



Effect of tillage and weed management on productivity and nutrient uptake of maize (*Zea mays*)

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ABSTRACT

An investigation was carried out at Palampur during rainy season of 2002 and 2003 to assess the influence of three tillage methods (zero tillage, conventional tillage and raised seed-bed) and four weed-control methods (unweeded check, acetachlor 0.75 kg/ha, acetachlor 1.25 kg/ha and atrazine 1.5 kg/ha) on nutrient uptake and productivity of maize (*Zea mays* L.). Zero tillage resulted in significantly higher soil-moisture content and bulk density than conventional tillage and raised seed-bed. Raised seed-bed resulted in significantly lowest count and dry matter of weeds. Compared with zero tillage, the conventional tillage and raised seed-bed methods being statistically at par, resulted in significantly higher N, P and K uptake by maize crop (18.1, 25.0 and 20.2% by the former and 16.1, 36.2 and 16.7% respectively by the latter method) and lower depletion of these nutrients by weeds (13.5, 15.6 and 10.8% by the former and 30.3, 30.3 and 29.0%, respectively by the latter method), increasing the average grain yield of the crop by 16.9 and 13.7% by these methods. Among weed-control methods, atrazine 1.5 kg/ha, being statistically on a par with acetachlor 1.25 kg/ha, significantly reduced the population and dry matter of total weeds. Compared with the unweeded check, atrazine 1.5 kg/ha and acetachlor 1.25 kg/ha, being statistically at par, significantly increased the N, P and K uptake by the crop (93.3, 105.3 and 95.4% by the former and 87.0, 88.8 and 88.9%, respectively by the latter) and lower depletion of N, P and K by weeds (79.4, 87.2 and 81.5% by the former, and 81.9, 88.7 and 83.5% respectively by the latter herbicide), increasing in the grain yield of maize by 75.2 and 71.7% by these two herbicides.

Key words: Maize, Nutrient uptake, Productivity, Tillage, Weed control

Uninterrupted nutrient supply during growth period is pivotal to realize full yield potential of a crop. Weeds, being a serious negative factor in crop production are responsible for marked loss (28-100%) in crop yield (Pandey *et al.*, 2001). In maize (*Zea mays* L.) the wider row spacing and sowing of the crop with the onset of monsoon provide favourable environment for weed growth and help them to absorb more nutrients over the crop plants, apart from offering competition for light, space and moisture. The extent of nutrient loss varies from 30 to 40% of the applied nutrients (Mundra *et al.*, 2002). Management of weeds through integration of tillage methods with herbicides can increase the uptake of nutrients and productivity of the crop by decreasing the biomass and nutrient removal by the weeds. Keeping above aspects in view, the present investigation was carried out to find out the effective tillage and weed-control method for increasing the productivity and nutrient uptake in maize.

MATERIALS AND METHODS

A field experiment was conducted during rainy season (*kharif*) 2002 and 2003 at Palampur on silty clay-loam soil, being acidic in reaction, and medium in available N, P and K. The experiment was conducted in split-plot design with three replications, by keeping three tillage methods (zero tillage, conventional tillage and raised seed-bed) in main plots, and four weed-control methods (unweeded check, acetachlor 0.75 kg/ha, acetachlor 1.25 kg/ha and atrazine 1.5 kg/ha) in sub-plots. Maize hybrid 'PSCL 3438' was sown on 11 June during both the years with recommended package of practices and harvested on 27 and 24 September during the first and second years, respectively. The crop was sown with zero tillage maize planter under zero-tillage method and raised seed-bed planter under raised seed-bed method. The herbicidal treatments were given immediately after sowing with Maruyama power sprayer as per the treatment using water @ 600 litres/ha. The soil-moisture content before sowing

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the crop from two soil depths (0-15 cm and 15-30 cm) was determined by standard oven-dry method. Bulk density of the soil from 0-15 cm and 15-30 cm soil depths after the harvest of crop was determined by using standard core method. Weed count, dry matter of weeds and nutrient uptake by weeds were recorded at their maximum dry matter stage (at 60 DAS). Data on weed count and dry matter was analysed after $\sqrt{x + 1}$ transformation. The nutrient uptake by weeds and crop was calculated by multiplying the content of each nutrient with dry matter of weeds and crop respectively. For expressing the total weed-control efficiency in a particular tillage and weed-control method, the average values of weed-control efficiencies for different treatments falling in particular tillage and weed-control methods were obtained.

RESULTS AND DISCUSSION

Soil-moisture content and bulk density

Tillage methods influenced the soil-moisture content in different layers significantly at the time of sowing. Zero tillage resulted in significantly highest soil moisture content at each soil-depth (0-5 cm and 5-10 cm) during both the years, except at 0-5 cm soil depth during first year where conventional tillage was statistically on a par with zero tillage. Conventional tillage, being statistically on a par with raised seed-bed was the next best treatment in the soil-moisture content in both the depths during both the years (Table 1).

While zero tillage resulted in significantly highest bulk density of the soil, raised seed-bed being statistically on a par with conventional tillage was the next best in influencing bulk density at 0-15 cm and 15-30 cm soil depths during both the years. However, raised seed-bed resulted in lowest bulk density of the soil at each of the soil depths during both the years (Table 1). The higher bulk density due to zero tillage may be ascribed to decrease in volume of the soil due to its less disturbance. Ball-Coelho *et al.* (1998) also reported similar trend in higher bulk-density values due to zero tillage.

Weeds

The major weeds of the experimental field were *Digitaria sanguinalis* (L.) Scop. (38.08%), *Echinochloa colona* (L.) Link. (25.37%), *Panicum dichotomiflorum* Michx. (13.84%), *Commelina benghalensis* L. (11.54%), *Cyperus iria* L. (4.96%), *Brachiaria ramosa* L. (3.56%) and others including *Oxalis latifolia* L., *Ageratum conyzoides* L., *Cynodon dactylon* L., *Ipomoea purpurea* (L.) Roth. and *Polygonum alatum* L. (5.70%).

Significantly lowest population and dry biomass of total weeds were recorded in raised seed-bed during both the years (Table 2). Conventional tillage was the next best, perhaps owing to delay in emergence of weeds in more number due to the presence of less moisture content in the top layer under these two tillage methods compared with zero tillage (Table 1), which ultimately resulted in better weed control efficiencies. However, during *khariif* 2002 conventional tillage was statistically at par with raised seedbed in significantly reducing the dry matter of weeds compared with zero tillage.

Among weed-control treatments, atrazine 1.5 kg/ha resulted in significantly lower count and dry matter of weeds during both the years. These findings are in conformity with the findings of Sharma *et al.* (2000). However, acetachlor 1.25 kg/ha was statistically on a par with atrazine 1.5 kg/ha in reducing the population of weeds but was next best in reducing the dry matter of weeds. Atrazine 1.5 kg/ha gave total weed-control efficiency of 83.6 and 77.8%, respectively during 2002 and 2003, whereas acetachlor 1.25 kg/ha gave 81.1 and 75.94%, respectively.

Nutrient depletion by weeds

Raised seed-bed significantly reduced the N, P and K depletion by weeds, followed by conventional tillage compared with zero tillage during the first year (Table 2). Zero tillage also behaved similar to conventional tillage in depleting the N and K uptake in the second year. All the weed-control methods were significantly superior to unweeded check in decreasing the total uptake of N, P and K during both the years. Atrazine 1.5 kg/ha, being statisti-

Table 1. Effect of tillage methods on moisture content at sowing and bulk density of soil at harvest of maize

Tillage method	Moisture content (%)				Bulk density (Mg/m ³)			
	0-5 cm		5-10 cm		0-15 cm		15-30 cm	
	2002	2003	2002	2003	2002	2003	2002	2003
Zero	23.50	25.00	26.20	28.77	1.209	1.216	1.238	1.248
Conventional	21.77	22.40	23.63	24.23	1.178	1.179	1.214	1.193
Raised seed-bed	20.30	21.23	22.13	23.97	1.172	1.156	1.198	1.181
SEM _±	0.80	0.98	0.73	1.37	0.006	0.013	0.008	0.014
CD (P=0.05)	2.23	2.72	2.03	3.82	0.016	0.036	0.021	0.039

Table 2. Effect of tillage and weed-control methods on weed count, dry matter of weeds, weed-control efficiency and nutrient uptake by weeds at 60 DAS

Treatment	Total weed count (no./m ²)		Total dry matter (g/m ²)		Weed-control efficiency (%)		N		P		K	
	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Tillage method												
Zero	13.8 (206.0)	16.5 (283.3)	10.0 (112.6)	11.4 (139.4)	50.20	47.42	22.50	27.12	5.55	5.89	24.43	29.37
Conventional	13.1 (186.0)	16.1 (270.0)	9.2 (94.6)	11.1 (131.3)	58.17	50.44	18.90	25.30	4.42	5.24	20.46	27.52
Raised seed-bed	12.4 (164.3)	15.3 (241.0)	8.1 (73.7)	9.8 (107.3)	67.39	59.51	14.74	20.78	3.48	4.49	15.78	22.43
SEM±	0.2	0.2	0.2	0.1			0.95	0.43	0.15	0.13	0.52	0.76
CD (P=0.05)	0.7	0.5	0.4	0.3			1.20	2.64	0.43	0.37	1.44	2.10
Weed control method												
Unweeded	19.4 (377.3)	21.2 (447.1)	14.8 (219.0)	16.3 (265.3)	3.11	-0.15	44.63	52.38	12.35	13.32	50.45	59.65
Acetachlor 0.75 kg/ha	12.9 (165.8)	16.2 (260.0)	8.7 (75.5)	10.8 (115.8)	66.60	56.28	15.09	22.42	2.97	3.86	14.98	22.64
Acetachlor 1.25 kg/ha	10.3 (104.9)	13.5 (180.9)	6.7 (42.8)	8.1 (63.8)	81.08	75.94	8.18	11.97	1.41	1.90	8.31	12.23
Atrazine 1.50 kg/ha	9.8 (93.8)	13.2 (171.1)	6.2 (31.2)	7.8 (59.0)	83.55	77.75	6.95	10.83	1.19	1.73	7.15	11.23
SEM±	0.3	0.3	0.2	0.1			0.55	0.65	0.29	0.18	1.07	0.65
CD (P=0.05)	0.6	0.6	0.5	0.3			1.37	1.15	0.60	0.39	2.25	1.36

Values in parentheses are means of original values

cally on a par with acetachlor 1.25 kg/ha, reduced the total uptake of N, P and K by weeds during both the years. The weeds in the unweeded check removed N, P and K by of 44.63, 12.35 and 50.45 kg/ha, respectively during the first year, and 52.38, 13.32 and 59.65 kg/ha respectively during the second year.

Nutrient uptake by crop

Conventional tillage and raised seed-bed reduced the N, P and K depletion by weeds by 13.5 to 30.3, 15.7 to 30.5, and 11.3 to 29.5% respectively and increased the N, P and K uptake by the crop by 16.1 to 18.1, 25.0 to 36.2 and 16.6 to 20.2%, respectively compared with zero tillage (Table 3). Raised seed-bed, being statistically on a par with conventional tillage, resulted in significantly higher uptake of N, P and K by maize crop during both the years except for P uptake during 2002 where tillage methods had no significant influence. Higher nutrient uptake by the crop in these treatments might be due to the reduction in the state of crop-weed competition and favourable physical conditions such as reduced bulk density of the soil.

Chemical weed-control methods increased the N, P and K uptake by the crop by 59.4 to 93.3, 49.1 to 105.3, and 57.2 to 95.4%, respectively compared with unweeded check. Among weed-control treatments, atrazine 1.5 kg/ha resulted in significantly higher N, P and K uptake by maize plants during both the years, except for P uptake during the first year, where weed control method did not have any significant influence. However, acetachlor 1.25 kg/ha was also statistically on a par with atrazine 1.5 kg/ha in significantly increasing the uptake of N and K during both the years and was the next best for the uptake of P during the second year. The effective control of weeds by these two weed control treatments provided a competition-free environment, which led to increased growth of the crop and thereby increase in nutrient uptake by increasing the grain and stover yields of maize.

Grain yield

Raised seed-bed and conventional tillage, being statistically on a par with each other, produced significantly higher values of yield-contributing characters (number of rows/cob and 1,000-grain weight) and grain and stover yields of maize during both the years (Table 3). The possible reason for higher yield in these tillage practices may be the improved physical condition of the soil due to reduced bulk density, which favourably increased the uptake of nutrients by the crop and also reduced the state of crop-weed competition by lowering the weed population and dry biomass, leading to increase in values of yield-contributing characters. On the basis of 2 years, conventional and raised seed-bed gave 15.2 and 14.1% higher

Table 3. Effect of tillage and weed-control methods on nutrient uptake by crop at harvest and grain and stover yields of maize

Treatment	Nutrient uptake by crop (kg/ha)						Grain yield (t/ha)		Stover yield (t/ha)	
	N		P		K		2002	2003	2002	2003
	2002	2003	2002	2003	2002	2003				
<i>Tillage method</i>										
Zero	148.0	142.7	29.1	24.8	105.8	98.8	5.86	5.74	12.63	11.99
Conventional	174.7	168.7	37.0	30.6	121.7	123.8	6.87	6.69	14.70	14.15
Raised Seed-bed	169.5	168.0	43.5	30.6	118.9	119.5	6.64	6.55	14.12	13.93
SEm±	3.0	4.3	1.4	0.5	3.6	3.8	0.09	0.16	0.41	0.17
CD (P=0.05)	8.4	12.0	NS	1.5	9.9	10.6	0.24	0.45	1.14	0.47
<i>Weed control methods</i>										
Unweeded	102.9	99.6	27.9	15.0	72.2	70.9	4.38	4.17	9.26	8.71
Acetachlor 0.75 kg/ha	159.2	163.7	31.4	27.9	109.2	115.7	6.38	6.54	13.53	13.77
Acetachlor 1.25 kg/ha	194.9	183.8	42.0	34.2	138.3	132.0	7.53	7.15	16.13	15.19
Atrazine 1.50 kg/ha	199.2	192.2	44.9	37.6	142.1	137.5	7.54	7.43	16.35	15.76
SEm±	5.5	4.8	1.5	1.2	4.5	3.2	0.15	0.14	0.35	0.28
CD (P=0.05)	11.5	10.1	NS	2.5	9.5	6.7	0.31	0.29	0.75	0.59

grain and stover yields, respectively during the first year compared with zero tillage, and 15.4 and 17.1%, respectively during the second year. Fausey (1990) also reported significantly higher yield of maize with ridge tillage over zero tillage.

The weed-control treatments recorded significantly higher grain and stover yields than unweeded check. Atrazine 1.5 kg/ha, being statistically on a par with acetachlor 1.25 kg/ha produced significantly higher maize grain and stover yields during both the years. Mean data of 2 years showed that effective weed control by atrazine 1.5 kg/ha and acetachlor 1.25 kg/ha increased the grain and stover yields by 75.4 and 72.1%, respectively compared with unweeded check during the first year and 77.8 and 74.8% during the second year. These findings are in line with the results of Sharma *et al.* (1998) for atrazine 1.5 kg/ha and with Tomordi (1987) for acetachlor.

Among tillage methods raised seed-bed and conventional tillage, and among weed control methods atrazine 1.5 kg/ha and acetachlor 1.25 kg/ha, being statistically on a par with each other gave effective control of weeds and significantly increased nutrient uptake by the crop through decreasing the depletion of these nutrients by weeds and thus leading to significantly increased maize-crop yield.

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