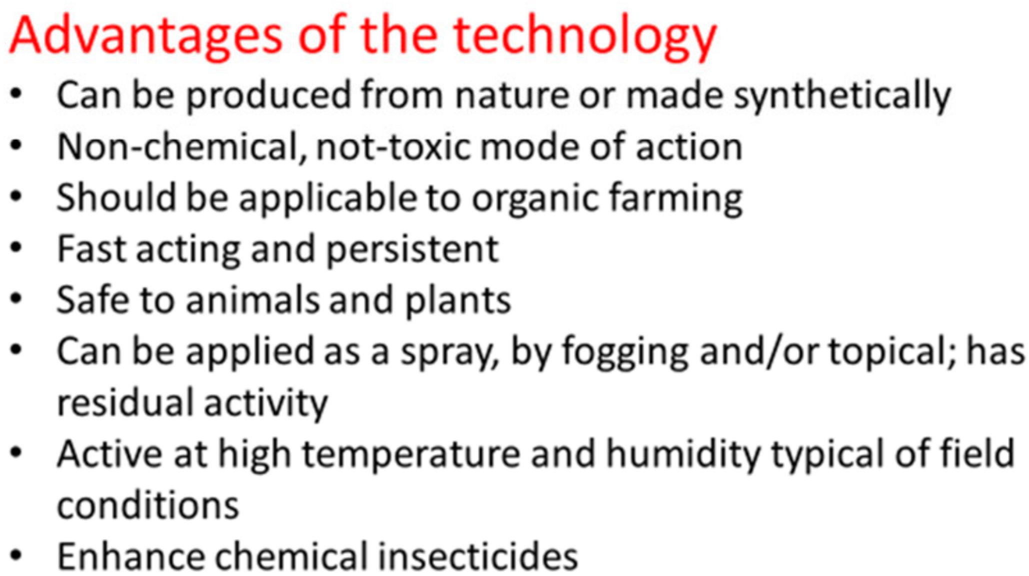

Figure 6: Major advantages of the Imerys mechanical insecticides.

Acknowledgements

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