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COMPARATIVE EFFICACY OF INTEGRATED PRE- AND POST-EMERGENCE HERBICIDE APPLICATIONS AND MANUAL WEEDING IN MUSTARD (*BRASSICA JUNCEA* L.) UNDER IRRIGATED CONDITIONS OF GRID REGION OF GWALIOR INDIA

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ABSTRACT

During the 2024–2025 *Rabi* season, a field experiment was carried out at the Crop Research Centre (CRC-1) to assess the Comparative Efficacy of Integrated Pre- and Post-Emergence Herbicide Applications and Manual Weeding in Mustard under Irrigated Conditions of Grid Region of Gwalior. The study comprised ten treatments, including pre-emergence, post-emergence, and integrated herbicide-hand weeding combinations, arranged with three replications in a randomised block arrangement. Metribuzin @ 175 g a.i. ha^{-1} *fb* HW at 45 DAS produced the highest seed yield (2350.17 kg ha^{-1}) of all the treatments. Likewise, this integrated treatment also led to a considerable increase in the number of branches, leaf area index, dry matter accumulation, and plant height. The weedy check consistently recorded the lowest growth and yield performances. Results indicate that integrated weed management practices, especially Metribuzin followed by hand weeding at 45 DAS, can be recommended under the Grid region of Gwalior under irrigated conditions, as it is highly effective and economically viable for maximizing mustard productivity.

Keywords **:** Mustard, Hand-weeding, Pre-emergence, post-emergence herbicide

Introduction

Mustard, derived from the Latin word *mustum*, is a significant edible oilseed crop cultivated in over 53 countries. In India, eight species of rapeseed-mustard are grown, including Indian mustard (*Brassica juncea*), which contributes over 70% of the total area and production. Globally, mustard ranks third among oilseed crops after soybean and oil palm, contributing 6.7% to world oilseed production (Rathore *et al*., 2022). Its oil content ranges from 37 to 49%, and it is well-suited to dryland farming due to its short growing season and adaptability to marginal soils. India cultivates mustard on 8.85 million hectares, producing 12.64 million tonnes with a productivity of 1428 kg/ha. Major producing states include Rajasthan (49%), Haryana, Uttar Pradesh, Madhya Pradesh, and Gujarat. In Madhya Pradesh, mustard had a production of 1.55mt and productivity of 1540 kg/ha (Ministry of Agriculture, 2023). Whereas in Gwalior productivity remained lower (1052 kg/ha), potentially due to poor agronomic practices, especially weed infestation (Department of Farmers Welfare & Agricultural development, M.P., 2023). Weeds are a major constraint, causing 25–35% yield losses, particularly during the critical period of 15–40 days after sowing. Common weeds include *Phalaris minor*, *Chenopodium album*, and *Cyperus rotundus*. Weed control methods include mechanical, cultural, and chemical approaches. Herbicides are preferred where labour is scarce and have proven effective when used at pre- and post-emergence stages. Integration of herbicides with hand weeding helps keep weed populations below economic thresholds. Therefore, this study was carried out to compare the effectiveness of pre- and post-emergence herbicides for efficient weed management in mustard.

Materials Methods

The present experiment was conducted during the *Rabi* season 2024-25 at Crop Research Centre (CRC-1) ITM University, Gwalior. The experiment was laid out in RBD design having 10 treatments and 3 replications. Among the 10 treatments, three treatments included solely pre-emergence herbicides, and two included post-emergence herbicides, while the remaining three included pre- and post-emergence herbicides along with physical measures (hand-weeding).

The treatment details are: T_1 – Pendimethalin @ 1000 g a.i. ha^{-1} (PE), T_2 – Metribuzin @ 175 g a.i. ha^{-1} (PE), T_3 – Oxyfluorfen @ 250 g a.i. ha^{-1} (PE), T_4 – Clodinafop propargyl @ 60 g a.i. ha^{-1} (PoE), T_5 – Propaquizalofop @ 100 g a.i. ha^{-1} (PoE), T_6 – Pendimethalin @ 1000 g a.i. ha^{-1} (PE) fb HW at 45 DAS, T_7 – Metribuzin @ 175 g a.i. ha^{-1} fb HW at 45 DAS, T_8 – Clodinafop propargyl @ 60 g a.i. ha^{-1} fb HW at 45 DAS, T_9 – Weed free check, T_{10}- Weedycheck. The variety Rukmani (DRMR 1165-40) was sown on 9th October 2024 with row spacing of 45 cm and plant spacing of 15 cm, with an RDF (recommended dose of fertiliser) of 90:50:40:30 kg ha^{-1} N: P_2 O_5 : K_2 O: S, respectively, and a seed rate of 5 kg/ha. Half dose of nitrogen as urea and full dose of phosphorus as DAP and potassium as MOP were given as a basal dose. The remaining quantity of nitrogen was applied in two equal splits. The herbicides were sprayed using a knapsack sprayer fitted with a flat fan nozzle, applying at a volume of 500 liters per hectare. Following seeding, a light irrigation was applied during the rosette stage and pod development stage. The crop was harvested on 10th February 2025. The RBD analysis of data along with mean comparison test was performed using online tool Agri Analyze Popat *et al.* (2024).

Results and Discussion

Plant height and dry matter accumulation

The data revealed that plant height and dry matter accumulation (g m^{-2}) of mustard varied significantly due to different weed management treatments from 60 DAS onwards, although no significant differences were observed at 30 DAS. At the early stage (30 DAS), all treatments showed comparable plant height, ranging from 67.64 cm under the weedy check (T_9) to 70.44 cm under weed-free check (T_{10}) and dry matter accumulation, ranging from 59.37 under weedy check (T_{10}) to 61.83 under the weed-free check (T_9). However, as the crop advanced in age, weed interference began to markedly influence plant height. At 60 DAS, significantly maximum height was observed in (T_7) Metribuzin @ 175 g a.i. ha^{-1} *fb* hand weeding (152.46 cm), followed by the treatment Pendimethalin *fb* HW (147.56 cm), similarly in case of dry matter accumulation significantly higher dry matter accumulation was observed under Metribuzin @ 175 g a.i. ha^{-1} *fb* hand weeding (380.63 g m^{-2}), found statistically at par with Pendimethalin *fb* HW (368.32 g/m^2),. Conversely, the weedy check plot recorded significantly minimum plant height (93.82 cm) and dry matter accumulation (234.17g m^{-2}) indicating severe competition and suppressed crop growth. At 90 DAS and at harvest, (T_7) continued to dominate followed by (T_6) while the weedy check (T_{10}) lagged significantly.The improved height and dry matter accumulation which peaked from 60 DAS, might be due to the inclusion of hand weeding along with herbicide, which controlled weeds effectively, ultimately increasing crop growth (height and dry matter) due to improved availability of nutrients. Similar findings were also recorded by Pandey (2022) and *Maurya et al.* (2024).

Table 1: Effect of Weed Management practices on plant height (cm) and dry matter accumulation (g/m^2)

Symbols	Treatments	Plant Height (cm)				Dry matter accumulation (g m^{-2})			
		30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
T_1	Pendimethalin @ 1000g a.i. ha^{-1}	69.15	120.52	147.46	150.35	60.17	300.81	522.62	544.99
T_2	Metribuzin @ 175g a.i. ha^{-1}	69.48	127.95	156.04	159.24	60.99	319.50	553.09	577.11
T_3	Oxyfluorfen @ 250g a.i. ha^{-1}(PE)	69.30	118.8	145.50	148.14	60.70	292.17	509.51	531.01
T_4	Clodinafop propargyl @ 60g a.i. ha^{-1}(PoE)	68.33	106.04	131.59	133.64	59.77	265.01	465.03	484.56
T_5	Propaquizalofop@100g a.i. ha^{-1} (PoE)	68.22	117.05	143.78	146.43	59.89	279.08	486.24	507.80
T_6	Pendimethalin@1000g a.i. ha^{-1}(PE) *fb* HW at 45 DAS	69.72	147.56	175.52	180.40	61.20	368.32	625.68	654.15
T_7	Metribuzin@175g a.i. ha^{-1}*fb* HW at 45 DAS	69.94	152.46	180.82	186.00	61.40	380.63	644.32	674.56
T_8	Clodinafop propargyl@60g a.i. ha^{-1} *fb* HW at 45 DAS	69.03	137.56	164.84	169.07	60.59	343.34	587.47	613.30
T_9	Weed Free	70.44	165.44	192.76	199.31	61.83	412.94	686.95	722.95
T_{10}	Weedy check	67.64	93.82	107.75	108.57	59.37	234.17	377.56	394.34
S. Em±		3.64	3.11	5.38	4.05	3.40	8.43	20.10	14.66
CD (P=0.05)		NS	9.25	15.99	12.02	NS	25.05	59.72	43.55

* *fb*= followed by, HW=Hand weeding

PE = Pre-emergence application, POE= post-emergence application,

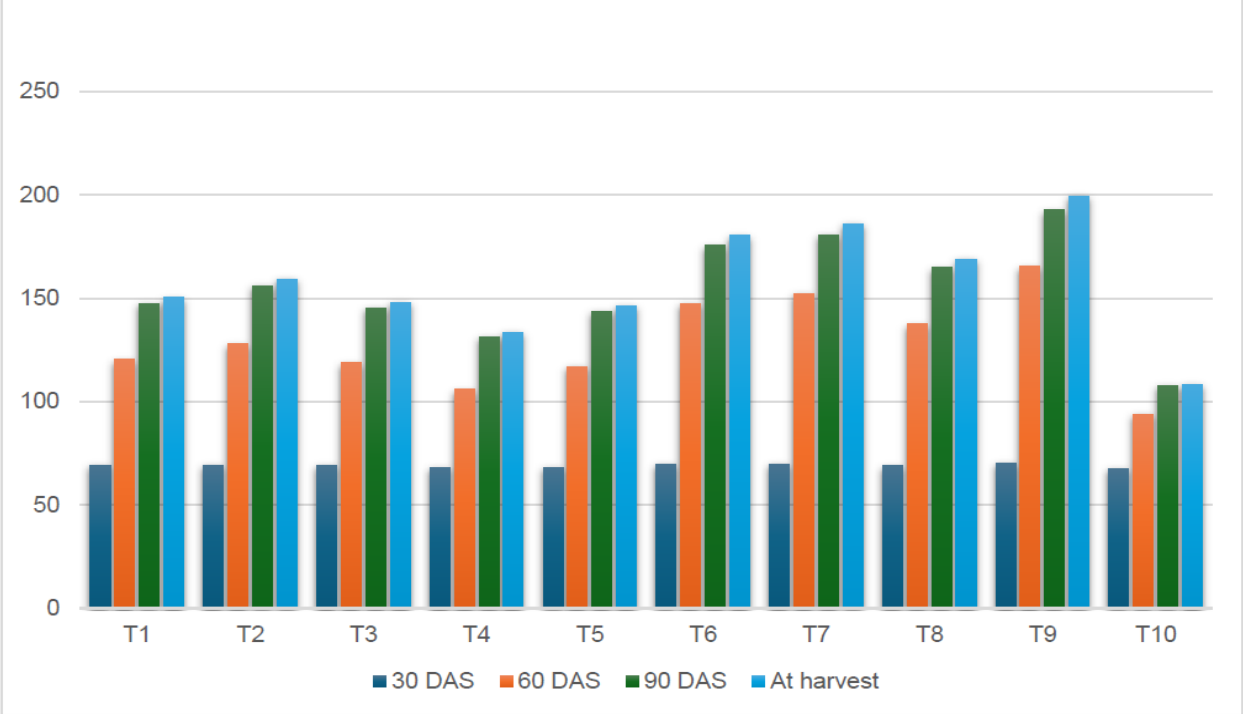

Fig. 1: Effect of Weed Management practices on plant height (cm)

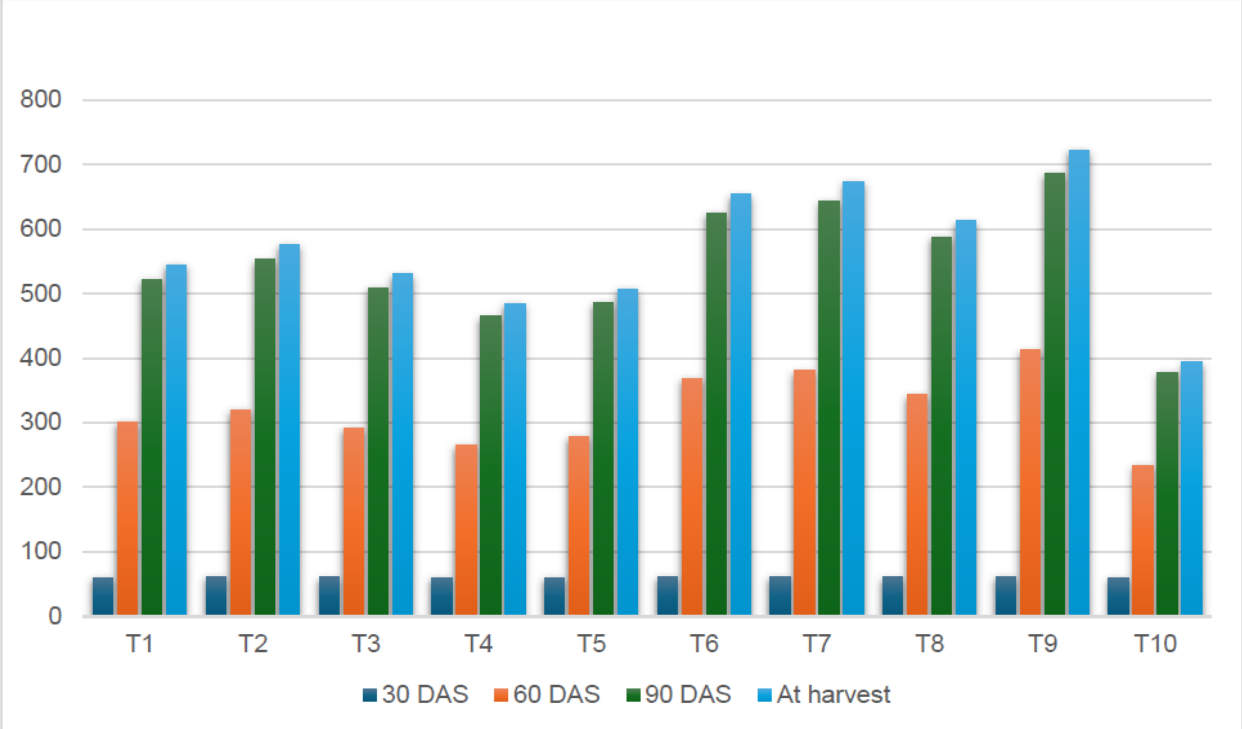

Fig. 2: Effect of Weed Management practices on dry matter accumulation (g/m^2)

No of Branches

The number of primary and secondary branches per plant in mustard were significantly influenced by different weed management practices. The maximum number of branches were observed under the (T_7) Metribuzin @ 175 g a.i. ha^{-1} *fb* HW at 45 DAS which was closely followed by (T_6) Pendimethalin @ 1000 g a.i. ha^{-1} (PE) *fb* HW at 45 DAS. These integrated treatments effectively suppressed weed growth, thereby reducing interspecific competition for light, water, and nutrients, particularly nitrogen resulting enhanced vegetative growth of the plants which was

characterized by robust stem development and an increase in number of branches. On the contrary, the weedy check (T_{10}) recorded the minimum number of branches, likely may be due to intense weed competition that reduced resource availability which might have resulted in restricted branching. This improvement in branching under integrated weed management treatments aligns with the findings of Maurya *et al.* (2024), who reported that effective weed control enhances nutrient uptake and light interception, promoting the better development of branches in mustard.

LAI

Maximum leaf area index at 30, 60 and 90 DAS was recorded with Metribuzin@175g a.i. ha^{-1} *fb* HW at 45 DAS **(T_7)** found at par with and Pendimethalin @ 1000g a.i. ha^{-1} (PE) *fb* HW at 45 DAS **(T_6)** when compared to other treatments and minimum leaf area index was recorded in weedy check **(T_{10})**.The observed increase in leaf number and leaf area index under integrated weed management treatments may be due to increased plant height and abundant branching, which naturally resulted in more leaves per plant, increased leaf number and leaf area index under integrated weed management methods. A larger leaf area index is a result of the increased foliage since it increases the overall leaf area. Additionally, enhanced weed control under integrated management systems guarantees higher nutrient availability, especially nitrogen, which is essential for encouraging both lateral (branch) and vertical (plant height) growth. Under such conditions, effective nutrient uptake and utilisation promote vegetative growth, which in turn increases the photosynthetic surface area. Prithvi Raj, *et al.* (2021) reported similar results, observing improved leaf area parameters under successful weed management techniques.

Table 2: Effect of Weed Management practices on No of branches and Leaf area index

Symbols	Treatments	No of branches		Leaf Area Index		
		60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T_1	Pendimethalin @ 1000g a.i. ha^{-1}	15.06	21.53	2.16	4.58	3.28
T_2	Metribuzin @ 175g a.i. ha^{-1}	16.00	22.78	2.49	4.86	3.71
T_3	Oxyfluorfen @ 250g a.i. ha^{-1}(PE)	13.97	20.10	2.35	4.25	3.28
T_4	Clodinafop propargyl @ 60g a.i. ha^{-1}(PoE)	13.27	19.21	2.07	4.03	3.13
T_5	Propaquizalofop@100g a.i. ha^{-1} (PoE)	14.63	20.99	2.28	4.45	3.42
T_6	Pendimethalin@1000g a.i. ha^{-1}(PE) *fb* HW at 45 DAS	18.44	25.63	2.88	5.61	4.18
T_7	Metribuzin@175g a.i. ha^{-1}*fb* HW at 45 DAS	19.06	26.40	2.91	5.79	4.30
T_8	Clodinafop propargyl@60g a.i. ha^{-1} *fb* HW at 45 DAS	17.19	24.07	2.67	5.23	3.92
T_9	Weed Free	20.68	28.14	3.23	6.29	4.74
T_{10}	Weedy check	11.73	15.75	1.81	3.56	2.56
S. Em±		0.42	0.82	0.10	0.13	0.12
CD (P=0.05)		1.25	2.45	0.30	0.38	0.37

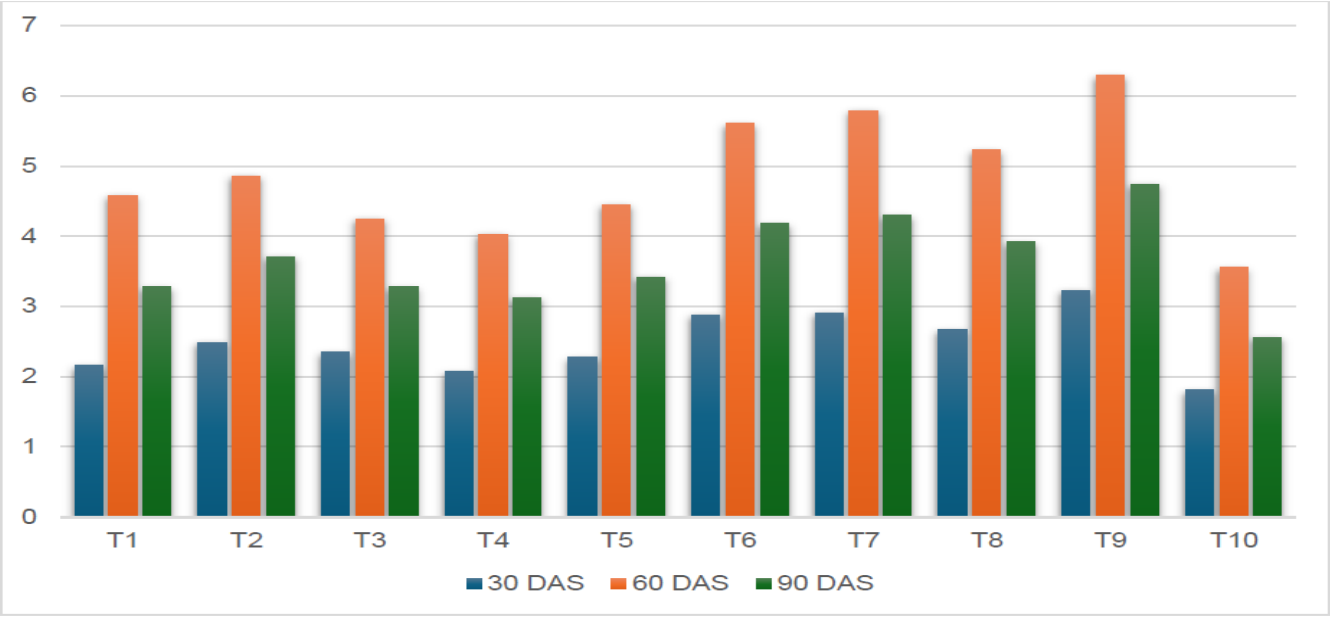

Fig. 3: Effect of Weed Management practices on Leaf Area Index

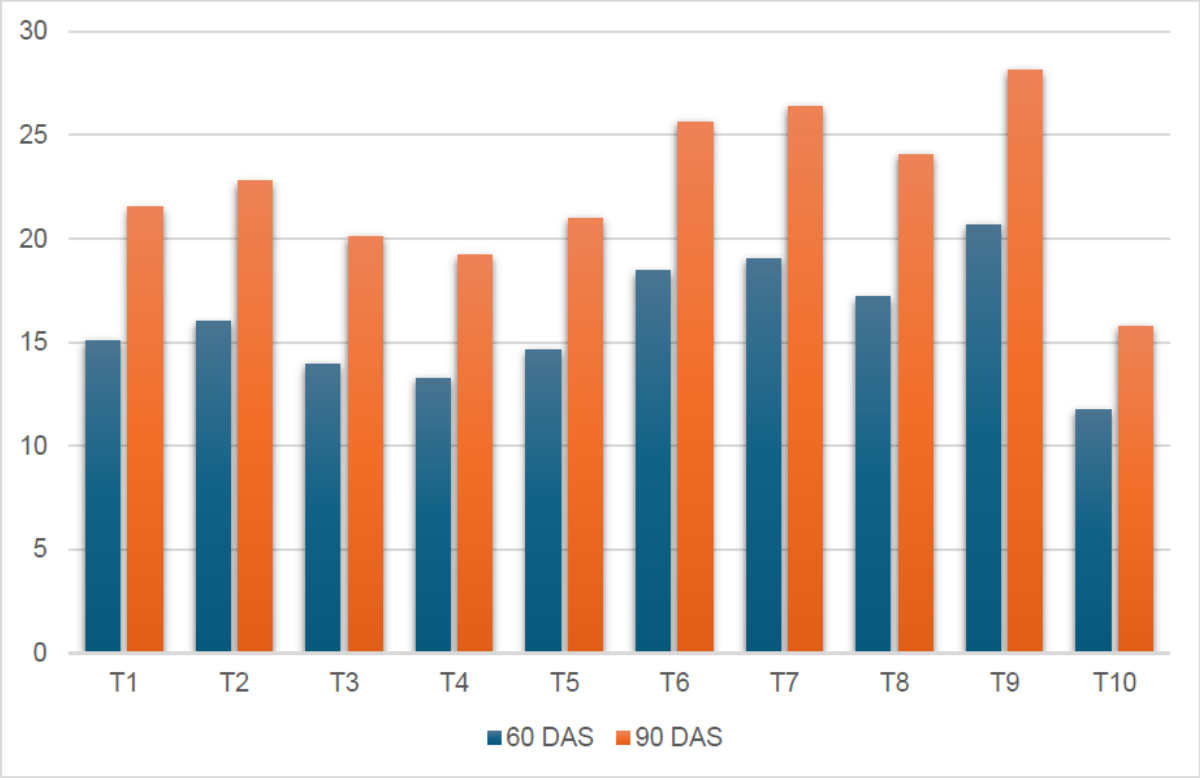

Fig. 4: Effect of Weed Management practices on No. of Branches

Yield

Yield is the result of various bio-physiological processes arising from the coordinated interaction of growth traits and yield components. In the present study, both seed and stover yields (kg ha^{-1}) were significantly affected by weed management practices. Treatment (T_7) Metribuzin @ 175 g a.i. ha^{-1} followed by hand weeding at 45 DAS recorded a higher seed yield of 2350.17 kg ha^{-1} and stover yield of 5733.55 kg ha^{-1}, which was found statistically at par with (T_6) Pendimethalin @ 1000 g a.i. ha^{-1} (PE) followed by hand weeding at 45 DAS, yielding 2243.91 kg ha^{-1} of seed and 5524.90 kg ha^{-1} of stover. All herbicidal treatments significantly outperformed the weedy check (T_{10}), which recorded the lowest seed (1260.39 kg ha^{-1}) and stover yields (3367.12 kg ha^{-1}), highlighting the detrimental effect of weed competition. The enhanced performance of the treatments involving weed management practices can be attributed to effective suppression of weed flora, which enhanced nutrient uptake, improved physiological growth responses, and optimized resource use efficiency. Comparable findings were reported by Yadav et al. (2023) and Maurya et al. (2024), who noted that efficient weed management substantially boosts mustard yield by reducing competition and promoting better crop growth and vigour.

Table 3: Effect of Weed Management practices on Seed yield, Stover yield and biological yield (kg ha^{-1})

Symbols	Treatment	Seed Yield (kg ha^{-1})	Stover Yield (kg ha^{-1})	Biological Yield (kg ha^{-1})	Harvest Index (%)
T_1	Pendimethalin @ 1000g a.i. ha^{-1}	1800.02	4608.14	6408.16	28.09
T_2	Metribuzin @ 175g a.i. ha^{-1}	1911.05	4876.16	6787.21	28.13
T_3	Oxyfluorfen @ 250g a.i. ha^{-1}(PE)	1748.20	4493.06	6241.26	28.05
T_4	Clodinafop propargyl @ 60g a.i. ha^{-1}(PoE)	1583.79	4112.20	5695.99	27.79
T_5	Propaquizalofop@100g a.i. ha^{-1} (PoE)	1669.83	4303.15	5972.97	27.96
T_6	Pendimethalin@1000g a.i. ha^{-1}(PE) *fb* HW at 45 DAS	2243.91	5524.90	7768.81	28.89
T_7	Metribuzin@175g a.i. ha^{-1}*fb* HW at 45 DAS	2350.17	5733.55	8083.72	29.07
T_8	Clodinafop propargyl@60g a.i. ha^{-1} *fb* HW at 45 DAS	2054.63	5151.30	7205.93	28.53
T_9	Weed Free	2471.06	6023.67	8494.73	29.09
T_{10}	Weedy check	1260.39	3367.12	4627.52	27.24
S. Em±		38.20	92.78	97.23	--
CD (P=0.05)		113.49	275.67	288.88	--

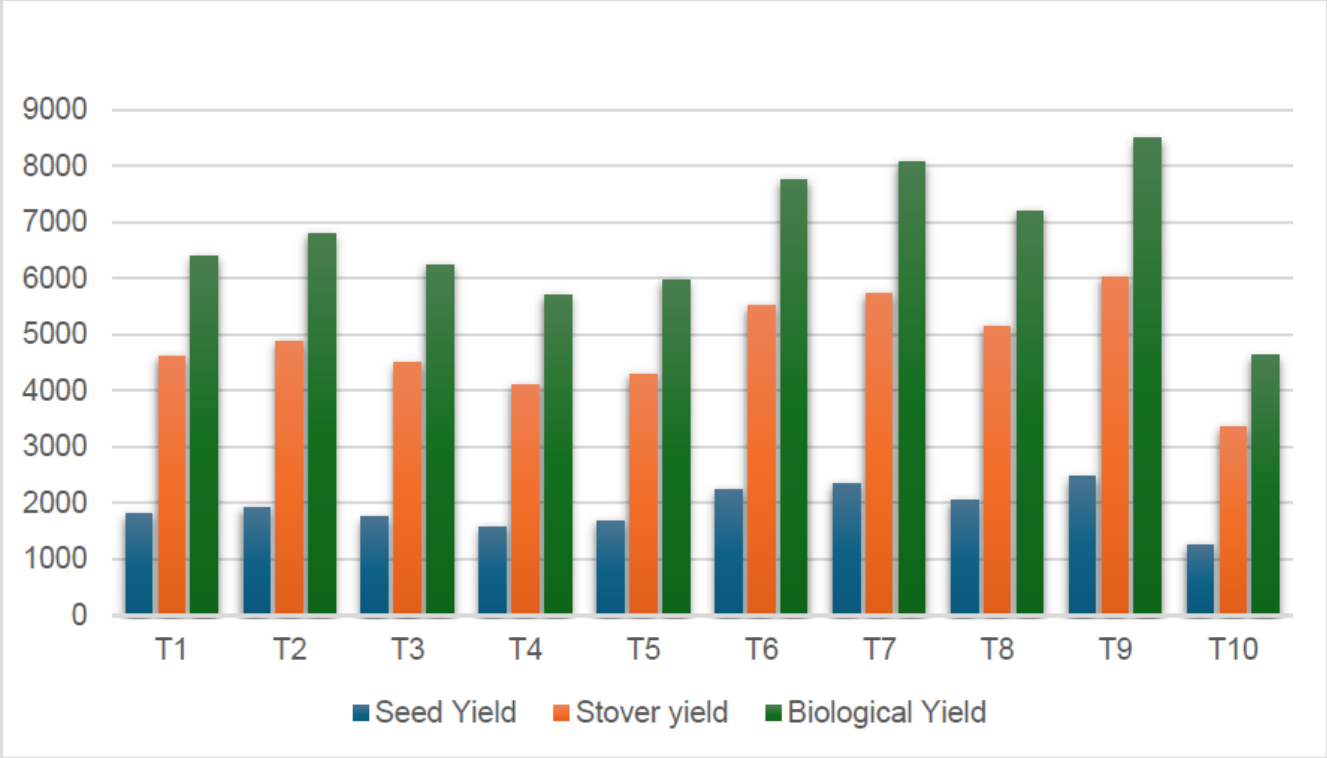

Fig. 5: Effect of Weed Management practices on Seed yield, Stover yield and biological yield (kg ha^{-1})

Conclusion

The results of the study indicate that treatment T7, comprising Metribuzin @ 175 g a.i. ha^{-1} followed by hand weeding at 45 DAS, was the most effective and economically viable weed management strategy under irrigated conditions, resulting in significantly higher seed yield and harvest index. Moreover, T7 also demonstrated superior agronomic and physiological performance, as evidenced by greater dry matter accumulation, increased plant height, an enhanced leaf area index, and a higher number of primary and secondary branches.

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