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Vegetable, fish and mineral oils control grapevine powdery mildew

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Summary. Laboratory, greenhouse and field experiments were performed on vegetable, fish and mineral oils to evaluate their phytotoxic effects on grapevine and their effectiveness in the control of grapevine powdery mildew. None of the oils tested showed detectable phytotoxic effects at concentrations of 2% or less applied up to 4 times per week. In greenhouse trials, the efficacy of paraffin oil, refined rapeseed oil and partially refined fish oil against powdery mildew was similar to that obtained with the standard fungicides (tebuconazole or colloidal sulphur). In field trials, the three oils tested (paraffin oil, crude soya oil, and fish oil: 1% in aqueous emulsion) were at least as effective as the standard fungicide Quinoxifen, with crude soya oil being the most effective. The oils used in the field trials were also effective for controlling eriophyd mites such as *Calepitrimerus vitis*.

Key words: IPM, *Vitis vinifera*, *Uncinula necator*, *Oidium*, *Calepitrimerus*.

Introduction

Pest and disease control in vineyards is mostly based on synthetic chemicals but there is an increasing trend to favour products with a less severe impact on the environment and on human and animal health. Mineral oils have been used in crop protection for many years, mainly as insecticides against winter phases of mites, scale insects and mealybugs (Metcalf *et al.*, 1962; Chapman, 1967). Due to phytotoxicity problems they were used only during winter periods on woody plants, until the introduction of "summer oils" (i.e. narrow-range mineral oils). In addition, vegetable and fish oils are now being used in some crops, mainly as fungicides, with promising results. These oils are natural products composed of the fatty acid esters of glycerol. As an alternative to synthetic fungicides and insecticides they are especially attractive to home gardeners (Horst *et al.*, 1992; Osnaya and Schlöser, 1998) and organic producers, because refined vegetable and fish oils are now readily available and safe for human consumption. The main advantages of using oils for the control of plant diseases in agricultural crops are good control at low doses for some pest and pathogens, low cost, excellent spreading and sticking properties on leaf surfaces, and little or no toxicity to animals and some auxiliary organisms.

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The main disadvantage of oils is their phytotoxicity to some crops, so that before testing the biocidal efficacy of a natural oil it is first necessary to assess its phytotoxic effect at different doses and under different conditions (Finger *et al*., 2002).

Although at present oils are not widely used in vineyards of Europe, there have been recent reports of their use in several countries. Some authors have used mineral oils for the control of various pathogens in grapevine (Northover and Schneider, 1996; Dell *et al*., 1998; Wicks *et al*., 1999). In other crops, non-mineral oils have given good results against powdery mildew and leaf spot fungi (Northover and Schneider, 1993; Osnaya and Schlösser, 1998; McGrath and Shishkoff, 1999) and against insects and mites (Beattie *et al*., 1999, 2002).

In the present study, we investigated the phytotoxic effects of various natural oils in grapevine, and assessed the efficacy of these oils for the control of powdery mildew in this crop. Specifically, two sets of experiments were performed in 2000 and 2001 under laboratory, greenhouse and open-field conditions. For comparative purposes the study included not only vegetable and fish oils, but also mineral (paraffin) oil, which was more extensively characterized.

Materials and methods

Plant material

Depending on the experiments performed in two consecutive years (2000 and 2001) the following plant materials were used: 4-months-old grapevine plants (cultivar Mencía) planted in 300 cm^3 pots (growth chamber and greenhouse experiments); 2-year old Mencía plants (phytotoxicity experiments in the field); detached Mencía mature leaves (effect of oils on germination of conidia of *O. tuckeri*: laboratory experiment); 9-year-old cv. Tempranillo plants (spacing 3×3 m^2) in a vineyard in El Pego, Zamora Province (oil efficacy against powder mildew in the field).

Oils

The oils used in the phytotoxicity experiments and for the control of powder mildew were the following: SunSpray Ultrafine 85% w:v (Sun Oil Company, Aartselaar, Belgium; distributed in Spain by Agrichem S.A.), a high-purity paraffin oil; Codacide 95% w:w (Microcide Limited, Suffolk, United Kingdon; distributed in Spain by Agrodan S.A.), an emulsified oil based on polyethoxylated esters of rape-seed (*Brassica napus* L.); AP- 117, a crude fish oil, and AP-121, a crude oil partially refined with 0.2° acidity (A.F.A.M.S.A., Vigo, Spain), both oils used in the food industry; a crude and a refined soya and rapeseed oils (M.O.Y.R.E.S.A., A Coruña, Spain). All fish and vegetal oils (except Codacide) were mixed with 10% Tween 20® prior their use. All oils were applied as emulsions in distilled water.

Growth-chamber phytotoxicity experiments

Two experiments were carried out with grapevine plants maintained at 24ºC day/15ºC night with a 16-h photoperiod. In the first replicate four oils were tested: paraffin, rapeseed (codacide), AP-117 and AP-121 fish oils; in the second replicate crude fish oil (AP-117) was eliminated because of its foul smell and viscosity. The oils were tested at 0.25, 0.5, 1 and 2%, with 8 plants per oil and treatment, plus 8 control plants sprayed with distilled water (total 136 or 104 plants), randomly distributed in the growth chamber. The plants were sprayed weekly for six weeks and data were recorded one week after the last spraying. A separate hand-held aerosol sprayer for each type of oil was used and during spraying the spraying nozzles were held approximately 30 cm away from the plants; for spraying the pots were temporarly removed from their positions in the growth chamber to avoid spray drift and cross-contamination, and were then returned. The general condition of the plants was monitored and a number of parameters were evaluated: length of shoots, number of leaves, number of internodes, and leaf area. Statistical analysis of these data was by one-way ANOVA, followed by LSD tests.

Phytotoxicity in the field

Paraffine, rapeseed (Codacide) and AP-121 fish oil, were applied at concentration as above, to 91 plants planted at 250×50 cm (7 plants per treatment, plus 7 control plants sprayed with distilled water). Spraying was started when the shoots were 10 cm long, and was continued weekly for 6 weeks. Net photosynthesis, stomatic conductance and transpiration rate were estimated on the basis of measurements taken at noon, on sunny days, from three leaves per plant, using an Infrared gas analyzer (ADC-LCA-3) equipped with a Parkinson PLC-2 leaf chamber. Statistical analysis of these data was by one-way ANOVA, followed by LSD tests.

Post-infection effectiveness of oils against grapevine powdery mildew in greenhouse

Three oils were tested (paraffin, rapeseed, fish), at 1% v:v. To obtain plants with powdery mildew infection, grapevine leaves with conidia of *Oidium tuckeri* Berk. were brushed into 100 ml of distilled water plus two drops of Tween 20® and the resulting suspension was sprayed on the test plants. The plants were then placed in a growth-chamber at 25ºC with faint light; and the relative humidity was maintained at over 90% with a plastic tunnel and a humidifier running continuously. After this, the pots were placed in the glasshouse. As soon as powdery mildew symptoms were evident, three leaves from each plant were selected and tagged, and the affected leaf area was evaluated. The plants were then sprayed (8 plants per treatment, plus eight control plants sprayed with distilled water). In addition, two sets of 8 plants were sprayed with two standard commercial fungicides: a systemic compound (Folicur® 25 EW, containing tebuconazole at 25%) at the suggested concentration of 0.05% v:v, and a colloidal sulphur (Spersul 80% w:w) at 0.3 g l^{-1}. In all cases plants were sprayed only once and the leaf area affected on the same three leaves was evaluated after one and two weeks. The data were analysed by one-way ANOVA, followed by a LSD test (5% significance level).

Effect of oils on germination of conidia of *O. tuckeri*

A suspension of conidia of *O. tuckeri* was prepared as previously reported and sprayed onto mature leaves collected from the field. Two hours later, ten leaves were sprayed with each oil emulsion using hand-held aerosol sprayers. Sprayed leaves were placed in plastic beakers with their petioles dipped in water, and maintained in the laboratory at 21–24ºC, with high humidity and faint light to favour conidia germination. At 2, 4 and 6 days after inoculation, we counted the number of germinated conidia on the surface of each leaf (back side, right half) using a stereomicroscope.

Efficacy of oils against grapevine powdery mildew in the field

The three oils (i.e. paraffin, crude soya and AP-121) that showed the best protective effect in the experiment on detached leaves were applied on 9-year-old Tempranillo vines. The oils were assessed when used alone and when used in combination with Quinoxifen (Arius®) a synthetic fungicide commonly applied to prevent powdery mildew in the field. When combined, the application dose of both the oil and the Quinoxifen was halved. Thus the 8 treatments tested were: (1) paraffin oil at 1%; (2) AP-121 at 1%; (3) crude soya oil at 1%; (4) paraffin oil at 0.5% + Quinoxifen at 0.15 ml l^{-1}; (5) fish oil at 0.5% + Quinoxifen at 0.15 ml l^{-1}; (6) crude soya oil at 0.5% + Quinoxifen at 0.15 ml l^{-1}; (7) Quinoxifen at 0.30 cc l^{-1} and (8) unsprayed control. As noted, the fish and soya oils were mixed with 10% Tween 20® before preparing the emulsion in water. A completely randomized block experimental design was used, with 4 blocks (4 plots per treatment) and 8 treatments. Individual plots consisted of 10 plants in two rows of 5 plants each. The treatments were first applied after bloom and fruit set and each treatment was applied four times at two-week intervals (16 June, 30 June, 15 July, 30 July) at approximately 400 l ha^{-1} using a back-pack power sprayer operating at 10 atm. After the first spraying some phytotoxicity symptoms were observed at the end of June; therefore the spraying time for the remaining three applications was carefully chosen to avoid the hottest hours of the day.

Experimental plots were checked weekly for vine phytotoxicity and powdery mildew infection. Powdery mildew symptoms first appeared on the leaves (not on the berries) at the end of July, after a few days of heavy rains. Both phytotoxicity symptoms and infection symptoms were quantified using the Barrat-Horsfal scale which ranges from 0 to 11 (0; 1, <3%; 2, 3–6%; 3, 6–12%; 4, 12–25%; 5, 25–50%; 6, 50–75%; 7, 75–87%; 8, 87–93%; 9, 93–97%; 10, >97%; 11, 100%) (Horsfal and Barrat, 1945). Thirty leaves per plot were assessed (5 leaves per plant from the 6 most central plants in the plot). Bunches were to be evaluated in a similar way but no symptoms of powdery mildew appeared in the control plants. In addition, in young vine leaves the characteristic symptoms of infection by the eriophid mite *Calepitrimerus vi-*

tis were observed during assessment prior to treatment. The effect of the treatments on this mite was thus also assessed weekly, by estimating the proportion of mite-infected leaves with respect to the total number of leaves on the plant. Statistical analysis of the data collected was by one-way ANOVA, followed by LSD tests.

By the end of June various species of thrips (Thysanoptera) and leaf-hoppers (Homoptera: Cicadellidae) were observed feeding on the vine plants. To compare the abundance of these insects among the oil-sprayed and control plots, two yellow and two blue sticky traps were placed on 1 July in the central area of each of the 4 plots per treatment. The traps were collected two days later and the number of thrips captured in the blue traps and leaf-hoppers captured in the yellow traps were counted (separately on each side of each trap).

Results

Phytotoxicity trials

None of the oils tested showed major phytotoxic effects in any of the experiments. In the growth-chamber, none of the phytotoxicity indicators evaluated (length of shoots, number of leaves, number of internodes, leaf area) differed significantly (5% level) from the corresponding control values. At the end of the assay, some changes consisting in leaf border reddening or light necrosis on the nerves were observed in oldest leaves of the plants sprayed with the highest doses (2%) but these changes had no evident effects on the plant growth. In field experiment, CO_2 exchange was significantly lower than in control plants (P<0.05%) after 6 treatments with oils at 2%, the highest dose: however, no significant effects were detected in plants sprayed with oils at lower doses or after only 4 treatments (Tables 1 and 2). Stomatic conductance and transpiration rate were significantly lower for the water control after the first 4 treatments, but at the end of the assay there were not significant differences among oils and comparing to the water control at any doses (Tables 1 and 2).

Post-infection efficacy trials

All three oils (paraffin, rapeseed, and fish oil; 1% v:v) significantly reduced the percentage of leaf area with powdery mildew (Fig. 1). Stereomicroscopic examination of the leaves showed that both

Table 1. Mean and standard deviations of the parameters analysed in the field phytotoxicity assay, one week after the fourth treatment. Transpiration rate in mol/(m^2·seg), stomatic conductivity in mol/(m·seg) and CO_2 exchange in μmol/(m^2·seg).

Parameter	Treatment	Dose				
		0.25%	0.5%	1%	2%	Mean[a]
Transpiration rate	SunSpray	3.39±0.06	3.19±0.09	3.39±0.05	3.62±0.06	3.40 c
	Codacide	3.56±0.09	3.69±0.07	3.80±0.07	3.95±0.16	3.75 b
	Afamsa 121	4.06±0.12	3.90±0.09	3.88±0.07	3.87±0.08	3.93 a
	Control	3.03±0.11	—	—	—	3.03 d
	Doses mean[a]	3.67 c	3.59 d	3.69 b	3.81 a	
Stomatic conductivity	SunSpray	0.099±0.005	0.092±0.005	0.092±0.003	0.102±0.003	0.096 b
	Codacide	0.095±0.005	0.091±0.001	0.095±0.004	0.106±0.008	0.097 b
	Afamsa 121	0.115±0.008	0.112±0.004	0.112±0.005	0.108±0.004	0.112 a
	Control	0.084±0.007	—	—	—	0.084 c
	Doses mean[a]	0.103 b	0.098 c	0.100 c	0.105 a	
CO_2 exchange	SunSpray	5.71±1.39	5.20±2.06	5.62±2.25	4.40±1.45	5.23 a
	Codacide	5.27±2.55	4.37±0.79	4.48±1.03	4.39±3.67	4.63 a
	Afamsa 121	5.45±3.30	4.24±2.08	4.14±1.96	4.10±1.28	4.48 a
	Control	5.16±2.70	—	—	—	5.16 a
	Doses mean[a]	5.48 a	4.6 a	4.75 a	4.30 a	

[a] Values marked with the same letter are not statistically different (P=0.05).

Table 2. Mean and standard deviations of the parameters analysed in the field phytotoxicity assay, one week after the sixth treatment. Transpiration rate in mol/(m^2·seg), stomatic conductivity in mol/(m·seg) and CO_2 exchange in mmol/(m^2·seg).

Parameter	Treatment	Dose				
		0.25%	0.5%	1%	2%	Mean[a]
Transpiration rate	SunSpray	4.36±0.46	4.26±0.57	4.36±0.25	4.20±0.54	4.30 a
	Codacide	4.54±0.72	4.35±0.6	4.35±0.64	4.47±0.44	4.43 a
	Afamsa 121	4.26±0.51	4.46±0.57	4.57±0.28	4.23±0.69	4.38 a
	Control	4.27±0.47	—	—	—	4.27 a
	Doses mean[a]	4.39 a	4.36 a	4.43 a	4.3 a	
Stomatic conductivity	SunSpray	0.094±0.012	0.102±0.022	0.116±0.025	0.102±0.02	0.104 a
	Codacide	0.111±0.026	0.106±0.024	0.103±0.019	0.108±0.018	0.107 a
	Afamsa 121	0.103±0.019	0.106±0.025	0.112±0.017	0.100±0.023	0.105 a
	Control	0.103±0.022	—	—	—	0.103 a
	Doses mean[a]	0.103 a	0.105 a	0.110 a	0.103 a	
CO_2 exchange	SunSpray	4.68±1.43	6.04±1.97	6.39±2.52	4.03±1.39	5.29 a
	Codacide	8.07±2.85	6.60±2.42	5.10±1.87	4.23±1.44	6.00 a
	Afamsa 121	7.69±3.68	8.06±3.71	5.64±1.45	4.08±1.69	6.37 a
	Control	7.89±4.15	—	—	—	7.89 a
	Doses mean[a]	6.81 a	6.9 a	5.71 a	4.11 b	

[a] Values marked with the same letter are not statistically different (P=0.05) .

conidia and mycelium had been destroyed. This effect lasted at least 14 days. The three oils showed similar efficacy, which was in all cases markedly (though not significantly) higher than the reference treatments (systemic fungicide or colloidal sulphur).

Effect of oils on germination of conidia of *O. tuckeri*

All the oil treatments significantly reduced conidia germination over that of the unsprayed control, and there were also differences among treatments (Fig. 2). Paraffin oil and the fish oil were significantly more effective than the vegetable oils at the first and second assessment (days 2 and 4 after inoculation); however, by the third assessment (day 6) crude soya oil had become equally effective. By contrast, the refined vegetable oils (refined soya and refined rapeseed) were still less effective in preventing conidia germination by day 6. This was in contrast with the results of the previous experiment, in which refined rapeseed oil showed good post-infection control.

On the basis of these results we selected paraffin, fish (AP-121) and crude soya oils for field evaluation.

Efficacy of oils against powdery mildew in the field

Some phytotoxicity symptoms were observed after the first application (June 16), consisting of small necrotic spots at the leaf borders, where the drops gather after spraying. The maximum intensity of these symptoms was observed on July 16, one month after spraying. The severity of phytotoxic symptoms observed on July 16 (not shown) varied significantly among treatments, with mineral oil the most toxic (mean proportion of leaf area affected with necrosis 2%, significantly higher than with all other oils), followed by crude soya oil (1%), fish oil (0.75%) and the reference fungicide Quinoxifen (0.60%); there were no significant differences between these latter percentages.

The spring and summer of 2001 were quite dry and no serious powdery mildew infection was observed in the area where the trial was carried out. However, after some storms with heavy rains in late July and early August, clear symptoms of powdery mildew appeared only on the leaves. Four assessments of these symptoms had been conducted by this time. The results (Fig. 3) showed that symptom development was significantly faster in the unsprayed control than with any of the other

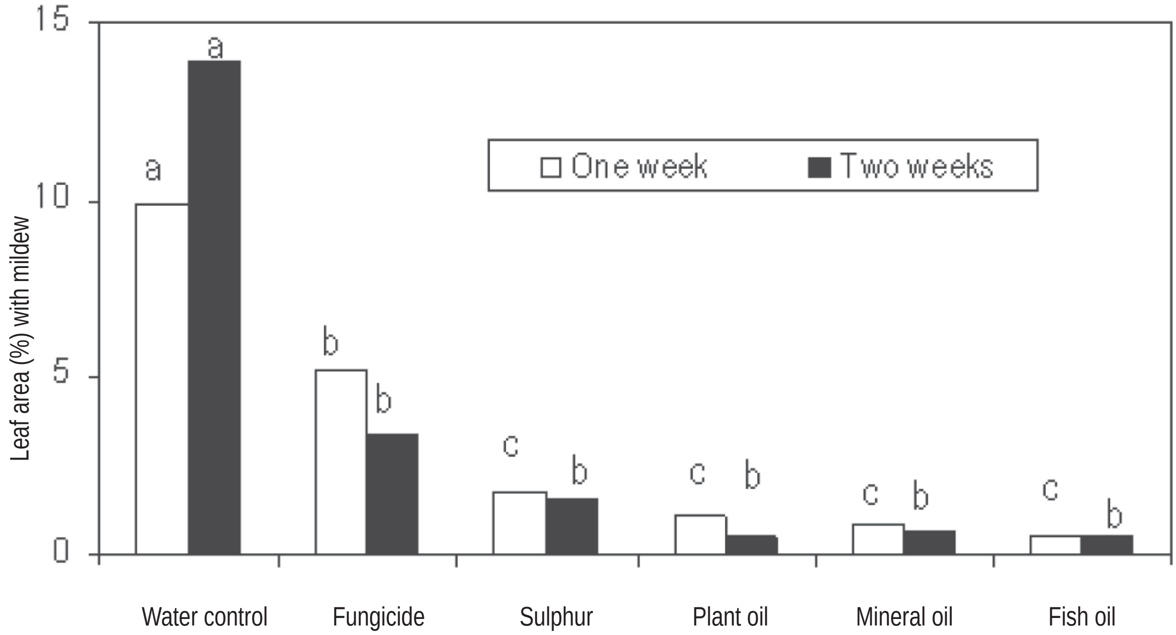

Fig. 1. Mean percentage of affected leaves one or two weeks after spraying oils at 1%, fungicide (Tebuconazole) at 0.05% or colloidal sulphur at 3 g l^{-1}. Means with the same letter do not differ significantly at the 5% level (Tukey HSD tests).

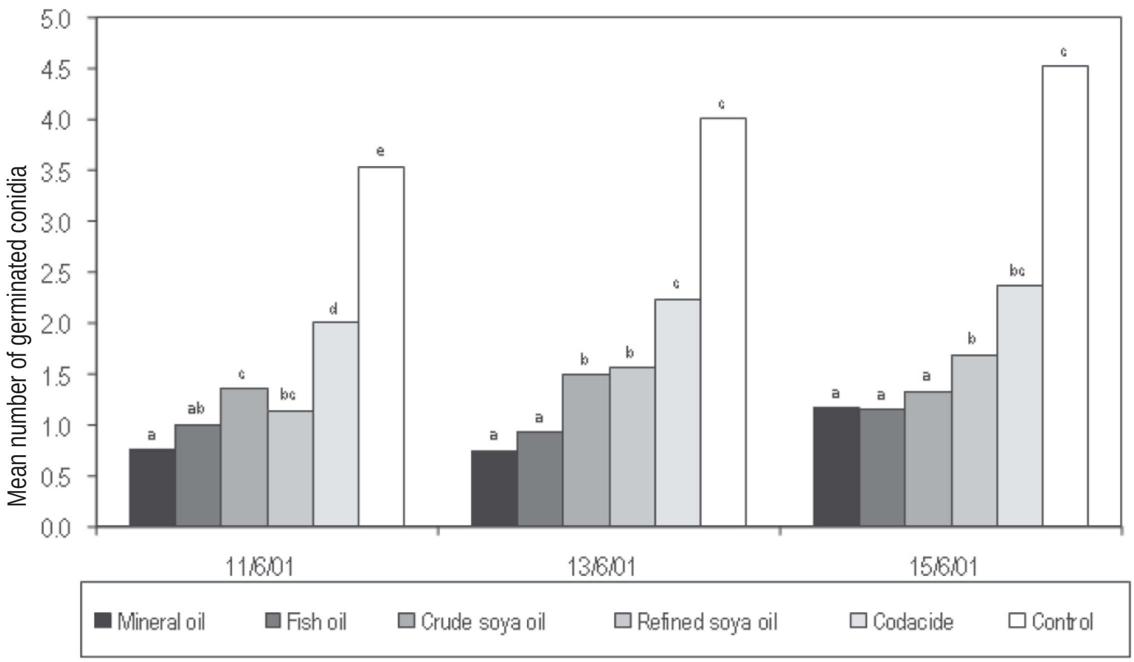

Fig. 2. Mean number of germinated conidia on Mencía leaves inoculated with of *Oidium tuckeri* and thereafter treated with various oils.

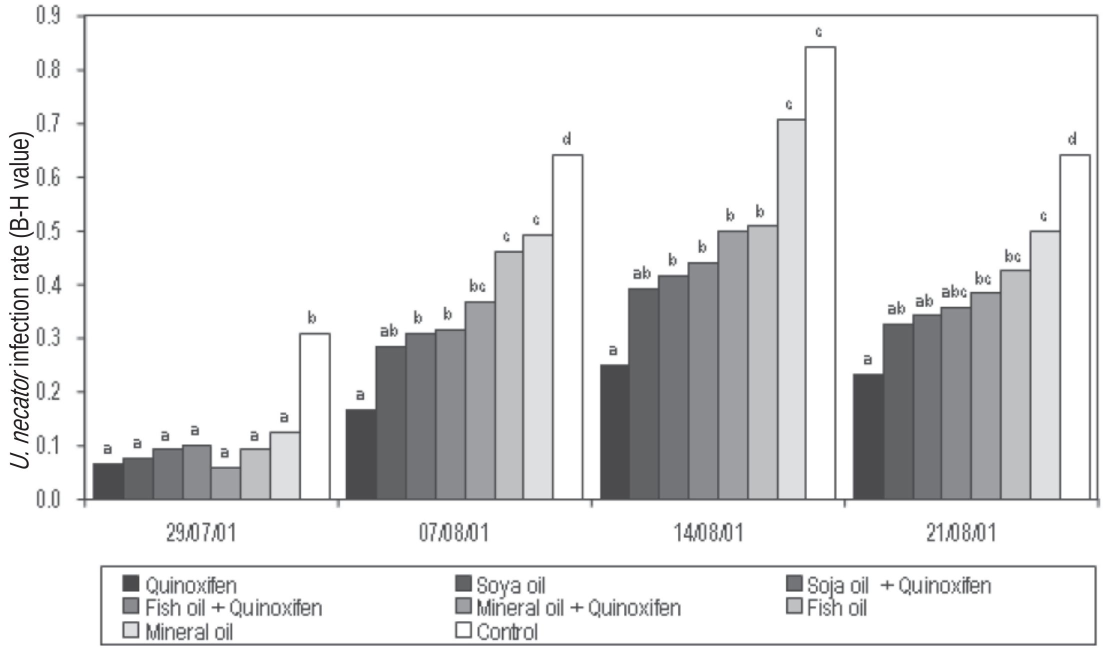

Fig. 3. Powdery mildew infection rate on leaves (Barrat-Horsfall scale) at different times after oil spraying, in a field experiment with Tempranillo vines to assess the efficacy of oils applied alone or in combination with Quinoxifen.

treatments. The most effective treatment was the standard fungicide Quinoxifen, applied at the dose recommended by the manufacturer (0.3 ml l^{-1}). The mean efficacy of crude soya oil was less than that of Quinoxifen but the difference was not statistically significant; the fish oil and the paraffin oil were however significantly less effective, so much so that by mid-August, two weeks after the last spraying, symptom severity in the paraffin-oil-treated plants was not significantly different from that in the unsprayed controls. All combinations of oils + Quinoxifen achieved very similar rates of intermediate control effectiveness. This suggested that it was Quinoxifen that ensured the efficacy of the mixture, and also that there were no synergic interactions between this fungicide and any of the oils.

The most serious pest observed in the field trial during the 2001 growing season was *C. vitis*. The proportion of leaves showing symptoms of this eriophid before the first treatment application ranged from 1.5 to 4%. Despite these differences in initial symptom severity, the effects of treatments on *C. vitis* populations were clearly apparent (Fig. 4). All three oils, (crude soya oil, fish oil and paraffin oil) were effective in controlling the spread of the mite, with significant differences over the unsprayed control after two applications. The oil that showed the best control and slightly better persistence was crude soya oil. Interestingly, this oil at the intermediate dose of 0.5% (in combination with Quinoxifen) showed a similar efficacy to this oil at 1%, while the other two oils were less effective at lower doses, particularly fish oil, where the difference between doses was significant.

In addition, the oils had some effect on the two insect types most frequently observed feeding on vine plants, leaf-hoppers and thrips. The mean number of insects captured in the traps was markedly lower in the oil sprayed plots than in the control plots: 33% lower for leaf-hoppers and 56% lower for thrips (Fig. 5). In both cases, fish oil was the most effective control agent.

Discussion

Previous studies have found that oils applied at concentrations of 2% or higher could be phytotoxic. Beattie and Rippon (1978) and Beattie

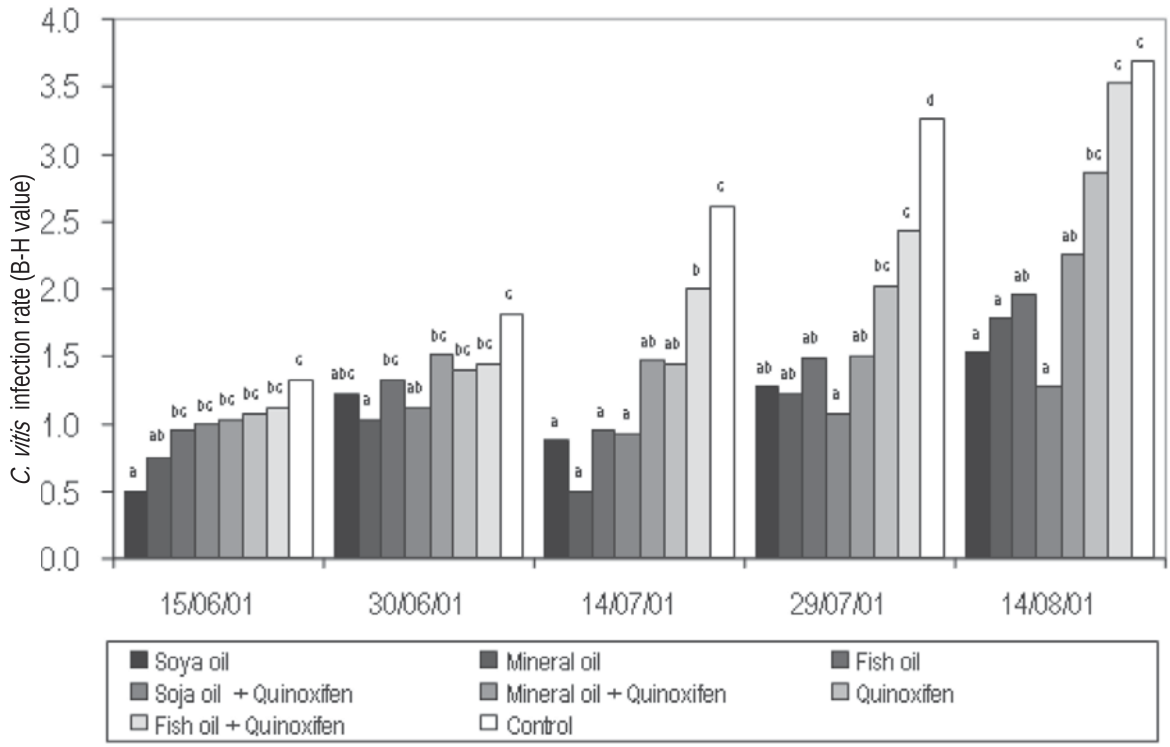

Fig. 4. Mean *Calepitrimerus vitis* infection rate (Barrat-Horsfall scale) at different times after oil spraying in a field experiment (Tempranillo vines).

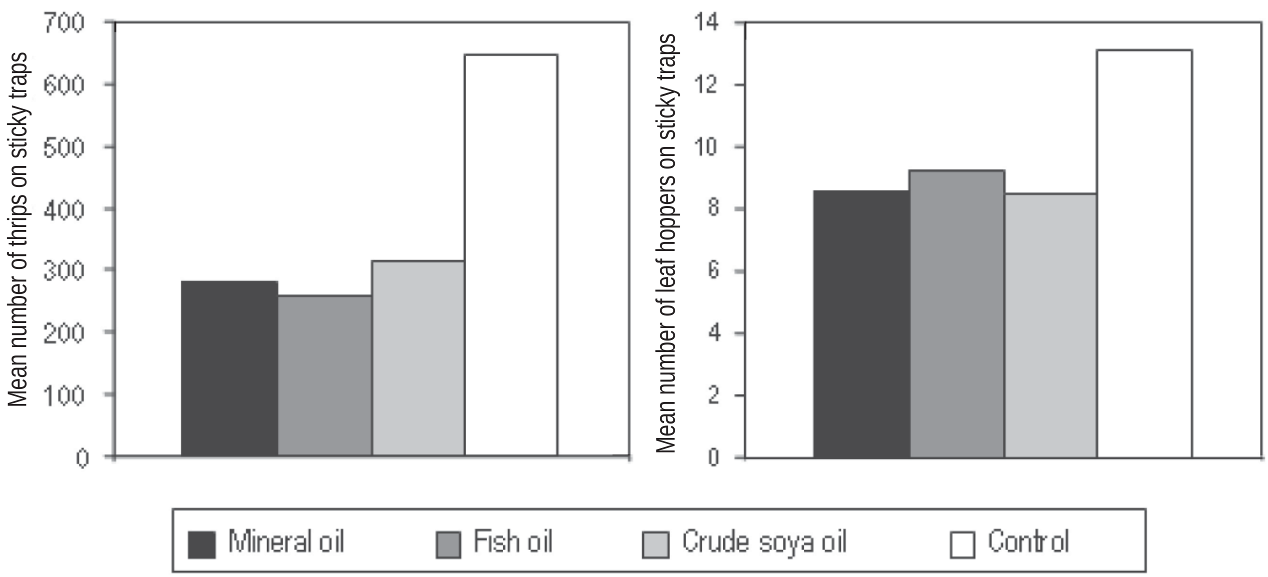

Fig. 5. Average number of insects captured over a three-day-period (1–3 July) on both sides of sticky traps placed in the central area of field plots treated with oils, and control plots. A) Leaf-hopper on yellow traps; B) thrips on blue traps.

et al. (2002) reported leaf drop and smaller leaf size among the symptoms; however, number of fruits and fruit quality were not affected even at 2%. In a previous study we observed changes in general appearance of raspberry and black currant leaves, with marginal necrosis and characteristic leaf spots and leaf drop (Cabaleiro *et al*., 2003). In grapevine, Wicks *et al*. (1999) detected some problems with a mineral oil (DC Tron Plus) applied at concentrations over 1%, but other oils of various origins were not phytotoxic at concentrations below 2%. Taking into account that in our experiments the oldest leaves received a 2% dose about six times, it seems likely that doses of 2% or more are fully tolerated because we did not observe phytotoxicity symptoms on the leaves; but we observed that oil spraying at 2% let to a reduction in photosynthesis rate in the field also observed by Calpouzos (1966) in banana leaves sprayed with mineral oils. This reduction could also affect plant development and crop yield components in the medium term as recently reported by Finger *et al*. (2002). This could justify the 2% maximum dose often recommended in the literature but, as far as we are aware, there have been no experimental studies to support this recommendation in grapevine. The phytotoxicity symptoms described in the last field experiment were only observed in plant leaves exposed to direct sunlight, and were probably partially attributable to the sunshine and high temperatures (maxima over 30°C) that occurred during and after the first application; when time of spraying was chosen to avoid the hottest hours of the day no more symptoms were observed.

Severe adverse effects of oil spraying are typically associated with unusually high application volumes applied at low pressure using a hand-held sprayer, but Finger *et al*. (2002) pointed out that the use of an appropriate sprayer such as an airblast sprayer enables better coverage to be achieved with lower application volume. According to our laboratory and field data, no detrimental effect on grapevines should be expected for applications spaced 10–14 days apart, and for application volumes under 600 l ha^{-1} at a rate of 1–1.5%. High temperatures and sunshine during application should always be avoided.

The oils investigated in this work had curative and preventive properties against grapevine powdery mildew. In agreement with Northover and Schneider (1996) oil treatments were more effective to cure the infection than to prevent it. Under field conditions, the efficacy of the oils was slightly lower than that of the reference fungicide Quinoxifen, while in the greenhouse trials the oils were more effective than both sulphur and tebuconazole in controlling fungus spread. All combinations of oils with Quinoxifen, achieved very similar intermediate control efficiencies. This suggests that Quinoxifen is basically responsible for the efficacy of the mixtures, and also that there are no synergic interactions between this fungicide and the various oils. This field assay under low inoculum pressure did not allow us to check the efficacy of the oils against powdery mildew on the bunches; therefore, more work remains to be done to prove the possibility of using them in practice in the vineyards.

Despite their different origins, all the oils tested showed a similar effectiveness against powdery mildew in greenhouse and laboratory experiments. However, the laboratory results suggested that the refined vegetable oils (refined rape-seed oil and refined soya oil) were less effective in preventing conidia germination. This might be due to the lower viscosity of these oils: crude oils being more viscous are less volatile and hence remain longer on the leaf surface. This may also explain why crude soya oil was more effective than mineral and fish oils against powdery mildew and *C. vitis* in the field. The viscosity of fish oil was also initially very high, but this oil oxidized very quickly when exposed to the air. Besides having a longer persistence, viscous oils may also be less phytotoxic and cause less photosynthesis reduction, since they do not penetrate the leaf but cover the leaf surface (Finger *et al*., 2002).

The present study is the first report on the use of a fish oil against powdery mildew of grapevine. It would be interesting to carry out further experiments with fish oils refined to different degrees, including an assessment of whether they transmit their bad smell to the musts. It would also be interesting to examine the effectiveness of these oils against other grapevine pathogens such as downy mildew or grey mould. Northover and Schneider (1996) did not find oils at all effective against *Plasmopara viticola*, but Dell *et al*.

(1998) found that *Botrytis cinerea* in grapevine bunches could be controlled in this way, without any fermentation problems. Powdery mildew was effectively controlled by mineral and plant oils in the experiments performed by Wicks *et al*. (1999), Northover and Schneider (1996), and Dell *et al*. (1998).

For several decades, mineral oils have been recommended as acaricides in fruit crops during the dormant phases in winter (Metcalf *et al*., 1962; Chapman, 1967). Several more recent works have focused on the insecticide effects of oils against different plant pests; however, only very few authors have investigated the effects of oils on mite species (Agnello *et al*., 1994; Chauvel and Brustel, 1998; Ocete *et al*., 1998). Our results are promising as regards the possible use of oils against mites in grapevines, in view of the good control of the eriophid *C. vitis*, and also because no tetranychid mite colonies were observed in the oil-treated plots, even though these mites were very common in this area. Sulphur applications have traditionally been used in central Spain to control both powdery mildew and mites. When sulphur is replaced by other products, an increase in pests such as mites is commonly observed. Oils, as an alternative to sulphur, may avoid this problem. A significant reduction in thrip and leaf-hopper populations was observed in our oil-treated plots; this was in agreement with Ocete *et al*. (1998) who reported that oils gave good control of the leaf-hopper *Jacobyasca lybica* in vineyards of south-eastern Spain.

In conclusion, modern agriculture tends to favour management strategies in which applications of traditional pesticides are greatly reduced and replaced by more environmentally compatible alternatives. In this respect the main advantage of natural oils is that they can be of food quality and can therefore be readily incorporated into IPM programs.

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