Article

Comparison of mineral oil spray with current synthetic pesticides to control important pests in citrus orchards and their side effects

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Received 25 January 2016; *Accepted 5 March 2016*; *Published online 1 June 2016*

Abstract

Over the past years the most important citrus pests poorly controlled despite multiple spraying and growers suffered heavy damage. To this end, a study was done to evaluate and compare the conventional insecticides with mineral oil spray (MOS) for the control of citrus pests and adverse effects in citrus orchards in Mazandaran province. In this study, the diversity and abundance of carabid beetles, as a specific predator of snails, were compared in conventional and free protocol pesticide (or MOS) orchards. The results showed that the frequency and distribution of important citrus pests in free protocol pesticide orchards after three years of treatment was significantly lower than conventional orchards. The comparison showed that continual use of synthetic pesticides in citrus orchards in the province , leading to a sharp reduction in their population and species diversity. The results of this study indicate that the use of mineral oil can be a useful alternative to synthetic pesticides in citrus orchards of the East province.

Keywords citrus pests; mineral oil; insecticides.

Arthropods
ISSN 2224-4255
URL: http://www.iaees.org/publications/journals/arthropods/online-version.asp
RSS: http://www.iaees.org/publications/journals/arthropods/rss.xml
E-mail: arthropods@iaees.org
Editor-in-Chief: WenJun Zhang
Publisher: International Academy of Ecology and Environmental Sciences

1 Introduction

Mazandaran province has a 36.78% of the acreage of fertile citrus orchards as well as 38.73% of total production of this crop in the first place is allocated .Therefore, citrus alongside rice is one of the strategic crops in Mazandaran province (Abdullahi Ahi, 2011). Despite the many investigators confirmed the existence of predators, parasitoids and parasites of citrus orchards in the province, yet thousands of citrus trees are sprayed in indiscriminate and clumsy, resulting in pest insurgence, the emergence of resistance to insecticides , and inefficiency of natural enemies in the region (Damavandian, 2007). Nowadays, due to severe insurgence of citrus brown scale, *Chrysomphalus dictyospermi* Morgan and pest resistance such as citrus cushion, *Pulvinaria aurantii* Cockerell and *C. dictyospermi* to pesticides (Damavandian, 2007), some citrus growers have come to

believe that should protect present natural enemies in the orchards and fields and repeated spraying is not a proper and fundamental solution. Though Carabid beetles are not known as specialized predators, but is proven their efficacy as voracious natural enemies to control the different pests (Eyre et al., 2009). According to Van toor (2006), long-term use of insecticides and molluscides in an agricultural environments can reduce species diversity and abundance of carabid beetles. One way of protecting natural enemies is the use of mineral oil instead of insecticide and acaricide (Rae et al., 1996). According to Davidson et al. (1991), a lot of citrus pests including scales, mealybugs and mites can be controlled by mineral oils. Since harmful effect of oils on the natural enemies of the pests is minimal compared with pesticides (Rae et al., 1996), and affect resistant strains of pests and is not reported on emerging resistance to mineral oils (Helmy et al., 2012). Therefore, their application may support and preserve natural enemies such as parasitoids, predatory mites and carabid beetles and will decrease emerging resistance because of reducing the application of chemical pesticides. The aim of this study was to compare the mineral oil spray (MOS) with conventional pesticides for control of the main citrus pest, to evaluate their impact on the diversity and abundance of citrus pests and some their natural enemies in Mazandaran citrus orchards. To this is that the results of this study be the first step to remove conventional pesticides in Mazandaran citrus orchards and is replacing them with mineral oil.

2 Materials and Methods

The study in the form of two separate experiments were conducted:

2.1 Experiment 1: Comparison of conventional pesticides with MOS to control important citrus pests

2.1.1 Orchard profile

This study was conducted in two areas of Sari (36˚.0′N, 53˚4′E) and Babolsar (36˚45′N, 52˚45′E) cities (Mazandran province, north of Iran). Two orchards were selected each with an area of 1.5 and 2 ha in Sari and two other orchards were selected with an area of one ha and 3,000 m^2 in babolsar. All trees were Thomson novel orange variety of *Citrus sinensis* Linnaeus on *Citrus aurantium* root stock.

2.1.2 Experiment

The method of pest control in the four orchards was in this way that be used insecticide and acaricide based on plant protection experts's recommendation, so Dursban (EC40.8%) and Nissorun (EC10%) with concentrations of 200 and 100 ml, in 100 l of water for the first control, Gusathion (EC20%) with concentration 250ml in 100 l of water for the second control and amitraz (EC20%) with concentration 200ml in 100 l of water for the third control were used. These orchards was compared with three other orchards in the same cities that their pests had been controlled only by mineral oil with 80% active ingredient and the 92% unsulfonated residue (UR) for 3 years. Since the economic injury level (EIL) of citrus pests has not been determined, therefore, the control time was determined empirically (Pedigo, 2004). This study lasted two years.

2.2 Experiment 2: Comparison of the abundance and diversity of carabid beetles in conventional and free protocol pesticide (=MOS) orchards

2.2.1 Orchard profile

This experiment was conducted in a citrus orchard with an area of about 70 ha. Citrus trees were mostly Thompson novel orange variety of *C. sinensis* with 15-years old and also there were a few Satsuma Mandarin trees (*Citrus unshiu* Marc.). In one plot 7 ha of above orchard, pest control was depended on MOS and natural enemies. In the central part of the mentioned block, were selected 14 rows of trees that each row included 32 trees. In other part of orchard that pest control is conducted using conventional and synthetic pesticides according to the time table, were selected 448 trees that their position was similar to position of selected trees in free protocol pesticide block.

2.2.2 Experiment

In each block of the selected orchards (MOS and conventional), 12 pit fall traps were installed. Traps with an inter-row distance of 12 m and 50 cm from the trunk were placed in the ground. The method of controlling was similar to the previous experiment but had this difference that in sprayed parts for the second and third steps of control were used mollucides including Methiocarb (WP50%) and Metaldehyde (P60%) as bait besides mentioned pesticides. The first sampling is conducted about three months after the third control in both blocks of experimental orchards and then continued with intervals every two weeks for ten months. In sampling, all the contents of the pit fall trap transferred to a glass dish separately in the laboratory and then all samples of carabid beetles were identified in the genus and species (Lindroth, 1974). After identification, the number of beetle species are counted respectively. The survey was conducted for one year. All data obtained from two orchards tested using statistical software MSTATC and the means were compared using T-TEST.

3 Results

3.1 Experiment 1

Population diversity of pests was significantly more in conventional orchards than free protocol pesticide (MOS) orchards (Table 1). From four common scales in the Mazandaran citrus orchards, only citrus cushion, *P. aurantii* needed to be controlled by mineral oil in the MOS orchards. In conventional orchards, in addition to the cushion citrus, also other scales including citrus brown scale and citrus mealybug had a large population that needed to be sprayed, and the population of *P. aurantii* in conventional orchards was much more compared with MOS (free protocol pesticide) orchards (Table 1 A, B). In each four conventional orchards, citrus red mite, *Panonychus citri* McGregor and citrus rust mite, *Phyllocotruta oleivora* Ashmed populations was abundant that required to be controlled, but in MOS orchards, mentioned pests was not observed and very low population *P. citri* was reported only in an orchard that did not need to be controlled (Table 1 A, B).

3.2 Experiment 2

After one year, 7 and 12 species of carabid beetles were identified in the sprayed and MOS plots, respectively (Table 2). The average number of species of carabid beetles in the conventional and MOS orchards are presented in table 2. The results of this study showed that one of the fatal effects of synthetic insecticides and acaricides in orchard ecosystems is reduction of biodiversity and abundance of population of carabid beetles. Between 12 identified species of carabids, population of four species including *Broscus karelinii* Zoubkoff, *Harpalus rufipes* Degeer, *Brachinus brevicollis* Motschulsky and *Poecilus cupreus* Linnaeus was more significantly compared to other species (Table 2). On the other hand, 4 the mentioned species have been reported as valuable and important predators in orchards and fields (Symondson et al., 2002; Mckemey et al., 2003; Oberholzer and Frank, 2003). So the population of four mentioned species was also examined separately. Overall, the average population of carabid beetles was significantly higher in citrus orchard without synthetic pesticides than citrus orchard that were sprayed by synthetic pesticides during different dates of sampling (Fig. 1).

T-TEST results show that the average population of carabid beetles in free protocol pesticide orchards are significantly different ($p \leq 0.01$) compared with conventional orchards at 10 dates of sampling, except 5 dates of sampling that began in early December and ended in mid-February. The abundance of *B. karelinii* that was most abundant carabid species during dates of sampling in two studied citrus orchards is shown in Fig. 2.

Table 1 The controlled pest in experimental citrus of Mazandran province in two years.

Pest	A: pests in conventional citrus orchards			
	Sari city		Babolsar city	
	Baharestan 1	Baharestan 2	Shorak	Moghrikola
Pulvinaria aurantii	xxx	xxx	xxx	x
Chrysomphalus dictyospermi	-	x	x	xxx
Icerya purchasi	x	x	x	x
Pseudococcus citri	xx	xx	-	-
Panonychus citri	xxx	xxx	xxx	xxx
Phyllocoptruta oleivora	xxx	xxx	xxx	xxx
B: pests in MOS (=free protocol pesticide) orchards after 3 years				
Pest	Sari (badeleh)		Babolsar	
			Kalehbast 1	Kalehbast 2
Pulvinaria aurantii	xxx		xx	xx
Chrysomphalus dictyospermi	x		x	x
Icerya purchasi	x		x	x
Pseudococcus citri	-		-	-
Panonychus citri	x		-	-
Phyllocoptruta oleivora	-		-	-

Key: xxx = high pest population and the control was necessary, xx = moderate pest population and the control was done, x = low pest population and the control was not done, - = pest was not found

Table 2 Identified species of carabid beetles in conventional and free protocol synthetic pesticide (=MOS) orchards and the average number of carabids trapped during 15 stages of sampling per each trap.

Conventional orchard		MOS (=Free protocol pesticide) orchard	
Species	Mean	Species	Mean
Laemostenus caspius	0.06	*Laemostenus caspius*	0.42
Brachinus brevicollis	4	*Brachinus brevicollis*	4.7
Agonum dorsale	0.39	*Agonum dorsale*	0.78
Poecilus cupreus	0.3	*Poecilus cupreus*	1.4
Amara aenea	0.01	*Amara aenea*	0.2
Harpalus rufipes	1.7	*Harpalus rufipes*	5.7
Broscus karelinii	2.3	*Broscus karelinii*	11.6
		Harpalus distinguendus	0.03
		Pterostichus macer	0.22
		Brachinus crepitans	0.02
		Asaphidion flavicorne	0.01
		Harpalus subtruncatus	0.01

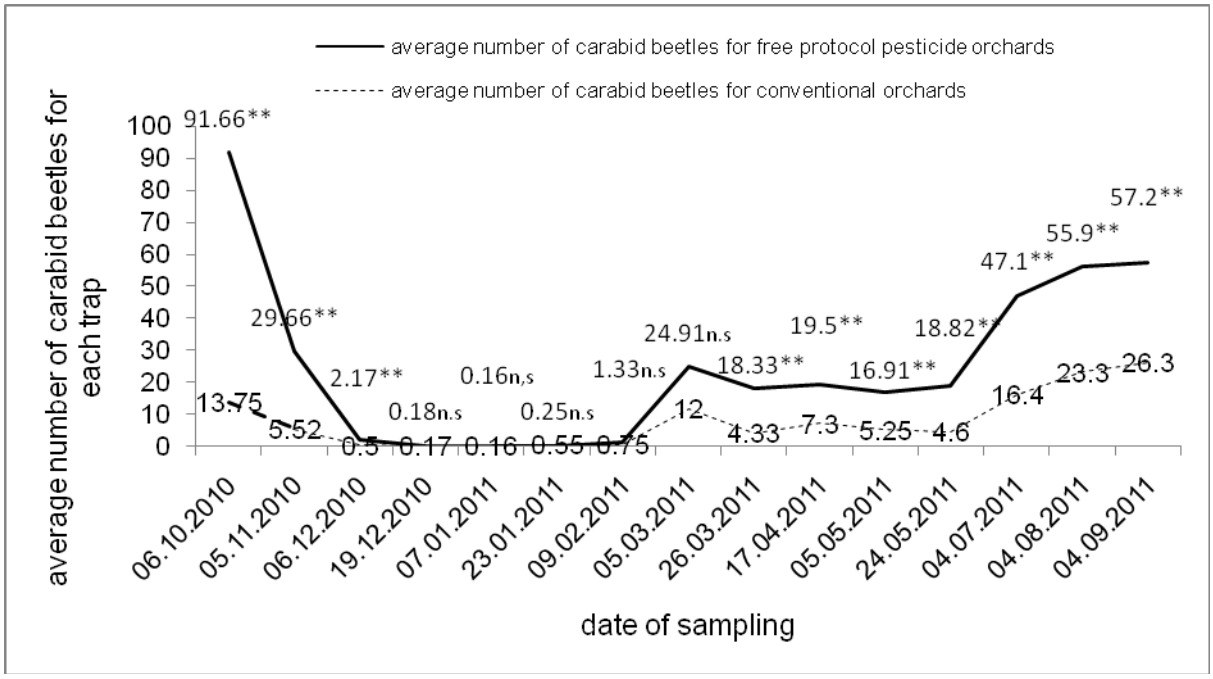

Fig. 1 The abundance and mean comparison of population of carabid beetles in conventional and MOS (=free protocol pesticide) citrus orchards at 12 dates of sampling (the dates that marked ** are significantly different ($p \leq 0.01$), and the dates that marked n.s are not significantly different).

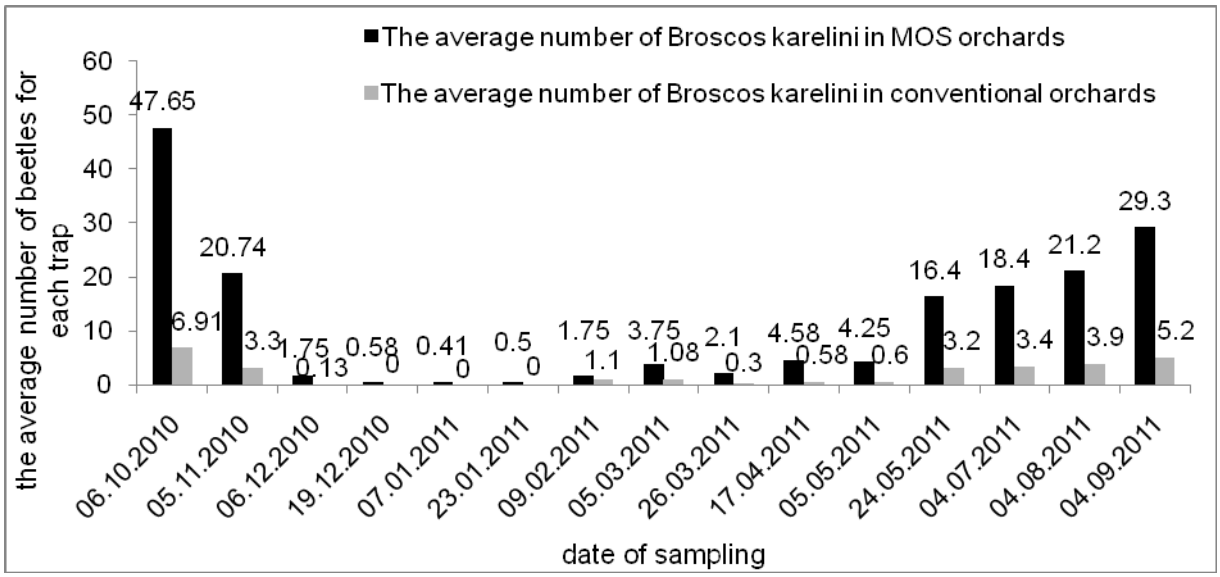

Fig. 2 The average population of *Broscus karelinii* in 15 dates of sampling per each trap.

The results of the T-TEST indicated that there were significant differences among the average number of *B. karelinii* in the conventional orchard (3.2) and free protocol pesticide (MOS) orchard (6.11) in each date of sampling per each trap (T=3.1452; p=0.0072). As it is known, the number of *B. karelinii* was always more rich in the free protocol pesticide citrus orchard than the conventional citrus orchard. Continual use of synthetic pesticides led to a sharp decline of the population and decreased the diversity of predatory carabid beetles in citrus orchards of Mazandaran province (Table 2).

4 Discussion

Since 1945, MOS and other pest control methods which were compatible with the IPM were forgotten. The cause of this is probably due to the supply of new broad-spectrum and cheap insecticides that easy to use and their effect was very rapid (Damavandian, 2009). Nowadays, the mineral oil is recommended as an important tool to control many citrus pests. In Australia, mineral oils is recommended to control of soft and armoured scales, mealybugs, mites and citrus leaf miner (Beattie, 2005).

The most important citrus pests of Mazandaran province such as citrus brown scale, *C. dictyospermi*, (Damavandian, 1994; Ghafari Lashkenari and Damavandian, 2013), citrus wax scale, *Ceroplastes floridensis* Comstock (Damavandian, 2003), citrus rust mite, *P. oleivora* (Damavandian, 2005), citrus cushion, *P. aurantii* (Damavandian, 2006; Rajabpour et al., 2007; Damavandian, 2010), citrus red mite, *P. citri* (Damavandian, 2007; Damavandian and Asghari Jafarabadi, 2007), citrus leaf miner, *Phyllocnistis citrella* Stainton (Amiri – Besheli, 2008; Kurd Firouzjaei et al., 2013; Damavandian and Kiaeian Moosavi, 2014), aphids (Razzaghi Chemazkoti and Damavandian, 2013) and citrus brown snail, *Caucastachea lencoranea* Musson (Kheirodin et al., 2012) can be controlled by mineral oil and do not need to use synthetic pesticides. Liang et al. (2007) and Leong et al. (2012) stated that the mineral oil controls Asian citrus psylla, *Diaphorina citri* Kuwayama. Helmy et al. (2012) reported that mineral oils controlled citrus scale insects without any harmful effect on citrus trees. Also, they stated that mineral oils have low toxicity to many organisms, including parasitoids and predators of whiteflies. According to Damavandian (2010), after pest control was performed, Phytoseiid predatory mite population and process of their population growth was higher and faster in the MOS orchards than the conventional orchards.

Similar results were reported by Van toor (2006) related to the decrease of population and diversity of predatory carabids in fields and orchards in Europe due to continuous use of pesticides. Inactivity or reduced activity of predatory carabid beetles lead to outbreaks of pests such as aphids, Dipterans, butterflies, thrips, leafhoppers and snails (Lang et al., 1998; Kromp, 1999; Nash et al., 2008). According to Kheirodin (2012), annually 50 tons types of molluscicides such as methaldehyde and methiocarb are applied to control snails and slugs in citrus orchards of Mazandaran province. Barker (1982) reported that methiocarb is caused mortality to earthworms and carabid beetles species such as *P. cupreus*, *H. rufipes* and *P. melanarius* (Langan et al., 2004), the considerable point is that the species of mentioned natural enemies are very effective in controlling snails and slugs (Oberholzer and Frank, 2003; Tulli et al., 2009). Carabid beetles have been proposed in many literatures as biological indicators (Werner and Raffa, 2000; Heyborne et al., 2003). The abundance and diversity of these beetles are strongly influenced by environmental conditions (Bromham et al., 1999; Duchesne et al., 1999) and can be attributed to environmental health related to the various factors such as pesticides (Kheirodin et al., 2012). These natural enemies have the ability to rebuild their population, and while, synthetic pesticides are removed from the environment, they will quickly rebuild their population (Prasifka et al., 2005; Devoto et al., 2007). Fortunately, in citrus orchard without synthetic pesticides, reconstruction process of the natural enemies population was observed.

In conclusion, the studying during five years showed that important citrus pests can be control acceptably without the use of synthetic pesticides. In the first year, the complete removal of pesticides from some orchards is not possible, but the desired results will be achieved gradually. It should be noted that the transitional period to Traverse from the pesticide spray to MOS orchards last between 1 to 3 years, that depending on the circumstances of each orchard and region and the controlling methods are used in the past. In some orchards that activities of natural enemies have not been seriously disrupted, this time may last a year. As a result, the use of MOS in Mazandaran citrus orchards, where environmental conditions are very suitable for their use, besides control common pests as well as, does not lead to emerging new pests and pest resistant

strains, on the other hand also they preserve the natural enemies that a big step is to achieve sustainable agriculture in the region. At the end should be noted that controlling of citrus pest by MOS is not the final solution and wide and comprehensive studies is required to identify the natural enemies of the predominant pests (especially citrus cushion, brown scale and mealybug) and methods of rearing and the release of them.

Acknowledgments

Therefore, will be sincerely grateful research Deputy of Agricultural Sciences and Natural Resources University of Sari because of fund and respectable management of the Baharestan orchards, Mr. Ismail Mohammad Nejad and Mr. Jafarian for sharing citrus orchards and Mr. Alireza Jafari because of sincere cooperation and data collection during three consecutive years.

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