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Impact of Conservation Agricultural Practices on Depth-wise Distribution of Soil Physico- chemical Attributes and available Soil Nutrients under Cotton- Maize-*sesbania* Cropping System

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ABSTRACT: Industrial agriculture employed by the majority of the farmers as to increase the level of crop production had depleted soil nutrients required to boost plant nutrition. The farmers in Southern Telangana region follow conventional cereal- based production which removes large quantities of the soil nutrients rendering the soil infertile thereby posing the main challenge on soil health enhancement. A transition into conservation agriculture (CA) is the best strategy to save the soil resource and sustain productivity. This study is aimed to evaluate the impact of tillage and weed management on soil physico-chemical properties and soil nutrients distribution in two different depths after harvest of maize (after third year) in CA. Three tillages (main treatments); T_1: conventional – conventional – fallow, T_2: conventional – zero – zero and T_3: triple zero + residue retention and weed management (sub-treatments): herbicides (W_1 and W_2), W_3: IWM and W_4: unweeded were laid in split-plot design. soil samples collected depth-wise (0–15, 15–30cm) post-harvest of maize were analysed for pH, EC, N, P, K and soil organic carbon (SOC) by following the standard protocols. The salient findings had indicated higher SOC (64.6%), N (21.37%), P (17.00%), K (11.89%), EC (8.89%) and lower pH (1.56%) in 0–15 cm soil depth under conservation tillage (T_3) over T_1. All soil properties decreased with increase in depth. Weed management did not significantly affect these soil physico-chemical and soil nutrient's parameters. These results signify conservation tillage (T_3) as the prime management practices to enhance and maintain the soil nutrients, hence the solution for preservation of overall soil properties essential for soil quality improvement in agro-ecosystem.

Keywords: Soil quality, Soil health, Conservation agriculture, Soil properties, Depth-wise, Soil organic carbon.

INTRODUCTION

Conservation agriculture (CA) is a system designed to achieve agricultural sustainability by improving the biological functions of the agro-ecosystem with limited mechanical practices and judicious use of chemical inputs. The impending crises for food production have put forward the use of synthetic fertilizers as to meet the food demand of the population. However, these industrial agricultural practices with over-use and excess chemical fertilizers have been interlinked with deterioration of soil quality. Maize is the second most important crop grown during the winter season, after rice in Telangana state, India. It was cultivated in 0.187 million hectares in 2020-21, with a production of 1.307 million tonnes and productivity of 7.01 tonnes per hectare (Agriculture action plan, 2021). However, to increase productivity in order to meet the demand of the population with shrinking land resources, food production must always be accompanied by a sustainable management of agricultural lands to stop or at least slow down the negative impacts on the quality and quantity of soil resources, land degradation and biodiversity (Weiss *et al*., 2020). In the light of this challenging context for agriculture, soil organic carbon

(SOC) forms the base for sustainable soil resources being a reservoir for the overall soil available nutrients (Debano and Wood 1990). Soil nutrients play an essential role in plant nutrition and their availability in the soil determine crop yields, thus, the linkage between long-term specific soil management practices like Conservation agriculture (CA) through various tillage systems and weed control strategies should be evaluated as to comprehend soil management practices which maximize crop yield and improve soil quality (Zulu *et al.*, 2022). Several research studies have reported build- up of soil nutrients on the surface with limited research on spatial distribution to lower profile depth. The insights into soil nutrient's distribution with the stratum is of utmost importance on signifying the soil quality for the entire soil profile in croplands. Farm management practices which entails conservation tillage and crop residue incorporation in CA have been observed to furnish some soil health gains with regard to improvement of essential soil quality parameters (e.g. SOC, nitrogen (N), phosphorus (P), potassium *etc*.) in Southern Telangana Zone (STZ) of India (Parihar *et al*., 2016).

The introduction of new generation selective herbicides and shortage of manual labour available for manual weeding has resulted in a significant increase in pre-emergence and post-emergence herbicide use in these crops. Several studies have confirmed the negative as well as the positive influence of agrochemicals on crop productivity (Dhanker *et al*., 2021). However, overuse and excessive application of such herbicides tend to exude into the soil environment resulting in bioaccumulation and generation of a vast quantity of residues which in turn lead to nutrient imbalance and quality-drop off in crop production. Hence, the current three years CA experiment was taken up to investigate the depth-wise distribution of physico-chemical properties and available soil nutrients, as impacted by tillage practices and weed management strategies after third year (5^{th} maize crop cycle) in cotton-maize-*sesbania* cropping systems.

MATERIALS AND METHODS

Site description

Location of the experimental site: The present on-going field experiment was conducted on the fixed plots at college farm, All India Coordinated Research Project on Weed Management, Professor Jayashankar Telangana Sate Agricultural University, Rajendranagar, South Telangana Zone, India in *Rabi* (Winter season) 2022-23 after third year in the 5^{th} crop cycle (maize crop). The initiation of the study was during the year 2020 in *Kharif* (Monsoon), *Rabi* (Winter) and Summer seasons under cotton, maize, *sesbania* rotation respectively. Geographically, the experimental field is situated at 17°19' 18" North latitude and 78°24' 37" East.

Climate: The climate of the area is semi-arid tropical. The average annual rainfall of the region is 708 mm. The average annual temperature is 24.8°C and the monthly mean maximum and minimum temperatures vary between 32.8 to 16.8 °C. Summers (March– June) are hot and humid, with average highs in the mid-to-high 30˚C. Maximum temperatures often exceed 40°C between April and May. The coolest temperatures occur in December and January when the lowest temperature occasionally drops to 10 °C. More than 75% of rainfall is due to the South-West monsoon and occurs between June to September.

Weather during the crop growth period: The data on weather parameters during the crop growth period was recorded from the meteorological observatory located at Agricultural Research Institute, Rajendranagar, Hyderabad. During the experimental period in the year 2022-2023, total rainfall received was 222.2 mm received in 7 rainy days. The monthly mean bright sunshine hours varied from 7.3 to 9.1 hours with an average of 8.2 hours, mean evaporation was 3.1 to 6. 1 mm with an average of 4.6 mm and mean wind speed was in the range of 2.8 to 3.9 km hr^{-1} with an average of 3.4 km hr^{-1}. These were similar to the normal sunshine hours, normal wind speed and normal evaporation in general. The monthly mean maximum temperature during the crop growth period ranged from 30.0 to 36.7°C with an average of 33.4°C while the mean monthly minimum temperature varied from 13.7°C to 24.1°C with an average of 18.9°C, respectively. The average relative humidity fluctuated from 85.0 % to 76.0 % with an average of 80.5 %.

Soil characteristics: The soil of the experimental field comes under the soil order *Inceptisols*. This soil is sandy clay loam in texture, red chalk in colour, slightly alkaline in soil reaction due to presence of lime concretion in the lower horizon. Details of some important physical, chemical and physico-chemical characteristics of the surface soil (0 – 15 cm) of the experimental site at initiation of experiment are depicted in Table 1.

Experimental design and treatments: The experiment was laid out in split plot design with main plots and sub-plots treatments and replicated thrice. The treatments consist of combination of three tillage (s) as the main plots *viz*., T_1: conventional tillage (CT) – conventional tillage (CT) – fallow (no *Sesbania*), T_2: conventional tillage (CT) – zero tillage (ZT) – zero tillage (ZT) and T_3: triple zero tillage (ZT) + residue retention (R) for cotton, maize and *Sesbania*, respectively (Table 2a). In T_1: conventional tillage treatments, the field was ploughed twice followed by rotovator and sowing. For T_2: zero tillage treatments, there was no tillage operations done and in T_3: zero tillage (ZT) + residue retention (R), the previous crops (cotton and *sesbania*) were shredded and the residues were incorporated into the soil without any tillage operations (Table 2a). Four weed management options as sub-plots treatments included: W_1: chemical control, W_2: Herbicide rotation, W_3: IWM and W_4: Unweeded control and elucidated in table 2b. *Sesbania* in summer season was sown only for the purpose of incorporation into the soil and as a legume cover crop, hence there were no tillage operations and weed management treatment done during that period and treatment T_1 was fallowed (no *Sesbania*).

Table 1: Soil physico-chemical characteristics at initiation of the experiment (0-15 cm depth).

Sr. No.	Soil property	Value	Method
i.	Soil type	Red soil	Bouyoucos hydrometer (Piper, 1966)
ii	Mechanical separates (%)		
	Sand	66.00	
	Silt	12.50	
	Clay	21.40	
	Texture	Sandy clay loam	
iii.	Bulk density (Mg/m^3)	1.23	Gravimetric method (Blake and Hartge 1986)
iv.	Soil pH (1:2)	7.82	pH meter (Jackson, 1973)
v.	EC (dS/m) (1:2.5)	0.33	Conductivity meter (Jackson, 1973)
vi	Organic carbon (g/kg)	6.50	Wet digestion method (Walkley and Black 1934)
vii	Available nutrients (kg/ha)		
	Nitrogen	220.80	Alkaline permanganate method (Subbiah and Asija 1956)
	Phosphorus (P_2O_5)	52.10	Olsen's method (Olsen *et. al.*,1954)
	Potassium (K_2O)	528.75	Neutral ammonium acetate method (Jackson, 1973)

Table 2a: Main plots – Tillage.

Treatments	***Kharif*** **(Monsoon)**	***Rabi*** **(Winter)**	**Summer**
T_1	CT (Cotton)	CT (Maize)	Fallow (no *Sesbania*)
T_2	CT (Cotton)	ZT (Maize)	ZT (*Sesbania*)
T_3	ZT +R (Cotton)	ZT+R (Maize)	ZT+R (*Sesbania*)

CT-Conventional Tillage ZT-Zero Tillage R-Residue retention

Sowing and fertilizer application: The maize seeds of DHM 117 cultivar were sown at 60 cm × 25 cm in a net plot area of 41.4 m^2 with 10 rows per plot. Before sowing, the field preparation was done with a plough twice followed by rotovator and levelling with the hand operated implements in T_1: conventional tillage plots while sowing was done directly without any tillage operation in zero tillage plots. A seed rate of 20 kg ha^{-1} was adopted. Thinning and gap filling were done 12 days after germination. The crop was principally raised with irrigation water with few rainfall amounts received during winter season. Recommended dose of 200:60:50 kg ha^{-1} of N: P_2O_5: K_2O through urea, di-ammonium phosphate and muriate of potash were applied, respectively. Nitrogen and potassium were applied in three equal splits *i.e.*, as basal dose, at knee high and tasselling stage. The recommended dose of phosphorous was applied as a basal dose.

Soil sampling and standard methodology: Composite soil samples were collected after harvest of maize crop in the 5th crop cycle from each plot at a depth of 0 – 15 and 15 – 30 cm. These collected samples were passed through 0.5 mm mm sieve and analysed for soil organic carbon (SOC). For the analysis of other physico-chemical parameters *viz*., soil pH, electrical conductivity (EC), and soil nutrient status *viz*., available nitrogen (N), phosphorus (P_2O_5), potassium (K_2O), the 2 mm sieved soil samples collected was used and the following standard protocols were adopted for each parameter analysed.

Soil organic carbon: It was determined according to Walkley and Black method(1934). Soil samples passed through 0.5 mm sieve are used for determining organic carbon. 1 g of soil was taken in an Erlenmeyer flask to this 10 ml of potassium dichromate and 20 ml of concentrated H_2SO_4 were added and is allowed for digestion for 30 min. To this solution, 100 ml of distilled water followed by a pinch of NaF and few drops of diphenylamine indicator were added. The contents turn to violet color. It was titrated against 0.5*N* ferrous ammonium sulphate till the color change to green.

Soil available nitrogen (N): It was determined by alkaline potassium permanganate method (Subbiah and Asija 1956).

Soil available phosphorus (P): It was determined by Olsen's method of 0.5M sodium bicarbonate as an extractant using a double beam spectrophotometer at 420nm (Olsen *et al*., 1974).

Soil available potassium (K): It was determined by neutral normal ammonium acetate method using flame photometer (Jackson, 1973).

Soil pH: pH of the soil was determined by soil suspension (1:2.5 soil: water) with glass electrode method pH meter after equilibrating soil with water for 30 minutes with occasional stirring (Jackson, 1973).

Electrical conductivity (EC): EC was determined in soil suspension (1:2.5 soil: water) after equilibrium of soil with water and keeping the sample undisturbed till the supernatant solution is obtained and measured by a conductivity meter (Jackson, 1973).

Table 2b: Weed management (W) sub-treatment details and interaction with tillage (T) main treatments.

<table>
<tr><th colspan="5">Monsoon (Cotton)</th><th colspan="4">Winter (Maize)</th></tr>
<tr><th></th><th>W_1: Chemical Weed Control</th><th>W_2: Herbicide Rotation (Every year)</th><th>W_3: IWM</th><th>W_4: Control</th><th>W_1: Chemical Weed Control</th><th>W_2: Herbicide Rotation (Every year)</th><th>W_3: IWM</th><th>W_4: Control</th></tr>
<tr><td>T_1</td><td rowspan="3">Diuron pre-emergence application PE 0.75 kg/ha fb tank mix application of pyrithiobac-sodium 62.5 g/ha + quizalofop-ethyl 50 g/ha as PoE (Post-emergence application) (2-3 weed leaf stage) fb directed spray (inter-row) of paraquat 0.5 kg/ha at 50-55 DAS</td><td rowspan="3">Diuron PE 0.75 kg/ha *fb* tank mix application of pyrithiobac-sodium 62.5 g/ha+ quizalofop-ethyl 50 g/ha as PoE (2-3 weed leaf stage) *fb* directed spray (inter-row) of paraquat 0.5 kg/ha at 50-55 DAS. Pendimethalin 1.0 kg/ha fb tank mix application of pyrithiobac-sodium 62.5 g/ha +quizalofop ethyl 50 g/ha as PoE (2-3 weed leaf stage) *fb* directed spray (inter-row) of paraquat 24% SL 0.5 kg/ha at 50-55 DAS.</td><td rowspan="3">Diuron PE 0.75 kg/ha *fb* mechanical brush cutter twice at 25 and 60 DAS.</td><td rowspan="3">One hand weeding was done after the critical period of crop-weed competition *i.e.* between 45-50 days after sowing)</td><td rowspan="3">Atrazine 1.0 kg/ha + paraquat 600 g/ha PE *fb* tembotrione 120 g/ha at 20-25 DAS as PoE (T_2, T_3). Atrazine 1.0 kg/ha PE *fb* tembotrione 120g/ha at 20-25 DAS as PoE (T_1)</td><td rowspan="3">Atrazine 1.0 kg/ha + paraquat 600 g/ha PE *fb* tembotrione 120 g/ha at 20-25 DAS as PoE (T_2, T_3). Atrazine 1.0 kg/ha PE *fb* tembotrione 120g/ha at 20-25 DAS at PoE (T_1). Atrazine 1.0 kg/ha + paraquat 600 g/ha PE *fb* halosulfuron-methyl 67.5 g/ha at 20-25 DAS as PoE (T_2, T_3). Atrazine 1.0 kg/ha PE *fb* halo- sulfuron methyl 67.5 g/ha at 20-25 DAS as PoE (T_1)</td><td rowspan="3">Tembotrione 120 g/ha Atrazine 50% WP 0.5 kg/ha as Early post-emergence) EPoE fb brush cutter at 40 DAS</td><td rowspan="3">One hand weeding was done after the critical period of crop-weed competiti-on *i.e.* between 45-50 days after sowing)</td></tr>
<tr><td>T_2</td></tr>
<tr><td>T_3</td></tr>
</table>

RESULTS AND DISCUSSION

Soil organic carbon: After harvest of maize crop, at the end of third year, the results on soil organic carbon (SOC) indicated that SOC was positively influenced by various tillage combination practices and weed management options at 0 –15 and 15–30 cm soil depths (Table 3). The distinctiveness in SOC was significant for tillage practices and non- significant for weed management options at both depths (0–15 and 15–30 cm). At 0 –15 cm, tillage and weed management treatment recorded greater SOC levels in comparison with the initial value (6.5 g kg^{-1}) (Table 3) and among the tillage practices, T_3 recorded significantly highest SOC (10.74 g kg^{-1}) over T_2 and the farmers practice (T_1) (Table 3). At 15 – 30 cm, SOC decreased with increase in depth of the soil profile in all the treatments as compared to 0 – 15 cm (Table 3). However, the trend at 15 – 30 cm was similar to that of the soil surface (0 – 15 cm) with overall SOC contents being higher in all the treatments than the initial value (Table 3). The highest SOC obtained under T_3 might be ascribed to continuous adoption of no- till, cumulative retention and incorporation of the previous crops into the soil which in turn acted as protective soil cover against SOC loss through erosion, and also inclusion of the legume (*sesbania*) within the cropping system. These results are supported by Bitew *et al*. (2022) who had reported that continuous use of CA – based maize – legume cropping system increased the organic carbon by 37% over the continuous use of CT– maize. The decrease in SOC concentration in conventional tillage system (T_1) might be due to heavy machinery operations used to till the soil which had in turn disrupted the soil aggregates creating the soil conditions to become highly prone to erosion due to crop residue removal. Similarly, the decline in SOC concentration with increase in profile depth is ascribed to less concentration of residues below the soil surface.

Soil pH: Soil pH as influenced by tillage and weed management practices ranged from 7.04 – 7. 15 and 7.29 – 7.49 at 0 – 15 cm and 15–30 cm respectively. Soil pH was significantly (P = 0.05) lower under T_3 (7.04) than T_1 (7. 15) and T_2 (7.14) at 0 – 15 cm. pH was not significant among all weed management options at the same profile depth (0 – 15 cm). At 15 – 30 cm, the soil pH was lower under T_3 and W_3: IWM but not significant. In general, all tillage and weed management treatments reduced the soil surface (0 – 15) pH compared to the initial value (7.82) (Table 3). The lower pH obtained at upper soil surface under conservation tillage (T_3) compared to other tillage practices might be the result of cumulative retention and incorporation of crop residues which tend to acidify the soil conditions. Similar outcomes were reported by Singh *et al*. (2014); Limousin *et al.* (2007) that the upper soil layer of the soil is more acidic than the bottom one and the decreasing the pH in top soil profile under conservation agriculture (CA)-based practices results in the accumulation of soil organic matter (SOM) and release of organic acids during decomposition in the soil upper layer. The increase in pH with increase in depth of the soil profile might be attributed to erosion, tillage and root distribution of the plant which restricts the movement of plant debris down the profile layer, lesser release of organic acids with regard to low content of SOM and also leaching and accumulation of basic cations in the soil sub-surface (Kaur *et al*., 2020). These present results are in congruence with that of Dhaliwal *et al*. (2023) who had observed an increase in soil pH by 3.4% at lower soil depths of up to 100 cm in comparison with 0 – 10 cm soil depth.

Electrical conductivity: The electrical conductivity (EC) ranged from 0.40 – 0.45 dS m^{-1} and 0.27 – 0.44 dS m^{-1} in all the treatments at 0 – 15 and 15 – 30 cm respectively (Table 3). EC decreased with depth across all the treatments except W_1: chemical weed control which significantly increased by 4.76%. T_3, T_2 and W_3: IWM recorded significantly lower EC than T_1 and other weed management practices respectively at 0- 15 cm (Table 3). At 15 – 30 cm, there was no significant difference observed on EC values in terms of tillage. W_3: IWM significantly lowered the EC (0.27 dS m^{-1}) compared to other weed management strategies at 15 – 30 cm. The EC values were completely lower than the critical value of 4.00 dS m^{-1} in all the tillage and weed management treatments with no significant interaction. However, all the soil surface (0 – 15 cm) EC values were significantly (P=0.05) higher than the initial value (0.33 dS m^{-1}). soil EC was greater in T_3 compared to other tillage practices and initial value due to lower pH values in T_3 *i.e*., there is inverse proportion between the soil pH and EC such that the higher EC values, the lower is the soil pH and vice-versa. The lower EC value (s) under W_3: IWM compared to other weed management options at soil sub-surface might be the result of different tactics employed to manage the weeds.

Available nitrogen, phosphorus and potassium: It is evident from the data that at 0 – 15 cm soil depth, available N, P and K ranged from 231.63 – 297.14, 46.88 – 56.48 and 487.52 – 553.31 kg ha^{-1} respectively in all tillage and weed management practices (Table 4). At 15 – 30 cm, the variation was 155.07 – 181.86, 38.99 – 43.21 and 431.52 – 479.04 kg ha^{-1} for N, P and K respectively. At 0 – 15 cm, the soil exhibited the remarkable increase on available soil N (297.14 kg ha^{-1}) under T_3 in comparison with T_2 (251.24 kg ha^{-1}) and T_1 (233.63 kg ha^{-1}) after harvest of maize at the completion of third year (Table 4). Among weed management strategies, W_4: unweeded recorded higher though there was no significant difference which was observed. At 15 – 30 cm, the trend was similar to the one exhibited at 0 – 15 cm. Overall, available N at soil surface (0 – 15 cm) increased in all the treatments compared to the initial value (220.80 kg ha^{-1}). At 0 – 15 cm, soil available P was significantly (P = 0.05) higher (56.48 kg ha^{-1}) under conservation tillage (T_3) than T_2 (50.64 kg ha^{-1}) and T_1 (46.88 kg ha^{-1}). Weed management had no significant influence on soil available P at soil surface (0 – 15 cm) and the treatment interaction was also not significant. It was further observed that conservation tillage (T_3) and W_2: herbicide rotation treatments were above the initial soil available P value (52.10 kg ha^{-1}) (Table 4). The trend for soil available P at 15 – 30 cm was similar to that of 0 – 15 cm.

Soil available K, at 0 – 15 cm was significantly (P=0.05) higher (553.31 kg ha^{-1}) under conservation tillage (T_3), above the initial value (528.75 kg ha^{-1}) compared to T_2 (515.24 kg ha^{-1}) and T_1 (487.52 kg ha^{-1}) which fell below the initial value (Table 4). Among weed management treatments, W_3: IWM recorded higher soil available P (532.95 kg ha^{-1}) above the initial value though no-significant difference was observed among the treatments at 0 – 15 cm (Table 4). At 15 – 30 cm, the trend was similar to 0 – 15 cm depth. The treatment interaction was significant at both soil depths. In general, soil nutrients increased under conservation tillage (T_3) compared to the initial value (s), T_2 and T_1 at surface and decreased drastically with increase in depth. Similar findings were reported by Nthebere *et al*. (2020).

The significantly higher available N, P and K concentrations obtained under conservation tillage (T_3), above the initial value(s), T_1 and T_2 particularly on the soil surface might be attributed to imposition of T_3 in fixed plots for three consecutive years retaining and accumulating the residues from the previous crops which in turn decompose into soil organic matter (SOM). These results are in congruence with the ones obtained by Sapre *et al*. (2019) who have reported numerical increment on soil available N, P, K under conservation tillage with *sesbania* and maize residues retained in rice, rice residues in wheat and wheat residues in maize in rotation than other tillage systems in a four years CA experiment due to regular accumulation of crop residues in conservation tillage treatments, enriching the soil with N, P, K resulting in SOM decomposition. Alam *et al*. (2014) had reported greater available N on the soil top layer in ZT than CT in wheat- mungbean cropping system. Soil nutrient responses to weed control methods remain quiet unknown which was indicated by no variance among the treatments. The remarkable decrease in overall soil nutrients with increase in profile depth might be ascribed to lower soil organic carbon at soil sub-surface and more soil nutrients uptake by the roots at the surface as a result of roots concentration at upper soil depth which lead to less distribution at lower depths and hence less soil available nutrients at sub-surface layer.

Table 3: Effect of tillage and weed management options on soil pH, electrical conductivity (EC) and soil organic carbon (SOC) after harvest of maize in winter, 2022–23.

Treatments	pH				EC (dS m^{-1})				SOC (g kg^{-1})			
	0-15 cm		15-30 cm		0-15 cm		15-30 cm		0-15 cm		15-30 cm	
Tillage practices												
Initial (s)	7.82		-		0.33		-		6.50		-	
T_1 (CT– CT– Fallow)	7.15		7.40		0.41		0.32		8.56		5.95	
T_2 (CT – ZT– ZT)	7.14		7.39		0.41		0.37		9.13		6.58	
T_3 (Triple ZT + R)	7.04		7.35		0.45		0.41		10.74		7.33	
SE(m)±	0.02		0.05		0.003		0.02		0.42		0.22	
CD(P=0.05)	0.07		NS		0.01		NS		1.71		0.89	
Weed management options												
W_1- Chemical control	7.11		7.31		0.42		0.44		9.63		6.26	
W_2- Herbicide rotation	7.09		7.44		0.43		0.38		9.43		6.72	
W_3- IWM	7.13		7.29		0.45		0.27		9.23		6.76	
W_4- Unweeded control	7.11		7.49		0.40		0.38		9.58		6.74	
SE(m)±	0.05		0.06		0.01		0.03		0.36		0.16	
CD(P=0.05)	NS		NS		0.04		0.08		NS		NS	
Interaction	W at same level of T	T at same level of W	W at same level of T	T at same level of W	W at same level of T	T at same level of W	W at same level of T	T at same level of W	W at same level of T	T at same level of W	W at same level of T	T at same level of W
SE(m)±	0.03	0.08	0.09	0.10	0.01	0.02	0.04	0.05	0.85	0.68	0.44	0.32
CD(P=0.05)	0.26	0.24	NS	NS	NS	NS	NS	NS	2.11	2.32	0.95	1.13

Abbreviations; T= tillage; W= weed management, CT= conventional tillage, ZT= zero tillage; R= crop residue retention; IWM= integrated Weed management, (Triple ZT + R) =ZT +R – ZT +R – ZT +R, CD (P= 0.05) = critical difference at 5% probability level, NS = not significant, SE(m) = standard error of the mean,

Table 4: Effect of tillage and weed management options on soil available nitrogen (N), phosphorus (P_2O_5) and potassium (K_2O) in kg ha^{-1} at two various soil depths after harvest of maize in winter, 2022 – 23.

Treatments	Available N				Available P_2O_5				Available K_2O			
	0-15 cm		15-30 cm		0-15 cm		15-30 cm		0-15 cm		15-30 cm	
Tillage practices												
Initial (s)	220.80		-		52.10		-		528.75		-	
T_1 (CT– CT– Fallow)	233.63		155.07		46.88		38.99		487.52		431.54	
T_2 (CT – ZT– ZT)	251.24		157.78		50.64		39.89		515.24		452.01	
T_3 (Triple ZT + R)	297.14		181.86		56.48		43.21		553.31		479.04	
SE(m)±	7.58		5.40		0.57		0.36		8.77		6.08	
CD(P=0.05)	30.55		21.77		2.30		1.46		35.37		4.51	
Weed management options												
W_1- Chemical control	231.61		163.59		50.46		40.24		523.76		455.41	
W_2- Herbicide rotation	272.77		170.39		52.85		40.62		524.71		463.07	
W_3- IWM	264.41		165.13		51.20		41.42		532.95		466.79	
W_4- Unweeded control	273.88		160.51		50.83		40.50		493.34		431.52	
SE(m)±	18.67		9.08		1.02		0.78		16.64		8.50	
CD(P=0.05)	NS		NS		NS		NS		NS		25.45	
Interaction	W at same level of T	T at same level of W	W at same level of T	T at same level of W	W at same level of T	T at same level of W	W at same level of T	T at same level of W	W at same level of T	T at same level of W	W at same level of T	T at same level of W
SE(m)±	15.16	29.01	10.80	14.66	1.14	1.64	0.72	1.22	17.54	26.46	12.16	14.12
CD(P=0.05)	99.11	88.92	49.32	45.94	NS	NS	NS	NS	NS	NS	46.91	45.00

Abbreviations; T= tillage; W= weed management, CT= conventional tillage, ZT= zero tillage; R= crop residue retention; IWM= integrated Weed management, (Triple ZT + R) =ZT +R – ZT +R – ZT +R, CD (P= 0.05) = critical difference at 5% probability level, NS = not significant, SE(m) = standard error of the mean.

CONCLUSIONS

Conservation tillage (T_3) enhanced the SOC, soil nutrients status (NPK) at 0 – 15 cm. Overall, soil parameters declined with increase in profile depth indicating less distribution at lower soil depth. Significantly higher SOC (64.6% and 25.47%) was recorded under conservation tillage (T_3) over the initial value and farmers practice (T_1) respectively at soil surface which had promoted overall soil quality properties. Thus, this present field experiment offers a decisive knowledge on the impact of tillage practices and weed management strategies on evaluating soil nutrient status variation with soil depth and on identifying the best management practices to be advocated for maintenance of soil quality and sustainable crop production under cotton – maize – *Sesbania* rotation systems.

FUTURE SCOPE

— Long-term tillage practices should be implemented in CA practices under diversified cropping system in order to identify and comprehend tillage system that can sustain the soil physico-chemical, nutrient status and their distribution in the soil profile.

— Stratification ratio of soil nutrients and physico-chemical properties should be quantified under CA as to monitor the changes on soil quality.

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Conflict of Interest. None.

REFERENCES

Agriculture Action Plan (2021). Department of Agriculture, Government of Telangana.

Alam, K., Islam, M., Salahin, N. and Hasanuzzaman, M. (2014). Effect of tillage practices on soil properties and crop productivity in wheat-mungbean-rice cropping system under sub-tropical climatic conditions. *The Scientific World Journal*, 1-15.

Blake, G. R. and Hartge, K. H. (1986). Bulk density by core method. *Methods of Soil Analysis, Klute, A., Ed. Part I*, 364-367.

Bitew, Y., Derebe, B., Worku, A. and Chakelie, G. (2022) Maize–legume systems under conservation agriculture. *Agronomy Journal*, *114*(1), 173-186.

DeBano, L. F., and Wood, M. K. (1990). Soil loss tolerance as related to rangeland productivity. In *Proceedings of Soil Quality Standards Symposium*, 15-27.

Dhaliwal, S. S., Sharma, V., Shukla, A. K., Kaur, J., Gupta, R. K., Verma, V. and Singh, P. (2023). Interactive effect of land use systems on depth-wise soil properties and micronutrients minerals in North-Western, India. *Heliyon*, *9*(2).

Dhanker, R., Goyal, S., Kumar, K. and Hussain, T. (2021). Bacterial community response to pesticides polluted soil. In *Recent Advancement in Microbial Biotechnology*, 339-355. Academic Press.

Jackson, M. L. (1973). Soil chemical analysis. An advanced course, Second Edition, University of Wisconsin, Madison, USA.

Kaur, R., Singh, B. and Dhaliwal, S. S. (2020). Dynamics of soil cationic micronutrients in a chronosequence of poplar (*Populus deltoides* Bartr.)-based agroforestry system in India. *Journal of Soil Science and Plant Nutrition*, *20*, 2025-2041.

Limousin, G., Gaudet, J. P., Charlet, L., Szenknect, S., Barthès, V. and Krimissa, M. (2007). Sorption isotherms: A review on physical bases, modeling and measurement. *Applied Geochemistry, 22*, 249–275.

Nthebere, K., Sharma, S. H. K., Kumari, C. P. and Qureshi, A. A. (2020). Different Cropping System Effects on Depth-wise distribution of Available NPKS in an *Inceptisol* of Southern Telangana Zone. *International Research Journal of Pure and Applied Chemistry*, *21* (17), 32-39.

Olsen, S. R., Cole, C. V., Watanabe, F. S., Dean, L. A. (1974). Estimation of available phosphorous in soils by extraction with $NaHCO_3$, USDA Cir.939. U.S. Washington.

Parihar, C. M., Yadav, M. R., Jat, S. L., Singh, A. K., Kumar, B., Pradhan, S. and Yadav, O. P. (2016). Long term effect of conservation agriculture in maize rotations on total organic carbon, physical and biological properties of a sandy loam soil in north-western Indo-Gangetic Plains. *Soil and Tillage Research*, *161*, 116-128.

Piper, C. S. (1966). Soil and plant analysis (Asia Edition), Hans Publishers, Bombay, India.

Sapre, N., Singh, P., Kewat, M. L. and Sharma, A. R. (2019). The cumulative effect of tillage and weed management practices on soil property, weed dynamics and productivity of mungbean (*Vigna radiata* L.) in the rice-wheat-mungbean cropping system. *Journal of Pharmacognosy and Phytochemistry*, *8*(1), 1881-1886.

Singh, A., Phogat, V. K., Dahiya, R. and Batra S. D. (2014). Impact of long-term zero till wheat on soil physical properties and wheat productivity under rice–wheat cropping system. *Soil Tillage Research*, *140*, 98–105.

Subbiah, B. V. and Asija, G. L. (1956). A rapid procedure for the determination of available nitrogen in soils. *Current Science*, *25*, 259-260.

Walkley, A. and Black, C. A. (1934). Estimation of organic carbon by chromic acid titration method. *Soil Science*, *37*, 29-38.

Weiss, M., Jacob, F. and Duveiller, G. (2020). Remote sensing for agricultural applications: A meta-review. *Remote Sensing of Environment*, *236*, 111402.

Zulu, S. G., Magwaza, L. S., Motsa, N. M., Sithole, N. J. and Ncama, K. (2022). Long-Term No-Till Conservation Agriculture and Nitrogen Fertilization on Soil Micronutrients in a Semi-Arid Region of South Africa. *Agronomy*, *12*(6), 1411.

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