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The effect of cover crops on composition and diversity of weeds in an apricot orchard

Kayısı bahçesindeki yabancı otların yoğunluğu ve çeşitliliği üzerine örtücü bitkilerin etkisi

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ABSTRACT

Apricot, Turkey's exports is the important role played by fruit, the weeds are the main factors that cause problems in the apricot orchards. This study was carried out in Malatya between 2014-2016 in order to determine the effects of cover crops on the control of weeds that cause problems in these areas and also on species distribution, diversity and dominance. As annual winter cover plants in the study: *Vicia villosa* Roth (hairy vetch), *Vicia pannonica* Crantz (Hungarian vetch), *V. pannonica* + Triticale (*V.pannonica* 70% + Triticale 30%) mixture and *Phacelia tanacetifolia* Bentham (lacy phacelia) and *Fagopyrum esculentum* Moench (buckwheat) was used as a summer cover plant. Weed diversity index (H) and Simpson's dominance index (Sd) values were also calculated in the study. In addition, applications were subjected to canonical discriminant analysis. The highest value of the weed diversity index (H) in the two-year period was obtained from the weed control plots. It has been determined that perennial weeds (*Convolvulus arvensis* and *Sorghum halepense*) are the dominant species in cover plants and there are also differences between practices. It has been determined that annual weeds are generally suppressed and their diversity has decreased significantly in the plots except for *F. esculentum*. The results obtained from the canonical discriminant analysis showed that the highest numbers of weed species in the 1st and 2nd years were found in the weedy control plots and that the cover crops suppressed the weeds.

INTRODUCTION

Apricot (*Prunus armeniaca* L.), which is known to have origins from Central Asia, Turkey and Western China, is one of the important crops. Apricot is produced on 580.000 hectares globally and its annual yield is 3.88 million tons (FAO 2018). It is cultivated most widely in Asia, Europe, and Africa (55.5%, 26%, and 14%, respectively). In Turkey, it is grown mainly in Malatya province. As in fruit growing, besides the total herbicides, also the tillage is widely used as a mechanical method for weed managements in apricot orchards. Instead of frequently performing the tillage, the practices that will control the weeds without damaging the balance of agro-ecosystem and/or ensure the natural control of other damaging factors harming the fruit trees by increasing the biodiversity of the medium should be popularized (Isik et al. 2014). The use of herbicides in weed control is the most commonly preferred method. The herbicides also have many negative effects such as the problem of residues on soil, water, and foods, health risks for humans, effects on non-targeted organisms, and environmental pollution (Isik et al. 2018). In both conventional and organic farming systems, the weeds are one of the factors limiting the productivity (Stopes and Millington 1991). The most popular one among the conventional control methods is the use of chemical herbicides but there are many scientific reports emphasizing that there is no effective weed control method especially in the organic farming (Wszelaki et al. 2007). The mechanical weed control methods including handpicking and hoeing are among the most popular methods used for suppressing the weeds (Hiltbrunner et al. 2007). However, the handpicking method has also several disadvantages such as the costs and difficulty of finding workers (Kruidhof et al. 2008). The repetitive treatments applied to the soil in the hoeing method affect the stability of soil structure and increase the risk of soil erosion (Wszelaki et al. 2007). Moreover, there are few herbicides allowed to be used in organic farming and they are very expensive and non-selective chemicals; for this reason, they might damage the cultivated plant too (Knezevic 2009).

The agricultural biodiversity includes the diversity and amplitude of crop-related weeds, the presence of other organisms, and ratios between different species. The diversity indexes are widely used for examining the biodiversity in agricultural products. Moreover, the diversity and dominance indexes are also used for determining the changes in the weed population on the cultivation areas (Pawlonka et al. 2014). Having an important place in agricultural biodiversity, the cover crops decrease the soil erosion, water loss, and pollution, as well as enhance the soil structure and increase the number of useful microorganisms, water infiltration, moisture ratio, and amounts of nitrogen and organic carbon (Demir and Isik 2019, Demir et al. 2019). The use of cover crops in weed control in fruit orchards gradually increases (Isik et al. 2014, Isik et al., 2018, Robacer et al. 2016). The use of cover crops in organic farming increases the organic matter content of the soil through the mixture of plant biomass and other organic agents into the soil and the protection of herbal wastes. The increase in organic matter content of the soil increases the formation of aggregate, stabilizes the soil, and decreases the erosion and flow of surface water (Demir and Isik 2019, Demir et al. 2019,). As a result of their competition with weeds for light, moisture, and nutrient, and through the allelochemicals, the cover crops prevent the germination and growth of other plants. It was reported that many plant species (*Vicia* spp., *Tripholium* spp., *Sorghum vulgare, Secale cereale*) have been successfully used as cover crops in suppressing the weeds (Mennan et al. 2009a, 2009b).

In literature, there are very few studies on the weed control in apricot growing by using cover crops. This study aims to calculate the weed diversity index (H) and Simpson dominance index (Sd) values in the apricot growing by making use of mechanical weed control, non-selective herbicide (glyphosate), and cover crops (by mowing and incorporation them into the soil). Moreover, the canonical discriminant analysis was performed and the effects of practices on the weeds were investigated.

MATERIALS AND METHODS

Experimental site and field trial

This study was carried out between 2014 and 2016 in the experimental apricot orchard of the Agricultural Faculty of Inonu University, Turkey. The study area (38.47 N - 38.34 E) has an argillaceous soil structure (52% clay, 28% silt, 20% sand, 1.7% organic matter, and pH 7.4). In the growing season 2015-2016, the mean temperature was 13.4 °C and the mean annual precipitation was 420 mm. The apricot orchard was 10-year-old and the trees were planted with 8 m (between the rows) x 8 m (between the trees in the same row).

Annual cover crops were used in the study area. *Vicia villosa* Roth (hairy vetch), *Vicia pannonica* Crantz (Hungarian vetch), *V. pannonica*, Triticale (*V. pannonica* 70% + Triticale 30%) mixture, and *Phacelia tanacetifolia* Benth (lacy phacelia) were used as winter cover crops and *Fagopyrum esculentum* Moench (buckwheat) as summer cover crop. Being a summer cover crop, *F. esculentum* was planted between 21.04.2014 and 05.05.2015, whereas other winter cover crops were between 23.10.2014 and 23.10.2015 hand spreading method. The results were recorded for summer and winter cover crops in 2015 and 2016.

The experiments were conducted in a randomized complete block design with four replications. This study also includes weedy control, herbicide, and mechanical weed control plots. The experiments were established in a 6-year-old apricot garden, and the mechanical control application was carried out at the time of sowing of the covering plants, and the herbicide application when the weeds had 2-6 leaves. Each plot was set to be 80 m^2 (4 x 20 m). The successive plots were separated as a region containing no cover crop. The seeds of cover crops were planted with plantation norm of 15 kg/ha for hairy vetch and Hungarian vetch, 30 kg/ha for lacy phacelia, and 50 kg/ha for buckwheat. The cover crops were kept at the same plots during the experiment period.

After bloom of cover crops, half of the cover crop plots was mixed down to 10 cm depth by using double-disc cultivator with two passes (incorporation process), whereas the other half was mowed (without another process) and the mowed plants were left on the soil as mulch (mowing process). In germination and active growth period, mechanical weed control by using a rotary hoe machine and glyphosate herbicide (6 l/ha) were applied.

The first weed counting was performed before incorporation the cover crops into the soil (initial counting) and the weeds were determined. In order to determine the suppressive effects of cover crops, the numbers of weeds were counted on 7th, 14th, and 28th days after the initial counting by using a 50 cm x 50 cm frame randomly thrown three times on each plot (in both incorporation process and mowing process) and the diversity and density of weeds were calculated.

Statistical analysis

At the end of the experiment, the densities of weeds observed in the study field were calculated using the formula given below.

$$\text{Density} = \frac{\text{Number of the weed species}}{\text{Number of all of the weed species}} \text{X100}$$

Shannon-Wiener diversity index (H') was used in determining the diversity of weeds in the study field. The following formula was used in the Shannon-Wiener diversity index (H').

$H' = -\sum pi \ln(pi)$

where,

pi : ratio of i^{th} species to the others

ln: base of natural logarithm (Magurran 1988, Magurran 2004).

Simpson's dominance index (Sd) was used in determining the dominance between the weeds in the study area. The formula used in this process is given below.

$Sd = \sum ni(ni\ 1)/\ N(N\ 1)$

where,

i: number of weed species

ni: Number of individuals from the same species in the experimental practices

N: the sum of all individuals from the species in each experimental practices (Magurran 1988, Magurran 2004).

The canonical discriminant analysis was performed in order to determine the effects of cover crops on the weeds. On each sampling date, the composition of the current weed population was subjected to canonical discriminant analysis by using CANDISC practice in SAS. In order to evaluate the relationship between the presence of weed species and the cover crop practices, a vector diagram based on the total canonic coefficient of each weed species was combined in the same diagram (Isik et al. 2009a). The type and degree of the relationship between the presence of weed species and the cover crop practices were represented in a coordination dual-graph by adding a vector diagram to the distribution graph by using vectors representing the weed species (Shrestha et al. 2002). The emergence of weed species vectors and cover crop practices in the same coordination area showed the relationship between those weeds and cover crops (Legere et al. 2005).

RESULTS AND DISCUSSION

The dominant weed species in the experimental apricot orchard, in which the present study was carried out, were found to be *Amaranthus retroflexus* L., *Convolvulus arvensis* L., *Tribulus terrestris* L., *Sisymbrium officinale* (L.) Scop., *Sorghum halepense* (L.) Pers., *Lamium amplexicaule* L., *Chenopodium album* L., *Thlaspi arvense* L. and *Vaccaria pyramidata* Medik (Table 1). The densities of other weed species such as *Lactuca serriola* L., *Sinapis arvensis* L., *Glycyrrhiza glabra* L. were found to be lower than 1%. In counting practices performed in both years, the most important weed species were found to be *A. retroflexus* (22%), *C. arvensis* (16%), *T. terrestris* (16%), *S. officinalis* (14%), and *S. halepense* (7%) and the population of these weed species constituted more than 75% of the total weed population (Table 1).

Table 1. Dominant weed species in the experimental area and their relative proportion just before treatments (2015 and 2016, combined)

Weed species	Bayer code	Relative abundance (%)
Amaranthus retroflexus L.	AMARE	22
Convolvulus arvensis L.	CONAR	16
Tribulus terrestris L.	TRBTE	16
Sisymbrium officinale (L.) Scop.	SSYOF	14
Sorghum halepense (L.) Pers.	SORHA	7
Lamium amplexicaule L.	LAMAM	3
Chenopodium album L.	CHEAL	3
Thlaspi arvense L.	THLAR	3
Vaccaria pyramidata Medik.	VACPY	3
Papaver rhoeas L.	PAPRH	2
Cirsium arvense (L.) Scop.	CIRAR	2
Xanthium strumarium L.	XANST	1
Portulaca oleracea L.	POROL	1
Convolvulus galaticus Rost. ex Choisy	CONGA	1
Anthemis arvensis L.	ANTAR	1
Others		<5

Table 2. The effects of different practices on the intensity-dominance (Shannon diversity index (H´) and Simpson dominance index (Sd values) of significant weeds in cover crops (2015 and 2016, combined).

Treatments	Weeds					
	H	AMARE	CONAR	TRBTE	SSYOF	SORHA
V. villosa		Sd	Sd	Sd	Sd	Sd
FWC	1.5753	0.0000	0.2125	0.0000	0.0913	0.0000
mowing (7. days)	0.7120	0.0000	0.6046	0.0000	0.0000	0.0000
incorporation (7. days)	0.4535	0.0000	0.0551	0.0000	0.0000	0.1484
mowing (14. days)	0.8901	0.0000	0.3486	0.0000	0.0000	0.0005
incorporation (14. days)	0.6805	0.0000	0.3844	0.0000	0.0000	0.0370
mowing (28. days)	0.9193	0.0000	0.2216	0.0831	0.0000	0.0316
incorporation (28. days)	0.8876	0.0000	0.4901	0.0051	0.0000	0.0000
V. pannonica						
FWC	1.8225	0.0000	0.0211	0.0000	0.0760	0.0000
mowing (7. days)	0.7130	0.0000	0.5666	0.0000	0.0000	0.0000
incorporation (7. days)	0.6914	0.0000	0.0317	0.0000	0.0000	0.0648
mowing (14. days)	1.2755	0.0000	0.2244	0.0000	0.0000	0.0334
incorporation (14. days)	1.0021	0.0000	0.1665	0.0000	0.0000	0.0311
mowing (28. days)	1.3073	0.0000	0.1502	0.0829	0.0000	0.0095
incorporation (28. days)	0.9498	0.0000	0.4242	0.0083	0.0000	0.0010
Triticale+V. pannonica						
FWC	1.5552	0.0000	0.1275	0.0000	0.0703	0.0000
mowing (7. days)	1.2202	0.0000	0.2857	0.0000	0.0000	0.0000
incorporation (7. days)	0.5006	0.0000	0.2548	0.0000	0.0000	0.0000
mowing (14. days)	1.1298	0.0000	0.3260	0.0000	0.0000	0.0000
incorporation (14. days)	0.6630	0.0000	0.5426	0.0000	0.0000	0.0000
mowing (28. days)	1.3740	0.0000	0.3027	0.0026	0.0000	0.0176
incorporation (28. days)	1.0388	0.0000	0.3632	0.0185	0.0000	0.0013
P. tanacatifolia						
FWC	1.3022	0.0000	0.0883	0.0000	0.2582	0.0000
mowing (7. days)	0.9277	0.0000	0.5507	0.0000	0.0000	0.0010
incorporation (7. days)	0.0056	0.0000	0.5000	0.0000	0.0000	0.0000
mowing (14. days)	0.9388	0.0000	0.2886	0.0000	0.0000	0.0000
incorporation (14. days)	0.0879	0.0000	0.2442	0.0000	0.0000	0.0601
mowing (28. days)	1.1268	0.0000	0.4129	0.0076	0.0000	0.0053
incorporation (28. days)	0.0989	0.0000	0.5068	0.0020	0.0000	0.0008
F. esculentum						
FWC	1.4547	0.0349	0.0304	0.2391	0.0000	0.0015
mowing (7. days)	1.3645	0.0541	0.1913	0.0519	0.0000	0.0001
incorporation (7. days)	1.4424	0.0047	0.1831	0.0883	0.0000	0.0000
mowing (14. days)	1.4552	0.0687	0.0314	0.0810	0.0000	0.0671
incorporation (14. days)	1.5063	0.0198	0.1223	0.0519	0.0000	0.0103
mowing (28. days)	1.5681	0.0437	0.0187	0.1756	0.0000	0.0034
incorporation (28. days)	1.3274	0.0000	0.1311	0.0505	0.0000	0.0912
Mechanical weed control						
FWC	1.6488	0.0234	0.0228	0.1101	0.0786	0.0078
7. days	0.7390	0.0009	0.0373	0.0045	0.0000	0.0352
14. days	0.9107	0.0064	0.0685	0.0096	0.0000	0.0163
28. days	1.3100	0.0099	0.0951	0.0102	0.0000	0.1218
Herbicide						
FWC	1.5828	0.0121	0.0047	0.1787	0.1141	0.0022
7. days	0.6903	0.0174	0.0837	0.0381	0.0000	0.0101
14. days	0.5852	0.0218	0.0321	0.0893	0.0000	0.0062
28. days	0.5884	0.0542	0.0062	0.1443	0.0000	0.0024
Weedy control						
FWC	1.8173	0.1236	0.0056	0.0235	0.0270	0.0208
7. days	1.8057	0.1236	0.0057	0.0235	0.0273	0.0209
14. days	1.9725	0.1042	0.0065	0.0199	0.0198	0.0191
28. days	2.0711	0.0863	0.0066	0.0183	0.0160	0.0178

The Shannon diversity index (H´) and species-based Simpson dominance index (*D*) values of the top 5 weed species seen in Table 1 are given in Table 2. It was observed that, considering the average of 2 years, the highest weed diversity index (H) value was obtained in the weedy control. In the herbicide and mechanical weed control practices, the diversity of weeds was found to be higher when compared to the initial counting values. In the control plots, increases were observed in the weed diversity between the initial counting and the counting performed on the 28th day. From the aspect of weed diversity, it was found as a result of the counting practices performed before mowing and incorporation the plants that the highest weed diversity was obtained with *V. pannonica* cover crops, followed by *V. villosa*, Triticale + *V. pannonica*. In suppressing the weed species diversity by using cover crops, the highest suppression effect was obtained by incorporation *P. tanacatifolia* into the soil. When cover crops were examined in general, it was found that their incorporation into the soil gave better results compared to mowing and the effect of both processes decreased since new weeds grow as they passed time. As a result, weed diversity has increased (Table 2).

Examining the Simpson dominance index (Sd) values of top 5 most important weeds found in the study field in the 2-year period, it was determined that generally the perennial weeds [*Convolvulus arvensis* (CONAR) and *Sorghum halepense* (SORHA)] were dominant among the cover crops and there were differences between the cover crops. It was also found that the annual plants were generally suppressed and their diversity significantly decreased (except for *F. esculentum*). In the previous studies, it was reported that the cover crop practices control the weed populations but some (especially the perennial ones) species in these populations could not be suppressed. Considering the dominance values of each species reported in the previous studies, it was found that the use of the cover crops, mechanical weed control, and total herbicide suppressed the weed species. After the mowing and incorporation practices, the numbers of certain weeds decreased in the counting performed on the 7th day but their populations re-increased in 14th and 28th-day values. Kostrzewska et al. (2012) examined the effect of the summer barley and pea mixture on the weed species and they reported that, according to the Shannon-Wiener diversity and Simpson dominance values of cultivated plants grown after them, they reduced the number of weed species. In this study, it was found that the cover crops had similar effects on the weed species.

In the canonical discriminant analysis on the results obtained from the present study, it was found that 27 weed species were detected in apricot orchard at the end of 1st year and 26 species at the end of the 2nd year. In the counting performed at the end of 1st year, the highest number of weed species was observed in the weedy control plots (9.5 species), whereas the lowest number of species (4 species) was found in *P. tanacetifolia* plots. The most frequently seen weed species in *V. villosa*, *V. pannonica*, and triticale + *V. pannonica*, *P. tanacetifolia* plots was SSYOF, whereas the most frequently seen weed species in *F. esculentum* plots, mechanical weed control, and total herbicide was TRBTE. The most frequently seen weed species in the control plot was found to be AMARE. In the first counting in 2nd year, the highest number of weed species was observed again in the weedy control plot (7.5 species), whereas the lowest number (2.5 species) was obtained in the mechanical weed control plot. The most frequently seen weed species were found to be CIRAR in *V. villosa*, triticale + *V. pannonica*, and *P. tanacetifolia*, TRBTE in *F. esculentum*, *V. pyramidata* in *V. pannonica*, and SSYOF in mechanical weed control, total herbicide, and control plots. Canonical discriminant analysis was performed at the 1st counting to determine the relationship between the practices and weed species (Figure 1). The canonical discriminant analysis showed variation between the practices in terms of the weed species. It was determined that 94% of the weed correlation between the practices was explained by the 1st canonical axis and 88% was explained by the 2nd canonical axis (Table 3). Weed plot constituted a significantly separate group, whereas *F. esculentum* constituted a separate group since it couldn't establish a sufficient coverage as a cover crop and couldn't prevent the weed growth.

In the 7th day mowing in 1st year, the number of weed species was 19, whereas the number of weed species was found to be 15 in the 2nd year. In the mowing on the 7th day in the 1nd year, the highest number of weed species was found in weedy control plots (9.5 species), whereas the lowest number of weed species was found to be 1 in *V. villosa* plot.

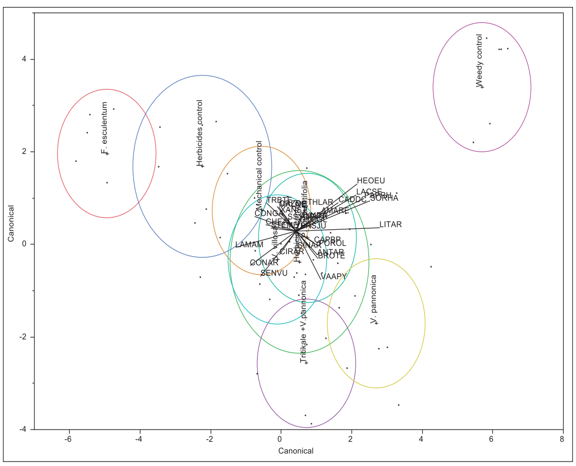

Figure 1. Diagram of 1st counting canonical discriminant analysis on weed species and practices

Table 3. The 1st and 2nd canonical axis values

Application	Counts	Cononical axis values (%)	
		1st canonical axis values	2nd canonical axis values
	1st count	94	88
Mowing	7th day	98	71
Mowing	14th day	99	81
Mowing	28th day	99	86
Incorporation	7th day	98	78
Incorporation	14th day	99	86
Incorporation	28th day	99	88

The most frequently seen weed species was found to be CIRAR in *V. villosa*, *V. pannonica*, triticale + *V. pannonica*, *P. tanacetifolia*, and TRBTE in *F. esculentum* parcel, mechanical weed control, and total herbicide. The most frequently seen weed species in control parcel was AMARE. In the mowing on the 7th day in 2nd year, the highest number of weed species was found in weedy control plots (7.5 species), whereas the lowest number was found to be 2.5 species in *V. pannonica* plot. The most frequently seen weed species was found to be SSYOF in control plot and CIRAR in other plots. The canonical discriminant analysis also showed variation between the practices in terms of weed species in the 7th day mowing practices (Figure 2). It was observed that 98% of the weed correlation between the practices was explained by the 1st canonical axis and 71% by the 2nd canonical axis (Table 3).

Twenty weed species were found in the study field in the incorporation on 7th day in 1st year and 15 species in 2nd year. In the incorporation on the 7th day in 1st year, the highest number of weed species was found in weedy control plots (9.5 species), and the lowest number was found to be 1 in *V. villosa* parcel. The most widely seen species was found to be CIRAR in *V. villosa*, *V. pannonica*, triticale + *V. pannonica*, *P. tanacetifolia*, and *F. esculentum* and TRBTE in mechanical weed control and total herbicide parcels. The most frequently seen weed species in the control plot was found to be *A. tricolor*. In the incorporation on the 7th day in 2nd year, the highest number of weed species was found in weedy control plots (7.25 species) and no weed was observed in *V. villosa*, *V. pannonica*, triticale + *V. pannonica*, and *P. tanacetifolia* parcels. The most frequently seen weed species in the control plot was SSYOF (Figure 2). It was found that 98% of the weed correlation between the practices was explained by the 1st canonical axis and 78% by the 2nd canonical axis in the incorporation on the 7th day (Table 3).

In the first year, in the 14th day mowing practices, 17 and in the second year 18 weed species were identified. In the first year, mowing on the 14th day, the highest number of weed species was detected in weedy control plots (11.25 species) and the lowest number was determined to be 2 weed species in *V. villosa* plot. Again, the most frequently seen species were found to be CIRAR in *V. villosa*, *V. pannonica*, triticale + *V. pannonica*, and *P. tanacetifolia* plots and TRBTE weed species in mechanical weed control and total herbicide plots. The most frequently seen weed species in control parcel and *F. esculentum* was AMARE. In the mowing on the 14th day in 2nd year, the highest number of weed species was obtained in the weedy control parcel (10.25 species) and the lowest number of weed species was found to be 2.25 species in *V. villosa* plots. The most frequently seen species in control plot was found to be SSYOF (Figure 2). It was found that 99% of the weed correlation between the practices was explained by the 1st canonical axis and 81% by the 2nd canonical axis (Table 3).

In the 14th day incorporation practices, 17 weed species were observed in the 1st year and 18 species in the 2nd year. In the first year, the highest number of weed species was found in the weedy control plot (11.25 species), whereas the lowest number of weed species was found to be 1.75 species in *V. villosa* and triticale + *V. pannonica*. The most frequently seen weed species were found to be CIRAR in *V. villosa*, *V. pannonica*, triticale + *V. pannonica* plots, *P. tanacetifolia*, and *F. esculentum* and TRBTE in mechanical weed control and total herbicide parcels. The most frequently seen weed species in the control plot was AMARE. In the 14th day incorporation practices, the highest number of weed species in the 2nd year was found in the weedy control parcels (10 species), and the lowest number of weed species was found to be 1.5 species in *V. villosa*, *V. pannonica*, and triticale + *V. pannonica* vetch parcels. The most widely seen weed species was found to be TRBTE in *F. esculentum* plot, SSYOF in control plot, and CIRAR in other plots (Figure 2). It was found that 99% of the weed correlation between the practices was explained by the 1st canonical axis and 86% by the 2nd canonical axis (Table 3).

17 weed species were observed in the 1st year and 18 species in the 2nd year in the 28th day mowing practice. The highest number of weed species in the 1st year was found in the weedy control plots (12.5 species), whereas the lowest number of weed species was found to be 2.25 species in *V. villosa* plot. The most frequently seen weed species was CIRAR in *V. villosa*, *V. pannonica*, triticale + V. pannonica, *P. tanacetifolia*, and *F. esculentum* plot, TRBTE in mechanical

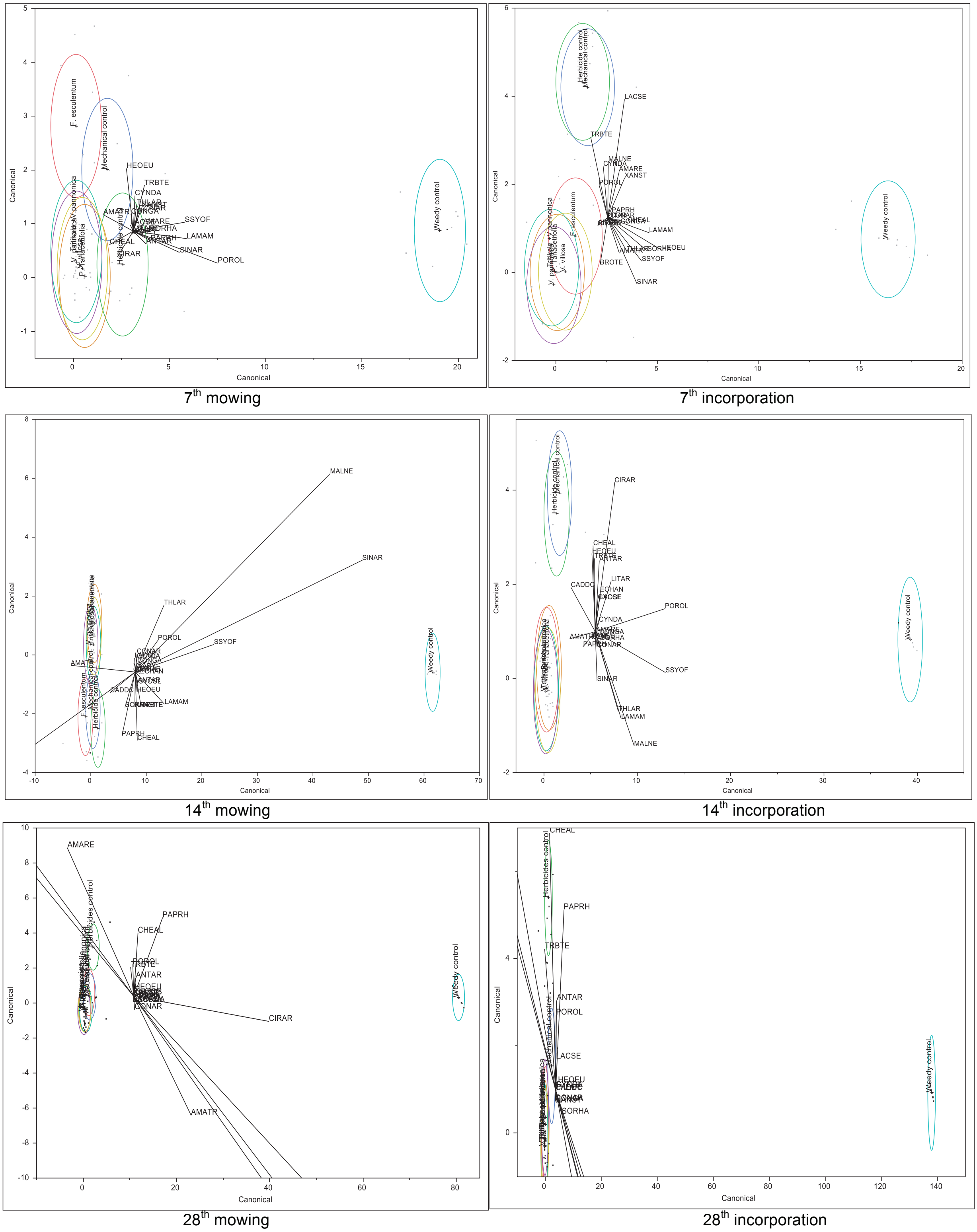

Figure 1. The diagram of 7th, 14th, and 28th day mowing and incorporation canonical discriminant analysis on weed species and cover crop practices.

weed control and total herbicide, and AMARE in control plot. In the 2nd year, the highest number of weed species in the 28th day mowing practice was found in the weedy control plots (11 species), whereas the lowest number of weed species was found to be 2 in V. pannonica and P. tanacetifolia plots. The most frequently seen species was TRBTE in *V. pannonica* and *F. esculentum*, CIRAR in *V. villosa*, triticale + *V. pannonica*, and *P. tanacetifolia*, *S. halepense* in mechanical weed control plot, ANTAR in total herbicide plot, and SSYOF in control plot (Figure 2). It was found that 99% of the weed correlation between the practices was explained by the 1st canonical axis and 86% by the 2nd canonical axis (Table 3).

In this study, the highest number of weed species in the 28th day incorporation practices were found to be 15 in both years. In the 1st year, the highest number of weed species was found in weedy control plots (12.5 species), whereas the lowest number of species was found to be 1.5 in *V. villosa* and triticale + *V. pannonica* plot. The most frequently seen weed species were CIRAR in *V. villosa*, *V. pannonica*, triticale + *V. pannonica*, *P. tanacetifolia*, and *F. esculentum*, TRBTE in mechanical weed control and total herbicide plots, and AMATR in control plots. In the 2nd year, the highest number of weed species in the 28th day incorporation practice was found in weedy control plots (11 species), whereas the lowest number of weed species was found to be 2.25 in *V. pannonica* and *P. tanacetifolia* plot. The most frequently seen weed species was SORHA in mechanical weed control plot, ANTAR in total herbicide plot, SSYOF in control plot, and CONAR in other plots (Figure 2). It was determined that 99% of weed correlation between the practices was explained by the 1st canonical axis and 88% by the 2nd canonical axis. In all practices, the weedy control plot constituted a significantly separate group (Table 3).

As a result of this study, the cover crops yielded a significant decrease in the weed intensities and the use of cover crops is a method that can be used in suppressing the weeds. By directly competing with weeds for light and nutrients, cover crops reduce their development and seed production (Peachy et al. 1999). Fisk et al. (2001) reported that the cover crops affect the density of weeds and the weight loss in biomass by decreasing the light transmittance, changing the soil temperature, increasing the soil moisture, revealing the allelopathic chemicals, and preventing the germination of weed seedlings by acting as a physical barrier. Moreover, Akemo et al. (2000) stated that hairy vetch suppresses the weeds through its shadowing effect. Furthermore, Kitis et al. (2007) reported in their study, in which they used *Vicia sativa* L. (hairy vetch) as a cover crop of Cukurova region, suppressed the weeds by 64% in 2004 and 38% in 2005. Again, Isik et al. (2009a, 2009b) reported that hairy vetch significantly suppressed the weeds in organic paprika and lettuce growing areas. In this study, however, the most cover crop that was effective against weeds at most was found to be lacy phacelia (approx. 75%), followed by buckwheat (approx. 73%) and hairy vetch (approx. 63%). When compared to the control, the lowest effect among the cover crops was obtained from Hungarian vetch (33%), while the effect increased above 50% with the combination of Hungarian vetch and triticale. The results obtained from the cover crops are in parallel with those reported in the studies cited here. Bocianowski and Majchrzak (2019) stated that cover crop was significant effect on number of weed species and density. Also they are think that degree to cover crops affect regulation of weed infestation is diversified and depends on weed species, habitat conditions, type of catch crop as well as method of its management. Blackshaw et al. (2001) reported that the use of *Melilotus officinalis* as a live cover crop in fallow systems suppressed the weed biomass by >95%. Moreover, incorporation *M. officinalis* into the soil was found to be effective in controlling the weeds by means of this plant's residual effect. Although no such high value could be achieved in controlling the weeds in this study, it is concluded that the use of cover crops, especially in fruit orchards, can suppress the weeds. Besides suppressing the weeds, it was also determined in the present study that legume cover crops enhanced the soil in terms of nutrients. Sainju et al. (2002) reported that, by using the cover crops, the nutrient elements in the soil can be kept and it might be a necessary part of sustainable agriculture. As a result of their 3-year study on the same plots, Ngouajio et al. (2003) determined that the population in the plots fallowed in summer was larger than the population in the plots, where the cover crops were used in summer. Again, Teasdale et al. (2007) reported that the use of cover crops decreased the weed intensity and biomass weight. Moreover, in their study employing cover crops in weed control in citrus orchards in Mediterranean region, Koloren (2004) stated that there was a negative relationship between the soil coverage area of cultivated plants (cover crop) and the general weed population and the lowest weed population was found in trefoil and grass plants. In this study, in which there were gravelly plots, similar results were achieved despite different legume plants were used as cover crops.It was determined that the most important weed in the experimental area was *Amaranthus retroflexus*, followed by *Convolvulus arvensis* and *Tribulus terrestris*. The highest weed diversity index (H) value was obtained in the weedy control. When compared with the 1st count, increases in weed density were determined on the 28th day. According to the Simpson dominance index (Sd), it was determined that the cover crops generally do not suppress perennial weeds (*C. arvensis* and *S. halepense*) very well. The experiments results pointed out that annual weeds were generally suppressed in the cover crops plots other than *F. esculentum* and their diversity decreased significantly. The results obtained from the canonical discriminant analysis showed that the highest numbers of weed species in the 1st and 2nd years were found in the weedy control plots and that the cover crops suppressed the weeds. The results also provide an opportunity for effective non-chemical weed control, which is important for organic fruit production.

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ÖZET

Kayısı, Türkiye'nin ihracatında önemli rol oynayan meyvelerden olup, yabancı otlar ise kayısı bahçelerinde sorun yaratan temel faktörlerdendir. Bu çalışma, örtücü bitkilerin bu alanlarda sorun oluşturan yabancı otların kontrol altına alınmasını, ayrıca tür dağılımı, çeşitliliği ve baskınlığı üzerindeki etkilerini saptamak amacıyla 2014-2016 yılları arasında Malatya'da yürütülmüştür. Çalışmada tek yıllık kışlık örtücü bitkiler olarak: *Vicia villosa* Roth (tüylü fiğ), *Vicia pannonica* Crantz (Macar fiğ), *V. pannonica* + Triticale (*V. pannonica* %70 + Tritikale %30) karışımı ve *Phacelia tanacetifolia* Bentham (arı otu) ve yazlık örtücü bitki olarak *Fagopyrum esculentum* Moench (karabuğday) kullanılmıştır. Çalışmada yabancı ot çeşitliliği indeksi (H) ve Simpson'ın baskınlık indeksi (Sd) değerleri de hesaplanmıştır. Ayrıca, uygulamalar, kanonical discriminant analizine tabi tutulmuştur. İki yıllık dönemde yabancı ot çeşitliliği indeksinin (H) en yüksek değeri yabancı otlu kontrol parsellerinden elde edilmiştir. Çok yıllık yabancı otların (*Convolvulus arvensis* ve *Sorghum halepense*) örtücü bitkilerde baskın türler olduğu ve uygulamalar arasında da farklılıkların bulunduğu belirlenmiştir. *F. esculentum* dışındaki parsellerde tek yıllık yabancı otların genel olarak bastırıldığı ve çeşitliliğinin önemli ölçüde azaldığı tespit edilmiştir. kanonical discriminant analizinden elde edilen sonuçlar, 1. ve 2. yıllarda en çok yabancı ot türünün yabancı ot kontrol parsellerinde bulunduğunu ve kaplayıcı bitkilerinin yabancı otları bastırdığını göstermiştir.

Anahtar kelimeler: kayısı, biyoçeşitlilik, örtücü bitkiler, tür dağılımı, yabancı ot

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