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The use of kaolin to control *Ceratitis capitata* in organic citrus groves

Gabriella Lo Verde, Virgilio Caleca, Valentina Lo Verde
Department DEMETRA, Entomological, Acarology and Zoology Section, University of Palermo, Italy

Abstract

The Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann) (Diptera Tephritidae), is the key pest in some organically managed citrus orchards in Sicily. The effectiveness of processed kaolin (Surround WP) for control of *C. capitata* damage was tested in field trials carried out in 2003-2004 on two early ripening citrus species: satsuma (*Citrus unshiu* Markow.) and clementine (*Citrus clementina* Hort. ex Tan.). Although the number of males captured in trimedlure baited traps was high in both years and in both orchards, the percentage of damaged fruit varied greatly from almost 0% (satsuma 2003) to more than 60% (clementine, both years). Nevertheless, the application of processed kaolin significantly reduced damage caused by *C. capitata* on both citrus species on preharvest fruit on some dates and on harvested fruits in both years. The kaolin was easily removed from harvested fruit by washing. Processed kaolin has potential for reducing damage caused by *C. capitata* in organic and conventional citrus orchards.

Key words: processed kaolin, Mediterranean fruit fly, citrus, satsuma, clementine, organic farming.

Introduction

Ceratitis capitata (Wiedemann) (Diptera Tephritidae), which is commonly called the Mediterranean fruit fly or medfly, attacks many species of wild and cultivated plants (Liquido *et al*. 1991; White and Elson-Harris, 1994). In Sicily, *C. capitata* completes several generations from early spring to late autumn, flying from one host species to another. Some early ripening citrus fruits, (mainly satsuma, clementine, and certain orange cultivars) are regularly attacked from September to December. The main damage resulting from *C. capitata* attack is fruit drop, which is caused by female egg laying activity and larval feeding inside fruits. Moreover, the stinging marks, due to ovipositing females, cause aesthetic damage that reduces fruit quality in the market.

In conventional farming, *C. capitata* is usually controlled by intensive use of pesticides or poisoned proteinic baits (Roessler, 1989). In recent years, however, researchers have searched for new and less toxic control methods. Because they have low toxicity and low environmental impact, plant extracts and mineral products have been considered. One of these mineral products, kaolin clay, is a fine powder that is mainly composed of kaolinite. For insect control, kaolin clay is sprayed onto trees as a water suspension. After drying, the kaolin forms a white and thin (usually < 3 μm) particle film on the surfaces of leaves and fruits. This film does not reduce photosynthesis and plant growth but does reduce water stress (Glenn *et al*., 1999; 2002; Kerns and Wright, 2000) and photoinhibition caused by intense solar radiation and the high vapour pressure differentials typical of warm areas (Jifon and Silversten, 2003).

The effectiveness of clays in reducing insect infestation was demonstrated in the late 1930s by Russo (1937). More recently, processed kaolin was successfully tested against several insect species and against the two-spotted spider mite, both in field and laboratory trials (Glenn *et al*., 1999; Knight *et al*., 2000; Lapointe, 2000; Unruh *et al*., 2000; Puterka *et al*., 2000; Liang and Liu, 2002; Saour and Makee, 2004; Wyss and Daniel, 2004; Caleca and Rizzo, 2006; 2007; Braham *et al*., 2007). The layer of kaolin reduces oviposition by several mechanisms. First, it masks the colour of leaves, stems, and fruits, making long-distance host recognition difficult (Saour and Makee, 2004). More specifically, the colour white is the least attractive colour for ovipositing females of *C. capitata* (Katsoyannos, 1987). Second, kaolin layer makes the fruit surface harder and less suitable for oviposition (Glenn *et al*., 1999; Saour and Makee, 2004).

The side effects of kaolin on beneficial arthropods are generally considered low (Lapointe, 2000; Showler and Sétamou, 2004; Glenn and Puterka, 2005) and are minimal if the kaolin is applied in autumn (Bürgel *et al*., 2005). Nevertheless, Markó *et al*. (2008) recently observed that processed kaolin treatments promoted woolly apple aphid infestations on apple, probably because it decreased parasitism of aphids by aphelinid wasps. A similar low biological control was observed by Alexandrakis and Neuenschwander (1979) in dusty olive groves.

The aim of this work is to evaluate the effect of processed kaolin on the damage caused by *C. capitata* on satsuma (*Citrus unshiu* Markow.) and clementine (*Citrus clementina* Hort. ex Tan.) fruits in Sicilian organic orchards. These citrus species are very susceptible to *C. capitata* attacks because of the almost complete absence of alternative host plants during their ripening periods, which occur in September for satsuma and from October to December for clementine.

Materials and methods

The research was carried out in Sicily in 2003 and 2004. In each of four experiments (two with satsuma and two with clementine, see the following sections), two sets of citrus trees received the same cultural management except that one set was treated with processed kaolin. Numbers of male *C. capitata* were monitored with wing traps (Super Track Ala by Serbios) baited with a trimedlure dispenser; three traps were placed in each grove and were checked every 10 days from July to November; the dispenser was replaced every month. Surround WP™ Crop Protectant (kaolin 95%, Engelhard Corporation, Iselin NJ, USA) was used at a rate of 5 kg of product in 100 l of water as suggested by the manufacturer. The first treatment was performed with a common sprayer about 1 week before fruits began to ripen (at the end of August for satsuma; from 5 October to 10 October for clementine), which is when fruits become susceptible to *C. capitata* attack. On clementines but not on satsumas in 2004, a second treatment was applied with the aim of improving fruit protection. The product satisfactorily adhered on the fruit surface of both citrus species, and a thin, white coating was still noticeable after rainfall.

In situ temperatures were measured and recorded every hour by Gemini miniature data loggers, and rainfall data were provided by the agrometeorogical station of Patti (Messina, 70 m above sea level).

Satsuma - year 2003

In both 2003 and 2004, the experiment was conducted in a 1.5 ha organic satsuma orchard (cultivar Miyagawa) in Brolo (20 m above sea level), Messina Province. The orchard consisted of 400 trees, including a small number of other citrus and fruit trees. Trimedlure traps were in the field from 2 July 2003 until harvest. On 28 August, about 250 adjacent trees were treated with kaolin, while the remaining 150 trees were left unsprayed and used as a control. On 10 and 17 September, 10 fruits on 10 trees in treated and untreated plots (100 fruits per plot in total) were randomly checked in the field for *C. capitata* stings. After fruits were harvested on 20 and 26 September, all harvested fruits were washed and then examined for evidence of *C. capitata* attack. Because satsuma fruits are usually harvested when they are still green, the presence of each stinging mark is evident as a yellow spot that can be easily detected by visual inspection.

Satsuma - year 2004

Trimedlure traps were in the field from 13 July 2004 to harvest (24 September). Two groups of 20 adjacent trees were used. On 30 August, 10 trees from each group (20 in total) were treated with kaolin, while the remainder were left untreated. To improve the detection of punctures in case of a low infestation level, samples of 12 large fruits from each of the 20 trees in each group were collected on 3, 11, and 24 September 2004, and observed with a stereomicroscope; large fruits were selected because they are more susceptible than small fruits to *C. capitata* attack. In each sample, the fruits with stings were counted, and the percentage of *C. capitata*-damaged fruits on each tree was calculated. At harvest, the commercial production of each marked tree was kept separate from the others, and damage was evaluated on 100 fruits per tree.

Clementine - year 2003

The clementine orchard used in 2003 was located in Naso (80 m above sea level), Messina Province, and consisted of about 300 trees (cultivar Monreal). Trimedlure traps were in the field from 2 July to 29 November 2003. On 7 October, half of the trees were treated with kaolin. Starting from 18 October 2003, samples were collected every 15 days from 20 treated and 20 untreated trees. Each sample consisted of approximately 200 treated and 200 untreated fruits (10 per tree); they were examined for *C. capitata* punctures with a stereomicroscope. Fruits were harvested once or twice per week starting from mid-October to the end of the November.

Clementine - year 2004

The clementine orchard used in 2004 was located in Brolo (20 m above sea level), Messina Province, and contained about 80 clementine trees (cultivar Monreal) mixed with an equal number of lemon and orange trees. Trimedlure traps were in the field from 13 July until 19 November 2004. A group of 20 trees was marked and treated with kaolin, and another nearby group of 20 trees was chosen to represent the untreated control. Treatments were applied on 8 and 18 October 2004. Starting from 11 October 2004, 15 large fruits from each of the 40 marked trees were collected every 15 days and assessed for *C. capitata* punctures with a stereomicroscope. As in the previous year, fruits were harvested once or twice weekly from mid-October until 19 November.

Statistical analysis

For data from the satsuma orchard in 2003, the observed frequencies of *C. capitata*-damaged fruits were compared to expected frequencies with a χ^2 test ($\alpha < 0.05$).

For data from the clementine orchard in 2003, damage data for the four sampling dates were arranged in a three-dimensional contingency table and subjected to a Cochran χ^2 test ($\alpha = 0.05$). According to this method (Cochran, 1954) and in the case of four samples, χ^2 is calculated as:

$$\chi^2 = \sum_{K=1}^{4} w_k d_k^2$$

with:

$$w_k = \frac{\bar{p}_k \cdot (1-\bar{p}_k) \cdot n_{k1} \cdot n_{k2}}{n_k}$$

and:

$$d_k = \frac{p_{k1} - p_{k2}}{\bar{p}_k \cdot (1-\bar{p}_k)}$$

where, on the different sampling dates, $\bar{p}_k$ is the weighted mean of the two frequencies of damaged fruits in the treatment (p_{k1}) and in the control (p_{k2}), and n_{k1} and n_{k2} are the number of examined fruits. To test whether damage differed among dates, we performed the homogeneity test for the standardized differences, with 3 degrees of freedom:

$$\chi^2_{hom.} = \sum_{k=1}^{4} w_k d_k^2 - \frac{\left(\sum_{K=1}^{4} w_k d_k\right)^2}{\sum_{k=1}^{4} w_k}$$

The association between the level of damage and the treatment was evaluated through the standardized difference and its standard error, with one degree of freedom, with the following formula:

$$\chi^2_{assoc.} = \frac{\left(\sum_{k=1}^{4} w_k d_k\right)^2}{\sum_{k=1}^{4} w_k}$$

For data collected from both orchards in 2004, damage percentages were statistically evaluated, after arcsin transformation, with a Student's *t* test at $\alpha = 0.05$.

Results

Satsuma - year 2003

In the satsuma orchard in 2003, the number of males captured peaked on 21 August (561 males/trap) and then declined relatively rapidly (figure 1). In field observations on 10 and 17 September 2003, stings were not detected on either treated or untreated fruits. The visual analysis of harvested fruits was carried out on 1314 kg of treated and on 1075 kg of untreated fruits, representing 72% of the entire year's harvest (table 1). The damage to treated and untreated fruits was lower than expected based on numbers of males in traps and was less than observed by the grower during the previous years, when more than 50% of the fruits had been damaged (personal communication). Nevertheless, damage was reduced by kaolin treatment (χ^2 test, $p < 0.01$, table 1).

Satsuma - year 2004

In the satsuma orchard in 2004, the number of males captured peaked on 2 August (458 males/trap) and then declined only slowly (figure 2). Fewer fruit were damaged by *C. capitata* in the kaolin treatment than in the control before harvest on 11 September ($p = 0.0049$) and on 24 September ($p = 0.000006$) (figure 3). The percentage of fruit damaged on the first sampling date (3 September) was higher than the percentage on the following date, most likely because fewer fruits were available for attack on the earlier date. Kaolin treatment also reduced ($p = 0.019$) the percentage of fruit damaged by *C. capitata* at harvest (figure 3).

Clementine - year 2003

In the clementine orchard in 2003, the number of males captured peaked three times: 21 August, 30 September, and 30 October (164, 258, and 309 males/trap, respectively) (figure 4). An intense rainfall occurred in October after the only kaolin treatment (figure 4). The percentages of infested fruits from treated and control

Table 1. Damage caused by *C. capitata* on kaolin treated and untreated fruits of satsuma in 2003. (** indicates levels of $p < 0.01$, chi-square test).

Treatment	Undamaged fruit (kg)	Damaged fruit (kg)	Damaged fruit %	χ^2 d.f. = 1
Kaolin	1308.4	5.6	0.43	17.16**
Control	1055.9	19.1	1.78	

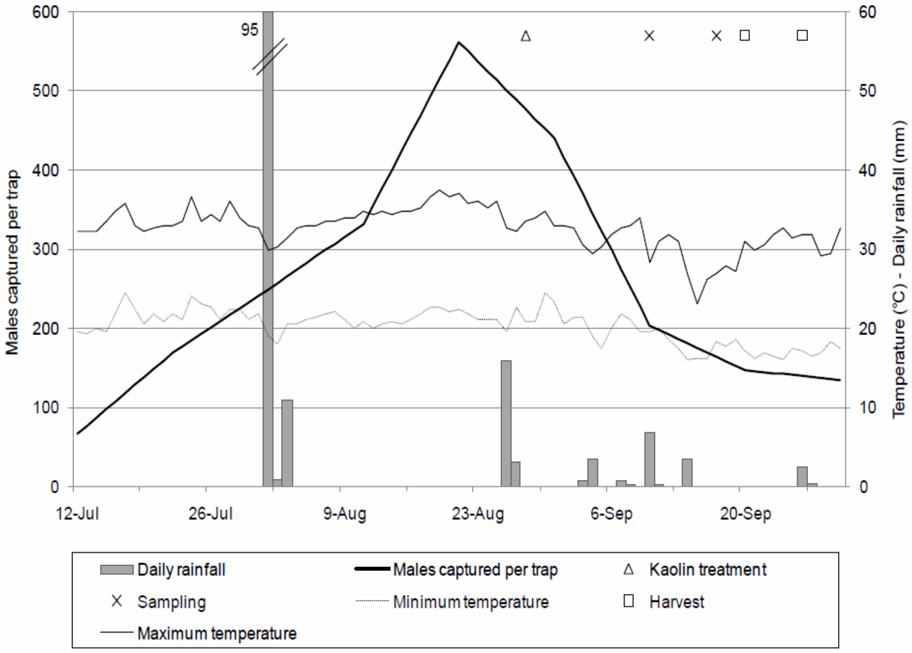

Figure 1. Mean number of *C. capitata* males captured per trap plus temperature and rainfall data: satsuma orchard in 2003.

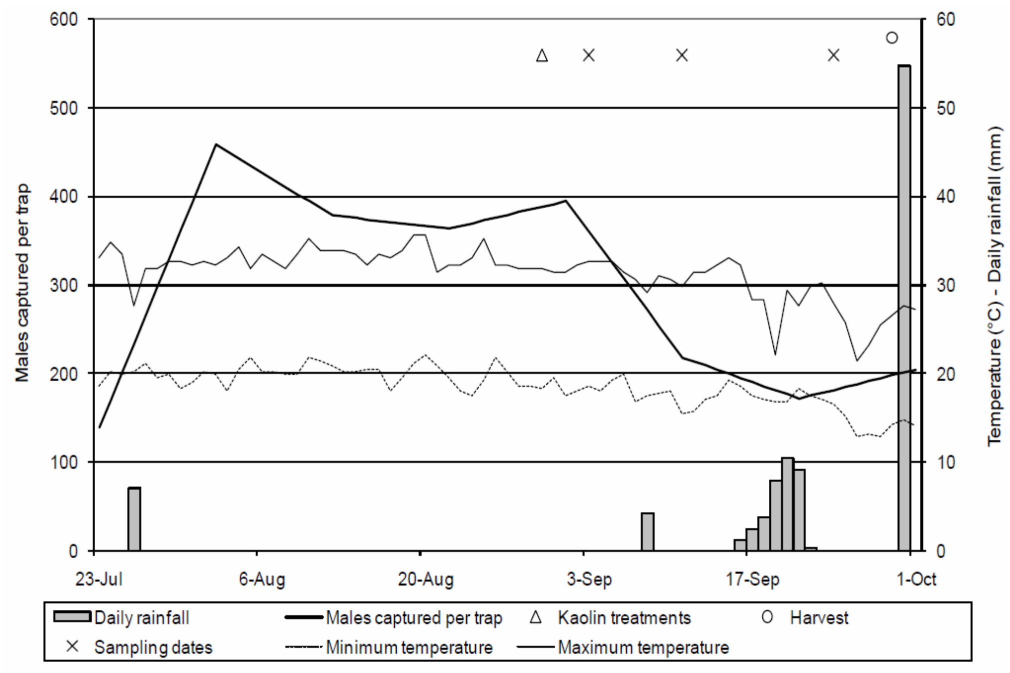

Figure 2. Mean number of *C. capitata* males captured per trap plus temperature and rainfall data: satsuma orchard in 2004.

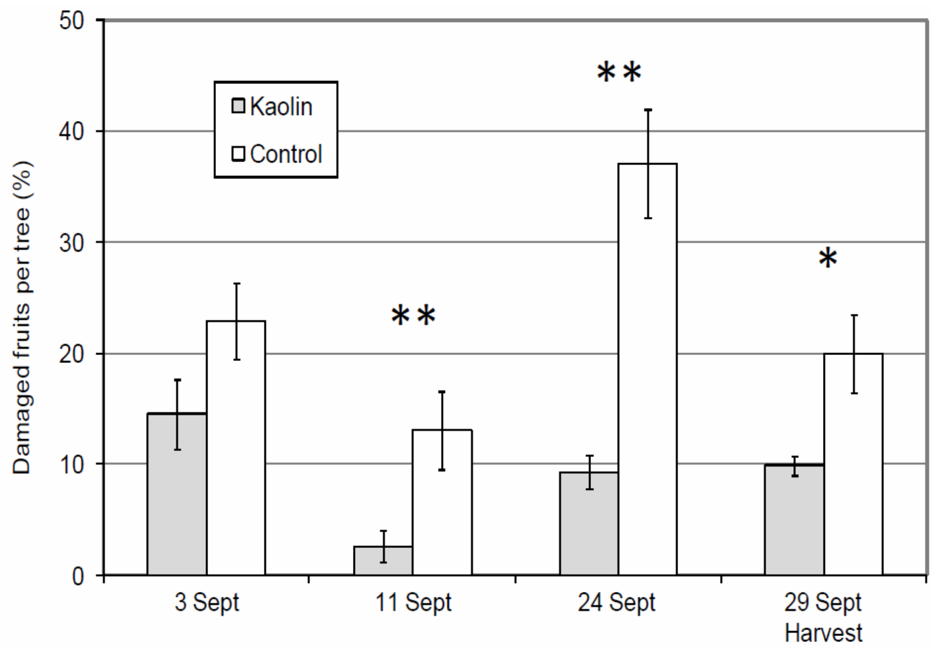

Figure 3. Percentage of fruit per tree damaged by *C. capitata* on different dates and as affected by kaolin treatment: satsuma orchard in 2004. * indicates $p < 0.05$ and ** indicates $p < 0.01$ based on Student's *t* test.

trees are reported in figure 5. The percentage of fruit damaged by *C. capitata* was smaller in the kaolin treatment than in the control on 30 October ($\chi^2 = 21.64$; $p < 0.01$) and on 13 November ($\chi^2 = 31.69$; $p < 0.01$); the standardized differences homogeneity test showed that the four samples were not homogeneous ($\chi^2_{hom.} = 31.19$; $p < 0.01$) because damage levels rose significantly during the observation period. Furthermore, the overall difference between kaolin treated and control trees across all sampling date resulted significant, showing an association between kaolin treatment and the lowering infestation levels ($\chi^2_{assoc.} = 23.23$; $p < 0.01$). The kaolin treatment reduced damage to the fruit for 36 days after application (figures 4 and 5). By 27 November, which was 50 days after kaolin was applied, a very high percentage of fruit was damaged by *C. capitata* regardless of treatment (figure 5).

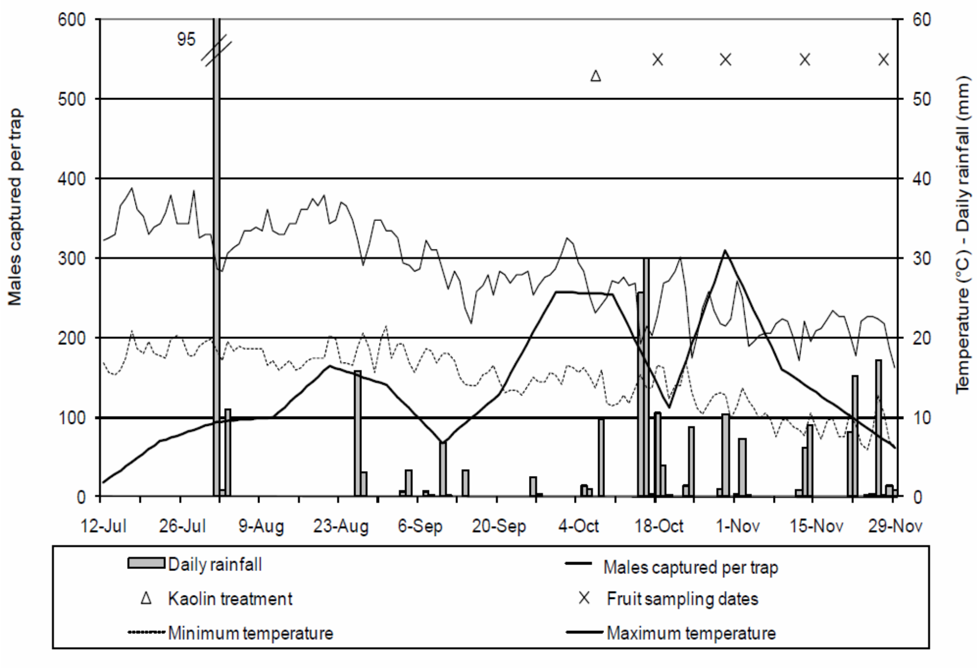

Figure 4. Mean number of *C. capitata* males captured per trap plus temperature and rainfall data: clementine orchard in 2003.

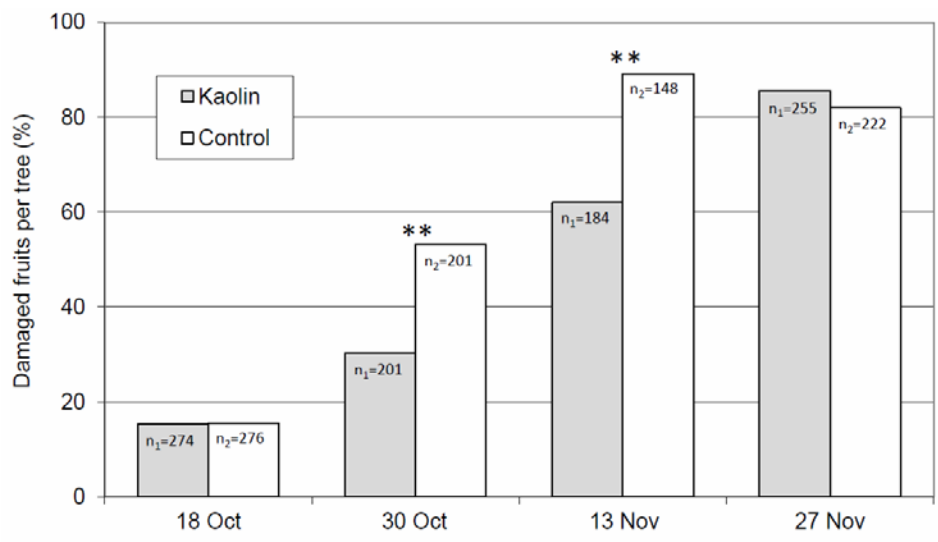

Figure 5. Percentage of fruit damaged by *C. capitata* on different dates and as affected by kaolin treatment: clementine orchard in 2003. Sample sizes are indicated (n_1 for Kaolin treated samples, n_2 for control samples). ** indicates $p < 0.01$ based on Cochran's χ^2 test).

Clementine - year 2004

In the clementine orchard in 2004, the number of males captured again peaked three times: 2 August, 1 September, and 11 October (217, 257, and 430 males per trap, respectively) (figure 6). The rainfall was much lower in October 2004 than in October 2003 (figure 6). Kaolin treatment significantly reduced the percentage of damaged fruits per tree on 26 October ($p = 0.007$) and on 9 November ($p = 0.00015$); on both dates, kaolin reduced the percentage of damage by about half (figure 7). There were clear differences in damage levels between the two sets of trees for 27 days after kaolin application (figures 6 and 7).

Discussion

The use of processed kaolin clearly reduced *C. capitata* damage to fruits, both on satsuma and on clementine, in spite of the cultural and biological differences between the two species and also in spite of intense rainfall, as occurred in the clementine orchard in 2003.

Even when *C. capitata* is abundant (maximum values of our male captures: 561 in 2003 and 458 in 2004), damage to satsuma may vary depending on the contemporaneous presence of other fruit species with a higher attractiveness (like pears and late peach varieties). This may explain why the damage to satsuma was less than expected.

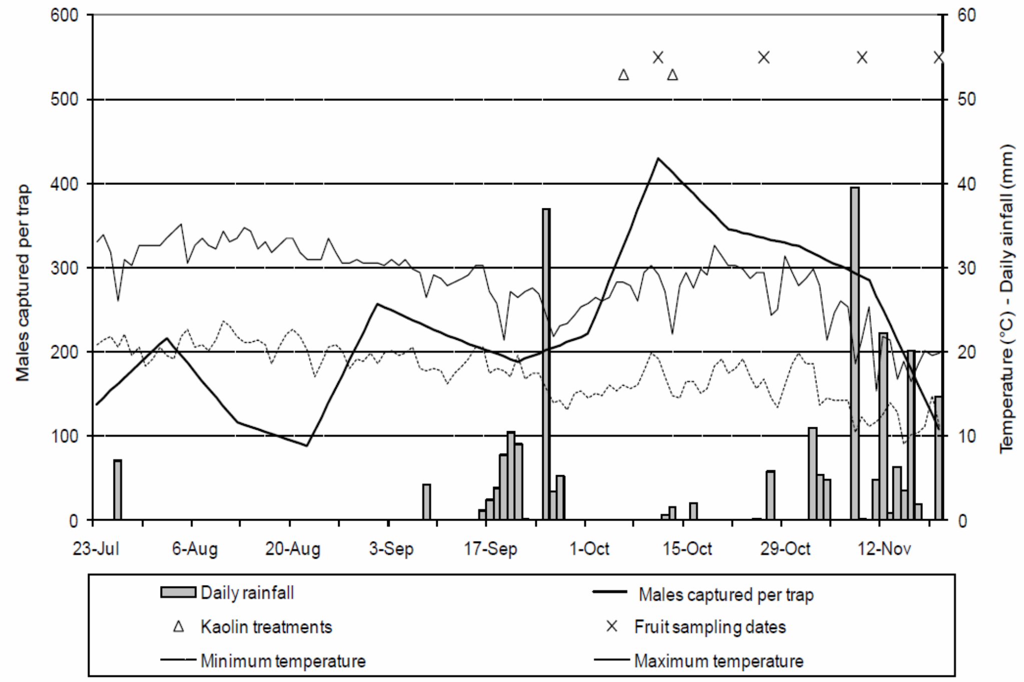

Figure 6. Mean number of *C. capitata* males captured per trap plus temperature and rainfall data: clementine orchard in 2004.

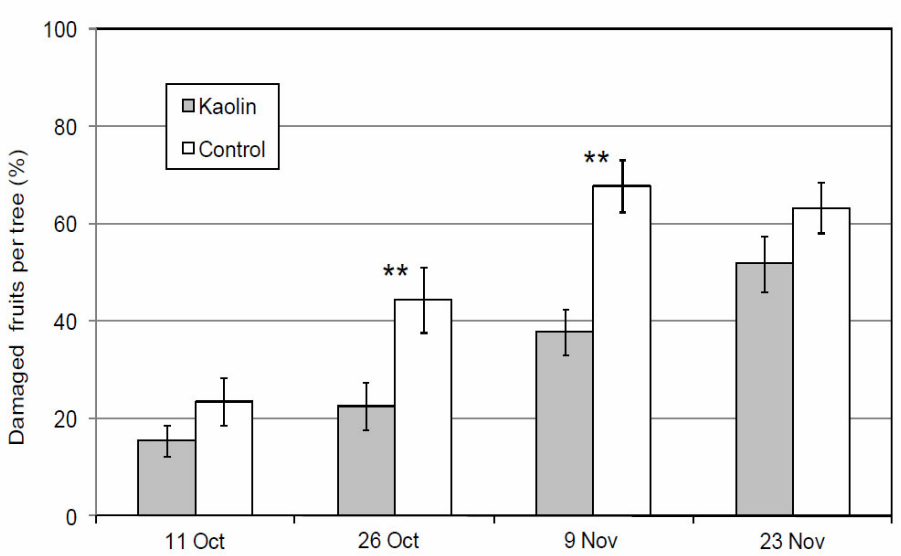

Figure 7. Percentage of fruit damaged by *C. capitata* on different dates and as affected by kaolin treatment: clementine orchard in 2004. ** indicates p < 0.01 based on Student's *t* test.

In contrast to satsuma, clementine is characterized by a very long ripening period lasting from October to December. In these months, a nearly complete lack of alternative host species for oviposition increases the probability that clementine will be attacked by *C. capitata*. Damage rapidly increases just after the fruits turn orange. Clementine also seems highly susceptible to *C. capitata* attack because the fruit skin releases compounds that stimulate female oviposition (Delrio *et al.*, 1990). Infestation levels in clementine orchards are often so high that even the chemical control by synthetic insecticides is difficult.

In all citrus orchards and in both years, the numbers of males captured in the trimedlure traps were quite high during the sampling and harvesting periods but resulted in quite different damage levels (i.e., much higher damage in clementine than in satsuma). Nevertheless, kaolin reduced damage whether damage levels were low or high.

The effectiveness of processed kaolin against *C. capitata* has been demonstrated on nectarines, both in laboratory tests (choice and no-choice tests) and in the field, and kaolin has also controlled *C. capitata* in field tests with apples and persimmons (Mazor and Erez, 2004).

Furthermore, processed kaolin reduced infestations of two other citrus pests, the weevil *Diaprepes abbreviatus* (L.) (Lapointe, 2000) and the thrips *Scircothrips citri* (Moulton) (Kerns and Wright, 2000); in the last study, processed kaolin did not affect photosynthesis, transpiration, or stomatal conductance of treated lemon leaves.

A full evaluation of kaolin requires assessment of how it affects the aesthetic qualities of fruits in the marketplace. In our research, the kaolin on treated citrus fruits was easily removed by the water and brushes commonly used to clean fruit before packaging (personal observation), as was previously demonstrated for other smooth-skinned fruits like apples, nectarines, and persimmons (Heacox, 2001; Mazor and Erez, 2004). Citrus fruits that are harvested with leaves (as is sometimes the case for sale in local markets) represent a potential problem because such fruits are not usually washed and would retain the white film.

In conclusion, processed kaolin has the potential to reduce damage caused by *C. capitata* in citrus while having few or none of the undesirable side effects of insecticides. Further studies are needed to assess the impact of rainfalls of different intensities on the retention of kaolin on fruit and leave surfaces.

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References

ALEXANDRAKIS V., NEUENSCHWANDER P., 1979.- Influence de la poussière des chemins sur *Aspidiotus nerii* Bouchè (Hom. Diaspididae) et son parasite principal, *Aphytis chilensis* How. (Hym. Aphelinidae), observés sur olivier.- *Annales de Zoologie Ecologie Animale*, 11 (2): 171-184.

BRAHAM M., PASQUALINI E., NCIRA N., 2007.- Efficacy of kaolin, spinosad and malathion against *Ceratitis capitata* in *Citrus* orchards.- *Bulletin of Insectology*, 60 (1): 39-47.

BÜRGEL K., DANIEL C., WYSS E., 2005.- Effects of autumn kaolin treatments on the rosy apple aphid, *Dysaphis plantaginea* (Pass.) and possible modes of action.- *Journal of Applied Entomology*, 129 (6): 311-314.

CALECA V., RIZZO R., 2006.- Effectiveness of clays and copper products in the control of *Bactrocera oleae* (Gmelin), pp. 275-282. In: *Proceedings of Olivebioteq 2006, Second International Seminar "Biotechnology and quality of olive tree products around the Mediterranean Basin"*, Vol. 2. November 5-10, Mazara del Vallo, Marsala, Italy.

CALECA V., RIZZO R., 2007.- Tests on the effectiveness of kaolin and copper hydroxide in the control of *Bactrocera oleae* (Gmelin).- *IOBC/wprs Bulletin*, 30 (9): 111-117.

COCHRAN W. G., 1954.- Some methods for strengthening the common χ^2 tests.- *Biometrics*, 10: 417-451.

DELRIO G., MELLONI G., PIREDDA R., USAI M., 1990.- Preliminary observations on oviposition stimulants of citrus fruits on medfly, *Ceratitis capitata*.- *IOBC/WPRS open meeting on fruit flies of economic importance*, November 26-27, 1990, Sassari, Italy.

GLENN D. M., PUTERKA G. J., 2005.- Particle films: a new technology for agriculture.- *Horticultural Review*, 31: 1-44.

GLENN D. M., PUTERKA G. J., VANDERZWET T., BYERS R. E., FELDHAKE C., 1999.- Hydrophobic particle films: a new paradigm for suppression of arthropod pests and plant diseases.- *Journal of Economic Entomology*, 92 (4): 759-771.

GLENN D. M., PRADO E., EREZ A., PUTERKA G. J., 2002.- A reflective, processed-kaolin particle film affects fruit temperature, radiation reflection, and solar injury in apple.- *HortScience*, 127: 188-193.

HEACOX L., 2001.- Particle film: proving its worth.- *Fruit Grower*, May: 26.

JIFON J. L., SILVERSTEN J. P., 2003.- Kaolin particle film applications can increase photosyntesis and water use efficiency of "Ruby Red" grapefruit leaves.- *HortScience*, 128 (1): 107-112.

KATSOYANNOS B. I., 1987.- Response to shape, size and colour, pp. 307-321. In: *Fruit flies: their biology, natural enemies and control* (ROBINSON A. S., HOOPER G., Eds).- Elsevier, Amsterdam, The Netherlands.

KERNS D. L., WRIGHT G. C., 2000.- Protective and yield enhancement qualities of kaolin on lemons.- *"2000 Citrus and Deciduous Fruit and Nut Research Report"* (publ. az1178), College of Agriculture and Life Sciences, the University of Arizona, Tucson, Arizona, 85721.

KNIGHT A. L., UNRUH T. R., CHRISTIANSON B. A., PUTERKA G. J., GLENN D. M., 2000.- Effects of kaolin-based particle films on oblique banded leafroller, *Choristoneura rosaceana* (Harris) (Lepidoptera Tortricidae).- *Journal of Economic Entomology*, 93: 744-749.

LAPOINTE S. L., 2000.- Particle film deters oviposition by *Diaprepes abbreviatus* (Coleoptera Curculionidae).- *Journal of Economic Entomology*, 93: 1459-1463.

LIANG G., LIU T. X., 2002.- Repellency of a kaolin particle film, surround, and a mineral oil, sunspray oil, to silverleaf whitefly (Homoptera Aleyrodidae) on melon in the laboratory.- *Journal of Economic Entomology*, 95: 317-324.

LIQUIDO N. J., SHINODA L. A., CUNNINGHAM R. T., 1991.- Host plants of the Mediterranean fruit fly (Diptera: Tephritidae). An annotated world list.- *Entomological Society of America, Miscellaneous Publications*, 77: 1-52.

MARKÓ V., BLOMMERS L. H. M., BOGYA S., HELSEN H., 2008.- Kaolin particle films suppress many apple pests, disrupt natural enemies and promote woolly apple aphid.- *Journal of Applied Entomology*, 132: 26-35.

MAZOR M., EREZ A., 2004.- Processed kaolin protects fruits from Mediterranean fruit flies infestations.- *Crop Protection*, 23: 47-51.

PUTERKA G. J., GLENN D. M., SEKUTOWSKI D. G., UNRUH T. R., JONES S. K., 2000.- Progress toward liquid formulation of particle film for insect and disease control in pear.- *Environmental Entomology*, 29: 329-339.

ROESSLER Y., 1989. Insecticidal bait and cover sprays, pp. 329-336. In: *Fruit flies: their biology, natural enemies and control* (ROBINSON A. S., HOOPER G., Eds).- Elsevier, Amsterdam, The Netherlands.

RUSSO G., 1937.- Primi esperimenti di un nuovo metodo di lotta contro la mosca delle olive.- *L'Olivicoltore, Roma*, 14: 1-3.

SAOUR G., MAKEE H., 2004.- A kaolin-based particle film for suppression of olive fruit fly *Bactrocera oleae* Gmelin (Dipt. Tephritidae) in olive trees.- *Journal of Applied Entomology*, 128: 28-31.

SHOWLER A. T., SÉTAMOU M., 2004.- Effects of kaolin particle film on selected arthropod populations in cotton lower Rio Grande Valley of Texas.- *Southwestern Entomologist*, 29: 137-146.

UNRUH T. R., KNIGHT A. L., UPTON J., GLENN D. M., PUTERKA G. J., 2000.- Particle films for suppression of the codling moth (*Cydia pomonella* L.) in apple and pear orchards.- *Journal of Economic Entomology*, 93: 737-743.

WHITE I. M., ELSON-HARRIS M. M., 1994.- *Fruit flies of economic significance: their identification and bionomics*.- CAB International, Wallingford, UK.

WYSS E., DANIEL C., 2004.- Effects of autumn kaolin and pyrethrin treatments on the spring population of *Dysaphis plantaginea* in apple orchards.- *Journal of Applied Entomology*, 128: 147-149.

Authors' addresses: Gabriella LO VERDE (corresponding author, loverde@unipa.it), Virgilio CALECA, Valentina LO VERDE, Department DEMETRA, Entomological, Acarology and Zoology Section, Università degli Studi di Palermo, viale delle Scienze 13, 90128 Palermo, Italy.

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