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Weed Management in Organic Horticulture by Cover Crop in Iran

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ABSTRACT

Objective: Citrus (*Citrus reticulata*) is one of the most important horticultural plant in Iran and weed management throuth ecological methods such as cover crop is a proper option in orchard management practices. **Methods:** The experiment was designed as a split plot on the base of complete randomized block design with four replications in Mazandaran Province, Sari, Voushka county from 2010 to 2012. The main plots were methods of cover crop management (desiccated with glyphosate at 0.85 kg ai ha^{-1}, mowed and incorporated with soil with rotivator that were done at the flowering stage), and the subplots were cover crop species [sainfoin (*Onobrychis viciifolia*), winter barely (*Hordeum vulgare*), triticale (×*Triticosecale*), sainfoin + barely and sainfoin + triticale] and one control treatment which was without cover crop. **Results:** An important reduction of seedling emergence and total weed dry weight were observed in the plots with cover crop dessicated compared with the plots mowed or incorporated with soil. The optimum cover crop species for weed control was sainfoin + barely mixes because it had the highest biomass and lowered the amount of light reaching the soil surface and reduced soil temperature fluctuations, resulting in a reduction in weed seedling emergence. In addition weed suppression by it has been attributed in part to allelopathy. In both years there were no differences among treatments in tree yield but to maximize and sustain the output of an orchard, weeds in the tree row have to be controlled efficiently.

1.INTRODUCTION

Iran is one of the important citrus producer in the world. The country has been ranked between eighth and tenth in terms of global fruit production in different years. Total area under citrus cultivation in Iran has been estimated at 235,000 hectares of which 91.4% are producing 3,712,000 tons annually (Ebrahimi, 2002). Citrus in Iran is grown in nine Provinces, 91.44% is presented in Mazandaran, Fars, Kerman, Hormozgan and Khuzestan. Mazandaran alone produces 38.83% of the Iran total, with Fars, Kerman, Hormozgan and Khozestan accounting for 28.91%, 11.24%, 11.18% and 1.28% respectively (F.A.O., 2008). Average yield of orange (*Citrus reticulata*) in Iran is 16077 kg/ha. Weeds are serious problems as a result of intensive production in Iran. Weeds compete with the crop for water, light, and mineral nutrients and thus they may significantly reduce the growth and yield of the crops. This detrimental effect of the weeds on the tree is particularly considerable when weeds are not controlled on time. There are many approaches in conventional and organic agriculture to this problem (Fischer, 2002; Granatstein, 2007). To date, weed management is primarily focused on curative

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control, as herbicides are highly effective and relatively cheap (Mortensen et al., 2000). Increasing concerns regarding the negative side effects of herbicides on the environment and the growing interest in organic agriculture have, however, led to a growing demand for alternative weed control measures (Bastiaans et al., 2008). Species for the cover crop will be selected for their chemical or physical characteristics to suppress or compete with weeds. Limiting safe sites for weed establishment through physical impedance of rolled mulches is likely one of the more prominent mechanisms of weed control from cover crops (Teasdale and Mohler, 2000). Cover crop residues have been reported to negatively affect germination and establishment of weed seeds (Kruidhof et al., 2008). Suppression of weed growth by barley and other plants was noted over 2000 years ago (Weston, 2005). Allelochemicals in barley may be candidates for natural herbicides and innovative approaches for integrating barley cover cropping with other cultural practices to improve the sustainable or ecologically-based weed management (Kremer and Ben-Hammouda, 2009). Cover crops including barley will remain important components in ecological or biological weed management, which involves the use of various biological approaches including allelopathy, bioherbicides, crop competition and other cultural practices such as reduced tillage to obtain dramatic reductions in weed infestations similar to those that may be realized with herbicides (Bender 1994; Kremer, 2002). Legume cover crops are generally reported to have more profitability potential than grass cover crops because they contribute nitrogen to the subsequent cash crop, reducing input costs (Roberts et al., 1998). Cover crops can be planted as a single species or in mixes. Mixes provide both advantages and disadvantages over single species. The most common mixes include a legume such as hairy vetch (*Vicia villosa* Roth) and a cereal grain such as rye (*Secale cere*ale L.). Although allelopathic potential of hairy vetch and other leguminous cover crops has been demonstrated, some studies have shown that weed suppression by a legume cover crop was generally less than grass cover crops (Wallace and Bllinder, 1992). However, legume cover crops are valued for their nutrient contribution to the soil, adding white clover to ryegrass improved both ground cover and weed suppression compared to either species alone (Fisher and Davies, 1991), and the legume component provided residual N for the succeeding crop. In organic systems, cover crops may be killed and incorporated into the soil by tillage, mowing, undercutting, or rolling. It has often been reported that cover crop species and residue management have a selective effect on weed species (Blum et al., 1997; Ilnicki and Enache, 1992; Schonbeck et al., 1991; Teasdale, 1998). Cover crops residues will be left on the soil surface to maximize allelopathic (chemical) and mulching (physical) effects. Kruidhof et al., (2009) reported that residue incorporation gave variable results, whereas placement of winter rye residue on top of the soil inhibited the emergence of all weed species.

The most preferable method for controlling weed in citrus growing areas is herbicide. But the chemicals cause significant problem such as herbicide resistant and pollution. Because of this all negative reasons, alternative weed control methods such as cover crop on weed population was investigated in this study. Rye, wheat, and hairy vetch are widely studied cover crops because of the potential of rye and wheat for weed suppression and the N contribution of vetch to soil, but sainfoin and triticale are less studied.

2. MATERIALS AND METHODS

2.1. Experimental site

The experiment was conducted at the Main Agricultural Experiment Station in Mazandaran province, Sari, Voushka county, from 2010 to 2012 (53° 11´ N, 37 °36 ´W). Orange orchard (9 years-old) was located on sandy soil with an organic 1.5% matter content and 6.9 pH. This orchard was drip irrigated. The long-term average yearly precipitation was 592.7 mm and the average yearly air temperature was 17.5 °C.

2.2. Experimental procedures

The experimental design in both years was a split plot with four replications, where the main plots were methods of cover crop management (desiccated with glyphosate at 0.85 kg ai /ha, cover crop mowed and cover crop was incorporated with soil with rotivator (that were done at the flowering stage) and the subplots were cover crop species [sainfoin (*Onobrychis vicifolia*) at 150 kg ha^{-1}, winter barely (*Hordeum vulgare*) at 200 kg ha^{-1}, triticale (× *Triticosecale*) at 200 kg ha^{-1}, sainfoin at 75 kg ha^{-1} + barely at 100 kg ha^{-1} and sainfoin at 75 kg/ha + triticale at 100 kg ha^{-1}] and one control treatment which was without cover crop. For the mixes, barely and triticale were planted first and then the sainfoin. All cover crops were fall-planted (November 22, 2010 and November 20, 2011), over-wintered, then managed by three methods. They were hand-seeded as 10 lines onto plots with 20 cm row spacing. Plot size was 144 m^2 (16×9 m) and they were established at the same site each year. The orchard was fertilized at the end of winter (February-March) and once again in the middle of spring (May). Nitrogen was band-applied at 74 kg ha^{-1} N in the form of NH_4NO_3.

On May 15, 2011, and May 10, 2012, before desiccation, mowing and incorporation, cover crops were sampled to estimate aboveground biomass; two 0.25-m2 quadrats were sampled per plot. Samples were dried at 70 °C for at least 3 days and weighed. The amount of photosynthetically active radiation at the ground level, relative to full sun readings, was measured with a quantum line sensor on cloudless days in the standing cover crop before managment and expressed as a percentage of light reduction. On May 17, 2011, and May

12, 2012, plots were desiccated by glyphsate and mowed with a rotivator, and residues were then left or incorporated with soil to a depth of 15 cm by two passes of a rotary tiller. The soil was naturally infested with weeds. The predominant weed species in both years were redroot pigweed (*Amaranthus retroflexus* L.), yellow nutsedge (*Cyperus esculentus*) and yellow foxtail (*Setaria glauca* (L.) P. Beauv.). Weeds were counted by species from 1 m^2 per plot in early-June, late-June and late-July. Weeds were harvested on September 11, 2011 and September 8, 2012. For three weed species present in high abundance, Dry weight was separately determined. Weed control was evaluated visually 12 week after cover crop managment using a 0 to 100 scale with 0 = no control and 100 = complete control. On December, 15 in 2011 and December 24 in 2012, yield (kg/tree) of the four center trees per plot was measured during harvest, and calculated as the mean of the 16 trees per treatment (four center trees × four replicates).

2.3. Statistical analysis

For data, a pooled analysis of variance for measurements over years was used (Gomez and Gomez, 1984). Prior to ANOVA, homogeneity of variances was tested. When needed, data were transformed (Gomez and Gomez 1984). The untransformed data are presented in all the tables and figures. Treatment means were compared using a Fisher's Protected LSD test at the 5% probability level.

3. RESULTS AND DISCUSSION

3.1. Cover Crop Biomass

Winter cover crops emerged within 10 days after planting in 2010 and two weeks after planting in 2011. On May 15, 2011, and May 10, 2012, cover crop biomass were measured. Cover crop biomass ranged from 3469 to 5103 g m^{-2} for sainfoin, from 5440 to 6353 g m^{-2} for barely, from 3998 to 4911 g m^{-2} for triticale, from 5969 g m^{-2} to 7363 g m^{-2} for sainfoin + barely mixes and from 5826 to 6836 g m^{-2} for sainfoin + triticale mixes. Analysis of variance showed significant effects or interactions between cover crop and year (p<0.001). The highest cover crop biomass on May, 2011 was observed for sainfoin + barely mixes followed by, sainfoin + barely mixes in 2011 and sainfoin + triticale mixes in 2012 (Fig. 1). Renalles and Wagger (1996) showed that mixes of rye (*Secale cereale* L.) and hairy vetch (*Vicia villosa* Roth) produced higher biomass than their monoculture. Teasdale and Abdul-Baki (1998) and Vaughan and Evanylo (1998) reported that rye monoculture biomass and its mixes with vetch is considerably higher than vetch monoculture. In both years the lowest biomass belonged to sainfoin in monoculture (Fig.1). Webster et al., (2013) reported that cover crop biomass was more than doubled when rye was mixed with vetch relative to the legume monoculture.

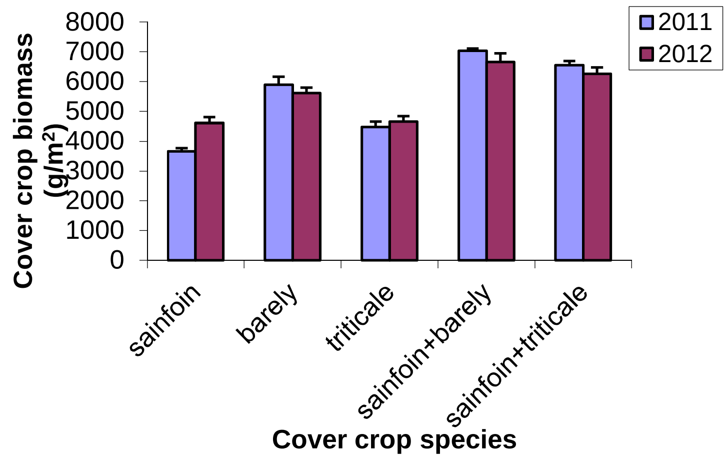

Fig. 1. The effects of cover crop species on cover crop biomass in two years. Error bars represent 95% confident intervals. Vertical bars represent the standard errors of the means across 4 replicates. LSD value = 572.7.

3.2. Percentage of light reduction

The light measurement below the cover crop canopy in both years plotted against cover crop biomass as a percentage of light reduction. Fig. 2 showed a linear increase in percentage of light reduction with an increase in cover crop biomass. High-biomass rye, legumes, and rye + legume mixes will suppress weeds (Akemo et al., 2000; Norsworthy et al., 2010; Price et al., 2007; Reberg-Horton et al., 2012; Reeves et al., 2005; Timper et al., 2011).

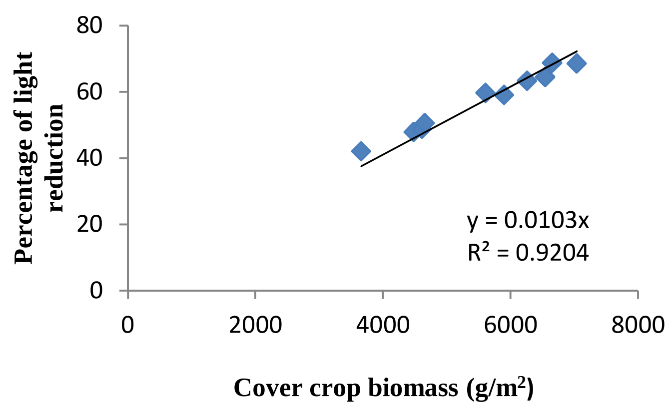

Fig. 2. Percentage of light reduction plots with cover crop biomass.

3.3. Weed density

Statistically significant interactions between cover crop management and cover crop species were found for percentages of weed density (p<0.001). Light quality and intensity, soil temperature, and moisture affect weed seed germination and are in turn influenced by cover crop mulch on the soil surface (Creamer et al. 1996;

Teasdale and Mohler, 1993). In agreement with Ohno et al. (2000) and Kruidhof et al. (2008), these data showed cover crop affect germination and establishment of weed seeds. Redroot pigweed densities ranged from 6 ± 0.59 to 10.25 ± 0.30 seedlings m^{-2} in early-June, from 4.75 ± 0.29 to 6.25 ± 0.14 seedlings m^{-2} in late-June and from 2.75 ± 0.29 to 4.75 ± 0.20 seedlings m^{-2} in late-July (Fig. 3A). Accumulated redroot pigweed density was higher in the mowed (ranged from16.37 ± 0.64 to 19.75 ± 1.05 seedling m^{-2}) and incorporated (ranged from 15.50 ± 0.67 to 21.25 ± 2.47 seedling m^{-2}) cover crops than dessicated cover crop (ranged from 16 ± 0.60 to 16.87 ± 0.48 seedling m^{-2}), likely due to the less complete soil coverage by the cover crops biomass and disturbance of the soil when cover crops were incorporated. Accumulated redroot pigweed density was highest in incorporated sainfoin (21.25 ± 2.47 seedling m^{-2}). Sainfoin + barely mixes reduced accumulated redroot pigweed densities to 15.5 ± 0.67 seedlings m^{-2}. Saavedra and Pastor (2002) reported that *Amaranthus* spp. are well adapted to no-tillage bare soil because their seeds need light for germination (Kigel, 1994).

Yellow foxtail densities ranged from 4.25 ± 0.88 to 10.25 ± 0.61 seedlings m^{-2} in early-June, 0.1 ± 0.58 to 5.41 ± 0.97 seedlings m^{-2} in late-June and 1.12 ± 0.40 to 4.12 ± 0.30 seedlings m^{-2} in late-July (Fig. 3B). Accumulated Yellow foxtail density was highest in dessicated triticale and dessicated barely (17.85 ± 1.31 and 17.05 ± 0.81 seedling m^{-2} respectively). The emergence of yellow foxtail seedling was lowest (8.82 ± 1.33 seedling m^{-2}) in mowed barely.

Yellow nutsedge densities ranged from 0.78 ± 0.42 to 4.37 ± 1.32 seedlings m^{-2} in early-June, 4.25 ± 0.50 to 8.25 ± 0.62 seedlings m^{-2} in late-June and 7.25 ± 0.43 to 11.25 ± 0.62 seedlings m^{-2} in late-July (Fig. 3C). Accumulated yellow nutsedge density was highest in incorporated sainfoin and incorporated triticale (21.75 ± 1.01 and 21.25 ± 1.76 seedling m^{-2} respectively). The lowest accumulated emergence of yellow nutsedge was achieved in sainfoin + barely mixes (14.12 ± 3.43 seedling m^{-2}). In contrast with redroot pigweed and yellow foxtail emergence, yellow nutsedge emergence was increased in late-July, so cover crop could not suppress this weed, because of the vegetative reproduction (Guertin, 2013).

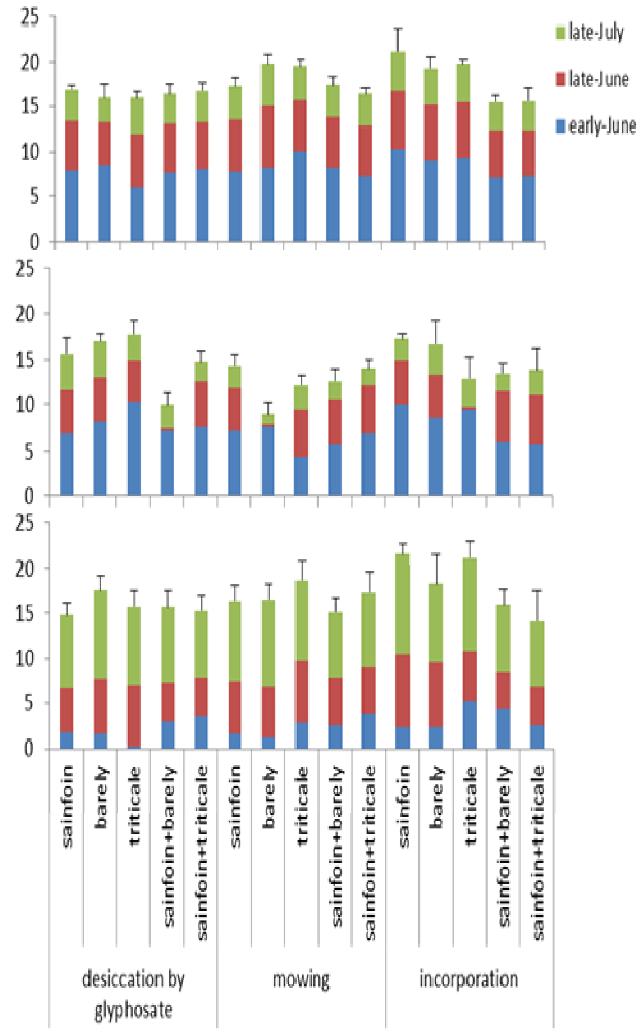

Fig. 3. The interactive effect between cover crop management and cover crop species on redroot pigweed density(A) LSD value =2.52, yellow foxtail density (B) LSD value =3.43, yellow nutsedge density (C) LSD value =4.31. Error bars represent 95% confident intervals. Vertical bars represent the standard errors of the means across 4 replicates.

The highest and lowest accumulated weed density was observed in incorporated sainfoin (60.35 ± seedling m^{-2}) and dessicated sainfoin + barely mixes (41.94 ± seedling m^{-2}), respectively because this mixes lowered the amount of light reaching the soil surface and reduced soil temperature fluctuations, resulting in a reduction in weed seedling emergence (Fig. 4). Weed suppression by it has been attributed in part to allelopathy. Bowman et al., (1998) reported that barley included in combinations with other grass and legume cover crop species contributes to a wider range of allelochemicals released into soil and thereby broadens the spectrum of weed control.

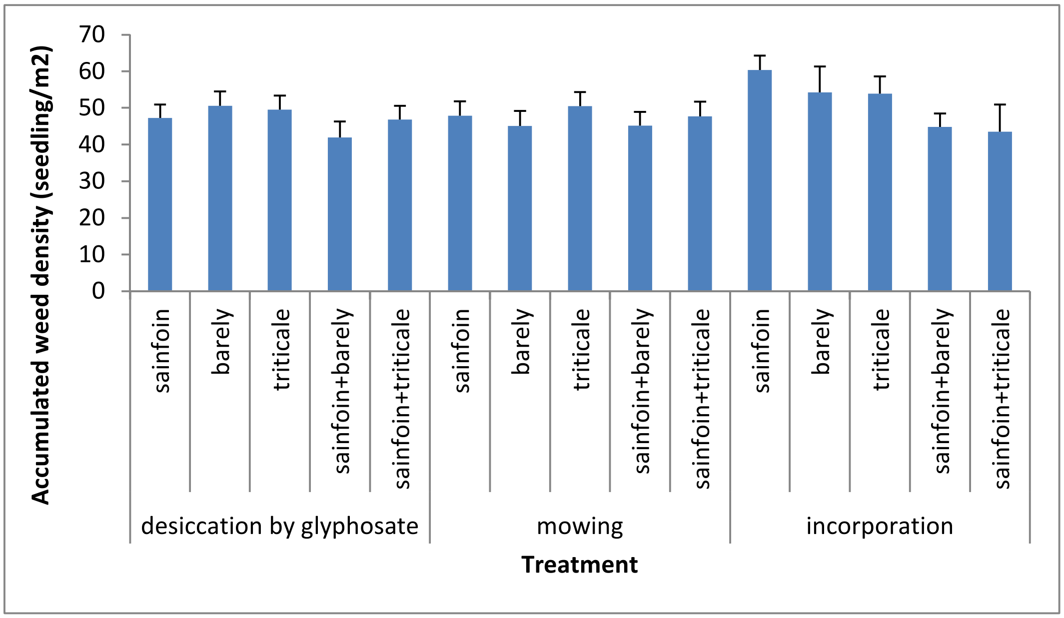

Fig. 4. The interactive effect between cover crop management and cover crop species on accumulated weed density. Error bars represent 95% confident intervals. Vertical bars represent the standard errors of the means across 4 replicates. LSD value = 8.56.

3.4. Weed dry weight

Statistically significant interactions among year, cover crop management and cover crop species were found for weed dry weight ($p<0.001$). The lowest redroot pigweed dry weight (149.5 ± 17.78 gm^{-2}) was observed in sainfoin + barely mixes desiccated by glyphosate in 2012. In dessicated sainfoin, in 2011 redroot pigweed produced the highest dry (340.08 ± 19.80 gm^{-2}). By early-June cover crop suppress redroot pigweed effectively with compared late-July. Previous studies have found rye cover to suppress weeds effectively early in the growing season, but that additional management was needed to control weed escapes (Price et al., 2007; Reeves et al., 2005; Zasada et al., 1997).

The lowes and highest yellow foxtail dry weight (106.50 ± 8.12 gm^{-2}, 249.50 ± 9.91 gm^{-2}) was observed in sainfoin + barely mixes desiccated by glyphosate in 2012 and mowed barely in 2011 repectively.

Yellow nutsedge produced the highest dry weight in mowed sainfoin (447.5 ± 25 gm^{-2}) in 2012 and lowest dry weight in sainfoin + barely mixes desiccated by glyphosate in 2011 (169.80 ± 15.22 gm^{-2}). This is in agreement with Akemo et al., (2000) who reported rye–pea mixes suppressed weeds more effectively than did pure pea. The highest and lowest total weed dry weight was produced in mowed sainfoin (950.8 ± 56.93 gm^{-2}) and sainfoin + barely mixes desiccated by glyphosate (425.8 ± 32.47 gm^{-2}) in 2012, respectively. This mixes is particularly effective as a cover crop for use in weed management because it rapidly establishes under a wide range of soil and environmental conditions and quickly grows to shade out weeds in addition to releasing allelochemicals to suppress weed growth (Bowman et al., 1998). A mix of cover crop species with complementary growth characteristics, could increase weed control compared to a single cover crop species by way of greater overall cover crop shoot biomass accumulation, appropriately timed degradation of shoot residue, and a broader spectrum of allelopathic activity (Creamer and Bennett, 1997).

Tabel 1: The interactive effect between cover crop management and cover crop species on Redroot pigweed dry weight (g m^{-2}), Yellow foxtail dry weight(g m^{-2}), Yellow nutsedge dry weight (g m^{-2}), Total weed dry weight (g m^{-2}) and Percentage of weed control. Mean + SE of four replicates was given.

Cover crop managment	Cover crop species	Redroot pigweed dry weight (g m^{-2})		Yellow foxtail dry weight(g m^{-2})		Yellow nutsedge dry weight(g m^{-2})		Total weed dry weight(g m^{-2})		Percentage of weed control	
		2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
Desiccation by glyphosate	Sainfoin	340.8 ±19.80	234.3 ±6.57	211 ±5.81	215.00 ±12.03	291.80 ±5.15	410.50 ±37.75	843.50 ±23.23	859.8 ±48.11	42 ±3.24	52.75 ±2.28
	Barely	193 ±11.81	208 ±9.46	141.8 ±5.27	145.50 ±7.02	232.80 ±16.01	228.50 ±29.90	567.50 ±21.08	582 ±28.06	63.25 ±3.56	63.75 ±2.25
	Triticale	238.8 ±12.5	271 ±12.25	162.5 ±11.16	198.80 ±4.17	249.00 ±25.13	325.30 ±11.81	650.30 ±44.64	795 ±16.67	50.5 ±2.06	53 ±2.79
	Sainfoin+Barely	170 ±29.43	149.5 ±17.78	127 ±17.41	106.50 ±8.12	211.30 ±31.41	169.80 ±15.22	508.30 ±69.64	425.8 ±32.47	78.25 ±2.32	77 ±4.06
	Sainfoin+Triticale	258.5 ±31.10	202.3 ±5.27	173.8 ±20.37	148.00 ±20.28	263.00 ±36.95	241.80 ±57.49	695.30 ±81.48	592 ±81.12	75.5 ±3.27	69.5 ±2.66
Mowing	Sainfoin	326.5 ±33.35	265.5 ±23.94	210.5 ±18.04	237.80 ±14.23	305.50 ±23.74	447.50 ±25.00	842.50 ±72.15	950.8 ±56.93	41 ±1.35	50 ±2.04
	Barely	298.8 ±21.22	248.8 ±7.35	249.5 (9.91	201.00 ±6.67	449.50 ±13.54	354.00 ±17.56	997.80 ±39.64	803.8 ±26.68	66.25 ±3.09	58.5 ±2.36
	Triticale	247 ±11.71	280.5 ±21.36	177.3 ±2.79	222.50 ±5.35	284.50 ±4.84	387.50 ±9.84	708.80 ±11.18	890.5 ±21.39	49.5 ±2.10	50.75 ±1.25
	Sainfoin+Barely	206 ±20.90	168.5 ±12.5	146.5 ±9.92	123.30 ±1.64	233.80 ±14.77	201.30 ±11.69	586.30 ±39.67	493 ±6.56	74.75 ±2.32	68.25 ±3.19
	Sainfoin+Triticale	238.3 ±11.70	177.8 ±8.27	166.5 ±10.97	135.80 ±7.68	260.80 ±23.81	229.80 ±16.10	665.50 (43.87	543.3 ±30.70	68 ±1.77	63 ±3.62
Incorporation	Sainfoin	312.5 ±27.97	320 ±16.65	247.5 ±17.93	229.00 ±12.29	430.00 ±27.04	367.50 ±20.25	990.00 ±71.74	916.5 ±49.17	43.25 ±1.03	43.75 ±0.75
	Barely	292.5 ±11.09	312.5 ±21.60	207.5 ±7.34	229.30 ±17.34	330.50 ±14.10	375.00 ±34.25	830.50 ±29.34	916.8 ±69.36	47.75 ±1.18	56.5 ±1.44
	Triticale	304.5 ±13.43	262.5 ±13.60	220.3 ±3.34	181.50 ±7.26	356.50 ±21.60	282.30 ±10.50	881.30 ±13.35	726.3 ±29.02	43.5 ±0.64	48 ±1.08
	Sainfoin+Barely	172.5 ±13.21	210 ±6.59	121 ±2.83	149.00 ±5.85	190.50 ±9.49	237.50 ±14.54	484.00 ±11.34	596.5 ±23.42	52.5 ±1.55	60.75 ±1.25
	Sainfoin+Triticale	185 ±6.45	232.5 ±13.15	134.3 ±1.17	172.80 ±5.83	218.50 ±4.35	285.00 ±6.45	537.80 ±4.67	690.3 ±23.33	49.75 ±1.75	57.25 ±0.75
LSD		50.75		32.45		66.79		130.0		6.254	

3.5. Percentages of weed control

Statistically significant interactions among year, cover crop management and cover crop species were found for percentages of weed control ($p<0.001$). The mowed sainfoin, the incorporated sainfoin, and incorporated triticale in 2011, the incorporated sainfoin and triticale in 2012 did not suppress weeds well (41%, 43.25%, 43.5%, 43.75% and 48% respectively).The sainfoin + barely mixes desiccated by glyphosate provided higher percentages of weed control in both years (78.25% and 77%), also saionfoin + triticale mixes desiccated by glyphosate and mowed sainfoin + barely mixes suppressed weeds 75.5% and 74.75% respectively.

Bordelon and Weller (1997) Reported that herbicide desiccated rye provided better weed suppression than when either mowed or incorporated. Mowed rye cover provided better weed control than soybean (*Glycine max* (L.) Merr) stubble in no-till field corn plots (Johnson et al., 1993). Use of two- or three-species winter cover crop mixes resulted in higher dry weight accumulation and more effective weed suppression, likely as a result of the interaction among system components (Linares et al., 2008).

3.6. Fruit yield

In both years there were no differences among treatments in tree yield ($p > 0.05$), althought triticale desiccated by glyphosate and incorporated sainfoin led to the highest and lowest orange yields, respectively (72.2 ± 1.31 kg tree^{-1} and 67.5 ± 1.84 kg tree^{-1}). The tree row weed management in any orchard is of major importance because it affects the vegetative and generative productivity of fruit trees. But in this experiment, the treatment trees were nearing 9 years old, presumably have well-established, relatively deep root structures, and perhaps exploit a different resource niche (in space or time) than understory weed. A few studies have shown that cover crops can influence yield. Establishment of alfalfa, fescue, strawberry clover and common vetch cover crops has also been found to reduce yield in an apple orchard (Sanchez et al., 2007). None of the cover crops improved size of apple (Bone et al., 2009). Shrestha et al., (2002) reported that fruit size were not affected by tillage type or cover crop, except that soybean yields were highest in plots with cover crops. Granatstein and Mullinix (2008) reported that alfalfa (*Medicago sativa* L.) mulch led to the highest fruit yields, followed closely by cover plots and there were no consistent effects on fruit size.

Table2: The interactive effect between cover crop management and cover crop species on tree yield (kg tree^{-1}). Mean + SE of four replicates was given.

Cover crop managment	**Cover crop species**	**Tree yield (kg tree^{-1})**	
		2011	**2012**
Desiccation by glyphosate	Sainfoin	70.25 ±1.03	69.25± 2.17
	Barely	69 ± 0.91	69.75± 1.70
	Triticale	72.25± 1.31	69.25± 0.85
	Sainfoin+Barely	71.5 ± 0.86	71.75± 1.65
	Sainfoin+Triticale	68.75 ± 1.65	70.25± 1.37
Mowing	Sainfoin	71.5 ± 1.04	70± 0.40
	Barely	71.25 ± 0.94	69.75± 1.54
	Triticale	68.75± 0.75	68.5± 0.64
	Sainfoin+Barely	70.75 ± 0.47	70.5± 0.86
	Sainfoin+Triticale	68 ± 0.70	71± 0.70
Incorporation	Sainfoin	67.5 ± 1.84	70.5± 1.84
	Barely	71.25 ± 1.43	70.5± 0.86
	Triticale	69.5 ± 1.32	68.75± 0.75
	Sainfoin+Barely	68.75± 0.85	71.75± 0.85
	Sainfoin+Triticale	71.5± 1.19	71± 0.40
LSD		3.259	

4. CONCLUSIONS

Overall, dry matter and weed suppression in a newly established organic citrus orchard varied by cover crop species. Annual cover crops can provide growers with an effective method for managing weeds in organic citrus systems. In agreement with Barberi and Mazzoncini (2001), weed growth suppression was usually higher in both years when cover crop biomass was higher. In this experiment, sainfoin + barely mixes and sainfoin + triticale mixes produced higher cover crop biomass. These results demonstrate that grass + legume mixes has a greater ability to suppress weed emergence and growth than do grass or legume in monoculture. The root exudates of sainfoin had inhibition on seed germination and seedling growth of 7 kinds of weed. The allelopathy of root exudates of sainfoin on different weeds was different (Rui-hua, 2009). Urbano et al., (2006) reported that sainfoin significantly reduced the total weed cover compared with the mechanical weeding and control. High allelopathic effectiveness of barley has resulted in its wide adoption as a cover crop in sustainable agricultural systems for weed management (Kremer and Ben-Hammouda, 2009). In this experiment sainfoin + barely mixes are more efficient than legume or grass alone in reducing weed dry weight. Planting mixes of cover crops can help a farmer to use the allelopathic potential of the cover crops to suppress weeds. Allelopathic suppression of weeds depends on both the cover crop and the weed. Therefore, a broader spectrum of weed control may be possible by growing a mixes of cover crops, with each species contributing allelopathic activity towards specific weed species (Creamer and Bennett, 1997). In addition the percentage of weed control achived by all cover crops dessicated by glyphsate was higher than when either mowed or incorporated. Dessicated cover crop can lead to decreased soil temperature fluctuations and reduced light penetration, which both have been shown to inhibit weed germination (Teasdale and Mohler, 1993; Liebman and Mohler, 2001). Althought there were no differences among treatments in tree yield, but to maximize and sustain the output of an orchard, weeds in the tree row have to be controlled efficiently.

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