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**IMPACT OF SOME ALTERNATIVE METHODS TO CHEMICAL CONTROL FOR CONTROLLING APHIDS
(HEMIPTERA: STERNORRHYNCHA) AND THEIR SIDE EFFECTS ON NATURAL ENEMIES ON YOUNG
CITRUS MOROCCAN GROVES
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ABSTRACT

Aphid control in Moroccan citrus orchards is based mainly on chemical sprays. This research aimed to assess the control of aphids with insecticidal soap, kaolin and augmentative biological control using the indigenous predator *Adaliadecempunctata* L. (Coleoptera: Coccinellidae). The insecticides were applied and the predators were released in April 2009 and 2010. Under field experimentation, the methomyl and imidacloprid foliar pulverization were very effective against aphids. In contrast, the insecticidal soap and kaolin application were less efficient while *A. decempunctata* adults were effective only in the first week after release. The side effects on beneficial insects were also assessed and discussed. The possibility of employing *A. decempunctata* in an integrated pest management package in citrus groves is discussed in relation to effectiveness and side effects on beneficial arthropods.

Keywords: *Adalia decempunctata*, Aphididae, Beneficial species, Biological control, Morocco.

RESUME

IMPACT DE QUELQUES MÉTHODES DE LUTTE ALTERNATIVE A LA LUTTE CHIMIQUE POUR LE CONTRÔLE DES PUCERONS (HEMIPTERA: STERNORRHYNCHA) ET LEURS EFFETS SECONDAIRES SUR LES ENNEMIS NATURELS SUR JEUNES PLANTATIONS D'AGRUMES AU MAROC.

La lutte contre les pucerons dans les vergers d'agrumes marocains est principalement basée sur les pulvérisations chimiques. Cette étude a pour objectif d'évaluer l'effet du savon insecticide, du kaolin et de la lutte biologique augmentative contre les pucerons, en utilisant le prédateur indigène *Adaliadecempunctata* L. (Coleoptera: Coccinellidae). L'application des insecticides ainsi que les lâchés du ont été réalisés en avril 2009 et 2010. En verger, la pulvérisation foliaire avec le méthomyl et l'imidaclopride a été très efficace contre les pucerons. En revanche, le savon insecticide et le kaolin étaient moins efficaces tandis que les populations d'*A. decempunctata* n'étaient efficaces que dans la première semaine après leur lâchés. Les effets secondaires sur les insectes bénéfiques ont également été évalués et discutés. La possibilité d'employer *A. decempunctata* dans un programme de lutte intégrée en vergers d'agrumes est discutée en relation avec l'efficacité des méthodes de lutte utilisées et leurs effets secondaires sur les ennemis naturels.

Mots-clés : *Adaliadecempunctata*, Aphididae, Espèces bénéfiques, Lutte biologique, Maroc.

INTRODUCTION

In Morocco, the citrus industry plays a very important socio-economic role with a total acreage of about 124,000 ha and an estimated production of 2.3 million tons per year (MAPM, 2015). In Morocco, several pests limit citrus production and can cause significant damage when conditions are favorable for the pests. Besides scales, medflies, mites and snails, aphids also are major pests, with negative effects on affecting citrus productivity (Mazih, 2011). In Morocco, the aphid species that infest citrus orchards are: spirea aphid (*Aphis spiraecola* Pach), black citrus aphid (*Toxoptera aurantii* Boyer de Fonscolombe), melon aphid (*Aphis gossypii* Glover), green peach aphid (*Myzus persicae* Sulzer), black bean aphid (*Aphis fabae* Scopoli) and cowpea aphid (*Aphis craccivora* Koch) (Hemiptera: Aphididae) (Delucchi, 1964; Smailiet al., 2001 & 2008; Sekkat, 2008). However, the brown citrus aphid *Toxoptera citricida* Kirkaldy (Hemiptera: Aphididae), which is a main citrus aphid pest on the north part of the Mediterranean zone, mainly in Portugal and Spain (Nieto-Nafria et al., 2005; EPPO, 2006; Ilharco & Sousa-Silva, 2009), currently does not exist in Morocco. In the Gharb area (north-west of Morocco), only the first three species are considered the most important citrus pests (Smailiet al., 2009). When conditions are favorable, these species can cause significant damage, especially to young citrus plantations, causing falling and growth stunting (Michaud & Browning, 1999). The two species *T. citricida* and *A. gossypii* are the main vector of CTV (*Citrus Tristeza* *Closterovirus* [Closterovirus: Closteroviridae]) (EPPO, 2004; Nieto-Nafria et al., 2005). However, *A. spiraecola* and *T. aurantii* can also, to less extent, be CTV vectors (Yokomi & Garnsey, 1987).

In the Gharb area and during certain years, aphids were considered as secondary pests in the old citrus orchards because the shoot infestations were very low (Smailiet al., 2009) while in young citrus plantations aphids are considered primary pests and damage often is visible requiring several chemical applications during the same year. In Morocco, an insecticide mix based with imidacloprid and methomyl, and sometimes with endosulfan and others active ingredients, is currently used to control aphids in citrus groves. Methomyl belongs to the carbamate class, widely used for controlling insects by inhibiting the enzyme acetylcholinesterase which hydrolyzes the neurotransmitter acetylcholine. Imidacloprid is a neonicotinoid substance which acts agonistically on the insect nicotinic acetylcholine receptor as molecular target and acts by interfering with the transmission of nerve impulses in insects (Mencke & Jeschke, 2002). In Morocco, these products are listed among the active ingredients recommended for controlling citrus aphids (AMPP, 2013). However, many efforts have been made to switch from chemical control to integrated pest management (IPM) on citrus. In this context, several so-called natural and commercial products compatible with IPM often are considered to be effective and recommended in controlling aphids in young citrus plantations, without taking into account their side effects and selectivity on the natural enemies. This is the case with insecticidal soap which acts on foliar insects by contact, dissolving their outer envelopes and causing the insect to dry up and die. It is also the case of kaolin, a natural mineral product in the form of fine white powder, which was reported as effective against several pests: Lepidoptera (Sackett et al., 2005; Jaastad et al., 2006), beetles (Showler, 2002), mites (Jaastad et al., 2006), fruit flies (Mazor & Erez, 2004; Saour & Makee, 2004; Villanueva & Walgenbach, 2007; Braham et al., 2007), thrips (Larentzaki et al., 2008) and aphids (Wyss & Daniel, 2004; Karagounis et al., 2006).

On the other hand, an augmentative biological control technique using especially native species often has been reported as a potential method to control some pests (Iperti, 1999; Michaud, 2001 & 2012; Van Lenteren et al., 2003; Crowder, 2007; Cock et al., 2009;). This work is part of an IPM program against citrus aphids and other pests in the Gharb region, and has two objectives: 1) to assess the efficacy of insecticidal soap, kaolin and augmentative biological control using *A. decempunctata* on young citrus plantations; 2) to assess side effects on beneficial insects under field trial.

MATERIAL AND METHODS

Area and field trial

The Gharb region is located in the Northwest part of Morocco. The climate is Mediterranean with an average rainfall ranging from 430 mm to 520 mm per year and mean

temperatures between 13°C in winter and 27°C during the summer. The experiment was conducted in a grove of 5 years old Clementine trees (*Citrus reticulata* Blanco), planted at a spacing of 4m x 5m (354 trees/ha), on a sandy soil located 9 km from the city of Kenitra (Gharb zone). Citrus grove was planted regularly with drip irrigated (daily watering) and routine fertilizer.

Treatment description

LANNATE25WP (25% methomyl, Amaro SA Casablanca Morocco) was sprayed at a dose of 250cc/hl. CONFIDOR (200 g/l imidacloprid, Bayer Crop Science, Casablanca Morocco) was applied at a dose of 50cc/hl. Black soap, a natural product derived from olive oil production (soap traditionally produced in Marrakech, Morocco) was used at a dose about 0.2 kg/hl. The kaolin (based powdery product is a non-toxic white concentrated and fine powder $Al_2[(OH)_2, Si_2O_5]$) was applied at a dose of (KAOLIN formulated product, Agriman Firm, Casablanca, Morocco about 2000 liters/ha was applied at a dose of 1.4%). Augmentative biological control involved the release of *A. decempunctata* adults less than one week old with one adult/tree (d1) and four adults/tree (d2) during April of 2009 and 2010 respectively. *A. decempunctata* larvae were picked *in situ* from other citrus orchards in the Gharb area where their abundance is high. They feed on aphids (*A. spiraeicola* and *T. aurantii*) infesting clementine shoots seedlings (*Citrus reticulata* Blanco cv Cadoux) inside Plexiglas (50cm x 51cm x 40cm) in the laboratory of entomology (Regional Agricultural Research Center, Kenitra, Morocco). They are then kept in a rearing cage until adult emergence. Infested citrus shoots were transplanted into moistened soil to keep their turgor under controlled conditions (temperature: 25±1°C, relative humidity: 70%) with natural lighting. Shoots showing signs of weakness were replaced by new ones. Before releasing in the field, *A. decempunctata* adults were placed separately and kept without aphid food in the Plexiglas for 24 hours, in order to maximize their predatory reflex toward aphids in the same controlled conditions mentioned above.

Field assays

Trials were conducted from March to June, in 2009 and 2010. The experiment was conducted as a Randomized Complete Block Design, with three blocks. Each block consisted of five treatments which included: 1/ methomyl/imidacloprid (plots with trees sprayed with methomyl in 2009 or imidacloprid in 2010); 2/ insecticidal soap (plots with trees sprayed with the soap); 3/ kaolin (plots with trees sprayed with kaolin); 4/ adalia/d1 or adalia/d2 (plots with trees where *A. decempunctata* adults were released with a dose d1 and d2 mentioned above, during 2009 and 2010 respectively) and 5/ a control: plots with trees sprayed only with water. In each block, each treatment consisted of fourteen trees with two rows, of which four were randomly selected (14 trees per treatment x 3 replications). Then on those trees, eight shoots per tree were selected again. (Thirty two seedlings per treatment x 3 replications). The young citrus shoot, noted here by "shoot" is easily recognizable by its green color and clear with flush or young leaves, which are infested with early and newly formed aphid colonies. On the contrary, old citrus shoots are wounded with dark green color and are already infested by aphid colonies. Treatments applied were foliar pulverization with a conventional 120l air blaster ground sprayer (capacity of 120 liters, Agriman Firm, Casablanca, Morocco), pulled by a mini tractor (Mark Victor BCSAR500, power 45 HP, Ramioui Firm Sarl, Casablanca, Morocco). One foliar spraying of each product listed above was applied about five to six liters per tree in the morning of April 07 2009 and April 06 2010. For each treatment, all rows and trees were covered by the product. This period often coincides with a high number of aphid colonies and citrus flush is very attractive. To avoid interference between treatments, the plots were separated by one row of trees acting as guards. No other insecticide treatments were applied while the trial was performed in clementine grove.

Monitoring and Assessment

Aphids

A total of six variables belonging to two categories were recorded at four dates (5, 7, 14 and 21 days) after treatment. The first category referred to the density of aphids (*T. aurantii*, *A. spiraeicola*

and the two species grouped together) and was estimated by the number of aphids per shoot. The second category referred to the level of shoot infestation by aphids (*T. aurantii*, *A. spiraecola* and the two species grouped together), and was estimated by dividing the number of infested shoots by the total number of shoots observed (per tree). Each shoot was considered infested when it hosted one or more colonies of *T. aurantii*, *A. spiraecola* or both species. Other important aphid species such as *M. persicae* or *A. gossypii* were absent during these field trials.

Natural enemies

Natural enemies were monitored using different methods. On citrus shoots, for each treatment, the number of natural enemies was counted in each citrus shoot used for aphids sampling. Many species of beneficial insects were recorded on Moroccan citrus groves (Smaliet *al.*, 2009 & 2013). The main groups of these beneficial species were the parasitoids (Aphelinidae, Braconidae, Encyrtidae and Eulophidae) and the predators (Coccinellidae, Syrphidae, Nitidulidae, Chrysopidae, Cecidomyiidae, Coniopterygidae and Phytoseiidae). The density of each species was estimated by recording the total number on eight shoots (4 observations x 3 replicates). Parasitism was estimated by dividing the number of parasitized aphids by the total number of aphids recorded on eight citrus shoots. With the beating method, in each treatment, twelve branches randomly selected were beaten (12 x 4 branches per treatment). To standardize the method, each branch was stricken ten times by a stick fitted at its end with a rubber. The natural enemies fell in the jar of the trap containing 70% alcohol. The density of each species was estimated by counting the total number of species found on the twelve branches (4 observations x 3 replicates). The yellow sticky traps were used to follow the hymenoptera species. In each treatment, one trap (20 x 6 cm²) was suspended on the south side of the tree. The number of species caught in the trap was counted in the laboratory under a binocular microscope. The density of each species caught was estimated by counting the total number in each trap (one observation x 3 replicates). The visual observation method was used for monitoring the hoverfly *Episyrphus balteatus* DeGeer (Diptera: Syrphidae). Its density was estimated by counting the number of hoverflies moving side by side to each sampling tree during a 15 minutes period (4 observations x 3 replicates).

Treatment effect and percentage efficacy

Effect of treatment was estimated by the rate of reduction (% Ri) using the following formula: $R_i\% = (1 - T_i / T_{0i}) \times 100$ (Abbott, 1925; Farmanullah *et al.*, 2005), where T_i is the average of the studied variable "i" (density or infestation) in the treated plots; T_{0i} is the average of the studied variable "i" in the untreated control plots. The percentage efficacy control ($E_i\%$) was estimated and computed using the following formula (Henderson & Tilton, 1955): $E_i\% = [(1 - T_{0i} \text{ before treatment} \times T_i \text{ after treatment}) / (T_{0i} \text{ after treatment} \times T_i \text{ before treatment})] \times 100$; with T_{0i} : average of the studied variable "i" for the control; T_i : average of the studied variable "i" in the treated plots.

Statistical analysis

At each date, ANOVA was used to compare the effect of the treatment on the variables; density of *T. aurantii*, *A. spiraecola* and aphids; the infestation of shoots per *T. aurantii*, *A. spiraecola* and aphids, and finally the densities of different beneficial species recorded. Separation of homogeneous groups (levels of the factor treatment) was made by t test (LSD at the $P=0.05$ level using the procedure SAS software version 9.1.3 (SAS Institute, 2005). Square-root and Arcsin (square-root) transformation of the number of aphids and transformation of the infestation of shoots were used to normalise the data.

RESULTS

Aphid density and shoot infestation

During 2009, there was a difference among the mean densities of aphids in the various treatments. Five days after product application, the mean aphid density was significantly much lower

in the methomyl treatment than in all others. However, this density was similar in the plots sprayed with insecticidal soap, kaolin and the untreated control. The aphid density had also increased in the adalia/d1 treatment about 99.63 ± 96.32 . Seven days later, the mean aphid density was significantly lower in the insecticidal soap, kaolin and adalia/d1 treatments than the untreated control. Furthermore, aphids were recorded on shoots previously sprayed with methomyl and aphid density was less in adalia/d1 treatment than others, however, this reduction was not statistically different among treatments. The mean of shoot infestation was statistically different among treatments during 2009. Five days after product application, shoot infestation increased in the kaolin and adalia/d1 treatments, while there were no infested shoots in the methomyl treatment. Two days later, mean shoot infestation was null and low for methomyl and adalia/d1 treatment respectively (for *T. aurantii*). At other sampling dates, mean shoot infestation was similar for all treatments.

During 2010, mean aphid density varied among the treatments. Five days after, the mean aphid density in adalia/d2 was similar compared to the insecticidal soap and kaolin treatments, but statistically less than the control. Seven days later, the aphid density was lower in adalia/d2 treatment than insecticidal soap and kaolin treatments. Two weeks later, imidacloprid and adalia/d2 treatments scored similarly, and were different from kaolin, the insecticidal soap and the untreated control. For other sampling date, the density was lower in the imidacloprid and adalia/d2 treatments than other treatments, but was not statistically significant compared to the untreated control. Also differences in the mean shoot infestation among treatments were significant. Five days later, no difference was observed among imidacloprid, kaolin, insecticidal soap and adalia/d2 treatments. Two more days after, shoot infestation was similar for adalia/d2 and imidacloprid treatments, but statistically lower than others. In the other sampling dates, a heavy shoot infestation was recorded in the plots pulverized by insecticidal soap and kaolin, but not significantly different from that registered on others treatments.

Effect of treatment

Considering mean aphids density, reduction was higher for the methomyl treatment one week after (100%) and further decreased (around 60%) during 2009 (Table I). For the insecticidal soap treatment, reduction was very low at first (6.26%) and varied later (38% to 57%), but became negative for the last sampling. For kaolin, reduction didn't exceed 65.4% the first week and became negative afterwards. Reduction in adalia/d1 treatment was about 63.5% one week later and then became negative. During 2010, reduction was always above 50% for imidacloprid treatment. Reductions for insecticidal soap and kaolin treatments were low or negative, except for kaolin treatment in the last sampling. adalia/d2 treatment allowed a great reduction (90.04%) one week after *A. decempunctata* was released. However, a small reduction was found later, ranging between 21.42% and 30.76%. Considering mean shoot infestation, reduction for methomyl application was higher (100%) after one week compared to 2009 (Table II). This reduction decreased at later dates (20% and 36.66%). During 2010, reduction was variable for the imidacloprid treatment (0% and 80%). The insecticidal soap application showed a low or negative reduction at one week, but an increase of shoot infestation was recorded afterwards. However in kaolin and adalia/d2 treatments, reduction was low only after one week.

Percentage of efficacy control

Considering mean aphid density methomyl and imidacloprid treatments were very effective during the first sampling date. Application of insecticidal soap and kaolin during 2009 has the maximum efficiency, about 63.1% and 83.6% respectively, one week after their pulverization. However, during 2010, these two products didn't seem very effective against aphids (except the last date for kaolin). The efficacy of adalia/d1 and adalia/d2 were ranging between 71.7% and 89.42%, only the first week after the *A. decempunctata* release. Regarding shoot infestation, methomyl and imidacloprid were very effective (100%) and ranging between 57% and 78.7%, respectively, during the first week. Insecticidal soap and kaolin treatments were not effective in 2009 (13% and 20%). The same observation was noted during 2010, with a negative efficacy for the

insecticidal soap and kaolin treatment. Adalia/d1 treatment was not very efficient in 2009 (<15%). However, efficacy of adalia/d2 treatment should be considered (55.40%) but only one week after the release of *A. decempunctata*. Effectiveness and percentage reduction classified arbitrary qualitatively varied among treatment. Methomyl and imidacloprid treatments were very effective following by adalia/d2 treatment.

Natural enemies

Differences among treatments in the density of beneficial species per sampling date were significant throughout the monitoring period. During 2009, the methomyl application reduced the number of natural enemies, compared to the others treatments. Coccinellid density was higher in adalia/d1 treatment than in the control after one week. The same observation was made for the lacewing *C. carnea* in adalia/d1. No difference was observed among treatments in the density of the syrphid *E. balteatus*, although the density was relatively higher in the untreated control and adalia/d1. During 2010, the coccinellids density was lower in imidacloprid trees than in control. However if species are considered separately, this density is not significant for all treatments. The density of the lacewing *C. carnea* was similar for adalia/d2, kaolin and control treatments. The density of spiders was higher for adalia/d1 and control treatments during the first week. Parasitized aphids were not observed in our samples during 2009. Except a maximum of 25.44% noted at the insecticidal soap treatment, no significant difference was observed among all treatments. During 2010, the hymenoptera density was higher in adalia/d2 and control treatment than in the others.

Table I: Taux de réduction (R%) et efficacité (E%) des traitements appliqués sur la densité des pucerons

(Reduction (R%) and effectiveness (E%) treatments applied to the density of aphids [dat= days after treatment]). [dat= days after treatment]

	5 dat		7 dat		14 dat		21 dat	
	R%	E%	R%	E%	R%	E%	R%	E%
Methomyl	100*	100	100	100	62.27	70.71	58.82	68.04
Imidacloprid	89.79**	90.35	97.85	97.96	50.00	52.75	80.76	81.83
Soap	6.26	19.60	56.96	63.09	38.28	47.06	-11.76	4.14
	6.63	-26.36	7.29	-25.47	-263.57	-392.08	-73.07	-134.25
Kaolin	17.63	61.10	65.43	83.67	-7.90	49.04	-4.57	50.61
	22.83	31.56	35.91	43.17	-273.57	-231.26	88.46	89.76
Adalia/d1	-35.02	-4.52	63.56	71.79	25.28	42.23	-54.24	-19.41
Adalia/d2	40.83	37.17	90.04	89.42	21.42	16.55	30.76	26.47

*; **: Values in 2009 and 2010 respectively. See text for definition and formula of reduction percentage and effectiveness percentage

Table II: Taux de réduction (R%) et efficacité (E%) des traitements appliqués sur l'infestation des pousses par les pucerons

(Reduction (R%) and Effectiveness (E%) treatments applied for shoot infestation [dat= days after treatment].)

	5 dat		7 dat		14 dat		21 dat	
	R%	E%	R%	E%	R%	E%	R%	E%
Methomyl	100*	100	100	100	20.00	28.42	36.66	43.33
Imidacloprid	53.01**	50.24	59.05	57.03	0.00	-6.15	80	78.76
Soap	-13.20	-22.84	0.00	-8.51	13.33	5.95	26.66	20.42
	6.25	-13.48	-4.76	-26.81	-118.75	-164.80	-200	-263.15

Kaolin	-22.64	-7.83	3.33	9.13	-13.33	0.34	-3.33	9.13
	42.18	46.81	-4.76	3.61	-13.25	-20.75	60	63.20
Adalia/d1	-32.07	-29.53	5.00	6.82	-20.00	-17.69	13.33	15.00
Adalia/d2	10.93	12.20	54.76	55.40	0.00	1.42	-60	-57.71

*; **: Value in 2009 and 2010 respectively. See text for definition and formula of reduction percentage and effectiveness percentage

DISCUSSION AND CONCLUSION

The imidacloprid and methomyl foliar spray reduced the aphid populations and shoot infestation in young citrus groves compared to untreated control. These products are very effective for controlling aphid; however they reduced the density of the most beneficial species. Methomyl is known for having side effects on several beneficial species, especially Hymenoptera (Krespit *et al.*, 1991; Schuster, 1994; Cerrillo *et al.*, 2005). The Environment Protection Agency (EPA), the European Chemical Classification (ECC) and the World Health Organization (WHO) classify methomyl as very toxic and hazardous (Mohamed, 2009). Imidacloprid is known for its side effects on natural enemies such as coccinellids (Smith & Krischik, 1999), Hymenoptera: Apidae in the laboratory (Schmuck *et al.*, 2001); Coccinellidae on peach groves (Karagouniset *al.*, 2006; Kourdoumbalouset *al.*, 2006); the Neuroptera Hemerobiidae on lettuce (Cole & Horne, 2006) and predatory beetles on okra (Solangi & Lohar, 2007) and some pollinators insects of wild flowers (Mommaertset *al.*, 2010). Under field trial, insecticidal soap and kaolin foliar spray have reduced aphid density for one week. In contrast, they don't seem very effective in reducing citrus shoot infestations. In a previous study, three products allowed in organic farming (kaolin, mineral oil and insecticidal soap) were applied for the control of *M.persicae* in a peach orchard (Karagouniset *al.*, 2006). According this study, all products showed good control in the first year, but in the next year they were less effective. However, a study examining the effects of kaolin particle film treatments on some pests in apple cv. Golden Delicious orchards in Europe showed that there was no effect on the number of colonies of rosy leaf curling aphid *Dysaphis devectora* Walker (Marko *et al.*, 2008). According to this study the level of infestation of rosy apple aphid *Dysaphis plantaginea* Passerini and the woolly apple aphid *Eriosoma lanigerum* Hausmann increased in the kaolin-treated plots. In our conditions, aphid density and citrus shoot infestation were reduced one week after *A. decempunctata* releasing. Ladybirds were effective during this week, probably because *A. decempunctata* adults released had in first a great capacity for research and predation. But after the first week, the predation was low. Two possible hypotheses can explain this: on the one hand, the low number of *A. decempunctata* adults released (both for d1 and d2), on the other hand, the presence of ants in this citrus orchard after this first week influence coccinellids predation of aphids.

Under citrus fields conditions, methomyl, imidacloprid and insecticidal soap also showed lower densities of natural enemies compared to kaolin treatment and *A. decempunctata* release. The density of coccinellids was higher in adalia/d1 and adalia/d2 plots for one week. However, the second year, the mean density of each species taken separately was similar for all treatments, except for imidacloprid which was much lower. On apples, spraying kaolin once a week for four weeks against *Choristoneura rosaceana* Harris (Lepidoptera: Tortricidae), altered the composition of generalist predators and reduced the abundance of some families such as the coccinellids (Sackett *et al.*, 2005). In olive groves, kaolin revealed during three years a significant deleterious effect on the natural enemy arthropod community such as *Scymnus mediterraneus* Labkoff-Khuzorian, *Stethorus punctillum* Weise and *Hyperaspis reppensis* Herbst (Pascualet *al.*, 2010). However, the previous study on *M.persicae* in a peach orchard showed that insecticidal soap and kaolin had little or no adverse effects on Coccinellidae (Karagouniset *al.*, 2006; Kourdoumbalouset *al.*, 2006). In contrast, insecticidal soaps application may be compatible with biological control of The Asian citrus psyllid (ACP), *Diaphorina citri* Kuwayama (Hemiptera: Psyllidae), by adult coccinellids like *Cycloneda sanguinea* (L.) (Coleoptera: Coccinellidae), but not the parasitoid *Tamarixia radiata* (Waterston) (Hymenoptera: Eulophidae) (Hall & Richardson, 2013).

Chrysopidae species are known as generalist predators that greatly contribute to the natural control of pest species in citrus orchards such as aphids, citrus leafminer and whiteflies (Michaud, 1999 & 2001). In our study, *C.carnea* density was high during the first week for adalia/d1 and untreated control treatments during 2009 and for adalia/d2, kaolin and untreated control treatment during 2010. However, in apple groves, despite the fact that the aphid prey supply was substantially higher, Chrysopidae adults did not aggregate in the kaolin-treated plots (Markoet *al.*, 2008). In olive fields, the numbers of Chrysopidae adults were lower in the kaolin plot than in the untreated control plot over the three years of study (Pascualet *al.*, 2010). The spiders Araneidae, Philodromidae and Salticidae were the most numerous family, with predation as a main behavior. During the two years, spider densities were similar for all treatments, slightly higher in adalia/d1 and adalia/d2 treatments. On apples, spraying kaolin altered and reduced the abundance of the spiders Salticidae and Philodromidae (Sackett *et al.*, 2005; Markoet *al.*, 2008). In olive groves, the family Philodromidae was the most vulnerable to kaolin spraying (Pascualet *al.*, 2010). In our field trials, hoverflies *E.balteatus* densities were similar for all treatments, despite their density was relatively high in the plots where *A.decempunctata* was released and in the untreated control. In apple, kaolin spraying reduced the abundance of polyphagous predators like predaceous Heteroptera and the red velvet mite *Allothrombium fuliginosum* Hermann (Markoet *al.*, 2008). Except a maximum of 25.44% noted for the insecticidal soap treatment, the parasitism seemed to be similar for all treatments. However, the hymenoptera recorded in the sticky traps were more numerous in the plot where *A.decempunctata* were released and the untreated plot. It appears that a single foliar application with kaolin, insecticidal soap and both densities of *A.decempunctata* release is not sufficient to control aphids on young citrus groves. Single foliar spraying with kaolin and insecticidal soap, does not prove to be a suitable solution to control aphids. However, frequent releases with higher doses than those experimented of *A.decempunctata*, is considered as a promising and potential alternative method to control aphids. It is the same for *Scymnus subvillosus* Goeze and *Coccinella septempunctata* L. (Coleoptera: Coccinellidae), species very abundant in most citrus orchards in Morocco with low dispersal behavior (Smali M.C., personal observation). This applied trial gave information, about which safe natural product (insecticidal soap and kaolin) merits consideration and also about the possibility to use indigenous natural enemies such as *A.decempunctata* into an integrated management strategy for controlling aphids in young citrus groves.

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