Soil & Tillage Research 162 (2016) 26–33

Contents lists available at ScienceDirect

Soil & Tillage Research

journal homepage: www.elsevier.com/locate/still

Effects of tillage management on productivity of wheat and chickpea under cold, rainfed conditions in western Iran

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ARTICLE INFO

Article history:
Received 7 September 2015
Received in revised form 31 March 2016
Accepted 15 April 2016
Available online 30 April 2016

Keywords:
No-tillage
Reduced tillage
Sonqor Kulliye

ABSTRACT

In order to investigate the effect of different tillage systems (i.e. conventional tillage, reduced tillage and no-tillage systems), on yield performance and yield components of wheat (*Triticum aestivum* L.) and chickpea (*Cicer arietinum* L.) crops, three experiments were conducted under cold rainfed conditions of Kermanshah province in west of Iran from 2012 to 2014. Results revealed that under reduced tillage, yield of wheat was 5.8 and 11.2% higher than conventional tillage in 2013 and 2014, respectively. However, the yield performance of chickpea and wheat crops in the no-tillage treatment were less than conventional tillage system. Increase in volumetric soil moisture (221, 196 and 258% from 2012 to 2014, respectively) in no-tillage treatment, was observed as compared to conventional tillage. Similarly in reduced tillage treatment, volumetric soil moisture content was 175, 163 and 209% higher than the conventional tillage during 2012–2014. The yield performance of chickpea in the reduced tillage treatment was 9.0, 8.6 12.7% higher than conventional tillage across three years, respectively. Although most of the measured traits of wheat and chickpea improved by reduced tillage, there was not considerable difference between no-tillage and conventional tillage. Findings indicated that yield of wheat and chickpea were significantly responsive to tillage systems and the reduced tillage treatment was the most efficient soil management practices for obtaining more yield as well as conservation soil and water resources for rainfed agriculture in Mediterranean climates.

1. Introduction

Tillage as a part of a cropping system is one of the basic agriculture operations because of its influence on soil properties, environment and crop growth (Sharma et al., 2011). There are some short and long term reasons for soil tillage including optimization of soil temperature and moisture, acceleration of germination, improvement of seedling establishment, enhancement of root development and minimizing the weed competition as the short term reasons; and maintenance of soil productivity and sustainable management of soil and water resources as the long term reasons. Since continuous soil tillage influence the soil properties (physical, chemical and biological), it is important to use appropriate tillage systems that avoid the degradation of soil structure, maintain crop productivity and provide sustainable agriculture system (Aina, 2011). The different aspects of water management such as soil water management and water resources management and crop yield have been investigated in the previous works (Valipour, 2015a; Valipour et al., 2015). Responses of soil and crop to tillage systems vary between soils and climatic zones, and their identification is important in the choosing of appropriate tillage systems for optimizing crop production in a particular region. The suitability of a tillage system in achieving the short and long term targets of crop production is determined by its effectiveness in soil and water conservation (Baker et al., 2005).

Conservation tillage can cause to some improvements of the water storage in the soil profile, loosens the soil and decreases soil bulk density (Moreno et al., 2001). However, conservation tillage (i.e., no-tillage and reduced tillage) is recommended as a means to control erosion and to increase water storage. No-till system has allowed farmers in the semi-arid regions to intensify the frequency of cropping and increasing the frequency of cropping has been successful (more yield performance) when reduced tillage system is used (Halvorson et al., 2001). Different studies have shown

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http://dx.doi.org/10.1016/j.still.2016.04.010
0167-1987/

ecological benefits as well as economic advantages of conservation tillage (Fischer et al., 2002; Bueno et al., 2006). Conservation tillage leads to greater macro-porosity, amount of continuous and interconnected pores, improve soil quality and enhancing crop productivity (McGarry et al., 2000; Wiermann and Horn, 2000). Physical properties of soil have an important effect on the different soil processes from physical, chemical and biological aspects and application of conservation tillage system can maintain them in an optimal mode (Mielke and Wilhelm, 1998). According to Valipour (2015b), links between water and other development-related sectors such as population, energy and food require reckoning, as they together will determine future food security.

Crop responses to tillage systems are different due to the relatively complex interactions among soil edaphic, crop requirements, and climatic condition. Thus, the suitability of conservation tillage systems needs to be locally evaluated before their recommendation to farmers. Cereal and legume crops respond differently to no-till and reduced tillage practices (Camara et al., 2003; Hemmat and Eskandari, 2006). Yield performances variability under conservation tillage systems still remain major concerns among agronomists. High yield performances are usually are obtained due to increased water conservation or utilization by the crop while low yield performances are observed due to greater disease and weed infestations (McMaster et al., 2002). Winter wheat (*Triticum aestivum* L.) is an important, well-adapted grain crop under rainfed condition of the west of Iran, where receiving 350–500 mm rainfall, and is grown commonly in a rotation with chickpea (*Cicer arietinum* L.). Compared to irrigated agriculture, rainfed dose not increase waterlogging and salinity in agricultural fields (Valipour, 2014). The yield performances of the mentioned crops in such areas are determined by poor physical properties, soil fertility, and climatic factors dictating water availability.

Conventional tillage methods used byfarmers result in physical degradation of soil and increased soil erosion problem in semi-arid areas while conservation tillage systems have been demonstrated to result in equivalent crop yield performance compared to conventional tillage over a wide range of environmental conditions (Hashemi-Dezfuli and Herbert, 1996). The comparison of different tillage systems has been performed in many areas of world and the influence such systems on the yield performance in different crops have been studied (Xu and Mermoud, 2001; Beyaert et al., 2002). However, influence of tillage systems on crop yield productivity and soil physical properties of upland rainfed of Iran is not well documented. Some researches have studied different tillage methods on productivity of wheat and chickpea in Iran (Hemmat and Eskandari, 2004a,2006), but such investigation has not been performed under cold rainfed conditions in west of Iran. This study was carried out to study the effect of different tillage systems on productivity of wheat and chickpea, some morphological traits, economic value and some soil properties under cold rainfed conditions, in west of Iran.

2. Materials and methods

2.1. The site description

Two experiments were conducted at Sonqor Kulliye (34°47′N 47°36′E), west Iran, during three growing seasons (2012–2014). The experimental site was 85 km northeast of Kermanshah, at an average altitude of 1700 m. Its average annual precipitation is around 535 mm, i.e. 270 mm higher than the mean annual precipitation of Iran and the average annual temperature is about 11.2 °C. Annual rainfall during this investigation was 455.5, 326.6 and 406.2 mm for 2012, 2013 and 2014, respectively, which on average, over 90% of rain falls between November and March. Mean temperature during growing season (March to June) was 13.1, 12.9 and 12.8 °C for 2012, 2013 and 2014, respectively. From 1982–2012, wheat and chickpea were grown in a 2-year rotation with conventional tillage system. The soil is a sandy loam which is representative of arable land in the west of Iran and is classified as a Typic Xerorthens type. The climate is characterized by a cold and rainy winter, and a moderate and dry summer. The soil analysis results of site are presented in Table 1.

2.2. The experiments condition

The first year trial (2012) was performed as a randomized complete block design layout with five replicates. Three tillage treatments including no-tillage, reduced tillage and conventional tillage systems were performed and chickpea (cultivar ILC482) was sown via pneumatic seed drill of Trashkadeh Company, Iran (Model AMAT-1450). The next 2-year trials were performed as a split-plot experiment in a randomized complete block design layout with five replicates. Therefore, both parts of the rotation were present both years and wheat and chickpea grown in rotation in the splits interchangeably. Tillage systems (no-tillage, reduced tillage and conventional tillage) were placed in main plots. No-tillage treatment was performed with a no-till seed drill (ASKE-2200 of Sazeh Kesht Kaveh Company, Iran) in 5 and 15 November 2013 and 2014, respectively. The reduced tillage treatment was performed with a chisel plow equipped with 43 cm sweeps and the conventional tillage treatment was performed with a 3-bottom general purposed mouldboard plow equipped with share points and cultivation was done by deep seed drill of Keshtgostar Company, Iran (Model DD-225). Crop residues were not removed. Tillage systems were performed around 5, 10 and 15 November 2012, 2013 and 2014, respectively. The depth of plowing in reduced tillage and conventional tillage systems were 10 and 20 cm, respectively and their plots were subsequently smoothed to a depth of 8–10 cm deep with a tandem disk.

Main plots were 10.0 m long × 8.0 m enough edge was left for the machinery operations. Wheat and chickpea seeds were sown in rows of 17 and 50 cm apart, respectively. Triple super phosphate fertilizer was broadcasted by hand at the rate of 100 kg ha^{-1} on wheat plots before sowing. Nitrogen fertilizer as urea was broadcasted by hand at the rate of 50 kg ha^{-1} on wheat plots before sowing and at the rate of 50 kg ha^{-1} before stem elongation. For chickpea plots, only triple super phosphate fertilizer was broadcasted by hand at the rate of 50 kg ha^{-1} before sowing. The grass weeds (*Avena ludovicana* Thell. *Hordeum spontaneum* Koch. *Bromus tectorum* L.) and broad-leaved weeds (*Galium tricornutum* Dandy. *Vicia hyrcanica* Fisch. *Vaccaria grandiflora* Fisch. *Anthemis cotula* L.) of wheat plots were controlled with Topic (Clodinafop-propargyl) + Granstar (Tribenuron methyl) herbicide by spraying while only broad-leaved weeds of chickpea plots were controlled with Super Gallant (Haloxyfop-*P* methyl ester) herbicide with spraying and grass weeds of chickpea plots were controlled manually. Winter wheat (cultivar Azar-2) was planted at a depth of 4 cm and a seed rate of 180 kg ha^{-1}, and chickpea (cultivar ILC482) was planted at a depth of 6 cm and a seed rate of 75 kg ha^{-1} with the above mentioned equipment.

Table 1
Results of soil analysis in Sonqor Kulliye.

EC (ds m)	pH	K (mg/kg)	P (ppm)	N (%)
0.1	7.8	800	0.1	0.136
Clay (%)	Silt (%)	Sand (%)	OC (%)	
35.76	18.56	45.68	1.36	

OC, Organic carbon.