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Research Article

Effect of Tillage, Residue Management and Cropping System on the Properties of Soil

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Abstract

A field experiment was conducted to evaluate the effect of tillage practices, residue management and cropping system on soil properties at NMRP, Rampur, Chitwan from November 2015 to April 2016. The experiment was laid on Strip split design with combination of 12 different treatments i.e, zero tillage & conventional tillage as main plot in the strip, residue retention & residue removal as sub-plot factor and maize – wheat, maize + soybean – wheat & soybean – wheat cropping system as sub-sub plot factor. Three replications of the treatments were made. Soil sample before experiment and after harvest of wheat was taken (0-15cm). The experiment showed significant effect of zero tillage on organic carbon (2.169%) and on total soil nitrogen (0.112 %). Zero tillage with retention of residues is valuable tool for the conservation agriculture and helps in sustainability of soil however long-term research for the tillage management and residue retention should be conducted to highlight the major effects on change in properties of soil.

Key words: Zero-tillage; residue management; tillage practices; organic carbon; soil nitrogen

Introduction

Sustainable agriculture simply implies farming with wisdom. In sustainable farming, no any serious damage is caused to the soil, plant, environment, water bodies, human beings and animals. A profitable farm producing high quality of food in adequate amount, protecting its resources being environmentally safe and independent to purchasing of materials such as fertilizers is said to be sustainable. Sustainable farm relies much on the renewable resources drawn from the farm itself (Papendick & Parr, 1990). Sustainable farming involves the profitable production and marketing of high quality products.

Tillage is defined as mechanical manipulation of soil aiming to provide favorable environment for good germination of seeds and production of healthy. Tillage helps to control the weeds, maintains the infiltration capacity and soil aeration. Favorable environment suitable for better germination and effective plant growth is provided by well-planned tillage. Additonally, it protects and maintains a strong soil structure and hence reduces soil

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erosion (Wolkowski, 1996). Aim of tillage is to create soil environment favorable for plant growth (Klute, 1982).

Different tillage system and tillage intensity has different effect on soil physical, chemical and biological properties of soil (Ishaq *et al*., 2002). The contradictory results on soil properties as effect of different tillage system 'may be due to differences in crop species, soil properties, climatic characteristics and their complex interactions (Ishaq *et al*., 2002). Thus, study on effect of tillage on soil properties should be done for long-term so that more accurate generalizations can be made regarding the conditions required for sustainable tillage systems (Ishaq *et al*., 2002). Therefore, it is necessary to examine the long-term effects of tillage at different locations and under various environmental and soil conditions so that more accurate generalizations can be made regarding the conditions required for sustainable tillage systems (Ishaq, *et al*., 2002).

Minimum tillage generally coincides with the retention of crop residues, and it can play major role in improving the sustainability of cropping. Crop residues act as a sink and source for the plant nutrients (Hubbard & Jordan, 1996). Different crop residues have different capacity to serve as sink and source of nutrients for crop yield depends largely on climatic conditions, soil properties, crop characteristics and tillage practices (Doran & Smith, 1991).

Materials and Methods

Layout and Experimental Design

The field layout was done in strip split plot design with altogether of 12 treatments and 3 replications. The treatment includes, types of tillage system as main plot (a. zero tillage & b. conventional tillage), residue retention as sub plot (a. residue kept & b. residue removed) and cropping system as sub-sub plot (a. maize, b. soybean & c. maize + soybean).

The individual plot size was 6 m x4 m (24m^2). There was 0.5 m space between two plots and the distance of 1 m was maintained at each replication. The row spacing was maintained at 20 cm with continuous sowing in the row consisting of 30 rows in each plot. There were three destructive rows for taking plant samples for growth analysis. Further, one row was kept as a guard row between net plot and destructive rows from both sides. Outermost two rows of both sides of each plot were used as guard row.

Field Management Practices

The wheat variety Vijay was used as test crop for the research purpose, and the standard seed rate of 120 kg ha^{-1} was used. In conventional tillage strip, the field was plowed twice using the tractor drawn cultivator, double passing each time up to depth of 20 cm. Seed and basal fertilizers were separately applied in rows manually in the conventional tillage strip. In zero tillage strip, the field was sprayed with glyphosate 47% SL before 10 days of sowing with the rate of 10 ml per liter. Wheat seed and fertilizer was drilled at depth of 3 cm by a using tractor drawn inclined plate zero-till drill.

All the plots were fertilized using same level of nitrogen, phosphorous, and potassium. Nitrogen (N) was applied @ 100 kg ha^{-1}, Phosphorus (P_2O_5) @ 50 kg ha^{-1}and potassium (K_2O) @ 50 kg ha^{-1} was applied in rows. Half dose of Phosphorous and potassium and only half dose of the nitrogen was applied at the time of sowing. Remaining nitrogen was applied in two equal splits as top dressings.

Table 1: Details of the treatments detail in a single replication with symbol

S.N.	Symbol	Treatment Detail
1	CTRRM-W	Conventional Tillage + Residue Removed + Maize-wheat
2	CTRRMS-W	Conventional Tillage + Residue Removed + Maize+ soybean-wheat
3	CTRRS-W	Conventional Tillage + Residue Removed + Soybean – wheat
4	CTRKM-W	Conventional Tillage + Residue Kept + Maize- wheat
5	CTRKMS-W	Conventional Tillage + Residue Kept + Maize + Soybean – wheat
6	CTRKS-W	Conventional Tillage + Residue Kept + Soybean – wheat
7	NTRRM-W	No Tillage + Residue Removed + Maize-wheat
8	NTRRMS-W	No Tillage + Residue Removed + Maize+ soybean-wheat
9	NTRRS-W	No Tillage + Residue Removed + Soybean – wheat
10	NTRKM-W	No Tillage + Residue Kept + Maize- wheat
11	NTRKMS-W	No Tillage + Residue Kept + Maize + Soybean – wheat
12	NTRKS-W	No Tillage + Residue Kept + Soybean – wheat

Result and Discussion

Chemical Properties of Soil before Experiment

The result of the chemical properties of soil is presented in Table 2. The Table shows the data on pH of soil, total nitrogen (%), available phosphorous, available potash and organic carbon (%).

Before experiment, all the soil chemical properties were found to be non-significant to each individual treatment. This is due to short term trial. This result was also similar to the research of (Comia, Stenberg, Nelson, Rydberg, & HaÊkansson, 1994). However, the highest soil pH (4.375) was recorded in maize + soybean – wheat cropping system and the least soil pH (4.275) was recorded in soybean-wheat cropping system. Total nitrogen (0.081%), available phosphorous (61 kg ha^{-1}) and organic carbon (1.691%) was observed to be highest in no tillage methods and they were observed to be least in conventional tillage methods. Highest available potassium (257.645 kg ha^{-1}) was recorded in plot kept with residue and least was recorded in the plot where there was no retention of residue. No any other interaction effects were observed in between different treatments. Average soil pH, total nitrogen (in percentage), available phosphorous, available potassium and organic carbon (in percentage) was calculated to be 4.331, 0.074%, 59.491 kg ha^{-1}, 277.453 kg ha^{-1} and 1.493 % respectively.

Table 2: Effects of tillage methods, residue management and cropping system on soil chemical properties before experimentation at Rampur, Chitwan, Nepal during winter season of 2015/16

Treatments	Soil chemical properties				
	pH	Total Nitrogen (%)	Available P_2O_5 (kg ha^{-1})	Available K_2O (kg ha^{-1})	Organic carbon (%)
Tillage Methods					
Conventional Tillage	4.361	0.067	57.722	244.709	1.259
No Tillage	4.300	0.081	61.000	249.590	1.691
SEm (±)	0.060	0.005	1.260	13.000	0.117
LSD (=0.05)	ns	Ns	Ns	Ns	ns
Residue Managements					
Residue Removed	4.344	0.069	59.202	237.260	1.458
Residue Kept	4.317	0.078	59.780	257.645	1.529
SEm (±)	0.084	0.004	1.593	7.250	0.052
LSD (=0.05)	ns	Ns	Ns	Ns	ns
Cropping Systems					
Maize – Wheat	4.342	0.076	58.682	249.114	1.473
Maize + Soybean – Wheat	4.375	0.071	58.863	247.586	1.538
Soybean – Wheat	4.275	0.075	60.928	245.658	1.469
SEm (±)	0.052	0.004	0.947	14.750	0.050
LSD (=0.05)	ns	Ns	Ns	Ns	ns
CV, %	4.976	24.971	8.486	19.692	24.859
Grand Mean	4.331	0.074	59.491	247.453	1.493

Note: Mean separated by DMRT and column represented with same letter(s) are non-significant at 0.05 level of significance.

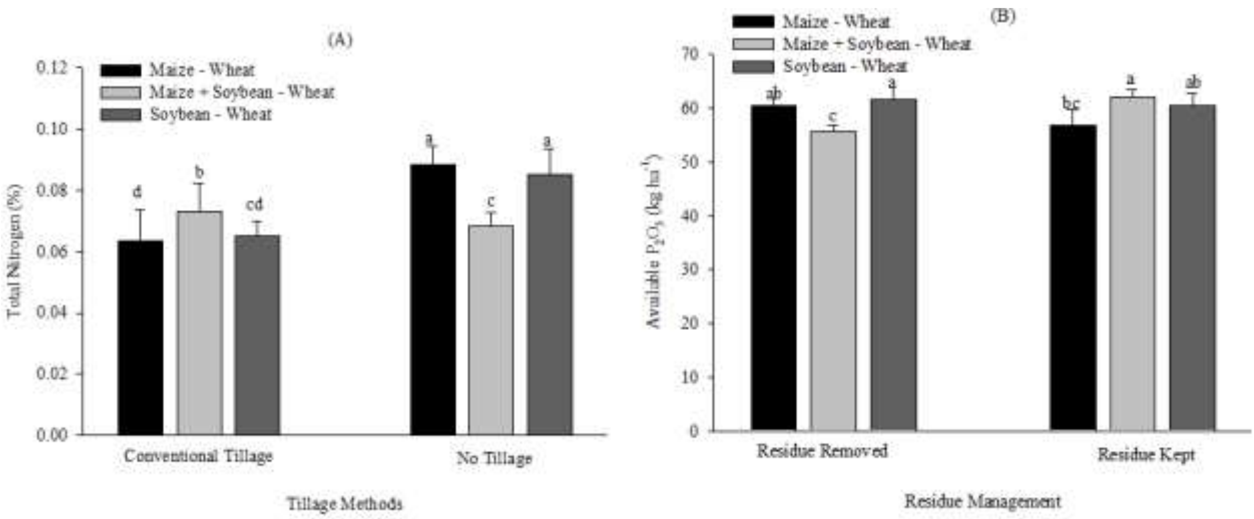

Fig. 1: Total nitrogen % in soil was influenced by interaction of (A) tillage methods and cropping system, and available phosphorous (kg ha^{-1}) in soil was influenced by interaction of (B) residue management and cropping system at Rampur, Chitwan, Nepal during winter season of 2015/16

[Note: Mean separated by DMRT and bars represented with same letter(s) are non-significant at 0.05 level of significance.]

Interaction effect between tillage and cropping system was observed for total nitrogen (%) in the experiment. Significantly higher LAI was observed in maize-wheat cropping system (under no tillage) which was statistically at par with soybean-wheat cropping system (under no tillage). The opposite effect was observed under conventional tillage (Fig. 1A).

For available phosphorous, interaction effect was observed between, residue and cropping system. Under both the residue management, available phosphorous was observed to be significantly higher in soybean-wheat cropping system, which was statistically at par with maize + soybean - wheat in residue kept plot and, it was also statistically at par with maize-wheat cropping system under residue removed plot (Fig. 1B).

Chemical Properties of Soil after harvesting of wheat

Result of chemical properties of soil is illustrated in Table 3. After harvest of wheat, chemical properties of soil, only total nitrogen percentage and organic carbon was found to be significant to tillage and rest of the other were non-significant. Total nitrogen was found to be significantly different in regard to tillage practice with significantly higher total nitrogen percentage being available in no till plot (0.112%) to conventionally tilled plot (0.093%). Soil nitrogen availability might have been influenced by tillage system due to its impact on soil organic carbon and nitrogen mineralization and subsequent plant nitrogen use or accumulation (Al-Kaisi & Licht, 2004). Likewise, organic carbon was significantly higher in no tilled plot (2.169%) in comparison to conventionally tilled plot (1.862%). Retention of residue leads to slow decomposition of the residues on the surface and increased organic carbon and total nitrogen in the top 5-15 cm of the soil but, this was not observed in the experiment as, the residue might not have decomposed in the given time frame.

Though other soil chemical properties were found to be non-significant, after harvest, higher pH was observed in plot with maize-wheat cropping system (4.733), higher available potassium was found in no plot with maize + soybean – wheat cropping system (243.735 kg ha^{-1}). This might be as a result of decarboxylation of organic anions on decomposition by microorganisms in undisturbed soil. But in long-term experiments (6±18 years) a decrease in the pH by 0.2± 0.3 pH-units in the topsoil (0±5 cm) was found after shallow tillage (Rasmussen, 1988). In contrast, higher available phosphorus was found in conventionally tilled plot (86.633 kg ha^{-1}).

Table 3: Effects of tillage methods, residue management and cropping system on soil chemical properties after experimentation at Rampur, Chitwan, Nepal during winter season of 2015/16

Treatments	Soil chemical properties				
	pH	Total Nitrogen (%)	Available P_2O_5 (kg ha^{-1})	Available K_2O (kg ha^{-1})	Organic carbon (%)
Tillage Methods					
Conventional Tillage	4.689	0.093^b	86.633	236.368	1.862^b
No Tillage	4.718	0.112^a	73.240	238.272	2.169^a
SEm (±)	0.100	0.001	3.580	17.880	0.019
LSD (=0.05)	ns	0.009	ns	ns	0.12
Residue Managements					
Residue Removed	4.683	0.101	79.177	234.418	2.014
Residue Kept	4.711	0.105	80.968	241.735	2.025
SEm (±)	0.063	0.007	2.890	9.040	0.113
LSD (=0.05)	ns	Ns	ns	ns	ns
Cropping System					
Maize – wheat	4.733	0.101	78.359	228.682	2.025
Maize + soybean – wheat	4.650	0.104	81.589	243.735	1.954
Soybean – wheat	4.708	0.104	80.269	241.813	2.079
SEm (±)	0.033	0.003	1.880	11.440	0.057
LSD (=0.05)	ns	Ns	ns	ns	ns
CV, %	4.030	15.650	15.150	16.822	12.886
Grand Mean	4.697	0.103	80.073	238.076	2.019

Note: Mean separated by DMRT and column represents with same letter(s) are non-significant at 0.05 level of significance.

Only soil pH was found to have interactive effect by management of crop residue and cropping system. There were no significant differences in the pH level in regard to either of cropping system for residue removed plot whereas, the plot managed with maize-soybean- wheat cropping system in residue retained plot were found to be significantly lower to rest of the plots in experiments (Fig. 2).

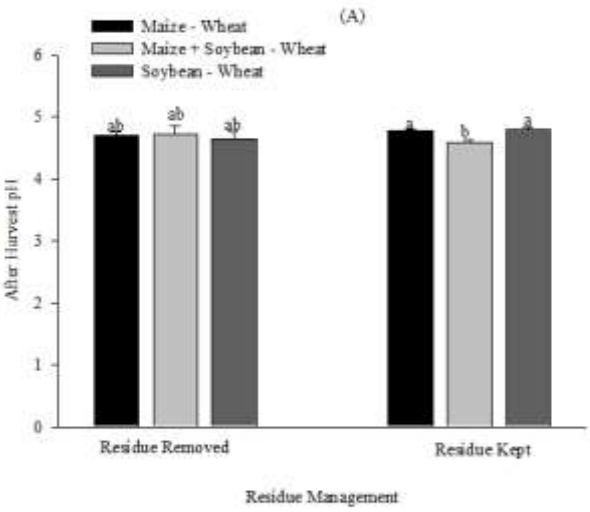

Fig. 2: Soil pH after harvest of wheat was influenced by interaction of (A) residue management and cropping system at Rampur, Chitwan, Nepal during winter season of 2015/16

[Note: Mean separated by DMRT, and bar column represented with same letter (s) are non-significant at 0.05 level of significance.]

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