Kaolin as a possible treatment against lepidopteran larvae and mites in organic fruit production

G. Jaastad[1], D. Røen[2], Å-M. Helgheim[1], B. Hovland[1] and O. Opedal[1]

Abstract

Few control methods are available in Norwegian organic fruit production that can prevent damage by early and late larvae. Also phytophagous mites are difficult to control without harming the beneficial mites. Processed kaolin function by coating trees and thus creating a physical barrier to infestation, impeding movement, feeding and egg-laying. Kaolin may reduce feeding and movement of over-wintering tortricide larvae and other larvae that hatch early in spring and have a repellent effect against egg-laying tortricide females in summer. Kaolin may also have a control effect against mites as it clings to the body and reduce feeding. Trials with kaolin were conducted in 2003, 2004 and 2005 in plum and apple orchards. Results show that kaolin reduces the population of rust mite, however it also affected the number of beneficial mites. The effect against early and late larvae was more variable. Treatments with kaolin resulted in a small reduction in early larvae and damage in some fields and years, however no clear effect against late larvae was found. The effect of kaolin will be discussed in relation to population size and number of treatments.

Keywords: kaolin, Surround®, rust mite, Lepidoptera larvae, beneficial mite

Introduction

Both noctuid, geometrid and tortricid larvae may damage shoots, leaves and fruits in apple, pear and plum production. Most lepidopteran larvae damaging fruit trees in Norway hatch from eggs early in spring, however some species of tortricids hatch in early autumn and over-winter as young larvae in fruit trees. These species may damage fruit trees both in spring and autumn. Rust mite (*Aculus schlechtendali* and *Aculus fockeui*) and European red mite (*Panonychus ulmi*) (ERM) are important pests in apple and plum. Rust mites over-winter in buds and start to feed on shoots and leaves in early spring. ERM hatch from over-wintering eggs in early spring.

Particle film technology is emerging as a new tool in management of agricultural and horticultural pests. Application of processed kaolin to leaves and fruit can function by creating a physical barrier to infestation, impeding movement, feeding and egg-laying. Kaolin has shown to be effective against a number of insect pests, both as a repellent (Saour and Makee, 2004; Mazor and Erez, 2004) and as a physical barrier to feeding and movement (Daniel et al., 2005; Saour, 2005). As both young larvae and phytophagous mites feed on buds and green leaves early in spring, treatment with kaolin around budbreak may impede feeding. Studies on effect of kaolin on beneficial arthoropods gives variable results. A control method recommended for organic production should not have a large negative effect on beneficial arthropods.

The objectives of this study were to: 1) evaluate the effect of kaolin against larvae in early spring, 2) evaluate the effect of kaolin against egg-laying tortricides in late summer and 3) evaluate the effect against rust mite, European red mite and beneficial mite.

Material and Methods

The kaolin particle film (product: Surround ®) used in this study was supplied from Engelhard Corporations (Iselin, NJ). Trials were carried out in an organic plum field and in two IPM apple fields in

[1] Bioforsk, Norwegian Institute for Agricultural and Environmental Research, Horticulture and Urban Greening Division, N-5781 Lofthus, Norway; [2] Bioforsk, Norwegian Institute for Agricultural and Environmental Research, Horticulture and Urban Greening Division, N-6861 Leikanger, Norway

Western Norway in 2003, 2004 and 2005. Varieties in the plum orchard are ‘Victoria’, ‘Reeves’, ‘Opal’, ‘Edda’ and ‘Mallard’. Distance between trees were 4,5 x 2,0 m. Trees were planted in 2000. Apple orchard number one was planted in 1994 and only the variety ‘Discovery’ was used in this trial. Distance between trees were 4 x 1 m. Apple orchard number two was planted in 2001, distance between trees were 5 x 2 m and only the variety ‘Summerred’ was used in the trial.

Trials with kaolin against early larvae, rust mite, ERM and beneficial mites were carried out in the plum field and in apple field number one in 2003, 2004 and 2005. Three different treatments were tested in this experiment: 1 x kaolin, 2 x kaolin and an untreated control. Kaolin treatments were applied with a tractor-mounted hand-sprayer at a concentration of 3 kg/100 l. Five replicates with three trees in each plot were used in each orchard. Between plots there were two boundary trees. First spray application was just before half inch (56 BBCH), second spray application just before balloon (59 BBCH) in both apple and plum trees in all three years. Effect of kaolin was measured as damage by larvae and number of larvae on leaves and shoot and as number of mites on leaves at the end of blossom (69 BBCH). Dates for spray application and registration varied between years due to varying phenological development. Dates also varied between apples and plums as development from half inch to ballon is more rapid in plums. 10 branches were inspected for damage and larvae in each plot. Number of damaged short shoots were counted on each branch. Larvae were collected from each plot and identified. Five leaves from each tree (15 from each plot) were collected and the number of rust mite, ERM and beneficial mites counted.

Trials with kaolin against egg-laying females in late summer were carried out in the plum field and in apple field number two only in 2005. Pheromone traps for *Archips podana*, *Pandemis heparana*, *Pandemis carasana* and *Hedya nubiferana* were used to monitor beginning of the flight period. Three traps of each species were placed in each orchard on the 26th of June. Traps were checked every week for 5 weeks. Three treatments were compared: 1 x kaolin, 2 x kaolin and untreated control. A concentration of 3 kg/100 l kaolin was used, applied as described above. Each treatment was replicated five times with four trees in each plot (apples) or three trees in each plot (plums) and two boundary trees between plots. First spray application was one day after first catch in pheromone traps (date 8th July), second application 11 (apples) and 14 (plums) days after first catch in pheromone traps (date 18th July and 21st July). Effect on damage was evaluated by inspecting leaves on three branches pr tree (9 pr plot) on 22nd August, and by registration of damage on apples and plums at harvest. All apples and plums were inspected.

Effect of treatments were analysed by two-way Anova with treatment and block as explanatory variables (SAS Institue Inc., 2005). Differences between mean were tested with Tukey’s test.

Results

<u>Kaolin against early larvae</u>

An effect of kaolin on damage by larvae was only found in apples in 2004 and on plums in 2003 (table 1). Number of larvae in different treatments were not affected by kaolin in the apple orchard (table 2). A negative effect of kaolin on number of larvae was found in plums in 2003. There was a tendency that kaolin had a negative effect on larvae when numbers were higher. Species found where *Orthoptera brumata*, *Eupsilia transversa*, *Hedya nubiferana*, *Pandemis cerasana*, *Pandemis heparana*, *Archips podana* and *Chloroclystis rectangulata*. The most numerous being *Hedya numbiferana* and *Pandemis cerasana*.

Table 1. Average number of damaged short shoots pr branch (10 branches pr plot) in plots treated with 1 x kaolin (3 kg/100 l), 2 x kaolin (3 kg/100 l x 2) and an untreated control.

	2003		2004		2005	
	apples	plums	apples	plums	apples	plums
Untreated control	4.6 ± 2.8 a	2.2 ± 1.8 a	3.6 ± 2.6 a	0.6 ± 0.9 a	2.3 ± 2.2* a	3.7 ± 3.1* a
1 x kaolin	3.6 ± 2.2 a	1.7 ± 1.5 a	2.5 ± 1.5 b	0.6 ± 0.8 a	2.1 ± 0.8* a	4.7 ± 4.3* a
2 x kaolin	3.6 ± 2.4 a	1.5 ± 1.3 b	2.1 ± 1.6 b	0.4 ± 0.6 a	2.2 ± 2.0* a	3.8 ± 3.3* a

Different letter indicate significant differences between treatments, variety and year (tukey's test, p < 0.05) * = average damage pr tree.

Table 2. Average number of larvae pr tree (collected from three branches pr tree) in plots treated with 1 x kaolin (3kg/100 l), 2 x kaolin (3 kg/100 l x 2) and an untreated control.

	2003		2004		2005	
	apples	plums	apples	plums	apples	plums
Untreated control	16.1 ± 6.5 a	8.1 ± 5.1 a	26.4 ± 8.2* a	5.0 ± 3.1* a	0.5 ± 0.7 a	0.7 ± 0.7 a
1 x kaolin	14.9 ± 5.5 a	5.1 ± 2.2 b	19.0 ± 7.6* a	3.8 ± 2.6* a	0.8 ± 0.8 a	0.7 ± 1.1 a
2 x kaolin	11.2 ± 7.1 a	3.6 ± 2.3 b	16.2 ± 8.0* a	3.2 ± 2.2* a	0.9 ± 1.0 a	0.7 ± 0.6 a

Different letters indicate significant differences between treatments, variety and year (tukey's test, p < 0.05) * = average number of larvae pr plot.

<u>Kaolin against mites</u>

On apples number of rust mite were negatively affected by kaolin treatments in 2003 and 2004 (table 3). However, on plums no significant differences in number of rust mite were found. The number of ERM differed between treatments in plum in 2004 and 2005, however there was no pattern (data not shown).

Table 3. Average number of rust mite pr leaf in plots treated with 1 x kaolin (3 kg/100 l), 2 x kaolin (3 kg/100l x 2) and untreated control.

	2003		2004		2005	
	apples	plums	apples	plums	apples	plums
Untreated control	8.4 ± 11.8 a	0.08 ± 0.3 a	0.3 ± 0.7 a	0 a	0.4 ± 1.2 a	0 a
1 x kaolin	0.5 ± 1.8 b	0.2 ± 0.8 a	0.07 ± 0.3 b	0.03 ± 0.2 a	0.6 ± 1.7 a	0.04 ± 0.3 a
2 x kaolin	0.1 ± 0.3 b	0.2 ± 0.6 a	0.04 ± 0.3 b	0.05 ± 0.3 a	0.5 ± 1.8 a	0.04 ± 0.3 a

Different letters indicate significant differences between treatments within variety and year (tukey's test, p < 0.05)

The population of beneficial mites were negatively affected by kaolin treatment in both apples and plums in 2004 and 2005 (table 4). Population of beneficial mites were greatest in these years. The most common species of beneficial mites recorded were *Tydeus* sp., *Typhlodromus* sp. and *Amblyseius* sp. No correlation between number of ERM and beneficial mites were found, neither no correlation between rust mite and beneficial mites (data not shown).

Table 4. Average number of beneficial mites pr leaf in plots treated with 1 x kaolin (3 kg/100 l), 2 x kaolin (3 kg/100 l x 2) and untreated control

	2003		2004		2005	
	apples	plums	apples	plums	apples	plums
Untreated control	0.06 ± 0.3 a	0.7 ± 0.1 a	0.3 ± 0.6 ab	1.8 ± 2.3 a	1.3 ± 1.8 a	2.3 ± 2.9 a
1 x kaolin	0.04 ± 0.2 a	1.0 ± 1.8 a	03. ± 0.7 a	1.4 ± 1.6 a	0.2 ± 0.5 b	1.8 ± 2.6 ab
2 x kaolin	0 a	0.6 ± 1.0 a	0.1 ± 0.5 b	0.6 ± 1.2 b	0.09 ± 0.3 b	1.1 ± 1.5 b

Different letters indicate significant differences between treatments within variety and year (tukey's test, $p < 0.05$)

<u>Kaolin against egg-laying tortricids</u>

Both *Hedya nuberiferana*, *Archips podana*, *Pandemis heparana* and *Pandemis cerasana* were trapped in pheromone traps, the most numerous being *H. nubiferana* (average of 5.2 moths pr trap during the season). Total number of tortricid moths were highest on first check of traps (8th July). No difference between treatments in neither number of tortricid larvae on trees nor damage on apples or plums at harvest was found. Mean percentages of damage on apples (pr tree) at harvest were 5.0 ± 8.0 in untreated plots, 2.0 ± 3.0 in plots treated once and 10.0 ± 26.0 in plots treated twice. Mean percentages of damage (pr tree) in plums at harvest were 27.5 ± 27.7 in untreated plots, 19.9 ± 27.8 in plots treated once and 34.7 ± 33.0 in plots treated twice. Plum variety had an effect on damage by larvae at harvest (data not shown).

Discussion

One or two treatments with kaolin before blossom had variable effect on pest management in apples and plums during this 3-year study. There was a tendency that kaolin was more effective against larvae and larval feeding at higher population densities. A single application of kaolin before initiation of budbreak in spring reduced number of larvae feeding inside leaf shelters by 75 % (Knight at al., 2000). In their study the population of leaf rollers was 1.6 ± 0.2 larvae pr tree on untreated trees. In our study number of larvae presented is an average of lepidopeteran larvae, including noctuids, geometrids and tortricids. Number of tortricide larvae on untreated apple trees are 14.2 ± 5.7 in 2003, 5.8 ± 2.6 in 2004 and 0.5 ± 0.7 in 2005. Thus, lack of effect in our study is probably not due to low population size. Knight at al. (2001) also reported that kaolin reduced the number of tortricides, however they compared untreated trees to trees treated 7 or 10 times during the season. Variable wether condition may have contributed to a lower coverage of foliage and thus explain the differences in results between our study and Knight et al.'s studies.

The effect of kaolin on number of rust mite is significant on apples in both 2003 and 2004. On plums the population of rust mite is very low in all years. Knight et al. (2001) did not find any difference between treated trees and untreated trees regarding phytopagous mites. However, the population of phytopagous mite was very low. Puterka et al. (2000) reported that pear rust mite damage was significantly reduced by kaolin treatment. Damage was recorded as damaged leaves, and in untreated trees an average of about 50 – 75 % of leaf surface was damaged. Treatment with kaolin might be more effective and visible when populations are high.

Beneficial mites were negatively affected by kaolin on both apples and plums in 2004 and 2005. Generally the population of beneficial mites was low in 2003. Knight et al. (2001) also reported that kaolin treatment significantly reduced the number of beneficial arthropods.

Several studies have shown that kaolin function as a repellent against egg-laying females (Unruh at al., 2000; Thomas et al., 2004). No effect of kaolin against egg-laying female toricides was found in this study. Thomas et al. (2004) reported that spray application of kaolin significantly reduced both the number of leaves and apples damaged by leaf rollers. However, population size of leaf rollers was reported as substantial in mid-June and late-July (numbers not given).

In summary, the effect of kaolin treatment in this study was variable. Treatment could explain reduction of larvae and larval feeding on apples and plums in spring in some years. There is some indication that the effect decreases with decreasing population size. Effect on phytophagous mites were also variable, however again there is a tendency that the effect decreases with decreasing population size. The effect of population size is also visible regarding beneficial mites as this group is negatively affected by kaolin treatment at higher densities. It might be that the effect of kaolin is difficult to measure when populations of arthropods are low. Based on results from this study it is to early to say whether kaolin can be recommended or not as a control method in organic fruit production in Norway. Further studies are needed on the effect of treatment on populations size, the effect of several treatments and treatment on different times.

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