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Influence of Tillage and Weed Management Practices on Yield and Nutrient Uptake of Maize

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment entitled 'Influence of tillage and weed management practices on yield and nutrient uptake of maize' was conducted during *Rabi*-2018 at all India coordinated research project on Weed Management, College of Agriculture, Rajendranagar, Professor Jayashankar Telangana State Agricultural University, Hyderabad to study the effect of different tillage and weed management practices on nutrient uptake of maize. The soil of the experimental field was sandy clay loam in texture with moderately alkaline pH, low in available nitrogen, medium in available P and high in available K. The field experiment was laid out in split plot design with (five tillage practices) in main plots and (three weed management practices) in sub plots. The results revealed that highest total nitrogen uptake was recorded with conventional tillage (Transplanted rice) – zero tillage (maize) and it is on par with conventional tillage (transplanted rice) – conventional tillage (maize) treatments. The highest total phosphorus and total potassium uptake was recorded with conventional tillage (transplanted) – conventional tillage (maize) and it was on par with conventional tillage (Transplanted) – zero tillage (maize). Integrated weed management was found to be significantly superior with nutrient uptake followed by chemical weed management.

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1. INTRODUCTION

Maize is the world's third most important cereal crop and is grown for grain as well as fodder. It is also known as "queen of cereals" and now being referred as "king of cereals" due to its cosmopolite nature and high productivity. In India maize ranks 5^{th} in area and 3^{rd} in production and is being cultivated in an area 11.52 M-ha with the production of 13.08 Mt and an average productivity of 1640 kg/ha [1]. In Telangana, the cultivated area of maize during 2019-20 is 8.02 lakh hectares with production of 26.63 lakh tonnes and an average productivity of 3321 kg/ha [1] Under the emerging and potential crop sequence (rice-maize) in Telangana state, conventional tillage maize after *Kharif* rice under heavy textured soil needs 25-30% more energy for field preparation, which limits the farm profitability and delays maize sowing leading to lower productivity.

Instead of conventional tillage, zero or reduced or minimum tillage facilitates timely sowing, increase yield, reduces production costs and boosts farm income. On the other hand, weeds are the major constraint in maize production, especially in reduced tillage practices, the weeds problem is more. Especially in reduced tillage practices, the weeds problem is more [2]. reported that crop yields can be similar for both conventional as well as in minimum tillage systems if weeds are controlled and crop stands are uniform. At present most of the farmers are applying various types of herbicides such as Atrazine as pre-emergence and 2,4-D as post-emergence to control the weed infestation in the maize field, But these herbicides effectively control only broad-leaf weeds. Control of grasses and sedges remain a problem for the farmers, especially when the excess or soil moisture deficient condition. Keeping in view of above constraints at farmer level this experiment was conducted.

2. MATERIALS AND METHODS

2.1 Description of Experimental Site

The experiment was carried out at AICRP, College Farm, College of Agriculture, Rajendranagar, Hyderabad situated in Southern Telangana Zone. The farm is geographically situated at 17°19' 16.4" North latitude and 78° 24' 43" East longitudes and at an altitude of 542.3 m above mean sea level. The climate of Hyderabad is semi-arid tropical [3].The average annual rainfall of the region is 821.7 mm.

2.2 Treatments and Design

The field experiment was laid out in split- plot design with five tillage practices *viz.,*T_1-conventional tillage (transplanted rice), CT(TPR) – conventional tillage (maize), CT(maize), T_2-conventional tillage (transplanted rice), CT (TPR) – zero tillage (maize),, T_3-conventional tillage (direct seeded rice), CT (DSR) – conventional tillage (maize), [CT (maize), T_4-zero tillage (direct seeded rice), ZT (DSR) – zero tillage (maize), [ZT (maize) and T_5-zero tillage (direct seeded rice) with residue cover, ZT(DSR)+R - zero tillage (maize) with residue cover, ZT (maize)+R in main plots and three weed management practices *viz.,*chemical weed management such as W_1-atrazine 50%WP @ 1000g/ha + paraquat 24%SL @ 600g/ha PE *fb* tembotrione @ 120g/ha + atrazine 50% WP @ 500g/ha at 20-25 DAS as PoE), W_2 - Integrated weed management (IWM) (atrazine 50%WP @1000g/ha + paraquat 24%SL @ 600 g/ha PE *fb* HW at 40 DAS) and W_3 -No weeding(control)in sub-plots.

Land preparation based on the treatments like in conventional tillage ploughing followed by rotavator and finally levelling, where as in zero tillage no tillage operations were carried. Fertilizer rate (150:60:60 kg ha^{-1} NPK) and fertilizer application method is pit, intercultural operations weeding done as per treatments, Total number of irrigations 13 were given, pre emergence herbicide was applied at 3 days after sowing (DAS) and post emergence application was at 20-25 (DAS) sowing was done on 15-12-2018 and harvesting was completed on 20-04-2019.

Crop samples (grain and straw) were collected at harvest. These samples were dried and ground to fine powder using Wiley mill and used for analysis of uptake of nutrients by crop. Nitrogen content (%) in the plant samples was estimated by the micro Kjeldhal method using Kelplus N analyzer after digesting the samples with H_2SO_4 and H_2O_2 [4]. Phosphorus content (%) in the plant samples was estimated by Vanado molybdo phosphoric acid after the samples were digested in the tri-acid (HNO_3, $HClO_4$ and $H2SO_4$) in the ratio of (9:3:1) respectively. The intensity of yellow colour developed was measured by using spectrophotometer at 420 nm [4]. Potassium content in the tri-acid was determined with flame photometer [4].

2.3 Statistical Analysis

The data collected from the experiment were analysed statistically by analysis of variance method for split plot design [5].

3. RESULTS AND DISCUSSION

3.1 Effect on Grain and Stover Yield

Grain yield and stover yield were significantly influenced by different tillage and weed management practices. Among different tillage treatments CT (TPR)- CT (maize) recorded significantly higher grain and stover yield this was followed by CT (TPR) - ZT (maize). These two treatments were on par with each other and were significantly superior over the other tillage treatments. Among different weed management practices, IWM recorded significantly higher grain and stover yield over recommended herbicides and unweeded control. The higher grain yield under IWM might be due to minimum weed seed bank and eradication of weeds providing healthy environment for crop growth. Similar results were reported by [6] and [3].

3.2 Effect on Nitrogen Uptake

The data revealed that the highest grain N uptake among the tillage practices was recorded with CT (TPR) – ZT (maize) (93.8kg ha^{-1}) and it was on par with CT (TPR) – CT (maize) (91.6kg ha^{-1}) and lowest grain N uptake was recorded under CT (DSR) – CT (maize) (66.9kg ha^{-1}), shown in Table 1. Highest stover N uptake among the tillage practices was recorded with CT (TPR) – CT (maize) (66.7kg ha^{-1}) and it was on par with CT (TPR) – ZT (maize) (66.5kg ha^{-1}) and lowest stover N uptake was recorded under CT (DSR) – CT (maize) (51.7kg ha^{-1}), shown in Table 2. Among the weed management practices higher grain and stover N uptake was recorded with IWM followed by chemical weed management. Lowest uptake was recorded in no weeding (control). Total N uptake was significantly influenced by tillage and weed management practices. Among the tillage practices highest total N uptake was recorded with CT (TPR) – ZT (maize) and it was on par with CT (TPR) – CT (maize) and lowest total N uptake was recorded under CT (DSR) – CT (maize).

Among the weed management practices, IWM has recorded significantly higher total N uptake (100.8 kg ha^{-1}) followed by chemical weed management (91.9 kg ha^{-1}). Lowest total N uptake was noted under no weeding (control)(48.2 kg ha^{-1}). On the other hand, interaction effect of tillage and weed management on total N uptake was found to be significant. Highest total N uptake (124.1 kg ha^{-1}) was recorded with adoption of IWM in CT (TPR) – ZT (maize) and it was superior over other treatments. Lowest total N uptake (37.5kg ha^{-1}) was recorded under no weeding plots of CT (DSR) – CT (maize). In addition, total N uptake in IWM and chemical weed management was found to be on par with each other under all the tillage practices. Similar reports were recorded by [7].

3.3 Effect on Phosphorus Uptake

The data revealed that the highest grain P uptake among the tillage practices was recorded with CT (TPR) – CT (maize) and it was on par with CT (TPR) – ZT (maize) and lowest grain P uptake was recorded under CT (DSR) – CT (maize), presented in (Table 3). Highest stover P uptake among the tillage practices was recorded with CT (TPR) – CT (maize) and it was similar with CT (TPR) – ZT (maize) and lowest stover P uptake was recorded under CT (DSR) – CT (maize). Among the weed management practices higher grain and stover P uptake was recorded with IWM followed by chemical weed management. Lowest uptake was recorded in unweeded control. Interaction effect of tillage and weed management practices on total P uptake was found to be significant. Highest total P uptake was recorded with adoption of IWM in CT (TPR) – ZT (maize) and it was on par with IWM and chemical weed management of CT (TPR) – CT (maize) and chemical weed management of CT (TPR) – ZT (maize). Lowest total P uptake was recorded under unweeded control of CT (DSR) – CT (maize). Unweeded control recorded significantly inferior total P uptake in all the tillage practices (Table 3).

The data revealed that the highest grain P uptake among the tillage practices was recorded with CT (TPR) – CT (maize) and it was on par with CT (TPR) – ZT (maize) and lowest grain P uptake was recorded under CT (DSR) – CT (maize). Highest stover P uptake among the tillage practices was recorded with CT (TPR) –

CT (maize) and it was on par with CT (TPR) – ZT (maize) and lowest stover P uptake was recorded under CT (DSR) – CT (maize). Among the weed management practices higher grain and stover P uptake was recorded with IWM followed by chemical weed management. Lowest uptake was recorded in unweeded control. Total P uptake was significantly influenced by tillage and weed management practices. Among the tillage practices highest total P uptake was recorded with CT (TPR) – CT (maize) and it was on par with CT (TPR) – ZT (maize) and lowest total P uptake was recorded under CT (DSR) – CT (maize). Among the weed management practices, IWM has recorded significantly higher total P uptake followed by chemical weed management. Lowest total P uptake was noted under unweeded control.

Interaction effect of tillage and weed management practices on total P uptake was found to be significant. Highest total P uptake was recorded with adoption of IWM in CT (TPR) – ZT (maize) and it was on par with IWM and chemical weed management of CT (TPR) – CT (maize) and chemical weed management of CT (TPR) – ZT (maize). Lowest total P uptake was recorded under unweeded control of CT (DSR) – CT (maize). Total P uptake in IWM and chemical weed management was found to be on par with each other under all the tillage practices except in ZT(DSR) -ZT + R (maize) and ZT +R (DSR) - ZT + R (maize). Unweeded control recorded significantly inferior total P uptake in all the tillage practices [8,9].

3.4 Effect on Potassium Uptake

Total K uptake was significantly influenced by tillage and weed management practices. The data revealed that the highest grain K uptake among the tillage practices was recorded with CT (TPR) – CT (maize) and it was on par with CT (TPR) – ZT (maize) and lowest grain K uptake was recorded under CT (DSR) – CT (maize), shown in Table 3).

Highest stover K uptake among the tillage practices showed the similar trends as grain K uptake. Among the weed management practices higher grain and stover K uptake was recorded with IWM followed by chemical weed management. Lowest uptake was recorded in un nweeded control (Table 4).

Among the tillage practices highest total K uptake was recorded with CT (TPR) – CT (maize) (write the numerical value) and it is on par with CT (TPR) – ZT (maize)(write the numerical value) and lowest total K uptake was recorded under CT (DSR) – CT (maize)(write the numerical value).

Among the weed management practices, IWM has recorded significantly higher total K uptake followed by chemical weed management. Lowest total K uptake was noted under unweeded control.

Interaction effect of tillage and weed management practices on total K uptake was found to be significant. Highest total K uptake was recorded with adoption of IWM in CT (TPR) – ZT (maize) (write the numerical value) and it was on par with IWM and chemical weed management of CT (TPR) – CT (maize) (write the numerical value) and chemical weed management of CT (TPR) – ZT (maize) (write the numerical value). Lowest total K uptake was recorded under un weeded control of CT (DSR) – CT (maize). Total K uptake in IWM and chemical weed management was found to be on par with each other under all the tillage practices. Un weeded control recorded significantly inferior total K uptake in all the tillage practices (Table 4) [9,10].

Table 1. Influence of tillage and weed management practices on yield of maize

Treatment		Grain yield (kg/ha)	Stover yield (kg/ha)	Harvest Index (%)
Tillage	**Weed management**			
CT(TPR) - CT (maize)	Chemical management	6537	7984	45
	IWM	6908	8248	46
	Unweeded control	3403	4614	42
CT(TPR) - ZT (maize) - GM	Chemical management	6657	8160	45
	IWM	7292	8572	46

	Unweeded control	2800		3600		44	
CT(DSR) - CT (maize) - GM	Chemical management	4868		6017		45	
	IWM	5028		6460		44	
	Unweeded control	2297		3372		41	
ZT(DSR)- ZT+R(maize) - GM	Chemical management	4929		6108		45	
	IWM	5335		6834		44	
	Unweeded control	2526		3844		40	
ZT+R(DSR) - ZT+R(maize) - GM	Chemical management	4886		6026		45	
	IWM	5580		6960		44	
	Unweeded control	3468		4740		42	
MEAN							
Tillage (main plots)							
CT (TPR) – CT (maize)		5,616		6,949		44	
CT (TPR) – ZT (maize) - GM		5,583		6,777		45	
CT (DSR) – CT (maize) - GM		4,064		5,283		43	
ZT (DSR) – ZT+R (maize) - GM		4,263		5,595		43	
ZT+R (DSR) – ZT+R (maize) -GM		4,645		5,909		44	
Weed management (sub plots)							
Chemical weed management		5575		6859		45	
IWM		6028		7415		45	
Unweeded control		2899		4034		42	
		SE(m) ±	**CD (P=0.05)**	**SE(m)±**	**CD (P=0.05)**	**SE(m) ±**	**CD (P =0.05)**
Tillage		212.4	703.4	100.0	331.0	-	-
Weed management		136.8	406.4	90.1	267.6	-	-
Sub at same level of main		367.9	952.6	173.1	616.9	-	-
Main at same level of sub		327.9	1021.0	192.4	589.4	-	-

Table 2. Nitrogen uptake in maize (kg ha^{-1}) at harvest as influenced by tillage and weed management

Treatments		**Nitrogen uptake (kg ha^{-1})**		
Tillage	**Weed Management**	**Grain**	**Stover**	**Total**
T_1- CT(TPR) - CT (maize)	W_1	106.6	79.5	186.1
	W_2	111.6	75.2	186.8
	W_3	56.5	45.2	101.7
T_2- CT(TPR) - ZT (maize) -GM	W_1	109.7	79.4	189.1
	W_2	124.1	85.4	209.5
	W_3	47.5	34.7	82.2
T_3- CT(DSR) - CT(maize) - GM	W_1	80.0	57.9	137.9
	W_2	83.2	62.7	145.9
	W_3	37.5	34.4	72.0
T_4- ZT(DSR) - ZT+R (maize)- GM	W_1	82.1	61.1	143.2
	W_2	89.6	66.7	156.3
	W_3	43.6	37.9	81.5
T_5- ZT+R(DSR)- ZT+R(maize)– GM	W_1	81.2	60.7	141.8
	W_2	95.8	69.0	164.8

Treatments		**Nitrogen uptake (kg ha^{-1})**					
Tillage	**Weed Management**	**Grain**		**Stover**		**Total**	
	W_3	56.4		46.2		102.7	
MEAN							
Tillage (Main plots)							
T_1 - CT (TPR) – CT (maize)		91.6		66.7		158.2	
T_2 - CT (TPR)- ZT (maize) - GM		93.8		66.5		160.2	
T_3 - CT (DSR) – CT (maize) - GM		66.9		51.7		118.6	
T_4 - ZT (DSR) – ZT+R (maize) - GM		71.7		55.3		127.0	
T_5 - ZT+R (DSR) – ZT+R (maize) – GM		77.8		58.6		136.4	
Weed Management (Sub plots)							
W_1 – Chemical management		91.9		67.7		159.6	
W_2 – IWM		100.8		71.8		172.6	
W_3 – Unweeded control		48.20		39.60		88.00	
		SE(m) ±	**CD (P=0.05)**	**SE(m) ±**	**CD (P=0.05)**	**SE(m)±**	**CD (P =0.05)**
Tillage		3.50	11.70	1.20	3.90	4.30	14.1
Weed Management		2.30	6.90	0.90	2.60	2.70	7.90
SUB AT SAME LEVEL OF MAIN		6.10	16.30	2.00	6.00	7.40	18.70
MAIN AT SAME LEVEL OF SUB		5.50	17.20	2.00	6.10	6.50	20.20

Table 3. Phosphorus uptake in maize (kg ha^{-1}) at harvest as influenced by tillage and weed management

Treatments		**Phosphorus uptake (kg ha^{-1})**		
Tillage	**Weed Management**	**Grain**	**Stover**	**Total**
T_1- CT(TPR) - CT (maize)	W_1	16.7	12.6	29.3
	W_2	18.0	14.7	32.7
	W_3	8.6	7.2	15.8
T_2- CT(TPR) - ZT (maize)- GM	W_1	16.5	14.0	30.5
	W_2	18.6	14.4	33.0
	W_3	7.4	5.1	12.5
T_3- CT(DSR) - CT(maize)- GM	W_1	11.5	9.4	20.9
	W_2	12.4	10.0	22.4
	W_3	6.5	4.9	11.3
T_4- ZT(DSR) - ZT+R (maize) – GM	W_1	11.3	8.3	19.6
	W_2	15.8	10.6	26.4
	W_3	6.4	5.6	12.0
T_5- ZT+R(DSR) - ZT+R(maize) – GM	W_1	12.5	8.7	21.2
	W_2	16.8	11.1	27.9
	W_3	9.4	7.5	16.9
MEAN				
Tillage (Main plots)				
T_1 - CT (TPR) – CT (maize)		14.4	11.5	25.9
T_2 - CT (TPR) – ZT (maize) – GM		14.2	11.2	25.3
T_3 - CT (DSR) – CT (maize) – GM		10.1	8.1	18.2
T_4 - ZT (DSR) – ZT+R (maize) – GM		11.1	8.2	19.3
T_5 - ZT+R (DSR) – ZT+R (maize) - GM		12.9	9.1	22.0
Weed Management (Sub plots)				
W_1 – Chemical management		13.7	10.5	24.3

Treatments		Phosphorus uptake (kg ha^{-1})					
Tillage	Weed Management	Grain		Stover		Total	
W_2 – IWM		16.3		12.1		28.4	
W_3 – Unweeded control		7.6		6.0		13.7	
		SE(m)±	CD (P=0.05)	SE(m) ±	CD (P=0.05)	SE(m)±	CD (P =0.05)
Tillage		0.58	1.91	0.45	1.48	0.86	2.80
Weed Management		0.42	1.26	0.37	1.11	0.63	1.80
SUB AT SAME LEVEL OF MAIN		1.00	NS	0.77	2.57	1.48	4.30
MAIN AT SAME LEVEL OF SUB		0.97	NS	0.82	2.50	1.43	4.41

Table 4. Potassium uptake in maize (kg ha^{-1}) at harvest as influenced by tillage and weed management

Treatments		Potassium uptake (kg ha^{-1})					
Tillage	Weed Managemen t	Grain		Stover		Total	
T_1- CT (TPR) - CT (maize)	W_1	76.7		84.7		161.4	
	W_2	80.4		86.8		167.2	
	W_3	40.4		50.0		90.4	
T_2- CT(TPR) - ZT (maize)-GM	W_1	76.8		85.1		161.9	
	W_2	81.4		86.0		167.3	
	W_3	31.5		36.4		67.9	
T_3- CT(DSR) - CT(maize)-GM	W_1	57.0		63.8		120.8	
	W_2	55.4		64.0		119.4	
	W_3	25.3		33.6		58.9	
T_4- ZT(DSR) - ZT+R (maize)-GM	W_1	57.9		65.3		123.2	
	W_2	63.8		74.2		137.9	
	W_3	30.1		41.6		71.7	
T_5- ZT+R(DSR)- ZT+R(maize) -GM	W_1	54.4		60.4		114.8	
	W_2	62.3		70.2		132.4	
	W_3	39.0		48.2		87.2	
MEAN							
Tillage (Main plots)							
T_1 - CT (TPR) – CT (maize)		65.9		73.8		139.7	
T_2 - CT (TPR) – ZT (maize) - GM		63.2		69.2		132.4	
T_3 - CT (DSR) – CT (maize) - GM		45.9		53.8		99.7	
T_4 - ZT (DSR) – ZT+R (maize) - GM		50.6		60.4		111.0	
T_5 - ZT+R (DSR) – ZT+R (maize) – GM		51.9		59.6		111.5	
Weed Management (Sub plots)							
W_1 – Chemical management		64.5		71.8		136.4	
W_2 – IWM		68.6		76.2		144.8	
W_3 – Unweeded control		33.2		41.9		75.2	
		SE(m) ±	CD (P=0.05)	SE(m)±	CD (P=0.05)	SE(m)±	CD (P =0.05)
Tillage		2.7	9.0	0.9	3.0	3.3	11.1
Weed Management		1.8	5.5	1.6	4.6	2.9	8.5
SUB AT SAME LEVEL OF MAIN		4.7	NS	1.6	10.5	5.8	19.6
MAIN AT SAME LEVEL OF SUB		4.3	NS	3.0	9.0	6.2	19.0

4. CONCLUSION

It is concluded that, CT (TPR) – CT (Maize) and gained higher nutrient uptake over all other treatment combinations. IWM involving application of atrazine + paraquat as PoE *fb* hand weeding is the best for higher nutrient uptake than chemical weed management as well as no weeding.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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