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Soil health and carbon stock as influenced by farming practices in Vertisol of Tamil Nadu

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Abstract
To study the effect of tillage practices in different cropping sequences with nutrient sources on soil health, the experiment was initiated in the Eastern bloc farm of Tamil Nadu Agricultural University, Coimbatore during 2012-13.The soil quality parameters viz., pH, EC, organic carbon, available N, P and K were estimated and the results indicated that, irrespective of cropping and manorial treatments, minimum tillage showed reduced pH, EC and increased organic carbon and available nutrients. Irrespective of tillage and cropping mulch + 75% recommended dose of N through fertilizers and 25% N through organics indicated reduced pH, EC and increased organic carbon and available nutrients. Among different cropping, lower pH and EC recorded in cotton green gram sequence and higher available P and organic carbon recorded in red gram- maize cropping and higher available K and N recorded in vegetable cowpea –sunflower cropping. Higher soil carbon stock recorded in mulch + 75% recommended dose of N through fertilizers and 25% N through organics and soil carbon content in bhendi-maize cropping.

Keywords: tillage, cropping sequences, mulch, fertilizers, organics, soil health

Introduction

Agricultural practices such as reduced tillage and crop rotations have a direct effect on the quantity, quality of the crop residues returned to the soil. In turn, these residues are directly related to the SOC content (Zuber *et al*., 2015) [c], which is a key indicator of soil health and quality. Varvel and Wilhelm (2011) [27] reported that after 20 years, the highest levels of SOC and soil N were found under reduced tillage compared to more intensive tillage. Kumar et al. (2012) [12] found that tillage practices were much more influential on soil properties than cropping system. Tillage has been part of most agricultural systems throughout history because it achieves many agronomic objectives. But, the excessive tillage practices adversely affect soil health, crop productivity and environment quality by affecting soil structure, soil carbon loss and emission of greenhouse gases (Beare *et al.*, 1994) [2]. But conservation tillage effects in retention of more than 30 per cent of crop residue that helps in improving the overall soil quality, carbon sequestration and crop productivity (Tessier *et al.,* 1990) [25]. Conservation tillage improves economic performance and energy efficiency and reduces production risks (Zentner *et al.,* 2002) [31]. He also reported, decrease soil disturbance, improve soil organic carbon (SOC), maintain and benefits soil quality (Zentner *et al.*, 2004) [30]. The area under no tillage has substantially increased in South Asia and particularly the Indo-Gangetic plains (Derpsch *et al.,* 2010) [6].

The surface soil beneath the canopy had higher SOM content in both tillage systems, particularly under no tillage. Wang *et al.* (2008) [29] after their 16 years study reported that continuous long-term conservation tillage practice significantly increased SOM, total N and available p in the surface soil (0 to 10 cm) layer. Many studies have reported lower SOC and water-stable aggregates content in conventional tillage when compared to no tillage (Six *et al.*, 1999) [20]. Also in one of the other study, SOC was significantly higher when stubble was left on surface. Under conservation tillage the organic carbon increased by 11 per cent as compared to conventional tillage after 5 years. Liang *et al.* (2007) demonstrated that no tillage significantly increased the concentration of SOC by 5.6-5.9 per cent on the clay loam soils after 3 years in the humid northeastern china. Hazarika *et al. (*2009) [10] observed 14-17 per cent higher SOC in surface layer under no tillage than conventional tillage, while a reverse trend was observed in the lower depths.

Many researchers have examined the effects on soil properties of crop rotation and tillage independently; the interactive effect of crop rotation and tillage has been less frequently studied. The nutrient sources on soil carbon storage also have many more literatures. The research on the effect of crop rotation, nutrient sources and tillage practices on soils has yielded inconsistent results. Due to the conflicting results of previous research and the specificity of results to soil type and climate, more work is needed to understand how crop rotations and tillage affect the soil. Hypothesize of the research is that both tillage and crop rotation have great impact on soil carbon. The work will be region and soil specific. Thus, the objective of this study was to determine the effect of crop rotation, nutrient sources and tillage on soil carbon stock. The results outcome of this study will be useful to further understanding of the impact of agricultural management practices on properties of Tamil Nadu soils.

Methods

To study the effect of tillage practices in different cropping sequences with nutrient sources on soil health, the experiment was initiated in the Eastern bloc farm of Tamil Nadu Agricultural University, Coimbatore during 2012-13. The treatments are tillage practices (minimum and conventional) and cropping sequences (CS_1: cotton - green gram, CS_2: vegetable cowpea – sunflower, CS_3: red gram – maize, CS_4: bhendi – maize) as main plots and mulch (M_1: No mulch, M_2: crop residue mulch (crop residue recycled as in- situ) and nutrient sources (F_1: Recommended Dose of Fertilizer (RDF), F_2: 75% RDF + 25% N through Organic Manure) as sub plots. Different levels of fertilizers were applied as per treatment schedule for different cropping sequences (table1). The post-harvest soil samples were collected after three years and analysed for carbon content and worked out the carbon stock and other soil health parameters.

The mean maximum and minimum temperature of the study site showed considerable fluctuations during different parts of the year. Summer temperature reaches up to 39°C, while winter in December and January and minimum temperature up to 20.5°C.In the minimum tillage cultivator one time and in the conventional tillage disking followed by cultivator two times followwwed. Soil pH was determined (1:2 soil: water suspension) using a pH meter fitted with a calomel glass electrode. EC of 1:2 soil: water supernatant (kept overnight) was estimated using a sol bridge. Oxidizable soil organic carbon was estimated using (Walkley and Black, 1934) [28] rapid titration method, using a biphenyl amine indicator. Alkaline $KMnO_4$ (potassium permanganate) method as described by Subbiah and Asija. (1956) [22] was used to determine available nitrogen in soil samples. Available phosphorus was determined by extracting the soil samples with 0.5 M $NaHCO_3$, pH 8.5 (Olsen *et al.,* 1954) [15] and measuring the P content in the extract by colorimetric method using a spectrophotometer at 660 nm wavelength using ascorbic acid method. Available potassium content in soil was estimated by extraction of soil with neutral 1N NH_4OAc solution of potassium in the extract was determined using flame photometer as described by Page *et al.* (1982) [16]. The carbon stock was worked out by multiplying carbon content (%) with bulk density (g/cm3) and depth in cm. The initial soil characteristics of the soil properties viz.,pH-8.12,EC-0.30 dS/m, organic carbon-4.8g/kg, available N- 218 kg/ha, available P-17.1 kg/ha and available K 438 kg/ha.

Results and Discussion

The experiment conducted to study the influence of innovative farming practices viz., tillage practices, fertiliser treatments, mulching effect and cropping sequences on soil properties are given below with discussion.

Electrical conductivity (EC)

The data pertaining to EC as affected by farming practices under different cropping sequences is presented in Table 1a. In the cotton- green gram sequence, irrespective of manorial treatments, higher EC was found under conventional tillage (conventional tillage) (0.40 dS/ m) followed by minimum tillage (MT) (0.26 dS/ m). Patni *et al.* (1998) [18] also reported decrease in soil EC under no tillage which might be due to more downward movement of salts along with water infiltration into deeper layers. Similarly, irrespective of tillage practices, with mulch and (with crop residue mulch) recorded lower EC value of 0.35 and 0.28 dS/m than without mulch of 0.38dS/m and 0.39 dS/m respectively. Mulching might have reduced the evaporation loss of water and in turn, the upward movement of salt reduced. Also, the lower temperature recorded in the present experiment itself indication of lower EC value. The similar trend of results observed in all other three cropping sequences viz vegetable cowpea-sunflower, redgram-maize and bhendi maize. Irrespective of cropping and tillage, with mulch +75 % fertilizer + 25 % N through organics recorded lower value (fig1). The released acidity by the crop residue might have contributed for the lower EC value. Among the cropping, cotton-green gram recorded lower EC value (fig2). The mucilaginous substances excreted from the root hairs might have contributed for lower EC value.

Soil pH

Effect of farming practices on soil reaction indicated that, in the cotton- green gram cropping sequence, minimum tillage recoded lower pH value of 8.37 than conventional tillage (8.66). Among the manures, with mulch +75 % fertilizer + 25 % N through organics recorded lower pH of 8.41 (Table2). The interaction is found to be non-significant. The same trend observed in red gram-maize cropping. Other two cropping sequences there was no significant differences observed among tillage or manure or its interactions. Among the manure treatments, though statistically on par values obtained, numerically lower pH value recorded with mulch + 75% recommended dose of N through fertilizers and 25% N through organics followed by mulch with 100 % recommended dose N fertilizers (fig2).Influence of innovative farming practices on soil reaction indicated that, irrespective of other treatments, the cropping sequence redgram-maize recorded over all grand mean value of higher soil pH and lower value observed in cotton-green gram sequence (fig2). Irrespective of cropping sequence and manures, the minimum tillage reduced the soil pH than conventional tillage (fig1). The year round green cover in the minimum tillage might have released the acidity and reduced the pH. The acid produced during the decomposition of mulch in the minimum tillage might have contributed for lower pH value. Rahman *et al.* (2008) [19] also observed no significant differences in soil pH among no tillage and conventional tillage practices. Tarkalson *et al.* (2006) [23, 24] reported 9 per cent decrease in soil pH under no tillage as compared to conventional tillage due to enhancement of acidification. Tillage treatments and associated cropping systems cause variation in ph values of soils and significant difference was found between no tillage and conventional tillage treatments. The lowest value for pH was reported with no tillage treatment.

Soil organic carbon

The data pertaining to SOC, as affected by tillage, residue management and cropping practices is presented in Table 3. The SOC is observed to be significantly affected by tillage practices in different cropping sequences. In the cotton green gram cropping sequences, irrespective of mulching and fertilizer treatments, minimum tillage recorded higher SOC of 5.15g/kg than conventional tillage (5.0g/kg). Among four manurial treatments, the higher SOC of 5.30 g/kg was recorded in the treatment of with mulch + 75% recommended dose of N through fertilizers and 25% N through organics. The same trend of results observed in all cropping sequences. Among the cropping sequences alone, redgram-maize recorded higher valve followed by cotton green gram (fig1). Irrespective of cropping and manure treatments, minimum tillage recorded higher organic carbon than conventional tillage (Fig 1). The increased soil organic carbon in the minimum tillage might be due to reduced soil disturbance. Improved SOC maintenance and soil quality also reported by Zentner *et al. (*2004) [30] and Bhattacharyya *et al. (*2006) [3]. Bricchi *et al.* (2004) [4] observed that the SOC was significantly higher when stubble was left on surface. Under conservation tillage the organic carbon increased by 11 per cent as compared to conventional tillage after 5 years. Hazarika *et al.* (2009) [10] reported 14-17 per cent higher SOC in surface soil under no tillage and reduced tillage than conventional tillage practices. The no tillage technology decrease soil disturbance, improve soil organic carbon and benefits soil quality (Arshad *et al.,* 1990, Zentner *et al.,* 2004) [1, 30].

Available nitrogen

The available nitrogen as affected by tillage practices under different cropping sequences and manure addition is depicted in Table 4. In the individual cropping sequences, in the cotton- green gram cropping, higher available N reported in the mulch + 75% recommended dose of N through fertilizers and 25% N through organics (226 kg/ha) which is on par with 100 % RDF with mulch (205 kg/ha). The mean higher available nitrogen was observed with mulch + 75% recommended dose of N through fertilizers and 25% N through organics (Fig1). Tillage practices significantly affected available nitrogen. Mminimum tillage recorded higher available N than conventional tillage (fig2) irrespective of cropping and manure treatments. Tillage operations and soil disturbance generally cause an increase in soil aeration, residue decomposition; Organic N mineralization and availability of N for plant use (Dinnes et al., 2002) [7]. Among the cropping sequences, vegetable cowpea-sunflower cropping recorded higher available N (Fig 1). Comparatively no mulch recorded lower value than without mulch (fig2). The same trend of results observed in all cropping sequences. Arshad *et al* (1990) [1] found that available N content of surface soil was 25% higher under no tillage than conventional plots. Moussa-Machraoui *et al.* (2010) [14] also reported more available N under no tillage due to more organic matter accumulation. The increased organic carbon in the present research also supports this result. So *et al.* (2000) [21] observed that tillage increased the mineralization of nitrogen through break down of organic matter which may increase crop yield in short-term but in longer term continuous tillage degrades soil organic matter and reduces soil fertility and structural stability.

Available phosphorus

Tillage and residue management practices had less effect on available phosphorus (Table 5). In the cotton green gram cropping sequence, minimum tillage recorded higher available P (19.0 kg/ha) than conventional tillage (16.8 kg/ha). Non-significant P result observed between manurial treatments and their interaction with tillage practices. In the vegetable cowpea- sunflower cropping tillage differences observed as that of cotton –greengram cropping sequence. Among the manurial treatments, mulch + 75% recommended dose of N through fertilizers and 25% N through organics recorded higher available P (22.4 kg/ha). In the other two cropping sequences also same trend of result observed. Among the cropping sequences, redgram -maize cropping recorded higher available P followed by bhendi-maize (fig2). Among the manurial treatment, mulch + 75% recommended dose of N through fertilizers and 25% N through organics recorded higher available P followed by with mulch and 100 % fertiliser (fig1). Palm *et al. (*2001) [17] also reported that no tillage favours the surface accumulation of phosphorus by contributing to increased P availability through release of inorganic P from decaying residues. In the present research also mulched plot recorded lower pH value might have favoured the release of P by increasing acidity. Moussa-Machraoui *et al.* (2010) [14] observed that some of the chemical parameters of soil were significantly modified under no tillage when compared to conventional tillage system. The nutrient (N, P, K, P_2O_5 and K_2O) contents were more under no tillage than conventional tillage. Gangwar *et al.* (2006) [9] reported no changes in soil available P and K due to tillage practices. But residue incorporation increased SOC and available P.

Available potassium

In the cotton green gram cropping sequence, mulch + 75% recommended dose of N through fertilizers and 25% N through organics recorded higher available K value of 444 kg/ha which is at par with mulch +100 % fertilizer (432 kg/ha) and no mulch with 75% recommended dose of N through fertilizers and 25% N through organics (426 kg/ha) (Table 6). In the interaction also conventional tillage with mulch + 75% recommended dose of N through fertilizers and 25% N through organics recorded higher value (452 kg/ha). In the vegetable cowpea cropping sequence, conventional tillage recorded higher value of 465 kg/ha than minimum tillage (435 kg/ha). In the interaction, conventional tillage with mulch + 75 % recommended dose of N through fertilizers and 25% N through organics (475 kg/ha) recorded higher available K. The effect of tillage practices on available K was higher under conventional tillage even though available N and P registered higher under minimum tillage (fig1). Irrespective of cropping and tillage practices, mulch + 75% recommended dose of N through fertilizers and 25% N through organics recorded higher available K value. This result might be due contribution of K from residue and less K loss by soil erosion. The cropping sequences red gram maize and bhendi maize recorded similar value as that of cotton green gram cropping sequence (fig2). Increased available K in untilled soil was correlated with increased organic matter content (Karathanasis and Wells, 1989) [11]. Franzluebbers and Hons (1996) [8] also reported that soil managed by no tillage had greater available K concentrations in the surface soil layer than with conventional tillage.

Soil carbon stock

Determining soil carbon is an important soil parameter which could contribute to soil health. The results indicated that irrespective of tillage and manures, the cropping sequence bhendi - maize recorded higher grand mean carbon stock of 11.24 t/ha/yr followed by cotton - green gram (10.86 t/ha/yr) (table 7). Irrespective of cropping sequence and manures, the minimum tillage recorded higher C stock of 10.92 t /ha /yr than conventional tillage (10.72 t/ha/yr). Among the manure treatments, irrespective of crops and tillage, with mulch + 75% recommended dose of N through fertilizers and 25% N through organics recorded higher C stock of 11.20 t/ha/yr followed by mulch with 100 % recommended dose N fertilizers (Table7) (fig1).Irrespective of cropping and manure treatments, minimum tillage recorded higher carbon stock than conventional tillage(fig 1). Among the cropping sequences, bhendi- maize recorded higher carbon stock followed by cotton-green gram and redgram- maize sequences (fig2). A study on tillage reported greater SOC under no-till compared to conventional tillage (Kumar *et al.*, 2012) [12]. Conventional tillage increases residue and soil organic matter decomposition by disrupting and aerating the soil, and exposing plant material and soil aggregates to the activity of soil microorganisms. Although organic matter is added to the soil each year from these crop residues, tillage exposes previously protected interior soil aggregates accelerating the loss of SOC from the existing soil organic matter pool.

Table 1: Crop production details of the experiment *Kharif* -Planting details

CS	Crop	Variety	Fertilizer Kg/ha N P K	Spacing (cm)	Seed rate (kg/ha)	Duration (days)
CS_1	Cotton	Bunny - Bt	150:75:75	90 x 60	1.350	140
CS_2	Veg. Cowpea	CO 2	25:50:25	30 x 15	25.0	90
CS_3	Red gram	VBN(Rg) 3	25:50:25	60 x 30	25.0	110
CS_4	Bhendi	Slender	200:100:100	60 x 30	2.5	120

Rabi - Planting details

CS	Crop	Variety	Fertilizer Kg/ha N P K	Spacing (cm)	Seed rate (kg/ha)	Duration (days)
CS_1	Green gram	Vamban 2	25:50:25	30 x 10	20	80
CS_2	Sunflower	Sunbreed	60:90:60	60 x 30	4	100
CS_3	Maize	NK 6240	150: 62.5:50	60 x 20	20	110
CS_4	Maize	NK 6240	150:62.5:50	60 x 20	20	110

Table 1a: Influence of farming practices on electrical conductivity (soluble salt content (dS/m) of the soil

Treatments	Cotton - Green gram			Veg. Cowpea -Sunflower			Red gram - Maize			Bhendi - Maize		
	Mini. Tillage	Con. Tillage	Mean	Mini. Tillage	Con. Tillage	Mean	Mini. Tillage	Con. Tillage	Mean	Mini. Tillage	Con. Tillage	Mean
M1- NM 100% RDF	0.31	0.45	0.38	0.34	0.54	0.44	0.36	0.47	0.42	0.45	0.69	0.57
M2- NM 75% RDF+25% OM	0.27	0.42	0.35	0.34	0.54	0.44	0.36	0.49	0.43	0.42	0.68	0.55
M3- WM 100% RDF	0.27	0.38	0.33	0.27	0.5	0.39	0.33	0.42	0.38	0.39	0.54	0.47
M4- WM 75% RDF+25% OM	0.2	0.35	0.28	0.23	0.49	0.36	0.28	0.34	0.31	0.38	0.45	0.42
Grand mean	0.26	0.40	0.33	0.30	0.52	0.41	0.33	0.43	0.38	0.41	0.59	0.50
CD (p=0.05)												
T	0.12			0.20			0.22			ns		
M	0.11			ns			0.20			ns		
T at M	0.14			0.17			0.28			0.20		
M at T	0.13			ns			0.25			ns		

Table 2: Influence of farming practices on soil reaction

Treatments	Cotton - Green gram			Veg. Cowpea -Sunflower			Red gram - Maize			Bhendi - Maize		
	Mini. Tillage	Con. Tillage	Mean	Mini. Tillage	Con. Tillage	Mean	Mini. Tillage	Con. Tillage	Mean	Mini. Tillage	Con. Tillage	Mean
NM 100% RDF	8.52	8.58	8.55	8.72	8.87	8.80	8.67	9.01	8.84	8.72	8.77	8.75
NM 75% RDF+25% OM	8.20	8.90	8.55	8.80	8.92	8.86	8.83	9.04	8.94	8.44	8.58	8.51
WM 100% RDF	8.41	8.68	8.55	8.65	8.71	8.68	8.50	8.58	8.54	8.62	8.75	8.69
WM 75% RDF+25% OM	8.35	8.47	8.41	8.62	8.70	8.66	8.46	8.55	8.51	8.58	8.65	8.62
Grand mean	8.37	8.66	8.51	8.70	8.80	8.75	8.62	8.80	8.71	8.59	8.69	8.64
CD (p=0.05)												
T	0.40			Ns			0.15			Ns		
M	ns			Ns			Ns			ns		
T at M	ns			Ns			0.30			ns		
M at T	ns			ns			0.37			ns		

Table 3: Influence of farming practices on soil organic carbon (g/kg)

Treatments	Cotton - Green gram			Veg. Cowpea -Sunflower			Red gram - Maize			Bhendi - Maize		
	Mini. Tillage	Con. Tillage	Mean	Mini. Tillage	Con. Tillage	Mean	Mini. Tillage	Con. Tillage	Mean	Mini. Tillage	Con. Tillage	Mean
NM 100% RDF	5.00	5.00	5.00	4.90	4.70	4.80	4.70	4.30	4.50	5.40	5.00	5.20
NM 75% RDF+25% OM	5.00	5.10	5.20	4.90	4.70	4.80	4.70	4.40	4.55	5.52	5.10	5.25
WM 100% RDF	5.20	5.00	5.10	5.20	5.20	5.20	4.80	4.60	4.90	5.30	5.00	6.15

WM 75% RDF+25% OM	5.40	5.20	5.30	5.40	5.20	5.30	5.00	4.80	4.70	6.30	6.10	6.20
Grand mean	5.15	5.00	5.08	5.10	4.95	5.03	4.80	4.53	4.66	5.63	5.30	5.70
CD (p=0.05)												
T	0.10			0.20			0.20			0.21		
M	0.22			0.31			0.28			0.54		
T at M	0.14			0.18			0.24			0.24		
M at T	0.34			0.42			0.30			0.62		

Table 4: Influence of farming practices on soil available nitrogen (kg/ha)

Treatments	Cotton - Green gram			Veg. Cowpea -Sunflower			Red gram - Maize			Bhendi - Maize		
	Mini. Tillage	Con. Tillage	Mean	Mini. Tillage	Con. Tillage	Mean	Mini. Tillage	Con. Tillage	Mean	Mini. Tillage	Con. Tillage	Mean
NM 100% RDF	190	184	187	249	218	234	224	202	213	168	166	167
NM 75% RDF+25% OM	202	190	196	260	227	244	227	221	224	182	176	179
WM 100% RDF	219	190	205	276	232	254	234	204	219	189	186	188
WM 75% RDF+25% OM	242	210	226	290	238	264	252	232	242	199	192	196
Grand mean	213	194	203	269	229	249	234	215	225	185	180	182
CD (p=0.05)												
T	15			18			16			ns		
M	30			24			24			22		
T at M	18			20			18			Ns		
M at T	34			28			26			26		

Table 5: Influence of farming practices on soil available phosphorus (kg/ha)

Treatments	Cotton - Green gram			Veg. Cowpea -Sunflower			Red gram - Maize			Bhendi - Maize		
	Mini. Tillage	Con. Tillage	Mean	Mini. Tillage	Con. Tillage	Mean	Mini. Tillage	Con. Tillage	Mean	Mini. Tillage	Con. Tillage	Mean
NM 100% RDF	18.1	16.1	17.1	21.6	14.7	16.3	20.2	18.7	19.5	17.9	16.9	19.3
NM 75% RDF+25% OM	19.8	16.1	18.0	23.5	15.4	18.4	20.8	19.7	20.3	21.3	16.4	20.0
WM 100% RDF	18.1	16.4	17.3	22.6	16.8	18.5	21.6	19.4	20.5	20.1	18.1	20.4
WM 75% RDF+25% OM	20.1	18.5	19.3	25.5	19.0	22.4	24.6	22.4	23.5	25.8	19.4	22.5
Grand mean	19.0	16.8	17.9	23.3	16.5	18.9	21.8	20.1	20.9	21.3	17.7	20.5
CD (p=0.05)												
T	1.8			3.5			1.5			3.2		
M	Ns			3.2			3.3			2.8		
T at M	Ns			Ns			Ns			Ns		
M at T												

Table 6: Influence of farming practices on soil available potassium (kg/ha)

Treatments	Cotton - Green gram			Veg. Cowpea -Sunflower			Red gram - Maize			Bhendi - Maize		
	Mini. Tillage	Con. Tillage	Mean	Mini. Tillage	Con. Tillage	Mean	Mini. Tillage	Con. Tillage	Mean	Mini. Tillage	Con. Tillage	Mean
NM 100% RDF	413	418	416	426	452	439	401	425	413	395	425	410
NM 75% RDF+25% OM	422	430	426	440	465	453	417	432	425	408	438	423
WM 100% RDF	432	432	432	432	468	450	435	465	450	410	442	426
WM 75% RDF+25% OM	436	452	444	440	475	458	438	472	455	428	458	443
Grand mean	426	433	429	435	465	450	423	449	436	410	441	426
CD (p=0.05)												
T	Ns			28			Ns			ns		
M	28			17			38			28		
T at M	30			32			26			27		
M at T	35			35			40			40		

Table 7: Influence of farming practices on soil carbon stock (t/ha/yr)

Treatments	Cotton - Green gram			Veg. Cowpea -Sunflower			Red gram - Maize			Bhendi - Maize		
	Mini. Tillage	Con. Tillage	Mean	Mini. Tillage	Con. Tillage	Mean	Mini. Tillage	Con. Tillage	Mean	Mini. Tillage	Con. Tillage	Mean
NM 100% RDF	10.44	10.24	10.34	10.42	10.22	10.32	10.49	10.44	10.47	10.69	10.44	10.57
NM 75% RDF+25% OM	10.57	10.40	10.49	10.44	10.30	10.37	10.65	10.53	10.59	10.85	10.79	10.82
WM 100% RDF	11.53	11.04	11.29	10.63	10.44	10.54	10.91	10.83	10.87	11.73	11.59	11.66
WM 75% RDF+25% OM	11.59	11.10	11.35	10.69	10.49	10.59	10.98	10.89	10.94	12.05	11.81	11.93
Grand mean	11.03	10.70	10.86	10.55	10.36	10.45	10.76	10.67	10.72	11.33	11.16	11.24
CD (p=0.05)												
T	0.18			0.16			Ns			0.15		
M	0.55			0.23			0.32			0.81		
T at M	0.22			0.18			0.11			0.20		
M at T	0.68			0.26			0.41			0.98		

Table 8: Influence of innovative farming practices on soil temperature in different cropping sequence

Treatments	Cotton - Green gram			Veg. Cowpea -Sunflower			Red gram - Maize			Bhendi - Maize		
	Mini. Tillage	Con. Tillage	Mean	Mini. Tillage	Con. Tillage	Mean	Mini. Tillage	Con. Tillage	Mean	Mini. Tillage	Con. Tillage	Mean
NM 100% RDF	40.3	43.13	41.72	39.87	40.83	40.35	34.77	42.97	38.87	38.69	42.07	40.38
NM 75% RDF+25% OM	38.07	41.03	39.55	36.96	37.87	37.42	33.8	42.87	38.34	37.57	40.6	39.09
WM 100% RDF	37.94	42.33	40.14	39.09	41.00	40.05	34.33	41.1	37.72	38.83	41.2	40.02
WM 75% RDF+25% OM	36.83	40.03	38.43	36.52	39.03	37.78	32.83	39.3	36.07	36.85	40.93	38.89
Grand mean	38.29	41.63	39.96	38.11	39.68	38.90	33.93	41.56	37.75	37.99	41.2	39.59
CD (p=0.05)												
T	3.40			1.12			4.20			2.10		
M	2.03			2.22			2.01			1.58		
T at M	2.24			1.54			5.80			2.95		
M at T	3.21			2.89			6.50			2.55		

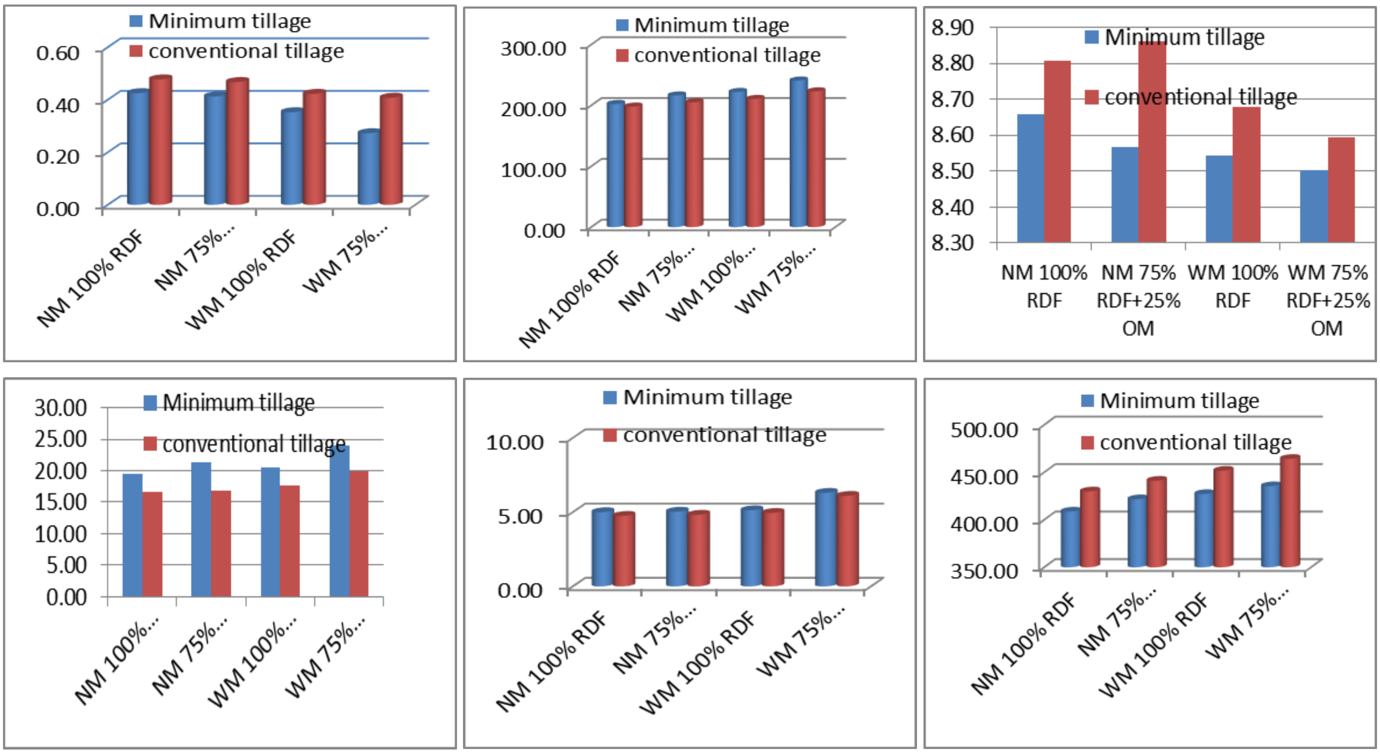
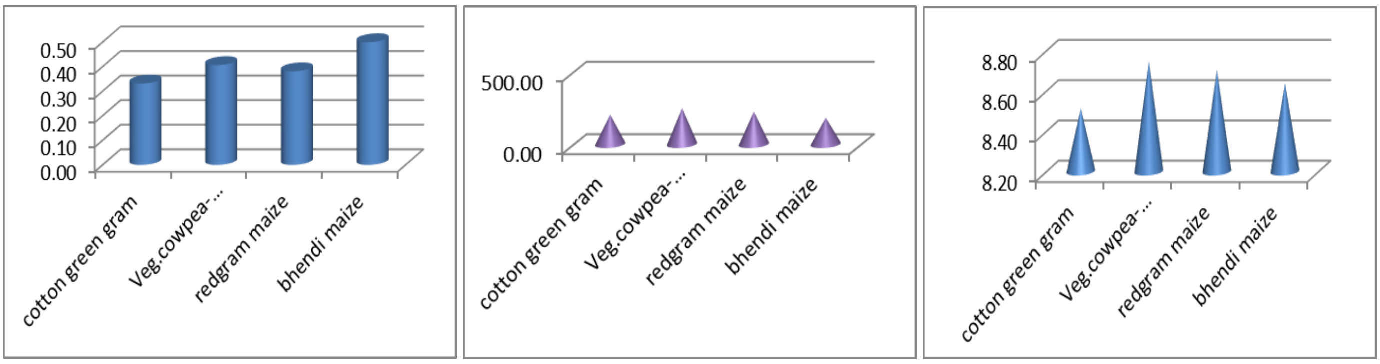
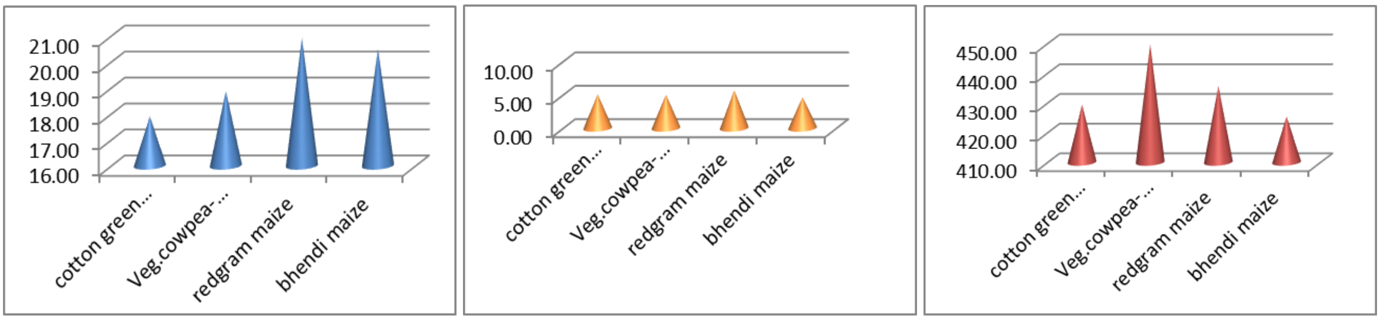


Fig 1: Influence of farming practices on soil properties irrespective of cropping sequences



EC value **Soil available N** **pH value**



Soil available P **Soil organic carbon** **Soil available K**

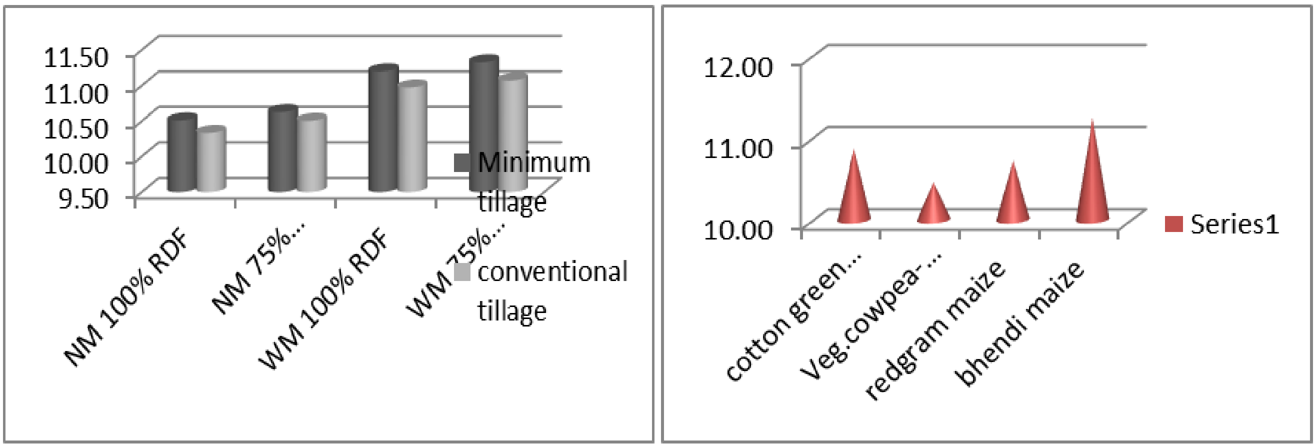


Fig 2: Influence of farming practices on soil properties as influenced by cropping sequences

Conclusion
The study concludes that minimum tillage with 75% recommended dose of fertilizer + 25% N through organics with mulching has improved the soil quality parameters such as pH EC, available nutrients and soil carbon stock. Among the cropping sequences, bhendi - maize cropping sequence is found to be registered more carbon in the soil, though vegetable cowpea-sunflower and redgram maize cropping sustained the nutrient availability over three years. Between two tillage practices, minimum tillage favours pH, EC, SOC and available nutrients.

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