The impact of ground vegetation on the most important plant mites (*Panonychus ulmi* (Koch) and *Tetranychus urticae* Koch) and their natural enemies associated with apple trees in Sweida, Syria

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Abstract

Population dynamics of the two-spotted spider mite Tetranychus urticae *Koch and the European red mite* Panonychus ulmi *(Koch) has been studied from 2010-2012 in an apple orchard in Sweida, Syria, planted with the varieties "Golden Delicious" and "Starking Delicious". The trial orchard has been divided into four sectors: the first was left without tilling since 2008, and without the leguminous cover plants, and the second section was planted with leguminous plants (*vetch *and* Lathyrus *sp.) in lines as a cover crop in the field from 2009. Then it was left without any cultivation for self multiplicatio. The third section was tilled normally annually but weeds left under the tree's crowns without tillage (mechanical cut only). The fourth sector was tilled normally annually and spring cultivation under the trees was done (as conventional treatments). Phytophagous mites and predatory mites have been counted in summer season from samples of leaves. Phytophagous mites were significantly less abundant in the no tillage sector on "*Golden *Delicious". There were significant differences in numbers of mites on "*Starking Delicious*" between the four sectors, and between the two species of mites. Two species of predatory phytoseiid mites, Typhlodromus pyri Scheuten and T. cotoneaster (Wainstein) were abundant in high numbers in the sector 1 and 2 on the two *apple varieties *(average 1 predator / leaf), and especially in the last year of the study. No acaricides have been used in both orchard sectors (which were left without tillage) in 2012 and 2013. In comparison, acaricides have been used annually in the mid of summer in other 2 orchard sectors because of the very high numbers of phytophagous spider mites. The high population density of predatory mites in the no-tillage sectors was the highest recorded in the study area since more than 10 years after annual follow-up in apple orchards there. Our results indicate the great importance of a better understanding of habitat management to control spidermites in apple orchards.*

Keywords: zero-tillage, spider-mites, natural enemies, apple, Syria

Introduction

There are many factors prevent rainfed agriculture from reaching its full potential productivity, so we have to do researches and efforts to Improve productivity in rainfed agriculture, like conservation agriculture which is a combination of reduced or zero tillage, mulch retention, crop rotations and cover crops. Those techniques offer multiple benefits for farmers in dry rainfed areas: control of soil erosion, better drought tolerance and improve soil nutrient levels, increasing water availability, productivity, soil organic matter and nutrient availability, and pest control, together with savings in labor and fuel costs. On the other hand, CA is supposed to be a key tool in sustainable production systems throughout the world, so we must support the adoption and spread of Conservation Agriculture In this way, the increasing challenges faced around the world (Haddad *et al*., 2011; Avci, 2011; Stewart *et al*., 2007, Kassam & Friedrich, 2010).

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Many agro ecosystems are unfavorable environments for natural enemies due to high levels of disturbance (Landis *et al*., 2000).

Increasing plant biodiversity in agroecosystems can reduce the impact of pests and diseases by many mechanisms as conservation of natural enemies and facilitation of their action against aerial pests (Ratnadass *et al*., 2011). So, biodiversity is considered as the key to sustainable biological control in orchard systems (Brown & TworkoskI, 2006).

Abundance of alternate food early in the spring may be critical to the ability of generalist predaceous mites to suppress spider mite pests later in the season. Early season abundances of *Typhlodromus pyri* (Phytoseiidae) and *Zetzellia mali* (Stigmaeidae) to be better correlated with early season pollen density than with abundance of mite prey (*Aculus schlechtendali*) (Addison *et al*., 2000). Both nectar and pollen resources may be effective tools for biological control within apple orchards (Spellman, *et al.,* 2006).

Cover crop management affected phytoseiid mite densities recorded on the vegetation. Herbicide application or mowing seems to reduce phytoseiid densities. Reducing mowing frequency could be a good alternative to let phytoseiid mites develop in the groundcover due to provision of food resources such pollen and nectar (Mailloux *et al.*, 2010). Most of *Typhlodromus* species listed in Type III group (generalist predators) based primarily on food habits, so it can reproduce on pollen (McMurtry & Croft, 1997). Elimination of ground cover beneath the trees results in greater tree vigor and higher leaf nitrogen levels which will favor spidermite increase before predators can build up sufficient densities to provide control. When weeds are allowed to grow under the trees, tree vigor may be reduced and spidermite population increases slower, which allows the predators to build up a higher predator/prey ratio and control the pest (Smith *et al*., 1989).

Materials and Methods

Trial orchard:

The experiment has been conducted in a 5 ha apple orchard in Sweida, southern Syria, planted with the varieties “Golden Delicious” and “Starking Delicious”.

The trial orchard has been divided into four sectors: the first was left without tilling since 2008 (0.5 hectar), but without planting legume plants in it. Second section (0.5 hectare) was planted with legumes (vetch and *Lathyrus* sp.) in lines as a cover crop in 2009, then it was left without any cultivation. The third section (3 hectares) was tilled as usual annually but weeds left under the trees crown without spring cultivation (mechanic cut only). The fourth sector (0.5 ha) tilled and cultivated annually with cultivation under trees as a conventional practice in that area. The research lasts three years (2010-2012).

Sampling Mites on apple leaves in trees:

Ten leaves from the middle of the annual shoots have been taken from each of ten apple trees in each sector for each variety, for a total of 100 leaves per sector. Leaves were taken at various heights from outer and inner canopy at representative locations throughout the canopy. Samples were collected at biweekly intervals from early May to the end of August and early September. Two samples have been taken in 2013 to confirm our results. Samples were stored for two days maximum at 2 °C, after which the leaves were counted and passed through a mite-brushing machine (Henderson & McBurnie, 1943) onto circular glass plate which is coated thin layer of glycerol to catch the mites. Plates are placed on same sized circles of paper divided into 16 sectors with alternating black and white arcs to facilitate counting subsamples under a binocular microscope. The number of motile mites and phytoseiids per leaf was identified and calculated.

We calculated correction factors to convert numbers of mites (*T. urticae*, *P. ulmi*) to mean densities per leaf by comparing direct counts on leaves with counts on plates.

Statistical analysis:

All data has been sorted out and analyzed using ANOVA and Duncan multiple range tests, using SPSS 18 professional.

Results

In the three years of the study (2010-2012) the abundance of *P. ulmi* was very low compared with *T. urticae*, but after that we took tow samples in 2013 and the number of *P. ulmi* has increased and reached to 4.67 motile stages/leaf on “Starking Delicious” (fig. 2).

2010:

In 2010 the number of *T. urticae* was significant higher in the tillage sector (2.92 motile stages/leaf), but there was no significant difference between the other treatments on “Golden Delicious”. On “Starking Delicious” the number of *T. urticae* was significally higher in the legumes sector on late June until the middle of July (0.36, 4.26, 13.0), whereas in early August it was significantly higher in the tillaged sector (42.76 motile stages/leaf). At the end of the season the density of *T. urticae* was decreased and the numbers was significaly higher in the no-till and tilled sector (1.1 motile /leaf,1.05 76 motile stages/leaf) (Table 1).

Table 1: Number of *T. urticae* motiles per leaf in 2010

Treatments[1]	N	Subset for alpha = 0.05					
		21/6	26/6	17/7	31/7	7/8	14/8
1	10	.04 a	.56 a	.36 a	5.78 a	8.10 a	1.10 b
4	10	.04 a	.40 a	.12 a	-	-	-
3	10	.06 a	.20 a	3.34 a	47.0 b	42.75 ab	1.05 b
2	10	.36 b	4.26 b	13.0 b	40.60 ab	12.40 b	.15 a
Sig.		.861	.749	.264	.730	.743	.896

There was no significant difference between the number of phytoseiids on “Golden Delicious”, although the number was higher always in the no-till treatment

Numbers of phytoseiids on “Starking Delicious” was significally higher in the no –till treatment from the end of June until the middle of august. There were no significant differences in numbers of phytoseiids between the four treatments at the end of the year table (2) although numbers were higher in it.

2011:

In 2011 the densities of *T. urticae* were greater than in 2010 in all treatments. The highest densities were in the block with legume cover. It reached to 105 T. urticae motile stages per leaf on “Starking Delicious”.

Table 2: Numbers of phytoseiids per 10 leaves in 2010

Treatments[1]	N	Subset for alpha = 0.05				
		26/6	17/7	31/7	7/8	14/8
2	10	.00 a	.00 a	.00 a	.00 a	.00 a
3	10	.00 a	.00 a	.00 a	.00 a	.00 a
4	10	.00 a	.00 a	.00 a	.00 a	.00 a
1	10	.30 b	.60 b	1.00 b	.75 b	1.00 b
Sig.		1.000	1.000	1.000	1.000	1.000

1 Treatments: 1=no-till, 2=legumes, 3=tillaged, 4=conventional

2 Means within columns followed by the same letter are not different at the 5% level (P < 0.05).

There were significant differences in numbers of phytoseiids between the 4 sectors. Densities of phytoseiids were nearly always higher with no-tell sector in the three years of the trial, followed by the legumes sector.

On In early season the significantly highest number of *T. urticae* was in the legume treatment (2.32 motile/leaf) and the significantly lower number was in the tilled (0.52 motile stages/leaf) treatment and no significant differences were found between the no-till treatment and the conventional one (1 and 1.6 motile stages/leaf, respectively). The highest number of *T. urticae* significantly was in the legumes and no-till (6.7, 6.2 motile/leaf) treatments in late June and no differences were found between the conventional and the tillaged treatments (2.2, 2.4 motile/leaf) (Table 3).

The significantly highest number of *T. urticae* in middle of July was in no-till treatment (28.9 motile/leaf) and the significantly lowest number was in conventional treatment (2.8 motile/leaf), and no differences were found between legume and tilled treatments.

At the end of July and early August the significantly lowest number was in conventional treatment (0 motile/leaf), and no differences were found between the other treatments (42.5, 43.4, 28.9 motile/leaf). The numbers of *T. urticae* was low in all treatments in the middle of august, but differences still found as the highest number was in no-till (2.86 motile/leaf) treatment and the lowest number was in legume and conventional treatments (table 3).

Table 3: Number of motile stage per leaf on “Golden Delicious” in 2011

Treatments[1]		N	Subset for alpha = 0.05					
			12/6	26/6	17/7	31/7	7/8	14/8
Duncan[a]	3	10	.5000a	2.4000a	9.5800ab	22.5200b	42.5333b	1.9333b
	4	10	1.0000ab	2.2000a	7.1600a	2.8000a	.0000a	.0000a
	1	10	1.6667ab	6.1778b	18.2000b	28.9200b	43.4667b	2.8000c
	2	10	2.3200b	6.6800 b	15.1200ab	25.0000b	28.9333b	.6000a

1 Treatments: 1=no-till, 2=legumes, 3=tillaged, 4=conventional

2 Means within columns followed by the same letter are not different at the 5% level (P < 0.05).

The significantly highest number of *T. urticae* on “Starking Delicious” in early season was in the no –till and legumes treatments (12.2, 11.04 motile/leaf), and the lowest was in tillaged treatment (3 motile/leaf). No significant differences were found between legumes and conventional treatments. In middle of July the significantly highest number of *T. urticae* was in the no-till treatment (27.2motile/leaf) no significant differences were found between conventional and tillaged treatment (16.4,14.9 motile /leaf). The significantly highest number of *T. urticae* from late July until middle of August was in legumes (59.4,105.06,10.1 motile /leaf) treatment, and the lowest was in conventional treatment (0 motile /leaf). The density of *T.urticae* at late august was low but the significantly highest number was in no –till treatment (2.7 motile /leaf) (table 4).

Table 4: The number of motile stages of *T. urticae* on "Starking Delicious"

Treatments[1]	N	Subset for alpha = 0.05					
		26/6	17/7	31/7	7/8	14/8	28/8
3	10	3.8000a	16.4800a	21.6000ab	52.2667c	1.4000b	1.4000b
4	10	5.8800ab	14.9200a	7.6200a	.0000a	.0000a	.0000a
1	10	12.2000b	27.2000b	27.4400b	32.8000b	5.4667b	2.7333c
2	10	11.0400ab	17.6800ab	59.4400c	105.0667d	10.1000bc	1.6000b

1 Treatments: 1=no-till, 2=legumes, 3=tillaged, 4=conventional

2 Means within columns followed by the same letter are not different at the 5% level (P < 0.05).

There was significant higher number of phytoseiid predatorty mites in the legume block and the no-tillaged block at the end of the season (table 5).

Table 5: Numbers of phytoseiids per 10 leaves in 2011

Treatments[1]		N	Subset for alpha = 0.05			
			"Golden Delicious"		"Starking Delicious"	
			12/6	12/6	31/7	28/8
Duncan[a]	2	10	. 0000a	.1000a	.2000a	.3333a
	3	10	.0000a	.2000a	.0000a	.0000a
	4	10	.0000a	.0000a	.0000a	.0000a
	1	10	.4000b	1.0000b	1.0000b	1.0000b

1 Treatments: 1=no-till, 2=legumes, 3=tillaged, 4=conventional

2 Means within columns followed by the same letter are not different at the 5% level (P < 0.05).

2012:

In 2012 on "Golden Delicious" There were no significant differences between the treatments in early season the number of *T. urticae* was significantly lower (0.32 motile/ leaf) in early July on no-till treatment and it was the highest in the tillaged treatment (4.4 motile/leaf), but at the end of the season the number was significantly higher in the tillaged treatment (0.66 motile/leaf) and no significant differences were found between the other treatments (table 6).

The number of *T.urticae* on "Starking Delicious" in early season was significantly higher in the no- till treatment (0.6 motile/leaf) and the lowest number was in the legumes treatment (0.02motile/leaf), but in early August until the end of the season the tillaged treatment was significantly higher (1.5motile/leaf) and no differences were found between the other treatments (table 6).

Table 6: Number of *T. urticae* motiles per leaf in 2012

Treatments[1]		N	Subset for alpha = 0.05			
			“Golden Delicious”		“Starking Delicious”	
			4/8	2/9	24/6	2/9
Duncan[a]	1	5	.3200a	.1000a	.6000b	.5000ab
	4	5	1.1400ab	.0000a	.0500a	.0000a
	2	5	1.1800ab	.0000a	.0200a	.1200a
	3	5	4.4440b	.6600b	.1600ab	1.5600b

1 Treatments: 1=no-till,2=legumes,3=tillaged,4=conventional

2 Means within columns followed by the same letter are not different at the 5% level ($P < 0.05$).

The number of phytoseiids on “Golden Delicious” was significantly higher in the no-till treatment (2.6 motile/10 leaves) compared with the others in early season, and there was significant difference between the no- till (7.8 motile/10 leaves) and the legume treatment (4.2 motile/10 leaves) with other treatments until late July. No difference were found at the end of the season between 1, 3 and 4 treatments, but the highest number significally was in no –till treatment (2.6 motile/10 leaves) (table 7).

The number of phytoseiids on “Starking Delicious” was significantly higher on no-till treatment from early season (2.6 motile/leaf) until the beginning of August the significantly higher number was in the legume treatment (5.2 motile/leaf) and at the end of the season the highest number was in the no-till treatment.

Table 7: Number of phytoseiids per 10 leaves of “Starking Delicious” in 2012

Treatments[1]		N	Subset for alpha = 0.05				
			24/6	7/7	21/7	2/8	2/9
Duncan[a]	3	5	.0000a	.4000a	1.4000a	3.6000ab	.0000a
	4	5	.0000a	.2000a	.2000a	.0000a	.0000a
	2	5	.6000a	5.0000b	4.2000b	5.2000b	.4000a
	1	5	2.6000b	10.0000c	7.8000c	2.2000ab	2.6000b

1 Treatments: 1=no-till,2=legumes,3=tillaged,4=conventional

2 Means within columns followed by the same letter are not different at the 5% level ($P < 0.05$).

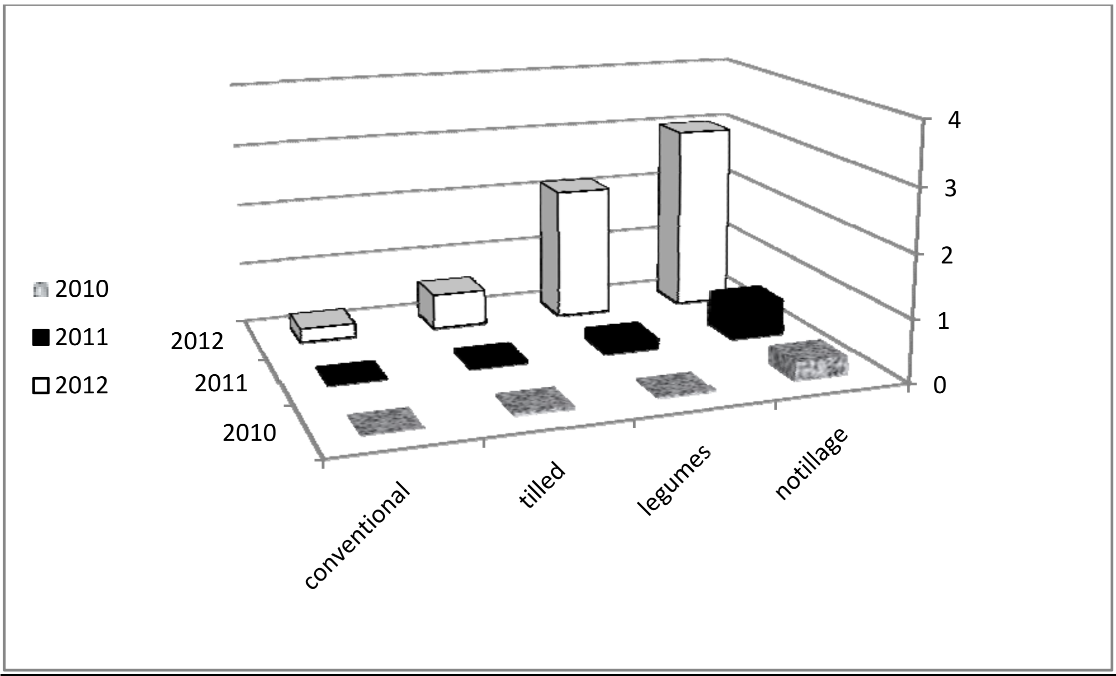

Figure 1: Number of motile stage of phytoseiids per 10 leaves in August in the three years study

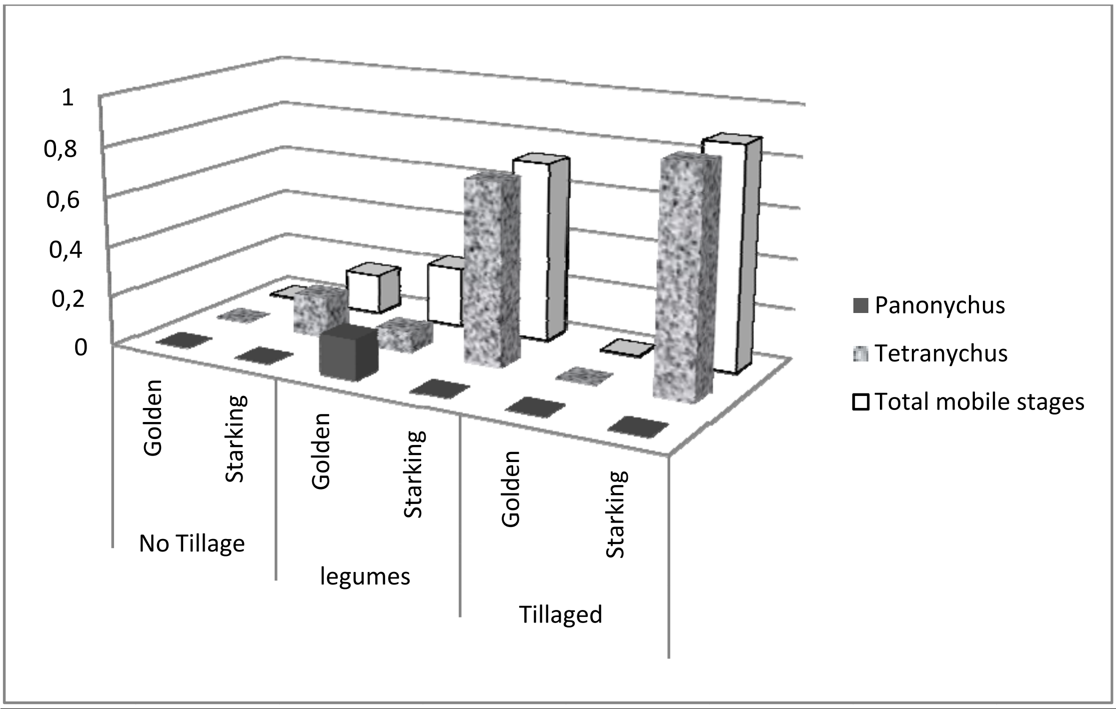

Figure 2: Number of motile stages of spider mites in August 2013

Discussion

This study showed important impacts of cover crop on spider mite and phytoseiid's populations. "Golden Delicious" was less sensitive to spider mite from Starking delicious which confirms previous researches (Alabdulla & Jaml, 2002, Skorupska,1994).

This experiment showed that in early season the number of *T. urticae* was highest in the tillaged apple orchard in 2010 and in 2012 because there were no alternate hosts on the ground, so it migrate to the apple trees; whereas in the ground cover treatment there were alternate food for the phytophagous spider mites. In the middle of the season the number was higher in the legumes treatment on “Starking Delicious” because it is rianfed orchard and the cover group dry early in the season and high population densities of spider-mite exist on legumes, so it migrates into the trees resulting high densities of spider mites on the apple trees on legume sector. Because of increased leaf nitrogen levels which are normal result of nitrogen supplies by legum plants. The high percentage of nitrogen in leaves increases the fecundity and development of *T. urticae* (Hanna *et al.,*1982). Also when legume cover crop incorporates into the soil, a substantial amount of nitrogen is usually mineralized (converted from organic to plant-available forms) within a few weeks (Ingels, 1994, Andrews, 2002; Smith, 1989) which means also higher supply of nitrogen.

The lowest number of *T. urticae* in the three years study was in conventional treatment because of two to three acaricide treatments each season.

Heavy density of *T. urticae* was found in 2011 in all treatment except the conventional one. This is due to the hot and dry weather in that year which is favorable to *T. urticae* (Praslicka & Huszar, 2004).

In 2012 the number of *T. urticae* was the lowest in legumes treatment in early season on Starking, because the density of legume plants on the ground was very low due to the consumption of the seeds by mice and birds. The increased number of phytoseiid mites lead to significant decrease of *T. urticae* populations (1 motile /leaf) high number of compared with the numbers in 2011.

The density of phytoseiids was low in all treatments in the first year of the study due to applying acarecides in the trial orchard for many years before beginning the study. Predatory mites increased year after year until reaching high density in 2012 in no tillage and legume soil surface treatment.

Number of phytoseiids was the highest in no-till treatment and sometimes in legumes in the three years of study. This is could be a result of the abundance of alternate foods early in the season (spring) like pollen which is important to the generalist predaceous mite to suppress spider mites (Addison *et al*., 2000). Cover crops produce suitable pollens in early season to promote the build-up of the high density of the phytoseiids. The number of phytoseiid mites in 2011 and 2012 was the highest from early season in the no–till treatment. It habitats in the orchards and can build up to provide adequate control of spider mites during the season.

Cover cropping in apple orchards should be considered as an important method of IPM of spider mite.

Acknowledgements

We would like to thank the German project of supporting conserving agriculture (CA) by the German Agency for International Cooperation (GIZ) for their help in establishing this trial, and to Mr. Berthold Hansmann for his personal encouraging of this study.

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