Three years field trials to assess the effect of kaolin made particle film and copper on olive-fruit fly (*B.oleae* Gmelin) infestations in Sicily

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Summary

In most countries of Mediterranean Basin, Bactrocera oleae (Gmel), *the olive fruit fly, is the key pest insect on olives. In Sicily this pest causes losses of fruits and a poor quality olive oil. Many researchers have recently carried out some field studies which were based on the use of kaolin and copper against the olive-fruit fly. In the last years these products have been effective several times in reducing olive fly infestation. Kaolin had, also, some important effect in reducing heat-stress in fruit crops and olive-trees. The aim of the present study was to assess the effect of kaolin and copper treatment on olive infestations in Sicily and to evaluate chemical and sensory parameters of oils extracted. For this reason, within 2003-2005, the IX Servizio of Assessorato Regionale Agricoltura e Foreste, selected some olive groves where to carry out trials with kaolin and copper and to realize information and divulgation activities.*

Key words: Olive-fruit fly, kaolin, copper, repellent.

Introduction

Olive fruit fly, *B.oleae* (Gmelin), is the key-pest of olive agroecosystem and it represents the major problem for many olive growers of the Mediterranean basin.

Thus, in Sicily, it can severely compromise olive fruit crops and reduce the quality of olive oil produced.

Alternative compounds to synthetic chemical insecticides have been recently used in several laboratory tests and field trials to control *B.oleae* (Gmelin), taking advantage of their repellent nature or anti-ovipositional qualities. (Belcari & Bobbio, 1999; Iannotta, 2001; Baldacchino & Simeone, 2002; Petacchi & Minocci, 2002; Sacchetti et al., 2002; Saour & Makee, 2004; Caleca & Rizzo, 2005; Perri et al.,2005; Rosi et al., 2005).

Among these last compounds, copper and kaolin attracted the interest of many olive growers thanks to their efficacy, shown in several field tests and their relatively simple usage.

Copper is universally known as fungicide and bactericide and it is also listed within the European Council regulation (2092/91) that governs organic farming in all EU member states, even if its use is under review because of environmental concerns, such as the possible build-up in the soil.

Kaolin is a white, nonporous, nonswelling, nonabrasive fine grained platy aluminosolicate mineral that easily disperses in water and is chemically inert over a wide pH range. It could be simply sprayed on crops in a water-based slurry which sticks to plant leaves and fruits forming a white powdery film. All over the world, kaolin film has controlled well over a dozen species of insects and mites. It doesn't interfere with photosynthesis and seems to be able to reduce heat stress and to lower temperature in tree canopy. Because of its white color, kaolin has light reflective properties which could make the plant visually or tactually unrecognizable as a host. (Glenn et al., 1999; U.S.D.A. – A.R.S., 2000). It is also listed in the Annex VI at EEC 2092/91 among the products which may be used in food processing of ingredients of organic agriculture origin.

Both products are mainly used as a physical barrier or repellent against the adults of olive-fruit fly. Copper could also play an important role to break down the epiphytic bacteria populations, which are considered an important source of food for *B. oleae*, and to produce mortality of 1st and 2nd instar larvae of the pest (Belcari e Bobbio, 1999; Sacchetti et al., 2002).

The use of both these substances is unusual against olive-fruit fly but, considering the extremely dangerousness of this insect-pest and the above mentioned features, since 2003, the IX Servizio of Regional Ministry of Agriculture carried out some field-trials whose aim was to assess the effectiveness of kaolin against the olive-fruit fly, comparing it with copper compounds.

Trials were carried out with a kaolin based product (Surround® WP - Engelhard Corporation), containing 95% of kaolin, specially sized and shaped for agriculture and made hydrophobic by a proprietary waterproofing surface treatment. Copper was used as Bordeaux mixture or oxycloride (Manica), containing respectively 15% and 40% of Cu.

Recently, other authors have reported trials where products containing 100% of kaolin, usually utilised for ceramic and other purposes, obtained similar results against *B.oleae* as Surround WP, unless they were affected by rainfall (Caleca & Rizzo, 2005).

Procedures and methodology

The field trials were carried out in four (15/20-yr-old) olive orchards located in the estern part of Sicily. Olive cultivars were Nocellara Etnea, Nocellara Messinese, Brandofino and Carolea (Table 1); they were irrigated and specialized with distances between trees of eight meters or less. In 2003 and 2004 every orchard was treated with kaolin compared to copper and to control. In 2005 kaolin effectiveness was compared to copper and to kaolin in addition to copper (Table 2). In every groves we choose 30 plants per thesis. Monitoring of adult flies was weekly done by the means of feromone traps. Active (Eggs+L1+L2+L3) and total (Active+Pupae+Exit holes+Sting scars+Mortality) infestations were determined weekly or every two weeks, sampling 100 olives from ten plants of each thesis. The chosen threshold of intervention was 3% infestation.

Kaolin particle-film was sprayed in dose of 3 kg in 100 liter of water and copper in dose of 150-200 gr Cu/l.

Both of them were sprayed mixed together in 2005 trial, using same concentrations in 100 litre of water.

Table 1.

Place	**Farm**	**Elevation (m)**	**Cultivar**
Motta S.Anastasia (CT)	Sapienza	150	Nocellara etnea
Sortino (SR)	Salemi	120	Nocellara messinese
Randazzo (CT)	Del Campo	650	Brandofino
Linguaglossa (CT)	Scilio	580	Brandofino-Carolea

Table 2.

Site/Year	**Control**	**1° thesis**	**2° thesis**	**3° thesis**
Motta S.A./2003	Not treated	Kaolin (Surround WP)	Copper (bordeaux m.)	-
Motta S.A./2004	Not treated	Kaolin (Surround WP)	Copper (bordeaux m.)	-
Sortino/2004	Not treated	Kaolin (Surround WP)	Copper (bordeaux m.)	-
Randazzo/2004	Not treated	Kaolin (Surround WP)	Copper (bordeaux m.)	-
Linguaglossa/2005	Not treated	Kaolin (Surround WP)	Copper (oxycloride)	copper+kaolin
Sortino/2005	Not treated	Kaolin (Surround WP)	Copper (bordeaux m.)	-

Results and discussion

2003 trials

During this year the extremely high summer temperature reduced dramatically the presence of the pest all over the country (Figure 1). In the olive grove located in Motta S.Anastasia (CT), where the cultivar was Nocellara Etnea, harvest occourred in late October so we decided, together with the olive-grower, not to harvest in a part of the grove, waiting for a possible later infestation.

Only in the November 3rd we detected the 3% active infestation (Figure 2) and so we proceeded to a treatment on three rows of twelve plants each.

The chosen rows were at a margin of the olive-orchard: the former was treated with kaolin (Surrond WP), the second one with bordeaux mixture (Manica) and the latter was not treated as control. Before the treatment, from each row we sampled 100 olives and we calculated the relative infestation level. The kaolin treated row was at 15 % infestation, probably because of an edge effect; the copper treated row has a 9 % infestation and the control a 3 % infestation.

After one month kaolin and copper treated plants showed lower infestation level despite of an incipient infestation affecting the control row (Figures 3 - 4).

During this period we registered some heavy precipitations which partially washed away kaolin and copper as well (Figure 1).

In the olive grove located in Sortino (SR) there was not any infestation because of warm weather and so we didn't proceed in our trial.

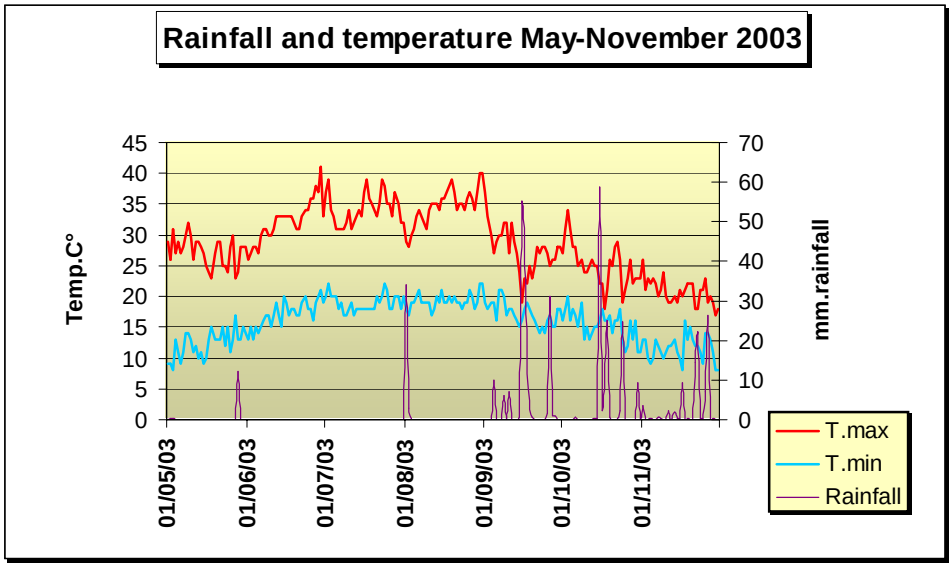

Figure 1. Total daily rainfall recorded in Motta S.Anastasia within May-November 2005

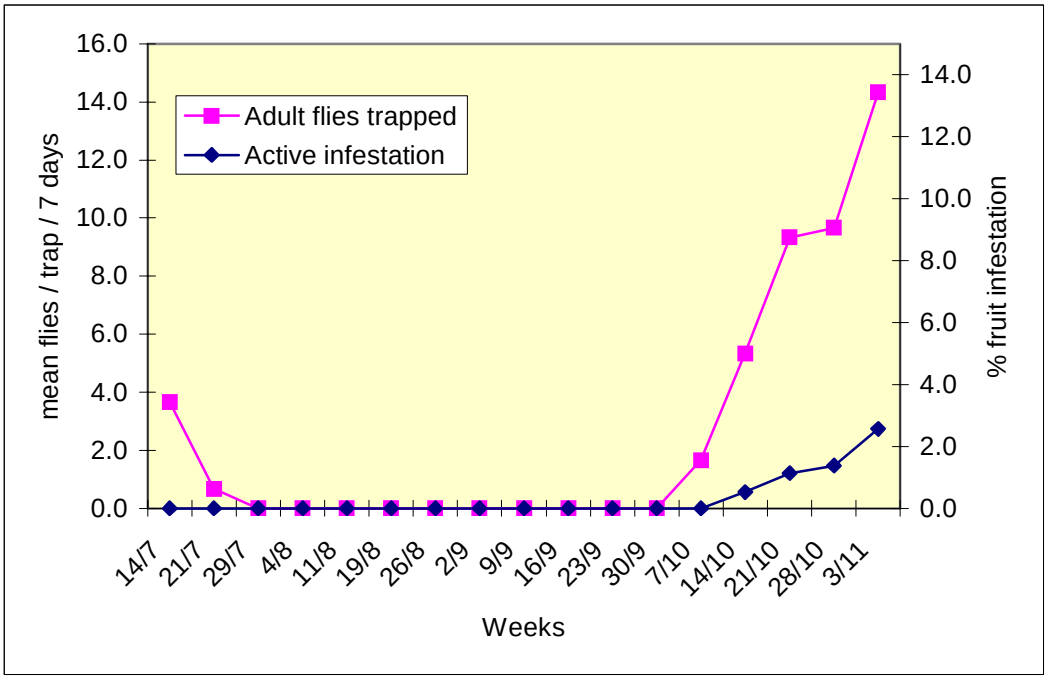

Figure 2. Trend of active olives infestation compared to number of adult flies captured in pheromone traps before first treatment in Motta S.Anastasia.

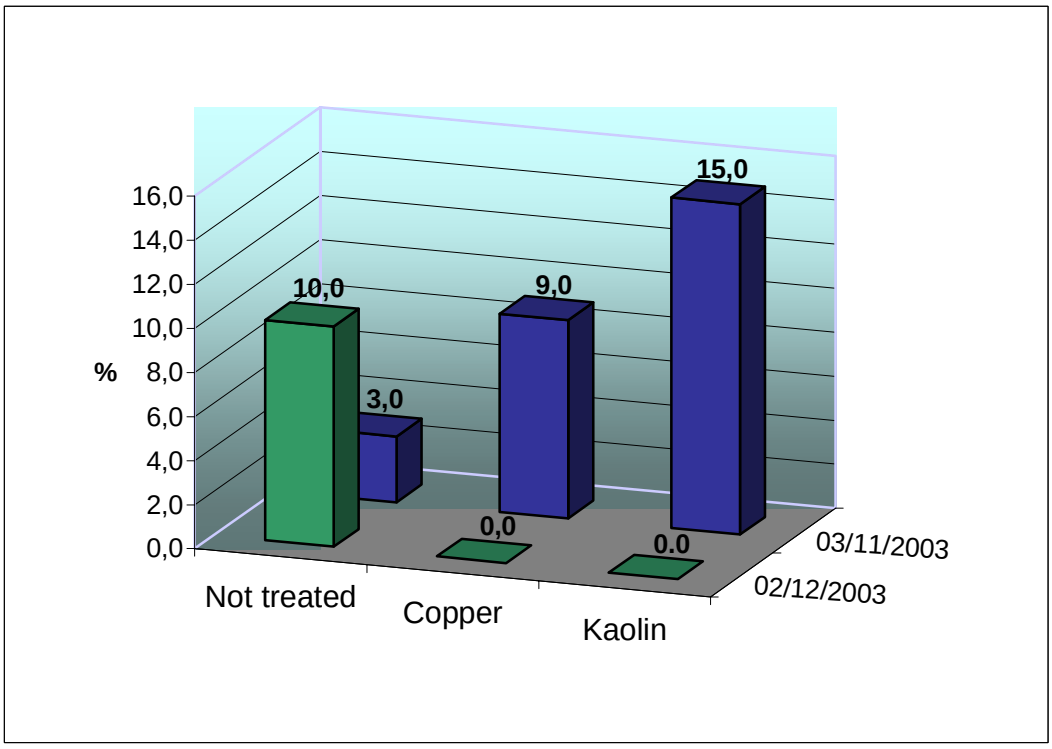

Figure 3. Differences of active olives infestation among treated and untreated plants in Motta S.Anastasia, cv. Nocellara Etnea, before and one month after treatment.

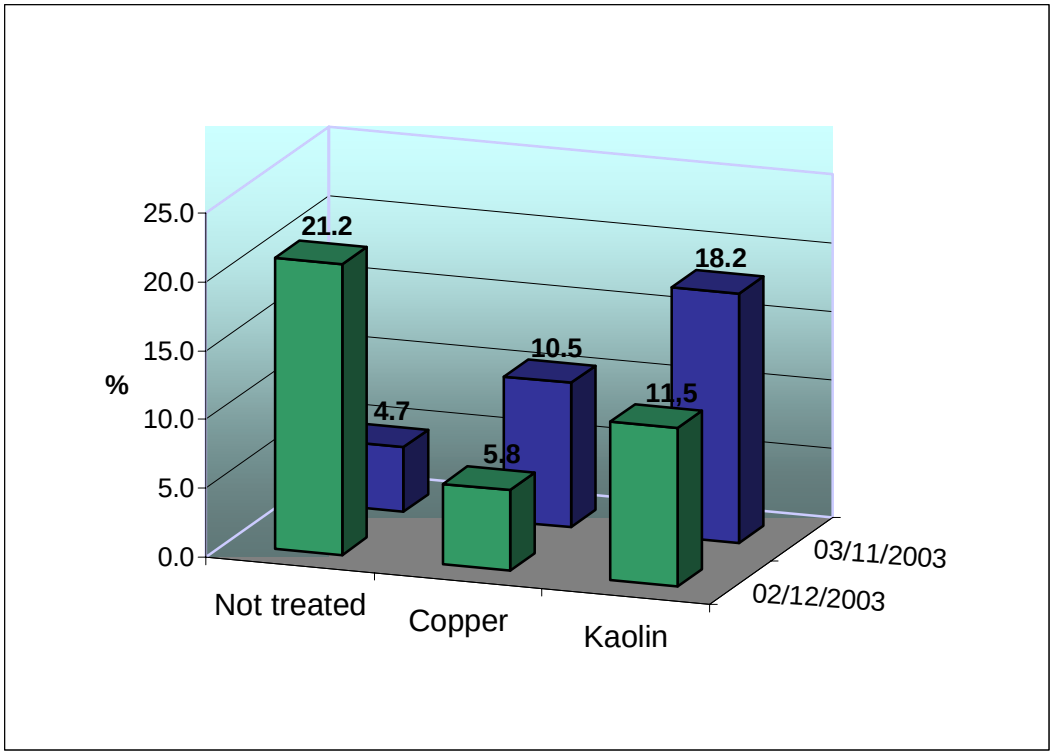

Figure 4. Differences of total olives infestation among treated and untreated plants in Motta S.Anastasia, cv. Nocellara Etnea, before and one month after treatment.

2004 trials

This year was characterized by a massive olive fruit fly infestation: in October mean captures of males by pheromone traps reached 50 – 60 individuals per week.

The number of olives attacked was always higher in untreated plants compared to kaolin or copper treated ones: at Randazzo, at harvest, they respectively reached 86%, 21% and 48% of total infestation. In this site a second treatment on plants belonging to copper thesis was realized the 15th of September as their infestation was already 10-15%. (Figures 5 – 6)

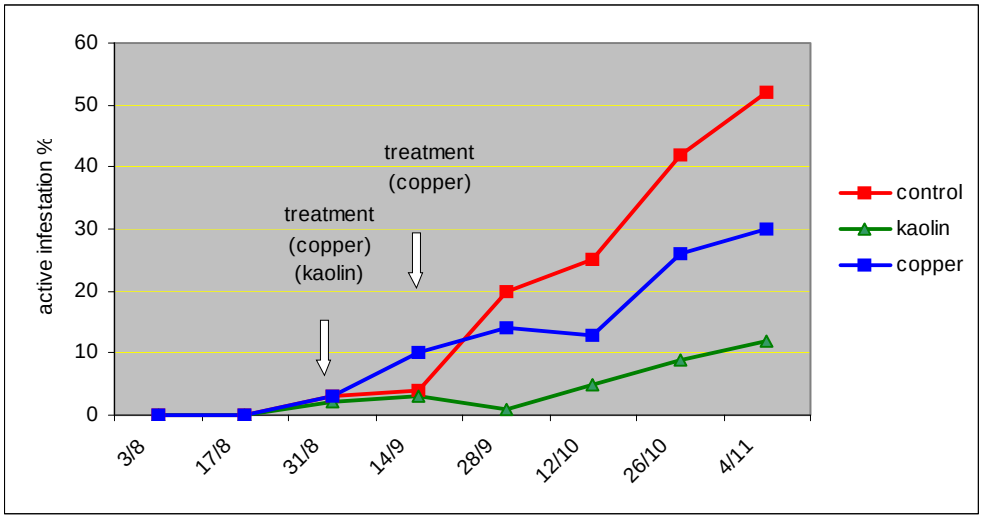

Figure 5. Trend of active infestation detected in olive-fruit samples of each thesis at Randazzo farm in 2004

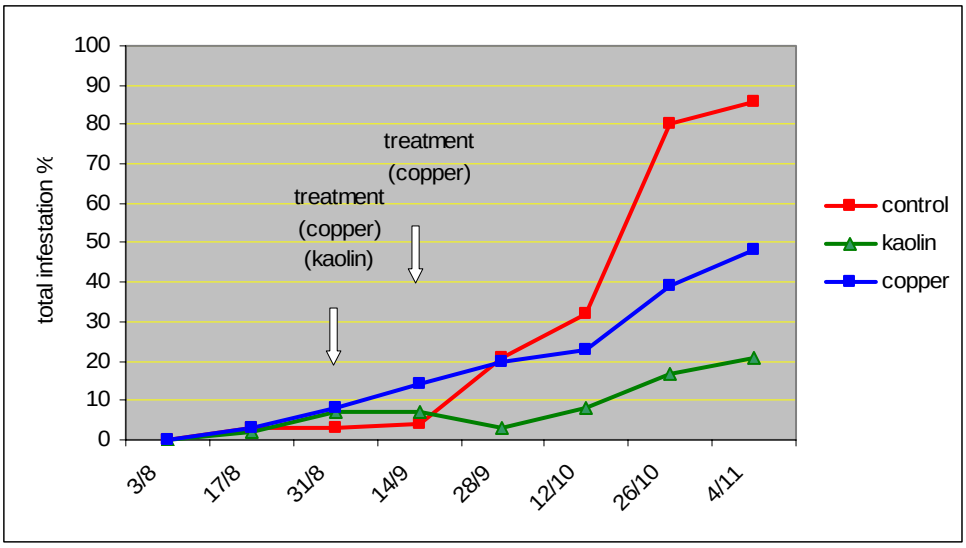

Figure 6. Trend of total infestation detected in olive-fruit samples of each thesis at Randazzo farm in 2004

At Motta S.Anastasia we made two treatments: the former was made in the 4th of August, the second in the 7th of September. After that, copper was partially washed away by rainfalls of 30 mm distributed in three rainy days, whereas kaolin particle-film showed to be very adhesive to the olives surface. Thus, active and total infestations gradually increased in copper thesis and in the untreated as well, reaching, at the 19th of October, 43-44% (percentage of active infestation for copper and control) and 55-80% (percentage of total infestation for copper and control respectively). At the same date percentage of active and total infestations of kaolin treated trees were 11% and 32%. At harvest there was not any difference among kaolin sprayed trees and other two thesis because of a fall of damaged fruit occurred both in copper and untreated plants (Figures 7 -8).

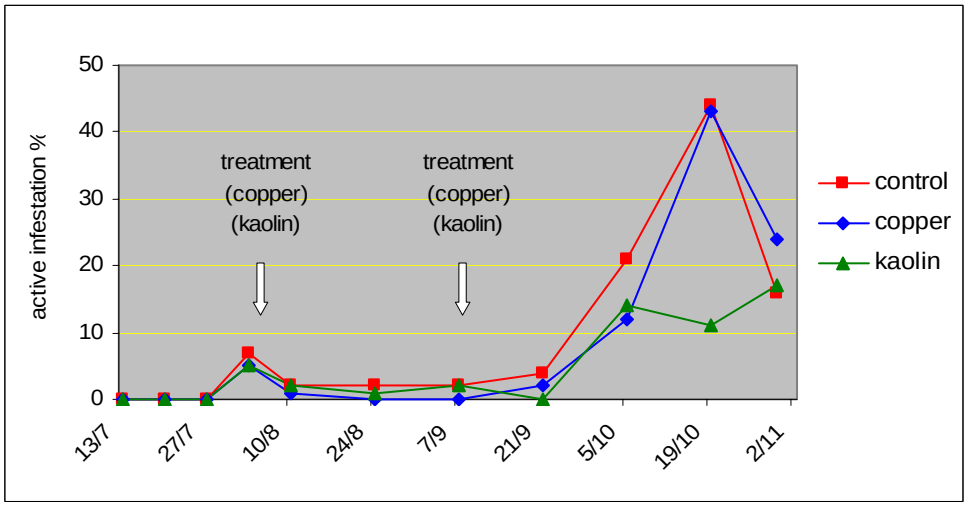

Figure 7. Trend of active infestation detected in olive-fruit samples of each thesis at Motta S.Anastasia farm in 2004

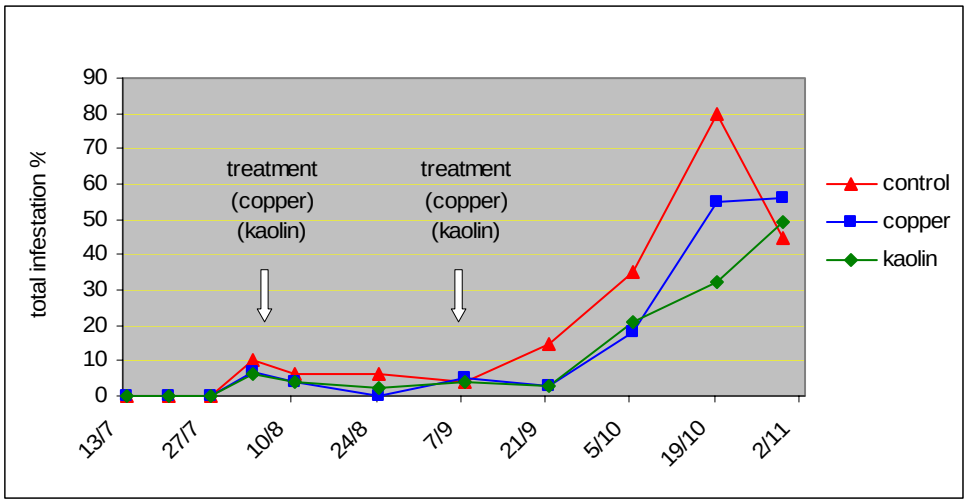

Figure 8. Trend of total infestation detected in olive-fruit samples of each thesis at Motta S.Anastasia farm in 2004.

In Sortino, copper treatment protected olives a little bit better than kaolin during the first three weeks after spraying but it reduced its grade of protection after 35 mm of rainfall distributed in three rainy days. Considering that at this time kaolin particle-film was still abundant on olives we decided to proceed only to a second copper treatment in September 29th (Figures 9 -10). At harvest, total infestation was considerably higher in the control trees than in those treated. Surround Wp and bordeaux mixture were both effective limiting *B.oleae* infestation at a 10-23% of olives instead of a 24-50% of untreated ones.

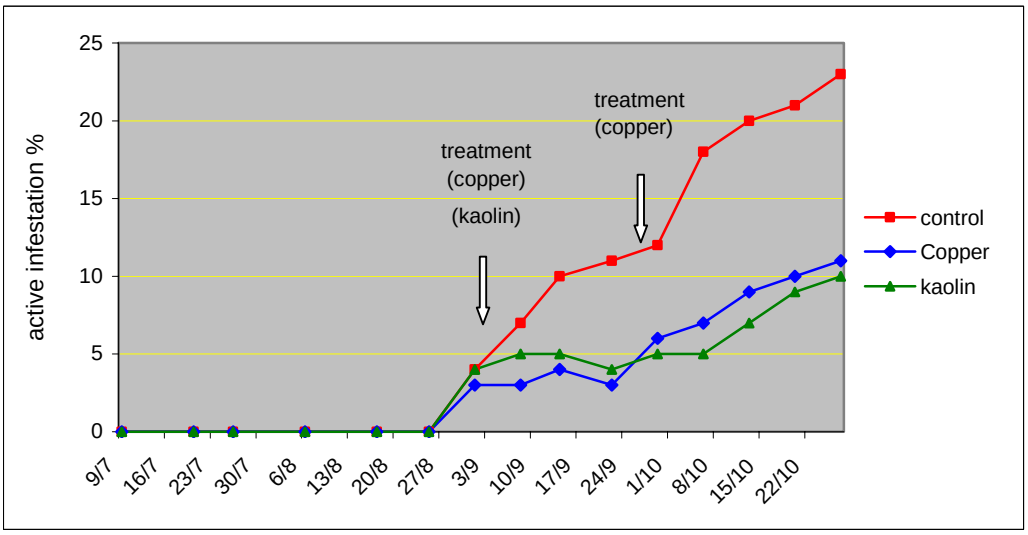

Figure 9. Trend of active infestation detected in olive-fruit samples of each thesis at Sortino farm in 2004

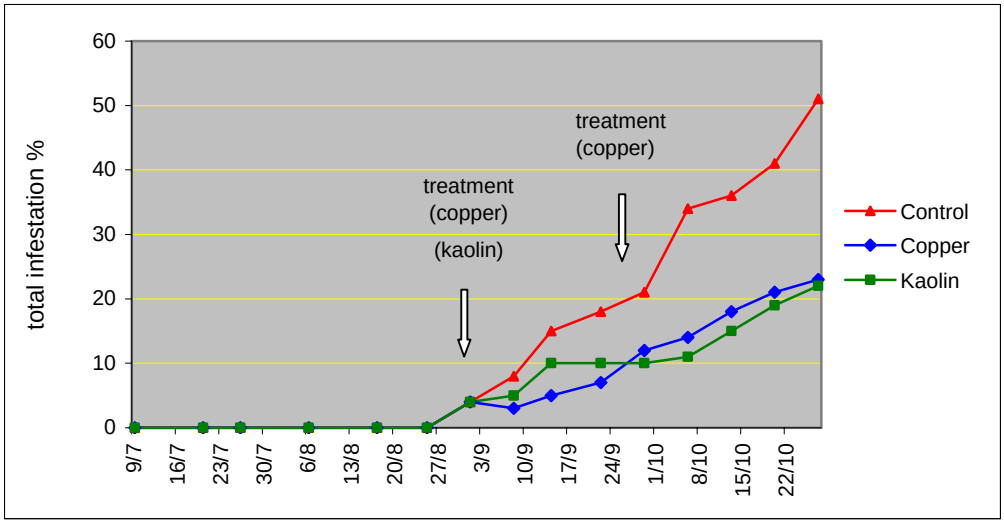

Figure 10. Trend of total infestation detected in olive-fruit samples of each thesis at Sortino farm in 2004

2005 trials

In this year the trials were carried out on two farms. In Linguaglossa, the season was very rainy in September and October. In this site we scheduled to compare the untreated control to three thesis as we decided to use a mixture where kaolin was added to copper. As in the previous trials, copper was not able to protect the plants during the whole period and so it was sprayed two times.

Both kaolin and copper/kaolin mixture treated plants showed lower infestation levels than copper sprayed and unsprayed ones. Copper/kaolin treatment performed better than kaolin for a long period even after some rainy days. Nevertheless, it gradually lost its protection features and that was particularly evident after a huge rainfall (263 mm the 22nd of October).(Figures 11 – 12)

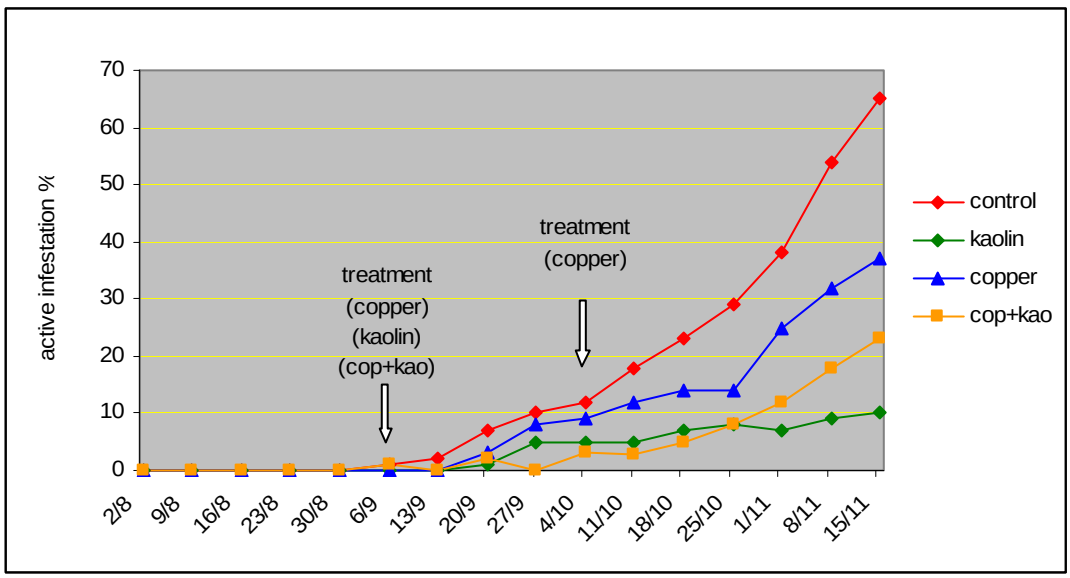

Figure 11. Trend of active infestation detected in olive-fruit samples of each thesis at Linguaglossa farm in 2005

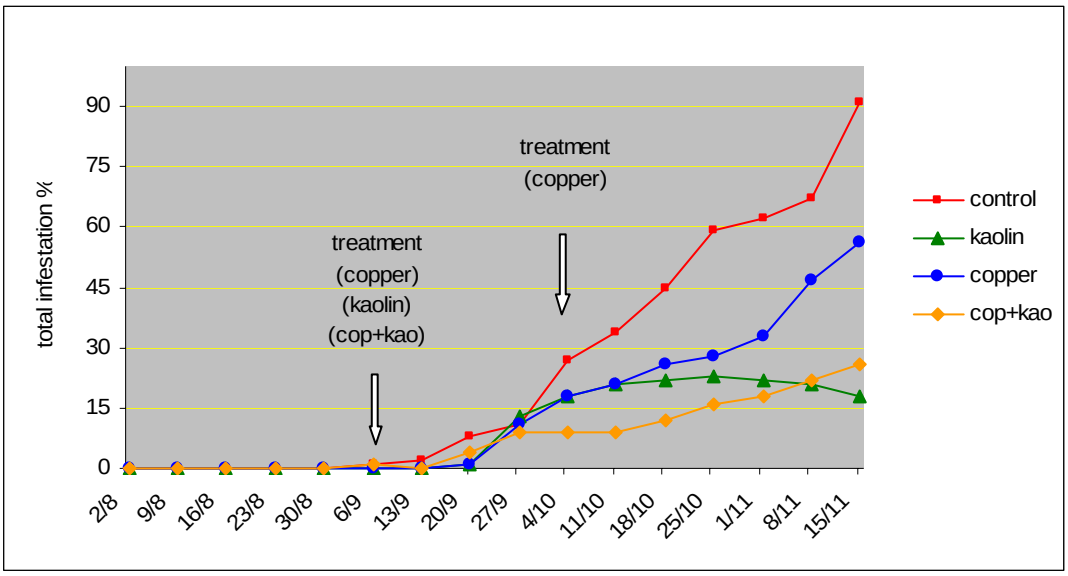

Figure 12. Trend of total infestation detected in olive-fruit samples of each thesis at Linguaglossa farm in 2005

As regard the Sortino farm, olive-fly infestation was, once more, lower in kaolin and copper thesis than that affecting the olives belonging to the control. Treatments were performed the Spetember 19th. At the end of the growing season the olives of Noccellara Messinese protected by kaolin showed a 18% of total infestation compared to 27% of copper treated ones and 39% of unsprayed olives. (Figure 13 – 14)

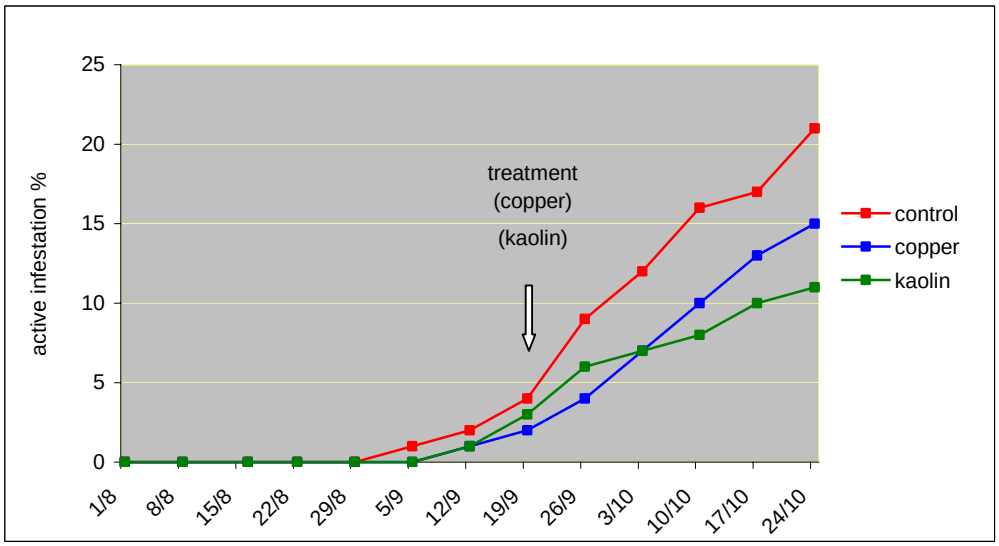

Figure 13. Trend of active infestation detected in olive-fruit samples of each thesis at Sortino farm in 2005

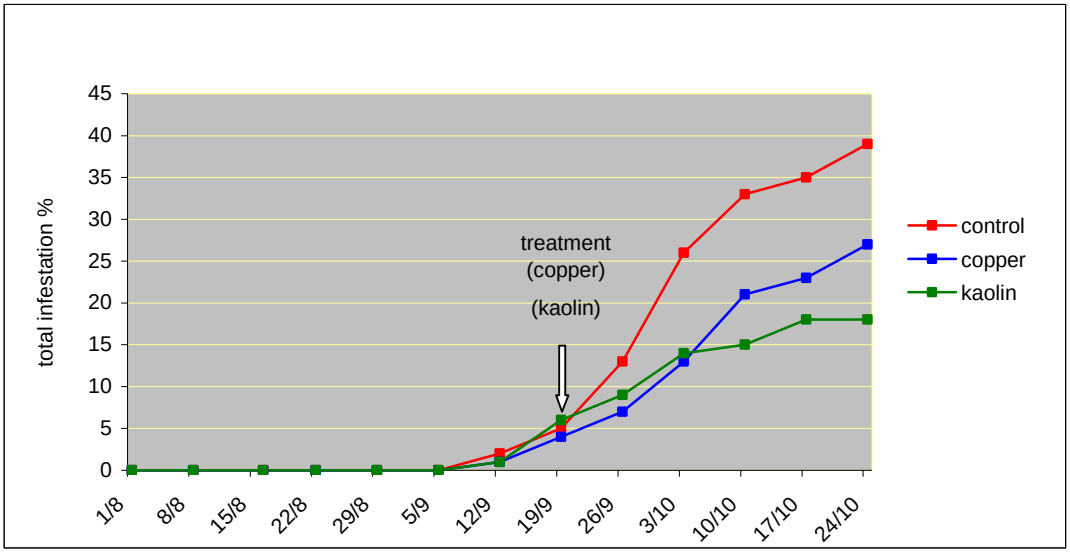

Figure 14. Trend of total infestation detected in olive-fruit samples of each thesis at Sortino farm in 2005

Olive oil quality

Starting from 2004 the determination of olive oil main chemical, fisical and sensory parameters was made by sampling and analyzing oils extracted from olives of each thesis. Extraction was made, within 6/12 hours from harvest, in olive oil mills working by continuos methods. Oils were packed in 250 ml. dark bottles and sent to CRA ISOL laboratory for analytical and sensory determinations.

With the exception of one sample, all the olive oils sensory and analytical features were conformed to virgin extra classification according to EC Reg.n.2568/91 and further modifications (Tables 3 - 4 -5). Fatty acid compositions agreeded or slightly differed with the mean values reported in other works as characteristics of the cultivars. (Regione Siciliana, A.A.F.F., IX Servizio, unpublished data).

Table 3. Mean values of olive oil free acidity, peroxide index and UV spectrophotometry for each treatment

CULTIVAR	SITE / YEAR	THESIS	FREE ACIDITY %	PEROXIDE INDEX (meqO2/kg)	K 232	K270	ΔK
Nocellara etnea	Motta S. Anastasia / 2004	Control	0.3	7.7	1.397	0.130	0.001
Nocellara etnea	Motta S. Anastasia / 2004	Copper	0.3	6.4	1.807	0.157	0.001
Nocellara etnea	Motta S. Anastasia / 2004	Kaolin	0.4	7.0	1.657	0.145	0.001
Brandofino	Randazzo / 2004	Control	1.1	8.5	2.250	0.122	-0.002
Brandofino	Randazzo / 2004	Kaolin	0.4	11.3	2.029	0.116	-0.002
Brandofino	Randazzo / 2004	Copper	0.7	8.7	2.126	0.125	-0.001
Brandofino-Carolea	Linguaglossa / 2005	Control	0.7	6.3	2.488	0.124	0.000
Brandofino-Carolea	Linguaglossa / 2005	Kaol + Copp	0.3	7.0	2.455	0.143	0.000
Brandofino-Carolea	Linguaglossa / 2005	Kaolin	0.3	6.0	1.160	0.042	-0.002
Brandofino-Carolea	Linguaglossa / 2005	Copper	0.3	7.3	1.865	0.456	0.000

Table 4. Fatty acids mean values for each treatment and cultivar

CULTIVAR / YEAR	THESIS	C 14:0	C16:0	C17:0	C17:1	C18:0	C18:1	C18:2	C18:3	C20:0	C20:1	C22:0	C24:0
Nocellara etnea – 04	Control	0.013	12.205	0.201	0.341	2.480	67.650	14.312	0.882	0.499	0.376	0.014	0.140
Nocellara etnea – 04	Copper	0.013	12.578	0.171	0.293	2.540	68.545	13.084	0.789	0.489	0.339	0.014	0.147
Nocellara etnea – 04	Kaolin	0.014	13.216	0.180	0.332	2.381	68.225	12.661	0.854	0.502	0.364	0.014	0.139
Brandofino – 04	Control	0.008	11.206	0.134	0.243	1.767	73.483	10.998	0.637	0.350	0.319	0.003	0.098
Brandofino – 04	Kaolin	0.008	11.560	0.154	0.225	1.789	72.564	10.369	0.547	0.423	0.221	0.004	0.010
Brandofino – 04	Copper	0.009	11.630	0.120	0.223	1.857	72.351	11.069	0.743	0.376	0.358	0.016	0.114
Brandofino-Carolea - 05	Control	0.007	8.501	0.074	0.160	0.518	81.550	6.173	0.700	0.389	0.458	0.005	0.133
Brandofino-Carolea - 05	Kaol + Copp	0.008	8.789	0.081	0.155	0.799	80.151	7.051	0.706	0.379	0.420	0.005	0.124
Brandofino-Carolea - 05	Kaolin	0.009	10.173	0.068	0.153	0.785	78.894	6.627	0.641	0.372	0.398	0.005	0.131
Brandofino-Carolea -05	Copper	0.008	11.404	0.028	0.068	1.023	74.301	9.530	0.608	0.367	0.307	0.014	0.140

Table 5. Mean values of poliphenols and tocopherols for each treatment and cultivar

CULTIVAR / YEAR	THESIS	Total Phenols (mg/kg)	Tocopherols (mg/kg)				
			α	β	γ	δ	Total
Nocellara etnea - 04	Control	100.23	324.07	2.67	11.37	39.05	377.16
Nocellara etnea - 04	Copper	148.95	292.74	0.63	3.79	4.79	301.95
Nocellara etnea - 04	Kaolin	110.11	283.39	0.83	8.35	32.89	325.46
Brandofino - 04	Control	117.88	210.31	0.78	6.31	25.42	242.82
Brandofino - 04	Kaolin	63.52	215.79	1.17	4.16	28.47	249.59
Brandofino - 04	Copper	80.46	194.22	0.63	5.59	2.68	203.12
Brandofino-Carolea - 05	Control	134.86	175.05	1.57	4.63	11.79	193.04
Brandofino-Carolea - 05	Kaol + Copp	201.48	166.82	3.95	6.94	102.14	279.86
Brandofino-Carolea - 05	Kaolin	115.27	181.98	3.19	2.03	86.08	273.28
Brandofino-Carolea - 05	Copper	97.19	169.56	1.62	1.78	24.75	197.72

Conclusions

The data collected during three years trials carried out in different farms and with different cultivars seem to show an evident effectiveness of two tested compounds. A different olive-fruit fly control was detected among them only after rainfalls that washed copper away more than kaolin film-particle.

Olive oils quality obtained by each sample confirms that an olive-fruit fly control strategy based on the use of this two products could be adopted with interesting results especially when coupled to an early harvesting.

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References

Baldacchino F., Simeone V., 2002 – Prove d'efficacia di sostanze repellenti nel controllo di *Bactrocera oleae* (Gmelin) in olivicoltura biologica – Proceedings of "XIX Congresso Nazionale Italiano di Entomologia", Catania 10-15 Giugno 2002: 1487-1491.

Belcari A., Bobbio E., 1999 - L'impiego del rame nel controllo della mosca delle olive, *Bactrocera oleae*. Informatore Fitopatologico, 12: 52-55.

Caleca V., Rizzo R., 2005 - Tests on the effectiveness of kaolin and copper hydroxide in the control of *Bactrocera oleae* (Gmelin). 2° European Meeting of the IOBC/WPRS Study Group "Itegrated Protection of Olive Crops", Florence, October 26-28. (in print)

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. J.Econ.Entomol. 92 (4): 759-771.

Iannotta N., 2001 - Esperienze di lotta contro *Bactrocera oleae* (Gmel.) con metodi conformi al Reg.Cee 2092/91 – Proceedings of "L'olivicoltura biologica e la lotta contro la mosca delle olive", Pisa 24 Aprile 2001. http://ento.sssup.it/olivoBio/relazioni/Iannotta.htm

Pennino G., Cartabellotta D., Di Martino V., 2004 - Effect of kaolin and copper on olive-fly infestations in Sicily. Proceedings of "V Jornadas Internacionales de l'Olivar Ecologico: Producion y Cultura", Puente de Genave, 21 Mayo 2004. (in print)

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

Perri E., Russo A., Caravita M.A., Pellegrino M., Parise A., Tucci P., Pennino G., Di Martino V. , Cartabellotta D., G. Giordano, 2005 - Caratteristiche qualitative degli oli di oliva da agricoltura biologica siciliani ottenuti da piante sottoposte a trattamento con caolino. VII Convegno Nazionale sulla Biodiversità, Catania 31 Marzo - 02 Aprile 2005. (in print)

Sacchetti P., Belcari A., Del Pianta R., 2002 – Utilizzo di prodotti ad azione antibatterica per il controllo della mosca delle olive. Proceedings of "La difesa dai fitofagi in condizioni di olivicoltura biologica", Spoleto 29-30 ottobre 2002.

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.

U.S.D.A./A.R.S., 2000 - Agricultural Research Magazine, Vol. 48, No. 11, http://www.ars.usda.gov/is/AR/archive/nov00/white1100.htm