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Effects of Orchard Cover Crop on Arthropod Population Density 【Research report】

果園之植被作物對節足動物族群密度之影響【研究報告】

Kun-Yaw Ho
何坤耀

*通訊作者E-mail :

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Abstract

Experimental results obtained from occurrences of arthropods (insects and mites) in different orchard ground cover treatments in 1992 at Kaysville Research Station of Utah State University indicated that weeds (dicotyledon) were better than grass (monocotyledon) as ground cover crops in apple and tart cherry orchards. More spider mites were found in treatment of grass than found in weeds ; in addition, more natural enemies were found in weed treatments in sweeping samples. From the summary of apple and cherry orchards, the preference of the grounnd covers for pest control was found to be weeds (Alfalfa, Clover, Bindweed)> Bare Ck (Herbicided and Cultivated)> grasses (Compa-nion, Redfescue, Ryegrass). Separating all the eight ground cover treatments, the preference order is as follows：Clover > Herbicided CK > Alfalfa = Bindweed > Culltivated CK > Companion > Redfescue > Ryegrass.

摘要

於1992年在猶他州立大學試驗站，調查昆蟲與瓢類在不同植被作物處理地之發生情形，在蘋果與酸櫻桃果園中，闊葉雜草比單子葉植物更適於當地面植被。在單子葉雜草上發現較多之葉瓢，而在掃網調查中卻在闊葉草上找到較多之天敵。綜合蘋果與櫻桃果園之調查，從蟲害防治之觀點考慮地上植被之適用性，則結果為闊葉草(紫花苜蓿、白花三葉草、田旋花)優於裸露地面(施殺草劑、耕培除草)，然後再優於單子葉雜草(複合禾草、葦狀羊茅、黑麥草)。若單獨以8個地面植被處理分開來比較，則其優越性依次為：白花三葉草(Clover)>殺草劑對照區>紫花苜蓿(Alfalfa) = 田旋花(Bindweed)>耕培除草區>複合禾草(Companion grass)>葦狀羊茅(Redfescue)>黑麥草(Ryegra-ss)。

Key words: Cover crop, arthropod, population density.

關鍵詞: 植被作物、節足動物、族群密度。

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Kun-Yaw Ho Chia-Yi Agricultural Experiment Station, TARI, 2 Min-Chuan Road, Chia-Yi, Taiwan, R.O.C.

ABSTRACT

Experimental results obtained from occurrences of arthropods (insects and mites) in different orchard ground cover treatments in 1992 at Kaysville Research Station of Utah State University indicated that weeds (dicotyledon) were better than grass (monocotyledon) as ground cover crops in apple and tart cherry orchards. More spider mites were found in treatment of grass than found in weeds; in addition, more natural enemies were found in weed treatments in sweeping samples. From the summary of apple and cherry orchards, the preference of the ground covers for pest control was found to be weeds (Alfalfa, Clover, Bindweed)> Bare CK (Herbicided and Cultivated)> grasses (Companion, Redfescue, Ryegrass). Separating all the eight ground cover treatments, the preference order is as follows: Clover > Herbicided CK > Alfalfa = Bindweed > Cultivated CK > Companion > Redfescue > Ryegrass.

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果園之植被作物對節足動物族群密度之影響

何坤耀 嘉義農業試驗分所 嘉義市民權路 2 號

摘　要

於 1992 年在猶他州立大學試驗站，調查昆蟲與蟎類在不同植被作物處理地之發生情形，在蘋果與酸櫻桃果園中，闊葉雜草比單子葉植物更適於當地面植被。在單子葉雜

草上發現較多之葉蟎，而在掃網調查中卻在闊葉草上找到較多之天敵。綜合蘋果與櫻桃果園之調查，從蟲害防治之觀點考慮地上植被之適用性，則結果為闊葉草(紫花苜蓿、白花三葉草、田旋花)優於裸露地面(施殺草劑、耕培除草)，然後再優於單子葉雜草(複合禾草、葦狀羊茅、黑麥草)。若單獨以8個地面植被處理分開來比較，則其優越性依次為：白花三葉草(Clover)＞殺草劑對照區＞紫花苜蓿(Alfalfa)＝田旋花(Bindweed)＞耕培除草區＞複合禾草(Companion grass)＞葦狀羊茅(Redfescue)＞黑麥草(Ryegrass)。

關鍵詞：植被作物、節足動物、族群密度。

Introduction

Integrated pest management (IPM) is an approach towards pest control that attempts to reduce primary reliance on pesticides by integrating multiple pest management tactics (e.g., cultural, biological, and chemical). An IPM approach advocates frequent biological monitoring of pests and is facilitative in improving the timing of pest control measures, use of lower pesticide rates, and use of selective compounds that are less toxic to natural enemies (Asquith et al., 1980; Prokopy et al., 1990; Whitford and Showers, 1987).

The economics and role of pesticides in crop production have changed in recent years. Alternative methods of pest control which rely on more ecologically based, environmentally sound principles are urgently required.

Cultural practices which emphasize management of the crop environment, and which are compatible with chemical and biological controls, have traditionally been under utilized in orchard pest management programs.

Additionally, natural enemies can be more effective in controlling populations of herbivores in diverse systems of vegetation than in simpler ones (Russell, 1989) because of the increased availability of alternate food (prey) or habitats. Cover crop management is a cultural practice that can provide the ecosystem with diversity and stability as based on ecological principles.

Ground covers may influence the timing of emergence, dispersal, and behavior of pests, and may harbor natural enemies which could be instrumental in pest control (Bugg and Dutcher, 1989). Cover crops in orchards and other agriculture crops generally produce greater plant biomass and structural diversity, support higher numbers of alternative prey, and harbor a larger complex of predators and parasitoids than bare ground agroecosystems (Ali & Reagan, 1985; Altieri & Schmidt, 1985; Barnett et al., 1989; Bugg et al., 1991; Naranjo & Stimac, 1987; etc).

Preliminary results revealed that cover crops in Utah apple orchards can have a significant effect on both phytophagous and predatory mite populations (Alston, 1990). Cover crop plants may sustain pests as well as benefit insect and mite species. Therefore, the potential for an increase in crop damage also exists. Theoretically, orchard cover crop species should be perennial, easy to establish and maintain, and should not serve as hosts for important pest species (Elmore, 1989).

Changes in ground vegetation status can generally alter the orchard ecosystem and may have a larger impact on the complexity of arthropod population

dynamics. However, the direct relationship between cover crop vegetation and arthropods has received little attention, especially in orchards in the arid, western U.S. A greater understanding of how different compositions of cover crops may influence arthropod populations is necessary to maximize the contribution of this cultural practice to arthropod pest management.

Materials and Methods

Field studies were conducted at Kaysville Research Station of Utah State University in 1992. Apple and tart cherry orchard plots were 12.2 X 18.3 m in size and consisted of five consecutive trees with one of five ground covers or no ground cover planted on either side of the tree row. Plots were arranged in a radomized complete block design with five (tart cherry) or six (apple) replications. Cover crop treatments included Companion grass, Elka perennial ryegrass, creeping redfescue, alfalfa (apple) or clover (tart cherry), and weeds planted at a 90–120 cm distance from each side of the tree row, and an herbicide (Glyphosate 150-fold) treated (apple) or cultivated (tart cherry) bare ground control in each block.

Six terminals and 12 leaves were collected from canopies of three center trees per plot. Also, one sweep-net sample of 26 sweeps was taken with a standard 38-cm diameter sweep-net from the ground cover in plots approximately every three weeks from May to September. Leaf and terminal samples were placed in paper bags and sweep samples placed in zip-lock plastic bags and transported to the laboratory in an ice chest with blue ice. Samples were examined via a 20–30X microscope to determine the density of spider mites, predatory mites, leafminers, parasitic wasps, aphids, ladybird beetles, white apple leafhoppers, spiders, and other major arthropods. Sweep samples were placed in the freezer to immobilize arthropods before separation into trophic groups (herbivore, predator or parasitoid) for counting. In order to determine which ground cover plants are good hosts for phytophagous mites and refuges for predatory mites, vegetation samples (50–100 g) were collected from each plot, placed in plastic bags, transported to the laboratory, and examined for the occurrence of mites. A score method (Ho, 1993) was used for counting both the spider mites and predatory mites (e.g., the mite number from 1 to 20 is "few" and gets 1 score, ranging from 21 to 100 is "many" and gets 5 scores, greater than 100 is "very many" and gets 10 scores).

The percentage of the bare ground and the composition of the cover vegetation were measured in each plot with a one square meter wood frame at three different times (mid-May, mid-July, and mid-September).

Another scoring method was used for the convenience of considering the preference orders for these ground cover treatments. The rules for that "score method" are:

1) If the pests are found from less to more in treatments, then we give the six treatments the scores from 6 to 1 (if equal, then give the average score). For example, if pests found in treatments are Alfalfa < Bindweed < Companion = Ryegrass < Redfescue < Bare CK, then their scores are 6, 5, 3.5, 3.5, 2, 1, from Alfalfa to Bare CK, respectively (3.5=(4 +3) / 2).

2) On the other hand, if the enemies are found from less to more, then we give the six treatments the score from 1 to 6.

3) The more scores the treatment receives implies that it is the better ground cover treatment.

Differences in the abundance of pests and natural enemies among the cover crop treatments were tested with ANOVA and Fisher's protected LSD. Arthropod densities across time were compared with

repeated measures analysis (Rowell & Walters, 1976).

Results and Discussion

More aphids in apple orchard were found on 7 September and most aphids were found in terminal and leaf treatments of Ryegrass. However, the occurrences of aphids might be coincidental since the higher population was just found in one of the six blocks.

Total number of insect pests (leafminers + aphids + leafhoppers + thrips) found in apple orchard are shown in Figure 1 . In apple terminals, more insect pests were found in treatmenets of Companion (28 May, 5 July, 7 September), Ryegrass (25 July, 7 September), Alfalfa (27 July), Bindweed (28 May, 7 Septem-

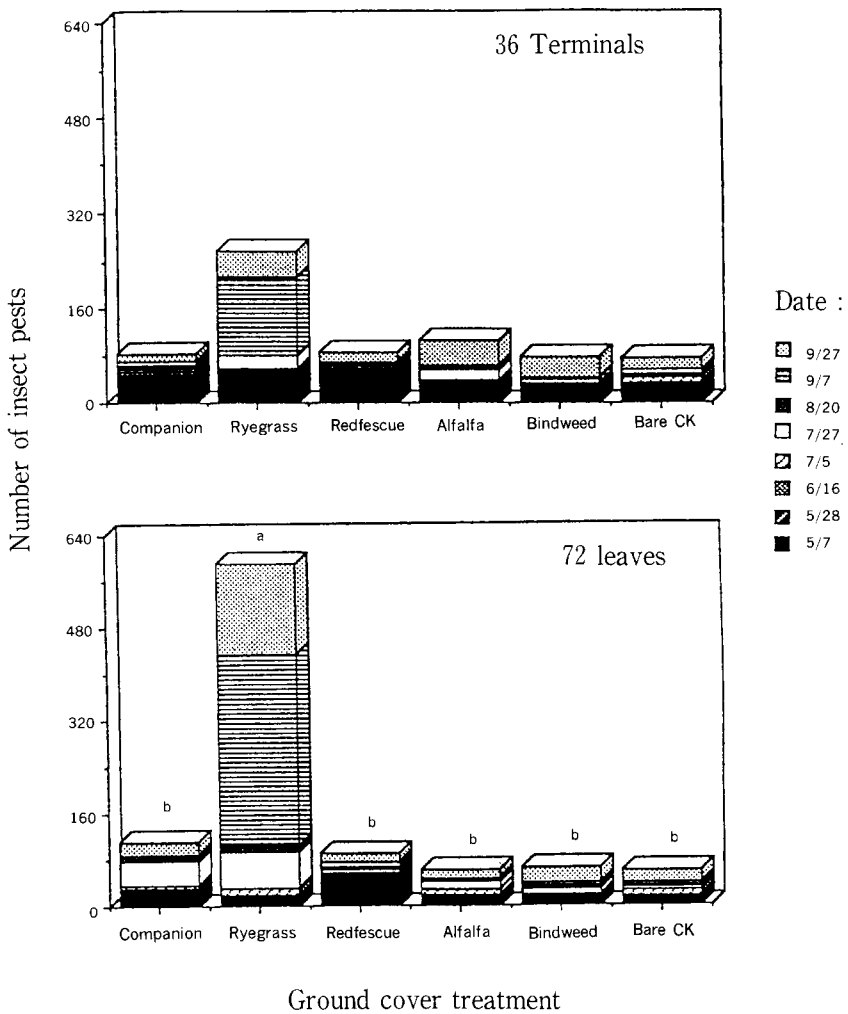

Fig. 1. Numbers of insect pests (leafminers + aphids + leafhoppers + thrips) on terminals and leaves of apple on different dates for each ground cover treatment. (The same letter in treatment means that there is no significant difference in 5% LSD.)

ber) and Bare CK (5 July, 7 September). In leaves, more pests were found in Companion (27 September), Ryegrass (7 and 27 September, and total), Bindweed (27 September) and Bare CK (27 September). The most insects having occurred in Ryegrass is due to the high aphid populations.

Total number of spider mites found in apple orchard is shown in Figure 2. The majority of spider mites (two-spotted and Macdaniel) were found in treatments of Companion and Ryegrass (27 July), and Redfescue (27 July, 7 September) in apple terminals. In ground vegetation, few spider mites were found in Alfalfa (7 May, 20 August, 7 and 27 September) and in Bindweed (7 and 27 September). Many spider mites were found in Companion (7 May to 5 July, and total) and Ryegrass (7 May to 16 June, and total).

In cherry orchard (Figure 2), most spider mites were found in treatments of Companion (7 May to 5 July, and total), Ryegrass (7 May to 16 June, and total) and Redfescue (7 May and total). These mites found in vegetation were not two-spotted mite or Macdaniel mite. Further identification of these mites may be required.

The results of sweeping samples found in apple orchard are shown in Figure 3. Most of parasitoids were found in Alfalfa (7 and 28 May, 5 and 27 July, and total), Bindweed (7 May to 27 July, and total), Companion (7 and 28 May, 5 and 27 July, and total), and Redfescue (7 May, 5 and 27 July, and total). Fewer parasitoids were found in Ryegrass (16 June, 27 July) and Bare CK (16 June). Number of predators found for each treatment in tart cherry orchard with decreasing order were Bindweed (27 July, 27 September, and total), Clover (27 July, 20 August, and total), Ryegrass and Companion (28 May and total), and next in Redfescue (27 September and total). No predator was found in Bare CK (Figure 3); in addition, apparently more predators were in weeds than in grass. More parasitoids were found in Bindweed (17 May to 16 June, 20 August, and total) and Clover (28 May, 16 June, 20 August, 7 September, and total). Some were found in Companion (7 May to 16 June, and total) and in Ryegrass (28 May to 16 June, and total), and few in Redfescue (7 May 16 June, and total). In addition, a few parasitoids were found in Bare CK (significantly only on 7 May).

In terms of the occurrence of insect pests and natural enemies in apple and tart cherry orchard, ground covers apparently did not facilitate the control of insect pests. Using the score method, however, the available information (all observed items and sample types) is summarized as Table 1. In an apple orchard, the total score preference order (from high to low) is Bindweed > Bare CK (herbicided) > Alfalfa > Redfescue > Companion > Ryegrass. In a tart cherry orchard, the preference order is Clover > Companion = Bare CK (cultivated) > Bindweed > Ryegrass > Redfescue.

Combining the data of apple with cherry orchards, the preference order (and average score) is Weed (4.0a, Alfalfa & Clover)> Bindweed = Bare CK (3.9a, herbicided & cultivated)> Companion (3.4ab)> Redfescue (3.2ab)> Ryegrass (2.8b). If analyzing with eight separate treatments and combining data of apple and cherry orchard, the preference order (and average score) was Clover (4.1a) > Herbicided CK (4.0ab)> Alfalfa = Bindweed (3.9ab)> Cultivated CK (3.7abc) > Companion(3.4bcd)> Redfescue (3.2cd)> Ryegrass (2.8d). The P-value is 0.017 from the ANOVA, and the same letter on the upper right hand corner of the score indicates that no significant difference occurs at 5% level of LSD.

In addition, experimental results also indicated that more spider mites were found in grass (Companion) and more predatory mites were found in weeds

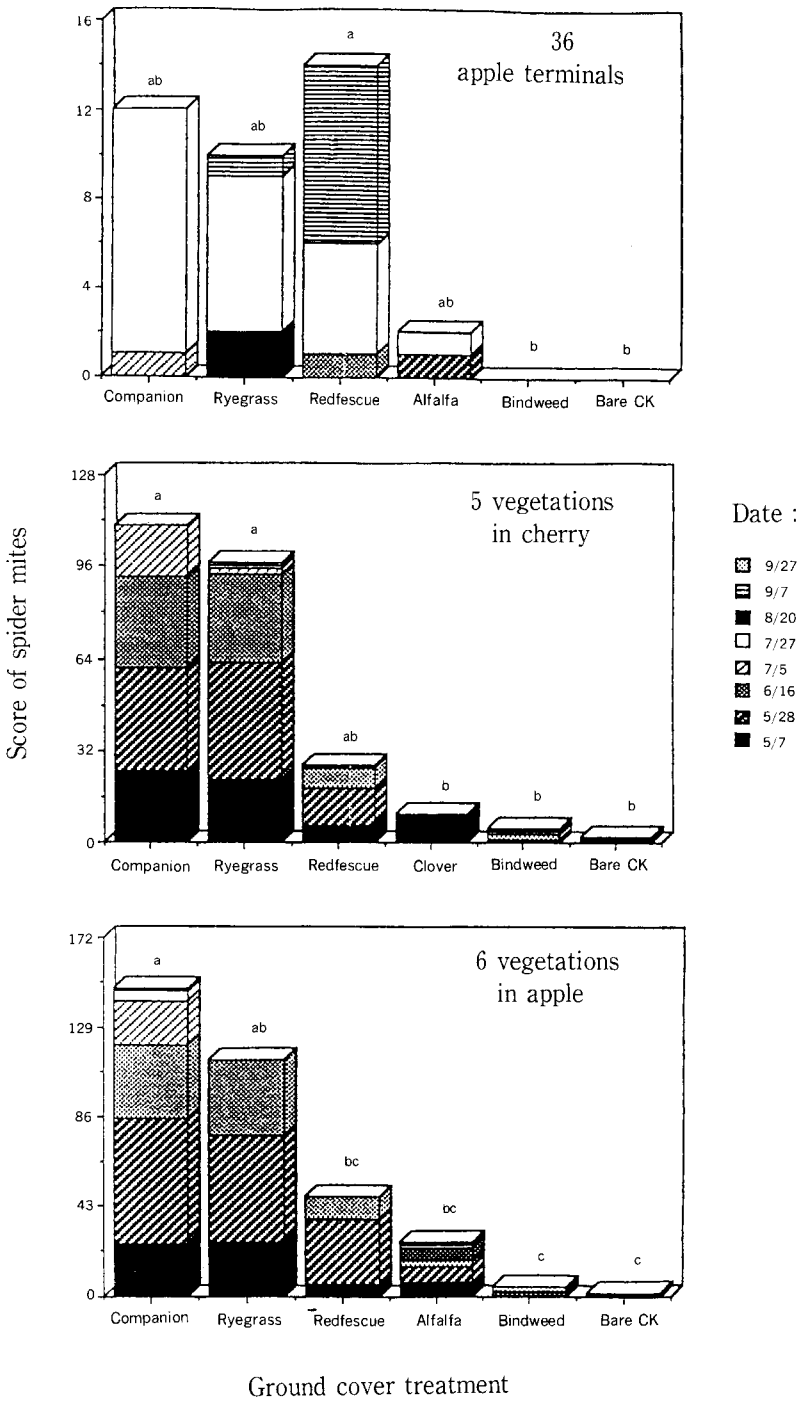

Fig. 2. Scores of spider mites on terminals and vegetation samples of apple and cherry on different dates for each ground cover treatment.

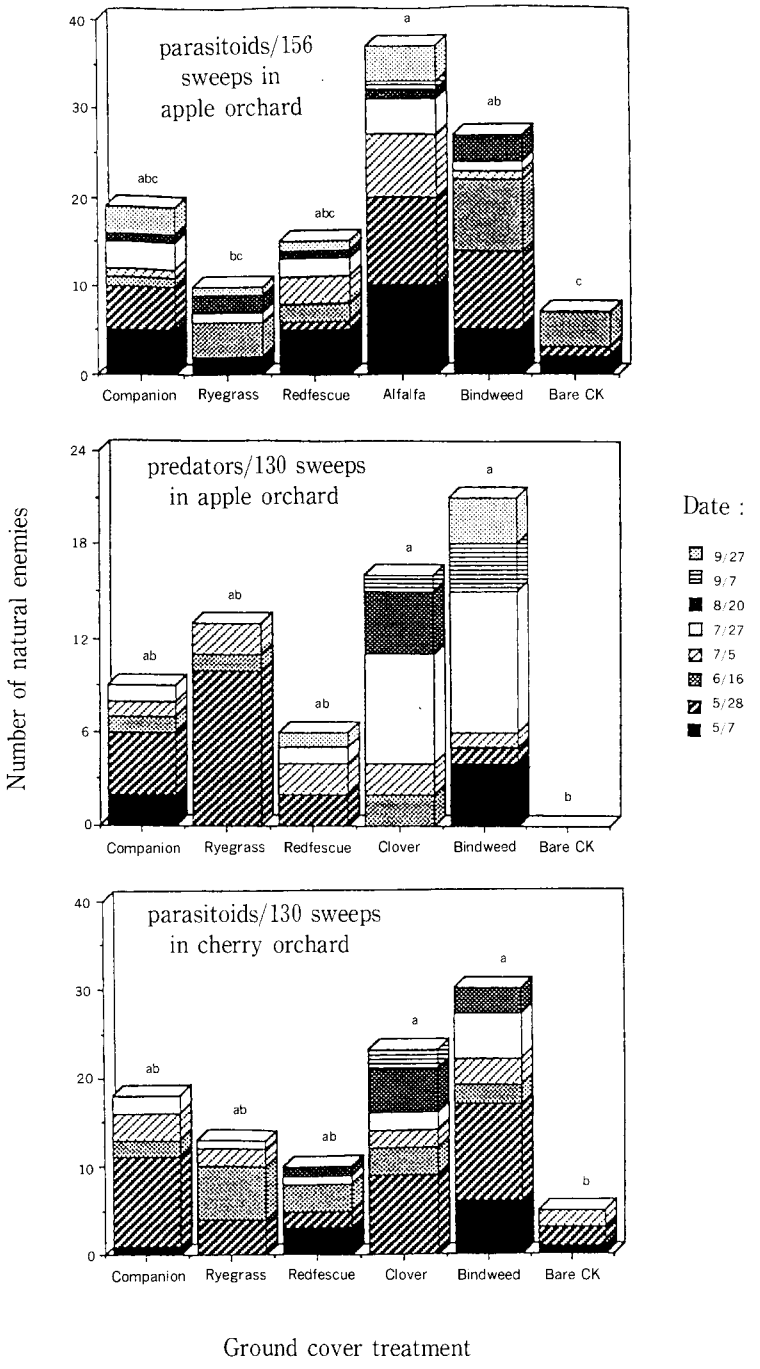

Fig. 3. Numbers of natural enemies on sweeping samples of apple and cherry orchards on different dates for each ground cover treatment. (Predators include predatory mites, lady beetles, spiders, predatory bees, danselflies and predatory bugs.)

Table 1. The preference scores for vegetation treatments about arthropods occurring in apple and cherry orchards

Observed items	Sample types	Scroes for vegetation treatments					
		Companion	Ryegrass	Redfescue	Weed[8]	Bindweed	Bare CK[9]
				Apple			
	terminal	2	3	1	4	5.5	5.5
Spider	leaf	3.5	3.5	5	6	1	2
mites[2]	vegetation	1	2	3	4	5	6
	mean±s.d.	2.2±1.3	2.8±0.8	3.0±2.0	4.7±1.2	3.8±2.5	4.5±2.2
	terminal	2.5	4.5	6	4.5	1	2.5
Predatory	leaf	6	3.5	1	2	5	3.5
mites[2]	vegetation	5.5	2	2	4	5.5	2
	mean±s.d.	4.7±1.9	3.3±1.3	3.0±2.6	3.5±1.3	3.8±2.5	2.7±0.8
	terminal	4	1	3	2	5	6
Insects[3]	leaf	2	1	3	5	4	6
	mean±s.d.[1]	3.0±1.4ab	1.0±0.0b	3.0±0.0ab	3.5±2.1ab	4.5±0.7a	6.0±0.0a
	terminal	3	3	3	6	3	3
Enemies[4]	leaf	2	2	5	2	5	5
	mean±s.d.	2.5±0.7	2.5±0.7	4.0±1.4	4.0±2.8	4.0±1.4	4.0±1.4
	herbivores[5]	3	2	5	1	4	6
Sweeping	predators[6]	2	6	3.5	5	3.5	1
samples	parasitoids[7]	4	2	3	6	5	1
	mean±s.d.	3.0±1.0	3.3±2.3	3.8±1.0	4.0±2.6	4.2±0.8	2.7±2.9
Average in apple		3.1±1.0ab	2.6±0.9b	3.4±0.5ab	3.9±0.5a	4.1±0.3a	4.0±1.4a
				Cherry			
	terminal	2.5	4	1	5.5	2.5	5.5
	leaf	4	4	4	4	1	4
Spider	vegetation	1	2	3	4	5	6
mites	sticky band	1	4	3	6	2	5
	mean±s.d.	2.1±1.4c	3.5±1.0abc	2.8±1.3bc	4.8±1.0ab	2.6±1.7c	5.1±0.9a
	terminal	3.5	3.5	6	5	1.5	1.5
	leaf	1	3	3	5	3	6
Predatory	vegetation	3	6	3	3	3	3
mites	sticky band	5.5	2.5	2.5	5.5	2.5	2.5
	mean±s.d.	3.3±1.8	3.8±1.6	3.6±1.6	4.6±1.1	2.5±0.7	3.3±1.9
	terminal	6	2.5	4	5	2.5	1
Insects	leaf	6	1.5	3	1.5	4	5
	mean±s.d.	6.0±0.0	2.0±0.7	3.5±0.7	3.3±2.5	3.3±1.7	3.0±2.8
	terminal	5	3	1	3	3	6
Enemies	leaf	3	3	3	3	6	3
	mean±s.d.	4.0±1.4	3.0±0.0	2.0±1.4	3.0±0.0	4.5±2.1	4.5±2.1
	herbivores	2	1	4	5	3	6
Sweeping	predators	3	4	2	5	6	1
samples	parasitoids	4	3	2	5	6	1
	mean±s.d.	3.0±1.0	2.7±1.5	2.7±1.2	5.0±0.0	5.0±1.7	2.7±2.9
Average in cherry		3.7±1.5	3.0±0.7	2.9±0.7	4.1±0.9	3.6±1.1	3.7±1.0

1) Means with the same letter are not significantly different at 5% level of LSD.
2) Both mites are measured with the score method.
3) Insects include leafminers, aphids, leafhoppers, and thrips.
4) Enemies include lady beetles, spiders, and parasitic wasps.
5) Herbivores include spider mites, leafminers, aphids, thrips, weevils, grasshoppers, and caterpillars.
6) Predators include predatory mites, lady beetles, spiders, bees, danselflies, and predatory bugs.
7) Parasitoids include parasitic wasps.
8) Weed is Alfalfa in apple and Clover in cherry.
9) Bard CK is Herbicided in apple and Cultivated in cherry.

Table 2. Abundance of ground cover (all weeds and grasses) on 3 different dates in apple and tart cherry orchards

Ground cover	Covering area(m^2)[1]			
	14−May	17−Jul	14−Sep	Average
		Apple		
Alfalfa	4.67	5.25	5.10	5.01
Redfescue	3.80	2.19	2.90	2.96
Ryegrass	3.85	1.88	2.65	2.79
Companion grass	3.90	2.20	1.80	2.63
Bindweed	0.02	0.30	2.60	0.97
Common mallow	0.60	0.89	0.00	0.50
Lambsquarter	0.31	0.48	0.00	0.26
Clover	0.17	0.50	0.08	0.25
Common purslane	0.12	0.28	0.00	0.13
Redroot pigweed	0.19	0.21	0.00	0.13
Orchard grass	0.21	0.00	0.00	0.07
Wheat grass	0.20	0.00	0.00	0.07
Sheperdspurse	0.16	0.00	0.00	0.05
Prickly lettuce	0.02	0.09	0.00	0.04
Downy brome	0.03	0.00	0.00	0.01
Dandelion	0.00	0.02	0.00	0.01
Creeping woodsorrel	0.02	0.00	0.00	0.01
Others	1.44	0.63	0.00	0.69
		Cherry		
Clover	0.07	3.94	4.18	2.73
Redfescue	2.80	1.85	2.40	2.35
Ryegrass	2.78	1.57	1.90	2.08
Companion grass	2.80	1.10	1.55	1.82
Bindweed	1.57	1.04	0.62	1.08
Black medic	0.50	0.28	0.61	0.46
Prickly lettuce	0.14	0.61	0.54	0.43
Alfalfa	0.75	0.04	0.20	0.33
Common mallow	0.06	0.24	0.27	0.19
Redroot pigweed	0.13	0.25	0.19	0.19
Dandelion	0.00	0.10	0.45	0.18
Lambsquarter	0.10	0.08	0.13	0.10
Common purslane	0.00	0.19	0.08	0.09
Western salsity	0.02	0.08	0.00	0.03
Wheat grass	0.09	0.00	0.00	0.03
Sheperdspurse	0.03	0.00	0.03	0.02
Blue mustard	0.03	0.00	0.00	0.01
Creeping woodsorrel	0.02	0.00	0.00	0.01
Others	1.19	0.18	0.13	0.50

1) The total observed areas (on each date) are 36 m^2 and 30 m^2 in apple and cherry, respectively.

(Alfalfa & Bindweed) in both ground vegetation and apple leaf treatments.

The all ground covers growing in both apple and cherry orchards were measured (by using an one m^2 wooden frame) in late spring, mid-summer and early fall. The abundances of all ground covers in apple and cherry orchards are summarized in Table 2. In the apple orchard, the more abundance of treatment covers are Alfalfa > Redfescue > Ryegrass > Companion > Bindweed. The next five common ground covers are Common mallow > Lambsquarter > Clover > Common purslane > Redroot pigweed. The others cover about 0.69 m^2 in the total 36 m^2 measured areas. In the cherry orchard, the more abundance of treatment covers ard Clover > Redfescue > Ryegrass > Companion > Bindweed. The next six common ground covers are Black medic > Prickly lettuce > Alfalfa > Common mallow = Redroot pigweed > Dandelion. The other species cover about 0.5m^2 in the total 30m^2 measured areas. Obviously, the ground covers in apple and tart cherry orchards are quite very similar; however, their abundances are somewhat different.

Generally speaking, the choice for orchard vegetation preference considering the less pests and the more enemies occurring in vegetation (Bugg & Dutcher, 1989) is Weeds the first, Bare ground the second, and Grasses the last. In all experiments of this season, however, the population densities of pests and enemies are not sufficiently high to draw a strong conclusion. In addition, sprinkling significantly influences the establishments of ground covers (water supplying) and arthropod populations in the orchard. Therefore, the sprinklers must be effectively controlled. Finally, other considerations are also relevant for the orchard management (Elmore et al., 1989; Flexner et al., 1991), e.g., cost of manipulation, time and labor, competition and fruit crop yields.

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