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Full Length Article

Effects of Different Cover Crops on Soil Quality Parameters and Yield in an Apricot Orchard

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Abstract

Cover crop treatments significantly increased yield in an apricot orchard according to the control. Effects of different cover crop treatments on some soil quality parameters and yield of a apricot orchard located in Turkey were investigated. For this purpose, *Vicia villosa* Roth. (VV), *V. pannonica* Crantz. (VP), a mixture of *V. pannonica* (70%) and *Triticale* (30%) (VPT) and *Phacelia tanacetifolia* Benth. (PT) were grown as winter cover crops, and *Fagopyrum esculentum* was grown as summer cover crop in the apricot orchard with clay soil. The experiment was done in a randomized complete block design with 4 replications including a plot mechanically cultivated (MC), herbicide treatment (HC) and bare control plot (BC). The soils were sampled from 0–20 cm and 20–40 cm depths in each plot for soil analyses. The cover crops enhanced soil quality parameters like organic matter (OM), total nitrogen (N), electrical conductivity (EC), basal soil respiration (BSR), structural stability index (SSI), aggregate stability (AS), saturated hydraulic conductivity (Ks), bulk density (BD), permanent wilting point (PWP), available water capacity (AWC) and field capacity (FC). The highest rises were in the treatment of the VV, diminishing the BD by 12.7% while raising the OM by 63.5%, Ks by 248.7%, AWC by 19.4% and SSI by 9.4% in the 0–20 cm soil depth. OM contents of cover crop treatments were ordered as; HC < BC < MC < PT < FE < VPT < VP < VV. The highest correlations among the soil parameters were obtained for the VV between OM and BD (-0.911**), BD and Ks (-0.906**), OM and Ks (0.989**). It was concluded based on current results that cover crops may be incorporated into cropping systems to improve soil quality. © 2019 Friends Science Publishers

Keywords: Cover crops; Soil quality; Soil quality parameters; Apricot orchard; Clay soil

Introduction

For a sustainable agriculture system, it is requisite to use renewable resources that may minimize the environmental hazards and maximize the ecological benefits (Vance, 1997). However, it is challenging for scientists to increase crop fertility while sustaining a clean environment. Therefore, the current practices need to be modified so that higher yields can be achieved, and environmental pollution is minimized in crop production. Crop residue management is an important element of maintainable crop production (Ruffo and Bollero, 2003). Plant residues have played a significant act as mulch for water and soil conservation and as an input for returning nutrients to soil and sustaining soil organic matter (Nawaz *et al*., 2017). It is important to use cover crops to obtain the purposes of sustainable cropping systems. Cover crops may be described as "close-growing crops that supply soil protection, and soil enhancement between periods of normal crop production, or between trees in orchards" (SSSA, 1997). Establishing cover crops has an important effect on improving soil physical, chemical, and biological properties and hence on increasing the yields of successive row crops (Fageria *et al*., 2005). Intensive utilize of chemical fertilizers caused to occur in ecological damage and environmental pollution, and increased production cost (Mitsch and Day, 2006). To decrease pollution, extreme utilise of our non-renewable resources such as petroleum, which are used in the chemical fertilizers production, and restoration of land and wetlands an alternative method must be developed. Therefore, environmental friendly produce such as cover crops should be used when recognizing maintainable ecosystem and agro-ecological restoration.

Planting cover crops before or between principal crops as well as between shrubs or trees of plantation crops may enhance soil chemical, physical, and biological features and eventually cause to enhanced yield of main crops and soil health. Leaving cover crops as surface mulches in crop

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production systems has the benefit of rising N economy (SAN, 1998), reducing soil erosion (Langdale *et al*., 1991), conserving soil moisture (Morse, 1993), rising nutrient retention (Dinnes *et al*., 2002), improving soil physical properties (Blevins and Frye, 1993), suppressing weeds (Creamer and Baldwin, 2000), rising soil productivity (Cavigelli and Thien, 2003), increasing crop yields (Triplett *et al*., 1996), decreasing global warming potential (Robertson *et al*., 2000) and decreasing insects and diseases (SAN, 1998). The soils can sustain their crop production potentials as long as organic matter contents are maintained (Mann *et al*., 2002). Crop fertility is directly associated to the organic matter content (Reicosky and Forcella, 1998). Organic matter enhances soil chemical, biological, and physical features and eventually crop yields (Franzluebbers, 2002). There is a relation between the amount of C supply in the soils and the rate of decompose of organic matter (Lal, 2002). Fertilization practices effect organic carbon content by modifying both carbon losses and inputs (Follett, 2001). Generally, the application of organic amendments like farmyard manure or crop residues rises importantly organic matter (Maltas *et al*., 2013). On the other hand, the effect of the application of only inorganic fertilizers for a long term frequently results in the opposite effect (Edmeades, 2003). In crop production, long-term productivity relies on maintaining soil organic matter (Goyal *et al*., 1999). Thus, the treatment of organic wastes affluent in organic matter to soil, like sewage sludge (Albiach *et al*., 2001), animal manure (Haynes and Naidu, 1998), plant residues (Neve and Hofman, 2000), by-products with high soil organic matter content (Tejada and Gonzalez, 2004), compost (Tejada and Gonzalez, 2003) etc. is a common environmental and agricultural practise for sustaining organic matter, improving destroyed soils and providing plant nutrients. The importance of cover crops increased in agricultural production gained importance to enhance soil quality and reduce chemical inputs. It is likely to increase the productivity along with making contributions to improve soil and water quality provided that cover crops are selected, used, and managed properly (Fageria *et al*., 2005). In organic systems soil management includes the utilize of mowed or tilled cover crops, composts, a consistent release of available nutrients to the trees as the soil organic matter breaks down and animal manures and the application of organic fertilizers to rise organic matter (Sanchez *et al*., 2007).

While there are many studies on cover crops, studies dealing with effects on soil quality of the *Vicia villosa* Roth., *Vicia pannonica* Crantz., *Vicia pannonica* Crantz. and Triticale mixture (70% + 30%), *Phacelia tanacetifolia* Benth., *Fagopyrum esculentum* Moench. in an orchard is very limited. Thus, the objective of this study was to evaluate the effect of different cover crops on some soil quality parameters and yield in an apricot orchard with clay soil located in Malatya province of Turkey.

Materials and Methods

Experimental Site

Experiments were conducted in the experimental apricot orchard at Inonu University in 2014 and 2016. Experimental site is located at 38.47 N – 38.34 E, mean annual precipitation of 420 mm, and had to average temperature of 13.4°C during 2014–2016 growing season. Plant spacing was 8 m between the rows and 8 m within the row. The apricot orchard was 10 years old.

Field Trial

Vicia villosa, *V. pannonica*, a mixture of *V. pannonica* and *Triticale* (*V. pannonica* 70% + *Triticale* 30%), and *P. tanacetifolia* were grown as winter cover crops, and *F. esculentum* was grown as summer cover crop. *F. esculentum* was planted on 21 April 2014 and 5 May 2015, and the other winter covering plants were planted in the fall periods of the years on 23 October 2014 and 23 October 2015. There was a 50 cm distance between the apricot plants and the cover crops. In each of the study years, the first soil cultivation was done during the first week of November, and soil preparation was done in mid-April before sowing of the cover crops. For the winter cover crops, the first soil cultivation was done in mid-September, and soil preparation was done during the first week of November. The results of the experiments were recorded in 2015 and 2016 for summer and winter cover plants.

The field experiments were done using randomized complete blocks design with 4 replications. Cover crops were grown on the same plot. Experiment also included control plots [bare control (BC), herbicide control (HC) and mechanical control (MC)]. Each plot was 80 m^2 (4 x 20 m). The cover crop seeds were broadcast and incorporated into the soil. Seeding rates were 30 kg ha^{-1} for *P. tanacetifolia* and 50 kg ha^{-1} *F. esculentum*, 150 kg ha^{-1} for *V. villosa* and *V. pannonica*. Cover crops were at flowering stage on 15 May 2015 in the first year of study and on 24 May 2016 in the second year of study. After the flowering period of the cover crops, the parcels with cover crops in experiment were incorporated into the soil using two passes of a double disk cultivator to a depth of approximately 10 cm. Cover crops were mowed or incorporated into the soil on 20 May during 2015 and 3 June during 2016. Herbicide application and mechanical control were practiced when the weeds were at 4–8 leaves stage (20 May 2015, and 25 May 2016). Glyphosate (isopropylamine salt, 360 g a.i. L^{-1}) was applied at 2880 mL ha^{-1} (1.39 kg a.i. ha^{-1}). Herbicide was applied with a spraying volume of 250 L ha^{-1} at 303.97 kPa pressure with a field sprayer, pressurized by a pump, and pulled by a tractor. Mechanical control comprised use of rotary hoeing and herbicide treatments contained the application of glyphosate at 2.40 kg a.i. ha^{-1} after the weeds emerged and were growing actively.

Soil Sampling

The soil in each treatment was sampled from two different depths (0–20 and 20–40 cm) 90 d after crop incorporate using a corkscrew-shaped soil drill. Initial soil characteristics are provided in Table 1 and 2. Initial analyses revealed that experimental soils were clay in texture (20% sand, 28% silt, 52% clay), slightly alkaline with low organic matter contents (Soil Survey Staff, 1993). After collecting the soil samples, it was stored in a plastic bag and identified. Soil samples were sieved using 2 mm sieve and were prepared for physico-chemical and biological soil analyses.

Soil Chemical Analyses

Soil particle size distribution was identified with hydrometer method (Demiralay, 1993); soil pH values were determined from 1: 1 (w : v) soil - water suspension with a pH meter; soil electrical conductivity (EC_{25^oC}) was identified from the same soil-water suspension with an EC meter (Kacar, 1994); exchangeable cations were determined with ammonia acetate extraction (Kacar, 1994); and available P contents were determined through extraction with 0.5 *M* $NaHCO_3$ at pH 8.5 (Olsen *et al*., 1954). Modified Walkley–Black method was employed to determine organic matter (OM) contents of soil samples (Kacar, 1994). Total N was determined by the LECO.

Soil Biochemical Analysis

Basal soil respiration (BSR) were measured in accordance with Isermayer (1952) through measuring CO_2 productions at 22°C. The CO_2 productions at the end of 24 h incubation period were expressed in mg CO_2 100 g^{-1}.

Soil Physical Analyses

Pressure plate device was utilized to measure the moisture contents at field capacity (FC) and at permanent wilting point (PWP) of the soil. Available water content was found by calculating the difference between FC and PWP (AWC) (Hillel, 1982). Soil bulk density (BD) values were determined in accordance with the principles specified in Tüzüner (1990). Then, Eq. 1 was used to calculate the total porosity (F) (Hillel, 1982):

$$F = 1 - (BD/2.65) \quad (1)$$

Gravimetric water content (W) was determined through weight wet and dry samples (at 105°C for 24 h). The product of gravimetric water content and bulk density was used to find the volumetric water content (θ). Hydrometer method and the following equation were used to determine soil structural stability index (SSI):

$$SSI = \sum b - \sum a \quad (2)$$

Where "b" is percent clay and "a" is silt + clay (Leo, 1963). A wet sieving device was used to assess the aggregate stability (AS) (Yoder type) (Kemper and Rosenau, 1986). Constant head permeameter was used to measure saturated hydraulic conductivity (Ks) of the soil samples (US Salinity Lab. Staff, 1954). Following Darcy equation was sued to calculate saturated hydraulic conductivity (Ks, cm h^{-1});

$$Ks = \frac{Q}{A\,t}\left(\frac{S}{S+H}\right) \quad (3)$$

Where, Q: volume of outflow (cm^3), A: cross sectional area of soil column (cm^2), t: time (hour), S: length of soil column (cm), H: water head over the soil column (cm).

Dry sieving method (with 4.00, 3.35, 2.00, 1.40, 1.20, 1.00, 0.50, 0.425 and 0.25 mm sieves) was used to calculate mean weight diameter (MWD) (Hillel, 1982):

$$MVD = \sum_{i=1}^{k} W(i)\,\bar{x}i \quad (4)$$

Statistical Analyses

Experimental results were subjected to statistical analyses using SPSS statistical software package. Duncan's multiple range test was used to compare the means and correlation analyses were done to express the relationships between experimental parameters (Yurtsever, 1984).

Results

Soil Chemical Properties

Cover crop treatments had significant effects on soil chemical quality parameters at 0 – 20 cm soil depth of an apricot orchard (Table 1). Comparing with the control, soil OM, EC, total N, available P, extractable K, Ca and Mg values increased and pH and exchangeable Na contents decreased with cover crop treatments. The improvements in the second year were better in soil properties compared with the first year. Organic matter contents of cover crop treatments at 0–20 cm of the soil depth in the second year of experiments (2016) were ordered as; HC (1.45%) < BC (1.56%) < MC (1.87%) < PT (2.24%) < FE (2.26%) < VPT (2.40%) < VP (2.53%) < VV (2.55%) (Table 1). Percent changes in soil chemical quality parameters as compared to control treatments are provided in Table 3. Percent increases in soil organic matter content as compared to bare control treatment at 0–20 cm soil depth in the second year of the experiments varied between 43.6% in PT and 63.5% in VV treatment (Table 3).

In the second year of the experiment at 0–20 cm soil depth, cover crop treatments significantly reduced pH and exchangeable Na from 7.47 and 0.35 meq 100 g^{-1} for the bare control treatment to 7.02 for the VV and VP treatments and to 0.20 meq 100 g^{-1} for the VP treatment, respectively (Table 1). In the second year of the experiment at 0–20 cm of the soil depth increased total N from 0.100% in the bare control to 0.175% in VV treatment in the apricot orchard (Table 1). EC values varied between 0.66 ds m^{-1} for the BC treatment and 1.11 dS m^{-1} for the VV treatment at 0–20 cm of the soil depth in the second year of the experiment

Table 1: Effects of different cover crops on chemical soil quality parameters at 0–20 cm soil depth

	pH (1:1)**	$EC_{25°}$ dS m^{-1}**	OM %**	N %**	NH_4OAc extractable meq 100 g^{-1}				P ppm**	BSR mg CO_2 100 g^{-1} soil**
2015										
					Ca	Mg	K**	Na*		
Beginning	7.43	0.66	1.73	0.097	18.3	5.78	1.03	0.37	15.9	12.2
BC	7.47 a	0.66 c	1.61 d	0.103 e	18.6	5.68	0.99 d	0.39 a	16.0 d	12.3 d
MC	7.45 a	0.66 c	1.85 c	0.120 d	18.0	5.88	1.01 d	0.38 a	16.9 d	12.6 d
VV	7.10 d	1.00 a	2.32 a	0.173 a	18.1	5.86	1.58 a	0.21 b	23.0 a	39.8 a
VP	7.13 d	0.98 a	2.26 a	0.164 ab	17.8	6.13	1.44 b	0.24 b	22.8 a	39.4 ab
VPT	7.19 c	0.84 b	2.12 b	0.156 bc	18.4	6.12	1.39 b	0.24 b	20.6 b	37.6 bc
PT	7.26 b	0.84 b	2.07 b	0.144 c	17.9	5.83	1.22 c	0.30 ab	18.6 c	35.9 c
FE	7.27 b	0.82 b	2.09 b	0.142 c	17.8	5.71	1.23 c	0.30 ab	19.0 c	36.1 c
HC	7.46 a	0.66 c	1.33 e	0.094 e	17.8	5.70	0.95 d	0.41 a	15.8 d	12.1 d
2016										
	pH (1:1)**	$EC_{25°}$ dS m^{-1}**	OM %**	N %**	NH_4OAc extractable meq 100 g^{-1}				P ppm**	BSR mg CO_2 100 g^{-1} soil**
					Ca**	Mg**	K**	Na*		
BC	7.47 a	0.66 d	1.56 e	0.100 e	18.3 a	5.55 c	1.03 d	0.35 a	16.7 d	12.5 d
MC	7.39 a	0.67 d	1.87 d	0.112 d	18.1 a	5.83 c	1.07 d	0.34 a	17.0 d	13.1 d
VV	7.02 c	1.11 a	2.55 a	0.175 a	16.1 b	7.83 a	1.73 a	0.21 cd	24.8 a	41.5 a
VP	7.02 c	1.10 a	2.53 a	0.171 a	16.4 b	7.58 a	1.69 a	0.20 d	24.6 a	41.1 a
VPT	7.16 bc	0.92 b	2.40 b	0.161 b	17.2 ab	6.90 b	1.52 b	0.24 bc	22.1 b	38.0 b
PT	7.20 b	0.89 c	2.24 c	0.145 c	17.1 ab	7.00 b	1.37 c	0.27 b	19.7 c	36.6 bc
FE	7.21 b	0.88 c	2.26 c	0.149 c	16.6 b	6.81 b	1.39 c	0.26 b	20.9 bc	36.0 c
HC	7.50 a	0.65 d	1.45 e	0.092 e	18.3 a	5.44 c	0.99 d	0.37 a	15.8 d	11.9 d

*Significant at 5% level, **Significant at 1% level

V. villosa VV), *V. pannonica* (VP), *V. pannonica* (70%) + Triticale (30%) mixture (VPT), *P. tanacetifolia* (PT); *F. esculentum* (FE), a plot mechanically cultivated (MC), herbicide treatment (HC) and bare control plots (BC)

Table 2: Effects of different cover crops on physical soil quality parameters at 0–20 cm soil depth

	Db g cm^{-3}	FC %	PWP %	AWC %	F %	Θ %	Ks cm h^{-1}	AS %	MWD mm	SSI %
2015										
Beginning	1.18	38.4	21.2	17.3	55.2	30.2	0.38	55.4	0.724	50.6
BC	1.19 a	39.0 b	21.4 b	17.5 bc	55.1 c	29.8 b	0.36 d	55.6 b	0.735	50.8 b
MC	1.18 a	39.3 b	21.5 b	17.9 abc	55.5 c	30.8 b	0.42 d	55.8 b	0.751	50.9 b
VV	1.07 b	42.9 a	23.4 a	19.5 a	59.6 a	37.1 a	1.25 a	59.5 a	0.869	54.7 a
VP	1.07 b	42.2 a	23.3 a	19.2 ab	59.6 a	37.2 a	1.19 a	59.2 a	0.853	54.7 a
VPT	1.09 b	42.2 a	23.1 a	19.1 ab	58.9 ab	36.8 a	1.06 b	59.0 a	0.829	54.0 ab
PT	1.11 ab	42.8 a	23.0 a	19.7 a	58.1 b	36.7 a	0.90 c	57.6 ab	0.825	53.5 ab
FE	1.11 ab	42.8 a	23.0 a	19.7 a	58.1 b	36.6 a	0.92 c	56.4 b	0.822	53.3 ab
HC	1.19 a	38.4 b	21.3 b	17.1 c	55. 1 c	29.9 b	0.35 d	55.5 b	0.718	50.8 b
2016										
	Db g cm^{-3}	FC %	PWP %	AWC %	F %	Θ %	Ks cm h^{-1}	AS %	MWD mm	SSI %
BC	1.18 a	38.4 b	21.2 b	17.2 b	55.5 c	30.9 c	0.37 d	55.4 c	0.730	50.6 b
MC	1.19 a	38.5 b	21.2 b	17.3 b	55.1 c	32.1 c	0.41 d	55.9 c	0.760	50.7 b
VV	1.03 b	43.6 a	23.1 a	20.6 a	61.1 a	38.8 a	1.29 a	59.8 a	0.879	55.4 a
VP	1.04 b	43.5 a	23.1 a	20.5 a	60.8 ab	38.7 a	1.25 a	59.5 a	0.864	55.2 a
VPT	1.05 b	43.4 a	23.0 a	20.4 a	60.4 ab	37.9 b	1.07 b	58.8 ab	0.862	54.8 a
PT	1.07 b	43.1 a	23.0 a	20.0 a	59.6 b	37.9 b	0.94 c	57.2 bc	0.855	53.9 ab
FE	1.07 b	43.2 a	22.9 a	20.4 a	59.6 b	37.8 b	0.94 c	56.3 c	0.819	53.9 ab
HC	1.20 a	38.1 b	21.1 b	17.1 b	54.7 c	31.5 c	0.35 d	55.1 c	0.716	50.5 b

$P < 0.01$

V. villosa (VV), *V. pannonica* (VP), *V. pannonica* (70%) + Triticale (30%) mixture (VPT), *P. tanacetifolia* (PT), *F. esculentum* (FE), a plot mechanically cultivated (MC), herbicide treatment (HC) and bare control plots (BC)

(Table 1). The highest available P (24.8 ppm) at 0–20 cm of the soil depth in the second year of the experiment was obtained in the VV treatment while the lowest available P (16.7 ppm) was in the BC treatment in the apricot orchard (Table 1).

The differences in exchangeable Ca and Mg contents of cover crop treatments at 0–20 and 20–40 cm soil depths were not significant in the first year of the experiment (Table 1). While the exchangeable K contents varied between 1.03 meq 100 g^{-1} for the BC and 1.73 meq 100 g^{-1} for the VV treatment; exchangeable Na contents ranged from 0.35 meq 100 g^{-1} for the BC to 0.20 meq 100 g^{-1} for the VP treatment) at 0–20 cm of the soil depth in the second year of the experiment. In both years of the experiment, the differences in soil chemical quality indicators at 20–40 cm soil depth were not found to be significant.

Soil Biochemical Property

The highest basal soil respiration values (41.5 mg CO_2 100

Table 3: Changes (%) in chemical soil quality parameters at 0–20 cm soil depth as compared to bare control treatment

Treatments	pH	EC	OM	N	NH_4OAc extractable				P	BSR
					Ca	Mg	K	Na		
2015										
MC	-0.2	0.3	14.9	16.5	-3.2	3.5	2.0	-2.6	5.6	2.4
VV	-5.0	50.9	44.1	68.0	-2.6	3.2	59.6	-46.2	44.2	223.6
VP	-4.6	47.9	40.4	59.2	-3.9	7.9	45.5	-38.5	42.7	220.3
VPT	-3.8	27.9	31.7	51.5	-0.9	7.8	40.4	-38.5	29.2	205.7
PT	-2.8	27.6	28.6	39.8	-3.4	2.6	23.2	-23.1	16.6	191.9
FE	-2.7	24.9	29.8	37.9	-3.9	0.5	24.2	-23.1	19.0	193.5
HC	-0.1	-0.8	-17.4	-8.7	-4.0	0.4	-4.0	5.1	-1.1	-1.6
2016										
MC	-1.1	1.2	19.9	12.0	-0.9	5.1	3.9	-2.9	1.4	4.8
VV	-6.0	67.4	63.5	75.1	-11.7	41.1	68.0	-40.0	48.2	232.0
VP	-6.0	65.3	62.2	71.0	-10.5	36.6	64.1	-42.9	47.0	228.8
VPT	-4.2	38.2	53.9	61.2	-5.9	24.3	47.6	-31.4	32.4	204.0
PT	-3.6	34.2	43.6	45.1	-6.4	26.1	33.0	-22.9	18.0	192.8
FE	-3.5	32.1	44.9	49.0	-9.4	22.7	35.0	-25.7	24.9	188.0
HC	0.4	-1.7	-7.1	-8.0	-0.1	-2.0	-3.9	5.7	-5.8	-4.8

V. villosa (VV), *V. pannonica* (VP), *V. pannonica* (70%) + Triticale (30%) mixture (VPT), *P. tanacetifolia* (PT), *F. esculentum* (FE), herbicide control (HC), mechanical control (MC) and bare control (BC)

Table 4: Changes (%) in physical soil quality parameters at 0–20 cm soil depth as compared to bare control treatment

Treatments	Db	FC	PWP	AWC	F	Θ	Ks	AS	MWD	SSI
2015										
MC	-0.8	1.0	0.2	1.9	0.7	3.6	16.7	0.3	2.2	0.1
VV	-10.1	10.0	9.2	11.1	8.2	24.8	247.2	7.1	18.2	7.7
VP	-10.1	8.4	8.5	9.4	8.2	25.2	230.6	6.6	16.1	7.6
VPT	-8.4	8.3	7.5	9.3	6.9	23.8	194.4	6.1	12.8	6.2
PT	-6.7	9.8	7.4	12.6	5.5	23.5	150.0	3.6	12.2	5.3
FE	-6.7	9.8	7.4	12.4	5.5	23.0	155.6	1.6	11.8	4.8
HC	0.0	-1.3	-0.5	-2.5	0.0	0.4	-2.8	-0.1	-2.3	-0.1
2016										
MC	0.9	0.4	0.3	0.5	-0.7	4.0	10.8	0.8	4.1	0.1
VV	-12.7	13.7	9.1	19.4	10.2	25.4	248.7	7.8	20.4	9.4
VP	-11.9	13.4	8.9	18.9	9.5	25.1	237.8	7.3	18.4	9.1
VPT	-11.0	13.2	8.6	18.7	8.8	22.6	189.2	6.1	18.1	8.2
PT	-9.3	12.2	8.7	16.4	7.5	22.6	154.1	3.1	17.1	6.5
FE	-9.3	12.6	8.0	18.3	7.5	22.2	154.1	1.6	12.2	6.4
HC	1.7	-0.6	-0.5	-0.8	-1.4	1.8	-5.4	-0.6	-1.9	-0.2

V. villosa (VV), *V. pannonica* (VP), *V. pannonica* (70%) + Triticale (30%) mixture (VPT), *P. tanacetifolia* (PT), *F. esculentum* (FE), a plot mechanically cultivated (MC), herbicide treatment (HC) and bare control plots (BC)

g^{-1}) at 0–20 cm of the soil depth in the second year of the experiment was obtained in the VV treatment while the lowest BSR values (12.5 mg CO_2 100 g^{-1}) was in the BC treatment in the apricot orchard (Table 1). Percent increases in BSR value as compared to bare control treatment at 0–20 cm depth of soil in the second year of the experiment (2016) varied between 188.0% in FE and 232.0% in VV treatment (Table 3).

Soil Physical Properties

Cover crop treatments had significant effects on soil physical quality parameters at 0–20 cm soil depth of an apricot orchard (Table 2). In both years of the experiment, cover crop treatments significantly affected soil bulk density (BD), available water capacity (AWC), permanent wilting point (PWP), total porosity (F), field capacity (FC), volumetric water content (θ), saturated hydraulic conductivity (Ks), aggregate stability (AS) mean weight diameter (MWD) and structural stability index (SSI) at 1% level (Table 2). In the second year of the experiment at 0–20 cm of the soil depth decreased bulk density from 1.18 g cm^{-3} in the bare control to 1.03 g cm^{-3} in VV treatment in the apricot orchard (Table 2). Total porosity values at 0–20 cm of the soil depth in the second year of the experiment were ordered as; HC (54.7%) < MC (55.1%) < BC (55.5%) < PT = FE (59.6%) < VPT (60.4%) < VP60.8%) < VV (61.1%). Total porosity values generally increased with decreasing soil bulk densities of cover crop treatments.

The cover crop treatments increased FC, PWP and AWC values of the soil compared with bare control treatment. The greatest FC (43.6%) and PWP (23.1%) values were observed in VV treatment and the least FC (38.1%) and PWP (21.1%) values were observed in HC treatment at 0–20 cm of the soil depth in the second year of the experiment. Percent changes in soil physical quality parameters as compared to control treatments are provided in Table 4. The increase rates in AWC varied between 16.4% in PT – 19.4% in VV treatment (Table 4).

The least θ value (30.9%) was observed in BC treatment and the greatest θ value (38.8%) was observed in VV treatment at 0–20 cm of the soil depth in the second year of the experiment (Table 2). In both years of the experiment, volumetric water contents at 0–20 cm of the soil depth generally increased with decreasing bulk densities of cover crop treatments. Saturated hydraulic conductivity values varied between 0.35 cm h^{-1} for the HC treatment and 1.29 cm h^{-1} for the VV treatment at 0–20 cm of the soil depth in the second year of the experiment (Table 2). Percent changes in Ks values as compared to bare control treatments are provided in Table 4. Percent the increase rates in Ks values at 0–20 cm of the soil depth in the second year of the experiment varied between 154.05–248.65% (Table 4).

As compared to control treatments, cover crop treatments significantly increased AS, MWD and SSI values (Table 2). The greatest AS value (59.8%) was observed in VV treatment and least (55.1%) in HC treatment at 0–20 cm of the soil depth in the second year of the experiment. In both years of the experiment, the differences in soil physical quality parameters at 20–40 cm soil depth were not found to be significant. The highest MWD values (0.879 mm) in the second year of the experiment was obtained in the VV treatment while the lowest MWD values (0.716 mm) was in the HC treatment at 0–20 cm soil depth in the apricot orchard. As compared to bare control treatment, percent increase rates in SSI values at 0–20 cm of the soil depth in the second year of the experiment varied between 6.4% in FE treatment – 9.4% in VV treatment (Table 4).

Table 5: Relationships between some physico-chemical and biochemical soil quality parameters

	EC	Total N	BSR	K	Na	Db	Ks	AS	FC
pH	0.784**				0.920**				
EC			0.873**			-0.810**	0.951**	0.752*	0.870**
OM	0.869**	0.978**	0.916**	0.918**		-0.911**	0.989**	0.703*	0.880**
Na							-0.885**		
Db							-0.906**		
Ks	0.951**		0.961**		-0.885**	-0.853**		0.748*	

*Significant at 5% level, **Significant at 1% level

Relationships Among the Soil Quality Indicators

Relationships between some physico-chemical and biochemical soil quality parameters are given in Table 5. Organic matter had significant positive correlations with Ks (0.989**), AS (0.703*), FC (0.880**) and significant negative correlations with BD (-0.911**). Ks had the greatest positive correlation (0.951**) with EC and the greatest negative correlation (-0.906**) with bulk density. Significant positive correlations were also observed between OM and total N (0.978**), between pH and EC (0.784**), between BSR and OM (0.916**) and between exchangeable K and OM (0.918**). Changes in OM and AS values and in EC and AS values at 0–20 cm soil depth are presented in Fig. 1 and 2, respectively. AS values generally increased with increasing soil OM contents and EC values due to cover crop treatments.

Apricot Yield

Effects of cover crops and other treatments on fruit weight in the apricot orchard are given in Fig. 3. Cover crop treatments increased mean fruit weight in apricot orchards in the following order; BC (31.2 g) < VP (32.4 g) < FE (32.6 g) < VV (32.7 g) < MC (32.8 g) < HC (32.8 g) < PT (33.3 g) < VPT (34.4 g). Percent changes in the fruit weight over the bare control are given in Fig. 4. As compared to bare control treatment, the highest increase rate in the mean fruit weight was determined 10.7% in the VPT treatment.

Discussion

Soil chemical and physical properties are improved by cover crop treatments due to increases in organic matter content, electrical conductivity, basal soil respiration, available water capacity, aggregate stability, saturated hydraulic conductivity, total porosity. The results suggested that the basal soil respiration and saturated hydraulic conductivity had the most high percent increase on the response of cover crop treatments. The rise in soil organic matter content with cover crop addition is compatible with findings of Marinari *et al*. (2000), Chikowo *et al*. (2004) and Nascente *et al*. (2013). Soil organic matter is considered the key factor that influences soil quality. Organic matter effects about all characteristics associated to healthy soils.

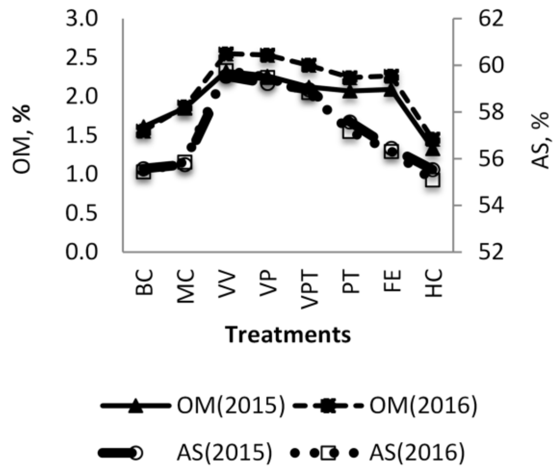

Fig. 1: Changes between average OM and AS values at 0–20 cm soil depth
V. villosa (VV), *V. pannonica* (VP), *V. pannonica* (70%) + Triticale (30%) mixture (VPT), *P. tanacetifolia* (PT), *F. esculentum* (FE), herbicide control (HC), mechanical control (MC) and bare control (BC)

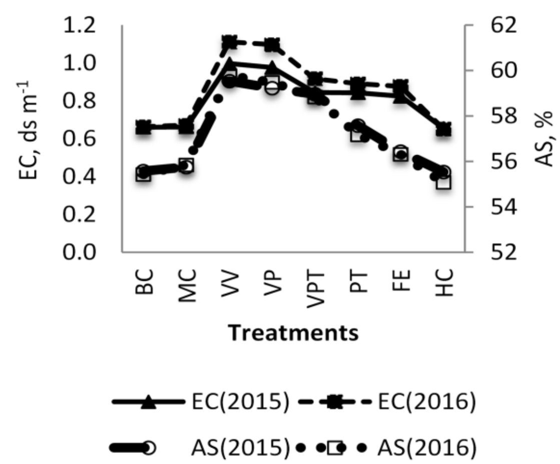

Fig. 2: Changes between average EC and AS values at 0 - 20 cm soil depth
V. villosa (VV), *V. pannonica* (VP), *V. pannonica* (70%) + Triticale (30%) mixture (VPT), *P. tanacetifolia* (PT), *F. esculentum* (FE), herbicide control (HC), mechanical control (MC) and bare control (BC)

Practices that support good organic matter management are therefore the very basis for healthy soils, high quality, and eventually lead to thriving agricultural ecosystems and

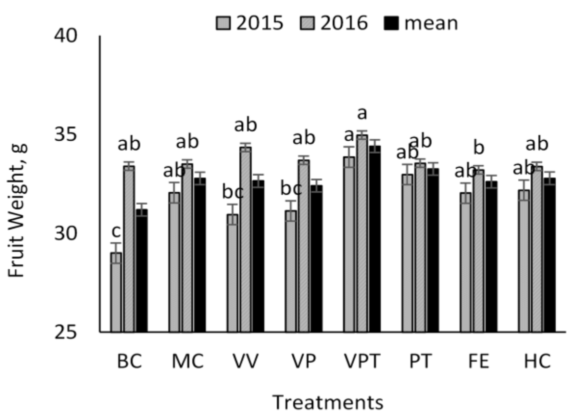

Fig. 3: Effects of cover crops and other treatments on fruit weight in the apricot orchard
V. villosa (VV), *V. pannonica* (VP), *V. pannonica* (70%) + Triticale (30%) mixture (VPT), *P. tanacetifolia* (PT), *F. esculentum* (FE), herbicide control (HC), mechanical control (MC) and bare control (BC)

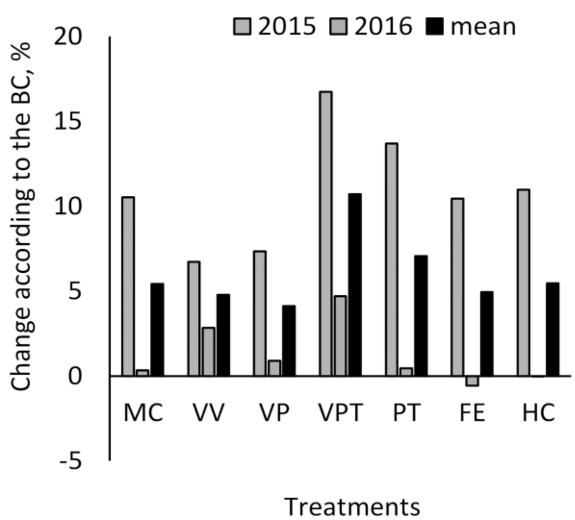

Fig. 4: Percent changes in the fruit weight over the bare control
V. villosa (VV), *V. pannonica* (VP), *V. pannonica* (70%) + Triticale (30%) mixture (VPT), *P. tanacetifolia* (PT), *F. esculentum* (FE), herbicide control (HC), mechanical control (MC) and bare control (BC)

more maintainable (Magdoff and Van Es, 2009). In this study, the application of cover crops affluent in organic matter to soil improved physico-chemical and biochemical properties of soils at 0–20 cm soil depth in the both years of experiment. In addition, this study distinctly indicates that soil properties improvement by cover crops hardly depends on the plant species.

Since addition of cover crops had significant effects on soil properties. Highest percent increases in the soil chemical and physical properties as compared to control treatment at 0–20 cm soil depth were especially determined in the *V. villosa* and *V. pannonica* treatments, increasing the organic matter content of soils. Similar findings were also determined by Silva *et al*. (2009), Carvalho *et al*. (2011) and Teodoro *et al*. (2011), who found greater soil organic matter with legume cover crops in comparison with the other cover crops. *V. villosa and V. pannonica* treatments, due to their great and depth root systems, can be larger ability to mobilize nutrients from deep soil layers to the topsoil. The leguminous cover crops used in the experiment in compared to the nonleguminous cover crops had a large variation at 0–20 cm soil depth in terms of the genetic potential of the legume species. Pacheco *et al*. (2011) identified that cover crops as a source of nutrients may importantly vary the soil properties and depend upon several factors, specially the species. Both legume and nonlegume cover crops effect nitrogen fertilizer management (Bauer and Roof, 2004). Legume cover crops fix atmospheric nitrogen (N_2) and build up soil nitrogen that benefits productivity and yield of subsequent cash crops while reducing inorganic N fertilizer requirements (Dabney *et al*., 2010).

Cover crop applications had a significant decrease on soil pH in comparison with the unamended control soil. The decrease in soil pH is compatible with results of Moreti *et al*. (2007) and Fabian (2009). Cover crops could importantly effect the soil pH (Guimarães, 2000; Moreti *et al*., 2007). In this study, soil pH values significantly decreased with cover crop treatments ($p < 0.01$). As compared to bare control treatment, decreases in pH values varied between 3.5 in FE – 6.0% in VV and VP treatments. Moreti *et al*. (2007) determined that plants have exudation of acids to the soil from their roots that could role directly on the soil pH. The soil favors nutrient accumulation at the surface rised organic matter contents and decreased in soil pH values (Franchini *et al*., 2000; Fabian, 2009). Besides, when organic matter is mineralized there is production of organic acids that could promote to rised soil acidity (Garcia and Rosolem, 2010).

The increase in basal soil respiration can be associated with soil microorganism's action in nutrient cycling through the decomposition of cover crops as green manures incorporated into soil. Soil health and long term soil respiration improve with increased soil organic matter. Numerous soil functions as well as ecological services are affected by soil microbial communities. These functions include maintanence of soil structure, soil organic matter turnover, and nutrient cycling (Kladivko, 2001). A number of chemical properties (nutrient availability and cycling, pH, buffering capacity, and cation exchange capacity) are affected by organic matter content in the soil (Tisdall *et al*., 1986).

In this study, cover crop applications had a significant impact on soil physical attributes at 0–20 cm soil depth in comparison with the control soils, increasing available water capacity, volumetric water content, total porosity, mean weight diameter, structural stability index, aggregate stability, saturated hydraulic conductivity and decreasing bulk density.

Plant residues effect soil structural attributes by enmeshing soil main particles and microaggregates into macroaggregation with direct physical action of roots, and production of cementing agents from improved microbial activities. Soil physical attributes are extensively effected by organic materials. Decrease in bulk density of soil due to build-up in organic matter has been well documented in literature (Sharma *et al*., 1995). In this study, reduced BD, increased total porosity and saturated hydraulic conductivity were observed with increasing organic matter contents compared with control soils. Plant residues could decrease pH and bulk density, as well as rised soil microbes and organic matter (Liu *et al*., 2006). In addition, Yang *et al*. (2005) determined that plant residues rised soil organic matter content, decreased bulk density, supported the formation of soil aggregates, and improved soil porosity. This results confirmed our hypothesis and was in support with findings showned by Marinari *et al*. (2000) and Chikowo *et al*. (2004). Similarly, Kumar and Goh (2000) and Demir and Gulser (2015) also reported improved soil physical quality attributes with crop residues left over the agricultural fields. Additionally, incorporation of woody legumes into the soil decreases bulk density and rises soil granulation and total porosity (Chikowo *et al*., 2004). Several previous researchers reported significant positive correlations between organic matter and aggregate stability (Hati *et al*., 2007; Candemir and Gulser, 2010). Gulser (2006) Bandyopadhyay *et al*. (2010) also indicated that treatment of green manures to soil bring about a rise in size and number of water stable aggregates. Murphy *et al*. (1993) reported that improvement in infiltration and soil hydraulic conductivity by modifying soil structure, macropores and aggregate stability.

In the present study, the increase in soil structural properties, total porosity and mean weight diameter of water stable aggregates may be associated with promoting the biological activity because of addition of cover crops upon decomposition by soil microorganisms. The quantity of basal soil respiration is an indicator of nutrients included in soil organic matter being converted to forms available to crops (*e.g.*, sulfate as SO_4, nitrate-nitrogen as NO_3, and phosphate as PO_4). Soil health and long term soil respiration improve with increased soil organic matter. Kladivko (2001) reported that soil microbial communities are liable for a large range of ecological services and soil functions, like nutrient cycling, organic matter turnover, and soil structure maintenance. Significant correlations between organic matter and soil physical properties were observed in this study, which indicated that may be related to soil organic matter deposition and loosening of soil by root action (Lampurlanés and Cantero-Martinez, 2003).

As compared to bare control treatment, cover crop treatments generally increased mean yield levels in apricot orchard. These results are supported by the other studies (Reddy, 2003; Harrington *et al*., 2005). Crop yields primarily depend on organic matter contents of soils (Mann *et al*., 2002). Organic matter directly improves physico-chemical and biological quality attributes of the soils, thus improves yield levels (Franzluebbers, 2002). However, the amount of increase in crop yield depends upon crops grown. Furthermore, management of cover crops also have effects on yield increases (Chalk, 1998).

Conclusion

This study showed that cover crops in both years of the experiment generally improved some soil quality attributes at 0–20 cm soil depth. Increasing organic matter contents also improved soil quality. Higher organic matter contents were observed in VV and VP treatments. Cover crop treatments generally had positive effects on soil quality parameters. Cover crop-induced increases in organic matter contents resulted in increasing total porosity, saturated hydraulic conductivity, total N and K contents and decreasing bulk density, pH and Na content. The greatest positive effects of cover crop treatments were observed in VV and VP treatments. In both years of the experiment, there were not any significant differences in the soil quality parameters at 0–20 cm soil depth of HC, MC and BC treatments. In both years, cover crop treatments increased fruit weight in apricot orchards according to the bare control. While the highest mean fruit weight (34.4 g) were found in the VPT treatment, the lowest mean fruit weight (31.2 g) were obtained with in the BC treatment. Based on the findings of this study, it was concluded that soil management in orchards can be integrated with cover crops to enhance soil quality, which can lead to sustainable soil management. Furthermore, cover crops could enhance soil, water, and environmental quality.

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