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Effect of different pre- and post-emergence herbicides on weed control, productivity and economics of maize

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ABSTRACT

A field experiment was conducted at Agricultural Research Station, Vizianagaram, Andhra Pradesh during rainy seasons of 2015 and 2016 to find out the best chemical weed management practices in maize (*Zea mays* L.). Twelve treatments were tested in randomized block design with three replications. Treatments consisted of pre-emergence (PE) and post-emergence (PoE) herbicides applications along with weed free check and weedy check. Experimental results indicated that PoE of tank mix formulation of tembotrione 50 g/ha + atrazine 0.5 kg/ha at 15-20 days after seeding (DAS) has recorded highest weed control efficiency (93.6 and 96.9%, respectively during 2015 and 2016) followed by hand weeding twice at 20 and 40 DAS (90.1 and 95.6%, respectively). Grain yield was significantly higher (9.79 t/ha and 8.70 t/ha, respectively) with hand weeding twice at 20 and 40 DAS, and it was closely followed by PoE of tembotrione 50 g/ha + atrazine 0.5 kg/ha (9.65 t/ha and 8.61 t/ha respectively). Net monetary returns (` 104357 and ` 97985, respectively) and B:C ratio (2.94 and 3.14, respectively) were also significantly high with PoE application of tembotrione 50 g/ha + atrazine 0.5 kg/ha.

Key words: Grain Yield, Maize, Pre- and post-emergence herbicides, Weed control efficiency

Maize (corn) along with wheat and rice is one of the world's most important food crops. Maize provides food to the human beings and feed to the cattle. During recent years, maize is being increasingly used as a feedstock and for the production of bio ethanol. Protecting maize from weeds, pests and diseases is very much essential to avoid heavy losses caused by them in maize yield and gain quality. Weed control is usually most important, as weed interference is a severe problem in corn, especially in the early part of the growing season due to its initial slow growth rate and wider row spacing. Yield losses due to weed infestation vary from 28-93% depending on the type of weed flora and their intensity, stage, nature and duration of crop weed competition (Sharma and Thakur 1998). The critical period of crop weed competition in corn range from 1 to 8 weeks after sowing. In order to realize the maximum yield potential of maize, weed management becomes indispensable during this period. Chemical weed management by using pre- or post-emergence herbicides can lead to the efficient and cost effective control of weeds during critical period of crop weed competition, which may not be possible in manual or mechanical weeding due to its high cost of cultivation. Hence, there is an immense need to find out the best chemical for effective weed management in maize and hence this study was undertaken to identify the best chemical weed management practices in maize (*Zea mays* L.)

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MATERIALS AND METHODS

A field experiment was conducted at Agricultural Research Station, Vizianagaram, Andhra Pradesh during rainy seasons of 2015 and 2016. The soil of the experimental site was sandy clay loam in texture with neutral soil reaction (pH-7.0), electric conductivity-0.13dS/m and low in organic carbon content (0.36%). Availability of nitrogen, phosphorus and potassium in the experimental site were low (198.4 kg/ha), high (70.5 kg/ha) and medium (230.2 kg/ha), respectively. Total rainfall received during crop season was 455.8 and 709.4 mm, respectively with mean maximum (31.6^{0}C and 30.3^{0}C, respectively) and mean minimum temperatures (28.0 ^{0}C and 28.3 ^{0}C, respectively) during 2015 and 2016.

Experiment was conducted in randomized block design with three replications. Treatments include atrazine 1.0 kg/ha as pre-emergence application (PE), pendimethalin 1.0 kg/ha as PE, alachlor 1.0 kg/ha as PE, atrazine 0.5 kg/ha + alachlor 0.5 kg/ha as PE, 2,4-D sodium salt 1.0 kg/ha at 15-25 days after seeding (DAS), 2,4-D amine salt 0.58 kg/ha at 15-20DAS, atrazine 1.0 kg/ha at 15-20 DAS, 2,4-D ethyl ester 0.9 kg/ha at 15-20 DAS, tembotrione 100 g/ha

at 15-20 DAS, tembotrione 50 g/ha + atrazine 0.5 kg/ ha at 15-20 DAS, hand weeding twice at 20 and 40 DAS unweeded check (control).

Maize hybrid "*DHM-117*" was sown on 21.07.2015 and 12.07.2016, during 2015 and 2016, respectively at 60 x 20 cm spacing. Before sowing, field was thoroughly ploughed and levelled. The crop was fertilized evenly irrespective of treatments with 180-200:60:50 kg NPK/ha with N in three equal split doses at the time of sowing, 30 DAS and 50 DAS. Pre-emergence herbicides were applied within two days after sowing. Post-emergence herbicides were applied at 15-20 DAS. All the herbicides were used after making the spray volume of 500 L/ha. Phytotoxic effect on crop was recorded at 3rd and 10th day after application of herbicides. Weed density was recorded at 20 DAS and 40 DAS by using a quadrate of 100 x 100 cm (1 m^2) size from the centre of the plot. The entire weeds inside the quadrate were uprooted and cut close to the transition of root and shoot in each plot and collected for dry matter accumulation (biomass). The samples were first dried in sun and then kept in oven at 70 ± 2°C. The dried samples were weighed and expressed as biomass (g/m^2). Cost of cultivation, gross returns, net monetary returns and benefit cost ratio for each treatment were calculated by taking into consideration of total costs incurred and returns obtained. Square root transformation was done for weed density and weed biomass by using the formula $\sqrt{x+0.5}$. Weed control efficiency (WCE), weed index (WI) and herbicide efficiency index (HEI) were calculated using formulae as suggested by Gill and Vijayakumar (1969), Mani *et al.* (1973), Krishnamurthy *et al.* (1995).

RESULTS AND DISCUSSION

Weed flora

Among the weeds, grasses and sedges were dominant in the experimental site compared to the broad-leaved weeds (**Table 1**). *Echinochloa colona* (L.) Link., *Eleusine indica* (L.), *Dactyloctenium aegyptium* (L.) Willd. , *Digitaria sanguinalis* (L.) Scop. were the major grassy weeds and *Cyperus rotundus* (L.) was the dominant sedge weed. *Trianthema portulacastrum* (L.), *Digera arvensis* Forsskal, *Cleome viscosa* (L.), *Commelina benghalensis* (L.), *Euphorbia hirta* (L.), *Tridax procumbence* (L.) and *Phyllanthus niruri* (L.) *etc.* were the major broad-leaved weed species during both the years of study.

Table 1. Major weeds density (no./m^2) in the experimental plot

Treatment	2015						2016					
	20 DAS			40 DAS			20 DAS			40 DAS		
	Grasses	Sedges	BLW	Grasses	Sedges	BLW	Grasses	Sedges	BLW	Grasses	Sedges	BLW
Atrazine 1000 g/ha as PE	5.6 (30.7)	5.7 (32.0)	2.7 (6.7)	7.5 (56.0)	4.1 (16.0)	1.8 (2.7)	2.5 (6.0)	4.4 (18.7)	1.8 (2.7)	7.4 (54.7)	3.9 (14.7)	3.3 (10.7)
Pendimethalin 1000 g/ha as PE	6.2 (37.3)	5.6 (30.7)	3.7 (13.3)	6.6 (42.7)	4.8 (22.7)	2.1 (4.0)	2.5 (6.0)	5.6 (30.7)	2.1 (4.0)	7.3 (53.3)	5.1 (25.3)	4.2 (17.3)
Alachlor 1000 g/ha as PE	5.9 (34.7)	7.0 (48.0)	2.9 (8.0)	4.8 (22.7)	6.8 (45.3)	1.8 (2.7)	2.3 (4.7)	5.9 (34.7)	2.4 (5.3)	7.5 (56.0)	5.3 (28.0)	4.2 (17.3)
Atrazine 500 g/ha + alachlor 500 g/ha as PE	3.7 (13.3)	7.2 (50.7)	1.4 (1.3)	3.5 (12.0)	7.9 (61.3)	2.1 (4.0)	1.8 (2.7)	4.6 (20.7)	2.0 (3.3)	7.3 (53.3)	4.8 (22.7)	2.9 (8.0)
2,4-D sodium salt 1000 g/ha at 15-25 DAS	11.3 (126.7)	6.4 (40.0)	2.9 (8.0)	10.4 (106.7)	4.5 (20.0)	0.7 (0.0)	9.3 (86.7)	5.7 (32.0)	3.6 (12.7)	10.4 (108.0)	4.8 (22.7)	0.7 (0.0)
2,4-D amine salt 580 g/ha at 15-20 DAS	14.3 (204.0)	4.8 (22.7)	2.4 (5.3)	9.3 (85.3)	6.7 (44.0)	0.7 (0.0)	9.5 (89.3)	5.6 (30.7)	3.4 (11.3)	9.8 (94.7)	5.3 (28.0)	2.1 (4.0)
Atrazine 1000 g/ha at 15-20 DAS	13.2 (174.7)	5.6 (30.7)	2.7 (6.7)	9.3 (86.7)	5.5 (29.3)	2.9 (8.0)	9.1 (82.0)	5.6 (31.3)	3.3 (10.7)	9.1 (82.7)	5.6 (30.7)	4.4 (18.7)
2,4-D ethyl ester 900 g/ha at 15-20 DAS	13.7 (188.0)	5.8 (33.3)	3.1 (9.3)	9.2 (84.0)	6.2 (37.3)	1.8 (2.7)	9.2 (83.3)	5.5 (29.3)	3.0 (8.7)	9.9 (97.3)	4.9 (24.0)	2.9 (8.0)
Tembotrione 100 g/ha at 15-20 DAS	15.7 (245.3)	3.5 (12.0)	1.8 (2.7)	3.7 (13.3)	3.7 (13.3)	1.8 (2.7)	11.1 (122.0)	5.3 (28.0)	3.4 (11.3)	3.3 (10.7)	4.5 (20.0)	0.7 (0.0)
Tembotrione 50 g/ha + atrazine 500 g/ha at 15-20 DAS	13.3 (176.0)	4.5 (20.0)	2.9 (8.0)	1.8 (2.7)	3.5 (12.0)	1.4 (1.3)	10.9 (118.7)	5.6 (31.3)	3.7 (13.3)	1.8 (2.7)	3.1 (9.3)	0.7 (0.0)
Hand weeding twice at 20 and 40 DAS	12.1 (145.3)	6.4 (40.0)	3.5 (12.)	3.5 (12.0)	3.3 (10.7)	0.7 (0.0)	11.1 (122.7)	5.6 (30.7)	3.8 (14.0)	2.7 (6.7)	3.1 (9.3)	2.1 (4.0)
Unweeded check (control)	15.1 (226.7)	5.1 (25.3)	3.1 (9.3)	11.1 (122.7)	7.5 (56.0)	3.5 (12.0)	11.7 (136.7)	5.1 (25.3)	4.0 (15.3)	12.0 (144.0)	6.0 (36.0)	5.5 (29.3)
LSD (p=0.05)	2.03	2.06	0.73	1.61	1.46	0.86	0.58	0.58	0.44	0.79	0.77	0.59

DAS=Days after seeding; Values in the parentheses are original values; Subject to square root transformation

Phytotoxicity on crop and weed

No phytotoxic symptoms were observed on maize due to herbicidal treatments. Tembotrione 100 g/ha at 15-20 DAS and tembotrione 50 g/ha + atrazine 0.5 kg/ha at 15-20 DAS, caused complete chlorosis of all weeds including grasses, sedges and broad-leaved weeds. After that weeds were withered and died. But, the sedges were again re-germinated from the underground corm within 15-20 days after application of herbicide. Meanwhile, maize grew rapidly and covered the entire space.

Effect on weeds

At 20 DAS, weed growth was found significantly low in PE herbicide treated plots and among them PE of atrazine 0.5 kg/ha + alachlor 0.5 kg/ha and atrazine 1.0 kg/ha recorded lowest weed density during both the years. Deshmukh *et al.* (2009) reported similar results of lowest weed population and weed biomass at 30 DAS with atrazine 1.0 kg/ha as PE. At 40 DAS, significantly lowest weed density was noticed in the treatment tembotrione 50 g/ha + atrazine 0.5 kg/ha at 15-20 DAS. It was 29.5% and 40.0% lower weed density over hand weeding twice at 20 and 40 DAS during 2015 and 2016, respectively (**Table 2**).

Weed biomass was significantly low with atrazine 1.0 kg/ha PE followed by atrazine 0.5 kg/ha + alachlor 0.5 kg/ha and pendimethalin 1.0 kg/ha compared to other treatments at 20 DAS. Chopra and Angiras (2008) also reported that atrazine1.5 kg/ha as PE was found promising in reducing weed biomass over other treatments. However at 40 DAS, weed biomass in tembotrione 50 g/ha + atrazine 0.5 kg/ha at 15-20 DAS treatment was significantly low (12.6 and 10.3 g/m^2) and it was closely followed by hand weeding twice at 20 and 40 DAS (19.6 and 14.7 g/m^2) (**Table 2**). During both the years, weed biomass was significantly high in weedy check.

Among the PE herbicide treatments, higher weed control efficiency (WCE) at 20 DAS was observed with atrazine 1.0 kg/ha followed by atrazine 0.5 kg/ha + alachlor 0.5 kg/ha (**Table 3**). Deshmukh *et al.* (2009) reported that PE application of atrazine 1.0 kg/ha has shown highest WCE at 30 DAS. Patel *et al.* (2006) was achieved maximum WCE with PE of atrazine + alachlor each applied at 0.5 kg/ha. At 40 DAS, WCE of tembotrione 50 g/ha + atrazine 0.5 kg/ha as PoE was significantly higher (93.6 and 96.9% respectively) over other treatments and it was closely followed by hand weeding twice at 20 and 40 DAS (90.1 and 95.6% respectively). Similarly Martin *et al.* (2011) observed improved control of individual weed species by 5 to 45% with tank mix application of tembotrione with atrazine 31 + 370 g/ha at four to five-collar leaf stage of corn. Joseph *et al.* (2008) reported that tank mix application of tembotrione and atrazine 92+560 g/ha as post-emergence in maize resulted in excellent control of grassy weeds. Jonathon *et al.* (2013) noticed 95% of weed control with the tank mix application of HPPD inhibiting herbicide tembotrione along with atrazine.

Weed index was significantly high in weedy check (53.3% and 49.2% in 2015 and 2016, respectively) whereas, it was significantly low in tembotrione 50 g/ha + atrazine 0.5 kg/ha (1.3% and 1.0% respectively) (**Table 3**). Similarly herbicide efficiency index was also high for tembotrione 50 g/ha + atrazine 0.5 kg/ha (138.7 and 94.8% during 2015 and 2016 respectively) (**Table 3**).

Table 2. Effect of different pre- and post-emergence herbicides on weed density and weed biomass

Treatment	Weed density (no/m^2)*				Weed biomass(g/m^2)			
	2015		2016		2015		2016	
	20 DAS	40 DAS	20 DAS	40 DAS	20 DAS	40 DAS	20 DAS	40 DAS
Atrazine 1000 g/ha as PE	8.3(69.3)	8.7(74.7)	5.3(27.3)	9.0 (80.0)	45.9	48.7	35.9	53.8
Pendimethalin 1000 g/ha as PE	9.0(81.3)	8.4(69.3)	6.4 (40.7)	9.8 (96.0)	49.2	43.3	49.1	65.1
Alachlor 1000 g/ha as PE	9.5(90.7)	8.4(70.7)	6.7 (44.7)	10.1 (101.3)	59.2	57.7	61.6	66.1
Atrazine 500 g/ha + alachlor 500 g/ha as PE	8.1(65.3)	8.8(77.3)	5.2 (26.7)	9.2 (84.0)	47.6	55.6	40.9	62.6
2,4-D sodium salt 1000 g/ha at 15-25 DAS	13.2(174.7)	11.2(126.7)	11.5 (131.3)	11.4 (130.7)	117.8	115.1	151.0	143.5
2,4-D amine salt 580 g/ha at 15-20 DAS	15.2(232.0)	11.4(129.3)	11.4 (131.3)	11.3 (126.7)	159.7	111.8	145.8	143
Atrazine 1000 g/ha at 15-20 DAS	14.5(212.0)	11.1(124.0)	11.1 (124.0)	11.5 (132.0)	164.5	112.9	163.5	154.7
2,4-D ethyl ester 900 g/ha at 15-20 DAS	15.2(230.7)	11.2(124.0)	11.0 (121.3)	11.4 (129.3)	159.1	130.3	149.2	153.7
Tembotrione 100 g/ha at 15-20 DAS	16.0(260.0)	5.4(29.3)	12.7 (161.3)	5.6 (30.7)	165.8	28.9	219.6	31.6
Tembotrione 50 g/ha + atrazine 500 g/ha at 15-20 DAS	14.2(204.0)	4.0(16.0)	12.8 (163.3)	3.5 (12.0)	171.7	12.6	219.6	10.3
Hand weeding twice at 20 and 40 DAS	14.0(197.3)	4.8(22.7)	12.9 (167.3)	4.5 (20.0)	159.4	19.6	233.6	14.7
Unweeded check (control)	16.2(261.3)	13.8(190.7)	13.3 (177.3)	14.3 (209.3)	175.0	198.0	239.1	332.4
LSD (p=0.05)	1.23	0.68	0.54	0.55	22.84	12.62	15.6	23.60

*Original figures in parentheses were subjected to square root transformation before statistical analysis

Effect on crop

Weed control treatments significantly affected the growth and yield attributing characters of maize over the weedy check. Plant height, cob length, cob diameter and number of rows per cob were significantly high in hand weeding twice at 20 and 40 DAS *fb* tembotrione 50 g/ha + atrazine 0.5 kg/ha, tembotrione 100 g/ha at 15-20 DAS and also in four PE herbicide treatments (**Table 4**). Martin *et al.* (2011) observed that yield attributes of sweet corn were higher when atrazine was applied along with tembotrione as PoE. Cob diameter was found significantly high in the treatment tembotrione 50 g/ha + atrazine 0.5 kg/ha *fb* hand weeding twice at 20 and 40 DAS during 2015. Highest 1000-grain weight was recorded in hand weeding twice at 20 and 40 DAS (278.2 and 251.0 g in 2015 and 2016, respectively) while, it was low in weedy check compared to other treatments (**Table 4**). Shelling per cent was significantly high in hand weeding twice at 20 and 40 DAS followed by tembotrione 50 g/ha + atrazine 0.5 kg/ha.

Grain and stover yields were significantly affected by different weed control treatments. Grain yields were more during 2015 compared to 2016 (**Table 5**). Heavy rainfall during crop season badly affected the yield during 2016. During both the years grain yields were significantly high with hand weeding twice at 20 and 40 DAS (9.79 and 8.70 t/ha, respectively) *fb* tembotrione 50 g/ha + atrazine 0.5 kg/ha (9.65 and 8.61 t/ha in 2015 and 2016, respectively). These results were in inconformity with the results obtained by Swetha (2015). The next best treatment was tembotrione 100 g/ha at 15-20 DAS. The grain and straw yields in weedy check were significantly low in both years. Straw yield was significantly high with hand weeding twice at 20 and 40 DAS *fb* tembotrione 50 g/ha + atrazine 0.5 kg/ha during 2015 and 2016 respectively. Harvest index (HI) was maximum in the treatments hand weeding twice at 20 and 40 DAS, tembotrione 50 g/ha + atrazine 0.5 kg/ha and tembotrione 100 g/ha at 15-20 DAS, while it was minimum in weedy check (36.2 and 37.0% in 2015 and 2016, respectively).

Table 3. Weed control efficiency and weed index as affected by pre- and post-emergence herbicides

Treatment	Weed control efficiency (%) 2015		Weed control efficiency (%) 2016		Weed index (%)		Herbicide efficiency index (%)	
	20 DAS	40 DAS	20 DAS	40 DAS	2015	2016	2015	2016
Atrazine 1000 g/ha as PE	73.8	75.4	85.0	83.8	17.6	8.3	99.7	80.4
Pendimethalin 1000 g/ha as PE	71.9	78.2	79.5	80.4	19.4	11.6	95.3	73.9
Alachlor 1000 g/ha as PE	66.1	70.8	74.2	80.1	19.2	11.9	95.8	73.4
Atrazine 500 g/ha + alachlor 500 g/ha as PE	72.8	71.9	82.9	81.2	16.9	9.8	101.4	77.4
2,4-D sodium salt 1000 g/ha at 15-25 DAS	-	41.9	-	56.8	35.6	17.5	56.1	62.3
2,4-D amine salt 580 g/ha at 15-20 DAS	-	43.5	-	57.0	38.4	31.9	49.2	33.9
Atrazine 1000 g/ha at 15-20 DAS	-	43.0	-	53.4	41.1	30.0	42.8	37.7
2,4-D ethyl ester 900 g/ha at 15-20 DAS	-	34.2	-	53.8	39.5	26.8	46.6	44.0
Tembotrione 100 g/ha at 15-20 DAS	-	85.4	-	90.5	9.3	9.6	119.8	77.9
Tembotrione 50 g/ha + atrazine 500 g/ha at 15-20 DAS	-	93.6	-	96.9	1.5	1.0	138.7	94.8
Hand weeding twice at 20 and 40 DAS	-	90.1	-	95.6		-	-	-
Unweeded check (control)	-	-	-	-	58.7	49.2	-	-

Table 4. Effect of pre- and post-emergence herbicides on growth and yield attributes of maize

Treatment	Plant height (cm)		Cob length (cm)		Cob diameter (cm)		No of rows/cob		Test wt (g)	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Atrazine 1000 g/ha as PE	255.6	245.7	17.5	16.2	15.5	16.1	15.6	14.5	259.0	218.2
Pendimethalin 1000 g/ha as PE	255.5	243.5	16.7	16.1	15.1	16.0	15.2	14.4	247.9	215.3
Alachlor 1000 g/ha as PE	258.5	241.1	17.0	15.9	15.1	16.1	14.8	14.3	254.7	213.7
Atrazine 500 g/ha + alachlor 500 g/ha as PE	256.8	244.5	17.4	16.1	15.5	16.0	15.5	14.6	258.2	217.5
2,4-D sodium salt 1000 g/ha at 15-25 DAS	238.5	217.7	15.5	14.9	14.7	14.3	14.3	13.8	245.8	194.9
2,4-D amine salt 580 g/ha at 15-20 DAS	235.9	219.1	15.1	14.8	13.6	14.6	14.3	13.3	251.6	199.5
Atrazine 1000 g/ha at 15-20 DAS	242.5	216.2	15.6	14.7	13.9	14.6	13.8	13.4	248.3	199.4
2,4-D ethyl ester 900 g/ha at 15-20 DAS	238.4	216.2	15.4	14.6	14.3	14.7	14.1	13.1	248.1	194.3
Tembotrione 100 g/ha at 15-20 DAS	261.1	238.3	17.0	16.2	15.9	15.7	16.2	14.5	261.2	218.9
Tembotrione 50 g/ha + atrazine 500 g/ha at 15-20 DAS	260.3	249.2	17.5	16.9	16.6	16.2	14.4	15.3	258.7	232.5
Hand weeding twice at 20 and 40 DAS	268.7	252.5	18.0	17.1	16.5	16.4	16.0	15.4	278.2	251.0
Unweeded check (control)	218.7	206.5	14.8	14.1	12.6	14.0	13.0	12.6	225.0	193.3
LSD (p=0.05)	15.91	16.95	1.25	1.10	1.26	0.96	1.07	0.96	12.31	12.60

Table 5. Effect of pre- and post-emergence herbicides on yield and economics of maize

Treatment	Shelling (%)		Grain yield (t/ha)		Stover yield (t/ha)		HI (%)		Net monetary returns (`/ha)		B:C	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Atrazine 1000 g/ha as PE	67.3	70.9	8.07	7.98	11.23	10.78	41.8	42.6	82865	89808	2.43	3.01
Pendimethalin 1000 g/ha as PE	69.9	64.6	7.89	7.69	10.95	10.43	41.8	42.4	79655	84847	2.29	2.78
Alachlor 1000 g/ha as PE	67.4	65.6	7.91	7.67	10.44	10.27	43.1	42.7	80355	84937	2.34	2.83
Atrazine 500 g/ha + alachlor 500 g/ha as PE	68.5	69.9	8.14	7.85	11.24	10.60	42.0	42.6	83728	87706	2.44	2.93
2,4-D sodium salt 1000 g/ha at 15-25 DAS	70.9	50.1	6.31	7.18	9.54	9.65	39.6	42.6	57816	77827	1.72	2.61
2,4-D amine salt 580 g/ha at 15-20 DAS	71.7	51.2	6.03	5.92	8.94	8.57	40.3	40.8	53731	58928	1.59	1.97
Atrazine 1000 g/ha at 15-20 DAS	67.8	56.3	5.77	6.09	9.26	8.42	38.3	42.0	49515	61474	1.45	2.06
2,4-D ethyl ester 900 g/ha at 15-20 DAS	69.2	52.9	5.92	6.37	9.01	9.22	39.7	40.9	51357	65141	1.49	2.15
Tembotrione 100 g/ha at 15-20 DAS	69.1	69.6	8.88	7.87	11.83	10.15	42.8	43.7	91864	85430	2.49	2.62
Tembotrione 50 g/ha + atrazine 500 g/ha at 15-20 DAS	71.1	72.4	9.65	8.61	12.47	10.79	43.6	44.4	104357	97985	2.94	3.14
Hand weeding twice at 20 and 40 DAS	71.5	77.4	9.79	8.70	12.94	10.87	43.1	44.5	104162	96505	2.76	2.84
Unweeded check (control)	68.4	47.1	4.04	4.42	7.12	7.38	36.2	37.0	25794	37338	0.79	1.29
LSD (p=0.05)	3.09	5.73	0.76	0.58	0.86	0.76	0.94	1.59	-	-	-	-

Note: Price of grain: ` 14.50/- (2015) and ` 15.00/-(2016) per kilogram

Economic

Preference of any herbicides by the farmers mainly depends on the weed control efficiency and economics. Generally, the cost of manual weeding is much higher than the chemical weed control, which encourages many farmers for switching over to herbicides from expensive and tiresome manual weeding. Considering the economics of different treatments, net monetary returns were found to be high in the treatment tembotrione 50 g/ha + atrazine 0.5 kg/ha *fb* hand weeding twice at 20 and 40 DAS during both years. Lowest net returns were recorded in weedy check mainly because of declined yields due to excess weed growth. Further, the Benefit: Cost ratio was also significantly high for tembotrione 50 g/ha + atrazine 0.5 kg/ha during both the years (2.94 and 3.14 respectively) *fb* hand weeding twice at 20 and 40 DAS (2.76) during 2015 and PE of atrazine 1.0 kg/ha (3.01) and atrazine 0.5 kg/ha + alachlor 0.5 kg/ha (2.93) during 2016. Lowest benefit cost ratio was observed in weedy check during both years (0.79 and 1.29 respectively) (**Table 5**).

It was concluded that post emergence application of tembotrione 50 g/ha + atrazine 0.5 kg/ha at 15-20 DAS was proved effective in improving weed control, maize yield and economics. Hence, it can be recommended to the maize crop grown in the North Coastal Zone of Andhra Pradesh.

REFERENCES

Chopra P and Angiras N. 2008. Effect of tillage and weed management on productivity and nutrient uptake of maize (*Zea mays* L.). *Indian Journal of Agronomy* **53**(1): 66-69.

Deshmukh LS, Jadhav AS, Jathure RS and Raskar SK. 2009. Effect of nutrient and weed management on weed growth and productivity of kharif maize under rainfed condition. *Karnataka Journal of Agricultural Sciences* **22**(4): 889-891.

Gill GS and Vijayakumar. 1969. "*Weed index*" A new method for reporting weed control trials. *Indian Journal of Agronomy* **16**: 96-98.

Jonathon R Kohrt and Christy L Sprague. 2013. Weed height and the inclusion of atrazine influence control of multiple-resistant *Palmer amaranth* with HPPD inhibitors. *Weed Technology* **43**(2).

Joseph D, Bollman M, Boerboom Roger L, Becker and Fritz. 2008. Efficacy and tolerance to HPPD-inhibiting herbicides in sweet corn. *Weed Technology* **22**: 666-674.

Krishnamurthy K, Rajshekara BG, Raghunatha G, Jagannath MK and Prasad TVR. 1995. Herbicide efficiency index in sorghum. *Indian Journal of Weed Science* **7**(2): 75-79.

Mani S, Malla ML, Gautam KC and Bhagwndas.1973. Weed killing chemicals in potato cultivation. *Indian Farming* **VXXII**: 17-18.

Martin M, Williams II, Boydston RA, Peachey, REd and Robinson D. 2011. Significance of atrazine as a tank-mix partner with tembotrione. *Weed Technology* **25**: 299-302.

Patel VJ, Upadhyay PN, Patel JB and Meisuriya MI. 2006. Effect of herbicide mixtures on weeds in kharif maize (*Zea mays* L.) under Middle Gujarat conditions. *Indian Journal of Weed Science* **38**(1&2): 54-57.

Sharma V and Thakur DR. 1998. Integrated weed management in maize (*Zea mays*) under mid hill condition of North-Western Himalayas. *Indian Journal of Weed Science* **30**(3&4): 158-162.

Swetha K. 2015.*Weed Management with New Generation Herbicides in Kharif Maize (Zea mays l.).* M.Sc. thesis, Department of Agronomy, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad-500 030.