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CONTROL OF *Brevipalpus chilensis* BAKER (ACARI: TENUIPALPIDAE) WITH AGRICULTURAL DETERGENTS UNDER LABORATORY AND FIELD CONDITIONS

CONTROL DE *Brevipalpus chilensis* BAKER (ACARI: TENUIPALPIDAE) CON DETERGENTES AGRÍCOLAS EN CONDICIONES DE LABORATORIO Y DE CAMPO

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RESUMEN

El uso de los detergentes agrícolas ha tenido un interesante incremento en el control de artrópodos plaga en el mundo. *Brevipalpus chilensis* (Acari: Tenuipalpidae) es una severa plaga que necesita de más alternativas de control en viñedos chilenos. Se evaluaron dos detergentes, SU 120 y TecsaFruta, en laboratorio y bajo condiciones de campo, ambos en concentración de 0,1; 0,5; y 1,5% v/v. El control (remoción por lavado + mortalidad) del ácaro en laboratorio fue directamente proporcional a la concentración usada. La remoción por lavado representó cerca del 20% del control obtenido en los tratamientos más eficientes (concentraciones más altas), pero fue mucho más baja a concentraciones menores. Solo SU 120 al 1,5 y 0,5% no fueron estadísticamente diferentes al estándar (acrinatrina). TecsaFruta tuvo un desempeño más bajo, pero conteniendo alrededor de un décimo (1,8%, xyleno sulfonato y nonilfenol) de los tensioactivos documentados en SU 120 (16,5%, sulfonatos y laurietersulfonatos). El control del ácaro en campo (= población remanente después de las aspersiones) fue directamente correlacionada a la concentración de detergente, especialmente en el caso de SU 120, teniendo un efecto significativo de control sobre estados móviles (≤ 3/hoja en algunas fechas postaplicaciones, respecto de 30/hoja o más en el control en igual fecha), pero los huevos fueron menos afectados. SU 120 a la mayor concentración evaluada fue tan eficiente como el acaricida acrinatrina en mantener las poblaciones bajo el umbral de daño económico. Se propone realizar aplicaciones repetidas de detergentes para plagas recurrentes como *B. chilensis*.

Palabras clave: laurietersulfonatos, nonilfenol, remoción de ácaros por lavado, sulfonatos, xyleno sulfonato

ABSTRACT

The use of agricultural detergents has had an increasing interest in arthropod control worldwide. *Brevipalpus chilensis* (Acari: Tenuipalpidae) is a serious pest in Chilean vineyards that needs more control alternatives. Two detergents against this mite species, SU 120 and TecsaFruta, both used at 0.1, 0.5, and 1.5% v/v, were evaluated under laboratory and field conditions. In the laboratory, mite control (dislodgement + mortality) was directly proportional to the concentration. Dislodgement represented about 20% of control in the more efficient treatments (higher detergent concentration), but it was much reduced at lower concentrations. Only SU 120 at 1.5 and 0.5% concentrations was not statistically different to the standard (acrinathrin). TecsaFruta had a lower performance with almost

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one tenth (1.8%, xylene sulphonate and nonilphenol) of the tensioactives reported for SU 120 (16.5%, sulphonates and laurietersulphonates). Mite control (= remaining population after spraying) in the field was directly related to detergent concentration, particularly in SU 120. This has a significant effect on mobile stages (≤ 3/leaf in some dates post sprays, against 30/leaf in check treatment at the same date), particularly during summer spraying, but eggs were less affected. SU 120 at the highest concentration was as efficient as acrinathrin in keeping the population below the economic injury level. Reiterative detergent sprays are proposed for recurrent pests such as *B. chilensis*.

Key words: laurietersulonates, mite dislodgement, nonilphenol, sulphonates, xylene sulphonate.

INTRODUCTION

Research on the use of detergents and soaps as alternative tools in pest management are being conducted, including recent studies on control of mollusks (Karunamoorthi et al., 2008), fungi (Sholberg and Boulé, 2009), and arthropods (Kumar et al., 2012). Surfactants have been used alone (i.e., not as adjuvants) to control insect and mite pests for years (Butler et al., 1991; Asiático and Zoebisch, 1992; Puri et al., 1994; Curkovic et al., 1995), and even their use by herbivore insects has been highlighted as a mechanism of defense against predators (Rostas and Blassmann, 2009).

During the last decade, agricultural detergents and other surfactants (including synthetic and natural compounds) have had an increasing interest in arthropod management worldwide, because they are compatible with insect and mite biological control, more ecofriendly, cheaper than most conventional miticides, safer to workers, easier to produce and use, and free of a pre-harvest interval (PHI), which make them available for sprays close to harvest (Szumlas, 2002; Arias et al., 2006; Pino et al., 2007; Curkovic, 2007; Sazo et al., 2008; Martínez et al., 2009; Gulsar Banu et al., 2010; Curkovic, 2013). Although some concerns on the use of these compounds on crops have been reported (e.g., phytotoxic responses on some plants, lack of residual effect on arthropods, or the need to wet the pest during application), detergents have been considered useful tools for Integrated Pest Management (IPM) programs (Curkovic, 2007). Because of that, warnings about susceptible crops (or varieties), specific spray time windows (avoiding applications during sensible stages of the crop), and optimum rates (not damaging plants, but with insecticide-miticide activity) have all been addressed and studied (Sholberg and Boulé, 2009; Curkovic and Ballesteros, 2011). Besides, reiterative applications to enhance control on recurrent pests (somehow replacing their lack of residual effect) have also been evaluated and recommended (Islam et al., 2003; Curkovic and Ballesteros, 2011).

This persistent search for spray windows to apply detergents is also particularly important to take advantage of their diverse and multiple modes of action against arthropods, which might help to either manage or avoid pest resistance to pesticides (Curkovic, 2007). Although detergent mode of action on insect and mites is still unclear, literature review suggests that these compounds act only by direct contact, probably by removing epicuticular waxes, producing dehydration and/or integument disruption and death, filling the tracheal system, drowning individuals, inhibiting enzymes, disrupting cell membranes, affecting arthropod physiology, dislodging mites off the foliage, or combinations of some or all of the above (Hassall, 1990; Ware, 1994; Curkovic and Araya, 2004; Santibáñez, 2010), all mechanisms which make resistance-development highly unlikely (Curkovic, 2007).

From a toxicological point of view, detergents represent a low risk for human health, except for eye or skin irritation, and some respiratory disorders after exposure (Mapp et al., 2000; Pedersen et al., 2005). However, there have been reported recently some concerns regarding that household products containing formula components could be related to cancer (Darbre and Charles, 2010), although under normal exposure conditions, the risks are low because no systemic toxicity is expected (Fruijtier-Pölloth, 2009). From an environmental point of view, surfactants are not serious pollutants, except when they reach water bodies, where they can be harmful to some aquatic organisms, particularly fish. However, toxicity depends on the chemical properties of the compound (Liwarska-Bizukojc et al., 2005), which for detergents is usually significantly lower than conventional insecticides (Conti, 1987).

Besides, pesticide regulations are much more permissive for surfactants (e.g., pre harvest intervals do not apply) because Maximum Residue Levels (MRLs) are not required in some countries (EPA, 2013). Despite this, when sold as pesticides, authorization for pest control use must be obtained from the agricultural authority. In Chile, agricultural detergents are authorized by the local Department of Agriculture, but only to be used in the field to wash trees out of honeydew and sooty mold fungi (a complex of fungi, including *Capnodium* spp., *Cladosporium* spp., etc), which open chances to apply them on infested plants (Curkovic, 2007).

Brevipalpus chilensis Baker (Acari: Tenuipalpidae) is a Chilean native mite and a serious pest in vineyards (Ripa and Luppichini, 2010), which needs chemical control with conventional miticides, particularly at bud breaking and the initial leaf development phase. Detergents are proposed as tools to manage this pest based on the efficacy reported on diverse mite species (Lawson and Weires, 1991; Sazo et al., 2005; Curkovic et al., 2006; Lee et al., 2006; Ripa et al., 2006; Petanovic et al., 2010) and their feasibility to be used in IPM and even organic (for natural surfactants and soaps) programs (Curkovic, 2007).

The objectives of this research were to measure the contribution of mite dislodging and mite mortality on the global control against this mite species in a laboratory assay, and to evaluate the impact from detergent sprays (at several concentrations) on *B. chilensis* populations in the field.

MATERIALS AND METHODS

Orchard and source of mites for bioassays

Field trials were conducted in a vineyard (*Vitis vinifera* L.) located at Padre Hurtado (33°34'S 70°50'W), Metropolitan Region, central Chile, in a block (cv. Carmenere) severely infested with *B. chilensis*. A bioassay was conducted in the Toxicology Laboratory, College of Agricultural Sciences, University of Chile, Santiago, Metropolitan Region. Leaves used in the bioassay were collected in the vineyard from severely infested plants, not previously sprayed with miticides.

Chemicals and treatments

Two liquid detergents, SU 120, with 14.9 to 17.8% anionic tensioactives (sulphonates and laurietersulphonates, Johnson & Diversey Co., Santiago, Chile; see Curkovic and Araya, 2004), and TecsaFruta, with 1.5 to 2% tensiactives (xylene sulphonate and nonilfenol, Protecsa S.A., Santiago, Chile; see Santibánez, 2010), and the miticide acrinathrin (Rufast 75 EW, Bayer CropScience, Santiago, Chile, recommended against *B. chilensis*), were evaluated. Both detergents were applied at three concentrations (v/v) 0.1; 0.5 and 1.5%, and the miticide was used at the commercial rate (20 mL commercial product hL^{-1}) (Table 1).

Handling of samples, exposure procedure, and evaluations in the laboratory

The infested foliage collected in the field was kept at ~6°C for 30 min to reduce mite mobility. Mobile mites were counted, and dead, quiescent individuals, eggs, and predatory mites were removed. The leaves were submerged 5 s in solutions of each treatment (Table 1), including a control consisting of only tap water. Then, the leaves were taken out, and the respective detergent solutions were filtered through paper tissue to determine the percentage of mites dislodged [100 x (mites in the solution/original mite amount before immersion)]. Afterwards, the leaves were kept hydrated by introducing their petioles inside a small glass vial full with tap water and sealed with a cotton wick, and maintained at ~22°C under a natural photoregime (~14 h of light/day). Mortality

Table 1. Percentage of *Brevipalpus chilensis* dislodgment (D, immediately after immersion), mortality (M, 7 d after immersion), and control (D + M) of infested leaves of *Vitis vinifera* cv. Carmenere submerged into detergents and acrinathrin solutions, in the laboratory.

Tabla 1. Porcentaje de remoción (D, inmediatamente después de la inmersión), mortalidad (M, 7 días después de la inmersión) y control (D + M) de *Brevipalpus chilensis* infestando hojas de *Vitis vinifera* cv. Carmenere, luego de su inmersión en soluciones de detergentes y acrinatrina en el laboratorio.

Treatments	D	M	D+M
		%	
SU 120 1.5%	22.3 b*	60.0 c	82.3 de
SU 120 0.5%	16.4 b	62.4 c	78.8 cde
SU 120 0.1%	7.5 b	55.6 c	63.1 c
TecsaFruta 1.5%	16.5 b	53.6 c	70.1 cd
TecsaFruta 0.5%	1.0 a	24.2 b	25.2 b
TecsaFruta 0.1%	0.8 a	20.0 b	20.8 b
Acrinathrin	0.4 a	90.2 d	90.6 e
Control	0.4 a	3.2 a	3.6 a
F/H-value	30.3**	47.4	94.1
p-value	<0.0001	<0.0001	<0.0001

*: Means with different letters within a column are significantly different according to Tukey test ($p \leq 0.05$).
**: Kruskall-Wallis H-calculated value.

(%) was estimated after 7 d, by visual examination under 20x magnification. Individuals considered dead were those that did not move when gently touched with a needle, as reported by Curkovic and Araya (2004). Mortality was calculated as 100 x (dead mites/original mite amount). Control % (dislodgement + mortality) was also calculated.

Field sprays and evaluations

Two spray rounds were conducted during the spring, respectively at particular phenological stages based on the BBCH (Biologische Bundesanstalt, Bundessortenamt and CHemical industry) classification codes 18 and 53, using the BBCH growth scale for grapes (Lorenz et al., 1995). One summer spray (at BBCH 81) was also conducted. Chemicals were applied with a motorized back pack sprayer, using volumes equivalent to 684 L ha^{-1} (first spring spray), 720 L ha^{-1} (second), and 838 L ha^{-1} (summer spray), from both sides of each row, achieving a complete coverage of the canopy. The number of alive and mobile mites was counted immediately before each spray, and then every 7-14 d after spray, for a 35 d period (Tables 2 and 3).

Table 2. Densities of *Brevipalpus chilensis* mobiles and eggs (both per leaf) before and several days after the first spring spray (DAFSS) with detergents and acrinathrin on *Vitis vinifera* cv. Carmenere (BBCH 19 at 0 DASS), Padre Hurtado, Metropolitan Region, Chile.

Tabla 2. Densidades de móviles y huevos (por hoja) de *Brevipalpus chilensis*, antes y varios días después de la primera aplicación (DAFSS) con detergentes y acrinatrina en *Vitis vinifera* cv. Carmenere (día de la primera aplicación de primavera en campo: BBCH 19), Padre Hurtado, Región Metropolitana, Chile.

Treatments	DAFSS									
	0		7		14		28		35	
	Mobiles	Eggs	Mobiles	Eggs	Mobiles	Eggs	Mobiles	Eggs	Mobiles	Eggs
SU 120 1.5%	26.5 a*	5.4 a	13.5 a	10.1 ab	19.9 ab	59.8 ab	2.6 cd	79.9 bc	4.6 ab	99.6 bc
SU 120 0.5%	23.0 a	4.8 a	20.3 a	14.2 ab	38.2 a	75.9 ab	19.4 bc	282.5 ab	20.3 a	300.1 ab
SU 120 0.1%	29.4 a	5.5 a	28.5 a	20.6 a	40.8 a	180.6 a	46.5 a	428.5 a	20.0 a	418.1 ab
TecsaFruta 1.5%	26.5 a	5.1 a	20.7 a	18.0 ab	29.0 a	101.8 ab	23.0 ab	173.4 abc	14.0 ab	135.5 bc
TecsaFruta 0.5%	28.0 a	5.3 a	27.0 a	26.7 a	52.8 a	172.1 a	40.1 ab	442.3 a	15.3 a	675.3 a
TecsaFruta 0.1%	23.6 a	5.1 a	21.4 a	17.2 ab	32.3 a	167.1 a	13.6 bc	167.6 abc	15.8 a	427.5 ab
Acrinathrin	31.8 a	6.5 a	0.1 b	2.6 b	1.0 b	9.8 b	0.0 d	17.8 c	0.3 b	21.1 c
Control	22.3 a	4.5 a	20.6 a	11.4 ab	29.4 a	158.1 a	29.6 ab	316.8 ab	11.1 ab	348.8 ab
F-value	1.04	1.37	11.4	3.49	5.26	5.22	13.68	7.21	3.7	8.18
p-value	0.27	0.20	<0.001	0.032	0.007	0.007	<0.001	<0.001	0.027	<0.001

*: Means with different letters within a column (DAFSS), and within a phenological stage, are significantly different according to Tukey test ($p \leq 0.05$)

Table 3. **Densities of *Brevipalpus chilensis* mobiles and eggs (both per leaf) before and several days after the summer spray (DASS) with detergents and acrinathrin on *Vitis vinifera* cv. Carmenere (BBCH 81 at 0 DASS), Padre Hurtado, Metropolitan Region, Chile.**

Tabla 2. **Densidades de móviles y huevos (por hoja) de *Brevipalpus chilensis* antes y varios días después de la aplicación de verano (DASS) con detergentes y acrinatrina en *Vitis vinifera* cv. Carmenere (día de la aplicación de verano en campo: BBCH 81), Padre Hurtado, Región Metropolitana, Chile.**

	DASS											
	0		**7**		**14**		**21**		**28**		**35**	
Treatments	Mobiles	Eggs	Mobiles	Eggs	Mobiles	Eggs	Mobiles	Eggs	Mobiles	Eggs	Mobiles	Eggs
SU 120 1.5%	16.9 a*	46.3 a	1.3 b	33.0 a	3.6 bc	18.4 b	3.0 bc	10.9 c	7.1 cd	11.9 b	12.0 d	35.3 cd
SU 120 0.5%	8.0 a	67.4 a	11.9 ab	54.3 a	16.9 ab	47.5 ab	21.6 ab	40.9 bc	13.5 bcd	33.3 ab	19.8 cd	42.8 c
SU 120 0.1%	20.8 a	120.9 a	28.3 a	84.0 a	35.5 a	73.0 ab	39.9 a	62.9 bc	54.8 a	73.5 a	69.8 a	140.9 a
TecsaFruta 1.5%	12.4 a	68.1 a	17.0 ab	55.8 a	20.5 ab	50.1 ab	21.5 ab	44.3 bc	22.8 abc	33.8 ab	30.8 bcd	48.3 bc
TecsaFruta 0.5%	26.9 a	124.8 a	23.1 a	141.4 a	36.0 a	128.4 a	40.6 a	125.6 a	46.9 ab	70.3 a	52.5 ab	81.3 abc
TecsaFruta 0.1%	16.3 a	135.8 a	27.6 a	112.8 a	24.0 a	78.4 ab	27.1 a	78.4 ab	28.0 abc	54.8 a	40.3 abc	68.3 bc
Acrinathrin	12.0 a	170.9 a	1.1 b	52.4 a	0.0 c	18.1 b	0.1 c	18.1 b	0.1 d	10.6 b	0.0 e	8.0 d
Control	27.5 a	154.4 a	22.0 a	84.1 a	30.6 a	74.1 ab	32.6 a	74.1 ab	35.5 ab	55.3 a	73.5 a	91.4 ab
F-value	0.97	1.38	7.19	2.26	10.24	4.91	11.48	4.91	22.99	7.55	30.08	16.18
p-value	0.28	0.20	<0.001	0.09	<0.001	0.03	<0.001	0.03	<0.001	<0.001	<0.001	<0.001

*: Means with different letters within a column (DASS), and within a phenological stage, are significantly different according to Tukey test ($p \leq 0.05$).

Experiment design, sample size, variables measured, and statistical analysis

A completely randomized design was used for the laboratory assay, with 5 replicates of ~50 mobile mites on 1 leaf/replicate. Percentage mortality, dislodged mites, and mite control were normalized by angular transformation ($\sin^{-1}\sqrt{\%/100}$). A completely randomized block design was used for field trials, with four replicates per treatment, of 10 plants each (5 contiguous plants in 2 adjacent rows). There was a 5 m buffer zone between plots. The same plots were used for all three sprays. Samples were 20 leaves/plot/date. Numbers of alive mites and viable eggs were transformed to log(x + 0.5) function. Data from both laboratory bioassays and field trials were subjected to ANOVA and Tukey tests ($p \leq 0.05$). When ANOVA assumptions were not fulfilled, the Kruskall-Wallis test was used (Steel and Torrie, 1985).

RESULTS

Lab bioassays

Dislodged individuals were significantly greater than the control in all SU 120 treatments. However, no significant differences were observed among the three SU 120 concentrations (Table 1). The greatest level of mite dislodgement (22.3%) was reached with the highest SU 120 concentration, while the lowest level of 0.4% occurred equally in both, the control and the standard (acrinathrin) treatments. The greatest Tecsa Fruta concentration (1.5%) caused a significantly greater dislodgement than the control (also not different from SU 120), while the lower concentrations (0.5 and 0.1%) and acrinathrin were not different from the control. Mortality at 7 d was significantly greater than the control in all treatments, but acrinathrin caused the highest mortality (90.2%), significantly greater than all the other treatments, while the lowest mortality occurred in the control (3.2%). A directly proportional trend was observed in mite mortality with concentration for Tecsa Fruta, but not for SU 120. Regarding the level of mite control (dislodgement + mortality), trends were similar to mortality results, except that SU 120 at the two greatest concentrations was not different from the standard treatment. Both detergents presented a significant and proportional trend between control and concentration.

Field trials

Spring mobile stages

Brevipalpus chilensis mobile populations were not significantly different between treatments right before the first spring spray (Table 2). Seven days later, populations were significantly smaller in the standard, and the same trend occurred over time (≤ 1 mites/leaf), up to 35 days after the first spring spray (DAFSS). Among detergent treatments, only SU 120 at 1.5% was not different from the standard and neither was the control at 14 DAFSS. By 28 DAFSS (first evaluation after the second spring spray conducted at 21 DAFSS), SU 120 at 1.5% was not different from the standard, but it was different from the control, while the other detergent treatments were not different from the control during the whole period. At 35 DAFSS results were similar to day 14, with the exception that the greatest Tecsa Fruta concentration was also statistically similar to the standard.

Spring eggs

As in mobile individuals, *B. chilensis* egg densities were not significantly different between treatments before the first spring spray (0 DAFSS; Table 2). Seven days later, egg densities were significantly smaller in the standard and the same trend was observed over time. Egg densities were usually greater in some detergent treatments than the control, although without differences between them, making the results less discriminatory. Both detergent treatments at the greatest concentrations (1.5%) were consistently and statistically similar to the standard, but they were not different from the control during the evaluation period.

Summer mobile stages

Brevipalpus chilensis mobile populations were not significantly different between treatments before the summer spray (Table 3). Seven days after the summer spray (DASS), populations were significantly smaller than the control in the standard and the SU 120 at 1.5% treatments, and the same trend occurred over time for both treatments (< 12 mites/leaf, which is below the economic injury level of 15 mites/leaf; Curkovic et al., 1994). The other detergent treatments were not different from the control up to 28 DASS and mite populations were frequently above the EIL. At 35 DASS, only SU 120 at 1.5 and 0.5%, and Tecsa Fruta at 1.5% were significantly different from the control, but none was statistically similar to the standard (which had no mites on the leaves) on that date.

Summer eggs

Brevipalpus chilensis egg numbers were not significantly different between treatments neither before the summer spray or seven days later (Table 3). At 14 DASS egg densities in the control were not different from those in any other treatment. Afterwards, between DASS 21 and 35, the standard and SU 120 at 1.5% (and SU 120 at 0.5%, particularly by day 35) consistently presented the smallest and statistically similar densities of egg/leaf, significantly different from the control.

DISCUSSION

Laboratory results demonstrated that mite control (dislodgement + mortality) was, in general, directly proportional to the concentration for both SU 120 and TecsaFruta, in agreement with reports describing the same trend for soaps, detergents, and surfactants evaluated against mites (Sazo et al., 2005; Lee et al., 2006; Ripa et al., 2006). It is possible that the increase of surfactants in solution either reaches the critical micelle concentration (CMC) (Bhairi and Mohan, 2007), allowing micelle formation with lipids removed from the epicuticle (Santibáñez, 2010), or reduces also the surface tension, allowing the solution to either penetrate the respiratory system (Ware, 1994), and/or remove arthropods from the substrate (Curkovic and Araya, 2004).

The laboratory assay revealed that, when considering detergent treatments significantly different from the control, an average ca. ~20% mite control was due to dislodgement of individuals washed off the leaves. Most individuals dislodged died, probably drowning in the detergent solutions, but if any could survive, dislodgement - highlighted recently as an anti-herbivore trait (Yamazaki, 2011) - will reduce their performance on the plant. The level of control was statistically similar between the acrinathrin (standard) and SU 120 at 1.5 and 0.5%, while the other detergent treatments were significantly less effective, but were also significantly better than the control. However, dislodgement in the two smallest concentrations of TecsaFruta was much smaller (in average not more than 4%), and mortality was the main (ca. 96%) component of mite control. This suggests that only above some threshold, dislodgement becomes significant on mite control, while mortality can be obtained even at smaller concentrations. Considering current experience that suggests recommending concentrations smaller than 1% to avoid potential damage to plants, the 0.5% concentration should be preferred. This conclusion becomes even more important since detergents, which do not provide residual effect, should be used in reiterative sprays to obtain control over time (Curkovic and Ballesteros, 2011) for recurrent pests like *B. chilensis*, as smaller concentrations represent also a lower risk of damage to plants.

However, no phytotoxic effects were observed in the field at any concentration for both detergents. TecsaFruta had a lower performance, but it contains almost one tenth (~1.8% in average) of the tensioactives than SU 120 (~16.5%). The surfactants are different molecules with different chemical and physical properties that affect their biological activity (Katagi, 2008). Although the particular mode (or site) of action has not been elucidated for these compounds, the miticide activity can be attributed to the amount of surfactants, but also to the particular surfactant affecting solubilization and/or surface tension (Jones, 1999), or to interactions between both variables.

Assuming similar properties occur in the surfactants evaluated, we conclude that Tecsa Fruta, being less effective against *B. chilensis*, is more efficient per unit of surfactant in terms of mite control. In fact, the ratio between the average mortality obtained with each detergent and the amount of tensioactives contained in the reported formulae was 4.5 (% control/% tensioactive) for SU 120, and 21.5 for TecsaFruta, almost 5 times greater for the latter detergent. Differences between the control level reached by different surfactants have been reported previously (Cowles et al., 2000; Arias et al., 2006).

This conclusion assumes that the other detergent components had no surfactant activity leading to affect mites. This should lead to new experiments to evaluate different surfactants, both singly and in mixture, as well as other formula components with suspected surfactant properties.

In the field, detergents had a significant effect on mobile stages, but egg density was almost not affected. The presence of viable eggs on leaves after sprays can be explained by the lack of ovicide activity on detergents (Lee et al., 2006), the absence of residual effect on mobile individuals, not stopping females from laying eggs, or combinations of all. There is also a reduction in oviposition during summer. However, it probably occurred because of the smaller density of mites (as a result of control of the mobile population) observed after detergent treatments. In fact, the smallest mobile mite densities were observed after the SU 120 1.5% summer spray, at 7 DASS (1.3 mites/leaf). The low presence of mites during summer after detergent sprays is interesting since mites tend to reach greater densities during this time of the year (Ripa and Luppichini, 2010). Thus, detergent treatments seem to have better effect during summer than spring on mobile mites, despite the fact that they were sprayed only once in summer (vs. twice early in the season).

Regarding the number of applications, two sprays during spring tend to reduce mite populations, in agreement with many reports stating the convenience of multiple applications when using detergents (Curkovic and Ballesteros, 2011). In fact, there was a notable reduction in mobile mites 7 d after the second spring spray (see Table 2, SU 120 at 1.5% at 28 DASS), suggesting that the double spray significantly contributed to reduce mite population density. Mite population (mobiles on leaves) was inversely related to detergent concentration, particularly in SU 120. At the two highest concentrations, this detergent reached a level of control statistically close to the acrinathrin, offering a convenient alternative for *B. chilensis* control. Depending on the vineyard pest complex, the same treatments can also help to control scales and mealybugs occurring simultaneously (Ripa and Luppichini, 2010), which have been successfully targeted with these compounds (Curkovic et al., 1995; Gulsar Banu et al. 2010).

B. chilensis is difficult to control in Chilean vineyards, particularly due to its biology (early colonization of leaves, up to 6 generations/season, high incidence in some varieties), the low numbers of predatory mites (found at very low densities in the field trial), and the reduced number of molecules authorized to be used by the wine industry (Duran, 2006; Ripa and Luppichini, 2010). Thus, these results for chemical control of *B. chilensis*, even close to harvest are very interesting to exploit. Therefore, sprays of detergents on vineyards should provide more alternatives and, consequently, be recommended once both phytotoxicity is ruled out for a given variety and phenological stage (Curkovic and Ballesteros, 2011), and the authorization for pest control is granted. Considering the low population densities reached with SU 120 at 1,5%, and taken into account the action threshold for *B. chilensis* in vineyards in Chile, a program of multiple detergent sprays should be considered a pest control alternative in phytosanitary programs for the Chilean wine industry.

CONCLUSIONS

Laboratory results indicated that mite control was directly proportional to the concentration for both detergents evaluated; most control was due to direct mite mortality, although mite dislodgement contributed with ca. 20% in treatments using the greatest detergent concentrations.

In the field, detergents also had a significant effect on reducing mobile stages densities, even similar to the conventional miticide when using them frequently at the greatest concentrations (1.5% v/v), but eggs were apparently less affected.

Frequent detergent sprays should be evaluated to develop an IPM mite control in vineyards in Chile.

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