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RESEARCH PAPER

Weed management strategy in sugarcane through early post emergence herbicides

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Abstract: A field experiment was conducted at Agricultural Research Station, Hukkeri (Dist. Belagavi), Karnataka during *suru* (January) 2020 on medium black clay loam soils, to study the weed management strategy in sugarcane through early post emergence herbicides. There were nine treatments laid out in randomized complete block design replicated thrice. The treatments consisted of different early post emergence herbicides alone and in combination with atrazine as tank mix application at 2-3 leaf stage of weeds and were compared with weed free check and recommended package of practice *i.e.*, Atrazine 50% WP @ 1.25 kg a.i., ha^{-1} as pre-emergence (PE) followed by (*fb*.) 2-4 D Na salt 80% WP @ 2.0 kg a.i., ha^{-1} as post emergence (PoE) application at 60 days after planting (DAP).Among the herbicide applied treatments to plant cane, Topramezone 33.6% SC @ 30.24 g a.i., ha^{-1} + Atrazine 50% WP @ 0.5 kg a.i., ha^{-1} (tank mix) as early post emergence (EPoE) application at 2-3 leaf stage of weeds recorded significantly lower weed density (5.46 m^{-2}), dry weight (2.94 g m^{-2}) and higher weed control index (81.17%) for total weeds at 40 days after herbicide application (DAHA) with lower weed index (3.17%)., which was on par with Topramezone 33.6% SC @ 30.24 g a.i., ha^{-1} alone as EPoE (5.88 m^{-2}, 3.31 g m^{-2}, 75.89 % and 7.46 %, respectively). Application of Topramezone 33.6 % SC @ 30.24 g a.i., ha^{-1} + Atrazine 50 % WP @ 0.5 kg a.i., ha^{-1} as EPoE also recorded significantly higher weed control index (84.42-76.29 %) at 20-60 DAHA, cane yield (134.10 t ha^{-1}), higher net returns (₹ 215736 ha^{-1}) and benefit cost ratio (2.41) and was on par with Topramezone 33.6 % SC @ 30.24 g a.i., ha^{-1} alone as EPoE. Phytotoxicity was not observed due to application of early post emergence herbicides on plant cane and succeeding intercrops (wheat and chickpea) in ratoon cane. As sugarcane is a long duration irrigated crop and labour availability is becoming scarce, these herbicide treatments can be better alternative to RPP and weed free check in plant cane.

Keywords: Cane yield, Economics, Herbicides, Sugarcane, Weed control index

Introduction

Sugarcane **(***Saccharum officinarum* L.) is an important commercial crop in India and holds a prominent position as a cash crop. India has second largest area and production of sugarcane next to Brazil in the world. Globally, it is cultivated on an area of 26.6 m ha with production of 1886 mt and productivity of 70.7 t ha^{-1}. In India, it is cultivated under a wide range of agro-ecological situations both in tropical and subtropical regions on area of about 4.86 m ha with annual production of 377.76 mt and productivity of 77.6 t ha^{-1}. Uttar Pradesh, Maharashtra, Karnataka, Tamil Nadu, Bihar and Andhra Pradesh are the leading states for the sugarcane production in India (Anon, 2020).

Karnataka state has tremendous potential for increasing the cane cultivation and achieving higher yields as the soil and climatic conditions are most favourable for planting cane in different seasons of the year. In Karnataka, sugarcane occupies an area of 4.5 lakh ha with production of 40.61 mt with productivity of 90 t ha^{-1} (Anon, 2020).

Among the various factors limiting the cane production, weed infestation is one of the major biotic constraints. In tropical agriculture, weeds are the major threat in crop production which affects the yields considerably. Weeds are considered as a major biotic constraint for higher production and the critical period of crop weed competition has been recorded as 60- 120 days after planting (DAP) in spring cane and 150 DAP in autumn cane (Rohitashav *et al*., 2011). Hence, weed management is must during this period in order to achieve higher yield of the crop. The reduction in cane yield due to weed infestation ranges from 10 per cent to total crop failure (Srivastava and Chauhan, 2006) and this yield loss depends upon nature, intensity and duration of weed infestation during the crop life cycle.

It is well known that, cultural methods of weed management are most effective but timely availability of labours is a problem besides increased wages. Therefore, chemical management of weeds is considered as the economical one in sugarcane. Hence, farmers have to rely on chemical weed management.

Several herbicides have been tried in sugarcane with varying degree of success but information on combined use of chemical or pre-mix combination of herbicides is scarce.Keeping this in view, the present investigation was undertaken to study the combined use of two or more herbicides having different mode of action in *suru* (January) planted sugarcane. Application of different herbicides were done individually and in combination at early post-emergence of weeds stage in order to manage dominant weed species in sugarcane.

Material and methods

A field experiment was conducted at Agricultural Research Station, Hukkeri, Dist.: Belagavi in Karnataka State during *suru* (January) 2020. There were nine treatments laid out in randomized complete block design replicated thrice. The treatments consisted of different early post emergence herbicides alone and in combination with atrazine as tank mix

application at 2-3 leaf stage of weeds and were compared with weed free check and recommended package of practice *i.e.*, Atrazine 50% WP @ 1.25 kg a.i., ha^{-1} as pre-emergence (PE) followed by (*fb.*) 2-4 D Na salt 80% WP @ 2.0 kg a.i., ha^{-1} as post emergence (PoE) application at 60 days after planting (DAP).

Planting of sugarcane (Co 09004) was done at 135 cm row spacing on 16th January 2020, with plant to plant spacing of 30 cm. Irrigation was provided through ridge and furrow method/ system.Spraying of atrazine 50% WP @ 1.25 kg a.i., ha^{-1} as pre emergence was done on next day of planting and spraying of tembotrione 42 % SC @ 50.4 g a.i., ha^{-1},topramezone 33.6 % SC @ 30.24 g a.i., ha^{-1} and ametryne 80 % WDG@ 2.0 kg a.i., ha^{-1} alone as early post emergence (EPoE) and in combination with atrazine 50% WP @ 0.5 kg a.i., ha^{-1} as tank mix application at 2-3 leaf stage of weeds for allotted experimental plots.Herbicides were applied using knapsack sprayer fitted with flat fan nozzle using a spray volume of 500 litres per ha. A quadrant of 0.5 m^2 was used to record the weed count at pre spray, 20, 40 and 60 DAHA and the fresh samples of weeds so obtained from that quadrat were kept in hot air oven at 70 °C (till constant weight is recorded) for determining weed dry weight and weed control index.

All cultural operations were followed as per recommended package of practices to raise a healthy cane crop except for the weed management practices. Observations on weed density, weed dry weight and weed control index were recorded at pre spray, 20, 40 and 60 days after herbicide application (DAHA) and weed index was recorded after harvest. Cost of cultivation, gross returns, net returns and B:C ratio were calculated treatment wise.

Experimental data obtained was compiled and subjected to statistical analysis by adopting Fischer's method of analysis of variance (Gomez and Gomez, 1984).

Results and discussion

Effect of early post emergence herbicides on weed parameters

The dominant weed species observed in experimental field were *Cynodon dactylon*, *Dactyloctenium aegyptium* and *Echinochloa colona* among grasses, *Parthenium hysterophorus*, *Argemone mexicana*, *Alternanthera sessilis*, *Phyllanthus niruri*, *Euphorbia geniculata*, *Tridax procumbens*, *Convolvus arvensis*, *Digera arvense*, *Tribulus terrestris* and *Oxalis corniculata* among broad leaved weeds and *Cyperus rotundus* among sedges. Similar weed spectrum was also noticed by Krishnaprabu (2017) and Rohitashav *et al.* (2011) in sugarcane.

Weed density varied markedly with respect to weed management practices. Weed free check recorded significantly lower weed density due to regular hand weeding resulting in complete weed removal. Amongst different herbicide applied treatments, Topramezone 33.6% SC @ 30.24 g a.i., ha^{-1} + Atrazine 50% WP @ 0.5 kg a.i., ha^{-1} (tank mix) as early post emergence (EPoE) recorded significantly lower density of total weeds (4.91, 5.46 and 5.17 m^{-2} at 20, 40 and 60 DAHA, respectively) and was on par with Topramezone 33.6% SC @ 30.24 g a.i., ha^{-1} alone as EPoE (5.37, 5.88 and 5.78 m^{-2} at 20, 40 and 60 DAHA,

Table 1. Total weed density in sugarcane as influenced by herbicide treatments

Tr. No.	Treatment	Total weed density m^{-2}			
		Pre-spray	20 DAHA	40 DAHA	60 DAHA
T_1	Tembotrione 42% SC @ 50.4 g a.i., ha^{-1} as EPoE (at 2-3 leaf stage of weeds)	7.13* (50.33)	6.49 (41.67)	7.05 (49.33)	6.54 (42.33)
T_2	Topramezone 33.6% SC @ 30.24 g a.i., ha^{-1} as EPoE (at 2-3 leaf stage of weeds)	6.89 (47.00)	5.37 (28.33)	5.88 (34.33)	5.78 (33.00)
T_3	Ametryne 80 % WDG @ 2.0 kg a.i., ha^{-1} as EPoE (at 2-3 leaf stage of weeds)	7.35 (53.67)	7.25 (52.00)	7.70 (59.33)	7.45 (55.00)
T_4	T_1 + Atrazine 50% WP @ 0.5 kg a.i., ha^{-1} (tank mix) as EPoE (at 2-3 leaf stage of weeds)	6.86 (46.67)	5.78 (33.00)	6.47 (41.33)	6.04 (36.00)
T_5	T_2 + Atrazine 50% WP @ 0.5 kg a.i., ha^{-1} (tank mix) as EPoE (at 2-3 leaf stage of weeds)	7.40 (54.33)	4.91 (23.67)	5.46 (29.33)	5.17 (26.33)
T_6	T_3 + Atrazine 50% WP @ 0.5 kg a.i., ha^{-1} (tank mix) as EPoE (at 2-3 leaf stage of weeds)	7.34 (53.67)	6.91 (47.33)	7.38 (54.00)	7.03 (49.00)
T_7	Atrazine 50% WP @1.25 kg a.i., ha^{-1} (PE) followed by 2-4 D Na Salt 80% WP @ 2.0 kg a.i., ha^{-1} as (PoE) at 60 DAP (RPP)	5.84 (33.67)	6.26 (38.67)	6.77 (45.67)	6.62 (43.33)
T_8	Weed free check	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
T_9	Weedy check	7.08 (49.67)	8.27 (68.00)	8.93 (79.33)	8.70 (75.33)
	S. Em. ±	0.12	0.17	0.27	0.13
	C. D. (P = 0.05)	0.37	0.50	0.82	0.38

*Transformed values ($\sqrt{x+0.5}$).Figures in the parentheses indicate original values.

SC- Suspension concentrates EPoE- Early post emergence WDG- Water dispersible granules
PE- Pre emergence WP- Wettable powder PoE- Post emergence
DAP- Days after planting RPP- Recommended package of practice DAHA- Days after herbicide application

respectively) (Table1). This was mainly due to tank mix application of herbicides, which act as a broad spectrum weed management. The treatment receiving herbicide tank mixture of Topramezone 33.6% SC @ 30.24 g a.i., ha^{-1} + Atrazine 50% WP @ 0.5 kg a.i., ha^{-1} as early post emergence managed grassy weeds, sedges and broadleaved weeds effectively.The results corroborated with the finding of Lakshmi and Luther (2017).

Dry weight of weeds varied markedly with respect to different weed management practices. Amongst herbicide applied treatments, Topramezone 33.6% SC @ 30.24 g a.i., ha^{-1} + Atrazine 50% WP @ 0.5 kg a.i., ha^{-1} (tank mix) as early post emergence (EPoE) recorded significantly lower dry weight of weeds (2.24, 2.94 and 3.87 g m^{-2} at 20, 40 and 60 DAHA, respectively) and was on par with Topramezone 33.6% SC @ 30.24 g a.i., ha^{-1} alone as EPoE (2.57, 3.31 and 4.32 g m^{-2} at 20, 40 and 60 DAHA, respectively) (Table 2). This might be due to tank mix application of Topramezone + Atrazine which was effective against broadleaved weeds, grasses and alsosedges to some extent and performed better than their sole application. As Topramezone controls grassy and broadleaved weeds and Atrazine controls the broadleaved and sedges effectively, achieved a broad spectrum weed management. The lower weed dry weight 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. These results were in agreement with Waghmare *et al.* (2018) and Soltani *et al*. (2012). (Table 2).

Weed control index (%) varied markedly with respect to different weed management practices. Weed free check treatment recorded hundred per cent weed control index due to timely removal of weeds. Among the herbicide applied treatments, Topramezone 33.6% SC @ 30.24 g a.i., ha^{-1} + Atrazine 50% WP @ 0.5 kg a.i., ha^{-1} (tank mix) as early post emergence (EPoE) recorded significantly higher weed control index (84.42, 81.17 and 76.29 % at 20, 40 and 60 DAHA, respectively) and was on par with Topramezone 33.6% SC @ 30.24 g a.i., ha^{-1} alone as EPoE (78.89, 75.89 and 70.31 % at 20, 40 and 60 DAHA, respectively) (Table 3). This was mainly due to reduced weed density and weed dry matter under the effect of combined herbicide application at proper growth stage. Results obtained were in close conformity with the findings of Swetha *et al.* (2015).

Weed index (WI) differed significantly due to different herbicide treatments in sugarcane. Weed free check was significantly lower over rest of the treatments. Weedy check recorded markedly higher WI (37.98 %) compared to rest all treatments. Among the herbicide applied treatments, Topramezone 33.6% SC @ 30.24 g a.i., ha^{-1} + Atrazine 50%WP @ 0.5 kg a.i., ha^{-1} (tank mix) as early post emergence (EPoE) recorded significantly least WI (3.17 %). It was followed by Topramezone 33.6% SC @ 30.24 g a.i., ha^{-1} alone as EPoE (7.46 %). However, Tembotrione 42% SC @ 50.4 g a.i., ha^{-1} alone as EPoE (16.56 %) and Tembotrione 42 % SC @ 50.4 g a.i., + Atrazine 50% WP @ 0.5 kg a.i., ha^{-1} (tank mix) as EPoE (12.75 %) were on par with recommended package of practice (15.16 %) (Table 3). This was mainly due to better control of weeds which ultimately recorded higher cane yields. The results

Table 2. Total weed dry weight in sugarcane as influenced by herbicide treatments

Tr. No.	Treatment	Total weed dry weight (g m^{-2})			
		Pre- spray	20 DAHA	40 DAHA	60 DAHA
T_1	Tembotrione 42% SC @ 50.4 g a.i., ha^{-1} as EPoE (at 2-3 leaf stage of weeds)	2.83* (7.50)	3.46 (11.47)	4.38 (18.67)	5.36 (28.23)
T_2	Topramezone 33.6% SC @ 30.24 g a.i., ha^{-1} as EPoE (at 2-3 leaf stage of weeds)	2.77 (7.20)	2.57 (6.13)	3.31 (10.48)	4.32 (18.17)
T_3	Ametryne 80 % WDG @ 2.0 kg a.i., ha^{-1} as EPoE (at 2-3 leaf stage of weeds)	2.98 (8.42)	3.79 (13.88)	4.79 (22.40)	5.84 (33.57)
T_4	T_1 + Atrazine 50% WP @ 0.5 kg a.i., ha^{-1} (tank mix) as EPoE (at 2-3 leaf stage of weeds)	2.93 (8.12)	3.34 (10.67)	4.22 (17.33)	5.10 (25.47)
T_5	T_2 + Atrazine 50% WP @ 0.5 kg a.i., ha^{-1} (tank mix) as EPoE (at 2-3 leaf stage of weeds)	2.88 (7.85)	2.24 (4.53)	2.94 (8.17)	3.87 (14.47)
T_6	T_3 + Atrazine 50% WP @ 0.5 kg a.i., ha^{-1} (tank mix) as EPoE (at 2-3 leaf stage of weeds)	2.91 (7.98)	3.67 (13.00)	4.68 (21.43)	5.69 (31.93)
T_7	Atrazine 50% WP @1.25 kg a.i., ha^{-1} (PE) followed by 2-4 D Na Salt 80% WP @ 2.0 kg a.i., ha^{-1} as (PoE) at 60 DAP (RPP)	2.31 (4.87)	3.44 (11.33)	4.23 (17.37)	5.21 (26.67)
T_8	Weed free check	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
T_9	Weedy check	2.91 (8.00)	5.45 (29.20)	6.64 (43.57)	7.86 (61.30)
	S. Em. ±	0.10	0.08	0.08	0.09
	C. D. (P = 0.05)	0.29	0.24	0.24	0.26

*Transformed values ($\sqrt{x+0.5}$).Figures in the parentheses indicate original values.

SC- Suspension concentrates EPoE- Early post emergence WDG- Water dispersible granules
PE- Pre emergence WP- Wettable powder PoE- Post emergence
DAP- Days after planting RPP- Recommended package of practice DAHA- Days after herbicide application

were in conformity with the findings of Satyendra *et al*. (2018), Vikram *et al.* (2017) and Swetha *et al.* (2015). Ametryne 80 % WDG @ 2.0 kg a.i., ha^{-1} alone as EPoE recorded significantly higher WI (19.68 %) compared to other herbicide treatments.

Effect of early post emergence herbicides on yield and yield parameters of sugarcane

Yield and yield attributes varied markedly with respect to different weed management practices. Weed free check recorded significantly higher number of millable canes (91443 ha^{-1}), millable cane height (220.67 cm), single cane weight (1.86 kg) and cane yield (138.50 t ha^{-1}). This was due to weed free condition prevailed throughout (Table 4). The increase in yield might have been attributed to effective suppression of weeds and improved soil physical condition with hand weeded treatment. Similar findings were reported by Singh and Rana (2004). Among the herbicide applied treatments, Topramezone 33.6% SC @ 30.24 g a.i., ha^{-1} + Atrazine 50% WP @ 0.5 kg a.i., ha^{-1} (tank mix) as early post

Table 3. Total weed control index (WCI) and weed index in sugarcane as influenced by herbicide treatments

Tr. No.	Treatment	Total WCI (%)			Weed
		20DAHA	40 DAHA	60 DAHA	index (%)
T_1	Tembotrione 42% SC @ 50.4 g a.i., ha^{-1} as EPoE (at 2-3 leaf stage of weeds)	60.57	57.08	53.67	16.56
T_2	Topramezone 33.6% SC @ 30.24 g a.i., ha^{-1} as EPoE (at 2-3 leaf stage of weeds)	78.89	75.89	70.31	7.46
T_3	Ametryne 80 % WDG @ 2.0 kg a.i., ha^{-1} as EPoE (at 2-3 leaf stage of weeds)	52.40	48.45	45.04	19.68
T_4	T_1 + Atrazine 50% WP @ 0.5 kg a.i., ha^{-1} (tank mix) as EPoE (at 2-3 leaf stage of weeds)	63.41	60.23	58.16	12.75
T_5	T_2 + Atrazine 50% WP @ 0.5 kg a.i., ha^{-1} (tank mix) as EPoE (at 2-3 leaf stage of weeds)	84.42	81.17	76.29	3.17
T_6	T_3 + Atrazine 50% WP @ 0.5 kg a.i., ha^{-1} (tank mix) as EPoE (at 2-3 leaf stage of weeds)	55.34	50.84	47.85	18.74
T_7	Atrazine 50% WP @1.25 kg a.i., ha^{-1} (PE) followed by 2-4 D Na Salt 80% WP @ 2.0 kg a.i., ha^{-1} as (PoE) at 60 DAP (RPP)	61.28	60.07	56.28	15.16
T_8	Weed free check	100.00	100.00	100.00	0.00
T_9	Weedy check	0.00	0.00	0.00	37.98
	S. Em. ±	1.67	1.30	1.31	1.19
	C. D. (P = 0.05)	5.00	3.89	3.94	3.57

SC- Suspension concentrates EPoE- Early post emergence WDG- Water dispersible granules
PE- Pre emergence WP- Wettable powder PoE- Post emergence
DAP- Days after planting RPP- Recommended package of practice DAHA- Days after herbicide application

Table 4. Yield and yield parameters of sugarcane as influenced by herbicide treatments

Tr. No.	Treatment	NMC (ha^{-1})	Millable cane height (cm)	Single cane weight (kg)	Cane yield (t ha^{-1})
T_1	Tembotrione 42% SC @ 50.4 g a.i., ha^{-1} as EPoE (at 2-3 leaf stage of weeds)	82620	195.3	1.6	115.6
T_2	Topramezone 33.6% SC @ 30.24 g a.i., ha^{-1} as EPoE (at 2-3 leaf stage of weeds)	85813	214.0	1.7	128.1
T_3	Ametryne 80 % WDG @ 2.0 kg a.i., ha^{-1} as EPoE (at 2-3 leaf stage of weeds)	81392	180.0	1.4	111.2
T_4	T_1 + Atrazine 50% WP @ 0.5 kg a.i., ha^{-1} (tank mix) as EPoE (at 2-3 leaf stage of weeds)	83510	209.0	1.7	120.8
T_5	T_2 + Atrazine 50% WP @ 0.5 kg a.i., ha^{-1} (tank mix) as EPoE (at 2-3 leaf stage of weeds)	89693	215.3	1.8	134.1
T_6	T_3 + Atrazine 50% WP @ 0.5 kg a.i., ha^{-1} (tank mix) as EPoE (at 2-3 leaf stage of weeds)	82232	184.0	1.5	112.5
T_7	Atrazine 50% WP @1.25 kg a.i., ha^{-1} (PE) followed by 2-4 D Na Salt 80% WP @ 2.0 kg a.i., ha^{-1} as (PoE) at 60 DAP (RPP)	84578	204.3	1.6	117.5
T_8	Weed free check	91443	220.6	1.8	138.5
T_9	Weedy check	54464	149.0	1.2	85.9
	S. Em. ±	1650	3.4	0.0	2.5
	C. D. (P = 0.05)	4940	10.1	0.1	7.5

SC- Suspension concentrates EPoE- Early post emergence WDG- Water dispersible granules
PE- Pre emergence WP- Wettable powder PoE- Post emergence
DAP- Days after planting RPP- Recommended package of practice

Table 5. Economic parameters of sugarcane cultivation as influenced by herbicide treatments

Tr. No.	Treatment	Cost of cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C ratio
T_1	Tembotrione 42% SC @ 50.4 g a.i., ha^{-1} as EPoE (at 2-3 leaf stage of weeds)	138939	317900	178961	2.2
T_2	Topramezone 33.6% SC @ 30.24 g a.i., ha^{-1} as EPoE (at 2-3 leaf stage of weeds)	141961	352458	210497	2.4
T_3	Ametryne 80 % WDG @ 2.0 kg a.i., ha^{-1} as EPoE (at 2-3 leaf stage of weeds)	135206	305845	170639	2.2
T_4	T_1 + Atrazine 50% WP @ 0.5 kg a.i., ha^{-1} (tank mix) as EPoE (at 2-3 leaf stage of weeds)	140564	332337	191773	2.3
T_5	T_2 + Atrazine 50% WP @ 0.5 kg a.i., ha^{-1} (tank mix) as EPoE (at 2-3 leaf stage of weeds)	143736	368775	225038	2.5
T_6	T_3 + Atrazine 50% WP @ 0.5 kg a.i., ha^{-1} (tank mix) as EPoE (at 2-3 leaf stage of weeds)	135849	309485	173636	2.2
T_7	Atrazine 50% WP @1.25 kg a.i., ha^{-1} (PE) followed by 2-4 D Na Salt 80% WP @ 2.0 kg a.i., ha^{-1} as (PoE) at 60 DAP (RPP)	135514	323125	187611	2.3
T_8	Weed free check	151314	380875	229561	2.5
T_9	Weedy check	126164	236230	110063	1.8
	S. Em. ±	-	6960	6960	0.03
	C. D. (P = 0.05)	-	20850	20850	0.1

SC- Suspension concentrates EPoE- Early post emergence WDG- Water dispersible granules
PE- Pre emergence WP- Wettable powder PoE- Post emergence
DAP- Days after planting RPP- Recommended package of practice

emergence recorded significantly higher number of millable canes (89693 ha^{-1}), cane height (215.33 cm), single cane weight (1.82 kg) and cane yield (134.10 t ha^{-1}) and was on par with Topramezone 33.6% SC @ 30.24 g a.i., ha^{-1} alone as EPoE application (85813 ha^{-1}, 214.0 cm, 1.79 kg and 128.17 t ha^{-1}, respectively) (Table 4). This might be due to less weed competition for resources, *viz.*, space, light, moisture, and nutrients. Crop grown with any of the weed management treatments recorded heavier cane weight compared to untreated check. These results were in conformity with the findings of Srivastava and Chauhan (2006). The increase in cane yield might be due to Topramezone and Atrazine (tank mix) controlled the weeds more efficiently (84.42 % WCI) and reduced the competition by weeds to a greater extent leading to faster growth and development of sugarcane crop resulting in higher value for all the yield attributing characters.

Effect of early post emergence herbicides one conomics of sugarcane cultivation

Weed free check recorded significantly higher cost of cultivation (₹ 151314 ha^{-1}), gross returns (₹ 380875 ha^{-1}) and net returns (₹ 229561 ha^{-1}). However, significantly higher BC ratio (2.57) was recorded with Topramezone 33.6% SC @ 3 0.24 g a.i., ha^{-1} + Atrazine 50 % WP @ 0.5 kg a.i., ha^{-1} (tank mix) as early post emergence application (T_5). The, T_5 was on par with weed free check for gross returns, net returns and benefit cost ratio. Higher cost of cultivation with weed free check was due to higher investment on labour for fulfilling the treatment requirement. Among the herbicide applied treatments, Topramezone 33.6 % SC @ 30.24 g a.i., ha^{-1} + Atrazine 50 %WP @ 0.5 kg a.i., ha^{-1} (tank mix) as early post emergence recorded higher cost of cultivation (₹ 143736 ha^{-1}), gross returns (₹ 368775 ha^{-1}), net returns (₹ 225038 ha^{-1}) and BC ratio (2.57) (Table 5). This might be due to higher weed control index and higher yield of sugarcane. The similar observation was made by Tiwari *et al*. (2018) and Swetha *et al*. (2015).

Conclusion

With the results obtained in the trial, it was concluded that tank mix herbicides application of Topramezone 33.6% SC @ 30.24 g a.i., ha^{-1} + Atrazine 50% WP @ 0.5 kg a.i., ha^{-1} as early post emergence (EPoE) application found effective in sugarcane with lower weed density at 60 days after herbicide application, weed dry weight and higher weed control index resulting into higher number of millable canes , single cane weight , cane yield and net returns.

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