Available online at www.sciencedirect.com
ScienceDirect
Soil & Tillage Research 98 (2008) 11–16
Soil & Tillage Research
www.elsevier.com/locate/still

Tillage and residual organic manures/chemical amendment effects on soil organic matter and yield of wheat under sodic water irrigation

N.P.S. Yaduvanshi *, D.R. Sharma

Division of Soil and Crop Management, Central Soil Salinity Research Institute, Karnal 132001, India

Received 15 June 2006; received in revised form 10 September 2007; accepted 24 September 2007

Abstract

The effect of no-tillage (NT) and conventional tillage (CT) practices applied either with NP fertilizer alone or in conjunction with gypsum or farm yard manure (FYM) or sulphitation pressmud (SPM) were evaluated on soil organic carbon (SOC), soil pH, sodium absorption ratio (SAR), infiltration rate, water saving and grain yield of wheat grown with sodic water in rice (*Oryza sativa* L.)–wheat (*Triticum aestivum* L.) rotation at Central Soil Salinity Research Institute Research Farm, Kaithal, India. In NT treatment the residue of previous rice (15 cm height) crop was left on the surface whereas in CT treatment no crop residue was involved. NT practice increased SOC and infiltration rate in all treatments. The mean organic carbon in 0–15 cm soil layer at the end of study was 3.17 g kg^{-1} in NT treatment against 2.84 g kg^{-1} in CT treatment. Organic carbon improvement in NT treatment was reflected in grain yield increament. Soil pH was lower in NT than CT treatment. In general, wheat yield increased with the increase in nitrogen (N) and phosphorus (P) fertilizer doses. The grain yield in the NT treatment remained below the CT treatment during the first year (2001) but was greater than CT treatment during the next two years (2002 and 2003). However, the average yields data for the three years remained statistically non significant. In NT practice, 32.44 cm irrigation water was used each year as compared to 39.66 cm in CT practice. No-tillage, thus, saved 7.22 cm of irrigation water. The results emphasized the necessity of using N120P26 kg ha^{-1} fertilizers dose with FYM or SPM or gypsum under NT practice for improving soil organic matter and sustaining wheat production under condition of sodic water irrigation.

Keywords: Soil organic carbon; Infiltration rate; Soil pH; No-tillage; Conventional tillage; Rice–wheat system; Sodic water

1. Introduction

Despite its negative environmental impact, the rice–wheat rotation is a popular and profit making cropping system for the farmers of Indo-Gangetic Plains of Northern India. It occupies about 9.8 million hectares area in this region (Yadav, 1998). Rice (*Oryza sativa* L.)–wheat (*Triticum aestivum* L.) is also grown on a sizable area with sodic water in conjunction with gypsum in the presence of adequate rainfall (Sharma et al., 2001). Soils irrigated with sodic waters are excessively poor in organic matter, soil fertility and physical properties and produce little biomass.

It is therefore essential that an alternative tillage option to augment their organic matter be evaluated. The zero-tillage or minimum tillage coupled with residual effects of integrated use of organic manures and chemical fertilizers practices is likely to boost soil fertility and organic matter status of such soil. The practice of zero-tillage is picking up as an energy saving and economical preposition in the fertile alluvial belt of normal soils in India particularly in areas planted with

* Corresponding author. Fax: +91 184 2290480.
E-mail address: npsingh@cssri.ernet.in (N.P.S. Yaduvanshi).

0167-1987/$ – see front matter © 2007 Published by Elsevier B.V.
doi:10.1016/j.still.2007.09.010

long duration basmati rice which often results in to delayed wheat sowing.

In temperate regions, the no-tillage concept of soil management has been adopted with some success. Similarly in north-west India and Pakistan, the beneficial role of zero-tillage on wheat yield has been widely reported (Aslam et al., 1993; Sheikh et al., 1993; Malik et al., 2002; Singh et al., 2002; Hobbs and Gupta, 2003). Studies by Bhagat and Acharya (1988) and Bhagat and Verma (1991) also reported that incorporation of plant residues, coupled with appropriate tillage, increases soil organic carbon and if used as mulch, modifies soil temperature. Similarly the beneficial effects of residue mulch with minimum tillage for improving soil quality and sustaining maize–wheat cropping system were also reported later by Ghuman and Sur (2001). Malik et al. (2002) and Singh et al. (2002) reported that zero-till produced higher average yield of wheat in comparison to produced by conventional tillage in Haryana, India. Although much is known about the changes in soil properties due to soil tillage, relatively little information is available on changes the tillage operation brings in chemical and physical properties of reclaimed sodic soil under sodic water irrigation. The major objective of this study was, therefore, to study the effects of tillage, crop residue and residual effect of organics on soil quality and grain production in rice (*O. sativa* L.)–wheat (*T. aestivum* L.) rotation on sandy loam soils irrigated with sodic water.

2. Materials and method

2.1. Experimental site

A field experiment was conducted at Bhaini Majra Farm, Kaithal of Central Soil Salinity Research Institute Karnal (29.79°N latitude; 76.45°E longitude) from June 2001 to April 2004. The soil texture is sandy loam. The soil is classified as Typic Ustochrept according to Soil Taxonomy (Soil Survey Staff, 1999). The initial experimental soil properties are given in Table 1.

Table 1
Initial surface soil (0–15 cm) analysis of experimental site

Soil properties	Mean	S.D.
pH	9.1	0.08
Sand (%)	52.4	0.84
Silt (%)	25.1	0.39
Clay (%)	22.5	0.26
Sodium absorption ratio (SAR) $(mmol/l)^{1/2}$	16.9	0.63
Organic carbon (g kg^{-1})	2.10	0.04
Available N (kg ha^{-1})	112.0	1.38
Available P (kg ha^{-1})	23.3	0.39
Available K (kg ha^{-1})	286.0	7.53
DTPA extractable Zn (kg ha^{-1})	1.06	0.10

2.2. Tillage experiment

Experiment was laid out as a randomized complete block in a split plot treatment arrangement with four replicates. The main plot treatments were: (1) no-tillage (NT) with residue of previous rice (15 cm height) crop left on the surface and (2) conventional tillage (CT) without residue. The sub plot treatments included nine combinations of fertilizer and organics viz.: control without fertilizer and organics, 75% NP recommended doses (N 90 + P 19.5 kg ha^{-1}), 100% NP recommended doses (N 120 + P 26 kg ha^{-1}), 75% NP recommended doses + gypsum 5 t ha^{-1}, 75% NP recommended doses + sulphitation pressmud (SPM) 10 t ha^{-1}, 75% NP recommended doses + farm yard manures (FYM) 10 t ha^{-1}, 100% NP recommended doses + gypsum 5 t ha^{-1}, 100% NP recommended doses + SPM 10 t ha^{-1} and 100% NP recommended doses + FYM 10 t ha^{-1}. However, the use of gypsum as soil or water amendment is commonly recommended to offset the deteriorating effects of sodic water. The FYM (a organic manure) and SPM (a waste of sugar industry) are also in practice. The inorganic NP fertilizer and organics were applied to rice crop as per treatments.

Rice cv IR 64 (30 days old seedling) was transplanted in standing water (5 ± 1 cm) in the first week of July at a spacing of 20 cm between rows and 15 cm between plants. A basal application of 40 kg N/ha as urea and 26 kg P/ha as single super phosphate were applied at the time of rice transplanting and remaining dose of nitrogen (80 kg N as urea) was top-dressed in two equal splits at 21 and 40 days after rice transplanting. The crop was irrigated with sodic ground water as and when required. The analysis of irrigation water is presented in Table 2. The crop was harvested in the third week of October. The cultural practices of crop were similar under both the tillage systems for the rice crop.

Table 2
Irrigation water analysis

Water properties	Mean	S.D.
pH	9.00	0.11
EC (dS m^{-1})	2.01	0.012
Residual sodium carbonate (RSC) (meq. l^{-1})	8.50	0.11
Ca + Mg (meq. l^{-1})	9.00	0.12
CO_3 HCO_3 (meq. l^{-1})	17.5	0.65
Na (meq. l^{-1})	18.6	0.56
SAR $(mmol/l)^{1/2}$	8.8	0.26