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Humic substances and available nutrients influenced by tillage and weed management practices

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ABSTRACT

Effect of tillage and weed management practices on soil organic carbon (SOC), production of humic substances and available N, P, K, S was studied after four years of experimentation (2016) at Agronomy Research Farm, CCS Haryana Agricultural University, Hisar, Haryana. Experiment initiated in 2012 having three tillage practices [T_1: conventional tillage (CT), T_2: furrow irrigated raised bed system (FIRBS) and T_3: zero tillage (ZT)] and four weed management practices (Two chemical weed management practices, one manual weeding practice and one weedy check practice). All the treatments were replicated thrice under spilt-plot design. The highest values of SOC (0.90%), Humic acid-C (0.352%), Fulvic acid -C (0.239%) and available nutrients: N (100.6 kg/ha), P (32.6 kg/ha), S (18.2 kg/ha), was observed under ZT system followed by FIRBS and CT system. However, highest available K (202 kg/ha) was observed under CT followed by ZT and FIRBS system. Post harvest available nutrients and SOC was significantly higher under weedy check treatment and at upper depth (0–5cm) under all tillage practices. Under ZT system, about 10% and 24% higher SOC was observed at upper depth and about 4% and 8% higher SOC was observed at lower depth than that of FIRBS and CT systems, respectively. Conservation tillage practices (ZT and FIRBS), since contribute towards increased soil organic matter are thus able to improve soil fertility and maintain it for a longer period.

Keywords: Available nutrient, Fulvic acid, Humic acid, Soil organic carbon, Tillage, Weed

Tillage practices in cropping systems have been part of most agricultural systems throughout history which aimed at improving soil conditions along with providing good seed bed for initial establishment of crops and also controls weeds effectively. Several researchers observed an increase of soil organic carbon (SOC) with conservation tillage practices in the top soil layer (Pinheiro *et al.* 2015, Kaushik *et al.* 2018). When soil organic matter (SOM) decomposes as a result of microbial activity, the nutrient contained within it may follow two paths- Mineralization and/or Humification. The SOM dynamics should not be restricted to total organic carbon, but it also includes the light fraction of SOM, a more sensitive indicator of changes in the quality of soil (Haynes 2005) and of the humic fractions of organic matter, the most stable components of SOM, representing 40–60% of SOM, and a significant part of total C and N of the soil (Horwath 2015). Tillage distributes organic matter in the soil and thus improves the availability of nutrients for plant growth through the formation of clay-humus complexes and the increase of charged surfaces for nutrient binding. Generally, tillage has caused C losses from 28–77% (Paustian *et al.* 1997) and resulted in poor soil physical conditions for crop growth and decrease soil's ability to retain nutrients for a longer period of time. Greatest challenges associated with CA practices, eliminating tillage result into increase in weed pressure during the early period of adoption (Chauhan *et al.* 2012). However, with good weed management practices, weed pressure should decrease over time, often within the first few years of adoption (Thierfelder and Wall 2015). Weed management have direct and indirect effect on soil quality that can range from negative to positive (Six *et al.* 2002, Kavinder 2016). The present research focus on the effects of the three tillage (ZT, FIRBS and CT) and four weed management practices on production of humic substances and available nutrient status of soil.

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MATERIALS AND METHODS

A field experiment was initiated during *rabi* 2012 to study the effect of tillage and weed management practices on yield and soil properties under maize-wheat system at Research Farm, Department of Agronomy, CCS Haryana Agricultural University, Hisar. The soil of experimental site was sandy loam in texture having alkaline *p*H (8.04), EC (0.4 dS/m), OC (0.74%), available N (98 kg/ha), P (22.7 kg/ha), K (208 kg/ha). The climate of the area is semiarid type, with very hot summers and relatively cool winters.

The experiment was laid out in split-plot design with three tillage treatment [T_1: conventional tillage (CT), T_2: furrow irrigated raised bed system (FIRBS) and T_3: zero tillage (ZT)] in main plot and four weed management practices [W_1: Atrazine (50% WP) 750 g/ha in maize and pinoxaden 50 g/ha + premix of metsulfuron and carfentrazone (Ally Express 50% DF) 25 g/ha + 0.2% NIS as post-emergence in wheat, W_2: Tembotrione (Laudis 42% SC 120 g/ha + S 1000 ml/ha (10–15 DAS/ 2–4 leaf stage) in maize and clodinafop 60 g/ha + metsulfuron 4 g/ha as post- emergence in wheat, W_3: Two HW in maize (20 to 40 DAS) and wheat (30 to 50 DAS), W_4: Weedy check in maize and wheat)] in sub plot. All the treatments were replicated thrice and test crops sequence was wheat (Cv.WH 1105) in *rabi* and maize (Cv. HQPM-1) in *kharif.*

Soil sampling and analyses: Soil samples were collected in triplicate from each plot at two depth (0-5 and 5-15cm) after the harvesting of wheat in the month of April, 2016 and mixed thoroughly for preparing composite sample of each plot. The soil samples were air dried ground and sieved through a 0.5 mm sieve before analysis. Available nitrogen, phosphorus, potassium and sulphur were analysed by Subbaiah and Asija (1956), Olsen *et al.* (1954), Jackson (1973) and Chesnin and Yien (1950), respectively. Soil organic C was determined by wet oxidation method (Walkley and Black 1934). Humic and fulvic acid carbon was determined with method given by Schlichting and Blume (1966).

Statistical analysis: The data obtained under study were statistically analyzed using spilt-plot design. Comparisons among treatment means were made using the least significant difference (LSD) calculated at P = 0.05 level of significance using OPSTAT software.

RESULTS AND DISCUSSION

Soil organic carbon: Soil organic carbon (SOC) content after 4 cycles of maize-wheat cropping system at both the depth was significantly affected by tillage practices. The highest SOC was observed under ZT (0.90%) followed by FIRBS (0.84%) and CT (0.78%) (Table 1). About 7 and 15% higher SOC was observed under ZT system as compared to FIRBS and CT system, respectively. The possible reason was minimum disturbances of soil under ZT and FIRBS, which reduces the oxidation of organic matter, thus more SOC retain in soil as compared to CT. Interaction between tillage and depth showed significant effect on SOC content. The SOC content decreased at 5-15 cm depth due to less amount of crop residue incorporation as compared to upper depth under ZT and FIRBS tillage system (Martinez *et al.* 2016, Jat *et al.* 2018). The SOC content varied from 0.78 (CT) to 0.97% (ZT) at 0-5 cm depth and 0.77 (CT) to 0.83% (ZT) at 5-15 cm depth under different tillage and weed management practices. Kaushik *et al.* (2018) also reported higher SOC in case of ZT and NT (no tillage) as compared to CT. Effect of different weed management practices on SOC content was non-significant however; slightly higher values were reported under weedy check treatment under all tillage practices.

Humic acid and fulvic acid carbon: In the present study, humic acid and fulvic acid carbon (HA-C and FA-C) content was significantly affected by tillage practices; however, effect of different weed management practices was non-significant. Highest HA-C (0.352%) and FA-C (0.239%) was recorded under ZT followed by FIRBS and CT (Table 1). Higher amount of SOC content and its slow oxidation under ZT practice is responsible for higher amount of humic substances produced under conservation tillage as compared to CT practices. It is also indicated by highly positive significant correlation between SOC and HA-C and FA-C observed in this present study (r=0.990, P=0.01 and r=0.771, P=0.01). Results of present study are conformity of findings of Horacek *et al.* (2014) who reported that ZT or reduced tillage practices significantly increased the humus content of soil as compared to CT practice. The HA-C and FA-C was significantly differing at both the depth. The mean value of HA-C in soil at upper depth varied from 0.268–0.397% and at lower depth varied from 0.278–0.318%, respectively under different tillage and weed management practices. Amount of FA-C varied from 0.193–0.258% at upper depth and 0.192–0.228% at lower depth, respectively. In case of CT practice, higher value of HA-C was recorded at lower depth but in ZT and FIRBS practices, higher values were reported under upper depth. The interaction between tillage and depth was found significant and magnitude of difference between HA-C and FA-C produced at upper and lower depth was more under ZT followed by FIRBS; however, under CT practice, the difference was not significant.

Available nitrogen: The highest mean value (100.6 kg/ha) of available N was observed under ZT and lowest mean value (91.1 kg/ha) was observed under CT practice (Table 2). The highest available N observed under ZT was due to accumulation of organic matter on soil surface which is an important source of mineralizable N; in addition, it also reduces the leaching and volatilisation losses of N. It was also indicated by highly positive correlation between SOC and available N (r=0.896, P=0.01). Significantly higher amount of available N was observed under weedy check treatment under all tillage management practices at both the depth. This was due to return of N by incorporation of weed in soil and less removal of N by crops under low yield condition. Available N content significantly decreased at lower depth as compared to upper depth under all tillage and weed management practices due to less availability of organic matter and fertilizer N at lower depth. The magnitude of difference in amount of available N present in upper and lower depth was highest in ZT followed by FIRBS and CT conditions. Results are on line with the findings of several other workers (Jat *et al.* 2018, Kaushik *et al.* 2018).

Available phosphorus: Highest available phosphorus (P) was found in ZT (32.6 kg/ha) and lowest value in CT (25.6 kg/ha) (Table 2). This may be due to less mixing of applied fertilizers and limited downward movement of particle bound P in ZT treatment. Another possible reason might be increase in SOC content under ZT and FIRBS which

Table 1 Effect of tillage and weed management practices on SOC and humic substances at different soil depths

Weed management	CT			FIRBS			ZT		
	Depth		Mean	Depth		Mean	Depth		Mean
	0-5 cm	5-15 cm		0-5 cm	5-15 cm		0-5 cm	5-15 cm	
				SOC (%)					
W_1	0.77	0.76	0.76	0.87	0.80	0.83	0.96	0.82	0.89
W_2	0.78	0.77	0.77	0.88	0.79	0.83	0.97	0.81	0.89
W_3	0.77	0.77	0.77	0.87	0.80	0.83	0.97	0.82	0.89
W_4	0.80	0.79	0.79	0.89	0.81	0.85	0.99	0.83	0.91
Mean	0.78	0.77	0.78	0.88	0.80	0.84	0.97	0.82	0.90
CD (P=0.05)	Tillage (T) = 0.07, T × W = NS,			Weed (W) = NS, T × D = 0.12, T × W × D = NS			Depth (D) = 0.08, W × D = NS,		
				HA-C (%)					
W_1	0.270	0.278	0.274	0.330	0.291	0.310	0.393	0.312	0.352
W_2	0.274	0.282	0.278	0.327	0.293	0.310	0.389	0.314	0.351
W_3	0.268	0.279	0.273	0.337	0.295	0.316	0.397	0.318	0.357
W_4	0.272	0.281	0.276	0.335	0.293	0.314	0.393	0.309	0.351
Mean	0.272	0.280	0.275	0.332	0.293	0.312	0.393	0.314	0.352
CD (P=0.05)	Tillage (T) =1.43, Weed (W) =NS, T × W = NS, T × D = NS, W × D = NS,						Depth (D) = 0.99 T × W × D = NS		
				FA-C					
W_1	0.210	0.192	0.201	0.234	0.202	0.218	0.248	0.221	0.235
W_2	0.193	0.194	0.193	0.230	0.199	0.215	0.254	0.220	0.237
W_3	0.211	0.198	0.204	0.240	0.205	0.223	0.258	0.228	0.243
W_4	0.200	0.196	0.198	0.236	0.202	0.219	0.256	0.223	0.240
Mean	0.203	0.195	0.199	0.235	0.202	0.219	0.254	0.223	0.239
CD (P=0.05)	Tillage (T) = 1.43, T ×W = NS,			Weed (W) = 1.03, T × D = NS, T × W × D = NS			Depth (D) = 0.99 W×D = NS		

in turns decrease the phosphorous fixation and increases its availability. This fact was confirmed by highly positive correlation (r=0.919, P=0.01) between SOC and available P in this study. Weed management practices significantly affected the available P content of soil and higher mean value of P observed under weedy check treatment was due to incorporation of weeds and their decomposition added phosphorous to soil and increased its availability. The less crop yield in weedy check plots was also responsible for higher amount of available P. Higher amount of available P at upper depth may be due to immobile nature of P, thus major amount of applied P remain in upper layer. Kaushik *et al.* (2018) and Meng *et al.* (2019) also reported similar results for available P in soil under similar conditions.

Available potassium: Highest value of available potassium (K) was recorded under CT (202 kg/ha) while lowest value was observed under FIRBS (178 kg/ha). The lower availability of K in FIRBS and ZT may be due to leaching of K in presence of macro pores and whose continuity was not break down under FIRBS and ZT. The higher amount of available K under CT as compared to ZT was also reported by Gangwar *et al.* (2004) and Kaushik *et al.* (2018). Different weed management practices had non-significant effect on available K. Tillage and depth interaction showed significant effect on available K content of soil and highest mean value of 219.78 kg/ha was found at 0–5 cm soil depth under CT practice, while lowest mean value of 173.03 kg/ha was observed in 5–15 cm soil depth under FIRBS system. The magnitude of difference in values of available K at upper and lower soil depth was highest under CT followed by ZT and FIRBS systems.

Available sulphur: The highest S content (18.2 kg/ha) was observed under ZT followed by FIRBS (13.7 kg/ha) and CT (10.1 kg/ha). This might be due to retention of more amount of crop residue on soil surface in ZT as compared to other tillage practices. Sulphur and organic carbon content have direct correlation (r= 0.943, P=0.01). Kaushik *et al.* (2018) also reported higher amount of S under ZT as compared to other tillage practices. Highest available S was recorded under weedy check treatment. Data also revealed

Table 2 Effect of tillage and weed management practices on available nutrients (kg/ha) of soil at different depths

Weed management	CT			FIRBS			ZT		
	Depth		Mean	Depth		Mean	Depth		Mean
	0-5 cm	5-15 cm		0-5 cm	5-15 cm		0-5 cm	5-15 cm	
					N				
W_1	96.7	81.6	89.2	99.3	84.0	91.6	110.6	87.7	99.1
W_2	98.6	82.9	90.7	100.3	84.4	92.3	109.0	88.8	98.9
W_3	98.2	83.3	90.8	101.5	85.9	93.7	108.7	89.6	99.1
W_4	99.0	88.6	93.8	107.0	91.5	99.2	114.6	95.5	105.1
Mean	98.1	84.1	91.1	102.0	86.4	94.2	110.7	90.4	100.6
CD (P=0.05)	Tillage (T) = 4.92,			Weed (W) = 3.64,			Depth (D) = 2.44		
	T × W = NS,			T × D = NS,			W × D = NS,		
				T×W × D = NS					
					P				
W_1	29.0	19.4	24.2	33.0	22.7	27.8	36.0	25.8	30.9
W_2	30.0	21.0	25.5	32.6	22.5	27.5	35.7	26.5	31.1
W_3	30.1	20.3	25.2	33.8	23.3	28.6	37.5	26.5	31.5
W_4	33.4	22.0	27.6	36.0	26.7	31.3	42.0	31.0	36.5
Mean	30.6	20.7	25.6	33.9	23.8	28.8	37.8	27.4	32.6
CD (P=0.05)	Tillage (T) = NS,			Weed (W) = 2.7,			Depth (D) = 0.7,		
	T × W = NS,			T × D = NS,			W × D = NS,		
				T × W × D = NS					
					K				
W_1	218	184	201	181	171	176	199	174	186
W_2	219	182	200	181	173	177	197	173	185
W_3	216	183	200	182	172	177	197	174	186
W_4	226	187	206	190	175	183	203	178	191
Mean	220	184	202	183	173	178	199	175	187
CD (P=0.05)	Tillage (T) = 6.10,			Weed (W) = NS,			Depth (D) = 3.97,		
	T × W = NS,			T × D = 6.88,			W × D = NS,		
				T × W × D = NS					

that available S significantly decreased at lower depth as compared to upper depth. This was might be due to less organic matter content at lower depth. Interaction between different tillage and weed management practices showed non-significant effect on S availability in soil.

Higher amount of SOC, HA-C, FA-C and available N, P, S was observed under ZT followed by FIRBS and CT practices. However, available K was observed higher under CT followed by ZT and FIRBS. Post harvest available nutrients, SOC and humic substances were significantly higher under weedy check and at upper soil depth under all treatments. Conservation tillage practices (ZT and FIRBS), since contribute towards increased soil organic matter are thus able to improve soil fertility and maintain it for a longer period.

REFERENCES

Chauhan B S, Singh R G and Mahajan G. 2012. Ecology and management of weeds under conservation agriculture: a review. *Crop Protection* **38**: 57–65.

Chesnin L and Yien C H. 1950. Turbiditric determination of available sulphates. *Proceedings of Soil Science Society of America* **14**: 149–51.

Gangwar K S, Singh K K and Sharma S K. 2004. Effect of tillage on growth, yield and nutrient uptake in wheat after rice in the Indo-Gangetic Plains of India. *Journal of Agricultural Science* **142**: 453–59.

Haynes R J. 2005. Labile organic matter fractions as central components of the quality of agricultural soils: an overview. *Advances in Agronomy* **85**: 221–68.

Horáček J, Strosser E and Čechová V. 2014. Carbon fraction concentrations in a haplic Luvisol as affected by tillage. *Plant Soil Environment* **60**: 262–66.

Horwath W and Paul E A. 2015. Carbon cycling: the dynamics and formation of organic matter. *Soil Microbiology, Ecology and Biochemistry* **4**: 339-82.

Jackson M L. 1973. *Soil Chemical Analysis*. Prentice Hall of India Pvt. Ltd. New Delhi.

Jat H S, Datta A, Sharma P C, Kumar V, Yadav A K and Choudhary M. 2018. Assessing soil properties and nutrient availability under conservation agriculture practices in a reclaimed sodic soil in cereal-based systems of North-West India. *Archives of Agronomy and Soil Science* 64(4): 531–45.

Kaushik U, Raj D, Rani P and Antil R S. 2018. Impact of zero tillage on available nutrients status on pearl millet wheat cropping system. *International Journal of Chemical Studies* **6**: 2997–3000.

Kavinder. 2016. Study of weed dynamics in wheat under long term FYM and nitrogen application. M Sc thesis, to Chaudhary Charan Singh Haryana Agricultural University Hisar, Haryana.

Martínez I, Chervet A, Weisskopf P, Sturny W G, Etana A, Stettler M, Forkman J and Keller T. 2016. Two decades of no-till in the Oberacker long-term field experiment: Part I. Crop yield, soil organic carbon and nutrient distribution in the soil profile. *Soil and Tillage Research* **163**: 141–51.

Meng T, Sun Z and Cheng J. 2019. Effects of tillage practices on soil fertility in loess plateau. In IOP conference series: *Earth and Environmental Science* **300**(2): 022069.

Olsen S R, Cole C V, Watanabe F S and Dean L A. 1954. Estmation of available phosphorous in soils by extraction with sodium bicarbonate. Circulation from United States Department of Agriculture 939, Washington DC, USDA.

Paustian K, Collins H P and Paul E A. 1997. Management controls on soil carbon. (*In*) *Soil organic matter in temperate agroecosystems: Long-term experiments in North America,* pp 15–49. CRC Press. Taylor and Francis Group, Boca Raton, Landon, NewYork.

Pinheiro E F M, De Campos D V B, De CarvalhoBalieiro F, Dos Anjos L H C and Pereira M G. 2015. Tillage systems effects on soil carbon stock and physical fractions of soil organic matter. *Agricultural Systems* **132**: 35–9.

Schlichting E and Blume H P. 1966. Boden Kundliches Praktikum. Paul Parey, Hamburg, Berlin, pp 136–38.

Six J, Elliott E T and Paustian K. 2002. Soil structure and soil organic matter: II. A normalized stability index and the effect of mineralogy. *Soil Science Society of American Journal* **64**:1042–49.

Subbaiah B V and Asija G L. 1956. A rapid procedure for the determination of available nitrogen in soil. *Current Science* **25**: 259–60.

Thierfelder C and Wall PC. 2015. Weed control in smallholder conservation agriculture. CIMMYT, Bulletin 6, pp 1–2.

Walkley A and Black C A. 1934. Estimation of soil organic carbon by the chromic acid titration method. *Soil Science* **37**: 29–38.