Comparative Efficacy of Tembotrione (420 SC) and their Combination for Weed Control in Sugarcane (*Saccharum officinarum* L.) Provides Sustainable Weed Management

Notes: The words with red colour words are meaning the words after correction.

ABSTRACT

Field experiment was undertaken for two consecutive years in the special season of June-September in 2015-16 and 2016-17 to examine the compatibility of tembotrione 420 SC as its combination with surfactant (isoxadifen-ethyl), atrazine, metribuzin and ethoxysulfuron as tank mix in sugarcane and its residual effect on succeeding crop. Application of PoE tembotrione at 120.75 g a.i/ha + surfactant at 1000 ml/ha + metribuzine at 1050 g a.i/ha significantly reduced the weed density and biomass of grasses, broad leaved weeds and this was comparable with tembotrione at 120.75 g a.i/ha + surfactant at 1000 ml/ha + atrazine at 500 g a.i/ha. Herbicidal combination of PoE tembotrione at 120.75 g a.i/ha + surfactant at 1000 ml/ha + metribuzine at 1050 g a.i/ha was recorded lesser dominant grassy and broad leaved weeds *viz*., *Sitaria verticillata* (L.), *Dactyloctenium aegyptium* Beauv., *Dinebra retroflexa* (Vahl) Panzer, *Trianthema portulacastrum* (L.), *Portulaca oleracea* (L.), *Digera arvensis* (Forsk), *Datura fastuosa* (L.) and *Cleome gynandra* (L.) with higher WCE (83.16% & 87.43% at 30 DAA) and cane yield (134.1 t/ha & 136.2 t/ha) in 2015-16 and 2016-17, respectively which was comparable with tembotrione at 120.75 g a.i/ha + surfactant at 1000 ml/ha + atrazine at 500 g a.i/ha of 129.8 t/ha in 2015-16 and 132.1 t/ha in 2016-17, respectively. Yield reduction in the untreated control plots of 46.46% in 2015-16 and 45.57% in 2016-17, respectively. Finally, the compatibility of tembotrione at 120.75 g a.i/ha + surfactant at 1000 ml/ha + metribuzine at 1050 g a.i/ha at 15 and 30 DAA can keep the total weed density and dry weight reasonably at lower level and enhance the productivity of sugarcane without causing any phytotoxicity to the main crop as well as the succeeding sunflower.

Keywords: *Atrazine, ethoxysulfuron, HPPD inhibitor, metribuzin, phytotoxicity, sugarcane, WCE*

1. INTRODUCTION

Sugarcane (*Saccharum officinarum* L.) is one of the most important agro-industrial cash crops in Indian economy. Being a long duration (above 180 days) widely spaced crop with slow initial growth, sugarcane provides a congenial ambiance to all weeds for their growth and development that causes 73.5% reduction in cane yield (Singh et al., 2011). The nature of weed problem in sugarcane cultivation is quite different from other field crops because sugarcane is planted with relatively wider row spacing and crop growth is very slow in the initial stages. It takes about 30-45 days to complete germination and next 60-75 days for developing full canopy cover (Anonymous, 2001). Weed control is the most critical in early season prior to sugarcane canopy closure over the row middles. Crop-weed competition has been recorded to be 60-120 days after planting in spring season and 150 days in autumn season (Patil et al., 1991; Singh et al., 2012). However, due to labour scarcity to use herbicide for weed management is gaining momentum. Several herbicides like atrazine, metribuzin and 2,4-D have been recommended in sugarcane. But all these herbicides effectively control only the specific weed species. Therefore, new herbicide combinations are required for broad-spectrum weed control in sugarcane. PoE application is essential option in sugarcane as escaped weeds, in order to optimize weed control efficacy and minimize the application costs, the use of complex combinations of pre and post become the rule rather than the exception. These concerns necessitated the use of herbicides for timely and effective control of weeds as well as an economic alternative to the costly labour (Bhullar et al., 2006).

Tembotrione 2-[2-chloro-4-(methylsulfonyl)-3-[(2,2,2 trifloromethoxy) methyl] benzoyl]-1,3-cyclohexanedione is a novel herbicide that is effective against a wide range of broad leaved and grassy weeds, especially as POST-emergence. It inhibits 4-hydroxyphenylpyruvate dioxygenase (HPPD) enzyme which catalyzes the conversion of 4-hydroxyphenylpyruvate to homogentisate leading to depletion of carotenoids and as absence of chloroplast development in emerging foliar tissue which then appearance bleached and stunted (Hawkes, 2007). Special season sugarcane remains in the field for a year or more and the space between sugarcane rows (90 cm) provide ample chance for profuse weed growth which draws huge amount of nutrients and moisture from the soil and thus reduce the cane yields. Yield losses due to the presence of weeds in sole sugarcane / intercropping system were estimated to the tune of 26-75% (Patil et al., 1991; Srivastava et al., 2005). Managing weeds through pre and post-emergence herbicides will be an ideal means for controlling the weeds in view of their economics and effectiveness in sugarcane. Continuous use of

herbicides with similar mode of action has to be restricted to avoid undesirable weed shift (Kamboj et al., 2008; Murali Arthanari et al., 2017). These strategies also represent an important tool to avoid problems related to herbicide resistance, but it requires some preliminary information to assist farmers with the process of herbicide and dosage selection depending on floristic situation. Hence, the present investigation was undertaken to identify the effective herbicidal options (particularly post-emergence) for weed control in sugarcane with suitable combination which can be provide broad-spectrum weed control in sugarcane without affecting growth and cane yield.

2. MATERIALS AND METHODS

2.1. Experimental site and initial soil characteristics

A field study was conducted for two years' special season (June-September) at the Research Farm of Eastern Block (Field No: 74), Tamil Nadu Agricultural University, Coimbatore, India. The experimental farm was located in Western Zone of Tamil Nadu is at 11°29" N latitude and 77°08" E longitude with an altitude of 426.7 m above MSL. The soils of the experimental fields were clay loam with moderate drainage. Soil fertility status of both the experimental fields is classified as low in available nitrogen, medium in phosphorus and high in potassium.

2.2. Treatments, experimental design and herbicidal doses

Treatments were arranged in a randomized complete block design with three replications. Herbicides included in the study were tembotrione (420 SC), atrazine 50% WP, metribuzin 70% WP, ethoxysulfuron 15% WG and surfactant (isoxadifen-ethyl). New molecule of herbicide combination of tembotrione (420 SC) was applied as PoE herbicide on 10 to 15 DAS (Table 1). Hand operated knapsack sprayer fitted with a flat fan type nozzle (WFN 40) was used for spraying the herbicides adopting a spray volume of 500 liters/ha.

Table 1. Treatments, dosage and formulation of the herbicides

T.No.	Treatments	Herbicide Doses	
		g (a.i./ha)	Formulation (g or ml/ha)
T_1	Tembotrione 420 SC + Surfactant	75.6 +1000 ml surfactant	180 + 1000
T_2	Tembotrione 420 SC + Surfactant	96.6 +1000 ml surfactant	230 + 1000
T_3	Tembotrione 420 SC + Surfactant	120.75 +1000 ml of surfactant	287.5 + 1000
T_4	Tembotrione 420 SC + Surfactant + Atrazine 50% WP	120.75 + 1000 ml surfactant + 500	287.5 + 1000 + 1000
T_5	Tembotrione 420 SC + Surfactant +	120.75 + 1000 ml	287.5 + 1000 +

	Ethoxysulfuron 15% WG	surfactant + 60	400
T_6	Tembotrione 420 SC + Surfactant + Metribuzin 70% WP	120.75 + 1000 ml surfactant + 1050	287.5 + 1000 + 1500
T_7	Tembotrione 420 SC	120.75	287.5
T_8	Atrazine 50% WP	500	1000
T_9	Ethoxysulfuron 15% WG	60	400
T_{10}	Metribuzin 70% WP	1050	1500
T_{11}	Hand weeding twice at 30 and 60 DAP	-	-
T_{12}	Untreated control	-	-

Applied at weeds are of 2-4 leaf stage except T_8 - to be applied as PE (1-2 DAP)

2.3. Selection of cultivar, sowing and agronomic practices

In each year, sugarcane (Variety - CO 86032 with the duration of 10-12 months) was planted in the special season (June-September). Seven months old cane nursery (short crop) obtained from Bannari Amman Sugars Ltd., was used for the preparation of setts and 75,000 two budded setts/ha were used. The setts were soaked in fungicide (Carbendazim 0.1% + 2.5 kg urea in 250 liters of water) for 15 minutes and then treated with *Azospirillum* (2000 g/ha) for 15 minutes before planting. After irrigating the plots, setts were placed in the center of the furrows continuously by keeping the buds in the lateral position and pressed gently beneath the soil. Farm yard manure was applied at 12.5 t/ha at last ploughing, incorporated and then levelled. The experimental plots were applied with inorganic fertilizers as per blanket recommendation (275:62.5:112.5 kg N, P_2O_5, K_2O/ha). The entire quantity of P was applied as basal through DAP. Remaining nitrogen in the form of urea and potassium as muriate of potash was applied in three equal splits at 30, 60 and 90 DAP.

2.4. Weed flora, weed density and dry weight of the experimental field

To account for the general weed flora of the experimental field, species wise weeds observed in the treatment plots were recorded during the period of maximum appearance of i.e. 15, 30 and 45 DAA. The weed flora of the experimental site was recorded species wise. The weed count was recorded species wise using 0.5 m x 0.5 m quadrant from four randomly fixed places in each plot and the weeds falling within the frames of the quadrant were counted and the mean values were expressed in number per m^2. The density of grasses, sedges and broad leaved weeds and also the total weeds were recorded at 15, 30 and 45 DAA and expressed in number per m^2. The weeds falling within the frames of the quadrant were collected, categorized into grasses, sedges and broad-leaved weeds, shade dried and later dried in hot-air oven at 80^{o}C for 72 hrs. The dry weight of grasses, sedges and broadleaved weeds were recorded separately at 15, 30 and 45 DAA and expressed in g per m^2.

2.5. Weed control efficiency

Weed control efficiency (WCE) was calculated as per the procedure given by Mani et al. (1973).

$$WCE\ \% = \frac{WD_c - WD_t}{WD_c} \times 100$$

Where,

WCE - weed control efficiency (per cent)

WD_c - weed biomass (g m^{-2}) in control plot

WD_t - weed biomass (g m^{-2}) in treated plot

2.6. Weed index

Weed index (WI) was calculated as per the method suggested by Gill and Vijaya Kumar (1969).

$$WI = \frac{X - Y}{X} \times 100$$

Where,

X = yield (kg ha^{-1}) from minimum weed competition plot

Y = yield (kg ha^{-1}) from the treatment plot for which WI is to be worked out.

2.7. Cane yield

Harvested canes were weighed from the net plot and the yield was expressed in t/ha.

2.8. Visual phytotoxicity rating

After herbicide application, the plants were observed to find out the phytotoxicity effects. Visual scoring for control of weeds for the experiment and phytotoxic symptoms (yellowing / chlorosis / stunting / scorching) in sugarcane crop were done on 3, 5, 7 and 10 DAA. The signs of herbicide injury were rated using 0 to 10 scale where 0 = no injury and 10 = complete destruction.

2.9. Statistical analysis

The data collected for sugarcane was statistically analyzed following the procedure given by Gomez and Gomez (2010) for randomized block design. The data pertaining to weeds was transformed to square root scale of $\sqrt{(X+2)}$ and analyzed as suggested by (Snedecor et al., 1967). Whenever significant difference existed, critical

difference was constructed at five per cent probability level. Such of those treatments where the differences are not significant were denoted as NS.

3. RESULTS AND DISCUSSION

3.1. General weed flora of the experimental field

General weed flora of the experimental fields was observed at 60 days after planting. Among the grasses, *Sitaria verticillata* (L.), *Cynodon dactylon* (L.) Pers., *Dactyloctenium aegyptium* Beauv., *Dinebra retroflexa* (Vahl) Panzer were the dominant species and the only one sedge weed are *Cyperus rotundus* (L.). Among the broad leaved weeds, *Trianthema portulacastrum* (L.), *Portulaca oleracea* (L.), *Digera arvensis* (Forsk), *Corchorus olitorius* (L.), *Parthenium hysterophorus* (L.) and *Datura fastuosa* (L.) were the dominant species.

3.2. Total weed dry weight

With regard to the total weed dry weight, significant variation was observed among the herbicidal weed management practices in sugarcane (Table 2). During both the years, lower total weed dry weight at 15 and 30 DAA was observed in PoE application of tembotrione at 120.75 g a.i./ha + surfactant at 1000 ml/ha + metribuzine at 1050 g a.i./ha (9.94 & 24.06 g/m^2 in 2015-16 and 4.96 & 17.70 g/m^2 in 2016-17) and it was closely followed by tembotrione at 120.75 g a.i./ha + surfactant at 1000 ml/ha + atrazine at 500 g a.i./ha (13.54 & 28.48 g/m^2 in 2015-16 and 7.86 & 26.52 g/m^2 in 2016-17), tembotrione at 120.75 g a.i./ha + surfactant 1000 ml/ha + ethoxysulfuron at 60 g .i./ha (14.30 & 37.24 g/m^2 in 2015-16 and 9.04 & 37.10 g/m^2 in 2016-17) and tembotrione 420 SC at 120.75 g a.i./ha + surfactant at 1000 ml (17.58 & 39.52 g/m^2 in 2015-16 and 12.60 & 36.14 g/m^2 in 2016-17). Addition of surfactant (isoxadifen-ethyl), was realized to attain satisfactory efficacy of tembotrione against mixed weed flora in maize was given by (Yadav et al., 2020). In sugarcane, PoE application of metribuzine 70% WP at l.00 kg/ha + 2,4-D sodium salt 80% WP as a tank mixed noticed lower weed density and dry weight and also found significantly superior over rest of the treatments (Waghmare et al., 2018). Weed dry weight is the most important parameter to assess the weed competitiveness for the crop growth and productivity. Sparse weeds with higher biomass might be more competitive for crops than dense weeds with lesser dry matter (Sathya Priya et al., 2013). Application of tembotrione at 120.75 g a.i./ha + surfactant at 1000 ml/ha + metribuzine at 1050 g a.i./ha applied at 2-4 leaf stage provided satisfactory control of all type of weeds (grassy, sedge and broad-leaf weeds) in special season sugarcane.

3.3. Weed control efficiency

During both the years, it was observed that PoE application of tembotrione at 120.75

g a.i./ha + surfactant at 1000 ml/ha + metribuzine at 1050 g a.i./ha resulted the higher WCE of 88.96 & 83.16% in 2015-16 and 93.91 & 87.43% in 2016-17, respectively and it was followed by tembotrione at 120.75 g a.i./ha + surfactant at 1000 ml/ha + atrazine at 500 g a.i./ha (84.96 & 80.06% in 2015-16 and 90.35 & 81.16% in 2016-17) and tembotrione at 120.75 g a.i./ha + surfactant 1000 ml/ha + ethoxysulfuron at 60 g a.i./ha (84.11 & 73.93% in 2015-16 and 88.90 & 73.65% in 2016-17) at 15 and 30 DAA (Table 2). Higher values of weed control efficiencies could be attributed to lower weeds number and weeds dry weight owing to better efficacy among various treatments which might have shifted the pendulum in favour of crops rather than weeds. Triveni et al. (2017) reported that PoE application of tembotrione at 50 g a.i./ha + atrazine at 500 g a.i./ha was registered higher weed control efficiency (93.6 & 96.9%) over other herbicidal treatments and it was closely followed by hand weeding twice at 20 and 40 DAS (90.1 & 95.6%) in maize. In farmer's participatory trial indicated that application of sulfosulfuron at 25 g/ha, sulfosulfuron + metsulfuron (ready-mix) at 32 g/ha, mesosulfuron + iodosulfuron (ready-mix) at 14.4 g/ha (or) pinoxaden at 50 g/ha provided effective weed control efficiency (83 to 97% control of weeds including *Phalaris minor* over the years) in sugarcane + wheat intercropping system (Yadav et al., 2020). In the present study, at 30 DAA, WCE with ranged from 49.62 to 72.33% in 2015-16 and 56.24 to 74.33% in 2016-17, respectively (sole herbicide application); 83.16 to 84.11% in 2015-16 and 87.43 to 81.16% in 2016-17, respectively (new herbicide combination).

3.4. Response of cane yield

Cane yield followed all herbicidal treatments ranged from 93.4 to 134.1 t/ha in 2015-16 and 95.7 to 136.2 t/ha in 2015-17, while the untreated control plots yield of 71.8 and 74.13 t/ha in 2015-16 and 2016-17, respectively (Table 2). Among the different treatments, PoE application of tembotrione at 120.75 g a.i./ha + surfactant at 1000 ml/ha + metribuzine at 1050 g a.i./ha recorded significantly higher cane yield of 134.1 t/ha in 2015-16 and 136.2 t/ha in 2016-17, respectively which was comparable with tembotrione at 120.75 g a.i./ha + surfactant at 1000 ml/ha + atrazine at 500 g a.i./ha of 129.8 t/ha in 2015-16 and 132.13 t/ha in 2016-17, respectively. The yield parameters like malleable cane, cane length, cane girth, cane weight were significantly influenced by weed control treatments over the untreated control. Tembotrione inhibits the enzyme 4-hydroxy phenyl pyruvate dioxygenase (HPPD) which disrupts the formation of carotenoids and depletion of carotenoids deprives chlorophyll, the sites of photosynthesis, its protection against an overdose of light resulting in chlorophyll oxidation which resulted in bleaching of sensitive weeds and reduced the weed population finally plants turned progressively white (Akhtar et al., 2015). All the treatments of

tembotrione herbicide on control of weeds and consequently reduction in competition for moisture, nutrients and sunlight might have resulted the conspicuous enhancement in cane yield. During both the years, maximum cane yield (89.3 and 98.9 t/ha) was recorded under PoE halosulfuron + metribuzin applied at 600 g/ha. The effective control of weeds at early stage of growth might have resulted in better growth and yield of sugarcane (Singh et al., 2017). Weed free environment diverted all the available resources towards crop utilization and resulted in higher cane yield. All the herbicidal treatment plots produced maximum crop growth thereby increasing the accumulation of photosynthates in reproductive parts of plants which ultimately improved the cane yield. The next best treatments, whereas the application of PoE tembotrione at 120.75 g a.i./ha + surfactant at 1000 ml/ha + ethoxysulfuron at 60 g a.i./ha (126.4 t/ha in 2015-16 and 127.6 t/ha in 2016-17) and that of tembotrione at 120.75 g a.i./ha + surfactant at 1000 g a.i./ha (121.7 t/ha in 2015-16 and 124.0 t/ha in 2016-17) registered conspicuously lower cane yield. This study clearly indicated, PoE application of tembotrione at 120.75 g a.i./ha + surfactant at 1000 ml/ha + metribuzine at 1050 g a.i./ha was very effective in reducing the population of BLWs and grasses as compared to sedges, without any phytotoxic effect on sugarcane and its succeeding sunflower. In earlier reports have also established suitability of sulfosulfuron, sulfosulfuron + metsulfuron, mesosulfuron + iodosulfuron and pinoxaden as PoE herbicides for weed control in sugarcane + wheat intercropping system (Kamboj et al., 2008).

3.5. Weed index

The best treatment with the maximum yield was taken as the base to work out the weed index that gives the magnitude of yield reduction due to weed competition in other treatments. Herbicide combination of PoE application of tembotrione at 120.75 g a.i./ha + surfactant at 1000 ml/ha + metribuzine at 1050 g a.i./ha registered maximum cane yield and therefore lower cane yield reduction of only 3.21% and 2.99% were recorded in tembotrione at 120.75 g a.i./ha + surfactant at 1000 ml/ha + atrazine at 500 g a.i./ha during both the years (Table 2). This can be probably ascribed due to improved growth of crops as a consequence of effective control of weeds and reduction in the crop weed competition. This enabled the crop to take up more nutrients attributed to lower weed number and dry weight. Similar results collaborate with the findings of (Singh et al., 2011; Yadav et al., 2012). Yield reduction in the treatment of tembotrione at 120.75 g a.i./ha + surfactant at 1000 ml/ha + ethoxysulfuron at 60 g a.i./ha and tembotrione at 120.75 g a.i./ha + surfactant at 1000 ml/ha were found to be 5.74 and 9.21% in 2015-16 and 6.31 and 8.94% in 2016-17, respectively. Yield reduction in untreated control plots of 46.46% in 2015-16 and 45.57% in 2016-17,

respectively. Maximum weed index value was observed in untreated control as compared to herbicide combination which recorded negligible yield loss due to absence of weeds provided there are no other limiting factors. This can be probably ascribed due to competition offered by unchecked weed growth for nutrients, moisture and light as indicated by poor growth and yield components under weedy conditions.

3.6. Effect on phytotoxicity symptoms in sugarcane

Phytotoxicity symptoms of herbicides on sugarcane were observed during both the years at 3, 5, 7 and 10 DAA. Phytotoxicity symptoms were observed in the three combination of tembotrione with atrazine, metribuzine and ethoxysulfuron and also higher doses of tembotrione alone, whereas the phytotoxicity symptoms were noticed at early stages of herbicide combination. Double doses of PoE application of tembotrione at 241.5 g a.i./ha + surfactant at 2000 ml/ha + atrazine at 1000 g a.i./ha, tembotrione at 241.5 g a.i./ha + surfactant at 2000 ml/ha + ethoxysulfuron at 120 g a.i./ha and tembotrione at 120.75 g a.i./ha + surfactant at 2000 ml/ha + metribuzine at 2100 g a.i./ha were noticed phytotoxicity symptomps with the rating of three, two and one (injury more pronounced but not persistent, some stand loss, stunting / discoloration) at 3, 5 and 7 DAA (Table 3). There was no phytotoxicity of tembotrione at 120 and 240 g a.i./ha (with surfactant) on maize at 15 and 30 DAT and no residual phytotoxicity on succeeding crop of wheat during both the years (Yadav et al., 2018). No phytotoxic effect in terms of scorching, necrosis, hyponasty and epinasty were seen in sugarcane crop with the application of halosulfuron + metribuzin at different doses (Srivastava et al., 2005). In this study, combination of herbicides at 10 DAA in sugarcane plants recovered completely from phytotoxicity symptomps and there was not evident thereafter. Phytotoxicity symptoms on sugarcane (in terms of leaf chlorosis, leaf tip burning, leaf necrosis, leaf epinasty and wilting *etc*.,) were observed with combination of tembotrione with double doses of different herbicide combination. Singh et al. (2012) reported that there was no phytotoxicity of tembotrione on maize and succeeding crop of mustard in rotation. Phytotoxicity symptoms were not evident thereafter at 10 DAA in all the double doses combination of tembotrione in sugarcane.

4. CONCLUSION

The findings and interpretation of the present study it could be concluded all among the herbicidal treatments, the individual application of PoE herbicides like tembotrione, atrazine, metribuzin and ethoxysulfuron showed lesser weed control efficacy in the complex weed flora in sugarcane trial during both the years. Addition of surfactant (isoxadifen-ethyl) was realized to attain satisfactory efficacy of tembotrione against mixed weed flora in

sugarcane. Herbicide combination of tembotrione 420 SC at 120.75 g a.i./ha + surfactant at 1000 ml/ha (isoxadifen-ethyl) + metribuzine 70% WP at 1050 g a.i./ha applied at 2-4 leaf stage (10-15 days after planting) provided satisfactory control of all type of weeds (BLWs and grasses as compared to sedges) in special season sugarcane without causing any crop phytotoxicity on sugarcane and consequently, it resulted into higher cane yield with more profitability.

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Competing Interest

The authors declare no competing interests.

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Table 2. Total weed dry weight, weed control efficiency, cane yield and weed index as influenced by different weed management practices in sugarcane

Herbicide treatments	Total weed dry weight (g/m^2), WCE (%), Cane yield (t/ha) & Weed Index (WI)											
	Special season, 2015-16						Special season, 2016-17					
	Total weed dry weight		WCE		Cane yield	Weed Index	Total weed dry weight		WCE		Cane yield	Weed Index
	15 DAA	30 DAA	15 DAA	30 DAA			15 DAA	30 DAA	15 DAA	30 DAA		
T_1 - Tembotrione at 76.5 g a.i./ha + surfactant at 1000 ml/ha	6.65 (42.20)	8.60 (71.96)	53.11	49.62	95.00	29.16	5.91 (32.88)	7.98 (61.61)	59.63	56.24	97.4	28.49
T_2 - Tembotrione at 96.6 g a.i./ha + surfactant at 1000 ml/ha	4.53 (18.50)	6.53 (40.58)	79.44	71.59	113.2	15.59	3.94 (13.52)	6.47 (39.92)	83.40	71.65	114.2	16.15
T_3 - Tembotrione at 120.75 g a.i./ha + surfactant at 1000 ml/ha	4.42 (17.58)	6.44 (39.52)	80.47	72.33	121.7	9.25	3.82 (12.60)	6.18 (36.14)	84.53	74.33	124.03	8.94
T_4 - Tembotrione at 120.75 g a.i./ha + surfactant at 1000 ml/ha + atrazine at 500 g a.i./ha	3.94 (13.54)	5.52 (28.48)	84.96	80.06	129.8	3.21	3.14 (7.86)	5.34 (26.52)	90.35	81.16	132.13	2.99
T_5 - Tembotrione at 120.75 g a.i./ha + surfactant 1000 ml/ha + ethoxysulfuron at 60 g a.i./ha	4.04 (14.30)	6.26 (37.24)	84.11	73.93	126.4	5.74	3.32 (9.04)	6.25 (37.10)	88.90	73.65	127.6	6.31
T_6 - Tembotrione at 120.75 g a.i./ha + surfactant at 1000 ml/ha + metribuzin at 1050 g a.i./ha	3.46 (9.94)	5.10 (24.06)	88.96	83.16	134.1	0.00	2.64 (4.96)	4.44 (17.70)	93.91	87.43	136.2	0.00
T_7 - Tembotrione at 120.75 g a.i./ha	5.58 (29.14)	7.51 (54.46)	67.62	61.87	95.8	28.56	4.98 (22.82)	7.27 (50.90)	71.98	63.85	98.0	28.05
T_8 - Atrazine at 500 at g a.i./ha	4.77 (20.72)	6.82 (44.54)	76.98	68.82	105.6	21.25	4.22 (15.84)	6.75 (43.50)	80.55	69.11	106.8	21.59
T_9 - Ethoxysulfuron at 60 g a.i./ha	5.92 (33.07)	7.92 (60.66)	63.26	57.53	93.4	30.35	5.39 (27.08)	7.74 (57.86)	66.75	58.91	95.73	29.71
T_{10} - Metribuzin at 1050 g a.i./ha	5.13 (24.32)	7.09 (48.30)	72.98	66.19	104.3	22.22	4.61 (19.28)	6.87 (45.22)	76.33	67.88	106.63	21.71
T_{11} - Hand weeding twice at 30 and 60 DAP	8.40 (68.58)	7.20 (49.86)	23.80	65.09	124.4	7.23	8.34 (67.52)	7.23 (50.22)	0.00	64.33	127.5	6.39
T_{12} - Untreated control	9.59 (90.00)	12.03 (142.84)	0.00	0.00	71.8	46.46	9.13 (81.44)	11.95 (140.8)	0.00	0.00	74.13	45.57
SEd	**0.26**	**0.29**	**-**	**-**	**5.30**	**-**	**0.24**	**0.32**	**-**	**-**	**5.6**	**-**
CD (P=0.05)	**0.52**	**0.60**	**-**	**-**	**10.6**	**-**	**0.48**	**0.64**	**-**	**-**	**11.2**	**-**

Figures in parenthesis are original values; Data subjected to square root transformation; DAA: Days after application; DAP: Days after planting

Table 3. Effect of different weed management treatments of phytotoxicity rating in sugarcane

Treatments	g a.i./ha	1 DAA	3 DAA	5 DAA	7 DAA	10 DAA
T_1 - Tembotrione 420 SC + Surfactant*	241.5 + 2000 ml surfactant	1.00	1.00	0.00	0.00	0.00
T_2 - Tembotrione 420 SC + surfactant + atrazine 50% WP	120.75 + 1000 ml + 500	0.00	0.00	0.00	0.00	0.00
T_3 - Tembotrione 420 SC + surfactant + atrazine 50% WP*	241.5 + 2000 ml surfactant + 1000	3.00	3.00	2.00	0.00	0.00
T_4 - Tembotrione420 SC + surfactant + ethoxysulfuron 15% WG	120.75 + 1000 ml surfactant + 60	0.00	0.00	0.00	0.00	0.00
T_5 - Tembotrione420 SC + surfactant + ethoxysulfuron 15% WG*	241.5 + 2000 ml surfactant + 120	4.00	3.00	2.00	1.00	0.00
T_6 - Tembotrione 420 SC + surfactant + metribuzin 70% WP	120.75 + 1000 ml surfactant + 1050	0.00	0.00	0.00	0.00	0.00
T_7 - Tembotrione 420 SC + surfactant + metribuzin 70% WP*	241.5 + 2000 ml + 2100	2.00	1.00	1.00	0.00	0.00

*** Treatment meant for only phytotoxicity studies; Surfactant (isoxadifen-ethyl) DAA - Days after application**