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Effect of Tillage, Mulching and Weed Management on Performance of Maize (*Zea mays*) in Karnataka

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ABSTRACT: A field experiment was conducted during *kharif* 2010 and 2011 to study the effect of tillage (conventional tillage, zero tillage and minimum tillage), mulching (no mulch and with mulch) and weed management practices (unweeded check, atrazine, and atrazine followed by 2, 4-D spray) on rainfed maize in Karnataka. Tillage, mulching and weed management practices significantly influenced the growth and yield of maize. Maize grain yield (5.91 t/ha) was significantly higher in conventional tillage system as compared to other tillage practices. Application of atrazine followed by 2,4-D recorded higher grain yield (5.99 t/ha) than rest of the treatments. Minimum tillage with mulching and application of atrazine @ 1.25 kg/ha followed by 2,4-D @ 2.00 kg/ha recorded highest net returns (₹ 36985/ha). The combined effect of conventional tillage with mulching and application of atrazine @ 1.25 kg/ha followed by 2,4-D @ 2.00 kg/ha and minimum tillage with mulching and application of atrazine followed by 2,4-D enhanced the vegetative growth, yield attributes and economics of maize compared to other treatments.

Key words: Atrazine, conventional tillage, grain yield, maize, mulching

Maize (*Zea mays* L.) is the most important cereal crop after rice and wheat in India. The use of conservation tillage or reduced tillage is expanding greatly during recent years. Although suitable weed control methods are already available for most of the crops grown under conventional tillage systems, very little information is available on weed management strategies for reduced/zero tillage crop production. Mulches are effective in manipulating crop growing environment to increase yield and product quality by controlling weed growth, conserving soil moisture, reducing soil erosion and influenced the physical and chemical properties of the soil (Govaerts *et al.* 2007). Weeds grow rapidly and compete with the crop for growth resources. Hence, managing weeds during critical stages is most critical for realizing higher yields. Usage of pre-emergence herbicides assumes greater importance in the view of their effectiveness from initial stages. Further, post-emergence herbicides applied at about 40-45 days after sowing (DAS) help in avoiding the problem of weeds at later stages. The literature on combination of tillage, mulching and weed management practices in maize is meager, hence the study was undertaken.

Materials and Methods

A field experiment was conducted at the Main Agricultural Research Station, University of Agricultural Sciences, Dharwad (15^0 26' N latitude, 75^0 07' E longitude and at an altitude of 678 m above mean sea level), Karnataka during *kharif* 2010 and 2011. The rainfall during maize growing period (June to September) was 574 mm during 2010 and 532 mm during 2011. The soil was medium black clay having 248.4 kg N, 30.6 kg P_2O_5 and 342.8 kg K_2O/ha with pH of 7.6. A total of 18 treatment combinations including three tillage practices as main plot [T_1: Conventional tillage (one ploughing + cultivator + tractor drawn harrowing twice + two hoeings except in mulched treatment), T_2: Zero-tillage (Glyphosate @ 3 l/ha was used as pre-plant desiccator at 10-15 days before sowing of crop) and T_3: Minimum tillage (two tractor drawn harrowing twice + one hoeing except in mulched treatment)] with two mulching treatments as sub plot [M_0: No mulch and M_1: With mulch (4 t/ha of maize stalk on dry weight basis)] and three weed control methods as sub-sub plot (W_0: Unweeded check, W_1: Atrazine (@ 1.25 kg/ha and W_2: Atrazine (@ 1.25 kg/ha followed by 2, 4- D (@ 2.0 kg/ha). Split –split plot design was followed with 3 replications.

Furrows were opened at 60 cm row spacing with the help of bullock drawn seed drill and seeds of maize hybrid Kargil 900 M gold were dibbled in furrows at an interval of 20 cm on 19 June 2010 and 10 June 2011. Recommended dose of fertilizers (100 kg N, 50 kg P_2O_5 and 25 kg K_2O/ha) were applied through urea, diammonium phosphate and Muriate of Potash. Full dose of P_2O_5 and K_2O and 50% dose of N was applied at the time of sowing. Remaining 50% of N was applied as top dressing. Herbicides were applied as per the treatments. Atrazine was applied on the next day of sowing, while 2,4-D was sprayed in between the maize rows at 25 days after sowing with knapsack sprayer. Maize stalk was chopped in to a size of about 5 cm length and spread in between the plant rows of maize.

Results and Discussion

Crop growth

Conventional tillage showed significantly higher plant height (182.3 cm), leaf area index (4.18) and total dry matter as compared to minimum tillage and zero tillage (Table 1). Availability of higher soil moisture content at tasseling and silking stage of crop as well as higher available nitrogen at harvest might have influenced growth parameters. These results are in conformity with the findings of Sharma and Gautam (2010) where tillage treatment recorded higher growth parameters as compared to no tilled practice.

Significantly higher plant height (179.5 cm) and LAI at 60 DAS (4.03) were recorded with mulching as compared to no mulching. This may be due to better source and sink capacity developed during the vegetative and reproductive phases of crop growth. The increase in growth parameters at different stages of crop growth might be ascribed to increase in availability of nutrients, microbial activity, less weed population and more moisture supply in mulched treatments over no mulch. Application of

Table 1 : Growth and yield parameters of maize as influenced by tillage, mulching and weed management practices (mean data of two years)

Treatment	Plant height (cm)	LAI at 60 DAS	Cob weight (g)	100-seed weight (g)
Tillage				
T_1	182.3	4.18	170.60	27.92
T_2	169.1	3.58	155.42	26.22
T_3	176.9	3.90	163.90	27.16
SEm±	1.3	0.02	2.02	0.26
CD (P=0.05)	5.2	0.09	7.93	1.02
Mulching				
M_0	172.7	3.74	160.51	26.67
M_1	179.5	4.03	166.10	27.52
SEm±	1.6	0.02	1.55	0.34
CD (P=0.05)	5.7	0.07	5.36	NS
Weed management				
W_0	165.5	3.31	150.77	25.59
W_1	179.2	4.07	167.02	27.61
W_2	183.6	4.29	172.14	28.10
SEm±	2.2	0.02	2.66	0.34
CD (P=0.05)	6.4	0.06	7.78	0.99
Interaction				
$T_1 M_0 W_0$	169.9	3.47	157.93	26.31
$T_1 M_0 W_1$	179.0	4.19	168.70	27.85
$T_1 M_0 W_2$	189.2	4.57	178.58	28.83
$T_1 M_1 W_0$	172.1	3.65	158.99	26.54
$T_1 M_1 W_1$	190.2	4.55	177.48	28.83
$T_1 M_1 W_2$	193.2	4.67	181.93	29.15
$T_2 M_0 W_0$	150.5	3.01	139.38	24.05
$T_2 M_0 W_1$	170.3	3.48	156.88	26.30
$T_2 M_0 W_2$	173.8	3.72	160.37	26.65
$T_2 M_1 W_0$	164.3	3.14l	143.88	25.18
$T_2 M_1 W_1$	175.3	3.83	162.24	27.06
$T_2 M_1 W_2$	180.6	4.30	169.78	28.06
$T_3 M_0 W_0$	166.7	3.21	150.83	25.45
$T_3 M_0 W_1$	177.1	3.96	164.57	27.24
$T_3 M_0 W_2$	177.9	4.04	167.39	27.36
$T_3 M_1 W_0$	169.3	3.34	153.62	25.99
$T_3 M_1 W_1$	183.0	4.39	172.22	28.38
$T_3 M_1 W_2$	187.2	4.43	174.79	28.52
SEm±	4.4	0.04	5.33	0.68
CD (P=0.05)	12.8	0.12	15.55	1.98

T_1: Conventional tillage; T_2: Zero tillage; T_3: Minimum tillage; M_o: Without mulch; M_1: With mulch;

W_0: Unweeded check; W_1: Atrazine (@ 1.25 kg/ha); W_2: Atrazine (@ 1.25 kg/ha followed by 2,4-D (@ 2.0 kg/ha

atrazine @ 1.25 kg/ha followed by 2,4-D @ 2.0 kg/ha recorded significantly higher plant height (183.7 cm) and LAI at 60 DAS (4.29) as compared to unweeded check and was on a par with application of atrazine @ 1.25 kg/ha, but it was significantly better with respect to LAI. Availability of higher soil moisture content, available nutrients and lower weed infestation at all the stages of crop growth might have influenced growth parameters. The above results are corroborated with the findings of Singh *et al.* (2007) where atrazine (1.0 kg/ha) with manual weeding recorded higher growth parameters of maize which was on par with atrazine followed by paraquat as direct spray.

Yield attributes and yield

The cob weight (170.60 g), 100-seed weight (27.92 g), grain yield (5.91 t/ha) and HI (42.3%) were significantly higher under conventional tillage as compared to minimum tillage and zero tillage. This may be due to efficient utilization of resources including available soil moisture, nutrients and solar energy at all the stages of crop growth and lower weed infestation. These results are in confirmity with the findings of Sharma and Gautam (2010). Similarly, significantly higher cob weight (166.10 g), 100-seed weight (27.52 g), grain yield (5.75 t/ha) and HI (42.3 %) were recorded with mulching as compared to no mulching. These results are in confirmity with the findings of Sharma *et al.* (2008) where polythene mulching recorded higher yield and yield parameter of maize, but was on a par with stover mulch and soil mulch. Singh *et al.* (2011) also indicated that *sunhemp* mulching recorded higher maize yield as compared to control.

Application of atrazine @ 1.25 kg/ha followed by 2,4-D @ 2.0 kg/ha recorded significantly higher cob weight (172.14 g), 100-seed weight (28.10 g), grain yield (5.99 t/ha) and HI (42.5%) as compared to unweeded check, but was on a par with application of atrazine @ 1.25 kg/ha. The increase in yield and yield parameters was mainly due to minimum crop- weed competition throughout the crop growth which is evident from significantly lower weed dry weight at harvest, thus enabling the crop for maximum utilization of nutrients, moisture, light and space which in turn influenced the yield and yield components. Similar results were reported by Chopra and Angiras (2008), where atrazine @ 1.5 kg/ha recorded higher yield of maize as compared to unweeded check.

Interaction effects of management practices

Significantly higher plant height (193.2 cm) and LAI at 60 DAS (4.67) were recorded in plot under conventional tillage with mulching and application of atrazine @ 1.25 kg/ha followed by 2,4-D @ 2.0 kg/ha as compared to the rest of the treatment combinations, and the combination of zero tillage with no mulching and unweeded check recorded significantly lowest plant height (150.5 cm) and LAI (3.01) (Table 1). Significantly higher cob weight (181.93 g), 100-seed weight (29.15 g) and grain yield (6.35 t/ha) were recorded in plots under conventional tillage with mulching and application of atrazine @ 1.25 kg/ha followed by 2,4-D @ 2.0 kg/ha as compared to the rest of the treatment combinations (Table 1). Whereas, HI was significantly higher in conventional tillage with no mulch and application of atrazine @ 1.25 kg/ha followed by 2,4-D @ 2.0 kg/ha, and minimum tillage with mulching and application of atrazine @ 1.25 kg/ha followed by 2,4-D @ 2.0 kg/ha.

Weeds

The total dry weight of weeds differed significantly due to tillage, mulching and weed management practices (Table 2). Significantly higher total dry weight of weeds was recorded in zero tillage plots as compared to minimum tillage and conventional tillage practices. These findings are in agreement with the findings of Angiras *et al.,* (2010). Similarly, significantly lower total dry weight of weeds was recorded with mulching as compared to no mulching. Whereas, significantly lower total dry weight of weeds was recorded with application of atrazine @ 1.25 kg/ha followed by 2,4-D @ 2.0 kg/ha as compared to the application of atrazine @ 1.25 kg/ha and unweeded check. Similarly, significantly lowest total dry weight of weeds was recorded in the plots under of conventional tillage with mulching and application of atrazine @ 1.25 kg/ha followed by 2,4-D @ 2.0 kg/ha.

Soil moisture

The tillage practices did not differ significantly with respect to soil moisture content at tasseling and silking stage of maize (Table 2). Chopra and Angiras (2008) reported that there was no significant differences with respect to soil water content among different tillage practices. However, significantly higher soil moisture content (28.98%) was recorded with mulching as compared to no mulching practice (28.73%). Significantly higher soil moisture content (29.08%) was recorded with application of atrazine @ 1.25 kg/ha followed by 2,4-D @ 2.0 kg/ha as compared to unweeded check (28.53%) and was on par with application of atrazine @ 1.25 kg/ha (28.95%). Similarly, the combined effect of tillage, mulching and weed management practices differed significantly with respect to soil moisture content. Soil moisture content (29.31%) was significantly higher in the plots under of zero tillage with mulching and application of atrazine @ 1.25 kg/ha followed by 2,4-D @ 2.0 kg/ha as compared to rest of the treatment combinations. Significantly lowest soil moisture content (28.04%) was recorded in the plots under of conventional tillage with no mulching and unweeded check.

Soil available nitrogen

Conventional tillage recorded significantly higher soil available nitrogen (240.6 kg/ha) as compared to minimum tillage and was on par with zero tillage practices (Table 2). Significantly higher soil available nitrogen (242.1 kg/ha) was recorded with mulching as compared to no mulching practice. Similarly, significantly higher soil available nitrogen (245.3 kg/ha) was recorded with application of atrazine @ 1.25 kg/ha followed by 2,4-D @ 2.0 kg/ha as compared to application of atrazine @ 1.25 kg/ha, and unweeded check. Similarly, the interaction effect due to tillage, mulching and weed management practices differed significantly with respect to soil available nitrogen. Significantly higher soil available nitrogen (252.0 kg/ha) was recorded with the combination of zero tillage with mulching and application of atrazine @ 1.25 kg/ha followed by 2,4-D @ 2.0 kg/ha as compared to the rest of the treatment combinations. Significantly lowest and similar soil available nitrogen was recorded with the combination of zero tillage with no mulching and unweeded check, and minimum tillage with no mulching and unweeded check.

Table 2 : Dry weight of weeds, soil moisture content at tasseling and silking stage and available nitrogen at harvest as influenced by tillage, mulching and weed management practices

Treatment	Dry weight of weeds (g/m²)			Soil moisture content (%)			Available N (kg/ha)		
	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled
Tillage									
T_1	4.5 (23.2)	6.1 (39.6)	5.3 (31.4)	28.7	28.6	28.6	240.3	240.9	240.6
T_2	7.1 (52.6)	10.6 (114.4)	8.8 (83.5)	29.1	28.9	29.0	239.8	240.3	240.0
T_3	6.2 (39.6)	8.6 (75.4)	7.4 (57.5)	29.0	28.9	29.0	238.0	236.8	237.4
SEm±	0.2	0.4	0.3	0.1	0.2	0.1	0.5	1.2	0.8
CD (P=0.05)	0.8	1.5	1.0	0.2	0.8	0.5	2.0	4.8	3.0
Mulching									
M_0	6.4 (43.8)	9.1 (89.7)	7.7 (66.7)	28.8	28.7	28.7	237.2	236.1	236.6
M_1	5.5 (33.1)	7.6 (63.3)	6.6 (48.2)	29.1	28.9	29.0	241.5	242.7	242.1
SEm±	0.2	0.2	0.2	0.0	0.1	0.0	1.0	1.7	1.3
CD (P=0.05)	0.8	0.8	0.6	0.1	0.2	0.2	3.5	5.9	4.6
Weed management									
W_0	7.8 (62.3)	10.1 (106.2)	9.0 (84.2)	28.5	28.5	28.5	231.0	230.4	230.7
W_1	5.5 (30.7)	7.9 (66.9)	6.7 (48.8)	29.1	28.8	29.0	242.1	242.1	242.1
W_2	4.5 (22.3)	7.2 (56.2)	5.8 (39.3)	29.1	29.1	29.1	245.0	245.6	245.3
SEm±	0.2	0.4	0.2	0.1	0.0	0.1	1.4	1.8	1.0
CD (P=0.05)	0.7	1.0	0.6	0.2	0.1	0.2	4.2	5.3	3.0
Interaction									
$T_1 M_0 W_0$	7.0 (50.0)	8.2 (66.5)	7.6 (58.3)	27.9	28.2	28.0	234.5	231.0	232.8
$T_1 M_0 W_1$	4.7 (21.5)	6.2 (38.4)	5.4 (30.0)	28.8	28.4	28.6	241.5	241.5	241.5
$T_1 M_0 W_2$	2.5 (5.7)	5.0 (27.9)	3.8 (16.8)	28.6	28.8	28.7	241.5	245.0	243.3
$T_1 M_1 W_0$	6.4 (40.9)	7.8 (63.3)	7.1 (52.1)	28.8	28.4	28.6	241.5	234.5	238.0
$T_1 M_1 W_1$	4.3 (17.7)	4.9 (24.1)	4.6 (20.9)	29.0	28.7	28.8	238.0	245.0	241.5
$T_1 M_1 W_2$	1.9 (3.2)	4.3 (17.6)	3.1 (10.4)	29.0	29.0	29.0	245.0	248.5	246.8
$T_2 M_0 W_0$	9.6 (91.6)	13.1 (170.5)	11.3 (131.1)	28.0	28.6	28.3	224.0	224.0	224.0
$T_2 M_0 W_1$	6.8 (47.2)	11.0 (120.6)	8.9 (83.9)	29.1	28.9	29.0	245.0	238.0	241.5
$T_2 M_0 W_2$	6.4 (40.5)	10.2 (103.0)	8.3 (71.7)	29.3	29.0	29.2	241.5	245.0	243.3
$T_2 M_1 W_0$	8.2 (66.7)	11.6 (132.8)	9.9 (99.7)	29.1	28.8	28.9	231.0	238.0	234.5
$T_2 M_1 W_1$	6.1 (36.1)	9.0 (84.61)	7.5 (60.4)	29.5	29.0	29.2	245.0	245.0	245.0
$T_2 M_1 W_2$	5.6 (33.2)	8.6 (74.7)	7.1 (54.0)	29.4	29.3	29.3	252.0	252.0	252.0
$T_3 M_0 W_0$	8.4 (70.9)	11.1 (123.3)	9.8 (97.1)	29.0	28.5	28.7	224.0	224.0	224.0
$T_3 M_0 W_1$	6.2 (36.9)	9.2 (86.1)	7.7 (61.5)	29.0	28.8	28.9	238.0	238.0	238.0
$T_3 M_0 W_2$	5.5 (29.7)	8.3 (70.5)	6.9 (50.1)	29.0	29.1	29.1	245.0	238.0	241.5
$T_3 M_1 W_0$	7.3 (53.6)	9.0 (80.8)	8.2 (67.2)	28.4	28.8	28.6	231.0	231.0	231.0
$T_3 M_1 W_1$	5.1 (25.1)	7.0 (47.9)	6.0 (36.4)	29.2	29.1	29.1	245.0	245.0	245.0
$T_3 M_1 W_2$	4.7 (21.6)	6.6 (43.5)	5.7 (32.6)	29.4	29.2	29.3	245.0	245.0	245.0
SEm±	0.5	0.7	0.4	0.2	0.1	0.1	2.9	3.7	2.0
CD (P=0.05)	1.4	2.1	1.2	0.5	0.2	0.3	8.3	10.7	5.9

T_1: Conventional tillage; T_2: Zero tillage; T_3: Minimum tillage; M_o: Without mulch; M_1: With mulch;

W_0: Unweeded check; W_1: Atrazine (@ 1.25 kg/ha); W_2: Atrazine (@ 1.25 kg/ha followed by 2,4-D (@ 2.0 kg/ha

Table 3 : Yield and economics of maize as influenced by tillage, mulching and weed management practices

Treatment	Grain yield (t /ha)			Harvest index (%)			Net returns (₹/ha)		
	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled
Tillage									
T_1	5.96	5.86	5.91	42.4	42.2	42.3	30175	36495	33335
T_2	5.41	5.23	5.32	41.8	41.9	41.8	28625	33417	31021
T_3	5.68	5.61	5.64	42.2	42.1	42.2	30928	37673	34301
SEm±	0.10	0.09	0.06	0.3	0.2	0.2	915	1037	633
CD (P=0.05)	0.40	0.37	0.25	NS	NS	NS	NS	4073	2485
Mulching									
M_0	5.56	5.44	5.50	41.8	42.1	41.9	30098	35733	32916
M_1	5.80	5.69	5.75	42.5	42.0	42.3	29721	35990	32855
SEm±	0.11	0.07	0.08	0.3	0.2	0.2	1000	821	752
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Weed management									
W_0	5.15	5.03	5.09	41.1	41.6	41.4	26112	31003	28558
W_1	5.84	5.75	5.80	42.6	42.3	42.4	31140	37753	34446
W_2	6.05	5.92	5.99	42.7	42.3	42.5	32476	38829	35653
SEm±	0.15	0.11	0.11	0.2	0.2	0.2	1332	1204	1033
CD (P=0.05)	0.43	0.32	0.31	0.7	0.6	0.5	3887	3513	3015
Interactions									
$T_1 M_0 W_0$	5.36	5.33	5.35	40.9	41.8	41.3	27275	33241	30258
$T_1 M_0 W_1$	5.89	5.94	5.91	42.1	42.9	42.5	30485	38012	34249
$T_1 M_0 W_2$	6.34	6.13	6.23	43.0	42.3	42.7	33743	39441	36592
$T_1 M_1 W_0$	5.50	5.35	5.42	42.8	41.7	42.3	25533	30580	28057
$T_1 M_1 W_1$	6.23	6.19	6.21	43.1	42.0	42.5	31250	38891	35071
$T_1 M_1 W_2$	6.44	6.26	6.35	42.2	42.5	42.3	32764	38801	35783
$T_2 M_0 W_0$	4.85	4.57	4.72	40.0	41.1	40.6	25975	28589	27282
$T_2 M_0 W_1$	5.46	5.28	5.37	42.2	42.2	42.2	30353	35247	32800
$T_2 M_0 W_2$	5.58	5.36	5.47	42.0	42.0	42.0	30853	35466	33159
$T_2 M_1 W_0$	4.94	4.73	4.84	41.1	41.3	41.2	23867	27516	25691
$T_2 M_1 W_1$	5.63	5.46	5.55	42.7	42.2	42.4	29102	34431	31767
$T_2 M_1 W_2$	5.97	5.96	5.96	43.0	42.4	42.7	31601	39253	35427
$T_3 M_0 W_0$	4.96	4.98	4.97	40.4	41.6	41.0	26916	33226	30071
$T_3 M_0 W_1$	5.76	5.67	5.71	42.5	42.3	42.4	32766	39315	36041
$T_3 M_0 W_2$	5.81	5.72	5.77	42.8	42.6	42.7	32515	39064	35789
$T_3 M_1 W_0$	5.30	5.21	5.25	41.6	42.0	41.8	27105	32868	29987
$T_3 M_1 W_1$	6.04	6.00	6.02	42.9	42.1	42.5	32884	40620	36752
$T_3 M_1 W_2$	6.17	6.10	6.14	43.1	42.3	42.7	33382	40948	37165
SEm±	0.29	0.22	0.21	0.5	0.4	0.4	2664	2407	2066
CD (P=0.05)	0.86	0.64	0.61	1.4	1.3	1.1	7775	7027	6030

Price: Maize grain: ₹ 850/q and 1050/q during 2010 and 2011, respectively Stover: ₹ 560/t in both the years

T_1: Conventional tillage; T_2: Zero tillage; T_3: Minimum tillage; M_o: Without mulch; M_1: With mulch;

W_0: Unweeded check; W_1: Atrazine (@ 1.25 kg/ha); W_2: Atrazine (@ 1.25 kg/ha followed by 2,4-D (@ 2.0 kg/ha

Economics

Minimum tillage recorded significantly higher net returns (₹ 34301/ha) as compared to zero tillage (₹ 31021/ha) and conventional tillage practice (₹ 33335/ha). There was no significant difference in net returns with respect to mulching practices. Application of atrazine @ 1.25 kg/ha followed by 2,4-D @ 2.0 kg/ha recorded significantly higher net returns (₹ 35653/ha) as compared to unweeded check (₹ 28558/ha) and was on a par with application of atrazine @ 1.25 kg/ha (₹ 34446/ha).

Significantly higher net returns (₹ 37165/ha) was recorded with minimum tillage with mulching and application of atrazine @ 1.25 kg/ha followed by 2, 4-D @ 2.0 kg/ha as compared to the rest of the treatment combinations (Table 3). The next best treatment combination was conventional tillage with no mulching and application of atrazine @ 1.25 kg/ha followed by 2,4-D @ 2.0 kg/ha. Zero tillage with mulching and unweeded check recorded significantly lowest net returns (₹ 25691/ha).

Conclusion

Minimum or conventional tillage systems with mulching and application of atrazine @ 1.25 kg/ha followed by 2,4-D @ 2.0 kg/ha were found better for realizing higher maize yields and profitability.

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