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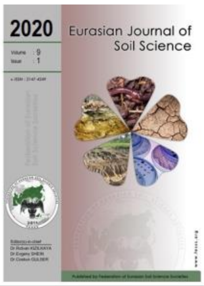

The evaluation of basal respiration and some chemical properties of soils under cover crop treatments in a cherry orchard

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Abstract

Effects of different cover crops (CCs), mechanical cultivation and herbicide treatments on some soil chemical properties [pH, EC, total N, available P, exchangeable cations (Ca, Mg, K, Na) and the DTPA-extractable micronutrients (Fe, Mn, Zn, Cu)] and basal soil respiration (BSR) were investigated in a cherry orchard from 2013 to 2014. The present study was conducted in a cherry orchard located at the Experiment Station of Black Sea Agricultural Research Institute in Samsun province on the Northern side of Turkey. CC treatments, included *Trifolium repens* L. (TR), *Festuca rubra subsp. Rubra* (FRR), *Festuca arundinacea* (FA), *T. repens* (40%)+*F. rubra rubra* (30%)+*F. arundinacea* (30%) mixture (TFF), *Vicia villosa* (VV) and *Trifolium meneghinianum* (TM). Control treatments included mechanical cultivated (weed-free), herbicide treated (weed-free) and control plots, i.e., bare ground plots (with no cover crop) were allowed to become weedy. The experiment was conducted in a randomized complete block design with four replicates. The CCs were mowed in the flowering stages of the plants. After 90 days following seed harvest, soil samples were collected from two depths (0-20 and 20-40 cm) in each plot. All cropping species showed positive effects on soil chemical properties and BSR. The CC treatments decreased soil pH and exchangeable Na and increased EC, total N, available P, exchangeable cations (Ca, Mg, K) and the DTPA-extractable micronutrients (Fe, Mn, Zn). Effects of mechanical cultivation and herbicide treatments on soil chemical properties and BSR values were not found significant for both soil depths as compared to control ($p<0.01$). Results of the study showed that CCs, especially TR and VV treatments as legume plants improved soil chemical properties and BSR values in short term period. However, longer term studies are needed to evaluate the long-term effects of these sustainable management practices which have the potential to improve soil quality variables are encouraged.

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Introduction

Turkey is a unique country in the world where several types of fruit can be cultivated under good conditions and with superior quality owing to vast, fertile agricultural fields suitable for production and with the help of the ecological diversity in various regions (Erogul, 2018). Turkey has a considerable share in fruit production, which is like apple, orange, banana, carob, loquat and cherry are the most prominent fruits regarding their share in Turkey's production. Cherry is an significant agriculture product which is generally produced and exported. For regional rural development one of the most significant sectors is agricultural production in Turkey. Recently in agriculture sector another activity is orchard production which increasing areas and economic importance (Doğanay, 1998). Among major countries producing cherry in the world, in our country ranks the first both in the northern hemisphere and in the world with 599.650 tons of

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production in 2017, corresponding to 20.3% of world cherry production (FAOSTAT, 2017). Cherry fruit cultivation is carried out in an area of 847.461 da in Turkey (TURKSTAT, 2018). The U.S. with 288.480 tons of production and 13.8% share and Iran with 220.393 tons of production and 11.8% follow it. Turkey is leader country in terms of volume of cherry production in the World (FAOSTAT, 2017). Cherry production is an significant production activity for the Turkish Economy (Bal and Cercinli, 2013).

Cover crops (CCs) is defined as crops that provides soil protection, seedling protection, and soil improvement between vines in vineyards and trees in orchards between periods of normal crop production, or between periods of normal crop production (SSSA, 2001). Cover crop management systems affect soil quality variables (Demir and Gülser, 2015; Çerçioğlu et al., 2019) and health and thereby orchards growth and productivity. CCs also are precisely grown to prevent loss of nutrients in deep layers through surface runoff and leaching (Kaye and Quemada, 2017). The CCs can be used as legume or non-legume. Leguminous crops are used to fix atmospheric nitrogen (N) which is used by succeeding crop (Blanco-Canqui et al., 2011). N fixation by leguminous helps to decrease the use of N fertilizers for next crop (Ladha et al., 2004). Genelrally, the legumes and non-legume crops are the plants that are grown to provide soil cover and help to enhance chemical, biological and physical characteristics of the soil (Reddy, 2016). A bicultural of leguminous and non-leguminous may be used with the purpose to provide both benefits together (Ranells and Wagger, 1996). The CCs provide some benefits to soils used for agriculture production. CCs primarily effect soil nutrient dynamics and balance by scavenging nutrients, fixing atmospheric N_2, decreasing nutrient erosion and decreasing nutrient leaching. Including CCs in intensively managed agroecosystems could thus effect nutrient recovery, accumulation, cycling and storage. In addition, the CCs can be utilized to manage N in agricultural soils by altering N cycling and availability. The CCs grown during fallow periods in cropping systems change the annual patterns of N uptake and mineralization. The CCs also impact soil N availability by increasing total N through prevention of N losses or additions of fixed N. The CCs that are grown during fallow periods in cropping systems to take up nutrients, especially N, that would be lost if plants are not present. Ultimately, successful management of N using the CCs requires that N availability be synchronized. Various aspects of the relationship between the CCs and total N have been discussed in a number of previous studies (Thorup-Kristensen et al., 2003; Demir et al., 2019a; Demir and Işık, 2019a).

Additionally, the CCs are helpful in sustaining and increasing microbial biodiversity in soils. The CCs that biologically fix atmospheric N can provide a source of orchard tree nutrition. Many crops are excellent nutrient scavengers and can aid in the recycling of orchard nutrients and prevention of runoff and groundwater losses, particularly of N (Delgado et al., 2007). In recent times, the CCs are also used for increasing exchangeable nutrients such as K^+ and Mg^{2+}. Lal et al. (1991) found that following factors effect soil fertility when the CCs are grown in the rotation cycle: cover crop species, quantity of biomass produced by cover crop, length and time of cover crop growth, and soil and weather conditions. Aside from the various benefits or effects of the CCs on soil discussed above, very little is known about the affect of the CCs on soil micronutrients and exchangeable cations. The amount of exchangeable cations (Ca, Mg, K and Na) are important attributes of soils and sediments for different processes.

Herbicide treatment and mechanical cultivation are significant among the current weed control practices in orchards. Using CCs for weed control in orchards is one of the broadly applied alternative methods to the mechanically cultivation and herbicide treatment (Mennan et al., 2009; Işık et al., 2009). Herbicide and mechanical cultivation are expected to provide weed-free orchards. However, coverless (bare) fields can bring about increased run-off and erosion, damage the soil chemical and physical properties (Keesstra et al., 2016). In this study, effects of different cover crops, mechanically cultivation and herbicide treatments on some chemical properties and basal respiration of soil were investigated in a cherry orchard (Latitude, 41°22′93″ N; Longitude, 36°50′19″ E) in Samsun province on the Northern side of Turkey between 2013 and 2014.

Material and Methods

Experimental site and treatments

The study was conducted in a cherry orchard at the Experiment Station of Black Sea Agricultural Research Institute in Samsun province (Latitude, 41° 22′ 93″ N; Longitude, 36° 50′ 19″ E) on the Northern side of Turkey from 2013 to 2014. The location of the orchard was in the Middle Black Sea region. Annual average precipitation was 685.5 mm and annual average temperature was 14.5 °C. There was 1 m spacing between the plots and 3 m between the blocks. Each plot had a size of 35 m^2 (5 × 7 m). Experiments were conducted in randomized complete blocks design with four replications.

The cover crop (CC) treatments consisted of *Trifolium repens* L. (TR), *Festuca rubra rubra* L. (FRR), *Festuca arundinacea* (FA), *Trifolium repens* (40%) + *Festuca rubra rubra* (30%) + *Festuca arundinacea* (30%) mixture (TFF), *Vicia villosa* (VV) and *Trifolium meneghinianum* (TM). *Vicia villosa* and *Trifolium meneghinianum* were used annual legume plants and *Trifolium repens* L. were used perennial legume plants. *Festuca rubra rubra* L. and *Festuca arundinacea* are perennial grass cover plants. Control treatments included mechanical cultivated (weed-free), herbicide treated (weed-free) and control plots, i.e., bare ground plots (with no cover crop) were allowed to become weedy. *Trifolium meneghinianum* seeds were supplied from Black Sea Agricultural Research Institute and the others were purchased from private seed companies. During the experiment, the CCs were continued to be applied in the same plots and no fertilizers were applied. Consecutive plots were separated with a buffer zone without any cover crops. Before the plantation of the CCs, existing weeds were manually or mechanically removed. Irrigation was performed twice (one in July and the other in August). CCs were planted through broadcast seeding at 50, 80 and 70 kg·ha^{-1} for *T. repens, Festuca* spp. and mixture of perennials respectively in April 2012. *V. villosa* (100 kg ha^{-1}) and *T. meneghinianum* (40 kg ha^{-1}) were sown in October 2012 and November 2013. Following the sowing, seeds were incorporated into the soil by shallow cultivation. Primary tillage was performed through chisel plow and disk harrow. The CCs were mowed at the flowering stages of the plants. Mowing was performed carried out with a motorized back-scythe. Following mowing, incorporation of the CCs into the soil was done by disking. While mowing of the CCs was performed on 23 June 2013 during the flowering stage in the first year, it was performed on 26 June 2014. A rotary hoeing machine was used for mechanical weed control. In the herbicide control plots, the glyphosate isopropylamine salt (360 g a.i L^{-1}) was implemented at a dose of 2880 ml ha^{-1} (1.39 kg a.i ha^{-1}). Glyphosate was implemented at 3 atm pressure (303.97 kPa) and 250 L ha^{-1} spraying volume with a portable hand sprayer (Honda WJR 2225).

Soil sampling and analyses

Soil samples were collected from 0–20 and 20-40 cm depths in each plot using a corkscrew-shaped soil drill 90 days after harvest period. Samples were sieved through 2 mm sieve and prepared for soil analyses. Initial soil properties were given in Table 1.

Table 1. Soil physico-chemical characteristics of the experiment

Parameters	Soil depth (cm)	
	0-20	20-40
Texture class	C	C
Clay, %	61.28	54.04
Silt, %	21.37	30.86
Sand, %	17.35	15.10
Organic carbon (OC), %	1.05	0.74
pH (1:1)	7.11	7.28
EC25°C, mmhos cm^{-1}	0.81	0.67
Ca, me 100g^{-1}	29.1	25.2
Mg, me 100g^{-1}	10.32	8.41
K, me 100g^{-1}	1.09	0.85
Na, me 100 g^{-1}	0.17	0.15

Particle size distribution was identified by using Bouyoucos hydrometer method (Bouyoucos, 1962). Soil reaction (pH) was measured by using a pH meter with glass electrode in a 1:1 (w:v) ratio soil-water suspension (Jackson, 1958). Electrical conductivity ($EC_{25ºC}$) was measured with an EC meter in a 1:1 (w:v) ratio soil-water suspension (Richards, 1954). Basal soil respiration (BSR) at field capacity (CO_2 production at 22°C without addition of glucose) was measured, as reported by Aşkın and Kızılkaya (2009); by alkali ($Ba(OH)_2.8H_2O + BaCl_2$) absorption of the CO_2 produced during the 24h incubation period, followed by titration of the residual OH^- with standardized hydrochloric acid, after adding three drops of phenolphthalein as an indicator. Data are expressed as µg CO_2 g^{-1} dry soil. Exchangeable cations (Ca, Mg, K, Na) were identified with the 1N ammonium acetate (NH_4OAc) extraction (Rowell, 1996). Soil organic carbon was identified by the modified Walkley-Black method (Black, 1965). Available P contents were determined through extraction with 0.5 M $NaHCO_3$ at pH 8.5 by Olsen's method (Olsen et al., 1954). Total N was identified by the LECO model (with a Tru-Spec CHN elemental analyzer). Micronutrients were identified by the extraction with DTPA extraction solution according to Kacar (1994).

Statistical analysis

Analysis of variance (ANOVA) was performed to evaluate experimental data using SPSS statistical package. Statistical disfferences were evaluated using Duncan's multiple range test at 0.01 and 0.05 alpha probability levels. Correlation analyses were performed to express the relationships between experimental parameters (Yurtsever, 2011).

Results and Discussion

Soil reaction (pH) and electrical conductivity ($EC_{25°C}$)

The pH of the soil is a determining factor of soil fertility greatly influenced by the crop residues incorporated in the soil. The simplest and most important factor in all growing systems is to maintain optimal soil pH levels. The pH level of soil influences microbial activity, nutrient solubility and root growth. Soil pH values were significantly affected by CC management in both years of the experiment ($p<0.01$). The CC treatments significantly reduced pH from 7.48 in control plot to 6.92 for VV treatment at the 0-20 cm soil depth in 2013 (Table 2). Soil pH significantly decreased from 7.46 in the control plot to 6.90 in TR treatment at 0-20 cm soil depth in 2014. Gülser (2004) found that values of soil pH importantly reduced with the cropping applications and percent decreases in pH compared the control soil were between 5.96% for crownvetch and 0.31% for bromegrass treatment. Similarly, cover cropping significantly reduced soil pH (Demir and Işık 2019b; Demir and Işık 2019c; Demir et al., 2019b), due to the acidic root exudates, and this may alter nutrient availability at the root surface (Rengel and Marschner, 2005). Such decreases were mainly because of CO_2 release into the soil ambient, decomposition of organic amendments and conversion of these organic amendments into carbonic acid (H_2CO_3) through reactions with water. Besides, when the organic matter is mineralized there is a production of organic acids that could raise the soil acidity (Garcia and Rosolem, 2010). In present study, when compared to the control plot, percent decreases in soil pH values between -3.3% in FRR treatment and -7.5% in VV treatment in 2013 and between -4.8% in TM treatment and -7.6% in TR treatments in 2014. The differences in soil pH values were not found to be statistically significant for the 20-40 cm soil depth in both years of the experiment (Table 3). The mean pH values for 20-40 cm soil depth were 7.46 in 2013 and 7.51 in 2014.

The CC treatments increased soil $EC_{25°C}$ values at 0-20 cm soil depth as compared to the soil of an untreated control plot (Table 2). The highest $EC_{25°C}$ values were obtained from TR treatment 1.185 ds m^{-1} in 2013 and 1.186 ds m^{-1} in 2014. $EC_{25°C}$ values significantly increased from 0.689 ds m^{-1} in the control to 1.186 ds m^{-1} in TR treatment at 0-20 cm soil depth at the end of the experiment. $EC_{25°C}$ has been used successfully as an indirect indicator of significant soil quality variables, such as soil salinity hazard (Demir and Gülser, 2015), soil water content (Khakural et al., 1998), topsoil thickness (Kitchen et al., 1999), clay pan thickness (Doolittle et al., 1994), nutrient levels (Heiniger et al., 2003) and depth of sand deposition (Kitchen et al., 1996). The soil EC is also a significant indicator of dissolved nutrients and can be used to monitor mineralization (Candemir and Gülser, 2010). The findings of this research suggest that soil EC may serve as a useful indicator of available N in soil as suggested by Gajda et al. (2000). Three potential pathways of EC exist in soil: through the liquid phase (via salts contained in soil water), through the solid phase (soil particles in direct and continuous contact with one another), and through the liquid-solid phase (primarily via the exchangeable cations associated with clay minerals) (Corwin and Lesch, 2003). Therefore, many soil attributes affect EC in soil (Sudduth et al., 2003). In this study, EC values significantly increased with the cropping treatments and percent increases in $EC_{25°C}$ over the control soil were between 37.7% in FRR and 69.9% in TR treatments in 2013 and between 41.0% in FA and 72.1% in TR treatments in 2014. Gülser (2004) reported that highest percent change in $EC_{25°C}$ values over the control plots was determined as 124.6% for alfalfa treatment while lowest percent increase in $EC_{25°C}$ values was 15.97% for bromegrass treatment. Eigenberg et al. (2002) determined that EC was effective in determining the dynamic changes in plant available soil N throughout the growing season of crops, i.e. over a range of soil water conditions. Zhang and Wienhold (2002) reported very strong correlation between EC and soil N in the upper 15 cm. In this study, increasing total N content in the soil due to crop applications caused increased in soil EC. However, legume cover crops (*Trifolium repens* L., *Vicia villosa* and *Trifolium meneghinianum*) were found more effective non-legume (*Festuca rubra rubra* L. and *Festuca arundinacea*). The differences in $EC_{25°C}$ values were not found to be statistically significant for the 20-40 cm soil depth in both years of experiments (Table 4). $EC_{25°C}$ values ranged from 0.624 ds m^{-1} in control treatment to 0.711 ds m^{-1} in TR treatment for the 20-40 cm soil depth in 2013. $EC_{25°C}$ values ranged from 0.611 ds m^{-1} in HC treatment to 0.733 ds m^{-1} in VV treatment for the 20-40 cm soil depth in 2014 (Table 3).

Total N

The CC treatments increased total N at 0-20 cm soil depth as compared to the soil of an untreated control plot in both years of the experiments (Table 2). The highest total N values (0.206%) were seen at 0-20 cm in 2013 in the VV treatment while the lowest total N value (0.120%) was seen in HC treatment. Total N significantly increased from 0.121% in the control to 0.210% in VV treatment at 0-20 cm soil depth in 2014.

Table 2. Effects of the treatments on soil properties at 0-20 cm soil depth in a cherry orchard

Treatments	pH, (1:1)	EC, ds m^{-1}	Total N, %	NH$_4$OAc extractable, me 100 g^{-1}				P, mg kg^{-1}	BSR, mg CO$_2$ 100 g^{-1}	DTPA-extractable micronutrients, mg kg^{-1}			
				Ca	Mg	K	Na			Fe	Mn	Zn	Cu
2013													
TR	7.02 b	1.185 a	0.205 a	33.36 ab	6.25 a	0.36	0.13 b	19.5 a	19.4 a	23.32 a	12.41 a	1.86 a	9.81
FRR	7.23 ab	0.960 c	0.177 c	32.74 ab	5.88 ab	0.30	0.16 ab	16.4 c	14.2 c	21.86 b	9.58 b	1.52 bc	9.80
FA	7.04 b	0.962 c	0.174 c	32.34 b	5.88 ab	0.30	0.18 ab	16.2 c	14.9 c	21.62 b	10.18 b	1.56 bc	8.81
TFF	7.09 b	1.031 bc	0.191 b	33.09 ab	6.02 a	0.33	0.16 ab	17.5 b	16.2 b	21.88 b	9.96 b	1.58 b	8.94
VV	6.92 b	1.153 ab	0.206 a	34.24 a	6.31 a	0.39	0.11 b	19.3 a	19.9 a	23.13 a	12.23 a	1.80 a	8.79
TM	7.20 ab	1.005 bc	0.190 b	32.43 b	6.01 a	0.30	0.18 ab	17.8 b	16.9 b	21.84 b	9.67 b	1.61 b	9.22
HC	7.52 a	0.735 d	0.120 d	29.65 c	4.87 c	0.27	0.24 a	13.9 d	9.1 d	19.89 c	8.17 c	1.44 c	9.19
MC	7.50 a	0.742 d	0.126 d	30.46 c	5.05 bc	0.29	0.22 a	14.6 d	10.2 d	20.24 c	8.62 c	1.46 c	9.12
C	7.48 a	0.698 d	0.123 d	30.67 c	4.99 bc	0.29	0.24 a	14.5 d	9.8 d	19.89 c	8.55 c	1.44 c	9.05
2014													
TR	6.90 b	1.186 a	0.207 a	35.79 a	6.50 a	0.40 a	0.12 b	20.6 a	20.1 a	23.60 a	12.53 a	1.89 a	9.59
FRR	7.04 b	0.978 b	0.182 c	34.03 ab	5.95 c	0.32 cd	0.15 b	16.9 c	14.9 c	22.04 b	9.36 c	1.57 bc	9.12
FA	7.04 b	0.972 b	0.178 c	33.05 ab	6.11 bc	0.34 bc	0.16 b	16.9 c	16.6 c	21.87 b	9.56 bc	1.57 c	9.27
TFF	6.98 b	1.046 b	0.192 b	32.48 ab	6.44 ab	0.37 ab	0.16 b	18.0 b	17.1 b	22.11 b	10.15 b	1.61 bc	9.55
VV	6.94 b	1.154 a	0.210 a	36.03 a	6.66 a	0.42 a	0.12 b	20.5 a	20.5 a	23.50 a	12.19 a	1.86 a	9.11
TM	7.10 b	1.031 b	0.194 b	33.67 ab	6.39 ab	0.31 cd	0.16 b	18.8 b	17.2 b	22.14 b	10.09 b	1.67 b	8.93
HC	7.50 a	0.722 c	0.123 d	30.93 b	5.03 d	0.27 d	0.25 a	13.9 d	8.9 d	19.56 c	8.34 d	1.41 d	9.17
MC	7.53 a	0.756 c	0.130 d	31.48 b	5.10 d	0.29 d	0.24 a	14.7 d	10.9 d	20.28 c	8.43 d	1.39 d	9.08
C	7.46 a	0.689 c	0.121 d	31.23 b	5.13 d	0.28 d	0.24 a	14.4 d	9.1 d	19.65 c	8.20 d	1.39 d	8.99

TR: *Trifolium repens* L., FRR: *Festuca rubra* subsp. *rubra*, FA: *Festuca arundinacea*, TFF: *T. repens* (40%) + *F. rubra rubra* (30%) + *F. arundinacea* (30%) mixture, VV: *Vicia villosa*, TM: *Trifolium meneghinianum*, MC: Mechanically cultivated, HC: Herbicide treatment, C: Control. pH: Soil reaction, EC: Electrical conductivity, Total N: Total Nitrogen, Ca: Exchangeable calcium, Mg: Exchangeable magnesium, K: Exchangeable potassium, Na: Exchangeable sodium, P: Available phosphorus, BSR: Basal soil respiration. Fe: Iron, Mn: Manganese, Zn: Zinc, Cu: Cupper.

Table 3. Effects of the treatments on soil properties at 20-40 cm soil depth in a cherry orchard

Treatments	pH, (1:1)	EC, ds m^{-1}	Total N, %	NH_4OAc extractable, me 100 g^{-1}				P, mg kg^{-1}	BSR, mg CO_2 100 g^{-1}	DTPA-extractable micronutrients, mg kg^{-1}			
				Ca	Mg	K	Na			Fe	Mn	Zn	Cu
2013													
TR	7.48	0.711	0.113	30.2	5.05	0.23	0.21	13.50	6.34	18.64	8.17	1.07	6.99
FRR	7.43	0.641	0.110	30.5	4.73	0.21	0.22	12.44	5.25	18.35	8.38	1.13	6.34
FA	7.55	0.668	0.108	31.7	4.96	0.26	0.21	13.07	6.33	17.87	9.33	1.01	6.12
TFF	7.55	0.703	0.112	29.4	5.85	0.25	0.23	13.75	5.25	17.64	8.35	1.17	5.88
VV	7.43	0.695	0.108	31.6	5.04	0.25	0.21	13.48	6.57	18.31	6.69	1.10	6.59
TM	7.42	0.668	0.105	31.4	5.52	0.22	0.23	12.84	5.53	18.36	6.74	1.07	6.14
HC	7.43	0.633	0.106	30.4	4.33	0.27	0.22	13.11	5.48	19.00	8.15	1.12	7.07
MC	7.48	0.691	0.113	30.9	4.37	0.26	0.20	13.14	5.43	18.60	7.55	1.09	6.15
C	7.41	0.624	0.107	29.4	4.39	0.27	0.19	12.78	5.65	17.49	7.65	0.91	6.26
2014													
TR	7.58	0.689	0.112	29.6	4.14	0.21	0.20	13.92	6.69	18.69	7.88	1.11	6.47
FRR	7.41	0.687	0.106	30.7	4.59	0.28	0.22	12.79	5.89	17.76	7.26	1.09	7.14
FA	7.49	0.723	0.109	28.7	5.00	0.22	0.20	12.97	5.94	17.59	8.00	1.08	6.58
TFF	7.57	0.620	0.107	31.0	4.07	0.29	0.21	13.21	5.96	18.99	6.74	1.08	6.21
VV	7.45	0.733	0.114	30.4	5.48	0.20	0.23	13.95	6.45	18.64	8.41	1.12	7.52
TM	7.53	0.698	0.108	29.2	5.00	0.28	0.23	12.42	6.11	17.99	8.14	1.17	7.89
HC	7.52	0.611	0.109	30.2	5.02	0.26	0.20	12.23	5.97	18.13	6.56	1.09	5.97
MC	7.54	0.722	0.105	30.1	5.25	0.20	0.22	13.20	6.10	19.00	8.12	1.06	6.50
C	7.47	0.631	0.105	29.4	4.81	0.25	0.21	13.65	5.82	17.99	7.58	1.15	6.57

TR: *Trifolium repens* L., FRR: *Festuca rubra* subsp. *rubra*, FA: *Festuca arundinacea*, TFF: *T. repens* (40%) + *F. rubra rubra* (30%) + *F. arundinacea* (30%) mixture, VV: *Vicia villosa*, TM: *Trifolium meneghinianum*, MC: Mechanically cultivated, HC: Herbicide treatment, C: Control. pH: Soil reaction, EC: Electrical conductivity, Total N: Total Nitrogen, Ca: Exchangeable calcium, Mg: Exchangeable magnesium, K: Exchangeable potassium, Na: Exchangeable sodium, P: Available phosphorus, BSR: Basal soil respiration. Fe: Iron, Mn: Manganese, Zn: Zinc, Cu: Cupper.

The results of this study showed that the CCs can be used to manage N in agricultural soils by altering N cycling and availability. The affects of CCs on soil nutrients, especially N, have been previously investigated (Dabney et al., 2010; Kaspar and Singer, 2011; Blanco-Canqui et al., 2011). Dabney et al. (2010) investigated this subject for four regions in the United States. The researchers found that significant total N can be derived from cover crops. Blanco-Canqui et al. (2011) reported that, after four rotation cycles, total N increased by 279 kg ha^{-1} under sunn hemp and by 258 kg ha^{-1} under late-maturing soybean compared with non-CCs plots when both leguminous CCs were planted after each winter wheat harvest in a winter wheat-grain sorghum rotation in eastern Kansas. Others also reported high total N contributions from legume CCs (Mansoer et al., 1997). Ramos et al. (2011) reported in a previous study that two cover crop (oat-vetch-*Vicia sativa* L. and oat-*Avena sativa* L.) treatments increased total N (32.5%) according to control. Similarly, greater N accumulation by hairy vetch compared to non-legume CCs like cereal rye, austrian winter pea (*Lathryrus hirsutus* L.), annual ryegrass (*Lolium multiflorum* Lam. cv. *Billion*), canola (*Brassica napus* L. cv. *Santana*), and no CC treatments was also reported by Kuo et al. (1997). Previous studies have found that legume crops have greater total N content due to their higher N concentration (Shipley et al., 1992). In this study, the CC treatments increased total N supply through improving the availability of residual N and through N_2 fixation with legume crops. The legume crops can have great effects on soil N. Gülser (2004) found that present increases in the total N over the control were between 8.85% for the crownvetch and 36.46% for the alfalfa application. Harris et al. (1994) determined that CCs impacted soil N availability by increasing total N through additions of fixed N or prevention of N losses. Reeves (1994) found that growing CC treatments contributed 36 to 226 kg N ha^{-1} by legumes and 25 to 50 kg N ha^{-1} by small grains. Similar results were found at by Kuo et al. (1997), who determined that leguminous CC treatments provide important quantities of total N. In this study, percent increases in the total N over the control soil varied between 41.4-66.9% in 2013 and 47.1-72.8% in 2014. Hoagland et al (2008) reported that a cover of mixed leguminous established in an cherry orchard raised the total N, potentially available N and soil biological activity for trees over a two-year period. Ingels et al. (1994) found that winter legumes can add 112-224 kg N ha^{-1} and cowpea and other summer legumes can contribute 112-145 kg N ha^{-1} to the soil nitrogen pool. Ladha and Peoples (1994) reported inputs of N from N fixation between 124-185 kg ha^{-1} for crimson clover, and 9-201 kg ha^{-1} for cowpea. Wagger (1989) reported crimson clover N fixation of 100-150 kg ha^{-1}, and Odhiambo and Bomke (2000) concluded that crimson clover could provide the rapid release of enough N to sustain the growth of crops. Present findings of total N well comply with the findings of those earlier studies. However, the differences in total N values were not found to be statistically significant for the 20-40 cm soil depth in both years of experiments (Table 3). Mean total N values at 20-40 cm soil depth varied between 0.105-0.129% with a mean value of 0.109%.

Basal soil respiration (BSR)

In both years of the experiment, the basal soil respiration (BSR) importantly increased with the CC treatments ($p<0.01$). In 2013, BSR values was the lowest (9.10 mg CO_2 100 g^{-1}) in the herbicide treatment followed by HC < C < MC < FRR < FA < TFF < TM < TR < VV treatments. The highest BSR values (26.48 mg CO_2 100 g^{-1}) were seen at 0-20 cm in 2014 in the VV treatment while the lowest BSR value (8.89 mg CO_2 100 g^{-1}) was seen in HC treatment (Table 2). CCs increase the potential for macro- and microfaunal activity in soils because they increase the total inputs of organic material to soils (Kaspar and Singer, 2011; Demir, 2019). CCs also are broadly growing strategy to improve soil microbial growth in agricultural systems. The soil microbial activity reflects the soil's ability to store and cycle nutrients. Crop residues are also known to enhance N fixation in soil by asymbiotic bacteria. Conventional tillage (Canadian Environmental Protection Act, 1993) and no-tillage system with a ryegrass cover crop in cotton (*Gossipium hirsutum* L.) was investigated for the microbial count in soil. Ryegrass cover crop in conventional tillage and no-tillage system maintained a higher microbial population in the upper layer compare to no-cover plots (Sharma et al., 2018a). Demir et al (2019a) found that highest basal soil respiration values (41.5 mg CO_2 100 g^{-1}) was obtained in the *Vicia villosa* Roth treatment while the lowest BSR values (12.5 mg CO_2 100 g^{-1}) was in the control in the apricot orchard with a clay textured. Reddy et al. (2003) found that after 3 yr with crimson clover or cereal rye CCs soil had greater microfaunal activity than the soil without a cover crop. In their research, the crimson clover cover crop had a greater stimulatory affect on soil biology than cereal rye. The researchers speculated that the leguminous CCs had more readily available amino acids and carbohydrates than the grass CCs due to a lower C to N ratio. In this study, the greatest increase in BSR values was obtained in VV treatment (164.9%) and the least increase was observed in MC treatment (4.0%) in 2013. As compared to control, percent increases in BSR values between 19.4% in MC treatment and 190.3% in VV treatment in 2014. Lundquist et al. (1999) found on the short-term (42-d) effects of cereal rye incorporation in contrasting vegetable management systems. Their findings illustrated that following rye incorporation, counts of active bacteria increased 24 to 52% in the first 7 d and populations of bacterial-feeding nematodes increased 400 to 600% between 7 and 14 d. Active fungal hyphal lengths and fungal-feeding nematodes were less responsive to rye incorporation during the 42-d period. In this study, legume cover crops (*Trifolium repens* L., *Vicia villosa* and *Trifolium meneghinianum*) treatments were found mostly more effective non-legume (*Festuca rubra rubra* L. and *Festuca arundinacea*) treatments. CC treatments enhance nutrient utilization when the species have root systems that are able to extract and mobilize nutrients from deeper layers and the leguminous may add nutrients to the soil by biological fixation (USDA, 1996). Therefore, in this study, the improvements in soil properties were more pronounced with legume and grass cover crops mixture (*T. repens* (40%) + *F. rubra rubra* (30%) + *F. arundinacea* (30%)) than with grass cover (*Festuca rubra* subsp. *rubra* and *Festuca arundinacea*) treatments. Availability of nutrients like N and P is especially dependent upon soil microbial activity and microbial biomass, which in turn depend on the supply of organic substrates in soil. The population of soil flora and fauna is positively correlated with the phyto-biomass present in soil. Beri et al. (1992) and Sindu et al. (1995) obtained that soil applicated with crop residues held 5-10 times more aerobic bacteria and 1.5-11 times more fungi than soil were either burn or removed. The study of Verhulst et al. (2011) reveled that, soil microbial activity increased with increasing amount of crop residues retained on the soil surface in the zero till treatments. Present findings of basal soil respiration well comply with the findings of those earlier studies. However, the differences in the BSR values were not found to be statistically significant for the 20-40 cm soil depth in both years of experiments (Table 3). The mean BSR values for 20-40 cm soil depth were 5.76 mg CO_2 100 g^{-1} in 2013 and 6.10 mg CO_2 100 g^{-1} in 2014.

Available P

The CC treatments significantly increased available P at 0-20 cm soil depth as compared to the soil of an untreated control plot in both years of experiments ($p<0.01$). In 2013, available P value was the lowest (13.9 mg kg^{-1}) in the herbicide treatment followed by HC< C< MC <FA < FRR < TFF < TM < VV < TR treatments (Table 2). Available P significantly increased from 14.4 mg kg^{-1} in the control to 20.6 mg kg^{-1} in TR treatment at 0-20 cm soil depth in 2014. In a study conducted on loamy sand soil by Beri et al. (1995), it has been seen that the incorporation of cover crops as increased the available P and K content. Gupta et al. (2007) reported from the 3 year study that P consantrations in soil increased with the incorporation of cover crops. Some research has been conducted using cover crops within orchard tree rows for potential nutrient contribution (Atucha et al., 2011; Mays et al., 2014). The potential benefits of cover crops use in annual cropping systems have been supported by many studies (Parr et al., 2011). Labarta et al. (2002) reported that available P values was higher for legume cover crops than for grass cover crops, probably due to higher P requirements for legumes due to the mechanisms involved in nitrogen fixation. In this study, available P values significantly increased with the cropping applications and percent increases in available P over the control soil were between 11.9% in FA and 35.2% in TR treatments in 2013 and between 17.5% in FRR and 43.2% in TR treatments in 2014. However, the differences in available P were not found to be statistically significant for the 20-40 cm soil depth in both years of experiments (Table 3). Available P values at 20-40 cm soil depth varied between 12.44-13.75 ppm with a mean value of 13.12 ppm in 2013 and between 12.23-13.95 ppm with a mean value of 13.15 ppm in 2014.

Exchangeable cations (Ca, Mg, K, Na)

In this study, it was found that whereas the CC treatments significantly increased the Ca, Mg and K, it reduced the Na in the soil (Table 2). The CC treatments significantly increased extractable K at 0-20 cm soil depth as compared to the soil of an untreated control plot ($p<0.01$). In addition, significantly higher exchangeable K was obtained in 2014 than in 2013. While the exchangeable K contents varied between 0.27 me 100 g^{-1} in HC treatment and 0.42 me 100 g^{-1} in VV treatment. Percent increases in the extractable K over the control soil varied between 3.4–34.5% in 2013 and 9.5–49.4% in 2014. Aside from the diverse benefits or effects of cover crops on soil, very little is known about the effect of CCs on exchangeable cations and micronutrients of soils (Sharma et al., 2018a). The amount of exchangeable Ca, Mg, K and Na are vital attribute of soils. They relate information on soils' abilities to sustain plant growth, retain nutrients, sequester toxic heavy metals, or buffer acid deposition. Sharma et al. (2018b) obtained accumulation of K at the surface due to deposition of crop residue and lack of incorporation. Eckert (1991) found that the accumulation of exchangeable K at the surface soil was improved by inclusion of rye cover crop. Sharma et al. (2018a) determined that incorporating cover crops in no-tillage seed soybean or maize cropping systems might help in maintaining the exchangeable Mg content better than no cover crop application.

Table 4. Correlation matrix among the soil properties in the 0-20 cm soil depth at the end of the experiment

	EC	Total N	BSR	P	Ca	Mg	K	Na	Ext. Fe	Ext. Mn	Ext. Zn	Ext. Cu
pH	-0.840**	-0.777**	-0.760**	-0.725**	-0.585**	-0.747**	-0.694**	0.964**	-0.653**	-0.675**	-0.681**	0.353*
EC		0.933**	0.941**	0.922**	0.811**	0.905**	0.836**	-0.855**	0.877**	0.883**	0.896**	-0.031
Total N			0.978**	0.948**	0.917**	0.980**	0.789**	-0.775**	0.939**	0.864**	0.906**	0.085
BSR				0.972**	0.919**	0.970**	0.848**	-0.781**	0.956**	0.922**	0.841**	0.073
P					0.895**	0.955**	0.841**	-0.763**	0.959**	0.965**	0.882**	0.054
Ca						0.924**	0.801**	-0.591**	0.929**	0.835**	0.865**	0.137
Mg							0.810**	-0.737**	0.947**	0.871**	0.911**	0.067
K								-0.686**	0.829**	0.876**	0.847**	0.015
Na									-0.674**	-0.725**	-0.727**	0.371*
Ext. Fe										0.923**	0.953**	0.171
Ext. Mn											0.988**	0.094
Ext. Zn												0.100

**correlation is significant at 0.01 level, *correlation is significant at 0.05 level.

pH: Soil reaction, EC: Electrical conductivity, Total N: Total Nitrogen, Ca: Exchangeable calcium, Mg: Exchangeable magnesium, K: Exchangeable potassium, Na: Exchangeable sodium, P: Available phosphorus, BSR: Basal soil respiration. Fe: Iron, Mn: Manganese, Zn: Zinc, Cu: Cupper.

Table 5. Correlation matrix among the soil properties in the 20-40 cm soil depth at the end of the experiment

	EC	Total N	BSR	P	Ca	Mg	K	Na	Ext. Fe	Ext. Mn	Ext. Zn	Ext. Cu
pH	-0.249	-0.065	-0.129	-0.092	-0.076	-0.156	-0.125	0.288*	-0.189	0.091	-0.275	0.145
EC		0.216*	0.379**	0.309*	-0.235*	0.254*	0.256	-0.264*	0.124	0.215	0.069	0.044
Total N			0.347**	0.125	-0.312	-0.024	0.189	0.109	0.301*	0.157	0.004	-0.118
BSR				-0.009	0.290	0.256*	0.274	-0.324*	0.289*	-0.104	0.165	0.086
P					0.280*	0.237*	-0.008	0.051	0.012	0.100	0.127	0.081
Ca						0.102	-0.241*	-0.195	-0.202	-0.230	0.222	0.136
Mg							0.014	0.133	0.259	0.208	0.340*	0.076
K								0.114	0.165	0.136	0.223	0.032
Na									0.190	0.081	0.317	0.306
Ext. Fe										0.198	0.103	-0.036
Ext. Mn											0.294*	0.127
Ext. Zn												0.073

**correlation is significant at 0.01 level, *correlation is significant at 0.05 level.

pH: Soil reaction, EC: Electrical conductivity, Total N: Total Nitrogen, Ca: Exchangeable calcium, Mg: Exchangeable magnesium, K: Exchangeable potassium, Na: Exchangeable sodium, P: Available phosphorus, BSR: Basal soil respiration. Fe: Iron, Mn: Manganese, Zn: Zinc, Cu: Cupper.

This would depend on the cover crop species used, as the crop rooting depths and nutrient uptake effect the distribution and magnitude of the nutrients and micronutrients in the soil profile. The CC treatments significantly reduced exchangeable Na from 0.248 me 100 g^{-1} in control to 0.116 me 100 g^{-1} in *Trifolium repens* (TR) treatment in 2014. As compared to control, percent decreases in exchangeable Na value at the 0-20 cm soil depth in 2014 varied between 30.6% in TFF treatment and 50.4% in TR and VV treatments. Demir et al (2019a) cover crop treatments in an apricot orchard with clay soil significantly reduced exchangeable Na and pH from 0.35 me 100 g^{-1} and 7.47 for the bare control treatment to 0.20 me 100 g^{-1} for the *Vicia pannonica* Crantz treatment and to 7.02 for the *Vicia villosa* Roth and *Vicia pannonica* Crantz treatments, respectively. The differences in the exchangeable cations (Ca, Mg, K, Na) were not found to be statistically significant for the 20-40 cm soil depth in both years of experiments (Table 3). The exchangeable Ca concentrations varied between 28.7-31.7 me 100 g^{-1}, the exchangeable Mg concentrations between 4.07-5.85 me 100 g^{-1}, the exchangeable K concentrations between 0.20-0.29 me 100 g^{-1}, the exchangeable Na concentrations between 0.19-0.23 me 100 g^{-1}.

The DTPA-extractable micronutrients (Fe, Mn, Zn, Cu)

Ext. Fe concentration of the soils generally increased with the CC treatments according to the control in the cherry orchard (Table 2). Ext. Fe contents (mg kg^{-1}) in the cherry orchard in 2013 was ordered as; HC (19.87) < C (19.89) < MC (20.24) < FA (21.62) < TM (21.84) < FRR (21.86) < TFF (21.88) < VV (23.13) < TR (23.32). As compared to control, percent increases at 0-20 cm soil depth in ext. Fe content varied between 8.7% in FA and 17.3% in TR treatments. The highest ext. Fe content (23.60 mg kg^{-1}) in 2014 was obtained in the TR application while the lowest ext. Fe content (19.56 mg kg^{-1}) was in the HC treatment at 0-20 cm soil depth. As compared to control, percent increases in ext. Fe content at 0-20 cm soil depth varied between 11.3% in FA and 20.1% in TR treatments in the cherry orchard. In addition to exchangeable cations, soil micronutrients also play an significant role in plant yield and growth. Shortage of micronutrients may limit the plant growth and could even cause plant death. The importance of micronutrients to a plant's health has gotten more attention recently with increasing trends of per area basis crop yields. This trend removes very high amounts of micronutrients from the fields, and soils can not be able to compensate this loss naturally. However, cover crops may have a big effect on soil micronutrients and help in their replenishment (Sharma et al., 2018a). The differences in ext. Fe content were not found to be significant for the 20-40 cm soil depth in both years of experiments (Table 3). Ext. Fe contents ranged from 17.49 mg kg^{-1} in control plots to 19.00 mg kg^{-1} in HC treatment for the 20-40 cm soil depth in 2013. Ext. Fe contents ranged from 17.59 mg kg^{-1} in FA treatment to 19.00 mg kg^{-1} in MC treatment for the 20-40 cm soil depth in 2014.

Ext. Mn contents of the soils generally increased with the CC treatments according to the control in the cherry orchard (Table 2). The highest ext. Mn content (12.41 mg kg^{-1}) in 2013 was observed in the TR application while the lowest ext. Mn content (8.17 mg kg^{-1}) was in the HC treatment at 0-20 cm soil depth. As compared to control, percent increases in ext. Mn content at 0-20 cm soil depth in 2013 varied between 12% in FRR and 45% in TR treatments in the cherry orchard. Ext. Mn contents (mg kg^{-1}) in the cherry orchard in 2014 was ordered as; C (8.20) < HC (8.34) < MC (8.43) < FRR (9.36) < FA (9.56) < TM (10.09) < TFF (10.15) < VV (12.19) < TR (12.53) treatments. As compared to control, percent increases in ext. Mn content in 2014 varied between 14.2% in FRR and 52.8% in TR treatments in the cherry orchard. The increase might be due to decline in soil reaction and improved dissolution of Mn compounds. Similar conclusions were also determined by Sidhu and Sharma (2010) and Yadav (2011). In this study, the CC treatments caused notable changes of ext. Mn. Wei et al. (2006) studied the influence of cropping practices on soil micronutrients in China. They suggested an important correlation between cropping practices and plant available micronutrients. Their conclusions indicate that available Fe and Mn consantrations in the surface layer were higher in cropped applications compared to the control treatment. Sharma et al. (2018a) found that CCs have the potential in maintaining the optimum levels of Fe, Mn and Zn in the topsoil as compared to the control. The differences in ext. Mn content were not found to be significant for the 20-40 cm soil depth in both years of experiments (Table 3). Ext. Mn contents ranged from 6.69 mg kg^{-1} in VV treatment to 9.33 mg kg^{-1} in FA treatment for the 20-40 cm soil depth in 2013. Ext. Mn contents ranged from 6.56 mg kg^{-1} in HC treatment to 8.41 mg kg^{-1} in VV treatment for the 20-40 cm soil depth in 2014.

Ext. Zn consantrations of the soils generally increased with the CC treatments according to the control in the cherry orchard (Table 2). Ext. Zn contents (mg kg^{-1}) at 0-20 cm soil depth in 2013 was ordered as; HC (1.43) < C (1.44) < MC (1.46) < FRR (1.52) < FA (1.56) < TFF (1.58) < TM (1.61) < VV (1.80) < TR (1.86). The highest ext. Zn concentrations (1.89 mg kg^{-1}) in 2014 was observed in the TR application while the lowest Zn concentration (1.39 mg kg^{-1}) was in the control at 0-20 cm soil depth. As compared to control, percent increases in ext. Zn over the control soil were between 6.1% in FRR treatment and 29.3% in TR treatment in

2013 and between 13.6% in FRR treatment and 36.7% in TR treatment in 2014. Franzluebbers and Hons (1996) also determined increases in ext. Zn consantration in soil under CC treatments. The differences in ext. Zn content were not found to be significant for the 20-40 cm soil depth in both years of experiments (Table 3). Ext. Zn contents ranged from 0.91 mg kg^{-1} in control plots to 1.17 mg kg^{-1} in TFF treatment for the 20-40 cm soil depth in 2013. Ext. Zn contents ranged from 1.06 mg kg^{-1} in MC treatment to 1.17 mg kg^{-1} in TM treatment for the 20-40 cm soil depth in 2014.

The differences in the ext. Cu concentrations of soils in the cherry orchard were not found to be statistically significant for 0-20 cm soil depths in both years of experiments (Table 2). Ext. Cu content in 2013 varied between 8.81 mg kg^{-1} in HC treatment and 9.81 mg kg^{-1} in TR treatment. Ext. Cu content at 0-20 cm soil depth in 2014 varied between 8.99 mg kg^{-1} in control and 9.59 mg kg^{-1} in TR treatment. Mengel et al. (2001) determined that Cu is taken up by the plants in very little amounts because the Cu requirement of crop plants is relatively low. The differences in the DTPA-extractable Cu of soils in the orchard were not found to be statistically significant for 20-40 cm soil depth in both years of experiments (Table 3). The ext. Cu contents between 5.88-7.89 me 100 g^{-1}.

Relationships among the selected soil properties

Significant positive correlations were observed between total N and EC (0.933**), BSR and EC (0.941**), total N and BSR (0.978**), total N and P (0.948**), EC and P (0.922**), BSR and P (0.972**), total N and ext. Fe (0.939**), P and ext. Fe (0.959**), total N and Mg (0.980**) at the 0-20 cm soil depth in a cherry orchard (Table 4). The positive association between total N, exchangeable Mg, K, Na, and soil micronutrients (Fe, Mn and Zn) indicate an increase in exchangeable Ca, Mg, K and ext. Fe, Mn and Zn consantrations with increasing total N contents. The pH had important negative correlations with EC (-0.840**), total N (-0.777**), BSR (-0.760**), ext. Fe (-0.653**), P (-0.725**), K (-0.694**) and important negative correlations with BD (-0.954**), RS (-0.821**) and PR (-0.869**) at the 0-20 cm soil depth in a cherry orchard (Table 3). Exchangeable Na consantration had important negative correlations with EC (-0.855**), total N (-0.775**), BSR (-0.781**), P (-0.763**), Mg (-0.737**), Ca (-0.591**) and K (-0.686**) at the 0-20 cm soil depth in a cherry orchard. Ext. Cu concentrations gave the lower correlations with all properties. The soil pH and exchangeable Na concentrations decreased with increase in total N, BSR, EC, available P, exchangeable cations (Ca, Mg and K) and the DTPA-extractable micronutrients (Fe, Mn and Zn). These results indicated that other than total N, EC, available P, exchangeable cations (Ca, Mg, K and Na) and the DTPA-extractable micronutrients (Fe, Mn, Zn and Cu) were useful indicators to define soil chemical properties and BSR under different cropping treatments. Correlation matrix among the soil properties in the 20-40 cm soil depth at the end of the experiment was given in Table 5. Significant correlations were observed between EC and BSR (0.379**), between the total N and BSR (0.347**), between the BSR and Na (-0.324*), between EC and total N (0.216*).

Conclusion

The findings of this study indicated that the cover crop managements in a cherry orchard with clay textured soil have ability to contribute to sustainable agriculture production. However, benefits of using cover crops depend on the selection of species (leguminous, non-leguminous and grasses). The cover crop treatments improved the chemical properties and basal respiration of soils at 0-20 cm depth compared to the control. These treatments decreased soil pH and exchangeable Na and increased total N, EC, available P, exchangeable cations (Ca, K, Mg) and the DTPA-extractable micronutrients (Fe, Zn, Mn). Effects of mechanical cultivation and herbicide treatments on chemical properties and basal respiration of soils were not found statistically significant for the 0-20 and 20-40 cm soil depths as compared to control ($p<0.01$). The improvements in soil quality variables were more pronounced with legume and grass cover crops mixture (*T. repens* (40%) + *F. rubra rubra* (30%) + *F. arundinacea* (30%)) than with grass cover (*Festuca rubra subsp. rubra* and *Festuca arundinacea*) treatments. It is clearly known that leguminous and grass crops have positive effects on soil quality variables, but these impacts vary depending on plant species. Therefore, it is very important to select the right cover crop species to enhance the soil quality variables. Researchers needed to demonstrate with farmers for long-term integrated studies that enhancing or maintaining soil productivity with cover crop provides long-term financial benefits. As a conclusion, cover crops especially *Vicia villosa* (VV) and *Trifolium repens* (VV) could be incorporated into cropping systems to improve soil chemical properties, basal respiration and to provide sustainable soil management.

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