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ORIGINAL ARTICLE

Evaluation of pre- and post-emergence herbicides for weed management in wheat crop (*Triticum aestivum* L.)

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ABSTRACT
A field experiment was conducted during the rabi seasons of 2023–24 and 2024–25 at the Crop Research Farm, School of Agricultural Sciences, GD Goenka University, Sohna, Haryana, to evaluate the bio-efficacy of pre- and post-emergence herbicides in wheat. The experiment was laid out in a Randomized Block Design with thirteen treatments and three replications. Weed management treatments significantly reduced weed density and dry matter, and improved weed control efficiency. Pyroxasulfone 127.5 g ha^{-1} + pendimethalin 1500 g ha^{-1} (PRE) fb pinoxaden 50 g ha^{-1} (PoE) recorded the lowest density of Phalaris minor (2.34 and 2.23 plants m^{-2}), while carfentrazone ethyl 20 g ha^{-1} + sulfosulfuron 25 g ha^{-1} resulted in the lowest density of Chenopodium album (2.39 and 1.53 plants m^{-2}). The highest weed control efficiency was recorded under pendimethalin 1500 g ha^{-1} fb one hand weeding (83.37 and 84.75%) with the lowest weed dry matter. In terms of productivity, treatment T_{11} recorded the highest grain yield (3822.25 and 3977.37 kg ha^{-1}), straw yield (5706.87 and 5754.53 kg ha^{-1}), and biological yield (9529.12 and 9731.90 kg ha^{-1}), and remained statistically at par with T_8. Harvest index varied marginally (40–41%). The weedy check (for comparison) resulted in substantially lower yields.
Keywords: *Wheat, weed control efficiency, Phalaris minor, sequential herbicide application*

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INTRODUCTION
Wheat (*Triticum aestivum* L.) is one of the most important cereal crops in the world and serves as a staple food for a large proportion of the global population. It provides nearly 55% of carbohydrates and 20% of dietary calories, making it a major contributor to food and nutritional security. In India, wheat occupies about 31.83 million hectares with a production of 113.29 million tonnes during 2023–24 [1]. However, despite the adoption of improved varieties and agronomic practices, weed infestation remains a major constraint in realizing the yield potential of wheat.
Weeds compete with wheat plants for nutrients, moisture, light, and space, particularly during the critical period of crop–weed competition, resulting in substantial yield losses. In India, losses due to weed infestation in wheat may range from 20 to 60%, depending upon weed density and composition [2]. Common weed flora in wheat fields includes grassy weeds such as *Phalaris minor* and *Avena ludoviciana*, and broad-leaved weeds such as *Chenopodium album* and *Rumex dentatus*. Efficient weed management is therefore essential to achieve higher wheat productivity.
Chemical weed control has become an integral part of weed management in wheat due to its efficiency and economic feasibility. Herbicides such as pendimethalin, metribuzin, sulfosulfuron, clodinafop-propargyl, and pinoxaden are widely used for effective control of grassy and broad-leaved weeds [3]. However, variations in weed flora and herbicide response necessitate the evaluation of suitable herbicide combinations and application timings for effective weed control in wheat. Sequential application of pre- and post-emergence herbicides has shown promising results in managing complex weed flora, improving weed control efficiency, and enhancing crop productivity.

Although several herbicides are recommended for wheat, their comparative bio-efficacy under different weed situations needs continuous evaluation for developing effective weed management strategies. Therefore, the present study was undertaken to evaluate the bio-efficacy of selected pre- and post-emergence herbicides for effective weed management in wheat under the prevailing agro-climatic conditions.

MATERIAL AND METHODS

A field experiment entitled "Bio-efficacy of pre- and post-emergence herbicides in wheat (*Triticum aestivum* L.)" was conducted during the rabi seasons of 2023–24 and 2024–25 at the Crop Research Farm, School of Agricultural Sciences, GD Goenka University, Sohna, Haryana, India. The experimental site is situated at 28.26° N latitude, 77.06° E longitude, at an altitude of 237 m above mean sea level. The region experiences a semi-arid subtropical climate with cool winters and hot summers.

The soil of the experimental field was sandy loam, slightly alkaline in reaction (pH 7.58), low in organic carbon (0.40%) and available nitrogen (192.5 kg ha^{-1}), medium in available phosphorus (15.4 kg ha^{-1}) and potassium (248.0 kg ha^{-1}). The experiment was laid out in a Randomized Block Design (RBD) with thirteen treatments replicated three times.

The treatments consisted of different herbicide combinations, including pre-emergence and post-emergence applications, along with weed-free and weedy check treatments: T_1: Pyroxasulfone 105 g ha^{-1} (PRE), T_2: Pyroxasulfone 127.5 g ha^{-1} (PRE), T_3: Pyroxasulfone 150 g ha^{-1} (PRE), T_4: Pyroxasulfone 127.5 g ha^{-1} + Pendimethalin 1500 g ha^{-1} (PRE), T_5: Pyroxasulfone 127.5 g ha^{-1} *fb* Pinoxaden 50 g ha^{-1}, T_6: Pyroxasulfone 127.5 g ha^{-1} + Pendimethalin 1500 g ha^{-1} *fb* Pinoxaden 50 g ha^{-1}, T_7: Pyroxasulfone 127.5 g ha^{-1} *fb* Clodinafop-propargyl 60 g ha^{-1}, T_8: Carfentrazone-ethyl 20 g ha^{-1} + Sulfosulfuron 25 g ha^{-1}, T_9: Mesosulfuron methyl + Iodosulfuron methyl sodium 14.4 g ha^{-1}, T_{10}: Clodinafop-propargyl 60 g ha^{-1} + Metsulfuron methyl 4 g ha^{-1}, T_{11}: Pendimethalin 1500 g ha^{-1} *fb* one hand weeding at 30 DAS, T_{12}: weed free, and T_{13}: weedy check.

Wheat variety HD-2967 was sown during the second fortnight of November in both years using a seed rate of 100 kg ha^{-1} with 20 cm row spacing. After the harvest of wheat, green gram variety MH-1142 was sown in the same plots during May using 25 kg seed ha^{-1} at 30 cm row spacing to study the residual effect of herbicides.

A recommended fertilizer dose of 120:60:25 kg $N:P_2O_5:ZnSO_4$ ha^{-1} was applied to wheat. Herbicides were sprayed using a knapsack sprayer fitted with a flat-fan nozzle, using 500 L ha^{-1} spray volume for pre-emergence and 400 L ha^{-1} for post-emergence applications.

Observations on weed density, weed dry matter and weed control efficiency were recorded at periodic intervals.

The experimental data were analyzed statistically by applying analysis of variance (ANOVA) appropriate for the Randomized Block Design (RBD) as suggested by [4]. Data on weed density and weed dry matter were subjected to square root transformation $(\sqrt{x+1})$to stabilize the variance before analysis. The significance of treatment differences was tested by F-test, and treatment means were compared using the critical difference (CD) at 5% probability level.

RESULT AND DISCUSSION

Effect on weed density of *Phalaris minor*

The density of *Phalaris minor* was significantly influenced by different weed management treatments at all growth stages during both years of experimentation. At harvest, among the herbicidal treatments, T_6 [Pyroxasulfone 127.5 g ha^{-1} + Pendimethalin 1500 g ha^{-1} (PRE) *fb* Pinoxaden 50 g ha^{-1} (PoE)] recorded the lowest *Phalaris minor* density (2.34 and 2.23 plants m^{-2}) during 2023–24 and 2024–25, respectively, and remained statistically *at par* with T_4 [Pyroxasulfone 127.5 g ha^{-1} + Pendimethalin 1500 g ha^{-1}] (2.38 and 2.27 plants m^{-2}). Both treatments significantly reduced the density compared to the weedy check (4.36 and 4.13 plants m^{-2}).

The lowest density of *Phalaris minor* under T_6 might be due to the effective pre-emergence control provided by pyroxasulfone and pendimethalin, followed by the post-emergence action of pinoxaden, which effectively controlled late-emerging grassy weeds. Sequential application of herbicides with different modes of action ensured season-long suppression of *Phalaris minor*, resulting in significantly lower weed density. Similar findings were reported by [3], who observed that pre-emergence herbicides followed by post-emergence grass herbicides significantly reduced the population of *Phalaris minor* in wheat.

Table 1: Bio efficacy of pre and post emergence herbicides on Species wise density of *Phalaris Minor* (no. m^{-2})

Tr. No.	Treatments	Phalaris Minor (no. m^{-2})									
		30 DAS		60 DAS		90 DAS		120 DAS		At Harvest Stage	
		2023-24	2024-25	2023-24	2024-25	2023-24	2024-25	2023-24	2024-25	2023-24	2024-25
T_1	Pyroxasulfone 105 gm/ha	2.43 (4.93)	2.37 (4.94)	2.98 (7.89)	2.82 (7.01)	3.59 (11.86)	3.38 (10.51)	3.52 (11.39)	3.33 (10.13)	3.49 (11.23)	3.30 (9.98)
T_2	Pyroxasulfone 127.5 gm/ha	2.42 (4.83)	2.33 (4.50)	2.96 (7.74)	2.81 (6.89)	3.56 (11.64)	3.36 (10.33)	3.49 (11.17)	3.30 (9.95)	3.47 (11.01)	3.28 (9.80)
T_3	Pyroxasulfone 150 gm/ha	2.35 (4.52)	2.12 (3.74)	2.87 (7.24)	2.74 (6.50)	3.45 (10.89)	3.27 (9.73)	3.38 (10.46)	3.22 (9.35)	3.36 (10.31)	3.19 (9.19)
T_4	Pyroxasulfone 127.5 gm/ha + Pendimethalin 1500 g/ha	1.56 (1.45)	1.48 (1.22)	2.07 (3.32)	1.99 (2.97)	2.44 (4.99)	2.33 (4.45)	2.40 (4.81)	2.29 (4.29)	2.38 (4.74)	2.27 (4.22)
T_5	Pyroxasulfone 127.5 g/ha *fb* pinoxaden 50 g/ha	2.90 (7.43)	2.20 (3.86)	1.97 (2.90)	1.89 (2.59)	2.31 (4.35)	2.20 (3.88)	2.27 (4.20)	2.17 (3.74)	2.26 (4.14)	2.16 (3.68)
T_6	Pyroxasulfone 127.5 g/ha + Pendimethalin 1500 g/ha (PRE) *fb* pinoxaden 50 g/ha (PoE)	1.53 (1.36)	1.42 (1.09)	2.04 (3.17)	1.95 (2.84)	2.39 (4.76)	2.28 (4.25)	2.35 (4.58)	2.25 (4.09)	2.34 (4.52)	2.23 (4.02)
T_7	Pyroxasulfone 127.5 gm/ha *fb* Clodinafop propargyl 60g/ha	2.33 (4.43)	2.27 (4.25)	2.01 (3.05)	1.93 (2.72)	2.35 (4.57)	2.25 (4.08)	2.32 (4.41)	2.21 (3.93)	2.30 (4.35)	2.20 (3.86)
T_8	Carfentrazone ethyl 20g/ha + Sulfosulfuron 25 g/ha (TM)	2.96 (7.79)	2.95 (7.75)	2.02 (3.13)	1.94 (2.79)	2.37 (4.70)	2.27 (4.19)	2.34 (4.53)	2.23 (4.03)	2.33 (4.47)	2.22 (3.97)
T_9	Mesoulfuron Methyl + iodosulfuron methyl sodium 14.4 g/ha (TM)	2.87 (7.26)	2.78 (6.71)	2.05 (3.23)	1.97 (2.89)	2.41 (4.85)	2.30 (4.33)	2.37 (4.67)	2.27 (4.17)	2.36 (4.60)	2.25 (4.10)
T_{10}	Clodinafop propargyl 60g/ha + metsulfuron Methyl 4g/h (RM)	2.94 (7.62)	2.85 (7.17)	2.18 (3.81)	2.09 (3.40)	2.58 (5.71)	2.46 (5.09)	2.54 (5.51)	2.42 (4.91)	2.52 (5.44)	2.40 (4.83)
T_{11}	Pendimethalin 1500 g/ha *fb* one hand weeding	2.15 (3.64)	2.08 (3.38)	1.34 (0.82)	1.31 (0.73)	1.47 (1.23)	1.43 (1.10)	1.46 (1.19)	1.42 (1.06)	1.46 (1.17)	1.41 (1.04)
T_{12}	Weed Free	1.00 (00)	1.00 (00)	1.00 (00)	1.00 (00)	1.00 (00)	1.00 (00)	1.00 (00)	1.00 (00)	1.00 (00)	1.00 (00)
T_{13}	Weedy Check	2.98 (7.89)	2.88 (7.31)	3.69 (12.64)	3.52 (11.36)	4.47 (19.02)	4.24 (17.01)	4.39 (18.25)	4.16 (16.34)	4.36 (17.98)	4.13 (16.04)
SE(m)±		0.06	0.15	0.10	0.09	0.13	0.12	0.13	0.14	0.13	0.13
LSD (P=0.05)		0.17	0.45	0.30	0.28	0.37	0.37	0.38	0.40	0.39	0.39

Note: Original values are given in parenthesis, transformation $\sqrt{x+0.5}$

Table 2: Bio efficacy of pre and post emergence herbicides on Species wise density of *Chenopodium album* (no. m-2)

Tr. No.	Treatments	*Chenopodium album* (no. m-2)									
		30 DAS		60 DAS		90 DAS		120 DAS		At Harvest Stage	
		2023-24	2024-25	2023-24	2024-25	2023-24	2024-25	2023-24	2024-25	2023-24	2024-25
T_1	Pyroxasulfone 105 gm/ha	2.53 (5.38)	2.46 (5.24)	3.19 (9.19)	2.93 (7.60)	3.85 (13.79)	3.33 (10.09)	3.74 (12.99)	3.24 (9.47)	3.71 (12.75)	3.18 (9.08)
T_2	Pyroxasulfone 127.5 gm/ha	2.51 (5.31)	2.46 (5.09)	3.17 (9.07)	2.92 (7.51)	3.82 (13.62)	3.31 (9.98)	3.72 (12.84)	3.22 (9.37)	3.69 (12.60)	3.16 (8.98)
T_3	Pyroxasulfone 150 gm/ha	2.46 (5.07)	2.29 (4.50)	3.14 (8.85)	2.89 (7.33)	3.78 (13.29)	3.28 (9.74)	3.68 (12.53)	3.18 (9.14)	3.65 (12.29)	3.12 (8.76)
T_4	Pyroxasulfone 127.5 gm/ha + Pendimethalin 1500 g/ha	1.79 (2.19)	1.72 (1.96)	2.15 (3.65)	2.01 (3.05)	2.54 (5.47)	2.25 (4.05)	2.48 (5.14)	2.19 (3.80)	2.45 (5.03)	2.16 (3.64)
T_5	Pyroxasulfone 127.5 g/ha *fb* pinoxaden 50 g/ha	2.60 (5.78)	2.57 (5.59)	3.29 (9.86)	3.02 (8.15)	3.97 (14.79)	3.44 (10.83)	3.87 (13.94)	3.34 (10.17)	3.83 (13.68)	3.28 (9.74)
T_6	Pyroxasulfone 127.5 g/ha + Pendimethalin 1500 g/ha (PRE) *fb* pinoxaden 50 g/ha (PoE)	1.73 (1.98)	1.66 (1.75)	2.06 (3.26)	1.97 (2.87)	2.43 (4.89)	2.19 (3.80)	2.37 (4.60)	2.14 (3.57)	2.35 (4.51)	2.10 (3.42)
T_7	Pyroxasulfone 127.5 gm/ha *fb* Clodinafop propargyl 60g/ha	2.63 (5.90)	2.42 (4.90)	3.22 (9.36)	2.96 (7.74)	3.88 (14.05)	3.36 (10.28)	3.77 (13.23)	3.26 (9.65)	3.74 (12.98)	3.20 (9.24)
T_8	Carfentrazone ethyl 20g/ha + Sulfosulfuron 25 g/ha (TM)	2.63 (5.92)	2.50 (5.29)	1.66 (1.77)	1.54 (1.43)	1.89 (2.63)	1.64 (1.75)	1.85 (2.46)	1.61 (1.62)	1.83 (2.39)	1.58 (1.53)
T_9	Mesoulfuron Methyl + iodosulfuron methyl sodium 14.4 g/ha (TM)	2.53 (5.42)	2.34 (4.47)	1.94 (2.81)	1.81 (2.28)	2.27 (4.18)	1.99 (2.96)	2.21 (3.92)	1.94 (2.77)	2.19 (3.82)	1.91 (2.65)
T_{10}	Clodinafop propargyl 60g/ha + metsulfuron Methyl 4g/h (RM)	2.58 (5.64)	2.41 (4.84)	1.92 (2.70)	1.79 (2.21)	2.24 (4.04)	1.98 (2.91)	2.19 (3.79)	1.93 (2.73)	2.17 (3.71)	1.90 (2.61)
T_{11}	Pendimethalin 1500 g/ha *fb* one hand weeding	1.86 (2.48)	1.79 (2.27)	1.60 (1.56)	1.51 (1.28)	1.82 (2.34)	1.63 (1.68)	1.78 (2.20)	1.60 (1.57)	1.77 (2.15)	1.58 (1.50)
T_{12}	Weed Free	1.00 (00)	1.00 (00)	1.00 (00)	1.00 (00)	1.00 (00)	1.00 (00)	1.00 (00)	1.00 (00)	1.00 (00)	1.00 (00)
T_{13}	Weedy Check	2.67 (6.17)	2.59 (5.73)	3.39 (10.47)	3.11 (8.68)	4.09 (15.73)	3.54 (11.53)	3.98 (14.82)	3.44 (10.83)	3.94 (14.54)	3.37 (10.38)
SE(m)±		0.04	0.12	0.07	0.06	0.07	0.06	0.06	0.05	0..05	0.05
LSD (P=0.05)		0.17	0.48	0.19	017	0.21	0.17	0.18	0.15	0.15	0.14

Note: Original values are given in parenthesis, transformation √x+0.5

Table 3: Bio efficacy of pre and post emergence herbicides on Species wise density of Weed control efficiency (%)

Tr. No.	Treatments	Weed control efficiency (%)									
		30 DAS		60 DAS		90 DAS		120 DAS		At Harvest Stage	
		2023-24	2024-25	2023-24	2024-25	2023-24	2024-25	2023-24	2024-25	2023-24	2024-25
T_1	Pyroxasulfone 105 gm/ha	52.58	54.79	44.35	45.78	54.65	55.39	57.67	58.42	57.68	58.43
T_2	Pyroxasulfone 127.5 gm/ha	53.76	55.90	45.07	46.10	55.26	55.95	58.27	58.93	58.21	58.93
T_3	Pyroxasulfone 150 gm/ha	58.04	59.96	46.75	47.71	56.64	57.31	59.55	60.20	59.48	60.20
T_4	Pyroxasulfone 127.5 gm/ha + Pendimethalin 1500 g/ha	78.91	79.88	69.29	70.13	75.19	76.21	76.90	77.91	76.82	77.91
T_5	Pyroxasulfone 127.5 g/ha *fb* pinoxaden 50 g/ha	57.67	59.64	63.80	64.60	56.30	58.09	59.24	60.86	59.20	60.86
T_6	Pyroxasulfone 127.5 g/ha + Pendimethalin 1500 g/ha (PRE) *fb* pinoxaden 50 g/ha (PoE)	80.15	81.03	70.25	70.86	76.00	76.51	77.65	78.20	77.56	78.20
T_7	Pyroxasulfone 127.5 gm/ha *fb* Clodinafop propargyl 60g/ha	55.96	57.98	65.09	65.74	57.84	59.48	60.69	62.18	60.62	62.18
T_8	Carfentrazone ethyl 20g/ha + Sulfosulfuron 25 g/ha (TM)	11.54	15.64	82.54	82.93	79.20	81.50	80.65	82.91	80.56	82.92
T_9	Mesoulfuron Methyl + iodosulfuron methyl sodium 14.4 g/ha (TM)	3.50	7.85	79.69	80.17	75.74	77.74	77.42	79.39	77.34	79.39
T_{10}	Clodinafop propargyl 60g/ha + metsulfuron Methyl 4g/h (RM)	7.90	12.17	79.77	80.19	75.82	77.00	77.48	78.71	77.39	78.71
T_{11}	Pendimethalin 1500 g/ha *fb* one hand weeding	66.67	68.19	85.02	85.37	82.22	83.49	83.47	84.75	83.37	84.75
T_{12}	Weed Free	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
T_{13}	Weedy Check	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Effect on weed density of *Chenopodium album*

The population of *Chenopodium album* was significantly influenced by different herbicidal treatments at all stages of crop growth during both years of experimentation. At 30 DAS, the lowest population among herbicidal treatments was recorded under T_6 [Pyroxasulfone 127.5 g ha^{-1} + Pendimethalin 1500 g ha^{-1} (PRE) *fb* pinoxaden 50 g ha^{-1} (PoE)], with 1.73 and 1.66 no. m^{-2} during 2023–24 and 2024–25, respectively, which was statistically *at par* with T_4 [Pyroxasulfone 127.5 g ha^{-1} + Pendimethalin 1500 g ha^{-1}] (1.79 and 1.72 no. m^{-2}) and T_{11} [Pendimethalin 1500 g ha^{-1} *fb* one hand weeding] (1.86 and 1.79 no. m^{-2}). At 60 DAS, the minimum weed population was observed under T_{11} (1.60 and 1.51 no. m^{-2}), which remained statistically *at par* with T_8 [Carfentrazone ethyl 20 g ha^{-1} + Sulfosulfuron 25 g ha^{-1}] (1.66 and 1.54 no. m^{-2}), T_{10} (1.92 and 1.79 no. m^{-2}) and T_9 (1.94 and 1.81 no. m^{-2}). Similar trends were observed at 90 DAS, 120 DAS, and at harvest, where T_{11} recorded the lowest population at harvest (1.77 and 1.58 no. m^{-2}) and remained statistically *at par* with T_8 (1.83 and 1.58 no. m^{-2}). The highest population among the herbicidal treatments at harvest was observed under T_5 [Pyroxasulfone 127.5 g ha^{-1} *fb* pinoxaden 50 g ha^{-1}], with 3.83 and 3.28 no. m^{-2}, followed by T_7, T_1, and T_2.

The lower population of *Chenopodium album* under T_{11} may be attributed to the effective control of early-emerging weeds by pendimethalin, followed by manual removal of escaped weeds through hand weeding, resulting in prolonged suppression of weed growth. The effectiveness of T_8 may be due to the combined action of carfentrazone ethyl + sulfosulfuron, which provided efficient control of broad-leaved weeds through inhibition of key metabolic processes. On the other hand, the comparatively higher weed population under T_5 suggests that pyroxasulfone followed by pinoxaden was less effective in controlling *Chenopodium album*, leading to greater weed survival. Similar results were reported by [5], who found that integrated weed management practices involving herbicides and hand weeding significantly reduced broad-leaved weed population in wheat. Likewise, [3] reported effective suppression of broad-leaved weeds with sulfosulfuron-based herbicidal treatments in wheat.

Effect on weed control efficiency

Weed control efficiency was significantly affected by different herbicidal treatments. At harvest, T_{11} [Pendimethalin 1500 g ha^{-1} *fb* one hand weeding] recorded the highest weed control efficiency (83.37 and 84.75%) during 2023–24 and 2024–25, respectively, followed by T_8 (80.56 and 82.92%) and T_6 (77.56 and 78.20%). The lowest weed control efficiency among herbicidal treatments was observed under T_1 (57.68 and 58.43%).

Higher weed control efficiency under T_{11} may be due to the integrated effect of pre-emergence herbicide application followed by manual removal of surviving weeds, which provided effective weed suppression throughout the crop growth period. This integrated approach reduced weed competition more efficiently than sole herbicide application. Similar observations were reported by [6], who stated that integration of chemical and manual weed control resulted in higher weed control efficiency in wheat.

Effect on total weed dry matter

Total weed dry matter was significantly reduced by different weed control treatments. At harvest, T_{11} recorded the lowest weed dry matter (3.84 and 3.56 g m^{-2}) during 2023–24 and 2024–25, respectively, and was found to be significantly superior over the remaining treatments; however, it remained statistically *at par* with T_8 (4.13 and 3.74 g m^{-2}). The next best treatment was T_6, which recorded 4.42 and 4.20 g m^{-2} during the respective years.

The lowest weed dry matter recorded under T_{11}, which remained *at par* with T_8, may be attributed to the effective suppression of weed emergence at the initial stage by the applied weed management practice, which reduced weed growth and dry matter accumulation throughout the crop period. The reduced weed biomass under T_8 also indicates the effectiveness of sequential herbicide application in suppressing weed growth. Similar findings were reported by [7], who observed significant reduction in weed dry matter with effective weed management practices in wheat.

Yield

The grain yield, straw yield, biological yield and harvest index were significantly influenced by different treatments during both years of experimentation. The weedy check (T_{13}) was included only for comparison purposes to assess the magnitude of yield reduction due to weed competition, as also reported by [8]

Pooled analysis revealed that treatment T_{11} recorded the highest grain yield (3822.25 and 3977.37 kg ha^{-1} during 2023–24 and 2024–25, respectively), which was statistically *at par* with T_8 (3934.92 and 4095.13 kg ha^{-1}). The superiority of T_{11} may be attributed to better crop growth, efficient utilization of nutrients, and reduced weed interference, resulting in higher photosynthate accumulation and translocation towards reproductive parts [9].

A similar trend was observed in straw yield, where T_{11} produced 5706.87 and 5754.53 kg ha^{-1}, remaining *at par* with T_8 (5870.48 and 5922.19 kg ha^{-1}). Consequently, biological yield was also found maximum under T_{11} (9529.12 and 9731.90 kg ha^{-1}), which was statistically comparable with T_8 (9805.40 and 10017.32 kg ha^{-1}). These findings are in agreement with earlier reports of [10].

Harvest index showed relatively less variation among treatments; however, slightly higher values were recorded under T_{11} (40.11 and 40.87%) and T_8 (40.13 and 40.88%), indicating efficient partitioning of assimilates towards economic yield [11].

The weed-free treatment (T_{12}) recorded higher yield levels (grain yield: 4110.00 and 4275.94 kg ha^{-1}), reaffirming the importance of effective weed control. In contrast, the weedy check (T_{13}), included solely as a control for comparison, recorded the lowest grain yield (2045.02 and 2128.61 kg ha^{-1}), straw yield (3101.13 and 3166.94 kg ha^{-1}), and biological yield (5146.16 and 5295.54 kg ha^{-1}), clearly demonstrating the adverse effect of unchecked weed growth on crop productivity [12]

Thus, it may be concluded that T_{11} was the most effective treatment, while T_8 remained statistically *at par*, and both treatments significantly improved yield and yield attributes over other treatments. The inclusion of weedy check further highlights the critical role of weed management in achieving higher productivity.

Table 4: Bio efficacy of pre and post emergence herbicides on Species wise density of total dry matter of weed

Tr. No.	Treatments	Total dry matter of weeds (g m^{-2})									
		30 DAS		60 DAS		90 DAS		120 DAS		At Harvest Stage	
		2023-24	2024-25	2023-24	2024-25	2023-24	2024-25	2023-24	2024-25	2023-24	2024-25
T_1	Pyroxasulfone 105 gm/ha	4.16 (16.32)	3.95 (14.63)	6.63 (43.01)	6.45 (40.59)	6.59 (42.45)	6.32 (38.93)	6.04 (35.53)	5.78 (32.39)	5.99 (34.92)	5.72 (31.78)
T_2	Pyroxasulfone 127.5 gm/ha	4.11 (15.91)	3.91 (14.27)	6.59 (42.49)	6.43 (40.34)	6.55 (41.92)	6.27 (38.29)	6.01 (35.07)	5.73 (31.86)	5.96 (34.50)	5.68 (31.27)
T_3	Pyroxasulfone 150 gm/ha	3.94 (14.56)	3.74 (13.06)	6.50 (41.21)	6.33 (39.13)	6.45 (40.65)	6.18 (37.19)	5.92 (34.01)	5.65 (30.94)	5.87 (33.46)	5.60 (30.36)
T_4	Pyroxasulfone 127.5 gm/ha + Pendimethalin 1500 g/ha	2.87 (7.25)	2.73 (6.51)	4.98 (23.81)	4.83 (22.36)	4.92 (23.30)	4.66 (20.76)	4.52 (19.51)	4.27 (17.21)	4.49 (19.17)	4.23 (16.88)
T_5	Pyroxasulfone 127.5 g/ha *fb* pinoxaden 50 g/ha	3.94 (14.53)	3.74 (13.03)	5.38 (27.99)	5.24 (26.50)	6.48 (40.93)	6.12 (36.45)	5.94 (34.23)	5.60 (30.39)	5.89 (33.68)	5.55 (29.82)
T_6	Pyroxasulfone 127.5 g/ha + Pendimethalin 1500 g/ha (PRE) *fb* pinoxaden 50 g/ha (PoE)	2.79 (6.89)	2.67 (6.19)	4.90 (23.05)	4.78 (21.81)	4.85 (22.52)	4.63 (20.48)	4.45 (18.86)	4.24 (16.97)	4.42 (18.55)	4.20 (16.65)
T_7	Pyroxasulfone 127.5 gm/ha *fb* Clodinafop propargyl 60g/ha	4.02 (15.24)	3.82 (13.67)	5.29 (27.02)	5.16 (25.64)	6.37 (39.52)	6.02 (35.26)	5.84 (33.05)	5.51 (29.38)	5.79 (32.52)	5.46 (28.83)
T_8	Carfentrazone ethyl 20g/ha + Sulfosulfuron 25 g/ha (TM)	5.62 (30.55)	5.33 (27.39)	3.81 (13.52)	3.71 (12.78)	4.53 (19.51)	4.13 (16.06)	4.16 (16.33)	3.77 (13.24)	4.13 (16.06)	3.74 (12.99)
T_9	Mesoulfuron Methyl + iodosulfuron methyl sodium 14.4 g/ha (TM)	5.86 (33.37)	5.56 (29.92)	4.09 (15.74)	3.98 (14.85)	4.87 (22.76)	4.52 (19.39)	4.47 (19.05)	4.13 (16.03)	4.44 (18.73)	4.09 (15.73)
T_{10}	Clodinafop propargyl 60g/ha + metsulfuron Methyl 4g/h (RM)	5.73 (31.80)	5.43 (28.51)	4.08 (15.67)	3.98 (14.83)	4.87 (22.68)	4.59 (20.04)	4.47 (18.99)	4.19 (16.56)	4.44 (18.68)	4.15 (16.25)
T_{11}	Pendimethalin 1500 g/ha *fb* one hand weeding	3.54 (11.56)	3.37 (10.37)	3.55 (11.62)	3.46 (10.96)	4.20 (16.70)	3.92 (14.44)	3.87 (13.99)	3.59 (11.91)	3.84 (13.75)	3.56 (11.68)
T_{12}	Weed Free	1.00 (00)	1.00 (00)	1.00 (00)	1.00 (00)	1.00 (00)	1.00 (00)	1.00 (00)	1.00 (00)	1.00 (00)	1.00 (00)
T_{13}	Weedy Check	5.96 (34.56)	5.79 (32.49)	8.85 (77.41)	8.71 (74.83)	9.73 (93.76)	9.39 (87.23)	9.22 (83.94)	8.88 (77.87)	9.14 (82.58)	8.80 (76.41)
SE(m)±		0.12	0.12	0.08	0.03	0.09	0.09	0.08	0.08	0.07	0.23
LSD (P=0.05)		0.38	0.34	0.25	0.08	0.25	0.25	0.24	0.23	0.20	0.31

Note: Original values are given in parenthesis, transformation √x+0.5

Table 5: Bio efficacy of pre and post emergence herbicides on Species wise density of yield

Tr. No.	Treatments	Yield							
		Grain yield		Straw yield		Biological yield		Harvest index	
		2023-24	2024-25	2023-24	2024-25	2023-24	2024-25	2023-24	2024-25
T_1	Pyroxasulfone 105 gm/ha	2907.37	2937.23	4393.80	4445.75	7301.17	7382.98	39.92	40.28
T_2	Pyroxasulfone 127.5 gm/ha	2928.30	3062.14	4400.34	4457.17	7328.64	7519.31	39.96	40.32
T_3	Pyroxasulfone 150 gm/ha	2979.30	3100.43	4472.52	4509.92	7451.83	7610.35	39.98	40.74
T_4	Pyroxasulfone 127.5 gm/ha + Pendimethalin 1500 g/ha	3672.84	3823.12	5505.22	5550.62	9178.06	9373.74	40.02	40.78
T_5	Pyroxasulfone 127.5 g/ha *fb* pinoxaden 50 g/ha	2967.93	3088.52	4457.57	4494.84	7425.50	7583.36	39.97	40.73
T_6	Pyroxasulfone 127.5 g/ha + Pendimethalin 1500 g/ha (PRE) *fb* pinoxaden 50 g/ha (PoE)	3702.26	3852.68	5535.01	5581.19	9237.27	9433.87	40.08	40.84
T_7	Pyroxasulfone 127.5 gm/ha *fb* Clodinafop propargyl 60g/ha	3024.78	3147.62	4537.23	4575.22	7562.01	7722.83	40.00	40.76
T_8	Carfentrazone ethyl 20g/ha + Sulfosulfuron 25 g/ha (TM)	3822.25	3977.37	5706.87	5754.53	9529.12	9731.90	40.11	40.87
T_9	Mesoulfuron Methyl + iodosulfuron methyl sodium 14.4 g/ha (TM)	3693.50	3843.92	5530.34	5576.30	9223.84	9420.22	40.05	40.80
T_{10}	Clodinafop propargyl 60g/ha + metsulfuron Methyl 4g/h (RM)	3695.67	3845.82	5528.18	5574.30	9223.85	9420.12	40.07	40.82
T_{11}	Pendimethalin 1500 g/ha *fb* one hand weeding	3934.92	4095.13	5870.48	5922.19	9805.40	10017.32	40.13	40.88
T_{12}	Weed Free	4110.00	4275.94	6130.29	6181.86	10240.29	10457.80	40.14	40.89
T_{13}	Weedy Check	2045.02	2128.61	3101.13	3166.94	5146.16	5295.54	39.74	40.20
SE(m)±		103.54	132.35	181.89	173.40	285.37	236.49	--	--
LSD (P=0.05)		302.21	386.31	530.89	506.13	832.94	690.26	--	--

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