Effectiveness of clays and copper products in the control of *Bactrocera oleae* (Gmelin)

Caleca V.[1*], Rizzo R. [1]

1) Dept. SENFIMIZO, Sezione di Entomologia, Acarologia e Zoologia, Università di Palermo, Viale delle scienze, 90128 Palermo ITALY.

*Corresponding Author: caleca@unipa.it

Abstract

Repellent and antiovipositional products in the control of Bactrocera oleae *(Gmelin) finds a great interest in organic farming, because of the lack of effective products able to kill the olive fruit fly larvae and eggs.*

This study is the continuation of a research on the effectiveness of kaolin and copper hydroxide carried out in 2003 and 2004 in Castelvetrano and Trapani (Sicily, Italy).

In 2005 a product containing 95% of kaolin, Surround WP, was tested in two organic table olive orchards, Nocellara del Belice cv., in Trapani province; in the first one (located in Castelvetrano) this kaolin was compared to copper hydroxide (Coprantol Ultramicron) and rotenone (Bioroten), in the second one (located in Partanna) it was compared to a product containing 100% of bentonite (Biobenton), to a product containing copper oxychloride (Cuprobenton) and to Surround WP + copper hydroxide.

In 2005, at Castelvetrano all plots gave no statistically significant differences, due to the low infestation level reached until harvesting on 8th October (total infestation in all plots 5-9%). On the other hand at Partanna, regarding the harmful infestation of the whole sampling period (11th August- 14th November), the two kinds of clays recorded statistically significant better results than untreated plot, while the results of copper oxychloride plot were intermediate, with significant differences from kaolin plots, but without differences with bentonite and untreated theses. The oils extracted from olives of the four treated theses resulted of excellent quality (free acidity 0.1-0.2%, peroxide value 3-4), while untreated olives produced a still extra virgin oil with a higher free acidity (0.6%, peroxide value 4).

In the different theses tested of this site the olive fruit fly infestation was limited to a level good for table olives until 18th, 28th September, 19th, 24th and 29th October in untreated, copper oxychloride, bentonite, kaolin and kaolin +copper hydroxide theses respectively.

The tested products containing kaolin, bentonite, copper hydroxide and oxychloride are effectively able to limit B. oleae *infestation to a good level for olive oil production, moreover, considering the earlier harvesting of table olives, these products, particularly the first three of them, give a new opportunity for controlling the olive fruit fly also in organic farms for table olives production.*

Keywords: olive fruit fly, kaolin, bentonite, antiovipositional, organic farming, Sicily.

Introduction

The use of repellent and antiovipositional products in the control of *Bactrocera oleae* (Gmelin) finds a great interest in organic farming, because of the lack of effective products able to kill the olive fruit fly larvae and eggs.

From 1937 to 1953 Russo and some other entomologist (Russo, 1937; Russo and Fenili, 1949; Russo, 1954) tested the effectiveness of clay, including bentonite, and Bordeaux mixture against the olive fruit fly, obtaining a similar protection, suggesting their use for early ripening olives to harvest before autumnal rainfall.

Visual and chemical stimuli lead the female olive fruit fly to oviposit into fruits (Katsoyannos and Kouloussis, 2001; Rotundo *et al.*, 2001; Solinas *et al.*, 2001); so the clay, especially white clays as kaolin, disrupts ovipositing females, while copper salts through their antibacterial action make fruits less attractive to ovipositing females because of the lack of some bacterial compounds on the surface of fruits (Tsanakakis, 1985; Belcari *et al.* 2003), furthermore the presence of the particles of these products on fruit surface could be another obstacle for the fruit recognition of the female olive fruit fly.

More recently some authors tested copper products (Prophetou-Athanasiadou *et al*, 1991; Belcari and Bobbio, 1999; Petacchi and Minnocci, 2002; Tsolakis and Ragusa, 2002) and kaolin (Saour and Makee 2004) against *B. oleae* obtaining interesting results. In 2003 and 2004 Caleca and Rizzo (in press) tested products containing kaolin and copper hydroxide proving their effectiveness in limiting *B. oleae* infestation to a very good level for olive oil production.

In a study on the susceptibility of Sicilian olive cultivars Rizzo and Caleca (in press) show Nocellara del Belice cultivar as the most attacked among the 16 tested cultivars.

The aim of this research is to test the effectiveness of two clays (bentonite and kaolin) and two copper products (copper oxichloride and hydroxide) in the control of the olive fruit fly in table olive orchards planted with the high susceptible Nocellara del Belice cultivar.

Material and Methods

In 2005 a product containing 95% of kaolin, Surround WP, was tested in two organic table olive orchards, Nocellara del Belice cv., in Trapani province. In the first one (located in Castelvetrano) this kaolin was compared to Coprantol Ultramicron (containing 35% of copper hydroxide) and Bioroten (containing 4% of rotenone); in the second one (located in Partanna), 10 km far from the first one, Surround WP was compared to Biobenton (containing 100% of bentonite), to Cuprobenton (a product containing 15% of copper oxychloride and about 80% of bentonite) and to Surround WP + Coprantol Ultramicron.

The doses per treatment (per hl of water) were 5 kg of kaolin or bentonite products, 0.3 kg of Coprantol Ultramicron (= 0.09 kg of copper hydroxide), 0.8 kg of Cuprobenton (= 0.1 kg of copper oxychloride + 0.7 kg of bentonite) and 0.3 kg of Bioroten (= 0.01 kg of rotenone).

Olive trees were sprayed once in Castelvetrano (on 14th September) and three times in Partanna (10th, 28th September, and 20th October). First treatment was realised after reaching the threshold of 5% of total infestation in one of the different theses. The second treatment was done when the fruit were no more covered by the kaolin because of the rain and the wind.

At Castelvetrano each thesis was replicated in two plots consisting of 7-18 trees, while at Partanna in one plot of 25-40 trees. Samples consisted of ten olives randomly collected from each of the eight sampled trees of the plots.

Collected fruits were analysed under the stereomicroscope to detect eggs, larvae, pupae, exit holes, empty galleries and punctures without oviposition. The infestation level was expressed as “active” (alive eggs, 1st and 2nd instar larvae), “harmful” infestation (3rd instar larvae, pupae, exit holes in absence of larvae and pupae) and “total” infestation (active + harmful infestation).

In each olive grove two traps with 1,7-dioxaspiro[5.5]undecane and two yellow sticky traps were placed to monitor male olive fruit flies.

Thermopluviometric data concerning Castelvetrano Seggio weather station, 6-7 km far from the two fields, were kindly provided by SIAS, Servizio Informativo Agrometeorologico Siciliano (Government of the Sicilian Region).

At Partanna after the beginning of the tests, the owner, due to his particular reasons, chose to produce olive oil instead of table olives, harvesting on 14th November, in contrast to the harvesting on 8th October correctly done for table olives in Castelvetrano orchard. This unexpected longer sampling period of Partanna orchard allowed us to evaluate also the effects of those treatments on oil quality. The oil was extracted from olives within six hours from harvesting by an Alfa-Laval decanter centrifuge. Three 500 ml oil samples per thesis were collected at the end of a unique oil extraction from the olives of each thesis; analysis done by two different laboratories of these oil samples comprises free acidity, peroxide value, K232, K270, ΔK, phenols, fatty acids, tocopherols and panel test.

Data on infestation of this orchard allowed also to calculate the day until when olives of the different theses were suitable for table olives processing, adopting a pre-sizing injury level of 10% of harmful infestation (with a max. of 5% of exit holes). This injury threshold derives from norms of Codex Alimentarius (1995) and C.O.I. (1980), and from a brief survey of thresholds applied by operators of table olives processing.

Data concerning fruit infestation were statistically analysed by repeated measurements ANOVA, 1-way ANOVA both followed by Tukey post-hoc test ($p < 0.05$).

Results

The thermopluviometric trend at Castelvetrano Seggio SIAS weather station in 2005, is shown in Fig. 1; a conspicuous daily rainfall occurred on 3rd and 26th October (46 and 34 mm).

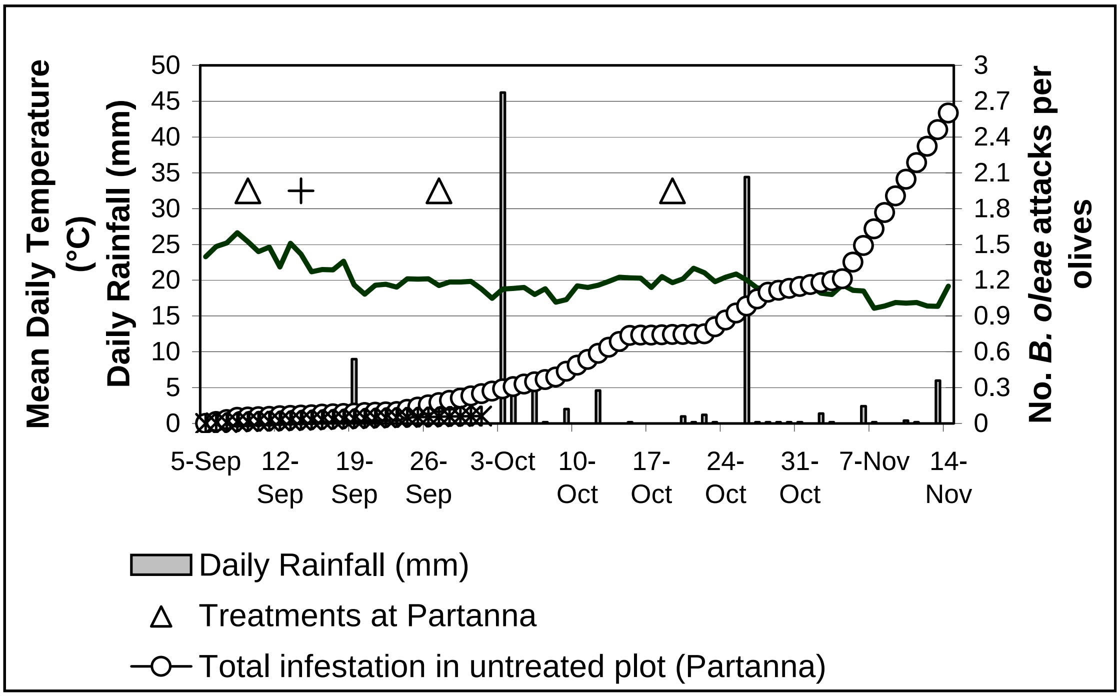

Figure 1. Thermo-pluviometric trend, treatments and total infestation in untreated plots in Castelvetrano and Partanna olive groves in 2005.

As shown in Fig. 2 *B. oleae* harmful infestation level reached until harvesting on 8th October was low, and no statistically significant differences were recorded among different theses both in harmful and total infestation (total infestation in all plots 5-9%).

At Partanna during the longer sampling period before harvesting (14th November) the infestation reached high levels (Fig. 1).

The trend of harmful infestation due to olive fruit fly is shown in Tab. 1 (expressed as no. of attacks per olive) and in Fig. 3 (expressed as a percentage of infested olives). Regarding the harmful infestation recorded in each single date, as shown in Tab. 1 and Fig. 3, the untreated olives began to be significantly more infested than treated ones since 22nd September, remaining in this condition until 15th October. Beyond this sampling date and until the harvesting the harmful infestation of olives treated with Cuprobenton did not recorded any statistically significant differences with untreated ones; in the last two sampling dates also Biobenton thesis did not significantly differ from untreated and Cuprobenton ones.

The statistical analysis of the whole period (8th Sep.-14th Nov. in Tab. 2) we notice that the trend of harmful infestation of theses treated with Surround WP (with or without Coprantol Ultramicron) is significantly lower than all other theses; in the same analysis Biobenton thesis differed from untreated one, but not from Cuprobenton one. The trend of infestation of this last treatment differed from untreated thesis until 22th October.

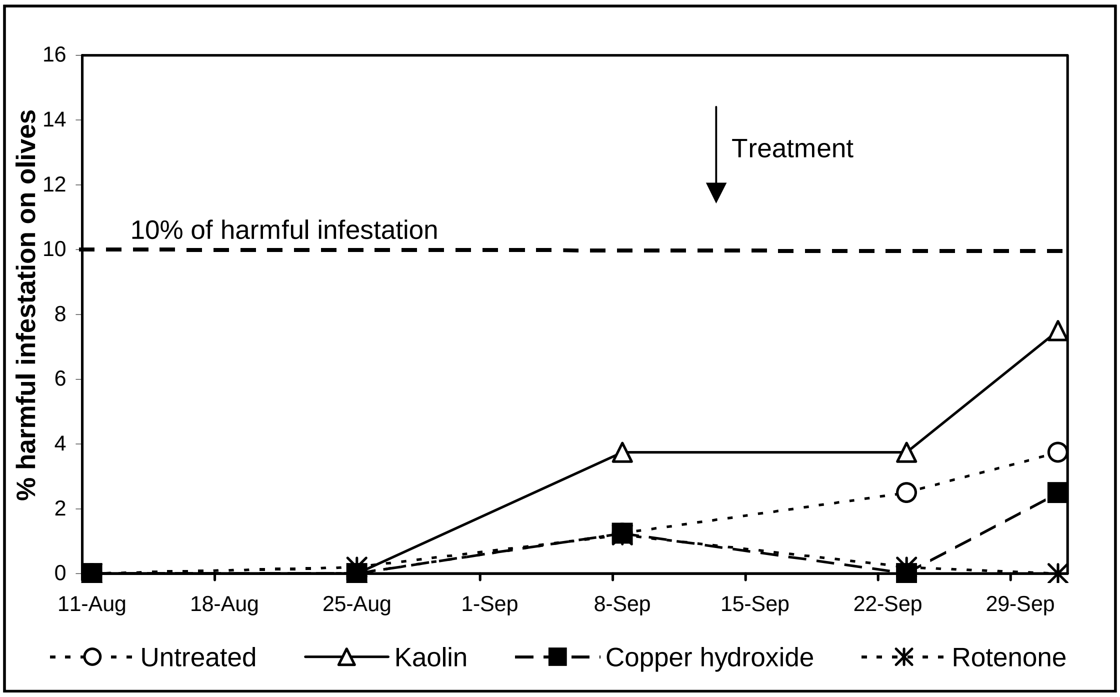

Figure 2. Harmful infestation due to *Bactrocera oleae* in Castelvetrano olive grove (cv. Nocellara del Belice) in 2005.

Table 1. Mean values of *B. oleae* harmful infestation (no. of *B. oleae* attacks per olive) in each date at Partanna in 2005 (Different letters in the column denote statistically significant differences; ANOVA 1-way followed by Tukey post-hoc test; p<0.05).

Thesis	8-Sep	23-Sep	1-Oct	8-Oct	15-Oct	22-Oct	28-Oct	4-Nov	14-Nov
Untreated	0.01 a	0.08 a	0.21 a	0.026 a	0.46 a	0.48 a	0.85 d	1.05 ab	1.80 a
Cuprobenton	0.05 a	0.04 ab	0.06 b	0.10 b	0.19 b	0.36 a	0.69 cd	1.13 a	1.80 a
Biobenton	0.01 a	0.00 b	0.03 b	0.00 b	0.04 b	0.15 b	0.45 bc	0.68 b	1.80 a
Surround WP	0.00 a	0.01 ab	0.06 b	0.01 b	0.01 b	0.06 b	0.21 ab	0.20 c	0.56 b
Surround WP + Coprantol Ul.	0.00 a	0.00 b	0.01 b	0.01 b	0.00 b	0.01 b	0.13 a	0.20 c	0.35 b

Table 2. . Mean values of *B. oleae* harmful infestation (no. of *B. oleae* attacks per olive) in three different periods at Partanna in 2005 (Different letters denote statistically significant differences; repeated measurements ANOVA followed by Tukey post-hoc test; p<0.05).

Thesis	8 Sep – 15 Oct	8 Sep – 22 Oct	8 Sep – 14 Nov
Untreated	0.12 a	0.22 a	0.52 a
Cuprobenton	0.09 b	0.11 b	0.44 ab
Biobenton	0.02 b	0.03 bc	0.32 b
Surround WP	0.02 b	0.02 bc	0.11 c
Surround WP + Coprantol Ul.	0.01 b	0.01 c	0.07 c

The statistical analysis of the whole period (8th Sep.-14th Nov. in Tab. 2) we notice that the trend of harmful infestation of theses treated with Surround WP (with or without Coprantol Ultramicron) is significantly lower than all other theses; in the same analysis Biobenton thesis differed from untreated one, but not from Cuprobenton one. The trend of infestation of this last treatment differed from untreated thesis until 22th October.

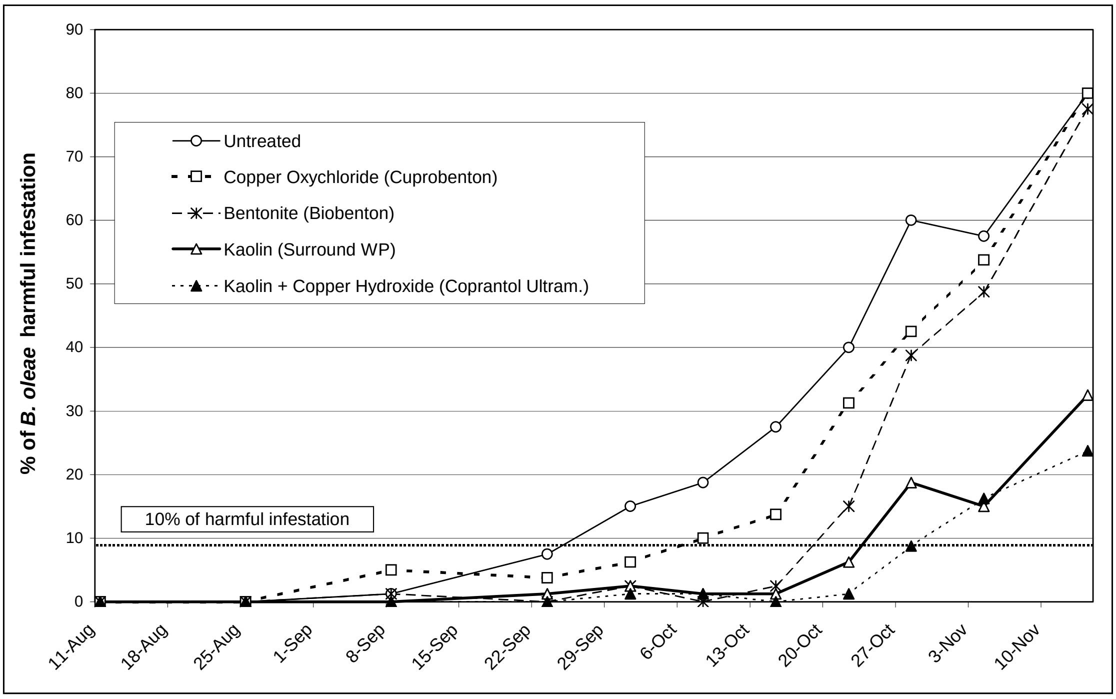

Figure 3. Harmful infestation due to *Bactrocera oleae* at Partanna olive grove (cv. Nocellara del Belice) in 2005.

As shown in Tab. 3 the oils extracted from olives of the four treated theses resulted of excellent quality (free acidity 0.13-0.26%, peroxide value 2.6-3.6) with some statistically significant differences among them, while untreated olives produced a still extra virgin oil with a higher free acidity (0.6%, peroxide value 3.7). The results concerning oil quality appear more related to the average infestation recorded in the whole period of samplings, even more to the average infestation of the whole period excluding the last 20 days before the harvesting (see Tab. 3), rather than to total or harmful infestation recorded at harvesting. In the case of Biobenton thesis, whose infestation was very low up to 15th October and rose in the last month, this relation is more evident: its oil quality is much better than that one of untreated thesis, from which Biobenton did not differ in total or harmful infestation at harvesting.

To evaluate these tests in the perspective of table olive production the application of the pre-sizing injury level of 10% of harmful infestation (with a max. of 5% of exit holes) implies the infestation reached this limit on 18th September in untreated olives, and on 28th Sep., 19th, 24th and 29th October in copper oxychloride, bentonite, kaolin and kaolin +copper hydroxide theses respectively (Fig. 3).

Table 3. . Quality of oil extracted from olives of the different theses at Partanna compared with infestation at harvesting, average infestation of the whole period (8th Sep.- 14th Nov.) and average infestation of another period lasting 23 days before the harvesting (8th Sep.- 22nd Oct.)

Thesis	Free acidity (%)	Peroxide value	Other extra-virgin oil parameters	Harmful infestation 14th Nov. (No. attacks per olive)	Total infestation 14th Nov. (No. attacks per olive)	Av. harmful inf. 8th Sep.-14th Nov. (No. attacks per olive)	Av. harmful inf. 8th Sep.-22th Oct. (No. attacks per olive)
Untreated	0.64 a	3.7 a	OK	1.8 a (80%)	2.6 ab (90%)	0.52 a	0.22 a
Cuprobenton	0.25 b	3.6 a	OK	1.8 a (80%)	2.0 b (89%)	0.44 ab	0.11 b
Biobenton	0.17 c	2.7 b	OK	1.8 a (77%)	3.3 a (94%)	0.32 b	0.03 bc
Surround WP	0.16 c	2.7 b	OK	0.6 b (32%)	1.0 c (59%)	0.11 c	0.02 bc
Surround WP + Coprantol Ul.	0.13 d	2.6 b	OK	0.3 b (24%)	0.7 c (47%)	0.07 c	0.01 c
Statistical analysis	1-way ANOVA	1-way ANOVA	-	1-way ANOVA	1-way ANOVA	Repeated measurements ANOVA	Repeated measurements ANOVA

Discussion

Our results proved that tested products containing kaolin, bentonite, copper hydroxide and oxychloride are effectively able to limit B. oleae infestation to a good level for olive oil production, in spite of the rise of the infestation in the last 20-30 days before harvesting recorded in trees treated with bentonite and copper oxichloride, probably because they were washed away more than the kaolin.

Moreover, considering the earlier harvesting of table olives and our results on the high susceptible cv. Nocellara del Belice, these products, particularly kaolin, bentonite and copper hydroxide, give a new opportunity for controlling the olive fruit fly also in organic farms for table olives production.

Acknowledgements

We thank the owners of the organic olive groves Paolo Sieli, Angelo e Fabio Failla.

Research funded by “Ricerca ed innovazione per l’olivicoltura meridionale” (RIOM) and by University of Palermo ex quota 60% (“Il controllo degl’insetti fitofagi nell’agricoltura biologica e convenzionale”).

References

AA.VV. 1995. Norme Codex les olives de table. Codex Alimentarius.

AA.VV. 1980. Norme du COI applicable aux olives de table dans le commerce international. International Olive Oil Council (IOOC).

Belcari, A. & Bobbio, E. 1999. L’impiego del rame nel controllo della mosca delle olive *Bactrocera oleae*. Informatore fitopatologico, 49 (12): 52-55.

Belcari, A., Sacchetti, P., Marchi, G., Surico, G. 2003. La mosca delle olive e la simbiosi batterica. Informatore Fitopatologico, 53(9): 55-59.

Caleca V. & Rizzo R. In press. Test of the effectiveness of kaolin and copper hydroxide in the control of *Bactrocera oleae* (Gmelin). 2nd European Meeting of the IOBC/WPRS Study

Group “Integrated Protection of Olive Crops” Florence, October 26-28 2005. IOBC/WPRS Bulletin.

Katsoyannos, B. I. & Kouloussis, N. A. 2001. Captures of the olive fruit fly *Bactrocera oleae* on spheres of different colors. Entomologia Experimentalis et Applicata 100, 165–172.

Petacchi, R. & Minnocci, A. 2002. Olive fruit fly control methods in sustainable agriculture. Acta Horticulturae. 2002; (586): 841-844

Prophetou-Athanasiadou, D. A., Tsanakakis, M. E., Myroyannis D., Sakas G. 1991. Deterrence of oviposition in *Dacus oleae* by copper hydroxide. Entomologia Experimentalis et Applicata, 61: 1-5.

Rizzo R. & Caleca V. In press. Susceptibility to *Bactrocera oleae* (Gmelin) of some sicilian olive cultivars. 2nd European Meeting of the IOBC/WPRS Study Group “Integrated Protection of Olive Crops” Florence, October 26-28 2005. IOBC/WPRS Bulletin

Rotundo G., Germinara G. S., De Cristofaro A., Rama F. 2001. Identificazione di composti volatili in estratti da diverse cultivar di *Olea europaea* L. biologicamente attivi su *Bactrocera oleae* (Gmelin) (Diptera: Tephritidae). Bollettino del Laboratorio di Entomologia Agraria “Filippo Silvestri”57: 25-34.

Russo G., Fenili G. 1949. Esperimenti antidachici eseguiti in Marina di Ascea (Salerno) nel 1949. Olearia (5-6): 1-12.

Russo G. 1937. Primi esperimenti di un nuovo metodo di lotta contro la Mosca delle Olive. L’Olivicoltore, Roma, 14 (11): pp. 3 (estratto)

Russo G. 1954: Reperti biologici, sistemi e metodi di lotta sui principali insetti dannosi all’olivo. Bollettino del Laboratorio di Entomologia Agraria “Filippo Silvestri” 13: 64-95.

Saour, G. & Makee, H. 2004. A kaolin-based particle film for suppression of the olive fruit fly *Bactrocera oleae* Gmelin (Dip., Tephritidae) in olive groves. Journal of Applied Entomology 128: 28-31.

Solinas M., Rebora M., De Cristofaro A., Rotundo G., Girolami V., Mori N., Di Bernardo A. 2001. Functional morphology of *Bactrocera oleae* (Gmel.) (Diptera: Tephritidae) tarsal chemosensilla involved in interactions with the host-plant. Entomologica 35: 103-123.

Tsanakakis, M. E. 1985. Considerations on the possible usefulness of olive fruit fly symbionticides in integrated control in olive groves. In: Cavalloro R. & Crovetti A. “Proceedings of Integrated control in olive groves”CEC7FAO/IOBC Int. Joint Meeting, Pisa 3-6 April, 1984: 386-393.

Tsolakis, H. & Ragusa E. 2002. Prove di controllo di *Bactrocera oleae* (Gmelin) (Diptera Tephritidae) con prodotti a basso impatto ambientale. Phytophaga 12: 141-148.