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Soil Properties, Nutrient Dynamics and Economics of Winter Maize (*Zea mays* L.) as Effected by Tillage and Irrigation in North Bihar

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ABSTRACT

The field experiments were conducted from 2002-04 in winter season at Rajendra Agricultural University, Pusa, Samastipur, Bihar comprising of sixteen treatment combination of different tillage methods (4) and irrigation frequency (4). Rotavator tilled maize reported superior over other tillage practices in respect of bulk density (1.33 and 1.30 mg m^{-3}), soil strength (2.10 and 2.05 MPa), infiltration rate (0.420 and 0.432 cm hr^{-1}) and porosity (49.81 and 50.94 %) in both the years, respectively. Rotavator tilled maize showed significantly higher water use efficiency (119.39 Kg/ ha-cm) over all other tillage practices, while it was found minimum at the highest level of irrigation (95.28 kg/ha-cm). Significantly higher nitrogen and potassium-uptake by plants were recorded under rotavator tilled maizeover zero tillage, while tillage practices did not show any significant differences w.r.t. phosphorus- uptake. Rotavator tilled maize with 5 irrigations fetched maximum grain yield (6590 and 6850 Kg/ha^{-1}) in both the years, respectively and was found at par with 6 irrigation. Significantly high net return and benefit: cost ratio were also recorded with rotavator tilled maize with 5 irrigations .

Key words: *Winter maize, tillage, Physical soil properties, nutrient uptake, irrigation, yield and economics*

INTRODUCTION

Among various factors responsible for low productivity, soil moisture availability is regarded as the most limiting factor because crops are very much sensitive to soil-moisture stress, particularly at their critical stages. Strategies to minimize crop water

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stress include irrigation, increased root zone and conservation of soil moisture by increased infiltration, reduced evaporation and maximum exploitation of available soil water. Tillage alters rhizosphere environment by modifying most of the physical properties due to formation, destruction and rearrangement of soil particles and aggregates and alternation in clod size distribution. Adequate soil moisture is required for normal development of maize crop at all stages of growth. However under limited availability of water, scheduling of irrigation at the most critical stages increases crop productivity and water use efficiency as deleterious effect of water deficit is not equally pronounced over all the growth stages of crop. Only quantity of water is not important for getting higher yield but time of application to the crop is considered as deciding factor for yield of any crop. In North Bihar, winter maize has become a well adopted crop with high yield potentials (50-60 q/ha) and area under the crop has increased tremendously. In spite of established yield and other advantages of tillage and irrigation, their adoption at farmer's level on a scientific pattern is hindered.

Thus, keeping the above facts in view the present investigation was planned and conducted with an objective to study the response of winter maize to different soil- tilth and irrigation frequencies and to evaluate the economics of the treatments.

MATERIALS AND METHODS

The field experiments were conducted during winter (*Rabi*) season of 2002-03 and 2003-04 at Tirhut College of Agriculture Farm, Dholi (Muzaffarpur), a campus of Rajendra Agricultural University, Pusa (Samastipur), Bihar in Split Plot design with three replications. The soil of the experimental plot was sandy loam in texture with pH value of 8.25, organic carbon 0.46%, available N,P and K (Kg/ha) :: 212.12, 20.5 and 125.2, respectively. The av. bulk density of the experimental soil was 1.47g/cc. Av. Evaporation during the experimental seasons were 23.7 and 19.5 mm. with a total rainfall of 134.0 and 138.5 cm, respectively. The treatments comprises of four tillage practices (Main plot): 1 disc ploughing + 2 harrowing+ planking (conventional tillage) as T_1, 2 cultivator+ Planking (T_2), Rotavator once (T_3) and zero-till planter (T_4) and four irrigation frequencies on different physiological stages stages (Sub plot): Pre-knee height (30 DAS) + Knee height(Kn) + Silking (total 3 irrigations) as I_1, Pre-knee height (30 DAS) + Knee height (Kn) + Silking + Milking (total 4 irrigations) as I_2, Pre-knee height (30 DAS) + Knee height(Kn) + Tasseling + Milking + Grain filling (total 5 irrigations) as I_3 and Pre-knee height (30 DAS) + Knee height (Kn) + Tassel initiation stage + Silking + Milking + Grain filling (total 6 irrigations) as I_4. The maize variety selected for experiment was Deoki (composite variety) which was sown on 18th October in both the years. Row to row spacing was maintained at 60 cm with a common fertilizer dose (N:P:K) of 120: 75: 50 (Kg/ha). All P and K fertilizers were applied as basal while, N was applied in three equal splits (1/3 as basal + 1/3 at Knee stage and 1/3 at tassel initiation stage). In each irrigation 6 cm. water was applied as per treatment. Observations on soil, plant, nitrogen, phosphorus and potassium –uptake were taken/calculated by following standard procedures while, yield was calculated on the basis of net plot area.

RESULTS AND DISCUSSION

Soil Studies

The lowest av. bulk density was recorded with rotavator tilled plots which was followed by conventional tillage and cultivator tilled plots (table 1). The maximum av. bulk density was recorded in zero-tilled plots during both the years of investigation. Reduction in bulk density may be attributed to increased soil volume by loosening the soil due to different tillage practices (Wahyuni,2001). As soil tilth get finer due to different tillage practices, it tend to decrease the average soil strength of the tilled plots. The decrease in rotavator tilled plots were 8.20 and 17.6 per cent during 2002-03 and 2003-04, respectively. Rotavator tilled plots had maximum average infiltration rate (0.420 and 0.432 cm hr^{-1}) during both the years of experimentation but minimum average infiltration rate did not follow the same trend in both the years. In the first year, zero-tilled plots showed minimum average infiltration rate (0.316 cm hr^{-1}) while, in the 2nd year cultivator tilled plots resulted in lowest average infiltration rate (0.325 cm hr^{-1}). Infiltration rate decreases with respect to time) in all the tillage treatments which has been presented in (Fig. 1 a & b). The increase in infiltration rate attributed to the maximum reduction in bulk density and had pronounced effect as total porosity and macro porosity both increased, may be correlated with the findings of Bhusan and sharma, 1997. As the soil

Table 1
Effect of Tillage on Physical Properties of Surface Soil (0-60 cm) after Harvest of Maize

Treatments		*Years*	
		2002-03	*2003-04*
(a)	**Bulk density (mg m^{-3})**		
	Conventional tillage	1.36	1.33
	2 cultivator + Planking	1.41	1.40
	Rotavator once	1.33	1.30
	Zero-till planter	1.43	1.40
(b)	**Soil strength (MPa)**		
	Conventional tillage	2.28	2.24
	2 cultivator + Planking	2.35	2.31
	Rotavator once	2.10	2.05
	Zero-till planter	2.56	2.39
(c)	**Infiltration rate (cm hr^{-1})**		
	Conventional tillage	0.331	0.337
	2 cultivator + Planking	0.328	0.325
	Rotavator once	0.420	0.432
	Zero-till planter	0.316	0.335
(d)	**Porosity (%)**		
	Conventional tillage	48.68	49.81
	2 cultivator + Planking	46.79	47.17
	Rotavator once	49.81	50.94
	Zero-till planter	46.02	47.17

Fig. 1(a): Effect of Tillage on Infiltration rate with Respect to time after Harvest of Maize (2002-2003)

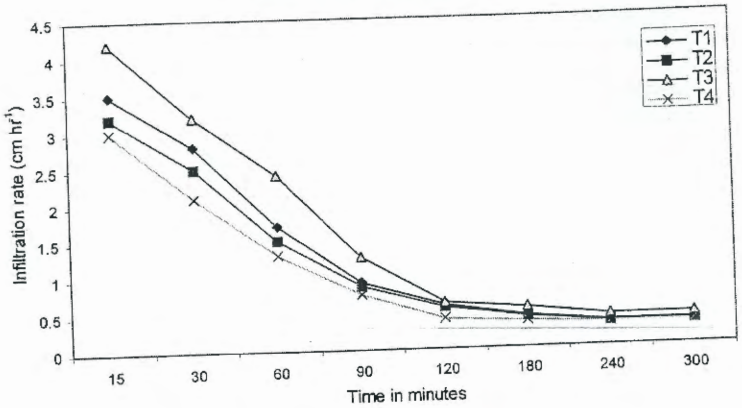
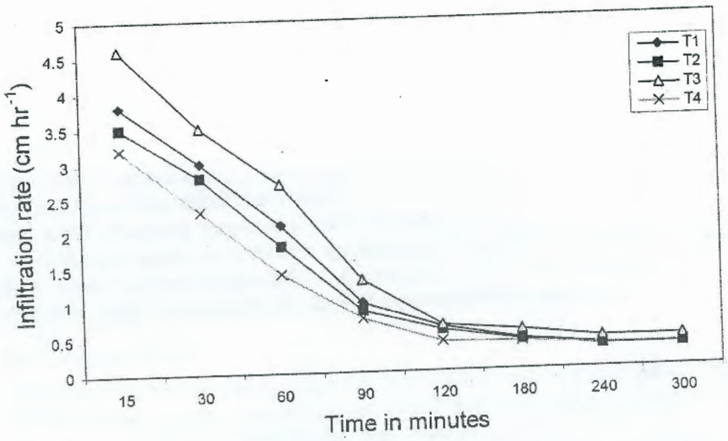


Fig. 1(a): Effect of Tillage on Irrigation rate with Respect to time after Harvest of Maize (2003-2004)



tilth get finer, porosity increases. Here, maximum average porosity was observed as 49.81 and 50.94 per cent in both the years, respectively in rotavator tilled maize while, the minimum porosity was recorded in zero-tilled maize in the first year only and in the 2nd year of experimentation cultivator tilled maize and zero-tilled maize showed equal porosity of 47.17 per cent.

Irrigation Studies

Significantly higher water use efficiency (WUE) was recorded under rotavator tilled maize (114.10 and 124.68 kg $ha^{-1}cm$) over zero tilled maize (66.03 and 76.40 kg ha^{-1} cm) which was 41.4 and 38.72 per cent more in rotavator tilled maize during first and 2nd year of experimentations, respectively. Significantly higher WUE was recorded under crop receiving 5 irrigations (110.80 and 109.58 kg $ha^{-1}cm$), which was found at par with 3 irrigations (102.41 kg $ha^{-1}cm$) in the 2nd year only and lowest under crop receiving 6 irrigations (90.99 and 44.57 kg ha^{-1} cm) in both the years of experimentation, respectively.

Maximum water expense efficiency (WEE) was recorded under rotavator tilled maize (114.10 and 124.68 kg ha^{-1} cm) which was found significantly superior over all other tillage practices. The minimum WEE was recorded under zero tilled maize (82.50 and 90.74 kg ha^{-1} cm) in both the years of experimentation, respectively. The magnitude of increase of WEE over zero tillage to rotavator tilled maize was (50.27 and 37.35 per cent) and to conventional tillage (39.8 and 27.8 per cent), respectively in both the years.

Water expense efficiency was recorded highest under crop receiving 5 irrigations and was found significantly superior (91.32 and 100.58 kg $ha^{-1}cm$) over all other higher frequencies of irrigation in both the years except crop receiving 3 irrigations which was found at par with each other (88.44 and 97.56 kg $ha^{-1}cm$), respectively (Table 4). This may be due to the fact that tillage operations had made better root contact with the soil and that is why more water expense efficiency was observed. Camp *et al*, 2002 and Liu W Z *et al*, 2002 concluded from their experiment that there is more ET demand at tasseling, silking and therefore, WUE and WEE will be also high and result in maximum yield. ET value that occurs maximum WUE equals the arithmetic square root of the ratio of the intercept of the function to the coefficient and function quadratic term.

Yield Studies

Significantly higher grain yield was recorded with rotavator tilled maize (5831 and 5960 kg ha^{-1}) which was followed by conventional tillage (4974 and 5226 kg ha^{-1}) and cultivator tilled maize (4892 and 5138 kg ha^{-1}) during both the years of experimentation. Rotavator tilled maize reported an increase in grain yield (60.7 and 63.8 per cent) over zero tilled maize in both the years, respectively. Similarly, grain yield was recorded significantly higher with crop receiving 6 irrigations (5478 and 5673 kg ha^{-1}) over 3 irrigations (4051 and 4119 kg ha^{-1}) and 4 irrigations (4259 and 4700 kg ha^{-1}) in both the years but was found at par with crop receiving 5 irrigations (5452 and 5638 kg ha^{-1}) at different stages of crop growth. There was increase of 34.6 per cent grain yield in crop receiving 5 irrigations over crop receiving 3 irrigations in the first year and 36.9 per cent during 2nd year of experimentation (Table 4).

Grain yield was significantly higher in rotavator tilled maize over other tillage practices at same level of irrigation. Grain yield of conventional tilled maize and cultivator tilled maize was statistically at par with each other but significantly superior over zero tilled maize at the same level of irrigation. Crop with 5 and 6 irrigations produced significantly higher grain yield than 3 and 4 irrigations in combination with different tillage practices. The maximum grain yield was registered at T_3I_4 to the extent of 6598 and 6868 kg ha^{-1} in first and second year, respectively which were significantly higher than all other treatment combinations of tillage and irrigation except T_3I_3 (6590 kg ha^{-1} and 6850 kg ha^{-1}) in first and second year, respectively. During second year of experimentation each level of irrigation resulted significant increase in grain yield except with 6 irrigations in combination with all tillage practices. The maximum grain yield obtained in rotavator tilled maize may be due to superiority in physical environment by maintaining lowest soil hardness, more infiltration rate and lesser bulk density over all other tillage practices, which resulted in more root volume, LAI and favoured yield attributes in positive manner. Lesser water saturation deficit and more relative leaf water content and increased WEE also helped yield attributes in positive manner (table 5). These all interlinked factors in association resulted in increased grain yield. The results are in conformity with the findings of Vogel , 1994 and Nyakatowa *et al*, 2002.

Nutrient-Uptake

N-uptake by grains

A significant higher N-uptake by grain was recorded under rotavator tilled maize (69.38 and 71.52 kg ha^{-1}) which was followed by conventional tillage and cultivator tilled maize over zero tilled maize (38.96 and 41.47 kg ha^{-1}) in both the years, respectively (Table 2 and 3).

Similarly, N-uptake by grains was also found significantly higher in crop receiving 6 irrigations (68.47 and 69.78 kg ha^{-1}) and was found at par with crop receiving 5 irrigations (65.42 and 65.40 kg ha^{-1}) over 3 and 4 irrigations, during both the years of experimentation, respectively.

N-uptake by stover

Maximum N-uptake by stover was reported under rotavator tilled plots (40.26 and 41.57 kg ha^{-1}) which was significantly higher over zero-tilled maize (26.73 and 29.24 kg ha^{-1}) in both the years, respectively (Table 2 and 3).

With each successive level of irrigation (upto 5 irrigations) significantly increased the N-uptake in stover but was statistically at par with crop receiving 6 irrigations (37.83 and 38.91 kg ha^{-1}) during both the years of experimentation, respectively.

Total Nitrogen uptake

Significantly higher N-uptake by plants was recorded under rotavator tilled maize (109.58 and 113.09 kg ha^{-1}) over zero tilled maize (65.69 and 70.71 kg ha^{-1}) during both the years of experimentation, respectively (Table 2 and 3).

Similarly, crop receiving 6 irrigations (106.30 and 104.69 kg ha^{-1}) was found significantly superior over crop receiving 3 irrigations (73.74 and 76.68 kg ha^{-1}) and 4 irrigations (80.19 and 87.89 kg ha^{-1}) during both the years, but was found statistically at par with crop receiving 5 irrigations at different critical stages (101.99 and 103.48 kg ha^{-1}) of crop growth.

Table 2
Effect of tillage and Irrigation on Nitrogen, Phosphorus and Potassium in Winter Maize During 2002-03

Treatments	*Nitrogen uptake (kg ha⁻¹)*			*Phosphorus uptake (kg ha⁻¹)*			*Potassium uptake (kg ha⁻¹)*			*Protein content in grain (%)*
	Grain N	*Stover N*	*Total N*	*Grain P*	*Stover P*	*Total P*	*Grain K*	*Stover K*	*Total*	
Tillage										
T_1	57.69	35.97	93.66	19.05	15.92	34.97	19.79	66.58	86.37	8.07
T_2	56.80	35.39	92.19	18.68	15.81	34.49	19.56	66.70	86.26	8.00
T_3	69.32	40.26	109.58	23.09	17.85	40.94	23.84	75.12	98.96	8.44
T_4	38.96	26.73	65.69	13.38	11.66	25.04	13.56	50.05	63.61	7.53
SE. m. (±)	3.72	1.52	5.05	0.41	1.85	1.95	1.56	2.85	3.68	0.29
CD (P=0.05)	12.87	5.25	17.47	1.42	NS	6.74	5.34	9.86	12.73	NS
Irrigation										
I_1	42.53	31.21	73.74	14.74	13.18	27.92	15.47	55.97	71.44	7.27
I_2	47.70	32.49	80.19	16.09	14.44	30.53	16.78	60.00	76.78	7.64
I_3	65.42	36.57	101.99	21.31	16.46	37.77	22.02	69.98	92.00	8.55
I_4	68.47	37.83	106.30	22.24	17.10	39.34	22.45	72.53	94.98	8.58
SE. m. (±)	1.70	0.38	2.60	0.15	1.62	1.21	0.52	1.92	1.61	0.29
CD (P=0.05)	4.96	1.10	7.58	0.44	NS	3.53	1.52	5.31	4.69	0.85

Note: Kn = Knee height, S = Silking, M = Milking, T = Tasseling, TI = Tassel initiation, G.F. = Grain filling.

Table 3
Effect of tillage and Irrigation on Nitrogen, Phosphorus and Potassium uptake in Winter Maize During 2003-04

Treatments	*Nitrogen uptake (kg ha⁻¹)*			*Phosphorus uptake (kg ha⁻¹)*			*Potassium uptake (kg ha⁻¹)*			*Protein content in grain (%)*
	Grain N	*Stover N*	*Total N*	*Grain P*	*Stover P*	*Total P*	*Grain K*	*Stover K*	*Total*	
Tillage										
T_1	61.66	37.80	99.46	20.06	17.00	37.06	20.85	70.03	90.88	8.12
T_2	59.08	36.91	95.55	19.63	16.30	35.92	20.34	68.95	89.29	8.02
T_3	71.57	41.57	113.09	23.66	18.49	42.15	24.43	77.42	101.85	8.42
T_4	41.47	29.24	70.71	14.45	12.73	26.88	14.69	54.12	68.81	7.51
SE. m. (±)	3.66	1.38	5.32	0.32	1.88	1.82	1.32	2.52	3.63	0.30
CD (P=0.05)	12.66	4.77	18.41	1.11	NS	6.29	4.56	8.71	12.55	NS
Irrigation										
I_1	43.66	33.02	76.68	15.11	13.90	29.01	15.73	59.30	75.03	7.23
I_2	52.64	35.25	87.89	17.86	15.44	33.35	18.56	63.56	82.12	7.60
I_3	65.40	38.08	103.48	21.98	17.11	39.02	22.89	72.72	95.61	8.55
I_4	69.78	38.91	104.69	23.08	17.71	40.79	23.31	74.93	98.24	8.69
SE. m. (±)	1.82	0.52	5.21	0.38	1.40	1.41	0.41	2.72	1.80	0.27
CD (P=0.05)	5.31	1.51	15.20	1.11	NS	4.11	1.20	7.93	5.25	0.79

Note : Kn = Knee height, S = Silking, M = Milking, T = Tasseling, TI = Tassel initiation, G.F. = Grain filling.

Table 4
Effect of tillage and Irrigation on Grain Yield, Water use Efficiency, Water Expense Efficiency, Net Return and B:C Ratio after Harvest During 2002-03 and 2003-04

Treatments	*Grain yield (kg/ha)*		*WUE (Kg/ha-cm)*		*WEE (Kg/ha-cm)*		*Net return*		*B:C ratio*	
	2002-03	*2003-04*	*2002-03*	*2003-04*	*2002-03*	*2003-04*	*2002-03*	*2003-04*	*2002-03*	*2003-04*
Tillage										
Conventional tillage (T_1)	4974	5226	96.58	108.20	88.66	99.50	11669	13,615	1.77	1.89
2 cultivator+ Planking (T_2)	4892	5138	94.08	105.61	86.74	97.55	11696	13630	1.79	1.91
Rotavator once (T_3)	5831	5960	114.10	124.68	107.4	114.61	16173	17493	2.08	2.17
Zero-till planter (T_4)	3542	3805	66.83	76.20	53.34	71.80	5014	6980	1.37	1.47
CD (P=0.05)	304	349	9.79	11.07	5.88	7.33	868	1031	0.07	0.07
Irrigation										
30 DAS+Kn +S (I_1)	4051	4119	92.91	102.41	88.44	97.56	8091	9249	1.57	1.66
30 DAS+Kn +S+M (I_2)	4259	4700	86.56	102.35	80.51	95.14	8722	11559	1.39	1.78
30 DAS+Kn+ T+M+G.F. (I_3)	5452	5638	110.80	109.58	91.32	100.58	14017	15613	1.93	2.03
30 DAS+Kn+ TI+S+M+G.F.(I_4)	5478	5673	90.99	99.57	82.50	90.74	13717	15311	1.88	1.96
CD (P=0.05)	327	251	4.90	7.44	3.82	5.13	692	724	0.06	0.06

Note: Kn = Knee height, S = Silking, M = Milking, T = Tasseling, TI = Tassel initiation, G.F. = Grain filling.

Table 5
Interaction Effect of tillage and Irrigation on Grain Yield (kg/ha) During 2002-03 and 2003-04

Irrigation	*Tillage 2002-03*				*Tillage 2003-04*			
	T1	*T2*	*T3*	*T4*	*T1*	*T2*	*T3*	*T4*
I1	4261	4242	4951	2752	4358	4284	4750	3083
I2	4479	4469	5186	2903	4925	4904	5374	3598
I3	5572	5428	6590	4215	5800	5642	6850	4259
I4	5587	5430	6590	4299	5822	5722	6868	4281
CD (P=0.05)	654				502			

P-uptake by grains

P-uptake in grain was found significantly higher in rotavator tilled maize (23.09 and 23.66 kg ha^{-1}) over all the tillage practices taken into consideration here, during both the years of experimentation (Table 2 and 3).

Each level of irrigation showed its superiority over its lower level of irrigation. The crop receiving 6 irrigations (22.24 kg ha^{-1}) was found significantly superior over all other lower frequency of irrigation in the first year but during the 2nd year of experimentation crop receiving 6 irrigations (23.08 kg ha^{-1}) was found at par with crop receiving 5 irrigations (21.98 kg ha^{-1}), respectively.

P-uptake by stover

Different tillage practices and frequency of irrigation either in combination or individually did not differed significantly in respect of P-uptake by stover in both the years of experimentation (Table 2 and 3).

Total P-uptake

Total P-uptake by maize crop was significantly higher in rotavator tilled maize (40.94 and 42.15 kg ha^{-1}) which was again followed by conventional tillage (34.97 and 37.06 kg ha^{-1}) and cultivator tilled maize (34.49 and 35.92 kg ha^{-1}) over zero tilled maize (25.04 and 26.88 kg ha^{-1}) during both the years of experimentation, respectively (Table 2 and 3).

Similarly, higher total P-uptake by plants were recorded by crop receiving 6 irrigations (39.34 and 40.79 kg ha^{-1}) over all other lower frequencies of irrigation except crop receiving 5 irrigations (37.77 and 39.09 kg ha^{-1}) during both the years of experimentation, respectively.

Potassium Uptake by Plants

K-uptake by Grains

Potassium uptake by grains were found significantly higher in rotavator tilled maize (23.84 and 24.43 kg ha^{-1}) which was followed by conventional tilled maize (19.79 and 20.85 kg ha^{-1}) and cultivator tilled maize (19.56 and 20.34 kg ha^{-1}) over zero tilled maize (13.56 and 14.69 kg ha^{-1}), respectively during both the years of experimentation (Table 2 and 3).

Similarly, crop receiving 6 irrigations resulted in significantly higher K-uptake by grains (22.45 and 23.31 kg ha^{-1}) and were found at par with crop receiving 5 irrigations (22.02 and 22.89 kg ha^{-1}) over crop receiving 3 irrigations (15.47 and 15.73 kg ha^{-1}) and 4 irrigations (16.78 and 18.56 kg ha^{-1}) in both the years of experimentation, respectively.

K-uptake by stover

Maximum K-uptake by stover (75.12 and 77.42 kg ha^{-1}) and was followed by conventional tilled maize (66.58 and 70.03 kg ha^{-1}) and cultivator tilled maize (66.70 and 68.95 kg ha^{-1}) which were found significantly superior over zero-tilled maize (50.05 and 54.42 kg ha^{-1}) in both the years of experimentation (Table 2 and 3).

Likewise, crop receiving 6 irrigations exhibited in significantly higher K-uptake by stover (72.53 and 74.93 kg ha^{-1}) and was found statistically at par with crop receiving 5 irrigations (69.98 and 72.72 kg ha^{-1}) over 3 irrigations (55.97 and 59.30 kg ha^{-1}) and 4 irrigations (60.00 and 63.56 kg ha^{-1}) in both the years, respectively.

Total K-uptake

Significant higher K-uptake by plants, were recorded in rotavator tilled maize (98.96 and 101.95 kg ha^{-1}) over all other tillage treatments in both the years, respectively (Table 2 and 3).

Similarly, crop receiving 5 and 6 irrigations having at par with each other resulted in significantly higher K-uptake by plants over 3 irrigations (71.44 and 75.03 kg ha^{-1}) and 4 irrigations (76.78 and 82.12 kg ha^{-1}) in both the years, respectively. These findings are in conformity with the findings of Kumar *et al.* (1996) and Mason *et al.* (2002).

Economics

Data on net return as affected by tillage and irrigation denote that rotavator tilled maize had the maximum (Rs. 16,173 and 17,493 ha^{-1}) net return which was significantly superior to conventional tillage by fetching 27.84 and 22.53 per cent more net return, respectively in both the years. All the tillage practices were found significantly superior over zero tilled maize (Rs. 5,014 and 6,980 ha^{-1}) in respect of net return in both the years, respectively (table 4). Similarly, crop receiving 5 irrigations resulted in significantly higher net return (Rs. 14,017 and 15,613) over 3 irrigations (Rs. 8,091 and 9,249) and 4 irrigations (Rs. 8,722 and 11,559) during both the years of experimentation, respectively.

Significantly higher B:C ratio was found with rotavator tilled maize (2.08 and 2.17) over all other tillage practices in both the years, respectively. Similarly, crop receiving 6 irrigations fetched significantly higher B:C ratio (1.88 and 1.96) over crop receiving 3 irrigations (1.57 and 1.66) and 4 irrigations (1.39 and 1.96) during both the years of experimentation, respectively. Crop receiving 5 and 6 irrigations were also found statistically at par with each other during both the years of experimentation. The economic superiority of rotavator tilled maize in comparison with other tillage practices and irrigation over precessive levels were due to the fact that rotavator tilled maize had lower cost of cultivation than other tillage practices except zero- tilled maize. Though, there was increase in grain yield with six no. of irrigations but yield advantage was not much over crop receiving five irrigations on expense incurred in one more irrigation and thus crop receiving five irrigations resulted into higher B:C ratio in both the years.

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