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Impact of zero tillage on rice-wheat cropping systems in Haryana

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Abstract

The present study was conducted to evaluate the long term effect of zero-tillage practices on physico-chemical properties of soil at 0-15 and 15-30 cm depth under rice-wheat cropping system in Karnal. Soil texture was loamy at Karnal sampling sites and results of the study revealed that pH, EC and BD (bulk density) was not significantly affected by zero-tillage (ZT) practices. On adopting ZT, soil organic carbon (SOC) increased from 0.49 to 0.52% at surface soil and 0.41 to 0.43% at sub-surface soil in comparison to CT. More available N, P, K, and total N were recorded in surface soil samples under zero tillage as compared to conventional system, however, C:N ratio was observed to be slightly affected by this management practice. Therefore, the ZT practices resulting, improved SOC, can be suitable for improving productivity and soil health under the rice- wheat cropping system (RWCS).

Keywords: Cropping system, crop productivity, soil quality and zero-tillage

Introduction

Soil quality highly depends on its structure, natural productivity and human influence. Tillage is the mechanical disturbance of the soil through plowing, cultivation or digging and has been used by the farmers since ancient time (Busari *et al.*, 2015) [4]. There are a number of advantages of tillage as it incorporates biomass in deeper layer of soil, fertilizers, manure and residues to the soil; optimize the bulk density; helps to maintain soil aeration; release nutrients from organic matter in available forms; controls several soil and residue born diseases and pests through residue incorporation (Hobbs, 2007) [10]. Tillage systems influence physico-chemical and biological properties of soil and have a major impact on productivity and sustainability (Giller *et al.*, 2015) [8]. Conventional tillage practices may adversely affect long-term soil productivity due to erosion and loss of organic matter in soils. As an alternative to conventional practices, zero-tillage have shown its effectiveness in sustaining and improving productivity of rice-wheat crop systems (RWCS) at the same time preserving scarce natural resources such as energy, labour, time, water and environment quality (Dikgwatlhe *et al.*, 2014) [5]. Sustainable soil management can be practiced through conservation tillage (including no tillage), high crop residue return, and crop rotation (Hobbs *et al.*, 2008) [11]. Studies conducted under a wide range of climatic conditions, soil types and crop rotations showed that soils under no- tillage and reduced tillage have significantly higher soil organic matter contents compared to conventionally tilled soils.

Conservation tillage is the practice in which at least 30% of crop residues are left in the field during sowing, thus reduce soil erosion (NRC, 2010) [19]. The advantages of conservation tillage practices over conventional tillage include reducing cultivation cost, allowing crop residues to act as an insulator and reducing soil temperature fluctuation, building up soil organic matter and conserving soil moisture. Different tillage practices cause changes in soil physical properties, such as bulk density (Singh *et al.*, 2018) [25] and stratification of soil organic matter has been observed in long-term conservation tillage system (Kushwa *et al.*, 2016) [17]. Thus, altered soil physical and chemical conditions under conservation tillage create significantly different habitats for microorganisms and shift in soil microbial community structure (Kandeler *et al.*, 1999) [13]. Conventional tillage can lead to soil microbial communities dominated by aerobic microorganisms, while conservation tillage practices increase microbial population and activity as well as microbial biomass (Balota *et al.*, 2003) [2].

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Despite economical and environmental benefits from low-intensity tillage systems, its adoption is still low due to reduced tillage and, especially, no tillage often results in lower crop yields than the conventional tillage system which is caused by soil compaction, residue management, germination problems and weed and pest incidence (Mankeviciene *et al.*, 2012) [18]. Nevertheless, long-term no tillage application increases organic carbon content, positively affecting not only soil structure, but also microbial activity (Desanctis *et al.*, 2012) [6]. The influence of tillage systems on the total soil organic matter content is detectable only after several years of its application. Microbial activity responds quickly to disturbances in a shorter period of time than other parameters. The specific objective of the study was to observe soil physico-chemical properties of soil under different tillage systems following rice-wheat cropping system in Karnal district of Haryana.

Materials and methods

Soil Samples

To study the effect of conservational practices on physico-chemical properties of soil under rice-wheat cropping systems, soil samples (0-15 and 15-30 cm depths) were collected from Karnal fields located at Haryana after harvesting of wheat, having following treatments:

1. No-till – no till
2. Conventional till-Conventional till

Preparation of soil for analysis

The soil samples collected were sieved through 2 mm sieve for different analysis.

Analytical methods

Bulk density (BD): Bulk density of oven dried soil samples was determined by volume-mass relationship by packing the soil material through tapping in a cylinder of known volume and from the measured weight of the soil in the cylinder.

Chemical properties

Soil pH, Electrical Conductivity (EC) and Organic Carbon

To measure the pH and EC of different soil samples, five-gram soil was mixed with 12.5 ml of distilled water. It was shaken for 30 minutes and pH of soil suspension was measured at room temperature with Systronics 331 pH meter and EC was measured with Naina electrical conductivity meter. The organic carbon content in different soil samples was determined by the method of Kalembassa and Jenkinson (1973) [14].

Total N, P and K

Total nitrogen content in different soil samples was estimated by Kjeldhal's method (Bremner, 1965). The total phosphorus content of different soil samples was determined by the method of John (1970) [12]. The total potassium content in soil samples was estimated on flame photometer as described by Antil *et al.* (2002) [1].

Available N, P and K

Available nitrogen content of soil was determined by alkaline permanganate method (Subbia and Asija, 1956) [27]. Available phosphorus was estimated by using Olsen's method and available potassium was estimated on flame photometer as described by Hanway and Heidal, 1952 [9].

Statistical analysis

To assess the effects of different tillage practices on the soil properties, the RBD statistical programme was used for two way analysis of variance (ANOVA).

Results and discussion

Soil texture: The texture of different soil samples collected from conventional and conservationally cultivated farms was loamy.

Effect of tillage on bulk density (BD)

Soil compaction remains a concern for farmers and scientists, especially in ZT system and the long-term zero tillage in RWCS under present study affected the soil bulk density that was lower in 0-15 cm soil layer as compared to 15-30 cm depth under CT and vice-versa under ZT. The bulk density under CT was 1.62 and 1.63 mgm^{-3} at 0-15 and 15-30 cm depth, respectively, and under ZT, corresponding values were 1.72 and 1.66 mgm^{-3} . Stanek-Tarkowska *et al.*, (2018) [26] also reported increased bulk density under reduced tillage at the 0-5 and 5-10 cm depths by 0.11 and 0.05 g cm^{-3} , respectively, as compared to traditional tillage.

Effect of tillage on pH, EC and organic carbon (OC)

The pH of soils under CT was 7.7 and 7.4 at surface and subsurface layer, respectively, and upon adoption of zero-tillage the values were 7.7 and 7.6 at 0-15 and 15-30 cm depth, respectively. Although, a slight change in pH was observed upon adoption of zero-tillage practice but no significant difference was observed between the two systems (Table 1). The results are similar with the observations of Singh *et al.*, (2014) [24] that CT and ZT had similar soil pH at surface layer though soil pH showed higher values under ZT at subsurface layer but the differences were not significant because the surface soil becomes more acidic under ZT practices than that under conventional practice. The lowering of pH in surface layer under CA-based system has been attributed to build up of soil organic matter and release of organic acids upon decomposition in the surface layer.

Conservational tillage had not much effect on EC contents of Karnal soils at 0-15 and 15-30 cm depth as compared to conventional tillage which might be due to buffering capacity of soils based on carbonate contents which resisted change in EC of soils during organic matter decomposition under conservational tillage. Similar findings were reported by Khan *et al.*, (2017) [16] in terms of an increased EC under NT which might be due to minimized leaching of nutrients along with water and enhanced nutrients availability under NT but in contrast, Roldan *et al.*, (2005) [23] reported that EC was not affected by the tillage practices.

The long-term ZT practice in RWCS resulted in accumulation of organic matter in soils surface layer whereas effect on C:N ratio was non-significant (Table 1). Increase in organic carbon (OC) was observed at 0-15 cm depth in loam soil which indicated build up of OC to a deeper depth with increase in fineness of soil texture. Studies that compared soil organic carbon content under ZT and CT have, however, reported inconsistent results with Busari and Salako (2015) [4] and Kaushik *et al.*, 2018 [15] who found that OC was higher under zero tillage system as compared to conventional tillage system.

Table 1: Effect of conventional and zero tillage on soil pH, EC, organic carbon and C:N ratio under rice-wheat crop rotations

Tillage	EC (dS/m)		pH		Organic carbon (%)		C:N ratio	
	Depth (cm)							
	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
CT	0.35	0.39	7.7	7.4	0.49	0.41	8.90	8.72
ZT	0.36	0.41	7.7	7.6	0.52	0.43	8.52	8.26

C.D. at 5%

Factors	pH	EC	Organic carbon	C:N ratio
A (Tillage)	NS	NS	0.023	NS
B (Depth)	NS	NS	0.023	NS
A X B	NS	NS	NS	NS

Effect of tillage on N, P and K content

Changes in total N, P and K content of soils under RWCS are shown in Table 2. The major affect produced by no-tillage RWCS was on total N, P and K at surface layer under CT and ZT. The findings are similar with the observations of Neugschwandtner *et al.*, (2014)^[20] in respect of total N, P and K content which were significantly influenced by tillage with depth but no rotation effect was observed and total N, P and K was higher at 0–10 cm than at 20–30 cm depth in no-till (NT) compared to shallow conventional tillage (CTs). An accumulation of P and K with reduced tillage (NT and CTs) occurred in the upper soil layers and depletion in the deepest sampled soil layer over time, therefore, NT resulted in an increase of P and K at 0–15 cm depth compared to CT. Similar observations were reported by Dorr de Quadros *et al.*, (2012)^[7] for the total N and P and found that N and P content

were significantly higher in the no-tillage system because of high microbial diversity and high accumulation of soil organic matter.

There was significant influence of tillage on available N, P and K content after RWCS at both 0-15 and 15-30 cm depth (Table 2). The available N, P and K content under ZT was 172, 12.9 and 231 kg ha⁻¹ at surface layer while at subsurface layer the respective values were 161, 12.1 and 218 kg ha⁻¹. Yadav *et al.*, (2016)^[28] reported 219.8, 24.9 and 203.1 kg ha⁻¹ of N, P and K at 0-15 cm soil after seven years of conservational tillage which was minimum under CT and similar results were reported by (Ram *et al.*, 2018)^[22] that available macro nutrients like N, P and K were higher at surface soil (0-5 cm) as compared to sub surface soil (10-15 cm) after rice-crop may be due to more organic matter accumulation at surface layer under no-tillage.

Table 2: Effect of conventional and zero tillage on total and available N, P and K content of soil under rice-wheat crop rotations

Tillage	Total N (%)		Total P (%)		Total K (%)		Available N (Kg/ha)		Available P (Kg/ha)		Available K (Kg/ha)	
	Depth (cm)											
	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
CT	0.055	0.047	0.33	0.28	0.89	0.82	159	152	12.4	11.6	224	202
ZT	0.061	0.052	0.39	0.34	0.99	0.85	172	161	12.9	12.1	231	218

C.D. at 5%

Factors	Total N	Total P	Total K	Available N	Available P	Available K
A (Tillage)	0.05	0.025	0.025	5.746	0.392	2.629
B (Depth)	0.05	0.025	0.025	5.746	0.392	2.629
A X B	NS	0.035	0.035	NS	NS	3.719

Conclusion

Zero-tillage under RWCS influenced various physico-chemical properties of soil which may affect crop growth and productivity by nutrient conservation.

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