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A documentation on changing of soil pH and soluble salt by crop residue managements under conservation agriculture in rainfed Vertisol of Central India

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Abstract

The experiment was conducted for intellect's most recent inference from studies on the role of tillage and organic residues to changes in soil reaction(pH)and electrical conductivity (EC). Changes in soil pH and EC influenced by crop residues under three tillage systems namely; conventional tillage with residue burning (CT), reduced tillage with residue incorporation (RT), and no-tillage with residue retention (NT) and having initial soil pH (pH 8.16, 8.17, 8.17 and 8.18) at 0-5, 5-15, 15-30 and 30-45 cm soil depths respectively. Changes in pH were related to crop residue incorporation/retention however, the comparative influence of crop residue on pH declines significantly ($P < 0.05$) at high initial soil pH (8.16). The data also revealed that under conservation tillage (NT and RT) soil pH was lower than conventional tillage at the surface layer (0-5 cm depth). It was also seen that after the end of4th crop cycle soil alkalinity get reducedmainlyunder NT for the maize + pigeon pea (7.45) cropping system followed by maize-gram (7.51), soybean-wheat (7.57), and soybean+ pigeon pea (7.57) at 0-5 cm depth. The results trend depicted that under different tillage systems the order NT < RT < CTwas followed over all the depths. The continuous addition of crop residue and minimal/no disturbance of soil resulted in changes in soluble salt concentration that was negligible across all the depths and it was very well underneath the threshold boundaries. This evidence focuses on a better appreciation of residue chemistry and its relationship with soil environs in order to predict the fluxes in biochemical properties such as pH.

Keywords: *Soil pH, tillage, cropping systems, crop residues, soluble salt concentration*

Introduction

Soil is the most wondrous gift of nature to human society [1]. Globally, more than 800 million hectares (Mha) of cultivated land are estimated to exist salt-affected [2] and in India about 3.78 Mha area is sodic and 2.96 Mha of saline soils out of 6.74 Mha of cultivated land comes under salt accumulated [3]. Conservation agriculture (CA) technologies have been achieving higher productivity in long run [4, 5]. According to Chen et al. (2009) carbon input can be increased and decomposition decreased by adopting residue management and using conservation tillage [6]. Crop residues retained on the soil surface in CA in general, serve a number of beneficial functions, including soil surface protection from erosion, enhancing infiltration [7] and reducing run-off, decreasing surface evaporation losses of water, moderating soil temperature [8] and providing substrate for the activity of soil micro-organisms, and a source of SOC [9]. However, short- and medium-term conservation tillage complicated to identify changes in SOC because of high background C content and its temporal and spatial variability [5, 10, 11, 12]. The addition of organic resources in soil influence crop productivity, over their effect on soil's physical, chemical, and biological properties [13]. All of the chemical reactions depend on the pH [14].

The soil reaction (pH) is a measure of the acidity or

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alkalinity in soils [15, 16]. Noble et al. (1996) also reported the alkalinity process depends on cation content, the chemical composition of residues, and soil environment and also represents the liming potential of residues[17]. Different edaphic factors such as pH, CEC, organic matter content, biological activity, and texture controlled the sequential removal of this alkalinity. The fate of N (mineralisation/ immobilisation) depends on C:N ratio of residues. Furthermore, the chemical composition is also important since a high proportion (~50%) of alkalinity in plant materials is potentially immediately available and also soluble and may have the ability to move through the soil profile[18, 19]. Soil reaction is one of the key concerns joining agricultural productivity and sustainability in India and around the world [20, 21, 22]. Infact due to high rainfall resigns soluble cations (Ca^{2+} and Mg^{2+}) leached out in the lower soil profile, leading behind soil rich in hydrogen (H^+) ions and aluminum (Al^{3+}) and Iron (Fe^{2+}) oxides, which caused soil acidity and infertile [23]. Agricultural residues and other plant materials can have a liming effect when added to soil in the absence of plants and leaching [18, 24, 25, 26]. On the other hand, the biochemical mechanisms for change in pH with organic residues are not completely concluded. However, the amount, type of organic resources and scheduling of residue applications are commonly conveyed by the agricultural management systems and organic plant materials may possibly important for the improvement of pH at surface soil. Ogbodo, (2011) also reported the incorporation of legume and rice residue reduced soil acidity [27].

Decreases in pH after adding crop residues are supposed to arise due to the humification of organic residue [28]. Nitrogenous fertilizers are considered a keycontrivance for pH change, through the exchange of organic nitrogen (N) to ammonium nitrogen (NH_4-N) and later change in to nitrate nitrogen (NO_3- N) and liberating hydrogen ions (H^+) [29]. Leaching of NO_3-N effects in net acidification and or else to be balanced by NO_3 absorption by plant. Additionally, the dissociated H^+adsorbed with organic complexes in the soil and the soil matrix might to be comes to change the soil pH.

Soil pH is considered a prime variable in soils and its affects many chemical and biochemical processes within soil [14]. These chemical variables greatly influence by mineral nutrition of plant roots and the activities of microorganisms are also affected. The mix of plant materials that dominate a landscape under natural conditions often reflects the pH of the soil [30, 31]). Especially affects plant nutrient availability by controlling the chemical forms of the different nutrients and influencing the lot of chemical reactions they undergo under soil systems [32]. Soil reaction depends on the inorganic (mineral) composition of the parent material and soil farming processes. In warm and humid climates chemical reactions are higher, results reduced ash alkalinity, and soil acidification arises over time. However, dry climates reduced the leaching loss and soil comes under neutral or alkaline in reaction [33].

The objective of the experiments reported here was to examine the effect of organic residue and tillage on soil pH change in rainfed agro-ecoregions. Hence, the study was undertaken to find out to (i) evaluate the tillage and crop residue impact on soil pH change (ii) to evaluate the soluble salts concentration under different tillage along with residue addition (iii) to determine the soil organic carbon in tillage and major cropping systems of rainfed condition in Vertisols of Central India.

Materials and methods

Study site and soil sampling

A field experiment was initiated during August 2011 with three contrasting tillage viz., no-tillage (NT), reduced tillage (RT), and conventional tillage (CT) in combination with four cropping systems on soil properties and crop productivity under rainfed conditions in Vertisols of Central India at Research Farm of ICAR- Indian Institute of Soil Science, Bhopal, India. The soils of the experimental area are classified as deep clayey Vertisol (Vertisols, IsohyperthermicTypicHaplustert) having 58% clay, 22% silt, and 20% sand. The geographical co-ordinate of the experimental site is 23°18' N, 77°24' E, and situated 485 m msal. The climate of the area is characterized as hot sub-humid type, with mean annual air temperature, mean annual rainfall, and potential evapo-transpiration are 25^{o}C, 1130 mm, and 1400 mm, respectively.

The experiment was laid down in a split-plot design with three tillage systems as the main treatments and four crop systems viz., soybean + pigeon pea (2:1), soybean - wheat, maize + pigeon pea (1:1), maize – chick pea as the sub-treatments in plots of 10 x 5 m size. The conventional tillage consisted of deep summer ploughing after residue burning and

3 to 4-pass tillage operations using a tine cultivator followed by sowing in *kharif* (rainy season) and *rabi* (winter season) crops. The reduced tillage consisted of one pass tillage operation using a duck foot cultivator and sowing through zero till seed drill in *Kharif* and *rabi* crops and no-tillage consisted of sowing crops without interruption soil by opening a slim slot of sufficient width and depth to shelter the seeds. The experimental soil's initial parametric properties had given in table 1. The recommended dose of fertilizers (soybean 30:60:30; pigeon pea 30:60:60; wheat 120:60:40; maize 120:60:40 and chick pea 40:60:30 ($N:P_2O_5:K_2O$ kg ha^{-1}) was added to the soil before each cropping season. The source of fertilizers was applied urea for nitrogen, single super phosphate (SSP) for phosphorus, and muriate of potash (MOP) for potassium.

Soil analysis

Soil samples were collected randomly from 2-3 locations from the plots at the end of 4^{rd} crop cycles at incremental depths (0-5, 5-15, 15-30 and 30-45 cm) during April 2015 with the help of a core sampler. Therefore, in each depth 36 soil samples and total 144 soil samples were studied. These samples were air dried in a shade house and grained with wooden mortal and petal and passed after removing large plant material through a 2 mm sieve diameter for pH and electrical conductivity and 0.5 mm pass soil samples for organic carbon analysis.

Table 1: Initial physico-chemical properties of experimental soil

Soil parameters	**Value**			
	0-5cm	**5-15 cm**	**15-30 cm**	**30-45 cm**
Soil texture				
Sand (%)	22			
Silt (%)	20		**Clay soil**	
Clay (%)	58			
pH	8.16	8.17	8.17	8.18
EC(dSm^{-1})	0.16	0.14	0.15	0.13

Results and Discussion

Effect of tillage and residue managements on pH

Results of soil reaction (pH) data were significantly ($P < 0.05$) lower than the initial value (8.17) after the completion of four crop cycles (Fig. 1). Overall, 0-5 cm depth recorded relatively lower pH than 5-15 cm and thereafter pH value slightly increased with increasing soil depth or remained more or less same. The result also revealed that tillage systems namely conventional tillage (CT), reduced tillage (RT), and no-tillage (NT) had no significant effect ($P > 0.05$) on soil pH across soil depths. Both cropping systems and the interaction of tillage x cropping systems have shown no significant effect on soil pH value at 0-5 cm soil depths after end of 4^{th}crop cycle. Similar results were reported by Neugschwandtner *et al.* (2014) [10]. However, NT and RT registered lower soil pH compared to CT but were not significantly different ($P > 0.05$). But, Neugschwandtner *et al.* (2014) reported higher pH in CT and mould board plough (MP) was due to acidifying effect and mineralization of organic matter, nitrification of surface applied N fertilizer, and root exudation. Moreover, many researchers have reported that the pH of the surface soil layers under NT may drop drastically owing to the acidifying effect of ammonium-based fertilizers [34, 35, 36]. Similarly, Lopez-Fando and Pardo (2009) have reported that lower soil pH under NT and ZT by 0.3 units was due to acidifying effect in the surface layers than CT at a 0-5 cm [37]. The decrease in soil pH is short-term effect owing to the decomposition of crop residues and also due to the production of organic acids and microbial respiration [38]. Irrespective of soil depth, soil pH data showed no significant trend under different tillage and cropping systems after the completion of 4^{th} crop cycles (Fig. 1). Lower pH in NT was attributed to the accumulation of organic matter in the upper few centimeters under NT soil causing increases in the concentration of electrolytes and reduction in pH [39, 40]. In contrast, Lal (1997) reported a significantly higher soil pH under NT plots compared to those in tilled plots [41]. However, Cookson *et al.* (2008) found that surface soil pH decreased with increasing tillage disturbances [42]. Therefore, tillage may not directly affect soil pH but its effects on pH will depend on the prevailing climatic condition, soil type, and management factors like N fertilizer addition, residue retention/ burning, etc. Moderation in soil pH may be possible if continuous additions of residue are made along with minimum soil disturbances under conservation agricultural practices. The results of the present study corroborate with the findings of Smith and Doran, (1996) who reported that across all depths there was no significant change in pH values and it was very well below the thresholds limits [43].

Across different soil depths, mean data of EC value

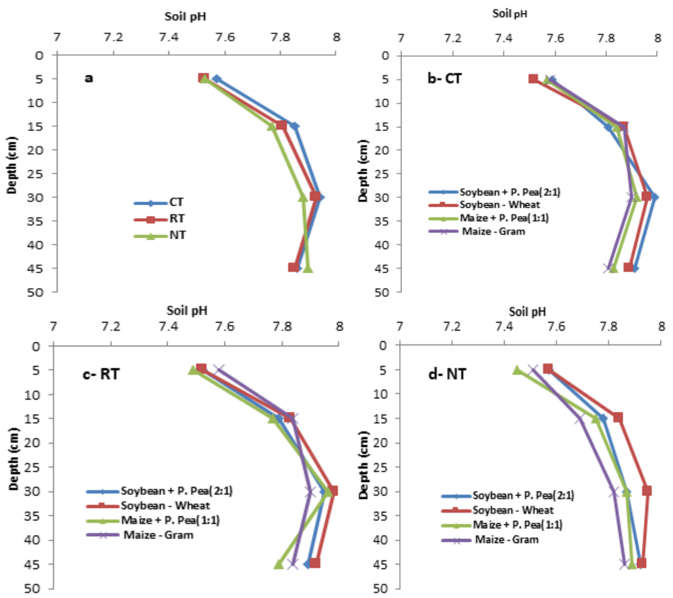

Fig.1: Change in soil pH under different tillage and crop residue management a) pH difference under CT, RT and NT tillage treatments b, c and d) variation in pH under various cropping systems underdifferent tillage CT, RT and NT respectively

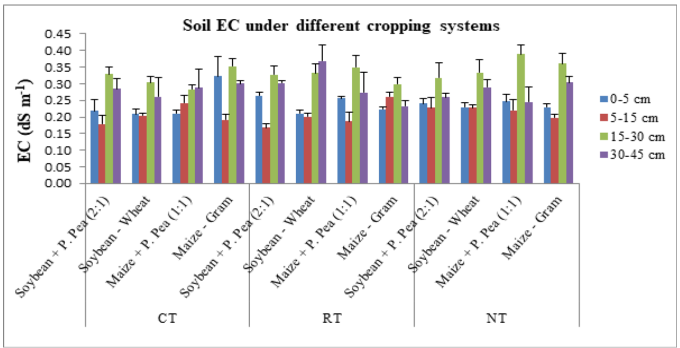

Fig. 2: Change in soil EC under different cropping systems and residue management

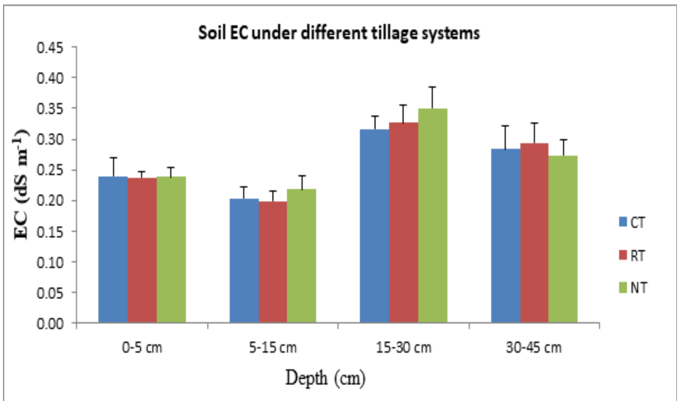

Fig. 3: hange in soil EC under different tillage systems and residue management

varied from 0.21 to 0.34; 0.19 to 0.35; 0.23 to 0.35 dS m^{-1}; 0.20 to 0.32; 0.18 to 0.33; 0.19 to 0.35 dS m^{-1} after third and fourth crop cycles, respectively. Overall, tillage and cropping systems and their interaction effect did not have a significant effect on electrical conductivity at the end of 4th crop cycles of experimentation (fig. 3). Moreover, a negligible change of EC occurred under lower depths across tillage treatments (Fig. 2). Changes in soil EC may be possible if continuous additions of residue along with minimum soil disturbances. The results of the present study corroborate with the findings of Smith and Doran, (1996) who reported that across all depths there was no significant change in EC values and it was very well below the thresholds limits [43]. Dalal (1989) also reported lower soil electrical conductivity under no-tillage than under conventional tillage in Vertisols of Queensland region [12].

Conclusions

The experiment of change in soil pH was influenced by the tillage and crop residue management practices in vertisol. It is evident from the results that no-tillage and reduced tillage with residue retention/ incorporation change the soil pH more than conventional tillage. At the surface layer (0-5 cm) application of chemical fertilizers with organic crop residue greatly influenced soil microbial activities that provide a significant change in soil pH and EC.Changes in soil pH and the addition of organic residues indicate the role of soil organic carbon to enhance microbial activity and maintain a better environment. A noble debt of the bio-chemical process is essential to precisely compute pH changes. Further studies is necessary to explore a varied kind of agriculturally significant residues and employ new technology to understand the interaction chemistry between crop residue and soil environment, especially in black soils.

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