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Weed Growth, Yield Components, Productivity, Economics and Nutrient Uptake of Maize (*Zea mays* L.) as Influenced by Various Herbicide Mixtures Applications under Irrigated Condition

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Abstract A field trial was conducted during *kharif* of 2014 to study weed growth, yield components, economics and nutrient uptake in maize as influenced by various herbicide applications under irrigated condition. The farmers practice of hand weeding at 20 and 40 DAS recorded highest yield attributes and yield (6,580 kg/ha) which was on par with tank mix of topramezone and tembotrione with atrazine and adjuvant as post-emergence (6,436 and 6,282 kg/ha). These treatments also recorded lowest total weed density, weed dry matter and lowest uptake of nutrients N, P and K by the weeds. Hence, farmers practice of hand weeding at 20 and 40 DAS was found to be effective in case easy availability of labors. Where there is labor scarcity and high cost of labor tank mix of hydroxy-phenyl pyruvate dioxygenase (4-HPPD) inhibiting herbicides (topramezone or tembotrione) with atrazine along with adjuvant was found to be effective.

Keywords Herbicides, Nutrient uptake, Methylated seed oil, Stefes mero, WCE.

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Introduction

Corn (*Zea mays* L.) is a versatile crop, allowing it to grow across a range of agro-ecological zone popularly called Queen of Cereals. Maize is one of the most popular and important cereal crop grown throughout the world for agricultural economy. There are many socio-economic, physical and biological factors limiting the productivity of maize crop. One of the major problems in maize productivity is posed by the weeds that have shown to reduce the yields. In rain-fed areas interculture of maize field is done for controlling weeds. It is costly, time and labor consuming. The crop requires large amounts of N, P and K in addition to other micro elements. Weed control can increase fertilizer use efficiency of the crop with checking wasteful removal of nutrients by weeds. Hand weeding, is time consuming, high expensive and is not feasible during critical period of weed competition due to scarcity of labor. Keeping this in view present investigation was under taken to study weed growth, yield components, economics and nutrient uptake in maize as influenced by new herbicides topramezone and tembotrione tank mixed with atrazine and adjuvants.

Table 1. Effect of different weed control treatments on weed density (No/m^2), weed dry matter (g/m^2), WCE (%) in maize at 60 DAS. Original values are given in parentheses, which are transformed to $\sqrt{x} + 1$.

Sl. No.	Treatments	Weed density Grasses	Sedges	BLW	Total	WDM 60 DAS	WCE 60 DAS
T_1	Atrazine (1.0 kg/ha) as PE fb inter-cultivation at 30 DAS	5.23 (26.44)	5.99 (34.90)	4.77 (21.82)	9.17 (83.16)	7.29 (52.27)	74.66
T_2	Topramezone (25.2 g/ha) + MSO (adjuvant) as PoE	6.39 (39.93)	7.86 (60.90)	4.73 (21.46)	11.10 (122.29)	8.18 (65.93)	68.04
T_3	Tembotrione (105 g/ha) + stefes mero (adjuvant as PoE	6.68 (43.73)	7.96 (62.40)	4.51 (19.30)	11.25 (125.76)	8.19 (66.23)	67.89
T_4	Topramezone + atrazine, (25.2 + 250 g/ha) + MSO tank mix as PoE	4.95 (23.53)	6.67 (43.60)	3.35 (10.23)	8.85 (77.36)	7.23 (51.36)	75.10
T_5	Tembotrione + atrazine, (105+250 g/ha) + stefes mero tank mix as PoE	5.47 (29.00)	7.04 (48.70)	3.60 (12.00)	9.51 (89.36)	7.41 (53.97)	73.84
T_6	Tembotrione (105 g/ha) as PoE	7.08 (49.26)	8.33 (68.40)	5.77 (32.33)	12.28 (149.90)	8.73 (75.27)	63.51
T_7	Intercropping of maize with cowpea and application of pendimethalin (1.0 kg/ha) as PE	6.51 (41.42)	8.44 (70.30)	5.97 (34.66)	12.13 (146.30)	8.56 (72.39)	64.91
T_8	Hand weeding at 20 and 40 DAS	3.35 (10.23)	3.20 (9.240)	2.55 (5.53)	5.09 (25.00)	3.61 (12.01)	94.17
T_9	Intercultivation at 20 and 40 DAS	4.26 (17.17)	4.42 (18.60)	3.30 (9.93)	6.83 (45.70)	5.03 (24.36)	88.19
T_{10}	Unweeded control	10.55 (110.49)	8.64 (73.70)	9.73 (93.80)	16.71 (277.90)	14.93 (206.32)	–
	SEm (±)	0.21	0.22	0.21	0.30	0.29	
	CD (0.05%)	0.64	0.66	0.64	0.90	0.87	

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Materials and Methods

A field experiment was carried out during *kharif*, 2014 at College Farm, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad situated at an altitude of 542.6 m above mean sea level (MSL) at 18 °50´ N latitude and 77°53´ E longitude. The experiment was laid out in randomized block design with three replications and ten treatments comprising of atrazine 50% WP @ 1.0 kg/ha as pre-emergence *fb* intercultivation at 30 DAS, topramezone 33.6% SC @ 25.2 g/ha along with methylated seed oil (adjuvant), tembotrione 42% SC @ 105 g/ha along with stefes mero (adjuvant), topramezone+atrazine @ 25.2 + 250 g/ha with methylated seed oil (adjuvant), tembotrione + atrazine 105 + 250 g/ha with stefes mero adjuvant, tembotrione 42% SC @ 105 g/ha as post-emergence, intercropping of maize with cowpea and pendimethaline 30% EC @ 1.0 kg/ha as pre-emergence, hand weeding at 20 and 40 DAS, intercultivation at 20 and 40 DAS and unweeded control. Maize hybrid, DHM-117 was sown on July 8th, 2014 with a spacing of 60 cm × 20 cm. Fertilizers @ 180-60-60 kg of N-P_2O_5-K_2O / ha in the form of urea, di-ammonium phosphate and muriate of potash was applied to all treatments. The dose of herbicides were calculated as per the treatments and applied as aquaeous spray @ 500 l/ha using knapsack sprayer with flat fan nozzle. Post-emergence herbicides were applied at 15 DAS. Intercultivation was done with hand operated intercultivator (star weeder) and hand weeding was done at 20 DAS and 40 DAS as per the treatments after recording the weed data.

Random soil sampling was done in the experimental field from 0–15 cm depth before initiation of the experiment. The soil samples were shade dried

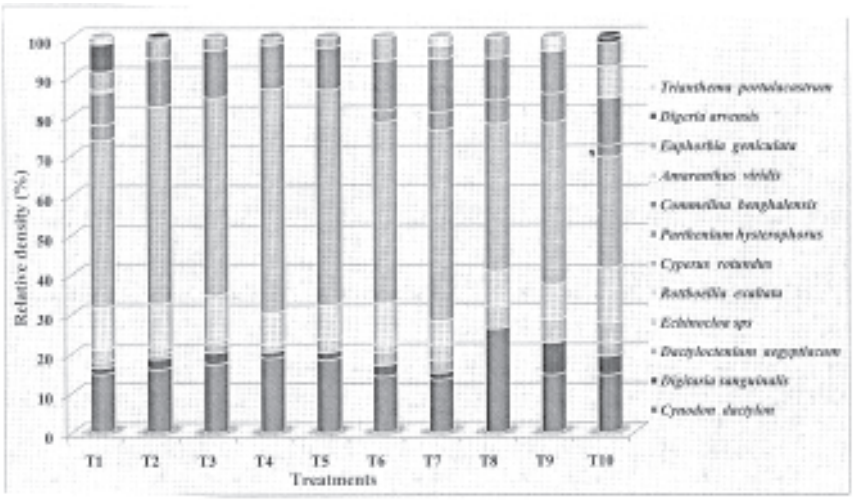

Fig. 1. Effect of weed control treatments on relative density (%) of maize at 60 DAS.

and passed through 2 mm sieve to make a composite sample which was later analyzed for physico-chemical and chemical properties, the results revealed that the soil was low in available nitrogen (255 kg ha^{-1}), medium in available phosphorus (25 kg ha^{-1}) and potassium (263 kg ha^{-1}). Nitrogen was applied in two more splits at knee height stage and at tasseling stage along with ½ of K_2O. Immediately after sowing light irrigation was given to the crop. All the pre-emergence and post-emergence herbicides were applied using knapsack sprayer fitted with flat fan nozzle by mixing in 500 L of water/ha as per treatment. Herbicide effects on weeds were measured by counting the number of weeds. The observations on weed density and dry matter were taken randomly using 0.25 m^2 quadrat and data were transformed to square root before statistical analysis.

Results and Discussion

Observation on weeds

Twelve weed species were observed in the experimental plots comprising of five grasses and six broad leaved weeds and sedge during crop growth period: *Cyperus rotundus* L., *Cynodon dactylon* L., *Rottboellia exaltata* L., *Commelina benghalensis* L., and *Euphorbia geniculata* L were the most pre-dominant species.

Weed density (total weed population No/m^2)

At 60 DAS hand weeding at 20 and 40 DAS recorded significantly lowest weed density of grasses, sedges and broad leaf weeds (10.23, 9.24, 5.53/m^2) (Table 1, Fig. 1). Intercultivation at 20 and 40 DAS recorded lower density of grasses (17.17/m^2), sedges (18.6/m^2) and total number of weeds (45.7/m^2) which was significantly superior to other treatments and also recorded lowest density of broad leaved weeds (9.93/m^2) but remained on par with topramezone+ atrazine @ 25.2+250 g/ha+MSO (10.23/m^2) and tembotrione + atrazine @ 105+250 g/ha +stefes mero (12.00/m^2). These results indicate that hand weeding or intercultivation at 40 DAS continued its effect due to effective removal of weeds that resulted in lower weed density at 60 DAS. Similar observation was reported by Singh et al. [1]. Unweeded control recorded significantly higher weed density.

Weed dry weight (g/m^2)

Weed dry matter is a better parameter to measure weed competition than weed density as it measures more precisely the growth resources utilized by weeds (Table 2). At 60 DAS, HW at 20 and 40 DAS recorded significantly lower weed dry matter (12.01 g/m^2) over other treatments. Intercultivation at 20 and 40 DAS

Fig. 2. Bleaching action of topramezone + atrazine + MSO on weeds.

recorded significantly lowest weed dry matter (24.36 g/m^2) followed by PoE application of topramezone + atrazine @ 25.2+250 g/ha+MSO (51.36 g/m^2), atrazine @ 1.0 kg/ha as PE *fb* IC at 30 DAS (52.27 g/m^2) and tembotrione + atrazine @ 105+250 g/ha as PoE (53.97 g/m). The lower dry matter in these treatments might be due to better efficacy and prolonged effectiveness of applied HPPD inhibiting herbicides which reduced weed growth and even resulted in rapid depletion of carbohydrate reserves of weeds already germinated through rapid respiration, bleaching of leaves, reduction in leaf area and diminution of photosynthesis process and it is in agreement with Bollman et al. [2] and all these treatments were statistically at par with each other.

Weed control efficiency (%)

Weed management practices recorded better WCE which ranged from 63.51% to 94.17% at 60 DAS. Highest WCE was recorded in HW at 20 and 40 DAS (94.17%) followed by IC at 20 and 40 DAS (88.19%) and was closely followed by topramezone or tembotrione tank mixed with atrazin+adjuvants (75.10 and 73.84%). This may be due to effective control of weeds during early stages of crop growth by herbicides. Lowest WCE was recorded in PoE application of tembotrione alone @ 105 g/ha (Figs. 3 and 4).

Relative density (%)

At 60 DAS, predominance of perennial weeds was more compared to annual weeds due to poor control of *Cyperus rotundus* and *Cynodon dactylon*, ranging from 27.8 to 56.4% and 13.4 to 26.4% in different treatments. Relative density of broad leaf weeds in different weed control treatments ranged from 13.2 to 32.2%. Relative density of *Cynodon dactylon* and *Cyperus rotundus* in topramezone+atrazine @ 25.2+250 g a.i. ha^{-1}+ MSO was 18.9% and 56.4% whereas in tembotrione + atrazine @ 105+250g a.i. ha^{-1}+ stefes mero as PoE the densities were 18.5% and 54.3%. The higher relative density of *Cyperus rotundus* (sedge) in these treatments could be due to the effective control of broad leaf weeds like *Parthenium hysterophorus*, *Amaranthus viridis* and *Trianthema portulacastrum* ; grasses *Dactyloctenium aegyptiacum* with zero predominance and presence of very few number of broad leaf weeds like *Digitaria sanguinalis*, *Echinocloa colonum*. This might be due to broad spectrum of weed control due to tank mixing of HPPD and triazine herbicides along with adjuvants

Fig. 3. Bleaching action of tembotrione + atrazine + stefes mero on weeds.

which resulted in control of majority of weeds except *Cyperus rotundus* in these treatments compared to other treatments. Similar reports of reduction in grasses and broad leaf weeds with tank mix application of HPPD inhibiting and triazine group of herbicides with adjuvant was reported by Schulte and Kocher [3] whereas application of topramezone and tembotrione @ (25.2 and 105 g/ha) with atrazine (250 g/ha) along with adjuvant recorded zero relative density of *Dactyloctenium aegyptium*, 1.7% and 1.9% relative density of *Digitaria sanguinalis*, 8.1% and 8.9% of *Rottboellia exaltata* which was lower compared to application of topramezone and tembotrione alone without atrazine. This might be due to the residual effect of atrazine in tank mix application with topramezone and tembotrione which resulted in lower relative density.

Effects on crop

Effect on growth attributes

Plant height (*cm*) : At 60 DAS, the plant height was significantly higher (212.6 cm) in HW at 20 and 40 DAS. This could be due to the reduced weed growth and providing weed-free environment for better vegetative growth of maize that reflected in plant height as reported earlier. Topramezone+atrazine @ 25.2+250 g/ha+MSO as PoE recorded tall plants which was on par with tembotrione+atrazine @ 105+250 g/ha + stefes mero as PoE (200.6 cm). Growth was minimum under unweeded control at all the respective stages which might be due to the suppression of vegetative growth of plants by weed competition.

Leaf area index (*LAI*) : At 60 DAS, HW at 20 and 40 DAS recorded higher leaf area index (3.86) which was significantly superior to other treatments followed by topramezone + atrazine @ 25.2+ 250 g/ha+ MSO and was on par with tembotrione+ atrazine @ 105+250 g/ha as PoE. The increase in the leaf area index might be due to increased number of leaves with higher plant population compared to control. Similar reports of enhancement in LAI with higher plant population were reported earlier.

Days to 50% silking : Weed management practices significantly influenced days to 50% silking in maize. Number of days to 50% silking in different treat-

Table 2. Effect of different weed control treatments on growth attributes, yield attributes and yield of maize.

Sl. No.	Treatments	Plant height at 60 DAS	LAI at 60 DAS	Days to 50% silking	No. of cobs (000 ha^{1})	Girth of cob (cm)
T_1	Atrazine (1.0 kg/ha) as PE *fb* inter-cultivation at 30 DAS	195.8	2.91	59	73.9	15.47
T_2	Topramezone (25.2 g/ha)+MSO (adjuvant) as PoE	184.9	2.37	60	72.2	14.58
T_3	Tembotrione (105 g/ha)+stefes mero (adjuvant) as PoE	179.8	2.35	60	70.2	14.43
T_4	Topramezone+atrazine, (25.2+250 g/ha)+MSO tank mix as PoE	203.6	3.16	57	75.1	15.84
T_5	Tembotrione+atrazine, (105+250 g/ha)+stefes mero tank mix as PoE	200.6	3.12	58	74.1	15.73
T_6	Tembotrione (105 g/ha) as PoE	173.5	2.26	61	71.2	14.17
T_7	Intercropping of maize with cowpea and application of pendimethalin (1.0 kg/ha) as PE	163.8	2.17	60	70.1	13.54
T_8	Hand weeding at 20 and 40 DAS	212.6	3.86	56	76.5	16.76
T_9	Intercultivation at 20 and 40 DAS	190.6	2.86	59	72.6	15.23
T_{10}	Unweeded control	134.9	2.03	61	66.3	12.07
	SEm (±)	3.4	0.06	1.0	0.76	0.2
	CD (0.05%)	10.2	0.18	3.1	2.3	0.68

Table 2. Continued.

Sl. No.	Treatments	Grains in a row	Grain number/ cob	Test weight (g)	Grain yield (kg/ ha)	Stover yield (kg/ ha)
T_1	Atrazine (1.0 kg/ha) as PE *fb* inter-cultivation at 30 DAS	26.8	364.48	24.7	5721	7020
T_2	Topramezone (25.2 g/ha)+MSO (adjuvant) as PoE	26.5	349.8	24.4	4992	6843
T_3	Tembotrione (105 g/ha)+stefes mero (adjuvant) as PoE	26.3	347.16	24.1	4834	6736
T_4	Topramezone+atrazine, (25.2+250 g/ha)+MSO tank mix as PoE	27.4	383.6	25.4	6436	7603
T_5	Tembotrione+atrazine, (105+250 g/ha)+stefes mero tank mix as PoE	27.3	371.28	25.2	6282	7496
T_6	Tembotrione (105 g/ha) as PoE	24.2	319.4	21.6	4527	6583
T_7	Intercropping of maize with cowpea and application of pendimethalin (1.0 kg/ha) as PE	24.0	307.2	21.2	(4711) (MEY)	6373
T_8	Hand weeding at 20 and 40 DAS	28.2	406.1	26.1	6580	8036
T_9	Intercultivation at 20 and 40 DAS	26.7	352.4	24.3	5486	6993
T_{10}	Unweeded control	19.2	230.4	18.2	2594	5362
	SEm (±)	0.19	8.17	0.17	120.3	142.4
	CD (0.05%)	0.65	25.2	0.54	360.3	426.5

ments varied from 56 to 61 days. HW at 20 and 40 DAS recorded early days to 50% silking followed by tank mix application of PoE herbicides with atrazine this might be due to timely weed control operations. Whereas maximum number of days to 50% silking was observed in unweeded control. This might be due to poor crop growth as a result of severe weed competition.

Table 3. Economics of different weed management practices on nutrient uptake of weeds and economics of maize.

Sl. No.	Treatments	Nutrient uptake (kg/ha^{-1}) Nitrogen	Phosphorus	Potassium	Gross returns (Rs/ha)	Net returns (Rs/ha)	B : C ratio
T_1	Atrazine (1.0 kg/ha) as PE *fb* intercultivation at 30 DAS	9.49	1.06	11.96	81493	55337	3.11
T_2	Topramezone (25.2 g/ha)+MSO (adjuvant) as PoE	11.76	1.62	13.27	71739	43133	2.50
T_3	Tembotrione (105 g/ha)+stefes mero (adjuvant) as PoE	13.42	1.80	13.96	69578	40972	2.43
T_4	Topramezone+atrazine, (25.2+250 g/ha)+MSO. tank mix as PoE	8/79	0.86	11.51	91389	62608	3.17
T_5	Tembotrione+atrazine, (105+250 g/ha)+stefes mero tank mix as PoE	9.43	1.02	11.80	88962	60181	3.10
T_6	Tembotrione (105 g/ha) as PoE	18.69	2.30	17.14	65434	37028	2.30
T_7	Intercropping of maize with cowpea and application of pendimethalin (1.0 kg/ha) as PE	14.18	1.32	14.14	67616	41175	2.55
T_8	Hand weeding at 20 and 40 DAS	5.90	0.53	9.61	93724	59368	2.72
T_9	Intercultivation at 20 and 40 DAS	9.98	1.11	12.90	78311	52355	3.01
T_{10}	Unweeded control	49.80	10.8	56.40	39084	14728	1.60
	SEm±	0.65	0.10	0.40	2332	1594	
	CD (0.05%)	1.91	0.31	1.30	6982	4773	

Yield attributes

Hand weeding at 20 and 40 DAS recorded significantly more number of (76.5 thousand) cobs ha^{-1}, higher cob girth (16.76 cm), highest number of grains in a row (28.2), highest number of grains (406.1) per cob and higher test weight (26.1 g) followed by tank mix application of topramezone+atrazine @ 25.2+250 g/ha+MSO and tembotrione+ atrazine @ 105+250 g/ha+stefes mero. Lowest yield attributes was recorded in unweeded control. This might be due to higher weed competition faced by plants in unweeded control.

Grain yield and stover yield (kg/ha)

Efficient utilization of soil and climatic resources by maize plant in the presence of relatively low weed density and dry weight led to maximum grain yield (6,580 kg/ha) in hand weeding at 20 and 40 DAS i.e. 60.5% increase over the unweeded control, which was on par with topramezone and tembotrione tank mixed with atrazine and adjuvants with 59.6% and 58.7% over the unweeded control (Table 2). These findings were substantiating with the results of Madhavi et al. [4] who showed that efficiency of maize crop to partition the dry matter into its economic yield was highest in tank mix application of HPPD inhibiting herbicides with atrazine. Atrazine @ 1.0 kg/ha as PE *fb* IC at 30 DAS recorded higher grain yield of 54.6% increase over the unweeded control, which was on par with intercultivation at 20 and 40. The yield reduction in intercropping treatment is due to the competition for space, light, water and nutrients as intercrop was having shading effect, curtailed the efficient utilization of natural resources and restricted the growth of maize from initial stages to harvest which resulted in lower yield and yield attributes. Similar findings were observed by Hussain et al. [5]. Grain yield in unweeded control (2,594 kg/ha) was significantly lower than other treatments. The highest weed density, weed dry matter in unweeded control reduced the seed yield due to severe competition from weeds. Similarly, several authors also reported losses in grain yield due to weed competition from 53% to 80%.

Highest stover yield (8,036 kg/ha) was recorded in HW at 20 and 40 DAS which was significantly superior to all other treatments followed by topramezone + atrazine @ 25.2 + 250 g/ha+MSO as PoE (7,603 kg/ha) which was on par with tembotrione +atrazine @105+250 g a.i./ha+ stefes mero as PoE (7,496 kg/ha). Higher stover yield in weed control treatments could be due to better growth and development of maize, which produced more biomass. Significantly lower stover yield of 5,362 kg/ha was recorded in unweeded control.

Nutrient uptake by weeds at harvest

Weeds being a serious negative factor in the crop production which are responsible for marked losses of crop yields. Weeds that grow with crop plants deplete considerable amount of costly fertilizer nutrients in addition to available soil moisture.

At harvest, nitrogen and phosphorus uptake by weeds was significantly lower (5.9 and 0.53 kg/ha) in hand weeding at 20 and 40 DAS. Further lower uptake was recorded in topramezone + atrazine @ 25.2 + 250 g/ha+MSO as PoE (8.79 and 0.86 kg/ha) and was on par with tembotrione+atrazine @ 105+250 g/ha + stefes mero as PoE (9.43 and 1.02 kg/ha), atrazine @ 1.0 kg/ha as PE *fb* intercultivation at 30 DAS (9.49 and 1.06 kg/ha) and intercultivation at 20 and 40 DAS (9.98 and 1.11 kg/ha). Potassium uptake by weeds was significantly lowest in hand weeding at 20 and 40 DAS (9.61 kg/ha) followed by topramezone + atrazine @ 25.2 + 250 g/ha + MSO (11.51 kg / ha) which was on par with tembotrione+atrazine @ 105 + 250 g/ha + stefes mero (11.80 kg/ha), atrazine @ 1.0 kg/ha as PE *fb* intercultivation at 30 DAS (11.96 kg/ha).

Hand weeding and herbicide application checked the nutrient drain by weeds very effectively. This might be due to efficient control of weeds with lower weed density and weed dry weight which resulted in lower nutrient depletion. Similar findings regarding nutrient depletion by weeds were reported by and Samanth et al. [6].

Economics

Higher gross returns (Rs 93,724/ha) were realized in hand weeding at 20 and 40 DAS which was on par with application of topramezone + atrazine @ 25.2 + 250 g/ha + MSO as PoE (Rs 91,389/ha) and tembotrione+atrazine @ 105 + 250 g/ha + stefes mero as PoE (Rs 88,962/ ha) followed by application of atrazine @ 1.0 kg a.i./ha as PE *fb* intercultivation at 30 DAS (Rs 81,493/ha) (Table 3). These returns are significantly superior over other treatments, this can be attributed to better weed control in these treatments resulting in the increased grain yield and thereby increasing the gross returns. Gross returns was significantly lower (Rs 39,084/ha) in unweeded control which can be attributed to the lowest grain yield recorded because of more weed competition. Significantly higher net returns (Rs 62,608/ha) were realized in topramezone + atrazine @ 25.2 + 250 g/ha + MSO as PoE which was on par with tembotrione + atrazine @ 105 + 250 g/ha + stefes mero (Rs 60,181/ha) and hand weeding at 20 and 40 DAS (Rs 59,368/ha) compared to other treatments while unweeded control recorded significantly lower net returns (Rs 14,728/ha).

The B : C ratio was significantly higher (3.17) in treatments with application of topramezone + atrazine @ 25.2 + 250 g/ha + MSO as PoE, atrazine @ 1.0 kg/ha as PE *fb* intercultivation at 30 DAS (3.11), tembotrione + atrazine @ 105 + 250 g/ha as PoE (3.10) and intercultivation at 20 and 40 DAS (3.01), this is due to lower cost for herbicides and mechanical intercultivation compared to labor cost in manual weeding. Hand weeding at 20 and 40 DAS recorded a B : C ratio of 2.72 which is due to higher costs involved in engaging human labor for weeding, whereas unweeded control recorded significantly lower B : C ratio (1.60) over other treatments this is due to lower grain yield.

Conclusion

Tank mix application of hydroxy-phenyl pyruvate dioxygenase (4-HPPD) herbicides (topramezone or tembotrione) along with atrazine and adjuvant was found to be more effective in providing broad spectrum of weed control where there is labor shortage in peak periods of weed control.

References

1. Singh M, Prabhukumar S, Sairam CV, Kumar Arun (2009) Evaluation of different weed management practices in rainfed maize on farmer's field. Pak J Weed Sci Res 15 : 187—189.
2. Bollman JD, Boerbcom CM, Becker RL, Fritz VA (2008) Efficacy and tolerance to HPPD-inhibiting herbicides in sweet corn. Weed Technol 22 : 666—674.
3. Schulte W, Kocher H (2009) Tembotrione and combination partner isoxadifenethyl- mode of herbicidal action. Bayer Crop Sci J 62 : (In press).
4. Madhavi M, Ramprakash T, Srinivas A, Yakadri M (2014) Topramezone (33.6% SC) + Atrazine (50%) WP tank mix efficacy on maize. Biennial Conf on Emerging challenge in weed management. Ind Soc Weed Sci 15—17, Feb.
5. Hussain F, Abouziena IM, EL-Metwally, EL-Dessoki ER (2008) Effect of plant spacing and weed control treatments on maize yield and associated weeds in sandy soils. Am Euras J Agric Environ Sci 4 : 09—17.
6. Samanth TK, Dhir BC, Mohanty B (2015) Weed growth, yield components, productivity, economics and nutrient uptake of maize (*Zea mays* L.) as influenced by various herbicide applications under rainfed condition. Ind J Weed Sci 2 : 79—83.