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Influence of tillage and weed management practices on weed growth and yield of maize-sunflower cropping system

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ABSTRACT

Field experiment was conducted at Tamil Nadu Agricultural University, Coimbatore during *kharif* and *rabi* seasons of 2005 and 2006 to study the weed population dynamics, and crop productivity in maize – sunflower cropping system as influenced by tillage and weed management methods. Among the tillage methods, weed density, weed dry weight were lesser under conventional tillage- conventional tillage. The weed control efficiency was higher under CT-CT during both the years. Lower total weed density and weed dry weight and higher weed control efficiency was recorded by hand weeding on 20 and 40 DAS, which was followed by pre-emergence application of herbicide followed by hand weeding on 40 DAS. Conventional tillage- CT with hand weeding twice recorded higher grain and seed yield of both maize and sunflower during both the years.

Key words : Weed management, Maize, Sunflower, Weed index, Yield.

INTRODUCTION

The world food grain production loss due to weeds was estimated to be 287 million tones accounting for 11.5 per cent of the total food production. Costs on weed control are the largest variable cost in most crop cultivation. In India, weed management accounts 30-50 per cent share of the total cost of cultivation (Bhan, 1997). Timely weeding after the crop emergence is not feasible due to demand and cost of agricultural labourers during peak cultivation period and frequent rainfall in monsoon season. These warrant the adoption of pre-sowing weed control methods in order to reduce the weed competition after the establishment of the crops.

Tillage is the mechanical manipulation of surface soil to provide a favourable environment for the germination and proper development of seeds in addition to suppression of native weeds. Tillage can affect weeds directly, as in the destruction of annual weeds during seed bed preparation, or the effect may be more subtle, as in the shift from large seeded broad leaved weeds to small seeded weeds in reduced tillage systems (Chinnusamy *et al.*, 2002). Hand weeding is labour intensive, costly and time consuming and often needs to be repeated at different intervals. Besides, frequent rainfall during cropping season does not permit manual weeding at the appropriate time. Thus, to eliminate weed competition from the germination stage of the crop and to reduce the yield losses, chemical control has become inevitable. However, indiscriminate use of herbicides may lead to other problems such as shift in weed flora, environmental pollution, herbicide resistant weeds, etc. Thus, there is a need for integrating two or more means of weed control for effective and economic management of weeds. Hence, a field experiment was under taken to find out suitable tillage and weed management methods to reduce the weed growth and increase yield of maize and sunflower cropping system.

MATERIALS AND METHODS

Field experiment was conducted at Tamil Nadu Agricultural University, Coimbatore during *kharif* and *rabi* seasons of 2005 and 2006 to study the weed population dynamics, and crop productivity in maize – sunflower cropping system as influenced by tillage and weed management methods. The experiments were laid out in split plot design with four replications. Main plot treatment consisted of four tillage methods *viz.*, zero tillage- zero tillage, zero tillage- conventional tillage, conventional tillage - zero tillage and conventional tillage - conventional tillage for maize- sunflower cropping system. Three weed management methods *viz.*, hand weeding on 20 and 40 DAS, pre-emergence herbicide (atrazine 0.5 kg ha^{-1} for maize and pendimethalin 1.0 kg ha^{-1} for sunflower) application followed by hand weeding on 40 DAS, along with an unweeded check for both the crops consisted the sub plot treatments.

The first crop of maize was raised during *kharif* (June-Sep) 2005 and 2006 and the second crop of sunflower during *rabi* (Oct-Dec) 2005 and 2006. Maize variety Co-1 with duration of 105-110 days and sunflower variety Co-4 with duration of 85-90 days were selected for the study. In zero tillage the seeds are dibbled in the stubbles of the previous crop without any tillage or soil disturbance, except that which is necessary to place the

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seeds at the desired depth. One mould board plough / disc plough was given as the primary tillage operation followed by one secondary tillage with a disc harrow for conventional tillage treatment. The recommended dose of 135: 62.5: 50 and 40:20:20 kg NPK ha^{-1} was applied in the form of urea, single super phosphate and muriate of potash by the side of seed rows for maize and sunflower, respectively. The weed density and weed dry weight were recorded in four quadrates of 0.25 m^{-2} at 20 and 40 DAS in each plot. The weed density and weed dry weight were subjected to log (X+2) transformation before statistical analysis.

RESULTS AND DISCUSSION

Effect of treatment on weeds:

The predominant among broad – leaved weeds were *Trianthema portulacastrum, Parthenium hysterophorus, Digera arvensis* and *Datura metal* . Among the grass weeds, *Panicum repens, Cynodon dactylon, Dactyloctenium aegyptium, Chloris barbata* and *Dinebra retroflexa* were the dominant ones. *Cyperus rotundus* was the only sedge present. The lower weed density, weed dry weight and higher weed control efficiency were observed with conventional tillage –CT (T_4) and CT-ZT (T_3) in first year maize due to the inversion of surface soil and burial of weed seeds by disc ploughing (Table 1, 2, 3, 4 and 5). Zero tillage (T_1 and T_2) was found to record higher total weed density, weed dry weight and lower weed control efficiency mainly due to the higher densities of both grasses and broad- leaved weeds. Zero tillage resulted in deposition of more seeds and propagules of predominant annual and perennial weeds near the soil surface. Higher weed seed densities in no tillage systems may be the result of reduced herbicide availability because of adsorption to near-surface organic matter (Sadeghi and Isensee, 1996).

Lower weed density, weed dry weight and higher weed control efficiency were recorded by continuous conventional tillage (T_4), conventional tillage (T_2) and continuous zero tillage (T_1) during first year sunflower. In second year maize, lower weed density, weed dry weight and higher weed control efficiency were observed with continuous conventional tillage (T_4) and conventional tillage (T_3). Higher weed density, weed dry weight and lower weed control efficiency were recorded by CT-ZT (T_3) and continuous zero tillage (T_1). In general, the weed density becomes higher with minimum than with moderate and intensive tillage systems (Dorado *et al*., 1999). Donovan and McAndrew, (2000) also observed that weed seedlings density in the field increased from 31 plants m^{-2} in the intensive tillage system to 315 plants m^{-2} in the zero tillage system. Lower weed density, weed dry weight and higher weed control efficiency were recorded by continuous conventional tillage (T_4) and conventional tillage (T_2) during second year sunflower. Higher weed density, weed dry weight and lower weed control efficiency were recorded by continuous zero tillage ((T_1) due to increase in perennial and annual grass weed species. Density of several annual grasses increased faster in reduced than in conventional tillage system over years (Buhler and Mester, 1991).

Lower grass, broad-leaved and total weed density and weed dry weight and higher weed control efficiency were observed with pre-emergence herbicide application (atrazine 0.5 kg ha^{-1} for maize and pendimethalin 1.0 kg ha^{-1} for sunflower) followed by hand weeding on 40 DAS (W_2) during initial period of crop growth (20 DAS). Application of herbicides at pre-germinated as well as at early establishment of weeds in both the crops was found to control graminacious weeds and broad-leaved weeds effectively (Arti Khare and Jain, 1995). Pre-emergence herbicides gave effective control of weeds by inhibiting the germination of the weed seeds and also killing the emerging weeds at the early stages (Vyas *et al*., 2000).

However, at 40 DAS hand weeding at 20 and 40 DAS (W_1) recorded lower grass, broad-leaved weed, total weed density and weed dry weight and higher weed control efficiency due to effective control of weeds at the critical stage of crop growth. Similar result was also reported by Rigi *et al*. (1992) and Singh and Chandel (1995).

Herbicide application (W_2) recorded higher weed density at 40 DAS than hand weeding twice (W_1), as herbicides were able to control weed growth up to 30 days, after which their efficacy decreased, resulting in higher dry weight of weeds (Chandel *et al*., 1995). Anju Amrita Singh (2005) reported that, regeneration of weeds was more in pendimethalin applied plots resulting in gradual increase of total weed density. The unweeded control (W_3) recorded the highest grass, broad-leaved weed, total weed density and weed dry weight due to increased weed growth at all growth stages in maize –sunflower cropping system.

Efficiency of different tillage practices on weed control could be further increased by integration of weed management practices. At 20 DAS, conventional tillage with herbicide application (T_4W_2 and T_3W_2 or T_2W_2) and at later stages conventional tillage with hand weeding (T_4W_1 and T_3W_1 or T_2W_1) recorded lower grass and broad-leaved weeds and total weed density. It is due to better exposure of weeds and their seeds to herbicides

Table 1 : Effect of tillage and weed management practices on weed density of maize (No. m^{-2})

Treatments	Grasses				Sedge				Broad-leaved weeds				Total weeds			
	Maize-I		Maize-II		Maize-I		Maize-II		Maize-I		Maize-II		Maize-I		Maize-II	
	20 DAS	40 DAS	20 DAS	40 DAS	20 DAS	40 DAS	20 DAS	40 DAS	20 DAS	40 DAS	20 DAS	40 DAS	20 DAS	40 DAS	20 DAS	40 DAS
T_1	4.19	3.74	3.24	4.35	2.00	1.61	2.85	2.68	4.18	3.55	2.49	2.85	4.91	4.35	4.00	4.72
	(67.33)	(43.50)	(25.07)	(90.00)	(5.39)	(3.17)	(16.63)	(14.00)	(69.67)	(39.17)	(12.23)	(20.67)	(142.39)	(85.83)	(53.93)	(124.67)
T_2	4.05	3.08	3.33	4.46	2.34	1.97	2.65	2.54	4.99	4.11	2.55	2.97	5.41	4.48	4.05	4.78
	(62.67)	(22.17)	(30.63)	(93.50)	(13.78)	(5.33)	(14.17)	(12.00)	(149.00)	(70.83)	(14.00)	(22.67)	(225.44)	(98.33)	(58.80)	(128.17)
T_3	3.31	2.97	2.30	3.29	3.12	1.79	3.07	3.19	3.84	3.10	1.60	3.51	4.71	3.91	3.53	4.45
	(30.17)	(19.00)	(9.00)	(26.00)	(21.50)	(5.83)	(20.17)	(23.00)	(59.83)	(30.50)	(3.30)	(40.00)	(111.50)	(55.33)	(32.47)	(89.00)
T_4	3.25	2.87	2.18	3.43	2.36	2.07	2.95	2.99	3.07	2.63	1.47	3.46	4.31	3.70	3.44	4.42
	(28.67)	(26.83)	(9.33)	(29.67)	(12.33)	(6.67)	(18.00)	(19.33)	(37.33)	(16.50)	(2.50)	(36.00)	(78.33)	(50.00)	(29.83)	(85.00)
S.E.±	0.03	0.02	0.01	0.002	0.006	0.02	0.02	0.01	0.01	0.01	0.02	0.01	0.02	0.04	0.01	0.001
C.D. (P=0.05)	0.06	0.05	0.03	0.004	0.01	0.05	0.04	0.01	0.01	0.03	0.04	0.01	0.04	0.09	0.04	0.002
W_1	3.52	2.59	2.44	3.42	2.24	2.19	3.12	3.27	4.54	2.72	2.41	2.29	4.97	3.62	3.80	4.19
	(39.13)	(13.63)	(13.15)	(31.00)	(9.58)	(8.38)	(21.13)	(24.75)	(102.75)	(15.63)	(11.28)	(9.00)	(151.46)	(37.63)	(45.55)	(64.75)
W_2	3.31	3.16	2.48	3.88	2.93	1.6	3.11	2.84	3.38	3.44	1.33	3.35	4.49	4.14	3.55	4.56
	(28.38)	(26.00)	(11.23)	(52.75)	(20.00)	(3.75)	(20.75)	(16.00)	(50.60)	(39.40)	(1.88)	(27.75)	(98.97)	(69.15)	(33.85)	(96.50)
W_3	4.28	3.74	3.37	4.35	2.19	1.72	2.40	2.44	4.13	3.87	2.34	3.95	5.05	4.58	3.91	5.04
	(74.13)	(44.00)	(31.15)	(95.63)	(10.17)	(3.63)	(9.85)	(10.50)	(83.53)	(62.72)	(10.88)	(52.75)	(167.82)	(110.35)	(51.88)	(158.88)
S.E.±	0.01	0.01	0.01	0.001	0.004	0.01	0.01	0.004	0.01	0.01	0.02	0.01	0.02	0.01	0.01	0.001
C.D. (P=0.05)	0.03	0.03	0.02	0.001	0.01	0.03	0.03	0.01	0.01	0.03	0.03	0.01	0.03	0.03	0.03	0.002
T at W -S.E. ±	0.04	0.03	0.02	0.002	0.01	0.03	0.03	0.01	0.01	0.03	0.03	0.01	0.03	0.05	0.03	0.001
T at W -C.D. (P=0.05)	0.08	0.07	0.04	0.004	0.02	0.07	0.06	0.02	0.02	0.07	0.07	0.02	0.007	0.10	0.07	0.002
W at T-S.E. ±	0.03	0.03	0.01	0.001	0.01	0.03	0.03	0.01	0.01	0.03	0.03	0.01	0.03	0.03	0.03	0.001
W at T-C.D. (P=0.05)	0.06	0.06	0.03	0.003	0.02	0.06	0.06	0.01	0.02	0.06	0.07	0.03	0.007	0.07	0.07	0.002

T_1- T_4- Tillage practices, W_1-W_3- Weed management methods

Table 2 : Effect of tillage and weed management practices on weed density of sunflower (No. m^{-2})

Treatments	Grasses				Sedge				Broad-leaved weeds				Total weeds			
	Sunflower-I		Sunflower-II		Sunflower-I		Sunflower-II		Sunflower-I		Sunflower-II		Sunflower-I		Sunflower-II	
	20 DAS	40 DAS	20 DAS	40 DAS	20 DAS	40 DAS	20 DAS	40 DAS	20 DAS	40 DAS	20 DAS	40 DAS	20 DAS	40 DAS	20 DAS	40 DAS
T_1	2.95	3.31	3.92	4.58	2.01	2.50	1.20	1.84	3.22	3.11	2.86	1.97	3.97	4.12	4.25	4.67
	(22.83)	(30.67)	(54.33	(102.83)	(7.17)	(10.83)	(1.67)	(4.33)	(24.67)	(21.17)	(20.17)	(5.17)	(54.67)	(62.67)	(76.17)	(112.33)
T_2	3.32	3.44	2.93	3.41	2.20	2.02	2.31	2.47	3.47	3.16	3.10	2.79	4.25	4.34	3.89	4.04
	(31.00)	(33.94)	(17.67)	(32.00)	(9.50)	(6.93)	(8.50)	(9.83)	(32.00)	(43.33)	(25.00)	(21.17)	(72.50)	(84.21)	(51.17)	(63.00)
T_3	3.22	3.56	3.60	3.96	2.88	2.13	1.95	2.13	3.83	3.72	3.37	2.56	4.45	4.45	4.26	4.54
	(26.83)	(40.73)	(36.83)	(62.17)	(16.33)	(7.17)	(5.33)	(6.67)	(48.67)	(45.67)	(31.50)	(37.50)	(91.83)	(93.57)	(73.67)	(106.33)
T_4	2.95	3.29	2.70	2.82	1.96	2.39	2.20	2.58	3.12	3.09	2.77	2.59	3.88	4.13	3.76	3.86
	(21.83)	(32.00)	(13.17)	(17.83)	(6.00)	(10.33)	(8.50)	(15.00)	(24.33)	(20.50)	(21.17)	(13.33)	(52.17)	(62.83)	(42.83)	(46.17)
S.E.±	0.02	0.03	0.01	0.02	0.02	0.02	0.01	0.004	0.03	0.03	0.02	0.02	0.03	0.03	0.019	0.001
C.D. (P=0.05)	0.05	0.06	0.01	0.04	0.05	0.05	0.03	0.010	0.06	0.06	0.04	0.04	0.06	0.07	0.043	0.003
W_1	3.43	2.60	3.16	3.07	2.30	2.74	1.70	2.61	3.46	3.06	3.42	2.14	4.28	3.85	4.08	3.87
	(29.75)	(11.88)	(25.00)	(26.13)	(10.50)	(13.70)	(5.00)	(14.25)	(32.75)	(20.38)	(29.00)	(7.75)	(73.00)	(45.95)	(59.00)	(48.13)
W_2	2.26	3.55	3.02	3.75	2.61	2.30	2.33	2.23	2.92	3.28	2.01	2.74	3.64	4.24	3.60	4.23
	(8.38)	(33.76)	(20.25)	(49.63)	(11.88)	(8.75)	(9.25)	(7.50)	(17.75)	(26.00)	(6.50)	(16.38)	(38.00)	(68.51)	(36.00)	(73.50)
W_3	3.64	4.06	3.68	4.27	1.88	1.74	1.70	1.93	3.84	3.80	3.64	3.30	4.49	4.68	4.44	4.73
	(38.75)	(57.38)	(46.25)	(85.38)	(6.88)	(4.00)	(3.75)	(5.13)	(46.75)	(51.63)	(37.88)	(33.75)	(92.38)	(13.00)	(87.88)	(124.25)
S.E.±	0.01	0.01	0.002	0.02	0.02	0.01	0.01	0.003	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.001
C.D. (P=0.05)	0.03	0.03	0.003	0.04	0.03	0.03	0.01	0.006	0.03	0.03	0.04	0.04	0.03	0.03	0.04	0.002
T at W - S.E.±	0.03	0.03	0.01	0.03	0.03	0.03	0.02	0.006	0.04	0.04	0.04	0.03	0.04	0.04	0.03	0.002
T at W -C.D. (P=0.05)	0.08	0.08	0.01	0.07	0.07	0.07	0.04	0.014	0.08	0.08	0.08	0.07	0.08	0.08	0.07	0.004
W at T- S.E.±	0.03	0.03	0.003	0.03	0.03	0.03	0.01	0.006	0.03	0.03	0.04	0.03	0.03	0.03	0.03	0.002
W at T-C.D. (P=0.05)	0.06	0.06	0.007	0.07	0.07	0.05	0.02	0.012	0.06	0.06	0.09	0.07	0.06	0.06	0.07	0.004

T_1- T_4- Tillage practices, W_1-W_3- Weed management methods

Table 3 : Effect of tillage and weed management practices on weed dry weight of maize-sunflower cropping system (kg ha^{-1})

Treatments	Maize-I		Maize-II		Sunflower-I		Sunflower-II	
	20 DAS	40 DAS	20 DAS	40 DAS	20 DAS	40 DAS	20 DAS	40 DAS
T_1	5.86	6.62	5.38	5.44	5.55	6.24	5.63	6.26
	(357)	(1020)	(227)	(270)	(277)	(607)	(293)	(730)
T_2	5.78	6.73	2.29	5.42	5.78	6.39	5.33	5.90
	(328)	(1020)	(217)	(283)	(327)	(707)	(212)	(487)
T_3	5.63	6.5	4.82	4.88	6.00	6.60	5.43	6.07
	(280)	(627)	(130)	(145)	(410)	(811)	(233)	(553)
T_4	5.61	6.31	4.64	4.71	5.58	5.60	5.25	5.76
	(278)	(587)	(108)	(127)	(280)	(642)	(200)	(442)
S.E.±	0.03	0.03	0.03	0.03	0.03	0.03	0.05	0.03
C.D. (P=0.05)	0.07	0.07	0.06	0.06	0.07	0.07	0.12	0.06
W_1	5.80	5.78	5.09	4.44	5.75	5.49	5.40	4.95
	(336)	(330)	(173)	(86)	(3.29)	(264)	(226)	(144)
W_2	5.58	6.63	4.60	5.11	5.51	6.38	5.28	6.12
	(266)	(772)	(104)	(178)	(265)	(626)	(201)	(470)
W_3	5.78	7.10	5.41	5.78	5.92	7.06	5.55	6.92
	(330)	(1337)	(235)	(355)	(376)	(1186)	(276)	(1045)
S.E.±	0.02	0.02	0.02	0.02	0.02	0.02	0.04	0.02
C.D. (P=0.05)	0.03	0.03	0.04	0.04	0.03	0.032	0.09	0.05
T at W - S.E.±	0.04	0.04	0.04	0.04	0.04	0.04	0.09	0.04
T at W - C.D. (P=0.05)	0.09	0.09	0.09	0.09	0.09	0.09	0.19	0.09
W at T- S.E.±	0.03	0.03	0.04	0.04	0.03	0.03	0.09	0.04
W at T- C.D. (P=0.05)	0.06	0.06	0.09	0.09	0.06	0.06	0.19	0.09

T_1- T_4- Tillage practices, W_1-W_3- Weed management methods

Table 4 : Effect of tillage and weed management practices on weed control efficiency and weed index in maize –sunflower cropping system-I*

Treatments	Maize					Sunflower				
	Weed control efficiency (%)				Weed index	Weed control efficiency (%)				Weed index
	20 DAS	40 DAS	60 DAS	Harvest index	(%)	20 DAS	40 DAS	60 DAS	Harvest index	(%)
T_1	-8.1	23.7	60.2	56.9	10.5	26.5	48.8	69.5	68.2	22.5
T_2	0.5	23.7	60.9	60.5	11.2	13.2	40.4	43.4	43.1	9.9
T_3	15.2	53.1	70.7	68.6	6.5	-9.0	31.6	40.6	35.1	28.7
T_4	15.7	56.1	68.9	69.2	5.8	25.6	45.8	69.2	65.9	4.2
W_1	-1.9	75.3	98.4	96.4	-	12.6	77.8	88.7	83.5	-
W_2	19.3	42.2	97.1	95.0	3.2	29.6	47.2	84.1	75.7	3.9
W_3	-	-	-	-	22.3	-	-	-	-	45.1

T_1- T_4- Tillage practices, W_1-W_3- Weed management methods Data not statistically analysed

Table 5 : Effect of tillage and weed management practices on weed control efficiency and weed index in maize –sunflower cropping system-II

Treatments	Maize					Sunflower				
	Weed control efficiency (%)				Weed index	Weed control efficiency (%)				Weed index
	20 DAS	40 DAS	60 DAS	Harvest index	(%)	20 DAS	40 DAS	60 DAS	Harvest index	(%)
T_1	3.5	23.9	55.6	58.9	17.3	9.8	30.1	38.1	32.9	40.2
T_2	7.8	20.2	34.2	29.7	45.4	19.5	53.4	66.2	64.7	4.2
T_3	44.7	59.2	70.5	69.4	8.5	-0.5	47.0	61.6	58.5	22.2
T_4	53.9	64.3	75.7	73.5	4.5	8.5	57.7	69.2	68.5	2.2
W_1	26.6	75.7	89.2	87.8	-	13.0	86.2	92.0	89.7	-
W_2	55.9	50.0	87.7	85.8	3.2	15.0	55.0	84.4	78.7	4.8
W_3	-	-	-	-	53.6	-	-	-	-	46.8

T_1- T_4- Tillage practices, W_1-W_3- Weed management methods Data not statistically analysed

Table 6 : Effect of tillage and weed management practices on yield of maize –sunflower (kg ha^{-1})

Treatments	Maize –sunflower-I			Maize –sunflower-II		
	Maize		Sunflower	Maize		Sunflower
	Grain yield	Stover yield	Seed yield	Grain yield	Stover yield	Seed yield
T_1	4293	7494	1383	4642	7558	948
T_2	4258	7454	1608	3067	6479	1518
T_3	4482	7862	1272	5133	8850	1234
T_4	4519	7901	1710	5362	9533	1551
S.E.±	118.4	219.7	52.3	204.1	309.9	57.5
C.D. (P=0.05)	NS	NS	118.3	461.8	701.1	130.0
W_1	4796	8931	1785	5613	9800	1586
W_2	4641	8032	1715	5434	9043	1509
W_3	3727	6070	981	2606	5471	844
S.E.±	105.9	200.1	42.6	169.6	271.6	37.5
C.D. (P=0.05)	218.5	412.9	88.1	350.2	560.6	77.5
T at W - S.E.±	209.5	393.8	87.1	344.1	541.1	84.0
T at W -C.D. (P=0.05)	NS	NS	186.1	NS	NS	NS
W at T- S.E.±	211.7	400.2	85.3	339.3	543.2	75.1
W at T-C.D. (P=0.05)	NS	NS	176.2	NS	NS	NS

T_1- T_4- Tillage practices, W_1-W_3- Weed management methods

and manual removal in well distributed soil layers due to deep tillage (Chinnusamy *et al.*, 2002).

Effect of treatment on yield of crops:

Tillage treatments failed to influence the yield of maize significantly during first year because all tillage practices produced similar and comparable yields (Table 6). According to Wilhelm and Wortmann, (2004), the soybean yield obtained under no-tillage was similar to yields with other tillage practices. During second year, treatments those received conventional tillage (T_4 and T_3) produced higher and comparable grain and stover yield which is an indication for higher efficiency of deep tillage over a longer cropping period. Zero tillage (T_2) resulted in minimum grain and stover yields of maize. Lower grain (42 per cent yield reduction) and stover (32 per cent yield reduction) yields of maize were due to poor growth parameters like shorter plants, lesser dry matter and leaf area as well as yield attributes. Higher grain and stover yields of maize were obtained with hand weeding on 20 and 40 DAS (W_1) during first and second year, respectively was due to efficient control of weeds and increased root growth.

Higher seed yield of sunflower was obtained with continuous conventional tillage (T_4) during both the years could be attributed to better growth parameters and favourable yield attributes. Comparable yields of sunflower were obtained with conventional tillage (T_2) to that of continuous conventional tillage due to better weed control and favourable soil environment. The lowest seed yield obtained with zero tillage (T_3) was due to higher weed competition during first year. During second year of the experiment, continuous zero tillage (T_1) recorded lowest seed yield with higher weed index (48.2 per cent) due to heavy competition for nutrients, space and light offered by annual and perennial grasses. Higher seed yield of sunflower obtained with hand weeding on 20 and 40 DAS (W_1) during both the years was due to better growth and yield parameters as a result of efficient weed control by hand weeding at critical crop weed competition. Comparable seed yield of sunflower was obtained with pre-emergence application of pendimethalin 1.0 kg ha^{-1} followed by hand weeding on 40 DAS (W_2) due to early application of broad spectrum selective herbicide which controlled and increased the seed yield of sunflower (Basavarajappan, 1992).

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