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Research Article

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Evaluation of Different Herbicides against Complex Weed Flora in Spring Planted Sugarcane

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ABSTRACT

The present study entitled "Evaluation of different herbicides against complex weed flora in spring planted sugarcane" was carried out during 2018-19 at Regional Research Station, Karnal of CCS Haryana Agricultural University, Haryana, India. The experiment was laid out in randomized complete block design with three replications in order to evaluate the effect of different herbicides on weed, growth and yield of sugarcane and to observe the phytotoxicity (if any) of different herbicides on sugarcane crop. The experiment was conducted on sugarcane variety CoH 167 with eighteen weed control treatments. The treatments were metribuzin 1.0 kg ha^{-1} PRE (T_1), metribuzin + halosulfuron 67.5 g ha^{-1} (TM) PRE (T_2), atrazine 2.0 kg ha^{-1} PRE (T_3), atrazine + halosulfuron (TM) PRE (T_4), metribuzin + halosulfuron PoE at 40 DAP (T_5), atrazine + halosulfuron PoE at 40 DAP (T_6), metribuzin PRE fb halosulfuron PoE 40 DAP (T_7), atrazine PRE fb halosulfuron PoE (T_8), sulfentrazone 720 g ha^{-1} PRE fb hoeing at 45 DAP fb 2,4-D ester 1.0 kg ha^{-1} at 60 DAP (T_9), sulfentrazone 720 g ha^{-1} PRE fb hoeing at 45 DAP fb almix 4g ha^{-1} at 60 DAP (T_{10}), atrazine PRE fb 2,4-D ester at 60 DAP (T_{11}), hoeing after first irrigation fb atrazine after second irrigation (T_{12}), glyphosate 1680 g ha^{-1} + metribuzin + surfactant (TM) at 15 DAP EPoE (T_{13}), atrazine PRE fb metsulfuron + carfentrazone 25 g ha^{-1} PoE at 60 DAP (T_{14}), atrazine PRE fb hoeing at 45 DAP fb topramezone 25 g ha^{-1} PoE at 60 DAP (T_{15}), paraquat EPoE 15 DAP fb atrazine PoE at 60 DAP (T_{16}), Three hoeing at 30, 60 and 90 DAP (T_{17}) and unweeded control (T_{18}).

The major weed flora recorded in the experimental field were Cyperus rotundus, Dactyloctenium aegyptium, Echinochloa colona, Brachiaria reptans, Amaranthus viridis, Portulaca oleracea, Convolvulus arvensis, Euphorbia microphylla and Ipomoea purpurea. Cyperus rotundus was the major weed constitutes 89.4 to 92% weed density at different stages of crop growth. The treatments metribuzin + halosulfuron (TM) PoE (T_5), metribuzin PRE fb halosulfuron PoE (T_7), atrazine PRE fb halosulfuron PoE (T_8), sulfentrazone as PRE fb hoeing at 45 days fb 2,4-D at 60 DAP (T_9) gave the excellent control of complex weed flora of sugarcane and hence, higher weed control efficiency (%) and per cent weed control was recorded from these treatments compared to rest of the treatments. None of the applied weed control treatments affect germination of the crop at 20 and 40 DAP. Among all the treatments maximum cane yield was obtained from three hoeing treatment -T_{17} (92.9 t ha^{-1}) and among herbicidal treatment T_5 (91.6 t ha^{-1}), T_7 (90.8 t ha^{-1}) were recorded with higher yield and benefit cost ratio. None of the applied herbicide alone, in combination and in sequence had any phytotoxic effect on sugarcane plant crop, except metsulfuron + carfentrazone (T_{14}).

Keywords: *Sugarcane, Halosulfuron methyl, Metribuzin, Atrazine, Sulfentrazone, Phytotoxicity, Weed control efficiency, % weed control, Cane yield*

INTRODUCTION

Sugarcane (*Saccharum* species complex hybrid) is a major crop of tropical and sub-tropical region and grown in more than 105 countries worldwide. It belongs to genus *Saccharum* L. in the Poaceae family. In India, sugarcane was grown on an area of about 4.73 million hectares with average productivity of 79.68 t ha^{-1} during 2018. Among the states, Uttar Pradesh ranks first both in area (2.39 mha) as well as in cane production (177.05 mt) while Kerala tops in terms of productivity (112.91 t ha^{-1}). Maharashtra has highest sugar recovery (11.25 per cent) while national average is 10.73 per cent. In Haryana during 2018, area, productivity and sugar recovery were 1.14 lakh ha, 84.50 t ha^{-1} and 10.25 per cent, respectively (Co-operative Sugar, 2019).

The average productivity of sugarcane is low in India (79.68 t ha^{-1}) compared with other countries like Egypt (121.14 t ha^{-1}) and Colombia (100.42 t ha^{-1}) and there is wide gap in actual and potential yield of sugarcane among the Indian states also. To achieve the production of 600 million tonnes by 2030 considering that a maximum of about 5.5 mha of land would be available for cane cultivation, increasing the yield to around 110 t ha^{-1} *i.e.* an increase of 57.1% over the current level is required (Sundara, 2011). Effective weed management is among one of the most proven and promising technique which can help to improve yield substantially. Sugarcane requires comparatively longer period (up to 60 days) for germination, its wider row spacing, slow initial growth and lateral spread, heavy fertilization and frequent irrigations provide favourable conditions for weed infestation. Hence, weeds germinate before the crop and affects germination, yield and quality of crop. It was reported by several researchers that yield reduction due to weed infestation ranges from 10 per cent to total crop failure (Srivastava & Chauhan, 2002) and this yield loss depends upon nature, intensity and duration of weed infestation during crop life cycle. Weed infestation reduces tonnage in the field, ratoon crop life cycle and sucrose recovery in the mills (Kathiresan et al., 2004).

Due to the variations in selectivity of herbicides, the species composition also influences and may increase or decrease, like due to continuous use of standard herbicides (atrazine, metribuzin and 2, 4-D) in sugarcane field, the population of broad leaved weeds has decreased whereas the population of *Cyperus* species (sedge) has increased tremendously. *C. rotundus* population has been reported to be 60-80% of total weed flora in sugarcane fields in India (Raskar, 2004). Standard herbicides used in sugarcane, applied as pre or post-emergence are mostly ineffective against it. Hence to control *Cyperus* we have to rely on chemicals with different mode of action. Halosulfuron and sulfentrazone-protoporphyrinogen oxidase inhibitors are currently labelled for use in sugarcane for the control of *Cyperus* species (Anonymous, 2009). In sugarcane mainly triazines group of herbicides are commonly used as pre-emergence herbicides, hence the late-emerged weeds and sedges are left uncontrolled with the application of these herbicides. In this context, there is need to evaluate new pre and post-emergence herbicides and the sequential application of these herbicides with different mode of action for the effective management of complex weed flora in sugarcane is required.

MATERIALS AND METHODS

The field experiment was conducted at Regional Research Station, CCS Haryana Agricultural University, Karnal during the year 2018–2019. Experimental site is located at longitude of 76°58′ East with a latitude of 29°43′ N at 245 m above mean sea level.

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The soil of the experimental field was clay loam (53.3% sand, 22% silt and 24.7% clay) in texture and slightly alkaline in reaction (pH-8.0) with EC-0.40 dsm^{-1}. Soil was low in available nitrogen (157 kg ha^{-1}), medium in available phosphorus (9.72 kg ha^{-1}) and potash (181 kg ha^{-1}). The experimental site has semi-arid subtropical climate with hot days accompanied with dry winds during summer (April to June) and severe cold winter months (December to first week of February). During the crop growth season weekly average maximum and minimum temperature values ranges from 42.6 ^{o}C (21st-27th May) to 3.1 ^{o}C (24th-30th December). The crop received 1270.3 mm of total rainfall during crop growth period, out of which 106.6 mm during the pre-monsoon, 813.1 mm during monsoon and 350.6 mm during post-monsoon season. Highest rainfall was recorded during 30th week (23rd - 29th July) of the crop season and no rainfall was received during winter months except 50th week (10th- 16th December). In nutshell there was a large variation in weather parameters during different stages of crop growth.

The experiment was conducted on sugarcane variety CoH 167 in randomized complete block design with total eighteen weed control treatments and three replications. Detail of applied weed control treatments is given in Table 1. Half ridge irrigation method was adopted for the planting of crop at 75 cm row to row spacing. This planting method was adopted to ensure continuous moisture supply during the germinating period. It involves the following sequence of practices *i.e.* opening of furrows in dry condition, applying fertilizers in furrows, putting two budded setts in furrows, covering the setts with one inch of soil, irrigation up to half of the ridge and followed by planking 3-4 days after irrigation (working condition).

A quadrate of size 0.5 m x 0.5 m (0.25 m^2) was placed two times in each plot and the weeds within the frame were counted and recorded. The densities of grasses, sedges and broad leaved weeds and total weeds were recorded separately at 75 and 105 DAP of the crop. Collected weeds from different treatments first dried in sunlight and then placed in oven at 70^{o}C for 72 hours till the constant weight was recorded. Dry weight of grasses, sedges and broadleaved weeds were recorded separately at both observations. The individual dry weights were summed up to obtain total weed dry weight (g m^{-2}) from that particular treatment. Weed index and weed control efficiency were calculated using the standard formula given by Gill and Kumar (1969) and Mani et al. (1972), respectively. For the studies of the crop growth parameters out of planted ten rows of sugarcane, central rows in each plot were used to take the growth observations of the crop in order to avoid any possible border effect.

Table 1: Details of applied weed control treatments

Tr. No.	Treatments	Dose (g ha^{-1})	Time of application
T_1	Metribuzin	1000	PRE
T_2	Metribuzin + halosulfuron methyl (TM)	1000 + 67.5	PRE
T_3	Atrazine	2000	PRE
T_4	Atrazine + halosulfuron (TM)	2000 + 67.5	PRE
T_5	Metribuzin + halosulfuron (TM)	1000 + 67.5	PoE 40 DAP
T_6	Atrazine + halosulfuron (TM)	2000 + 67.5	PoE 40 DAP
T_7	Metribuzin *fb* halosulfuron	1000 *fb* 67.5	PRE *fb* 40 DAP-PoE
T_8	Atrazine *fb* halosulfuron	2000 *fb* 67.5	PRE *fb* 40 DAP-PoE
T_9	Sulfentrazone *fb* hoeing *fb* 2,4-D Ester	720 *fb* 1000	PRE *fb* 45 DAP *fb* 60 DAP-PoE
T_{10}	Sulfentrazone *fb* hoeing *fb* almix	720 *fb* 4	PRE *fb* 45 DAP *fb 60* DAP-PoE
T_{11}	Atrazine *fb* 2,4-D Ester	2000 *fb* 1000	PRE *fb* 60 DAP-PoE
T_{12}	Hoeing after first irrigation *fb* atrazine after second irrigation	2000	PoE to Sugarcane but PRE to weeds
T_{13}	Glyphosate (41% SL) + metribuzin + surfactant (1%)- (TM)	1680 + 1000	15 DAP-EPoE
T_{14}	Atrazine *fb* metsulfuron + carfentrazone (RM)	2000 *fb* 25	PRE *fb* PoE-60 DAP
T_{15}	Atrazine *fb* hoeing *fb* topramezone	2000 *fb* 25	PRE *fb* 45 DAP *fb* 60 DAP-PoE
T_{16}	Paraquat *fb* atrazine	800 *fb* 2000	15 DAP-EPoE *fb* 60 DAP-PoE
T_{17}	Three hoeing	-	30, 60 and 90 DAP
T_{18}	Unweeded (Control)	-	-

DAP = Days after Planting, PRE = Pre-emergence, PoE = Post-emergence, EPoE = Early post- emergence, *fb*= Followed by, TM = Tank mix, RM = Ready mix

RESULTS AND DISCUSSION

Weed density

The major weeds recorded from experimental field at both stages of observations were *Cyperus rotundus* among sedges, *Brachiaria reptans. Dactyloctenium aegypticum, Echinochloa colona* among grasses and *Portulaca oleracea, Convolvulus arvensis, Euphorbia microphylla, Ipomoea purpurea* and *Digera arvensis* among broad leaved weeds. *Cyperus rotundus* was the only sedge recorded in the field and contributes maximum weed composition per cent at all stages of recorded observations ranges from 92.0 per cent at 75 DAP to 89.4 per cent at 105 DAP. While the grassy weed composition was 4.6 per cent at 75 DAP, which increases to 6.1 per cent at 105 DAP. The broad leaves weeds varied in between range of 3.4 to 4.5 per cent at 75 to 105 days after planting, respectively. Weed composition per cent of sedges slightly decreases with time while it increases for grassy and broad leaved weeds. Similar weed flora in sugarcane field has been also reported by Raskar (2004), Suganthi (2013) and Chand et al. (2014).

The data manifested about the weed density as affected by different weed control treatments at 75 and 105 days after planting of the crop is given in Table 2. It shows that all the weed control treatments significantly affected the weed count and hence, lower weed density was recorded in these treatments as compared to weedy check (T_{18}). The maximum control of weeds at both stages of observations was recorded from T_5 - metribuzin + halosulfuron (TM) PoE 40 DAP (14.7 and 23.1 weeds m^{-2}) followed by in T_7 - metribuzin PRE *fb* halosulfuron as PoE, 40 DAP (18.8 and 21.7 weeds m^{-2}). Combination of atrazine along with halosulfuron methyl also effectively controls the weeds count like in T_8 - atrazine as PRE *fb* halosulfuron as PoE at 45 DAP of crop (19.6 and 29.3 weeds m^{-2}) and T_6 - atrazine + halosulfuron as PoE at 40 DAP (25.8 and 38.2 weeds m^{-2}). Weed density in T_9 / T_{10} - Sulfentrazone as PRE *fb* hoeing at 45 DAP and 2, 4-D Ester / almix at 60 DAP were comparatively higher (44.7/ 46.7 weeds m^{-2}) at both stages of observation because of poor control of sedges due to hoeing operation done at 45 days. The weed density in the pre-emergence applied herbicides (T_1 to T_4) was found comparatively higher because of decrease in efficacy of the herbicides with time. Similarly, the highest weed density was recorded in T_{18} (178.8 and 181.5 weeds m^{-2}). Hoeing operations were not effective in controlling the density of sedges. Hence, higher weed count was recorded in T_{17}- three hoeing treatment (153.1 and 164 weeds m^{-2}). Application of halosulfuron methyl as PRE or PoE (40 DAP) effectively controls the *Cyperus rotundus* (sedge) at 75 and 105 DAP resulting in lower total weed density. Application of metribuzin along with halosulfuron methyl was comparatively more effective in controlling the weed flora of sugarcane than atrazine + halosulfuron methyl combination both at pre and post-emergence stages. These results were found in conformity with the findings of Chand et al. (2014) and Singh et al. (2017).

Weed dry matter accumulation, weed control efficiency and weed index

After perusal of data manifested in Table 3, it was found that the lowest weed dry weight was recorded at 75 and 105 DAP in T_5 - metribuzin at 1.0 kg ha^{-1} + halosulfuron at 67.5 g ha^{-1} PoE at 40 DAP (5.2 g m^{-2} and 17 g m^{-2}) followed by in T_7 – metribuzin PRE *fb* halosulfuron at 40 DAP (9.2 g m^{-2} and 22 g m^{-2}) and during both stages of observations highest weed dry weight was recorded from the control plot - T_{18} (136.8 g m^{-2} and 148.1 g m^{-2}).Three hoeing was not effective in reducing the total dry weight of weeds due to rapid regeneration of weeds.

As the weed control efficiency is concerned the highest WCE was recorded in

T_5 (96.1 and 88.5%) followed by in T_7 (92.4 and 84.2%). While the minimum WCE was recorded from T_3 – atrazine applied at pre-emergence (16.4 and 9.8%). T_2, T_6 and T_8 also gives higher WCE (>75%) also from these treatments higher % weed control data was recorded.

Weed index was found lowest in T_5 (1.41%) followed by in T_7 (2.31%). The maximum weed index recorded from T_{18} - unweeded control treatment (55.5%) which shows that the maximum loss to yield due to weeds occurs in this treatment. Among different herbicides, maximum yield loss was recorded from T_3 - atrazine at 2.0 kg ha^{-1} (29.5%) followed by in T_{14} - atrazine at 2.0 kg ha^{-1} *fb* metsulfuron + carfentrazone (RM) at 25 g ha^{-1} (28.9%) and closely followed by T_{16} - paraquat *fb* atrazine (28.7%).

Yield attributes and yield

Germination per cent is the base for deciding the potential yield of a crop. The data pertaining to germination per cent (Table 4) indicate that about 11 to 40 per cent germination was recorded at 20 DAP and 40 DAP, respectively. There was uniform germination in all the treatments. None of the pre germinated applied weed control treatments impose any adverse effect on the germination per cent of the crop both at 20 and 40 days. Hence the result of germination per cent were found non-significant with the applied weed control treatments.

Highest and lowest NMCs were recorded in T_{17} - three hoeing at 30, 60 and 90 DAP (1,04,000 ha^{-1}) and T_{18} - unweeded control (74,200 ha^{-1}). Among different herbicides lowest NMCs were recorded in T_{16} - paraquat as EPoE *fb* atrazine as PoE (81,500 ha^{-1}). T_2 (84,900 ha^{-1}), T_5 (91,600 ha^{-1}), T_7 (90,800 ha^{-1}) and T_{17} (92,900 ha^{-1}) being at par recorded significantly higher NMCs as compared to rest of the treatments.

The highest and lowest cane yield was recorded in T_{17} (92.9 t ha^{-1}) and T_{18} (40.7 t ha^{-1}), respectively. All the weed control treatments exhibited their superiority over the T_{18} control treatment (40.7 t ha^{-1}). T_5 (91.6 t ha^{-1}), T_7 (90.8 t ha^{-1}) and T_{17} (92.9 t ha^{-1}) being at par produced significantly highest cane yield among all the treatments. T_2 - metribuzin + halosulfuron PRE (84.9 t ha^{-1}), T_4 – atrazine + halosulfuron PRE (81.4 t ha^{-1}), T_8 - atrazine PRE *fb* halosulfuron PoE (84.9 t ha^{-1}), T_9 – sulfentrazone PRE *fb* hoeing *fb* 2, 4-D PoE (85.1 t ha^{-1}), T_{10} – sulfentrazone PRE *fb* hoeing *fb* almix PoE at 60 DAP (83.7 t ha^{-1}) were found at par with each other. These results were found in conformity with the findings of Singh et al. (2011) and Singh et al. (2017).

Phytotoxic effect

It is one of the important criteria for deciding the selectivity of a single herbicide, combination and sequential application of herbicides. Data on visual phytotoxicity at 7, 15, and 25 days after application on sugarcane crop showed that none of herbicides alone or in combination caused phytotoxicity to sugarcane crop except T_{14} - PoE application of metsulfuron methyl + carfentrazone which causes moderate phytotoxicity on sugarcane crop. Moderate phytotoxicity of scale 4 (moderate injury, recovery possible) of metsulfuron methyl + carfentrazone was recorded at 7 and 15 days after application of above said herbicide in T_{14}. Etheredge et al. (2010), Suganthi et al. (2013) and Chand et al. (2014) also did not observe any reduction in sugarcane growth later in the growing season and any injury to the crop due to application of halosulfuron methyl.

Table 2: Effect of different weed control treatments on density (No. m^{-2}) and % weed control at 75 and 105 DAP of crop

Treatment Number	Density (No. m^{-2}) of weeds at 75 DAP				Density (No. m^{-2}) of weeds at 105 DAP				% Weed Control	
	Sedges	Grassy	BLW's	Total weeds	Sedges	Grassy	BLW's	Total weeds	75 DAP	105 DAP
T_1	12.50 (155.3)	2.68 (6.2)	2.52 (5.4)	12.95 (166.9)	12.40 (153.0)	2.51 (5.3)	2.36 (4.6)	12.80 (162.9)	8.04	8.88
T_2	6.65 (43.3)	2.32 (4.4)	2.45 (5.0)	7.32 (52.7)	6.07 (36.0)	2.14 (3.6)	2.3 (4.3)	6.69 (43.9)	70.96	75.44
T_3	12.75 (161.6)	2.84 (7.1)	2.87 (7.3)	13.29 (176.0)	12.61 (158.0)	2.71 (6.3)	2.75 (6.6)	13.11 (170.9)	3.03	4.39
T_4	6.93 (47.1)	2.98 (7.9)	2.82 (7.0)	7.93 (62.0)	6.55 (42.0)	2.67 (6.1)	2.40 (4.8)	7.34 (52.9)	65.84	70.39
T_5	3.71 (12.8)	2.81 (6.9)	2.09 (3.4)	4.91 (23.1)	3.31 (10.0)	2.12 (3.5)	1.48 (1.2)	3.96 (14.7)	87.26	91.76
T_6	4.34 (18.2)	3.55 (11.6)	3.06 (8.4)	6.4 (38.2)	3.90 (14.0)	2.79 (6.8)	2.44 (5.0)	5.10 (25.8)	78.29	85.56
T_7	3.94 (14.6)	3.08 (8.5)	2.56 (5.6)	4.75 (21.7)	3.31 (10.0)	2.17 (3.7)	2.46 (5.1)	4.45 (18.8)	82.87	89.46
T_8	3.97 (14.8)	3.14 (8.9)	2.99 (8.0)	5.50 (29.3)	3.60 (12.0)	2.38 (4.6)	1.90 (3.0)	4.80 (19.6)	81.60	87.15
T_9	6.59 (42.6)	2.37 (4.6)	2.18 (3.8)	7.21 (51.0)	6.39 (40.0)	2.03 (3.1)	1.61 (1.6)	6.46 (44.7)	71.86	74.98
T_{10}	6.72 (44.2)	2.42 (4.8)	2.27 (4.2)	7.36 (53.3)	6.55 (42.0)	2.03 (3.1)	1.61 (1.6)	6.90 (46.7)	70.63	73.85
T_{11}	12.53 (156.3)	3.09 (8.6)	1.83 (2.3)	12.95 (167.2)	12.28 (150.0)	2.75 (6.6)	1.42 (1.0)	12.59 (157.6)	7.83	11.84
T_{12}	12.61 (158.1)	2.21 (3.9)	1.76 (2.1)	12.84 (164.1)	12.37 (152.0)	2.03 (3.1)	1.49 (1.2)	12.53 (156.3)	9.59	12.56
T_{13}	8.85 (77.4)	2.68 (6.2)	1.72 (2)	9.31 (85.6)	8.18 (66.0)	2.57 (5.6)	1.52 (1.3)	8.59 (72.9)	52.84	59.21
T_{14}	12.53 (156.0)	3.13 (8.8)	1.41 (1)	12.91 (165.8)	12.2 (148.0)	2.61 (5.8)	1.38 (0.9)	12.47 (154.7)	8.65	13.45
T_{15}	12.49 (155.0)	1.67 (1.8)	1.51 (1.3)	12.60 (158.1)	12.2 (148.0)	1.54 (1.3)	1.38 (0.9)	12.29 (150.3)	12.89	15.93
T_{16}	12.24 (149.0)	2.30 (4.3)	2.03 (3.1)	12.54 (156.4)	11.95 (142.0)	2.16 (3.6)	1.81 (2.3)	12.20 (147.9)	13.83	17.24
T_{17}	12.60 (158.0)	1.81 (2.3)	2.17 (3.7)	12.83 (164.0)	12.28 (150.0)	1.67 (1.8)	1.52 (1.3)	12.40 (153.1)	9.64	14.36
T_{18}	12.77 (162.1)	3.01 (8.1)	3.50 (11.3)	13.50 (181.5)	12.69 (160.0)	3.02 (8.1)	3.41 (10.7)	13.41 (178.8)	0.00	0.00
SE(m) ±	0.12	0.04	0.05	0.21	0.12	0.04	0.04	0.18		
CD at 5%	0.36	0.12	0.14	0.60	0.35	0.13	0.12	0.53		

** Figures in the parenthesis are original values and these are subjected to square root transformation*

Table 3: Effect of different weed control treatments on dry weight (g m^{-2}) of weeds and weed control efficiency (%) at 75 and 105 DAP of crop

Treatment Number	Dry weight of weeds at 75 DAP				Dry weight of weeds at 105 DAP				Weed Control Efficiency (%)	
	Sedges	Grassy	BLW's	Total weeds	Sedges	Grassy	BLW's	Total weeds	75 DAP	105 DAP
T_1	10.24 (104.0)	3.06 (8.3)	2.47 (5.1)	10.88 (117.4)	9.78 (94.8)	1.69 (1.8)	2.60 (5.7)	10.16 (102.3)	20.7	25.0
T_2	4.79 (22.0)	2.61 (5.8)	2.40 (4.7)	5.80 (32.5)	3.16 (9.0)	1.51 (1.2)	2.50 (5.2)	4.07 (15.40)	78.0	88.6
T_3	10.82 (116.3)	3.33 (10.0)	2.86 (7.2)	11.60 (133.5)	10.17 (102.7)	1.91 (2.6)	3.15 (8.9)	10.73 (114.2)	9.8	16.4
T_4	5.60 (30.6)	3.42 (10.7)	2.80 (6.8)	7.01 (48.1)	3.58 (11.9)	1.89 (2.6)	2.73 (6.4)	4.68 (20.9)	67.4	84.6
T_5	2.57 (5.7)	3.02 (8.1)	2.06 (3.2)	4.24 (17.0)	1.86 (2.5)	1.49 (1.2)	1.57 (1.4)	2.49 (5.1)	88.5	96.1
T_6	2.98 (7.9)	4.07 (15.6)	3.01 (8.1)	5.70 (31.6)	2.22 (3.9)	2.01 (3.0)	2.80 (6.8)	3.81 (13.7)	77.2	89.8
T_7	2.72 (6.4)	3.35 (10.2)	2.54 (5.4)	4.6 (22.0)	1.89 (2.6)	1.54 (1.3)	2.56 (5.3)	3.21 (9.2)	84.2	92.4
T_8	2.74 (6.5)	3.47 (11.1)	2.97 (7.8)	4.90 (25.4)	2.05 (3.2)	1.71 (1.9)	2.52 (6.0)	3.54 (11.1)	82.2	89.4
T_9	5.43 (28.5)	2.78 (6.7)	1.95 (2.8)	6.24 (38.0)	4.35 (18.0)	1.43 (1.0)	1.79 (2.2)	4.72 (21.2)	74.3	84.4
T_{10}	5.53 (29.7)	2.83 (7.0)	2.04 (3.1)	6.40 (39.8)	4.49 (19.2)	1.4 3(1.0)	1.82 (2.3)	4.85 (22.5)	73.0	83.4
T_{11}	10.87 (117.3)	3.68 (12.5)	1.66 (1.7)	11.52 (132.9)	9.83 (96.0)	1.87 (2.5)	1.54 (1.3)	10.04 (99.8)	11.1	26.9
T_{12}	11.01 (120.4)	2.49 (5.2)	1.59 (1.5)	11.32 (127.1)	8.31 (68.1)	1.43 (1.0)	1.63 (1.6)	8.46 (70.7)	14.1	48.2
T_{13}	7.67 (58.0)	2.92 (7.5)	1.57 (1.4)	8.25 (66.9)	6.33 (39.2)	1.70 (1.9)	1.80 (2.2)	6.65 (43.3)	54.7	68.2
T_{14}	10.86 (117)	3.57 (11.7)	1.31 (0.7)	11.41 (129.4)	8.82 (76.9)	1.72 (1.9)	1.50 (1.2)	9.00 (80.2)	12.6	41.3
T_{15}	10.82 (116.2)	1.74 (2.0)	1.40 (0.9)	10.95 (119.1)	6.14 (36.7)	1.22 (0.4)	1.49 (1.2)	6.27 (38.3)	19.5	71.9
T_{16}	10.64 (112.3)	2.58 (5.6)	1.83 (2.3)	11.01 (120.2)	9.87 (96.5)	1.58 (1.4)	2.02 (3.0)	10.10 (100.9)	18.8	26.0
T_{17}	8.21 (66.5)	1.49 (1.2)	1.61 (1.5)	8.38 (69.2)	8.18 (66.0)	1.27 (0.6)	1.65 (1.7)	8.31 (68.3)	53.2	50.0
T_{18}	11.21 (124.8)	3.60 (12.0)	3.50 (11.2)	12.20 (148.0)	10.64 (112.3)	2.60 (5.7)	4.44 (18.7)	11.73 (136.7)	0.0	0.00
SE(m) ±	0.19	0.05	0.03	0.16	0.17	0.02	0.04	0.15		
CD at 5%	0.56	0.15	0.10	0.46	0.49	0.07	0.13	0.44		

* ***Figures in the parenthesis are original values and these are subjected to square root transformation***

Table 4: Germination per cent, number of millable canes, cane yield, weed index and B:C ratio as affected by different weed control treatments

Treatment Number	Germination %		NMCs ('000 ha^{-1})	Cane Yield (t ha^{-1})	Weed Index (%)	B:C
	20 DAP	40 DAP	At harvest			
T_1	11.2	40.7	92.4	70.5	24.1	1.61
T_2	11.4	40.8	98.5	84.9	8.6	1.77
T_3	11.1	40.5	87.9	65.5	29.5	1.47
T_4	11.1	40.7	95.3	81.4	12.4	1.75
T_5	11.3	40.7	103.3	91.6	1.4	1.87
T_6	11.0	40.3	94.5	81.4	12.4	1.75
T_7	11.2	40.4	102.1	90.8	2.3	1.83
T_8	11.2	40.4	96.3	84.9	8.6	1.78
T_9	11.4	40.7	96.2	85.1	8.4	1.68
T_{10}	11.4	40.7	94.1	83.7	9.9	1.67
T_{11}	11.3	40.2	90.9	71.8	22.7	1.65
T_{12}	11.2	40.4	91.4	75.9	18.3	1.65
T_{13}	11.0	40.4	87.8	73.3	21.1	1.65
T_{14}	11.1	40.4	84.2	66.0	29.0	1.55
T_{15}	11.0	40.4	93.0	80.3	13.6	1.64
T_{16}	10.9	40.3	81.5	66.2	28.7	1.58
T_{17}	11.5	40.9	104.0	92.9	0.0	1.73
T_{18}	10.9	40.3	74.2	40.7	56.2	1.24
SE(m) ±	0.46	1.07	2.44	1.5		
CD at 5%	NS	NS	7.06	4.4		

CONCLUSION

On the basis of present investigation it can be inferred that metribuzin at 1.0 kg ha^{-1} + halosulfuron at 67.5 g ha^{-1} PoE (T_5), metribuzin at 1.0 kg ha^{-1} PRE *fb* halosulfuron 67.5 g ha^{-1} PoE (T_7), atrazine at 2.0 kg ha^{-1} PRE *fb* halosulfuron 67.5 g ha^{-1} PoE 40 DAP (T_8) were found best treatments for higher WCE (>75 %) and cane yield without any phytotoxic effect on sugarcane plant crop. None of the applied herbicide alone, in combination and in sequence had any phytotoxic effect on sugarcane crop, except metsulfuron + carfentrazone (T_{14}).

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