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Effect of new generation Post emergence herbicide 2,4-D 95% SP on weed, growth and yield of sugarcane

V Murugesh Prasanna*, S Jawahar
Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai Nagar, Tamil Nadu, India

Abstract
Field experiment was conducted at sebbakkam village, veppur taluk of cuddalore District during the year 2023-24 and 2024-25 to study the evaluation of bio-efficacy for post emergence herbicide 2,4-D 95% SP against weed flora in sugarcane. The experiment comprised of seven treatments laid out in randomized complete block design replicated thrice. The treatment comprised of 2, 4-D Sodium salt 95% SP @ 2210 g a.i. ha^{-1} (T_1), 2, 4-D Sodium salt 95% SP @ 2600 g a.i. ha^{-1} (T_2), 2, 4-D Sodium salt 95% SP @ 2990 g a.i. ha^{-1} (T_3), Diuron 80% WP @ 3200 g a.i. ha^{-1} (T_4), Metsulfuron methyl 20% WP @ 6 g a.i. ha^{-1} (T_5), Hand Weeding on 30, 60 and 90 DAP(T_6) and Untreated control (T_7). The results have been found that all the weed control measure significantly reduce the weed density and weed bio mass, at the same time effectively improves the crop growth and yield in comparison to control. Among the various herbicidal treatments, application of 2, 4-D Sodium salt 95% SP @ 2990 g a.i. ha^{-1} (T_3) on 20 DAP has recorded the lesser weed density and higher weed control efficiency. Additionally, it has acquired the maximum growth attributes (plant height, tillers count,), yield attributes (no. of millable cane, cane length, cane grith and individual cane weight) and cane yield. This was on par with the application of 2, 4-D Sodium salt 95% SP @ 2600 g a.i. ha^{-1} (T_2). The next best was application of 2, 4-D Sodium salt 95% SP @ 2210 g a.i. ha^{-1} (T_1). Hence it can be concluded that application of 2, 4-D Sodium salt 95% SP @ 2990 g a.i. ha^{-1} (T_3) holds immense potentiality to give higher yield of sugarcane.

Keywords: New generation herbicides, weed management, growth and yield

Introduction
Sugarcane (*Saccharum officinarum* L.) is an important long duration C_4 crop of tropical and subtropical areas which constitutes around 80% of the world's sugar production and 35% ethanol. In India, Sugarcane is the second most important industrial crop occupying an area of about 4.57 million hectares. India is the second largest producer country after Brazil contributing approximately 431.81 million tons production of millable cane from an area 5.15 million hectares with annual average productivity of 83.8 tons ha^{-1} (Anonymous, 2022) [2]. Kanwar *et al*., (1990) [6] concluded that the critical period of weed competition in sugarcane upto 90 days. Sugarcane crop faces tough competition with weeds during 60 to 120 days of its planting which causes heavy reduction in cane yield ranging from 40-67% (Shauhan and Srivastava, 2002) [10].

To realize the full potential of sugarcane, timely weed management is one of the most important factors otherwise there are chances of huge loss to farmers. It is well-understood that manual weed management is most effective to control weeds but timely availability of agricultural labours is a problem. Herbicidal control of weeds has been suggested to be economical in sugarcane (Chauhan *et al*. 1994) [3]. The present investigation was undertaken to study the effect of new generation post emergence herbicide 2,4-D 95% SP on weed dynamics, growth and yield of sugarcane.

Materials and Methods
A field experiment was conducted at sebbakkam village, veppur taluk of cuddalore District during the year 2023-24 and 2024-25 to study the evaluation of bio-efficacy for post emergence herbicide 2,4-D 95% SP against weed flora in sugarcane**.** The treatment comprised of 2, 4-D Sodium salt 95% SP @ 2210 g a.i. ha^{-1} (T_1), 2, 4-D Sodium salt 95% SP @ 2600 g a.i. ha^{-1} (T_2), 2, 4-D Sodium salt 95% SP @ 2990 g a.i. ha^{-1} (T_3), Diuron 80% WP @ 3200 g a.i. ha^{-1} (T_4), Metsulfuron methyl 20% WP @ 6 g a.i. ha^{-1} (T_5), Hand Weeding on 30, 60 and 90 DAP(T_6) and Untreated control (T_7). The experiment comprised of seven treatments laid out in randomized complete block design replicated thrice. For this study, double budded setts of sugarcane variety Co-86032 were planted at 90 cm row spacing and 20 cm plant to plant spacing using sett rate of 75000 two-budded setts ha^{-1}. The post-emergence herbicide *viz.*, 2, 4, D - Na salt, Diuron and Metsulfuron methyl were sprayed on the twenty days after planting. The herbicides were sprayed using knapsack sprayer fitted with flat fan nozzle. Herbicides were mixed with a calibrated amount of water and sprayed plot wise. The crop was raised as per the recommended package of practices.

Weed control efficiency (WCE)
To calculate the weed control efficiency (WCE), a formula by Mani *et al*. (1973) [7] was used.

$$WCE = \frac{weed\ population\ in\ control\ plot - weed\ population\ in\ treated\ plot}{weed\ population\ in\ control\ plot} \times 100$$

Weed control index (WCI)
The weed control index was calculated by formula suggested by Misra and Tosh (1979).

$$WCI = \frac{Dry\ matter\ of\ weeds\ in\ control\ plot - Dry\ matter\ of\ weeds\ in\ treated\ plot}{Dry\ matter\ of\ weeds\ in\ control\ plot} \times 100$$

Results and Discussion
The major weeds found in experiment field were *Cynodon dactylon, Brachiaria eruciformis,* and *Digitaria sanguinalis*

among grass weeds. While among broad leaf weeds *Trianthema portulacastrum, Commelina benghalensis, Convolvulus arvensis, Vernonia cinerea*, *Amaranthus spinosus* and *Amaranthus viridis* were dominant. *Cyperus rotundus* was found among sedges.

Effect on individual weed density

The data presented in table no.1 & 2 revealed that the lower individual weed count was recorded in treatment T_3 - 2, 4-D Sodium salt 95% SP @ 2990 g a.i. ha^{-1} and it was on par with treatment T_2 - 2, 4-D Sodium salt 95% SP @ 2600 g a.i. ha^{-1}. This might due to fact that most of the weed at 2-3 leaf stage was actively growing and herbicide was effectively absorbed by leaf that induce the expression of auxin responsive genes and thus production of ethylene and abscisic acid (Grossmann, 2003) [4]. As a result, uncontrolled and unsustainable growth that leads to stem curl over, leaf withering, and ultimately death of weed. Higher individual weed count was recorded in unweeded control. Among the herbicidal treatments, weed control efficiency was higher in the application of 2, 4-D Sodium salt 95% SP @ 2990 g a.i. ha^{-1} (T_3). It might be happened due to better suppression of the weed density. This was on par with the application of 2, 4-D Sodium salt 95% SP @ 2600 g a.i. ha^{-1} (T_2). Minimum weed control efficiency was registered in unweeded control.

Effects on total weed density, total weed dry weight, WCE & WCI

The data showed in table no.3 revealed that the lower total weed count and weed bio mass on 45 and 75 DAPS was recorded in treatment T_3 - 2, 4-D Sodium salt 95% SP @ 2990 g a.i. ha^{-1} and it was on par with treatment T_2 - 2, 4-D Sodium salt 95% SP @ 2600 g a.i. ha^{-1}. Among the herbicide treatments, application of 2, 4-D Sodium salt 95% SP @ 2990 g a.i. ha^{-1} (T_3) recorded higher values of WCE and WCI followed by application of 2, 4-D Sodium salt 95% SP @ 2600 g a.i. ha^{-1} (T_2). Because of the superior performance of 2,4-D Sodium salt on sedges and broadleaf weeds, the overall weed count and weed biomass were lower. Similar findings were reported by Yadav *et al*. (2021) [11].

Table 1: Effect of weed control treatments on individual weed density m^{-2} on 45 DAP and 75 DAP during 2023-24

Treatments	*Cynodon dactylon*		*Cyperus rotundus*		*Trianthema portulacastrum*		*Commelina benghalensis*		*Convolvulus arvensis*		*Vernonia cinerea*	
	45 DAP	**75 DAP**	**45 DAP**	**75 DAP**	**45 DAP**	**75 DAP**	**45 DAP**	**75 DAP**	**45 DAP**	**75 DAP**	**45 DAP**	**75 DAP**
T_1	1.73	2.15	1.79	2.24	1.88	2.95	1.86	2.76	1.73	2.47	1.61	2.23
	(2.49)	(4.12)	(2.70)	(4.52)	(3.03)	(8.20)	(2.96)	(7.12)	(2.49)	(5.60)	(2.09)	(4.47)
T_2	1.71	2.1	1.61	1.95	1.68	2.59	1.71	2.41	1.59	2.23	1.45	1.94
	(2.42)	(3.91)	(2.09)	(3.30)	(2.32)	(6.21)	(2.42)	(5.31)	(2.03)	(4.47)	(1.60)	(3.26)
T_3	1.68	2.08	1.57	1.89	1.62	2.49	1.66	2.31	1.54	2.15	1.39	1.85
	(2.33)	(3.84)	(1.95)	(3.06)	(2.14)	(5.69)	(2.27)	(4.85)	(1.87)	(4.11)	(1.43)	(2.93)
T_4	1.72	2.24	2.21	2.71	2.35	3.75	2.17	3.21	2.02	2.94	1.95	2.59
	(2.46)	(4.52)	(4.38)	(6.84)	(5.02)	(13.56)	(4.21)	(9.80)	(3.58)	(8.14)	(3.30)	(6.21)
T_5	1.66	2.19	2.15	2.62	2.26	3.59	2.11	3.16	2.15	2.89	1.88	2.65
	(2.26)	(4.30)	(4.12)	(6.36)	(4.61)	(12.39)	(3.95)	(9.49)	(4.12)	(7.85)	(3.03)	(6.52)
T_6	1.49	1.61	1.85	2.21	1.96	3.13	1.93	2.83	1.75	2.55	1.69	2.36
	(1.72)	(2.09)	(2.92)	(4.38)	(3.34)	(9.30)	(3.22)	(7.51)	(2.56)	(6.02)	(2.36)	(5.07)
T_7	2.85	4.39	3.67	5.23	4.26	6.51	4.11	6.25	3.78	5.48	3.08	4.87
	(7.62)	(18.78)	(12.98)	(26.87)	(17.67)	(41.83)	(16.37)	(38.51)	(13.79)	(29.54)	(8.98)	(23.21)
S.Ed	0.05	0.11	0.06	0.09	0.07	0.13	0.06	0.08	0.05	0.06	0.06	0.07
CD (P = 0.05)	0.11	0.23	0.13	0.18	0.14	0.26	0.12	0.17	0.10	0.13	0.11	0.15

(Figures in the parenthesis indicate the original values)

Table 2: Effect of weed control treatments on individual weed density m^{-2} on 45 DAP and 75 DAP during 2024-25

Treatments	*Cynodon dactylon*		*Cyperus rotundus*		*Trianthema portulacastrum*		*Commelina benghalensis*		*Convolvulus arvensis*		*Vernonia cinerea*	
	45 DAP	**75 DAP**	**45 DAP**	**75 DAP**	**45 DAP**	**75 DAP**	**45 DAP**	**75 DAP**	**45 DAP**	**75 DAP**	**45 DAP**	**75 DAP**
T_1	2.18	3.65	2.27	3.67	2.32	3.84	2.79	3.73	2.38	3.28	1.76	3.08
	(4.25)	(12.83)	(4.64)	(12.94)	(4.87)	(14.28)	(7.30)	(13.38)	(5.16)	(10.25)	(2.60)	(9.02)
T_2	2.07	3.46	2.09	3.47	2.10	3.65	2.52	3.55	2.09	3.08	1.57	2.84
	(3.79)	(11.46)	(3.87)	(11.56)	(3.92)	(12.83)	(5.84)	(12.08)	(3.87)	(9.02)	(1.96)	(7.59)
T_3	2.04	3.39	2.01	3.40	2.15	3.56	2.41	3.48	2.14	3.01	1.80	2.62
	(3.65)	(11.00)	(3.55)	(11.09)	(4.12)	(12.15)	(5.30)	(11.60)	(4.06)	(8.54)	(2.73)	(6.38)
T_4	2.37	3.84	2.49	3.89	2.59	4.07	3.04	4.14	2.67	3.58	2.00	3.50
	(5.11)	(14.28)	(5.72)	(14.62)	(6.22)	(16.04)	(8.76)	(16.65)	(6.62)	(12.30)	(3.51)	(11.77)
T_5	2.29	3.81	2.42	3.81	2.52	3.99	3.02	4.02	2.61	3.50	1.91	3.44
	(4.75)	(14.05)	(5.35)	(14.05)	(5.84)	(15.44)	(8.61)	(15.68)	(6.29)	(11.77)	(3.16)	(11.36)
T_6	2.22	3.73	2.34	3.73	2.42	3.93	2.88	3.83	2.49	3.34	1.81	3.13
	(4.41)	(13.38)	(4.99)	(13.38)	(5.35)	(14.97)	(7.80)	(14.17)	(5.72)	(10.65)	(2.78)	(9.29)
T_7	3.23	6.46	3.28	6.61	4.53	7.51	5.07	7.67	4.58	7.20	3.86	6.81
	(9.92)	(41.29)	(10.28)	(43.16)	(20.04)	(55.93)	(25.23)	(58.36)	(20.51)	(51.36)	(14.41)	(45.81)
S.Ed	0.04	0.08	0.08	0.07	0.09	0.06	0.13	0.07	0.11	0.08	0.07	0.11
CD (P = 0.05)	0.08	0.17	0.16	0.14	0.19	0.13	0.26	0.15	0.23	0.17	0.15	0.22

(Figures in the parenthesis indicate the original values)

Table 3: Effect of weed control treatments on total weed density, total weed dry weight, WCE & WCI in sugarcane

Treatments	Total weed density (m^{-2})				Total weed dry weight (g m^{-2})				WCE		WCI	
	2023-24		2024-25		2023-24		2024-25		2023-24	2024-25	2023-24	2024-25
	45 DAP	75 DAP	45 DAP	75 DAP	45 DAP	75 DAP	45 DAP	75 DAP	75 DAP	75 DAP	75 DAP	75 DAP
T_1 - 2, 4-D Sodium salt 95% SP @ 2210 g a.i. ha^{-1}	4.03 (15.78)	5.88 (34.03)	5.41 (28.82)	8.56 (72.71)	2.13 (4.05)	2.88 (7.78)	4.43 (19.09)	5.90 (34.30)	75.47	75.43	71.10	71.59
T_2 - 2, 4-D Sodium salt 95% SP @ 2600 g a.i. ha^{-1}	3.66 (12.89)	5.19 (26.47)	4.87 (23.25)	8.06 (64.54)	1.95 (3.31)	2.48 (5.66)	3.99 (15.40)	5.56 (30.45)	80.92	78.19	78.97	74.78
T_3 - 2, 4-D Sodium salt 95% SP @ 2990 g a.i. ha^{-1}	3.53 (11.99)	5.00 (24.48)	4.89 (23.42)	7.83 (60.76)	1.89 (3.08)	2.40 (5.24)	4.00 (15.51)	5.40 (28.66)	82.36	79.47	80.53	76.26
T_4 - Diuron 80% WP @ 3200 g a.i. ha^{-1}	4.84 (22.96)	7.04 (49.08)	6.04 (35.93)	9.28 (85.66)	2.53 (5.90)	3.38 (10.90)	4.93 (23.79)	6.40 (40.40)	64.62	71.05	59.51	66.53
T_5 - Metsulfuron methyl 20% WP @ 6 g a.i. ha^{-1}	4.75 (22.09)	6.89 (46.91)	5.87 (34.00)	9.10 (82.35)	2.49 (5.68)	3.34 (10.64)	4.80 (22.51)	6.27 (38.85)	66.19	72.17	60.48	67.82
T_6 - Hand Weeding on 30, 60 and 90 DAP	4.08 (16.13)	5.90 (34.35)	5.62 (31.04)	8.74 (75.84)	2.16 (4.14)	2.91 (7.95)	4.59 (20.56)	6.02 (35.78)	75.19	74.37	70.47	70.36
T_7 – Untreated control	8.83 (77.41)	11.80 (138.74)	10.04 (100.38)	17.22 (255.91)	4.57 (20.36)	5.24 (26.92)	8.18 (66.48)	11.01 (120.71)	-	-	-	-
S.Ed	0.12	0.13	0.15	0.14	0.05	0.08	0.09	0.11				
CD (P = 0.05)	0.23	0.26	0.31	0.30	0.11	0.17	0.18	0.21				

(Figures in the parenthesis indicate the original values)

Table 4: Effect of weed control treatments on growth, yield attributes and yield of sugarcane during 2023-24 and 2024-25

Treatments	90 DAP				At harvest									
	Plant height (cm)		No. of tillers $clumb^{-1}$		No. of millable canes ('000 ha^{-1})		Cane length (cm)		Cane girth (cm)		Individual cane weight (kg)		Cane yield (t ha^{-1})	
	2023-24	2024-25	2023-24	2024-25	2023-24	2024-25	2023-24	2024-25	2023-24	2024-25	2023-24	2024-25	2023-24	2024-25
T_1 - 2, 4-D Sodium salt 95% SP @ 2210 g a.i. ha^{-1}	109.13	116.77	11.71	12.53	123.67	132.33	296.31	331.87	2.89	3.24	1.51	1.69	182.85	207.37
T_2 - 2, 4-D Sodium salt 95% SP @ 2600 g a.i. ha^{-1}	116.78	124.95	12.28	13.14	127.82	136.77	325.29	364.32	3.14	3.52	1.55	1.74	194.81	218.19
T_3 - 2, 4-D Sodium salt 95% SP @ 2990 g a.i. ha^{-1}	118.67	126.98	12.43	13.30	129.66	138.74	337.82	378.36	3.26	3.65	1.57	1.76	198.70	218.81
T_4 - Diuron 80% WP @ 3200 g a.i. ha^{-1}	98.82	105.74	11.08	11.86	117.92	126.17	258.49	289.51	2.47	2.77	1.44	1.61	165.27	185.10
T_5 - Metsulfuron methyl 20% WP @ 6 g a.i. ha^{-1}	101.53	108.64	11.24	12.03	118.31	126.59	271.38	303.95	2.58	2.89	1.45	1.62	168.76	189.01
T_6 - Hand Weeding on 30, 60 and 90 DAP	105.67	113.07	12.92	13.82	122.26	130.82	292.26	327.33	2.81	3.15	1.49	1.67	179.63	201.19
T_7 – UTC	78.33	83.81	8.27	8.85	101.15	108.23	181.17	202.91	1.67	1.87	0.97	1.09	95.54	107.00
S. Ed	1.63	2.27	0.22	0.23	2.07	2.44	7.7	5.35	0.07	0.04	0.015	0.01	2.25	2.00
CD (P = 0.05)	3.25	4.57	0.45	0.47	4.12	4.89	15.61	17.67	0.16	0.13	0.03	0.04	4.57	6.59

Effect on growth, yield attributes and yield

The results showed in table no.4 indicated that weed control treatments significantly influenced on growth, yield attributes and yield of sugarcane. Among the herbicide treatments, application of 2, 4-D Sodium salt 95% SP @ 2990 g a.i. ha^{-1} (T_3) recorded maximum plant height and number of tillers, was on par with application of 2, 4-D Sodium salt 95% SP @ 2600 g a.i. ha^{-1} (T_2). This is because, weed free environment in critical period of crop resulting in higher availability of plant nutrients and moisture favouring increased growth characters. Similarly, the same treatment obtained the higher yield attributes (no. of millable cane, cane length, cane grith and individual cane weight). This might be due to higher weed control efficiency and the absence of weed competition by reducing weed density, increase of cane length and millable cane count. Similar findings were reported by Almubarak *et al*. (2012a) [1]. Higher sugar yield was obtained with the application of 2, 4-D Sodium salt 95% SP @ 2990 g a.i. ha^{-1} (T_3), the better expression of yield is due to effective control of weed which increased the higher yield attributing characters resulted in higher cane yield. However this treatment was on par with application of 2, 4-D Sodium salt 95% SP @ 2600 g a.i. ha^{-1} (T_2). The findings of these investigations were in line with Ramesha *et al*. (2018) [9].

Conclusion

Although treatment T_3 - 2, 4-D Sodium salt 95% SP @ 2990 g a.i. ha^{-1} registered maximum yield and higher weed control efficiency, it was on par with T_2 - 2, 4-D Sodium salt 95% SP @ 2600 g a.i. ha^{-1}. From the present investigation it can be concluded that post emergence application of 2, 4-D Sodium salt 95% SP @ 2600 g a.i. ha^{-1} (T_2) proved more convenient and economically best feasible weed control of sugarcane considering the cost of herbicide and returns per rupee invested on cultivation of sugarcane.

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