

Changes in some soil properties of wheat fields under conventional and reduced tillage systems in Northern Iraq

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Abstract

In this study, the effects of reduced tillage (RT) and conventional tillage (CT) systems on some soil properties of wheat fields in Northern Iraq (Duhok Province) under a hot and dry climatic condition were investigated. This study was carried out in a randomized plot design with four replications at three locations (Bardrash, Sumail, and Zakho) in the seasons 2017-2018. Four fields in each location at Duhok Province were equally separated into two groups for CT and RT systems. A group of 24 soil samples for each tillage system were taken from the locations. Soil organic matter content, pH, EC, bulk density and total porosity values were significantly ($p < 0.05$) affected by different tillage systems. Soil pH, EC and bulk density values generally significantly reduced with the RT compared with CT. On the other hand, soil OM content and total porosity were significantly increased with the RT system in all locations under a hot and dry climatic condition. In all locations, RT system decreased bulk density and increased total porosity with conserving soil OM due to preventing from rapid mineralization. However, rapid mineralization of soil OM in the CT system under dry climate condition caused increases in EC which indicated that there were high soluble ions in soil solution.

Keywords: Soil properties, conventional tillage, reduced tillage, wheat.

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Introduction

Wheat (*Triticum* spp.) is one of the main crops used for human food and animal feed in temperate and dry-land areas around the world. The main factors influencing the production and yield of wheat are generally crop rotation, tillage system, and plant residue managements. In northern Iraq, rainfed agriculture with intensive cereal cultivation for decades resulted in reduced wheat productivity due to topsoil loss and degradation of many fields (Izaurrealde et al., 2006; Brunel et al., 2011), hence, early symptoms of erosion are undetectable by simple observations (Fenton et al., 2005; Larney et al., 2009). In traditional tillage, depth of topsoil and clay content increase as a consequence of mixing with finer particles from lower horizons; this material has low levels of organic matter, and these characteristics are then transferred to the new upper horizon (Frye et al., 1982; Christensen and McElyea, 1988; Gülser et al. 2016). Furthermore, the loss of topsoil is followed by an increase in bulk density, structural deterioration, and alteration of the total porosity with various suppressing effects on crop yield (Gollany et al., 1992; Malhi et al., 1994). Thus, the depth of topsoil has been proved a significant parameter in determining soil quality and land productivity (Larney et al., 2009).

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Reduced tillage (RT) in the developing systems with wheat residue mulching in the northern Iraq is an alternative technology to protect the sub-soil against compaction and erosion by water. It can reduce water run-off throughout the year, reduce evaporative losses and increase water infiltration and also can increase the stability of the soil by increasing organic matter content as well as a source of nutrients particularly P, K, Mg and biological activity (Dexter et al., 2004; Czyz and Dexter, 2008; Malecka et al., 2016; Gajda et al., 2017). Reduced tillage affects some soil physical properties in the top layers such as; bulk density (Gajda et al., 2017), water content, aggregate stability (Rasmussen, 1999) and soil physical quality (Dexter, 2004). Horak et al. (2014) studied the short-term effects of conventional and reduced tillage with and without nitrogen fertilizer applications on soil respiration rate during 40 days. They reported that there was not a significant difference in CO₂ emission rates between conventional and reduced tillage systems. Ali et al. (2016) determined the effects of zero tillage and conventional tillage practices and row spacing on growth and yield of wheat. They found that zero tillage significantly enhanced yield components of wheat plants as compared to conventional tillage, and zero tillage and narrow row spacing (15 cm) had higher wheat yield for the wheat-maize rotation system in semi-arid regions. Vakali et al. (2011) determined that reduced tillage practices improved soil physical and biological properties without detrimentally affecting root growth of cereals under organic farming.

In the developing regions of Northern Iraq, crop yields decrease because of variety of reasons, such as lack of adequate tillage equipment and inadequate knowledge of farmers about the management of crop residues, the persistence of heavy residues in wet soil, pest and disease problems, weed control (Hejazi et al., 2010). Growing without crop rotation with heavy residues and stubble burning after harvesting for rapid seed preparation leads to loss of soil organic matter and reduction of fertility. The aim of this research was to compare the effects of conventional and reduced tillage systems on some soil properties of rainfed wheat grown fields located in Duhok Province of Northern Iraq having a dry climatic condition.

Material and Methods

The experimental locations were selected from the local wheat farmer's fields at Bardrash, Sumail, and Zakho of Duhok Province in the Northern Iraq (Table 1, Figure 1). The climate of geographical sites showed considerable fluctuations during different parts a year; summer temperature reaches to up 40°C, while winter experiences frequent frosty spells particularly in December and January. The average distribution of precipitation and dominant temperatures at these sites between 2010 and 2018 are shown in Figure 2.

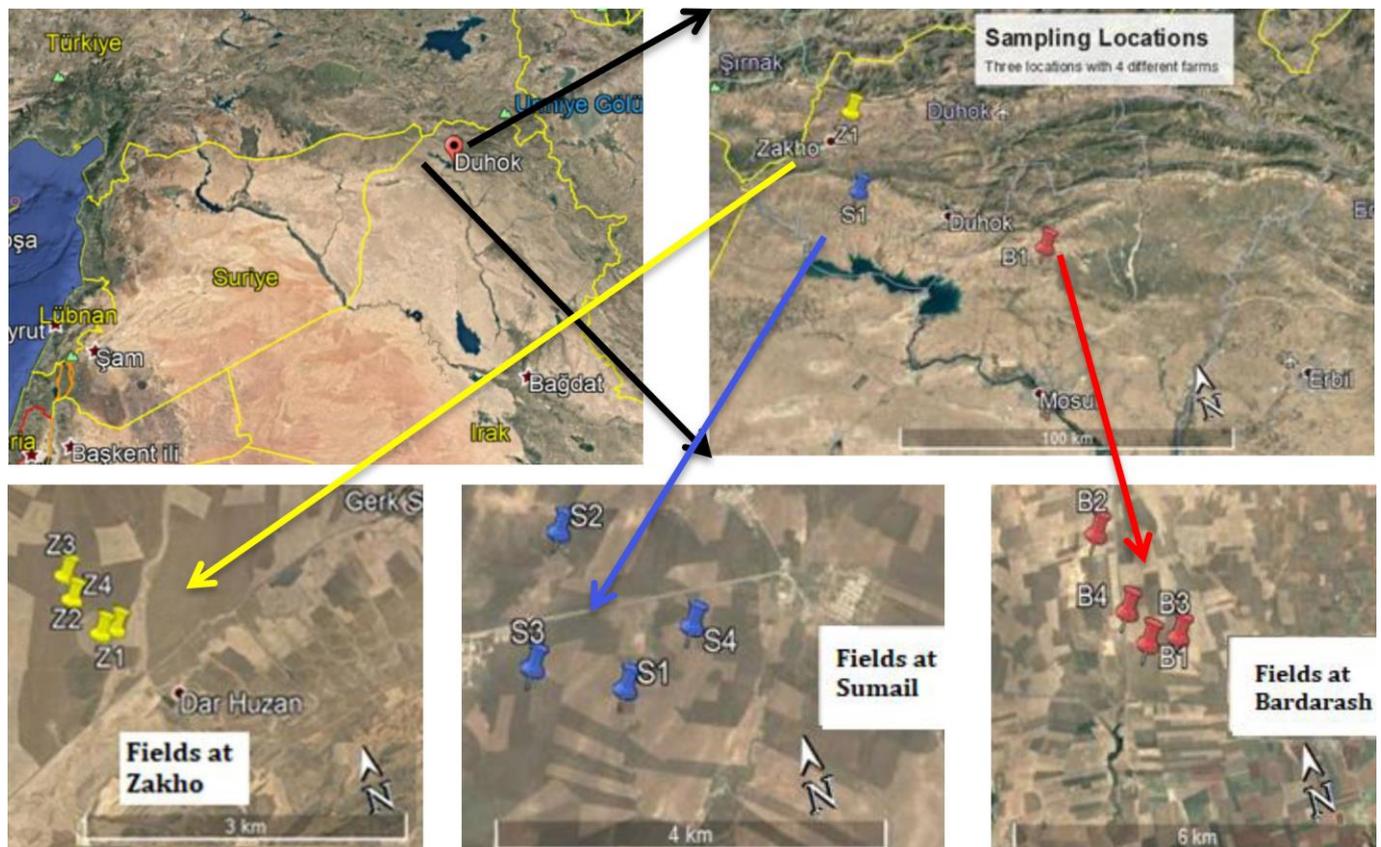


Figure 1. Locations of experimental sites Zakho, Sumail, and Bardrash.

Table 1. Geographical position of the experimental locations

Locations	Latitude N	Longitude E	Elevation, m
Bardarash	36.5018° N	43.5848° E	420
Sumail	36.8608° N	42.8476° E	525
Zakho	37.1505° N	42.6727° E	510

The study was carried out in a randomized plot design using conventional tillage (CT) and reduced tillage (RT) systems with four replications at three locations (Bardrash, Sumail, and Zakho) between 2017 and 2018. Four fields in each location were equally separated into two groups for CT and RT practices. Moldboard plow for CT system and chisel plow shanks for RT system were used for seedbed preparation before wheat cultivation. This research only covers some characteristics of the soil before planting. Experimental fields had been used for wheat production mainly for a long time. Moldboard and chisel plow shanks were used twice before winter wheat seed cultivation on May and July in both 2017 and 2018. Moldboard plow was used for 30 cm depth, and chisel plow shanks was used for 5-10 cm depth. The total sets of 48 surface soil samples (0-30 cm) were taken from all sampling locations as 24 samples for each tillage practice belong to CT and RT.

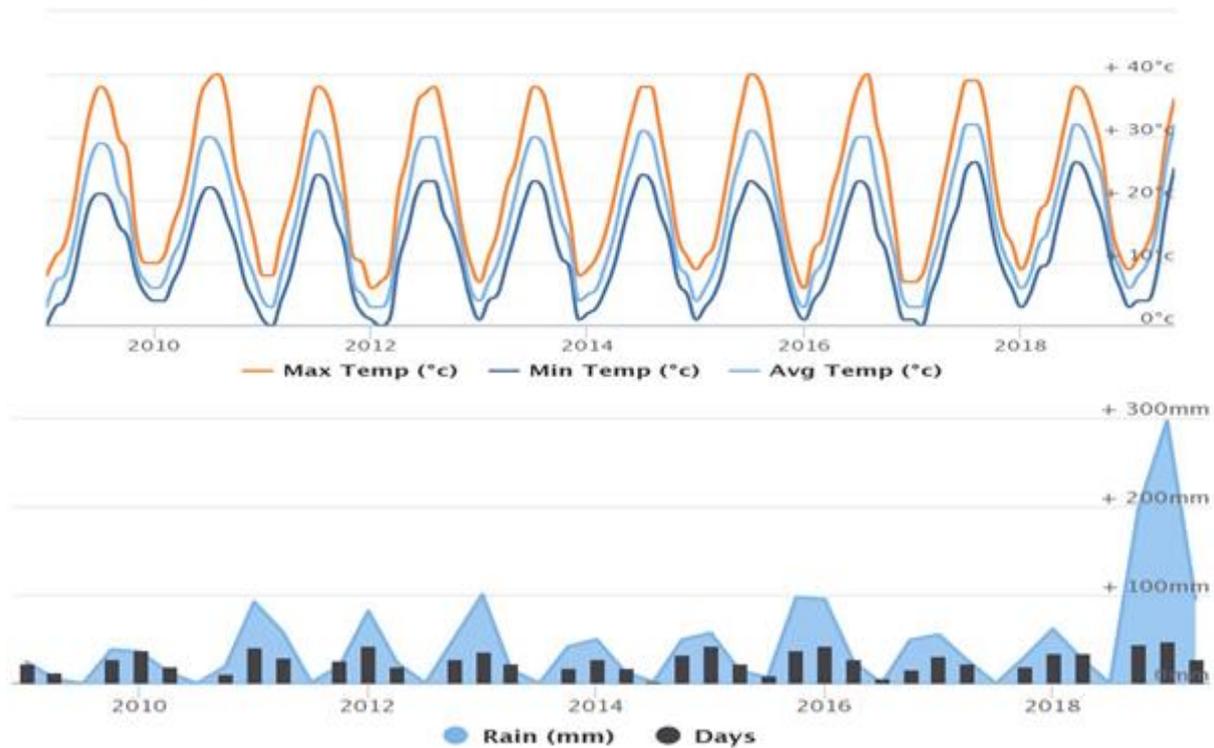


Figure 2. Meteorological data of Duhok Province (World weather online).

The soil samples were analyzed in the University of Duhok, College of Agricultural Engineering during 2017-2018. Main properties of soil were analyzed as; soil texture by Bouyoucos hydrometer method (Black, 1965), pH measured in 1: 2.5 (w:v) in soil: water suspension by pH-meter, electrical conductivity (EC) at the same suspension by EC-meter, soil organic matter (OM) by the wet oxidation method (Walkley-Black) with $K_2Cr_2O_7$, lime ($CaCO_3$) content by Scheibler Calcimeter method (Kacar, 1994). Bulk density (BD) was determined after soil core collection by oven-drying field-moist soil for 24 h at 105 °C and weighing the soil samples before and after drying (USDA, 2001). Total porosity (F) was calculated using the bulk density values in the equation; $F=1-(BD/2.65)$. According to soil properties given in Table 2, soils in experimental locations have generally fine textural classes (clay in Zakho and silty clay in Bardarash and Sumail), moderately alkaline, non-saline, limy and low in organic matter content (Soil Survey Division Staff, 1993).

Table 2. Some soil properties at experimental locations

Locations	Textural class	pH (1:2,5)	EC, dS/m	$CaCO_3$, %	OM, %
Bardarash	Silty clay	8,60	0,38	17,25	2,00
Sumail	Silty clay	8,25	0,36	17,35	1,85
Zakho	Clay	8,35	0,32	21,15	1,90

Data were statistically analyzed using SAS software (ver. 9.1; SAS Institute Inc., Cary, NC). Values expressed, as percentages were arcsine transformed and then analyzed. Analysis of variance ANOVA was performed at the $p \leq 0.05$ level and the mean values obtained for different treatments were compared according to Duncan's Multiple Range Test.

Results and Discussion

The effects of CT and RT on some soil properties are given in Table 3. There were significant differences among soil properties obtained from different tillage systems. The mean values of pH, EC and BD in the fields under CT were higher than that under RT. However, the mean values of OM and F in the fields under CT were lower than that under RT. The mean values of pH, EC and BD reduced as 3,4%, 29,6% and 4,7% with RT compared with CT, respectively. The mean values of OM and F increased as 16,3% and 7,6% with RT compared with CT, respectively.

Table 3. Effect of conventional tillage (CT) and reduced tillage (RT) systems on mean values of some soil properties.

	pH (1:2,5)	EC, dS/m	OM, %	BD, g/cm ³	F, %
CT	8,56	0,42	1,78	1,64	37,98
RT	8,27	0,29	2,07	1,57	40,88

OM: organic matter, BD: bulk density, F: total porosity

The changes in soil pH and EC values at different locations by the tillage systems are given in Figures 3 and 4. The soil pH values, except Bardarash, significantly reduced with RT application. The highest decrease in soil pH was determined at Sumail location as 6,2%. [Rhoton et al. \(1993\)](#) found that no-tillage plots in different soil types had higher organic C, exchangeable cations and acidity than conventional tillage plots. Similarly, [Hussain et al. \(1999\)](#) determined that moldboard plow had higher soil pH value (6,4) than chisel plow (6,2) in a silt loam soil. [Lilienfein et al. \(2000\)](#) reported that under no till, the average soil solution pH (5,5) significantly and EC (0.205 dS/m) were lower than pH (6.0) and EC (0.224 dS/m) in conventional tillage, and total organic C content in no till was higher than under conventional tillage. In this study, EC values in CT at different locations were significantly higher than that in RT. The highest reduction in EC as 31,6% in RT was determined at Zakho location compared with CT. In soil solution, EC value reflects dissolved nutrient elements in anion and cation forms and is one of the most important parameters for monitoring organic-matter mineralization in soils ([De Neve et al. 2000](#); [Candemir and Gülser 2011](#)). [Borie et al. \(2006\)](#) reported that higher C, N, S, total P and fulvic acid-P concentrations and pH occurred in an Ultisol soil under no till and RT than under CT after wheat harvest. In this study carried out under dry climatic condition, soil OM in CT system had more rapid mineralization rate than RT system due to undisturbing soil aggregates and increasing aeration all experimental fields. This mineralization of OM content reflected on the EC values of the soil samples taken from CT plots (Figure 4). Therefore, soil organic matter contents at different locations under RT practice were significantly higher than that under CT (Figure 5). Reducing soil tillage increased soil OM content by 10,5% at Bardarash, 30,2 % at Sumail and 9,9% at Zakho locations. Soil OM content increases with reducing tillage systems ([Rhoton et al. 1993](#); [Lilienfein et al. 2000](#)). [Ernst and Emmerling \(2009\)](#) determined that soil organic C content was increased in the topsoil under reduced tillage compared to ploughing. [Six et al. \(1999\)](#) reported that soil tillage strongly affects the amount and type of particulate soil OM contents associated with aggregates. Organic C sequestration in no till was greater than conventional tillage due to slower turnover of macroaggregates in no till. Also, it is known that the decomposition rate of soil organic matter depends on climatic conditions; the tillage effect on soil OM decomposition is lower in cooler regions than in hotter and more arid regions ([Soon et al., 2007](#)). In this study, RT system in hot and dry climatic locations helped preventing to organic matter decomposition in soil compared with CT system.

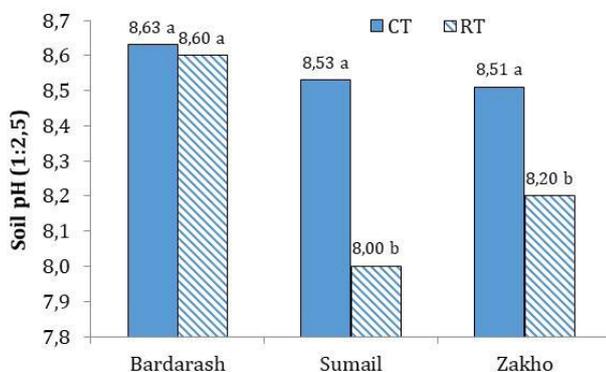


Figure 3. Effects of conventional (CT) and reduced (RT) tillage systems on soil pH.

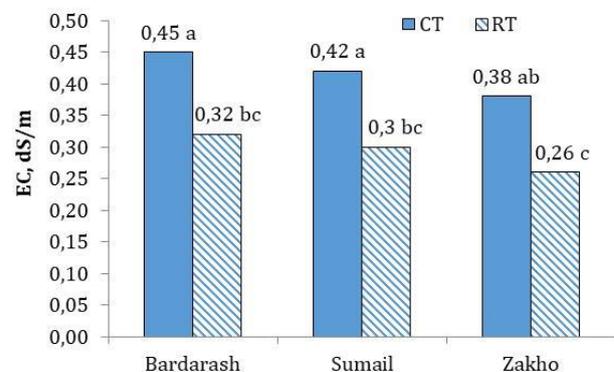


Figure 4. Effects of conventional (CT) and reduced (RT) tillage systems on EC.

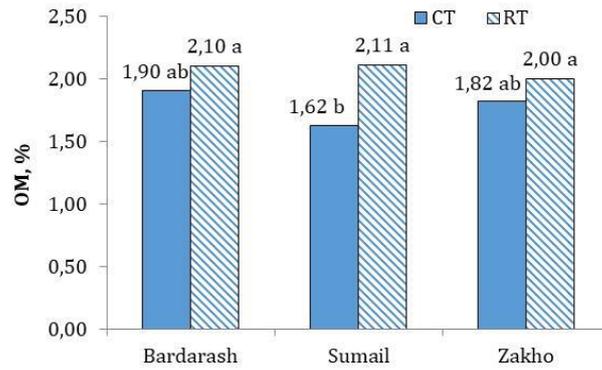


Figure 5. Effects of conventional (CT) and reduced (RT) tillage systems on soil organic matter (OM) content.

The bulk density values in all experimental fields under CT system were higher than that under RT system (Figure 6). According to CT system, the bulk density values in fields under RT system decreased as 4,8% in Bardarash, 4,7% in Sumail and 4,4% in Zakho locations. Grant and Lafond (1993) determined that the bulk density values at 5 cm interval of 0-15 cm layer of a clay soil depth were lower for minimum tillage system (0,90 to 1,29 g/cm³) than conventional tillage system (0,99 to 1,33 g/cm³). Gülser (2004) found that increasing soil organic matter content due to crop treatments decreased bulk density with increasing total porosity. Many studies reported that soil organic matter content gives a significant negative correlation with bulk density and a significant positive correlation with total porosity (Candemir and Gülser, 2011; Demir and Gülser, 2015). In this study, increasing soil OM contents in RT system caused to decrease the bulk density values in each location. Similarly, the total porosity values in RT system were greater than that in CT system (Figure 7). Selvi et al. (2019) determined that soil penetration resistance within 0-40 cm depth of a clay soil varied between 0,78 MPa and 1,20 MPa for fall chisel plowing and those values were lower than the values ranged between 0,81 MPa and 1,40 MPa for fall moldboard plowing. It is known that increasing the total porosity or decreasing bulk density causes to decreases in soil penetration resistance values. Gülser and Candemir (2012) reported that increasing total porosity and soil moisture content by the application of organic residues decreased penetration resistance of a clay soil. In another study, Gülser (2006) indicated that increasing macroaggregation in a clay soil due to forage cropping caused increases in organic matter content and decreases in bulk density and penetration resistance. In this study, RT system increased total porosity with preventing organic matter content in soil while CT system decreased total porosity with reducing organic matter content due to rapid mineralization under hot and dry climatic conditions. Percentage increases in the values of total porosity with RT over CT were determined as 8,1% in Bardarash, 8,3% in Sumail and 6,6% in Zakho locations. The effect of RT on total porosity was more effective on the silty clay textural fields in Bardarash and Sumail than the clay textural field in Zakho.

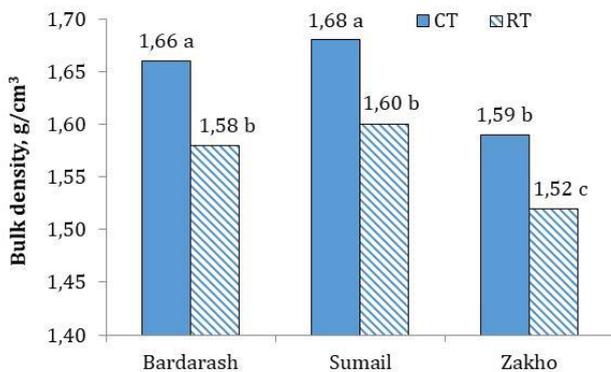


Figure 6. Effects of conventional (CT) and reduced (RT) tillage systems on soil bulk density.

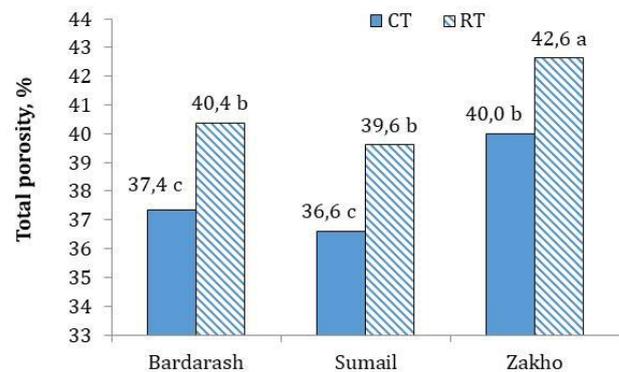


Figure 7. Effects of conventional (CT) and reduced (RT) tillage systems on total porosity.

Conclusion

The effects of CT and RT systems on some soil properties of rainfed wheat grown fields of Bardarash, Sumail and Zakho located on Duhok Province under a hot and dry climatic condition were investigated in this study. While the values of soil pH, EC and bulk density significantly reduced with the RT over the CT system, soil OM content and total porosity were significantly increased with the RT system in all locations under a hot and dry climatic condition. The RT system reduced bulk density and increased total porosity with conserving

soil OM content due to preventing from rapid mineralization rate under a hot and dry climatic condition. However, rapid mineralization of soil OM in the CT system under dry climate caused increases in EC which indicated the higher soluble ions in soil solution. This study showed that RT systems in fields under hot and dry climatic conditions are very important to prevent and improve soil physical and chemical properties.

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