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Effect of Tillage and Weed Management Practices on Nutrient Uptake and Yield of Wheat under Maize – Wheat Cropping Systems in Haryana, India

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Authors' contributions

This work was carried out in collaboration among all authors. Author Kavita designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors VSH, RG and Kavinder managed the analyses of the study. Author Kavinder managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

An ongoing field experiment established in 2012 at Agronomy Research Farm, Chaudhary Charan Singh (CCS) Haryana Agricultural University, Hisar, India was selected to evaluated the effect of three tillage practices (zero tillage, furrow irrigated raised bed system and conventional tillage with mouldboard plow) and four weed management practices (W_1: Atrazine (50% W.P.) at750 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 days/ 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 days) and wheat (30 to 50 days), W_4: Weedy check in maize and wheat) on nutrient uptake and yield of wheat. Treatment was replicated thrice with spilt plot design. Plant samples were collected in the month of April, 2016 after the harvesting of wheat. Significantly higher yield of wheat was reported under FIRBS (66.1 qha^{-1})

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followed by zero tillage and under weedy check treatment as compared to other under different tillage and weed management practices. These results suggest that zero tillage and FIRBS along with the weedy check treatment results in higher wheat yield followed by maize.

Keywords: Tillage; weed management; nutrient uptake; wheat yield.

1. INTRODUCTION

Tillage has been an important aspect of technological development in the evolution of agriculture, aimed at improving soil condition affecting the crop production. It provides a good seed bed for initial establishment of crops as well as helps in controlling weeds. The method of tillage used during the field preparation affecting the physical, chemical, and biological properties of soil and have a major impact on soil productivity and sustainability. Conventional tillage using a mouldboard plough, a hunk of deep soil to the surface, leads to formation of large pore in the plough layer, reduction in bulk density and increase soil porosity [1]. Conservational tillage is a collection of series of field operation that aimed at protecting soil and water resources, securing agricultural income, reducing soil and environmental degradation and conserving underlying natural resources [2]. It is a type of tillage system in which at least 30% of crop residues are left in the field. Conservation technologies might appear less profitable initially but their benefits come about over a period of time by reducing cost of cultivation, saving in labour, time and farm power [3]. The adoption of conservational management system can have beneficial effect on soil chemical, physical and biological properties that mitigate erosion and promote sustainability [4]. Zero tillage, a type of conservational tillage system, reduces erosion and other forms of land degradation with the corresponding benefit for national resource base. It improves environmental quality owing to less greenhouse gas emissions and air pollution, due to reduced use of diesel fuel. It also saves 25 per cent water.One of the greatest challenges associated with conservation agricultural practices implementation, in the early years of conversion is the increase in weed pressure as a result of eliminating tillage as a weed control mechanism [5,6]. Weed control is one of the most intensive management practices in different crop production systems and can influence both agriculture productivity and environment. Consequently, finding appropriate weed management strategies is crucial for maintaining adequate yields and compensating for additional labor demands in the first years after conservational agriculture implementation, thereby ensuring continued use of conservational agriculture practices thereafter [7,8]. The direct and indirect effects of weed management on soil quality can range from negative to positive. Presence of weed in the field with crop causes reduction in the yield of crop by providing competition to crop with respect to space, nutrient uptake, sunlight, establishment etc., which results in reduction of crop yield. Weeds cause yield reduction up to 70% in some wheat growing areas [9]. To properly address the weed problem in wheat, there is a dire need of developing a package of weed control technology for the wheat growers [10]. Soil and crop management practices, integrated use of minimum tillage combined with fertilizer and herbicide application can check the loss to a great extent. Weed management with the help of herbicides, made it possible to reduce mechanical approaches of weed control and increased adoption of reduced and no tillage crop production. Now a day's high yielding agriculture relies on herbicides as integral part of weed control practices. In recent years, herbicide have been developed and found promising tool in weed management. Sulfosulfuron, pendimethalin are promising herbicide for control of narrow and broad leaves weeds in wheat crops. The effectiveness of these herbicides has also been reported by some other wokers [11,12]. The presence research focus on the effects of the three tillage (ZT, FIRBS and CT) and four weed management practices on yield of wheat and nutrient uptake.

2. MATERIALS AND METHODS

2.1 Site Characteristics

A field experiment was conducted at Research Farm, Department of Agronomy CCS Haryana Agricultural University, Hisar. The experiment was established in 2012. The experimental sites are located at 29°16'N latitude and 75°7'E longitude at the mean sea elevation of 215.2 m in north-west part of India. The soil of experimental site was sandy loam, Typic Ustocherpt. The climate of the area is semiarid type, with very hot summers and relatively cool winters. The main

characteristics of climate in Hisar are dryness, extremes temperature, and scanty rainfall. The maximum daytime temperature during the summer varies between 40 and 46°C (104 and 115°F). During winter, its ranges between 1.5 and 4°C. Annual average maximum and minimum temperature is 32.3°C (90.1°F) and 15.4°C (59.7°F), respectively. Relative humidity varies from 5 to 100%. Hisar is located on the outer margins of the south-west monsoon region. The average annual rainfall is around 429 mm (16.9 in), most of which occurs during July and August. Dew is observed in December and January. Hot winds, locally known as *loo*, are strong and frequent from May to July.

2.2 Treatments

The above described experiment study was laid out with three tillage treatment (zero tillage, furrow irrigated raised bed system and conventional tillage)in main plot and four weed management practices ((W_1: Atrazine (50% W.P.) at 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 hand weeding (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 plots were arranged in a spilt plot design with three replications. Crop sequence was *kharif* maize (HQPM-1) and wheat (WH 1105).

2.3 Sampling and Analyses

Plant samples were collected after harvest of crops in 2016 and grain and straw yield was recorded. Samples of grain and straw were collected, dried in oven at 65±2°C for 72 hours. Then the samples were grounded in a stainless-steel grinder and stored in polythene bags for chemical analysis. For chemical analysis, grain and straw samples were digested in di-acid mixture of H_2SO_4 and $HClO_4$ in the ratio of 9:1 in digestion chamber. The digested plant samples were analysed for total N, P, K contents and uptake of these elements were calculated by multiplying the nutrients contents with yield. The concentration of Nitrogen was determined calorimetrically by using Nessler's reagent methods [13]. Phosphorus was determined by Ammonium molybdovandate yellow colour method [14]. Potassium was determined by flame emission spectroscopy.

2.4 Statistical Analysis

The data obtained under various treatment was subjected to statistical analysis for significance using OPSTAT software. Comparisons among treatment means were made using the least significant difference (LSD at $P < 0.05$).

3. RESULTS AND DISCUSSION

3.1 Yield of Wheat

Grain yield of wheat was significantly affected by different tillage practices. The grain yield of wheat varied from 45.2 to 47.2 q ha^{-1} under different tillage practices and weed management practices. Highest (47.2 q ha^{-1}) and lowest grain yield (45.2 q ha^{-1}) was recorded under FIRBS and CT, respectively. The higher grain yield under FIRBS was mainly due to higher number of effective tillers and number of grains per spike [15,16,17]. The grain and straw yield of wheat under ZT was statistically at par with CT. Similar type of results was also reported in other studies under Indian condition [18,19]. The data also revealed that significantly lower grain yield (31.7 q ha^{-1}) of wheat was observed under weedy check as compared to other weed management practices. Because weed compete for water, nutrients and sunlight with the crop, result in reduced yield of crop. Highest grain yield under ZT weed-free situation as compared to CT weed-free situation [20]. Straw yield of wheat followed similar trend to that of grain yield of wheat. The straw yield ranged from 63.2 to 66.1 q ha^{-1} under different tillage treatment and 44.47 to 71.6 q ha^{-1} under different weed management practices. The highest straw yield recorded under FIRBS (66.1 q ha^{-1}) followed by zero tillage (64.5 q ha^{-1}) and conventional tillage (63.2 q ha^{1}). The data also revealed that yield was significantly affected by different weed practices. Highest and lowest straw yield was recorded under manual weeding and weedy check treatment, respectively.

Highest straw yield observed under hand weeding treatment was due to better weed control which caused little turning of soil, proper space to individual plants, which enhanced proper utilization of nutrient, moisture and solar radiation and thus resulted in better photosynthesis activity which in turn gave higher plant yield.

3.2 Nutrient Uptake

The total NPK uptake varied from 57.79 to 124.10, 31.31 to 50.69 and 65.18 to 111.51 kg ha^{-1} under different tillage and weed management practices. Total N uptake was significantly affected by tillage while total P and K uptake have not shown any significant difference under different tillage and weed management practices. Highest mean value of total N and K uptake was recorded under FIRBS (107.23 kg ha^{-1} and 110.36 kg ha^{-1}) and lowest under CT (100.05 kg ha^{-1} and102.89 kg ha^{-1}). Highest total P uptake was found under ZT with mean value 45.95 kg ha^{-1} and lowest was reported under CT with mean value 42.61 kg ha^{-1}. Under FIRBS tillage more translocation of photosynthates into sink result in bold grain i.e. result in higher grain yield and nutrient uptake, which directly affect the nutrient uptake. The higher nutrient uptake under FIRBS is also due to higher grain and straw yield of wheat and other researcher reported higher nutrient uptake by wheat (but not always significantly) under ZT than CT [21].Different weed management practices showed significant effect on total NPK uptake by wheat and lowest total NPK uptake recorded under weedy check treatment. Higher nutrient uptake under weed control situation (W_1 to W_3) as compared to weedy check was due to higher crop yield and more nutrient availability for utilisation as compared to weedy situation. Weed control treatment increased the N, P and K uptake by the crop [22]. All the weed control treatments significantly increased NPK uptake by crop over weedy check treatment [23].

Table 1. Effect of tillage and weed management practices on grain and straw yield of wheat

	Grain yield (qha^{-1})				Straw yield (qha^{-1})			
Treatment	**CT**	**FIRBS**	**ZT**	**Mean**	**CT**	**FIRBS**	**ZT**	**Mean**
W_1	49.6	52.4	51	51	69.4	73.3	71.4	71.4
W_2	49.4	52.1	50.7	50.7	69.1	72.9	71.0	71
W_3	50	52.5	50.9	51.1	70	73.4	71.3	71.57
W_4	31.8	31.9	31.6	31.7	44.5	44.7	44.2	44.47
Mean	45.2	47.2	46.0	46.13	63.2	66.1	64.5	64.64
C.D.(p=0.05)	Tillage (T) =0.01 Weed (W) =2.9				Tillage (T) =0.03 Weed (W) =3.5			
	Tillage at same level of Weed = NS				Tillage at same level of Weed = NS			
	Weed at same level of Tillage = NS				Weed at same level of Tillage = NS			

Table 2. Effect of tillage and weed management practices on total (grain plus straw) N (kg ha^{-1}) uptake by wheat

Treatment	**Conventional tillage**	**FIRBS**	**Zero tillage**	**Mean**
W_1	113.19	122.08	117.71	117.66
W_2	113.08	122.75	117.64	117.83
W_3	115.4	124.10	118.70	119.4
W_4	58.55	60.00	57.79	58.78
Mean	100.05	107.23	102.96	103.42
C.D. (P=0.05)	Tillage (T) =2.5	Weed (W) =1.82		
	Tillage at same level of Weed = 3.5			
	Weed at same level of Tillage = 3.7			

Table 3. Effect of tillage and weed management practices on total (grain plus straw) P (kg ha^{-1}) uptake by wheat

Treatment	**Conventional tillage**	**FIRBS**	**Zero tillage**	**Mean**
W_1	47.78	50.05	50.69	49.51
W_2	43.85	48.04	50.24	47.38
W_3	47.00	48.15	50.19	48.44
W_4	31.81	31.31	32.7	31.94
Mean	42.61	44.39	45.95	44.32
C.D. (P=0.05)	Tillage (T) =NS	Weed (W) =1.52		
	Tillage at same level of Weed = NS			
	Weed at same level of Tillage = NS			

Table 4. Effect of tillage and weed management practices on total (grain plus straw) K (kg ha^{-1}) uptake by wheat

Treatment	Conventional tillage	FIRBS	Zero tillage	Mean
W_1	102.89	111.51	110.36	108.25
W_2	98.96	107.74	106.68	104.46
W_3	103.3	108.68	105.57	105.85
W_4	65.41	65.18	67.20	65.93
Mean	92.56	98.28	97.45	96.13
C.D. (P=0.05)	Tillage (T) =4.72		Weed (W) =2.79	
	Tillage at same level of Weed = NS			
	Weed at same level of Tillage = NS			

3.3 Nutrient Contents (NPK) in Grain and Straw of Wheat

Different tillage and weed controls methods significantly affected NPK content in grain and straw of wheat. The N content of wheat grain ranged from1.55 to 1.89% under different tillage and weed management practices. Similarly, P content varied from 0.46 to 0.54% and K content varied from 0.31 to 0.42% respectively, under different tillage and weed management practices. Data indicated that N content in grain slightly affected by different tillage practices. The highest N content (1.80%) reported under FIRBS followed by zero tillage (1.79%) and conventional tillage (1.78%). Data revealed that different weed management practices having significant effect on N content of grain and lowest N content observed under weedy check treatment.

Tillage practices showed significant effect on P (Table 6). In contrast to N content in wheat grain, highest P content was observed under conventional tillage (0.53%) followed by zero tillage (0.51%) and FIRBS (0.48%). Weed management practices also having non-significant effect on P content in grain and slightly higher value of P content reported under weedy check treatment.

Tillage practices significantly affected the K content, with K content in wheat grain found highest under zero tillage (0.40%) and lowest (0.34%) under conventional tillage. The weed management practices also have significant effect on K content and highest mean value of K content reported under weedy check treatment.

The N, P and K content in wheat straw ranged from 0.20 to 0.34; 0.27 to 0.37 and 1.20 to 1.26 %, respectively under different tillage and weed management practices. Tillage practices have no significant effect on N and K content in straw, while significantly affected P content. Data revealed that N content in straw, followed similar trend as in grain with highest (0.31%) found with FIRBS followed by zero tillage (0.29%) and conventional tillage (0.29%). Data also revealed that weed management practices have significant effect on N content with lowest N content reported in weedy check treatment.

Tillage practices significantly influenced P content of straw, where highest (0.36%) mean value of P was recorded under ZT followed by FIRBS (0.34%) and CT (0.30%). Weed management practices showed significant effect on P content, in which slightly higher P content in straw was recorded under weedy check

Table 5. Effect of tillage and weed management practices on N (%) content in wheat grain

Treatment	Conventional tillage	FIRBS	Zero tillage	Mean
W_1	1.85	1.87	1.86	1.86
W_2	1.87	1.88	1.87	1.873
W_3	1.86	1.89	1.87	1.873
W_4	1.55	1.57	1.55	1.56
Mean	1.78	1.80	1.79	1.79
C.D. (p=0.05)	Tillage (T) =NS		Weed (W) =0.025	
	Tillage at same level of Weed = NS			
	Weed at same level of Tillage = NS			

Table 6. Effect of tillage and weed management practices on P (%) content in wheat grain

Treatment	Conventional tillage	FIRBS	Zero tillage	Mean
W_1	0.53	0.48	0.49	0.5
W_2	0.51	0.46	0.50	0.49
W_3	0.52	0.47	0.51	0.5
W_4	0.54	0.49	0.52	0.52
Mean	0.53	0.48	0.51	0.50
C.D. (p=0.05)	Tillage (T) =0.029		Weed (W) =NS	
	Tillage at same level of Weed = NS			
	Weed at same level of Tillage = NS			

Table 7. Effect of tillage and weed management practices on K (%) content in wheat grain

Treatment	Conventional tillage	FIRBS	Zero tillage	Mean
W_1	0.34	0.38	0.40	0.373
W_2	0.31	0.36	0.38	0.35
W_3	0.33	0.35	0.38	0.353
W_4	0.38	0.36	0.42	0.39
Mean	0.34	0.36	0.40	0.37
C.D. (p=0.05)	Tillage (T) =0.020		Weed (W) =0.013	
	Tillage at same level of Weed = 0.02			
	Weed at same level of Tillage = 0.02			

Table 8. Effect of tillage and weed management practices on N (%) content in wheat straw

Treatment	Conventional tillage	FIRBS	Zero tillage	Mean
W_1	0.31	0.33	0.32	0.32
W_2	0.30	0.34	0.32	0.32
W_3	0.32	0.34	0.33	0.33
W_4	0.21	0.22	0.20	0.21
Mean	0.29	0.31	0.29	
C.D. (p=0.05)	Tillage (T) =NS		Weed (W) =0.020	
	Tillage at same level of Weed = NS			
	Weed at same level of Tillage = NS			

Table 9. Effect of tillage and weed management practices on P (%) content in wheat straw

Treatment	Conventional tillage	FIRBS	Zero tillage	Mean
W_1	0.31	0.34	0.36	0.34
W_2	0.27	0.33	0.35	0.32
W3	0.30	0.32	0.34	0.32
W_4	0.33	0.35	0.37	0.35
Mean	0.30	0.34	0.36	0.33
C.D. (p=0.05)	Tillage (T) =0.030		Weed (W) =0.014	
	Tillage at same level of Weed = NS			
	Weed at same level of Tillage = NS			

treatment. Effect of different tillage and weed management practices on K content in straw was non-significant and their value range from 1.20 to 126% under different treatment combination. The nutrient content of grain and straw directly depend upon the nutrient uptake under different tillage and weed management practices. The tillage and weed management practices which is having higher uptake of nutrient having higher nutrient content both in case of straw and grain.

Table 10. Effect of tillage and weed management practices on K (%) content in wheat straw

Treatment	Conventional tillage	FIRBS	Zero tillage	Mean
W_1	1.24	1.25	1.26	1.25
W_2	1.21	1.22	1.23	1.22
W_3	1.24	1.23	1.21	1.23
W_4	1.20	1.20	1.22	1.21
Mean	1.22	1.22	1.23	1.23
C.D. (p=0.05)	Tillage (T) =NS	Weed (W) =NS		
	Tillage at same level of Weed = NS			
	Weed at same level of Tillage = NS			

4. CONCLUSION

Grain and straw yield of wheat was significantly high under FIRBS followed by zero and conventional tillage. Grain and straw yield were also significantly affected by weed practices and, highest grain and straw yield of wheat was observed under weed free (W3: manual weeding) and weedy situation (W4: weedy check) respectively. Total uptake of N was significantly affected by tillage while total P and K uptake did not show any significant difference under different tillage and weed management practices. Highest total uptake of N and K were recorded under FIRBS and lowest under conventional tillage. Highest total P uptake was found under zero tillage with mean value 45.95 kg ha^{-1} and lowest under conventional tillage with mean value 42.61 kg ha^{-1}. Different weed management practices significantly affected the total NPK uptake and highest NPK uptake was noticed under W_3, W_1 and W_1 weed management practices, respectively. It is concluded from the that zero tillage and FIRBS along with the weedy check treatment results in higher wheat yield and nutrient uptake as compared to conventional tillage after maize.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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