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Effect of tillage and weed management practices on micronutrient availability in post-harvest soil under maize-wheat cropping system

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ABSTRACT

Tillage practices play a major role in nutrient dynamics under different cropping systems. The objective of this study was to examine the influence of different tillage practices and weed management on micronutrient availability in soil. The treatments included three tillage in main plot and four weed management practices in sub plot were arranged in a spilt plot design with three replications.Measurements made at the end of 4 years, showed that in the 0-15 cm soil depth, effect of different tillage and weed management practices on soil properties was significant. The values of soil pH and EC declined under ZT. The mean value of SOC (8.9 g kg^{-1}) was reported higher under ZT. Higher value of Zn and Fe was reported under ZT (3.63 mg kg^{-1}, 15.49 mg kg^{-1}) followed by CT (2.87 mg kg$^{-1,}$ 13.65 mg kg^{-1}) and FIRBS (2.47 mg kg^{-1},13.47 mg kg^{-1}) respectively. In case of Cu, the higher value (1.32 mg kg^{-1}) was reported under ZT followed by FIRBS (1.30 mg kg^{-1}) and CT (1.22 mg kg^{-1}). Trend was reverse in case of Mn and content was significantly higher (9.4 mg kg^{-1}) under CT followed by ZT (9.02 mg kg^{-1}) and FIRBS (8.70 mg kg^{-1}). The results suggested that ZT can play a vital role in sustaining micronutrient availability due to decreased soil pH and the greater amount of organic matter compared to other tillage methods.

Keywords: Tillage, weed management, micronutrient, maize-wheat cropping sequence

INTRODUCTION

Increase in world population has led to intensive farming systems resulting in an increase in high level of food security (Maharijan *et al.,* 2018). However, intensive farming is characterized by environmental degradations, loss of biodiversity and increase of soil erosion. The proper use of the plant nutrients for agricultural production is of importance to reduce the negative impacts on the environment caused by unsustainable farming systems (Foley *et al.,* 2011). Intensity of tillage significantly influences macro- and micronutrient availability in soil. Organic matter content of soil is the result of a dynamic and sensitive balance between the mechanisms of addition, transformation, and mineralization of the residues entering the system, affected by the local soil and climate characteristics . The quantity of mineralizable organic forms of micronutrient increases with the increase in soil organic matter (SOM), whereas nutrients become unavailable or decline when SOM decreases (Boggs *et al.,* 2003). Soil under conservation tillage (no-tillage, NT; zero tillage, ZT) had a greater amount of SOM as compared to soil under conventional moldboard tillage. Consequently, greater concentrations of some soil-extractable micronutrients, such as Mn and Zn, were reported under NT compared to conventional tillage. Other researchers have reported that NT enhanced the conversion of Fe and Mn oxides to exchangeable forms compared to conventional tillage, due to low soil pH and a high amount of SOM in NT plots than in conventionally tilled plots. On the other hand, Hickman(2002) reported that the tillage system did not affect extractable concentrations of soil Cu and Zn. The availability of micronutrients in soil directly and indirectly affects the productivity and quality of crops. Therefore, changes in the plant-available micronutrients in the soil are not only important for plant nutrition, but also for livestock and human nutrition. The importance of the connection between plant–human nutrition is evident in studies that have documented Zn deficiency as the most widespread micronutrient deficiency limiting crop production. Most studies on tillage systems investigated changes in the soil C, N, and P but very few studies have examined the changes in micronutrients as influenced by tillage systems under different cropping system.

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Since the beginning of agriculture tillage has been used to prepare the seedbed and reduce weeds that will compete with the crop. Tillage can be used in the spring, in-season and after harvest as a single tactic weed management tool or in combination with other control tactics. The weeds present in any given field will reflect the tillage management used; therefore, the weed community in a conventional tillage system will be very different than those in a no-till system. In recent years, herbicide have been developed and found promising tool in weed management and their use made it possible to reduce mechanical approaches of weed control and augmented the adoption of reduced and no tillage crop production system. Use of herbicides as a sole control mechanism increases the risk of herbicide-resistant weeds population in field (Norsworthy*et al.,* 2012) thus use of integrated weed management technique is a tool for management of weed in field. Keeping in view of above facts the present study was planned to observe the effect of conservation tillage and weed management practices on micronutrient availability in soil.

MATERIALS AND METHODS

A field experiment was initiated in *Rabi* 2012 at Research Farm, Department of Agronomy CCS Haryana Agricultural University, Hisar. The experimental sites is located at 29°16'N latitude and 75°7'E longitude at the mean sea elevation of 215.2m in north-west part of India. The soil of experimental site was sandy loam, *TypicUstocherpt*. Initial characterization of experimental soil were: organic carbon (7.6 g kg^{-1}), EC (0.41dSm^{-1}), pH (8.0), N (98 kg ha^{-1}), P (22.7 kg ha^{-1}) and K (208.4 kg ha^{-1}), respectively. The experiment was laid out with three tillage treatment (ZT, FIRBS and CT) in main plot and four weed management practices (W_1: Atrazine (50% W.P.) @ 750 g/ha in maize and pinoxaden 50g/ha + premix of metsulfuron and carfentrazone (Ally Express 50% DF) 25g/ha + 0.2 % NIS as post-emergence in wheat, W_2: Tembotrione (Laudis 42% Sc @ 120 g/ha + S 1000ml/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.The treatments were arranged in a spilt plot design with three replications. Experiment was started in *Rabi,* 2012 and crop sequence was wheat (WH 1105) in *Rabi* and maize (HQPM-1) in *kharif.* Soil samples were taken at two depth (0-5 and 5-15cm) after the harvesting of wheat were collected and air dried ground and sieved through a 0.5 mm sieve before analysis. The pH and EC were measured in 1:2 soil water suspensions by using potentiometric and conductometric method (Jackson, 1973). The concentration of available micronutrients was determined by DTPA extraction method (Lindsay and Norvell, 1978). Soil organic carbon was determined by wet oxidation method (Walkley and Black method, 1934).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 $P < 0.05$ subjected to statistical analysis for significance using OPSTAT software.

RESULTS AND DISCUSSION

Soil properties

The results indicated that soil pH was significantly affected by different tillage practices at both 0-5 cm and 5-15 cm soil depth (Table 1).The higher mean value of pH (7.76) was observed under CT followed by FIRBS (7.34) and ZT (7.16). The lower soil pH observed under ZT was mainly due to retention of more crop residue on soil surface and their subsequent decomposition released organic acids which lowered pH of soil. Several workers also observed lower pH under ZT as compared to FIRBS and CT (Martinez *et al.*, 2016, Kaushik *et al.,* 2018 and Issaka *et al.,* 2019). The data also showed that pH significantly increased at lower depth (5-15 cm) compared to upper depth (0-5 cm). The pH varied from 7.00 to 7.76 at upper depth (0-5 cm) and 7.17 to 7.86 at lower depth (5-15 cm) under different tillage and weed management practices. This might be due to more organic matter content at upper surface as compared to lower soil depth, acidification process caused by decomposition of organic matter and less homogenisation of soil (Martinez *et al.*, 2016). Effect of weed management on pH was non-significant however, numerically lower values were observed under weedy check treatment due more organic matter content. Interaction among the treatments showed non-significant difference.

Table 1: Effect of tillage and weed management practices on soil properties at different depth

Conventional tillage				FIRBS			Zero tillage		
Depth			Mean	Depth		Mean	Depth		Mean
	0-5cm	5-15cm		0-5cm	5-15cm		0-5cm	5-15cm	
					pH				
W_1	7.75	7.76	7.75	7.26	7.40	7.33	7.20	7.25	7.22
W_2	7.75	7.86	7.80	7.30	7.42	7.36	7.13	7.22	7.17
W_3	7.76	7.76	7.76	7.32	7.45	7.38	7.13	7.23	7.18
W_4	7.75	7.70	7.70	7.20	7.40	7.3	7.00	7.17	7.08
Mean	7.75	7.77	7.76	7.27	7.41	7.34	7.11	7.21	7.16
C.D. (P=0.05),		Tillage (T) = 0.018,			Weed (W) = NS,			Depth (D) = 0.070,	
TXW= NS,		TXD =NS,			WXD =NS,			TXWXD = NS	
					EC (dSm^{-1})				
W_1	0.27	0.24	0.25	0.24	0.22	0.24	0.23	0.20	0.21
W_2	0.26	0.22	0.24	0.24	0.22	0.24	0.22	0.20	0.21
W_3	0.28	0.24	0.26	0.25	0.20	0.24	0.21	0.21	0.21
W_4	0.26	0.23	0.24	0.25	0.21	0.23	0.23	0.20	0.21
Mean	0.27	0.23	0.25	0.25	0.21	0.24	0.22	0.21	0.21
C.D. (P=0.05),		Tillage (T) =.02,		Weed (W) =NS,			Depth (D) =1.334,		
TXW = NS,		TXD =.020,		WXD =NS,			TXWXD = NS		
					SOC ($g\ kg^{-1}$)				
W_1	7.7	7.6	7.65	8.7	8.0	8.35	9.6	8.2	8.9
W_2	7.8	7.7	7.75	8.8	7.9	8.35	9.7	8.1	8.9
W_3	7.7	7.7	7.7	8.7	8.0	8.35	9.7	8.2	8.95
W_4	8.0	7.9	7.95	8.9	8.1	8.50	9.9	8.3	9.10
Mean	7.8	7.7	7.76	8.8	8.0	8.38	9.7	8.3	8.96
C.D. (P=0.05),		Tillage (T) = 0.07,			Weed (W) = NS,		Depth (D) = 0.08,		
	TXD = 0.12,				WXD = NS,		TXWXD = NS		

Electrical conductivity

Electrical conductivity (EC) of soil was significantly affected by different tillage practices at both depths (0-5 and 5-15 cm). The higher mean value of EC (0.25 dSm^{-1}) was observed under CT followed by FIRBS (0.24 dSm^{-1}) and ZT (0.21 dSm^{-1}). Lower EC under ZT and FIRBS might be due to leaching of salts through continuity of macro pores present under conservation tillage conditions. The result of present study was on the line of finding of Kahlon and singh (2014) and Kaushik*et al.* (2018). Tillage and depth interaction was found significant among all interactions. Values of EC decreased at 5-15 cm soil depth and varied from 0.20 to 0.28 dSm^{-1} at upper depth and 0.20 to 0.24 dSm^{-1} at lower depth under different tillage and weed management practices. The difference in EC between the both soil depths was more under CT as compared to other tillage practices. Effect of weed management practices on EC was non- significant and numerically higher EC were observed under weedy check treatment.

Soil organic carbon

Soil organic carbon(SOC) content after 4 cycles of maize-wheat cropping system at both the depth significantly affected by different tillage practices (Table 1). The higher mean value of SOC was observed under ZT (8.9 gkg^{-1})) followed by FIRBS (8.4gkg^{-1}) and CT (7.8gkg^{-1}). 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. The SOC content significantly decreased at lower depth compared to upper depth in FIRBS and zero tillage conditions. However, such type of results was not observed under CT. Interaction between tillage and depth showed significant effect on

SOC content and difference between SOC content at upper and lower depth was maximum under ZT (16.87 % higher) followed by FIRBS (10 % higher) and CT condition. The SOC content decreased at 5-15 cm depth was due to less amount of crop residue incorporation as compared to upper depth under ZT and FIRBS tillage system (Martinez *et al.*, 2016). Mean value SOC content varied from 7.8 (CT) to 9.7 gkg^{-1} (ZT) at 0-5 cm depth and 7.7 (CT) to 8.2gkg^{-1}(ZT) at 5-15 cm depth under different tillage and weed management practices. ZT system showed increase of 9% and 19% of SOC at upper depth and 3% and 7% at lower depth over FIRBS and CT, respectively. Kaushik*et al.*(2018) and Zuber*et al,*(2018) also reported higher SOC in case of ZT and NT as compared to CT. While Issaka*et al.* (2019) observed 10.37 % higher TOC under CT than conservation tillage practice. 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. Interaction of tillage and depth showed significant difference whereas the other interactions were non-significant.

Table 2: Effect of tillage and weed management practices on post-harvest available micronutrient (mg kg^{-1}) status of soil at different depth

	Conventional tillage			FIRBS			Zero tillage		
	Depth		Mean	Depth		Mean	Depth		Mean
	0-5cm	5-15cm		0-5cm	5-15cm		0-5cm	5-15cm	
Zinc									
W_1	1.8	4.16	2.98	2.64	2.17	2.40	4.07	3.37	3.72
W_2	1.82	4.18	3.00	2.57	2.15	2.36	4.08	3.28	3.68
W_3	1.83	4.10	2.965	2.61	2.19	2.40	4.12	3.27	3.695
W_4	1.89	3.19	2.54	3.19	2.27	2.73	3.36	3.52	3.44
Mean	1.83	3.90	2.87	2.75	2.19	2.47	3.90	3.36	3.63
C.D. (P=0.05),		Tillage (T) = 0.52,			Weed (W) = NS,			Depth (D) = 0.25,	
TXW = NS,		TXD = 0.44,			WXD = NS,			TXWXD = NS	
Fe (mg kg^{-1})									
W_1	15.1	10.66	12.88	14.79	12.71	13.75	16.51	13.23	14.87
W_2	15.19	11.66	13.42	14.28	12.64	13.46	16.29	13.48	14.89
W_3	15.43	11.86	13.64	13.58	11.22	12.40	16.60	14.07	15.64
W_4	16.91	12.37	14.64	15.04	13.51	14.28	17.33	15.77	16.55
Mean	15.66	11.64	13.65	14.42	12.52	13.47	16.68	14.14	15.49
C.D. (P=0.05),		Tillage (T) = 1.43,			Weed (W) = 1.03,			Depth (D) = 0.99	
TXW = NS,		TXD = NS,			WXD = NS,			TXWXD = NS	
Mn (mg kg^{-1})									
W_1	8.9	9.70	9.3	8.51	8.41	8.46	9.42	8.23	8.83
W_2	9.43	8.98	9.2	8.63	8.27	8.45	9.37	8.64	9.01
W_3	9.25	9.3	9.28	8.71	8.47	8.59	9.37	8.17	8.77
W_4	9.77	9.86	9.82	9.17	9.45	9.31	10	8.92	9.46
Mean	9.34	9.46	9.4	8.76	8.65	8.70	9.54	8.49	9.02
C.D. (P=0.05),		Tillage (T) = 0.49,			Weed (W) = NS,			Depth (D) = NS	
TXW = NS,		TXD = NS,			WXD = NS,			TXWXD = NS	
Cu (mg kg^{-1})									
W_1	1.25	1.16	1.21	1.23	1.33	1.28	1.27	1.32	1.30
W_2	1.15	1.17	1.16	1.24	1.32	1.28	1.28	1.33	1.31
W_3	1.23	1.17	1.20	1.25	1.34	1.30	1.28	1.34	1.31
W_4	1.28	1.2	1.32	1.27	1.38	1.33	1.35	1.38	1.37
Mean	1.27	1.17	1.22	1.25	1.34	1.30	1.29	1.34	1.32
C.D. (P=0.05),		Tillage (T) = 0.058,			Weed (W) = 0.063,			Depth (D) = NS,	
TXW = NS,		TXD = 0.087,			WXD = NS,			TXWXD = NS	

Available Micronutrient

Zinc: Available Zn content of soil significantly influenced by tillage practices at different depth (Table 2). Higher value (3.63 mg kg^{-1}) of Zn reported under ZT followed by CT (2.87 mg kg^{-1}) and FIRBS (2.47 mg kg^{-1}). The amount of DTPA extractable Zn was higher under ZT due to crop residue accumulation on soil surface and less soil mixing. This is also due to higher SOC content in ZT and FIRBS as compared to CT (Czekała and Jakubus, 2000). Different weed management treatment showed non-significant difference on Zn status. However, numerically higher value of Zn observed under weedy check treatment. Available Zn content in soil at upper depth (0-5 cm) varied from 1.8 to 4.12 mg kg^{-1} and from 3.27 to 4.18 mg kg^{-1} at lowerdepth (5-15 cm) under different tillage and weed management practices. Data (Table 2) revealed that Zn content significantly decreased at lower depth as compared to upper depth under FIRBS and ZT practices, however reverse trend was observed under CT. That might be due to higher SOM levels and lower soil pH at the soil surface. Higher values of Zn was observed in lower depth as compared to upper depth only in CT due to mixing of soil after addition of Zn fertiliser and more removal of Zn from upper surface by crops. Lopez-Fando and Pardo (2009) also reported higher amount of Zn in upper layer of soil. Furthermore, the immobility of Zn in soil could be another reason for greater Zn concentration near the soil surface than in deep soil profile (Shiwakoti*et al.,* 2019). Interaction of tillage and depth showed significant difference on Zn content. While other interaction showed non-significant effect on Zn content. Result of present study was on line with the findings of Lopez-Fando and Pardo (2009) and Kaushik *et al.,* 2018. Whereas Nta *et al.* (2017) also recorded higher percentage of Zn on the tilled site.

Iron: The availability of Fe in soil under different tillage and weed management practices differed significantly at upper as well as lower depth of soil (Table 2). Higher value (15.49 mg kg^{-1}) of Fe was reported under ZT followed by CT (13.65 mg kg^{-1}) and FIRBS (13.47 mg kg^{-1}). This might be due to presence of high amount of organic matter under zero tillage as compared to other tillage practices. Kaushik *et al.*(2018) also reported higher value of Fe under ZT. Weed control methods significantly affected Fe availability and highest value of Fe was observed under weedy check treatment due to less removal by the crop. Under all tillage practices, availability of Fe significantly decreased at lower depth as compared to upper depth. Available Fe content in soil at upper depth (0-5 cm) varied from 13.58 to 17.33 mg kg^{-1} and at lowerdepth (5-15 cm) from 10.66 to 15.77 mg kg^{-1} under different tillage and weed management practices. Lopez-Fando and pardo (2009) also reported higher amount of Fe in upper layer of soil. Whereas Shiwakoti*et al.*(2019) reported no influence of tillage on Fe content in soil. Interaction effect of tillage, weed management and depth on availability of Fe was found non-significant.

Manganese: The available Mn content was significantly higher (9.4 mg kg^{-1}) under CT followed by ZT (9.02 mg kg^{-1}) and FIRBS (8.70 mg kg^{-1}). These results were on line with the finding of Santiago *et al.* (2008), Kaushik*et al.* (2018). Weed management treatment showed non-significant effect on Mn content. However numerically higher value of Mn was observed under weedy check treatment. Available Mn content in soil at upper depth (0-5 cm) varied from 8.51 to 10 mg kg^{-1} and at lowerdepth (5-15 cm) from 8.17 to 9.86 mg kg^{-1} under different tillage and weed management practices. The available Mn content in soil decreased at lower depth (5-15 cm) under FIRBS and ZT whereas increased under CT. Lopez-Fando and Pardo (2009) also reported higher amount of Mn in upper layer of soil. Interaction effect of tillage and weed management practices was found non-significant at both the depth.

Copper: Data (Table 2) revealed that Cu content in soil was significantly influenced by different tillage and weed management practices. Higher value (1.32 mg kg^{-1}) of Cu content was found under ZT followed by FIRBS (1.30 mg kg^{-1}) and CT (1.22 mg kg^{-1}). Santiago *et al.* (2008) and Kaushik *et al.* (2018) also reported higher amount of Cu under ZT. Weed management treatment showed significant difference on Cu content. Significantly higher value of Cu content was observed under weedy check treatment due to less removal by crops. The Cu content significantly decreased at lower depth under CT as compared to upper depth however reverse trend was observed under FIRBS and ZT. Cu content in soil at upper depth (0-5 cm) varied from 1.15 to 1.35 mg kg^{-1} and at lowerdepth (5-15 cm) from 1.16 to 1.38 mg kg^{-1} under different tillage and weed management practices. Interaction of tillage and depth showed significant difference. Other interactions showed non-significant difference. Govarts *et al.* (2008) and Shiwakoti *et al.* (2019) reported non-significant effect of tillage on soil Cu content.

Through the above research, it may be concluded that effect of different tillage practices on available micronutrients was significant. The amount of DTPA extractable micronutrient was higher under ZT Higher values of Zn and Fe were reported under ZT followed by CT and FIRBS respectively. In case of Cu, higher value was recorded under ZT followed by FIRBS and CT. Trend was reverse in case of Mn and content was significantly higher under CT followed by and FIRBS. Weed management treatment showed significant difference on Cu and Fe content but non-significant on Zn and Mn. However, higher values of all micronutrients were observed under weedy check treatment. Higher values of Zn were observed in lower depth as compared to upper depth only in CT. However, higher values of Fe, Mn and Cu were observed in upper depth as compared to lower depth.

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