J. Agr. Sci. Tech. (2023) Vol. 25(3): 733-745

Effects of Different Soil Management Practices on Some Soil Properties in a Semi-Arid Region, Igdir, Turkey

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ABSTRACT

Soil conservation practices aim to improve the degraded soil properties and to sustain soil quality. Intensive agriculture with conventional tillage in Igdır Province, Turkey, has led to soil degradation (compaction, loss of soil organic matter). For this reason, it is important to use soil conservation practices (minimum tillage, zero tillage, cover crops) in the region. The aim of this study was to determine the effect of different tillage practices and cover crops cultivated after corn (*Zea mays* L.) and wheat (*Triticum aestivum* L.) on selected soil properties during 2016-2018 in Igdır. In this study, wheat and corn were used as the main crops, conventional tillage and no tillage as tillage practices, and vetch, fodder beet, and mixture of vetch-fodder beet as cover crops. In the first year of the experiment, organic matter, aggregate stability, bulk density, plant available phosphorus and soil pH values were 1.5%, 20.88%, 1.71 g cm^{-3}, 47.2 kg ha^{-1}, and 8.57, respectively. In the last year, they were determined as 1.56%, 22.30%, 1.50 g cm^{-3}, 56.4 kg ha^{-1}, and 8.47, respectively. As the result of the study, it was determined that the use of cover crops and no tillage practices led to improvements in the selected soil properties and can be important for sustainability of soil quality in arid and semi-arid regions.

Keywords: Conservation tillage, Cover crops, No-tillage, Sustainability of soil quality.

INTRODUCTION

Soils, which are the indispensable key element of agricultural production, have been exposed to extreme and unconscious applications in the last century. This has led to higher yields in the short term, but in the process of time, it has caused significant negative effects on soil health and quality including soil compaction, reduction of soil organic matter, and soil degradation (Sessiz *et al.*, 2009; Gursoy *et al.*, 2010; Lal, 2015). Degradation in soil decreases plant production (Bindraban *et al.*, 2012). This situation reveals the necessity of sustainability for agricultural lands. Different management practices have been developed to maintain soil health and quality. Conservation tillage and cover crops are among the most frequently used practices (Sharma *et al.*, 2018).

Tillage is an important agricultural practice that has continued from the past to the present and has developed with the use of different methods over time. It is carried out for such purposes as preparing a good seed bed for the next planting period, controlling weeds, and mixing plant residues on the soil surface after harvesting (Sessiz *et al.*, 2010; Pittelkow *et al.*, 2015; Henry *et al.*, 2018). However, this process also brings along negative problems such as increased mineralization of organic matter, degradation of soil structure, soil compaction caused by field traffic, loss of soil moisture in tillage depth, and accelerated wind and water erosion (Şimşek *et al.*, 2017; Ramnarine *et al.*, 2018).

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[DOI: 10.22034/jast.25.3.733]

In line with these problems caused by tillage, new tillage techniques are being developed, including conservation tillage methods, which include various methods such as zero tillage, reduced tillage and minimum tillage. The advantages of conservation tillage such as preventing compacted layer on the soil surface, maintaining soil moisture, increasing the amount of organic matter, infiltration and aggregation in the soil make it important (Gursoy *et al*., 2010; Ramnarine *et al*., 2018; Zhang *et al.*, 2018). Considering the positive aspects of conservation tillage, conservation tillage may be more effective in agricultural production sustainability.

The effects of cover crops on soil properties have been investigated for a long time (Langdale *et al*., 1991). In addition, it is one of the ongoing practices since the plants cover the soil surface or are used as fertilizer for various purposes.

Cover crops improve soil health and quality by affecting the physical, chemical, and biological properties of soils (Sharma *et al.*, 2018). The fact that soil surface is covered has advantages such as preserving and increasing soil organic matter, improving soil structure, reducing bulk density, providing nutrient storage and increasing the availability of nutrients, preventing evaporation, increasing the maintenance of soil moisture and preventing soil erosion (Bronick and Lal, 2005; Sessiz *et al.*, 2009; Carvalho *et al*., 2014; Martínez-García *et al.*, 2018).

In the meantime, the incorporation of cover crops to no-tillage practices increase the positive effects of cover crops on soil properties (Nunes *et al.*, 2018). With these positive effects, worldwide, cover crops are preferred in areas under agricultural production.

This study aimed to test the hypothesis that no-till and cover crops will improve soil properties, so, the effects of different tillage methods (no-tillage and conventional tillage) and cover crops (common vetch and fodder beet) on some soil properties were investigated.

MATERIALS AND METHODS

Study Site

The study was carried out in the research area of Igdır, University Agricultural Research and Application Center. Igdır Province has a special microclimate feature due to its low altitude and being surrounded by high mountains in the Eastern Anatolia Region of Turkey. The altitude of the plain is 850 m, summers are hot and winters are mild. The highest rainfall in the region falls in May and the lowest falls in August (Anonymous, 2018). The average relative humidity during the experimental period was 57.32% in 2016, 58.40% in 2017 and 59.78% in 2018; total precipitation in 2016, 2017 and 2018 was 290, 221 and 276 mm, respectively, the average temperature was 12.84, 12.37 and 15.26 °C respectively, the coldest month was January and the warmest

Table 1. Soil properties at the experiment site.

Soil properties	Results
Clay (%)	34.7±1.60
Silt (%)	39.8±1.30
Sand (%)	25.5±1.00
Texture	Clay loam
Organic matter (%)	1.50±0.00
Wet aggregate stability (%)	20.88± 1.09
Bulk density (g cm^{-3})	1.71±0.04
Plant available phosphorus (kg ha^{-1})	47.2±0.13
pH (1:2.5)	8.57±0.03
Electrical conductivity (µmhos cm^{-1})	472±13.00

[DOI: 10.22034/jast.25.3.733]

is July (Anonymous, 2018). Some soil properties are given in Table 1.

Şimşek *et al.* (2019) reported that the soils were calcareous alluvial material formed as a result of floods of the Aras River, and that the horizons of the soil profile included Ap (0-35 cm), AB (35-55 cm), B (55-96 cm), BC (96-170 cm). The slope of irrigated lands in the central district of Igdır was 0-2% (Karaoğlu, 2012).

Experimental Design

The study consisted of cultivation of the main crops and cover crops in conventional tillage (moldboard plow to a depth of 30 cm, spring tine harrow) and no-tillage. The cover crops were sown in the same fields after harvest of the main crops. Vetch, fodder beet, vetch and fodder beet mixtures were used as cover crops, while wheat and corn were used as the main products. In the study, corn (*Zea mays* L.) was hybrid silage corn and wheat variety was common wheat (*Triticum aestivum* L.). Common vetch (*Vicia sativa* L.) was used as vetch and fodder beet (*Beta vulgaris var.* rapacea) was used as the beet variety.

The research was planned according to randomized complete block design and consisted of 48 parcels: two main crops, two different tillage methods, three different cover crops applications with no cover crops (control, C) and three replicates (2×2×4×3). The size of each experimental plot was 6×4 m. Service blanks with a width of 2 m was taken between the blocks and 1 m between the plots (Figure 1).

Starting from 2016, wheat was planted at 20 kg ha^{-1} seeds rate in the spring under conventional tillage and no tillage. In May 2016, corn was planted at 75,000 seeds ha^{-1} under conventional tillage and no tillage. After harvesting wheat and corn, the blocks were prepared for cultivation of cover crops, which were sowed under conventional tillage and no tillage (common vetch 120 kg ha^{-1}, fodder beet 40 kg ha^{-1}). Cover crops were left on the land surface until the main crops sowing period. The same procedures were repeated in 2017 and 2018.

Soil Sampling and Analysis

For soil physical and chemical analysis, disturbed and undisturbed soil samples were taken at the beginning of the research and after harvesting the main crops in each cultivation period from the depth of 0-30 cm. The samples were then air dried in the laboratory. Soil samples at the air-dry moisture content were crushed and made

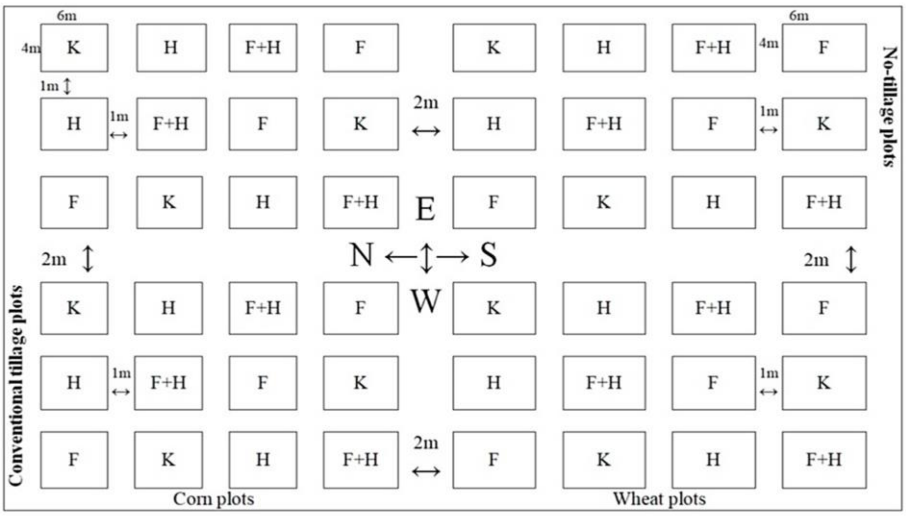

Figure 1. Experimental design (56×30 m; K: Control; F: Common vetch; H: Fodder beet).

ready for analysis after passing through a 2 mm sieve.

Bulk density was determined using undisturbed soil samples and soil texture, organic matter, wet aggregate stability, soil pH, plant available phosphorus and electrical conductivity were determined in disturbed soil samples. Soil texture (Gee and Bauder, 1986), soil organic matter (Walkley and Black, 1934), wet aggregate stability (Kemper and Rosenau, 1986), bulk density (Blake, 1965), plant available phosphorus (Olsen *et al.,* 1954), and electrical conductivity (Demiralay, 1993) were determined. Soil pH was tested with a soil/water ratio of 1:2.5 using a compound electrode in reference to McLean (1982).

Data Analysis

The data were analyzed using the SPSS statistical software program (SPSS, 2008). The distribution of the data for normality test was performed by Kolmogorov–Smirnov test (Onder, 2007) ($P> 0.05$). The homogeneity of the data was controlled by Levene test (Glass, 1966) ($P> 0.05$). For comparison of means to each group were tested by using ANOVA (Analysis Of Variance) tests. The differences between each group were detected for statistical significance ($P< 0.05$) and the differences between specified groups were determined by Duncan multiple comparison test ($P< 0.05$).

RESULTS AND DISCUSSION

Generally, cover crops significantly ($P< 0.05$) affected the selected soil properties, while tillage systems significantly affected pH, electrical conductivity, aggregate stability, plant available phosphorus and bulk density under wheat cultivation. The two-way interactions of cover crops x tillage systems significantly affected plant available phosphorus and bulk density.

Under corn cultivation, cover crops had significant effect ($P< 0.05$) on the selected soil properties; whist tillage systems significantly affected electrical conductivity, aggregate stability and plant available phosphorus. The two-way interactions of cover crops x tillage systems significantly affected plant available phosphorus.

Soil Organic Matter

In the study, cover crops affected soil organic matter in both wheat and corn plots (Tables 2 and 3). By the average values of the years, organic matter was found higher under cover crops than the control plots in wheat and corn (Figure 2-a). Between cover crops and control plots under common vetch cultivation, organic matter was 11.56 and 13.19% higher than control plots in no till and conventional till, respectively, in wheat (Table 2). In corn, it was detected 11.48 and 8% higher in no till and conventional till, respectively (Table 3). The increase in organic matter may be caused by cover plants, whose biomass production is quite high, and remain on the soil surface and decompose (Carvalho *et al.,* 2014).

Within the cover crops, the highest values of organic matter were in common vetch plots in wheat (1.64%, and 1.63%) and corn (1.65%, and 1.62%) in both no-till and conventional till. In common vetch plots, it was detected as 4.45 and 7.94% higher than fodder beet in wheat and 7.84 and 7.33% higher in corn under no-till and conventional till, respectively. Cooke and Williams (1972) and Tisdall and Oades (1982) also reported that leguminous crops, which can produce large amounts of vegetative parts, can be decomposed in a short time and cause an increase in soil organic matter. Some researchers also reported that cover crops increased soil organic matter content (Plaza-Bonilla *et al.*, 2016; Martínez-García *et al.*, 2018).

Tillage systems also affected soil organic matter content in wheat plots (Tables 2 and 3). The higher values of organic matter were

[DOI: 10.22034/jast.25.3.733]

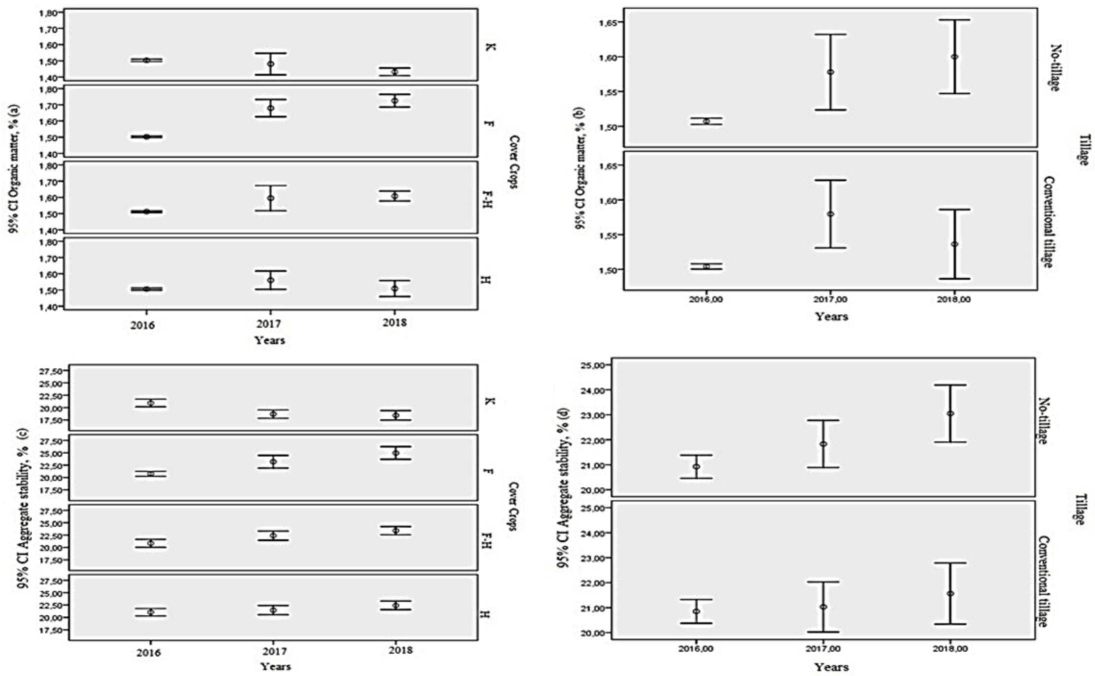

Figure 2. The changes in soil organic matter and aggregate stability between years of 2016-2018 under wheat and corn (CI: Confidence Intervals; K: Control; F: Common vetch; H: Fodder beet).

found in no-tilled plots under both wheat (1.56%) and corn (1.56%). The differentiation in soil organic matter may be caused by promoting soil organic matter mineralization by conventional tilled.

In a study in which tillage systems and cropping system were investigated, it was found that no-tillage increased soil organic matter by 17% compared to plow-till (Nunes *et al.,* 2018). In conformity with prior studies (Şimşek *et al.,* 2017; Ramnarine *et al.,* 2018; Zhang *et al.,* 2018), tillage decreased soil organic matter (Figure 2-b).

Aggregate Stability

In wheat and corn plots, aggregate stability was affected by cover crops (Tables 2 and 3). The higher values of aggregate stability were found in common vetch as cover crops than the control plots (Figure 2-c). In addition, aggregate stability was found 20.5 and 23.78% higher in common vetch than the control under wheat and 15.70 and 15.06% under corn in no till and conventional till, respectively. Besides, within the cover crops, higher values were in common vetch plots in no till (24.21%), conventional till (22.90%) under wheat and no till (22.84%), conventional till (21.92%) under corn. The values of aggregate stability were found 8.71% (no till) and 1.68% (conventional till) greater in common vetch than fodder beet under wheat, and 7.17 (no till) and 7.13% (conventional till) under corn. The variation in aggregate stability may be caused by organic compounds produced by the roots of leguminous (Rennie *et al.,* 1954; Tisdall and Oades, 1982) and the increase in organic matter content of the soils (Caravaca *et al.,* 2004; Bronick and Lal, 2005). Consistent with previous studies, we found that cover crops significantly increased aggregate stability (Belmonte *et al.,* 2018; García-González *et al.,* 2018).

Both no-tillage and conventional tillage affected soil aggregate stability (Tables 2 and 3). While aggregate stability was 22.39%, 21.48% in no tillage, it was 21.68 and 20.61% in conventional tilled under

[DOI: 10.22034/jast.25.3.733]

Table 2. Effects of cover crops and tillage systems on selected soil physical and chemical properties at 0–30 cm depth for the means of 2016, 2017, 2018 under wheat cultivation.

Tillage systems	Cover crops	Soil properties*					
		SOM (%)	AS (%)	BD (g cm^{-3})	P (kg ha^{-1})	EC (μmhos cm^{-1})	pH
No till	Control	1.47±0.07c	20.09±1.66c	1.76±0.05a	49.2±0.22d	478.56±22.71a	8.53±0.05a
	Common vetch	1.64±0.13a	24.21±3.00a	1.53±0.15d	73.9±2.08a	428.78±49.21b	8.48±0.07c
	Common vetch-Fodder beet	1.57±0.08b	23.01±2.06ab	1.58±0.13c	67.2±1.66b	423.78±46.49b	8.50±0.06b
	Fodder beet	1.57±0.06b	22.27±1.39b	1.63±0.07b	60.8±1.14c	440.33±34.82b	8.50±0.07b
Means of no till		1.56±0.10	22.39±2.53A	1.62±0.13A	62.8±1.67A	442.86±43.78A	8.50±0.06B
Conventional till	Control	1.44±0.06d	18.50±2.43b	1.65±0.07a	48.8±0.22c	433.22±33.01a	8.56±0.04a
	Common vetch	1.63±0.11a	22.90±2.47a	1.51±0.16c	55.8±0.71a	409.00±54.51c	8.50±0.06b
	Common vetch-Fodder beet	1.57±0.05b	22.80±1.16a	1.57±0.14b	53.7±0.47ab	413.00±42.70bc	8.50±0.07b
	Fodder beet	1.51±0.07c	22.52±1.39a	1.60±0.08b	51.9±0.40b	428.22±34.10ab	8.51±0.07b
Means of conventional till		1.54±0.10	21.68±2.64B	1.58±0.12B	52.5±0.53B	420.86±41.43B	8.52±0.06A

* Lower case and capital letters are used for vertical indicate significant differences according to DUNCAN test ($P< 0.05$). SOM: Soil Organic Matter; AS: Aggregate Stability; BD: Bulk Density; P: Plant available phosphorus; EC: Electrical Conductivity; pH: Soil pH.

Table 3. Effects of cover crops and tillage systems on selected soil physical and chemical properties at 0–30 cm depth ($P< 0.05$) under corn cultivation.

Tillage systems	Cover crops	Soil properties*					
		SOM (%)	AS (%)	BD (g cm^{-3})	P (kg ha^{-1})	EC (μmhos cm^{-1})	pH
No till	Control	1.48±0.07c	19.74±1.16c	1.64±0.07a	46.8±0.22b	464.33±37.85a	8.54±0.04a
	Common vetch	1.65±0.13a	22.84±2.05a	1.55±0.13b	52.9±0.52a	427.11±32.90b	8.48±0.08b
	Common vetch-Fodder beet	1.59±0.12ab	22.02±1.80ab	1.60±0.12a	51.1±0.33a	429.89±42.94b	8.51±0.08ab
	Fodder beet	1.53±0.05bc	21.31±1.03b	1.61±0.08a	50.8±0.34a	417.67±61.35b	8.50±0.07b
Means of no till		1.56±0.12	21.48±1.89A	1.60±0.10	50.4±0.42A	434.75±46.67A	8.51±0.07
Conventional Till	Control	1.50±0.08b	19.05±1.24c	1.65±0.08a	43.8±0.27	449.11±31.59a	8.56±0.04a
	Common vetch	1.62±0.10a	21.92±1.71a	1.54±0.14c	45.8±0.21	407.67±53.38b	8.50±0.07b
	Common vetch-Fodder beet	1.56±0.08ab	21.02±1.05ab	1.57±0.13bc	44.3±0.25	410.56±48.02b	8.49±0.07b
	Fodder beet	1.51±0.08b	20.46±1.06b	1.60±0.09b	44.8±0.23	418.44±45.98b	8.52±0.06ab
Means of conventional till		1.54±0.10	20.61±1.63B	1.59±0.12	44.7±0.24B	421.44±46.56B	8.52±0.06

* Lower case and capital letters are used for vertical indicate significant differences according to DUNCAN test ($P<0.05$). SOM: Soil Organic Matter; AS: Aggregate Stability; BD: Bulk Density; P: Plant available phosphorus; EC: Electrical Conductivity; pH: Soil pH.

wheat and corn. Therefore, the higher values of aggregate stability were detected in no tilled plots. The variation in aggregate stability may be caused by tillage that disrupt soil aggregates and promote mineralization of soil organic matter (Pikul Jr. *et al.*, 2009). In agreement with previous researches, (Şimşek *et al.,* 2017; Belmonte *et al.,* 2018; Blanco-Canqui and Ruis, 2018; Sarker *et al.*, 2018), we determined that conventional tillage decreased soil aggregate stability (Figure 2d). The decrease could be related to the separation of macro aggregates by conventional tillage practices. Similarly, Kasper *et al.* (2009) reported that conventional tillage increased the process of

[DOI: 10.22034/jast.25.3.733]

disaggregating by separating macro-aggregates.

Bulk Density

Soil bulk density was affected by cover crops under both wheat and corn (Tables 2 and 3). There was a decrease in the bulk density over the years (Figures 3-a and -b). The lowest bulk density was recorded in common vetch (1.53 g cm^{-3} in no till; 1.51 g cm^{-3} in conventional till) under wheat, and (1.55 g cm^{-3} in no till; 1.54 g cm^{-3} in conventional till) under corn, followed by mixture of common vetch-fodder beet (1.58 g cm^{-3} in no till; 1.57 g cm^{-3} in conventional till) under wheat, and (1.60 g cm^{-3} in no till; 1.57 g cm^{-3} in conventional till) under corn, fodder beet (1.63 g cm^{-3} in no till; 1.60 g cm^{-3} in conventional till) under wheat and (1.61 g cm^{-3} in no till; 1.60 g cm^{-3} in conventional till) under corn. Dissimilarity between control and cover crops in bulk density may be caused by the improvements in soil properties such as organic matter content, aggregate stability, and decomposition of organic residues that lowered density than soil (Haruna and Nkonglo, 2015; Mukherjee and Lal, 2015).

With respect to our findings, tillage systems significantly altered bulk density in wheat plots (Table 2). The lower values of bulk density were found in conventional tillage (1.58 g cm^{-3}), as the higher values were in no-tilled (1.62 g cm^{-3}) under wheat. The higher values in no tillage may be caused by field traffic operations. The lower bulk density observed under conventional tillage may be the result of a breakdown in the compact layer in the soil. A number of other authors (Haruna *et al.*, 2018; Schlüter *et al.*, 2018; Scarpare *et al.*, 2019) also reported that conventional tillage decreased bulk density in soil.

Plant Available Phosphorus

In the means of 2016, 2017 and 2018,

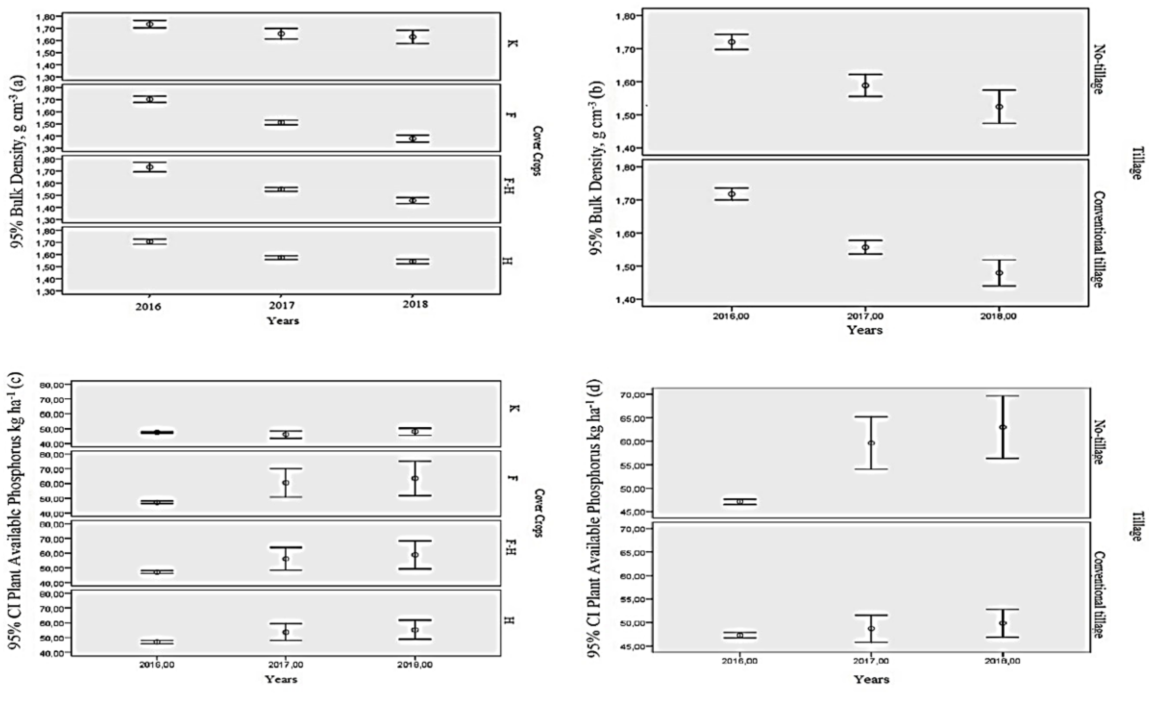

Figure 3. The changes in bulk density and plant available phosphorus between years of 2016-2018 under wheat and corn (CI: Confidence Intervals; K: Control; F: Common vetch; H: Fodder beet).

[DOI: 10.22034/jast.25.3.733]

plant available phosphorus contents of soil were affected by cover crops in wheat and corn (Tables 2 and 3). The lower values of phosphorus were detected in control plots (49.2 kg ha^{-1} in no till; 48.8 kg ha^{-1} in conventional tillage) under wheat and (46.8 kg ha^{-1} in no till; 43.8 kg ha^{-1} in conventional tillage) under corn, while the higher values were in common vetch (73.9 kg ha^{-1} in no till; 55.8 kg ha^{-1} in conventional tillage) under wheat and (52.9 kg ha^{-1} in no till; 45.8 kg ha^{-1} in conventional tillage) under corn. Available phosphorus was found 50.2% (no till) and 14.34% (conventional till) higher in common vetch than the control plots under wheat and 13.03 (no till) and 4.56% (conventional till) higher under corn. Among cover crops, it was determined that 21.54 (no till) and 7.51% (conventional till) under wheat and 4.13 (no till) and 2.23% (conventional till) under corn were higher in common vetch than fodder beet. Differences in plant available phosphorus may be caused by the increase in nutrient content of soil because of cover crops decomposition (Carvalho *et al.,* 2014). In line with numerous previous observations (Welch *et al.,* 2016; Teles *et al.,* 2017), cover crops increased available phosphorus in plants (Figure 3-c).

Tillage methods affected plant available phosphorus contents (Tables 2 and 3). In no-tilled, plant available phosphorus contents were increased more than conventional tillage throughout the study years (Figure 3-d). The higher values (62.8 kg ha^{-1}; 50.4 kg ha^{-1}) were observed in no-tilled under wheat and corn. As a side note, in no-tillage, phosphorus values were determined 19.61 and 12.75% greater than conventional tillage in wheat and corn, respectively. Dissimilarity between tillage methods in plant available phosphorus may be due to decreasing phosphorus losses in no-tillage (Reddy *et al.,* 2003; Carvalho *et al.,* 2014). In line with our results, Reddy *et al.,* (2003) and Saavedra *et al.* (2007) have reported that the higher values of plant available phosphorus were in no-till compared to conventional tillage.

Soil Electrical Conductivity and pH

Cultivation of cover crops affected soil electrical conductivity and pH (Tables 2 and 3). We detected that the higher values of electrical conductivity (478 µmhos cm^{-1} in no till; 433 µmhos cm^{-1} in conventional till under wheat; 464 µmhos cm^{-1} in no till; 449 µmhos cm^{-1} in conventional tillage under corn) and pH (8.53 in no till; 8.56 in conventional tillage under wheat; 8.54 in no till; 8.56 in conventional tillage under corn) were in the control plots, while the lower values were in cover crops under wheat and corn (Figures 2-e and -f). We observed no differences in soil pH and electrical conductivity values between cover crops. In accordance with the previous observations (Obade and Lal, 2014; Mukherjee and Lal, 2015; Husson *et al.,* 2018), cover crops decreased soil pH and electrical conductivity (Figures 4-a and -b).

The electrical conductivity and pH were affected by tillage treatments and there was a decrease in both electrical conductivity and pH over the years (Figures 4-c and -d). Soil pH (8.50; 8.51) was found to be lower while electrical conductivity (442 µmhos cm^{-1}; 434 µmhos cm^{-1}) was higher in no-till than conventional tillage in wheat and corn. The decrease in pH under no-tilled may be caused by increased organic matter (Mukherjee and Lal, 2015; Leogrande and Vitti, 2018). As a matter of fact, Leogrande and Vitti, (2018) have reported that acidic products released from the decomposition of organic matter affect soil pH. The lower values of electrical conductivity were found in conventional tillage (420 µmhos cm^{-1}; 421 µmhos cm^{-1}). Similar to our observations (Sánchez-Llerena *et al.,* 2016; Fangueiro *et al.,* 2017; Naujokienė *et al.,* 2018), some other authors reported that conventional tillage decreased electrical conductivity.

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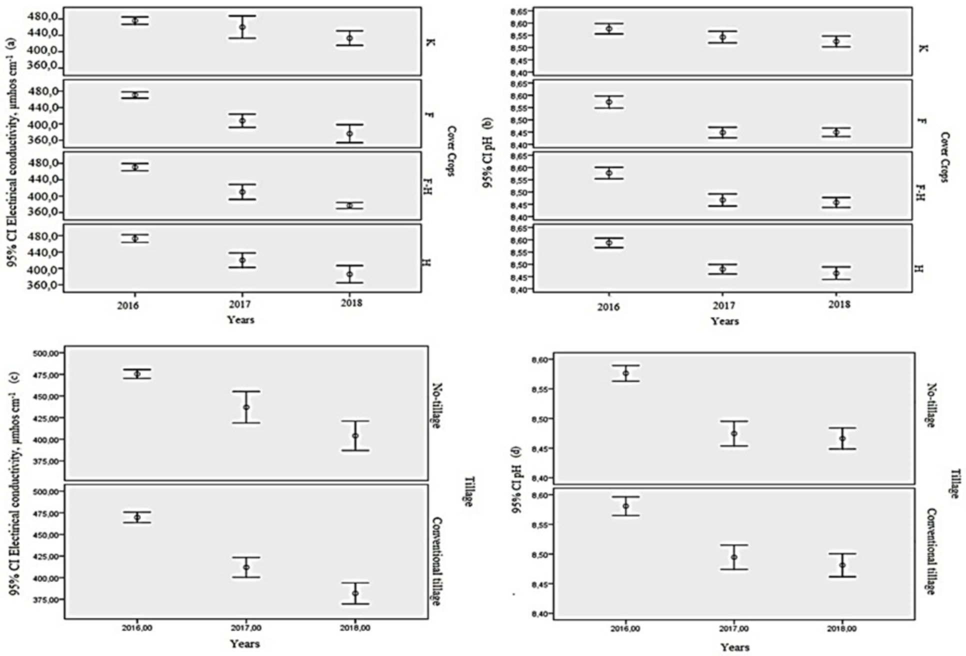

Figure 4. Changes in electrical conductivity and pH between years of 2016-2018 under wheat and corn (CI: Confidence Intervals; K: Control; F: Common vetch; H: Fodder beet).

CONCLUSIONS

According to our findings, Cover crops and tillage practices affected soil properties by affecting soil organic matter and soil bulk density. Both cover crops and no-till practices increased soil organic matter, aggregate stability and plant available phosphorus. The greater values of soil organic matter (1.64%; 1.65%), aggregate stability (24.21%; 22.84%) and plant available phosphorus (73.9 kg ha^{-1}; 52.9 kg ha^{-1}) were determined in common vetch, the lower values were in the control plots. The lower values of bulk density, electrical conductivity and soil pH were in common vetch, the higher values were in the control plots under both wheat and corn. Among tillage practices, greater values of soil organic matter, aggregate stability, plant available phosphorus and lower pH values were observed in no till, which had higher bulk density and electrical conductivity values. We conclude that cover crops and no-till practices improved some soil properties and the selection of cover crop spices will be critical for improving and sustaining soil quality.

ACKNOWLEDGEMENTS

This paper is part of the doctoral dissertation entitled "Effects of different soil management practices on some soil properties and yield parameters of corn (*Zea mays* L.) and wheat (*Tiriticum aestivum* L.)", completed by the first author under the supervision of the second author. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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[DOI: 10.22034/jast.25.3.733]

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[DOI: 10.22034/jast.25.3.733]

اثرهای شیوه‌های مختلف مدیریت خاک بر برخی از ویژگی های خاک در یک منطقه نیمه خشک در ایژدیر(Igdir)، ترکیه

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چکیده

اقدامات حفاظتی خاک با هدف بهبود ویژگی‌های خاک تخریب شده و حفظ کیفیت خاک انجام میشود. کشاورزی فشرده با خاک‌ورزی معمول در استان ایژدیر ترکیه منجر به تخریب خاک (فشرده شدن، از بین رفتن مواد آلی خاک) شده است. به همین دلیل استفاده از شیوه های حفاظت از خاک (حداقل خاک ورزی، بدون خاکورزی، گیاهان پوششی) در منطقه حائز اهمیت است. هدف این پژوهش، تعیین تأثیر روش‌های مختلف خاک‌ورزی و محصولات پوششی کشت شده پس از برداشت ذرت (*Zea mays* L.) و گندم (*Triticum aestivum* L.) بر ویژگی‌های خاک منتخب طی سال‌های ۲۰۱۸-۲۰۱۶ در ایژدیر بود. در این پژوهش، از گندم و ذرت به‌عنوان گیاهان اصلی، خاک‌ورزی متعارف و بدون خاک‌ورزی به‌عنوان روش‌های خاک‌ورزی و ماشک، چغندر علوفه‌ای و مخلوط چغندرماشک و علوفه به‌عنوان گیاهان پوششی استفاده شد. در سال اول آزمایش، مقادیر مواد آلی، پایداری خاکدانه، جرم مخصوص ظاهری، فسفر قابل دسترس گیاه و pH خاک به ترتیب ۱/۵%، ۲۰/۸۸%، ۱/۷۱ گرم در سانتی‌مترمکعب، ۴۷/۲ کیلوگرم در هکتار و ۸/۵۷ بود. در سال آخر، این مقادیر به ترتیب ۱.۵۶%، ۲۲.۳۰%، ۱.۵۰ گرم در سانتی متر مکعب، ۵۶.۴ کیلوگرم در هکتار و ۸.۴۷ تعیین شد. در نتیجه این پژوهش مشخص شد که استفاده از گیاهان پوششی و عدم خاک‌ورزی منجر به بهبود ویژگی‌های خاک انتخابی شده و می تواند برای پایداری کیفیت خاک در مناطق خشک و نیمه خشک مهم باشد.

[DOI: 10.22034/jast.25.3.733]