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INFLUENCE OF PRE AND POST EMERGENCE HERBICIDES ON CROP GROWTH, DEVELOPMENT AND YIELD ATTRIBUTES OF WHEAT (*Triticum aestivum* L.)

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ABSTRACT

A field experiment was conducted during the rabi seasons of 2024–25 and 2025–26 at the Research Farm of Maharishi Markandeshwar (Deemed to be University), Mullana, Ambala, Haryana, to study the "Influence of Pre and Post Emergence Herbicides on Crop Growth, development and Yield Attributes of Wheat (*Triticum aestivum* L.)". The experiment was laid out in a Randomized Block Design (RBD) with twelve treatments comprising metribuzin; pendimethalin + pyroxasulfone (tank mix); mesosulfuron + iodosulfuron (ready mix); sulfosulfuron + metsulfuron (ready mix); pinoxaden + metribuzin (tank mix); clodinafop + metribuzin (ready mix); their sequential combinations; an untreated weedy check; and a weed-free treatment. The results revealed that the weed-free treatment recorded the highest values for plant growth parameters, yield attributes, grain yield, and straw yield. Among the herbicidal treatments, the sequential application of pendimethalin + pyroxasulfone as pre-emergence followed by mesosulfuron + iodosulfuron as post-emergence proved to be the most effective. This treatment significantly enhanced plant growth and development, resulting in higher grain and straw yields compared with the other herbicide treatments. The findings indicate that this sequential herbicide program offers an effective and practical weed management strategy for improving wheat productivity under the agro-climatic conditions of Haryana.
Keywords **:** Plant height, no of tillers, Yield attributes, Weed density, Followed by, Sequential, Herbicides.

Introduction

Wheat (*Triticum aestivum* L.) is the most widely cultivated food crop in the world and serves as a staple for a large proportion of the global population. In India, wheat occupies a prominent place among cereal crops because of its contribution to food security and the agricultural economy. During 2023–24, wheat was cultivated on 31.83 million hectares in India, producing 113.29 million tonnes with an average productivity of 3559 kg ha^{-1} (Anonymous, 2024). In Haryana, wheat was grown on 2,369.53 thousand hectares during 2023–24, producing 11,191.27 thousand tonnes with an average productivity of 4,723 kg ha^{-1} (Anonymous, 2024). The total area, production and productivity of wheat in India during 2024–25 were 32.80 million hectares, 117.99 million tonnes and 3597 kg ha^{-1}, respectively (Anonymous, 2025). Wheat is commonly infested by a diverse weed flora comprising both grassy and broad-leaved weeds (BLWs). Among these, *Phalaris minor* Retz. (little seed canary grass) is one of the most problematic grassy weeds affecting wheat crops. Globally, this weed has been reported from more than 60 countries across all continents except the polar regions (Jabran *et al.*, 2010).

Wheat grains have high nutritional value and contain approximately 12.1% protein, 1.8% lipids, 1.8% ash, 2.0% reducing sugars, 6.7% pentosans, and 59.2% starch, along with essential minerals and vitamins, including nicotinic acid (Agam *et al.*, 2017). In addition to grain, wheat straw and bran are valuable feed resources for livestock (Yadav *et al.*, 2014).

Despite wheat's high production potential, several biotic factors limit its productivity, among which weeds are one of the most serious constraints. Wheat fields are infested with a diverse weed flora consisting of both grassy and broad-leaved species (Atnafu, 2019).

Material and Method

A field experiment was conducted during the rabi seasons of 2024–25 and 2025–26 at the Research Farm of Maharishi Markandeshwar (Deemed to be University), Mullana, Ambala, Haryana, to study the "Influence of Pre and Post Emergence Herbicides on Crop Growth, development and Yield Attributes of Wheat (*Triticum aestivum* L.)". The experiment was laid out in a Randomized Block Design (RBD) with three replications and twelve treatments. The experimental field was prepared following the recommended agronomic practices for wheat cultivation. Wheat was sown at the recommended seed rate and row spacing under irrigated conditions. A uniform dose of fertilizers, irrigation, and all other recommended crop management practices was maintained across all treatments, with weed management being the only experimental variable.

The experiment included twelve weed management treatments comprising pre-emergence (PRE) herbicides, sequential applications of pre-emergence followed by post-emergence (PoE) herbicides, tank-mix and ready-mix combinations, a weed-free treatment, and a weedy check. The treatments were: metribuzin @ 200 g ha^{-1} as PRE (T_1); pendimethalin + pyroxasulfone (tank mix) @ 1500 + 127.5 g ha^{-1} as PRE (T_2); metribuzin @ 200 g ha^{-1} as PRE followed by mesosulfuron + iodosulfuron (ready mix) @ 14.4 g ha^{-1} as PoE at 30–35 days after sowing (DAS) (T_3); metribuzin @ 200 g ha^{-1} as PRE followed by sulfosulfuron + metsulfuron (ready mix) @ 32 g ha^{-1} as PoE at 30–35 DAS (T_4); metribuzin @ 200 g ha^{-1} as PRE followed by pinoxaden + metribuzin (tank mix) @ 50 + 105 g ha^{-1} as PoE at 30–35 DAS (T_5); metribuzin @ 200 g ha^{-1} as PRE followed by clodinafop + metribuzin (ready mix) @ 174 g ha^{-1} as PoE at 30–35 DAS (T_6); pendimethalin + pyroxasulfone (tank mix) @ 1500 + 127.5 g ha^{-1} as PRE followed by mesosulfuron + iodosulfuron (ready mix) @ 14.4 g ha^{-1} as PoE at 30–35 DAS (T_7); pendimethalin + pyroxasulfone (tank mix) @ 1500 + 127.5 g ha^{-1} as PRE followed by sulfosulfuron + metsulfuron (ready mix) @ 32 g ha^{-1} as PoE at 30–35 DAS (T_8); pendimethalin + pyroxasulfone (tank mix) @ 1500 + 127.5 g ha^{-1} as PRE followed by pinoxaden + metribuzin (tank mix) @ 50 + 105 g ha^{-1} as PoE at 30–35 DAS (T_9); pendimethalin + pyroxasulfone (tank mix) @ 1500 + 127.5 g ha^{-1} as PRE followed by clodinafop + metribuzin (ready mix) @ 174 g ha^{-1} as PoE at 30–35 DAS (T_{10}); a weed-free treatment maintained through manual hoeing at 30 and 60 DAS (T_{11}); and a weedy check without any weed control measures throughout the crop growth period (T_{12}).

Observations on plant height, no of tillers, biological yield, grain yield and straw yield. The data obtained from both years were statistically analyzed using analysis of variance (ANOVA) appropriate for the Randomized Block Design, and treatment means were compared using the least significant difference (LSD) test at the 5% level of significance.

Observations Recorded

Plant growth and yield observations were recorded using standard procedures. Plant height was measured at 30,90 and at harvest by randomly selecting five representative plants from each treatment in every replication. The height of each plant was measured from the ground surface to the tip of the spike (excluding awns) using a measuring scale, and the average value was expressed in centimetres (cm). The number of tillers was determined by counting all tillers within a one-metre row length selected at random from each plot in every replication, and the average was expressed as tillers m^{-1} row length.

At maturity, the crop from a net plot area of 1 m^2 in each treatment and replication was harvested separately to determine biological yield. The harvested plants were tied into bundles and weighed immediately to obtain the biological yield. Thereafter, the bundles were threshed manually, and the grains were separated from the straw. The weight of the cleaned grains was recorded as grain yield, while the remaining dry biomass after threshing was recorded as straw yield. The biological yield was calculated as the sum of grain and straw yields. The yields recorded from the 1 m^2 net plot area were converted into kilogram per hectare (kg ha^{-1}) using the appropriate conversion factor for statistical analysis.

Results and Discussion

Wheat parameters

Plant height and the number of tillers were significantly influenced by different weed management treatments. The weed-free treatment recorded the maximum plant height and the highest number of tillers, which can be attributed to the absence of crop–weed competition for essential resources such as nutrients, moisture, light, and space. In contrast, the weedy check produced the lowest plant height and the fewest tillers due to severe competition from weeds throughout the crop growth period. Among the herbicidal treatments, the sequential application of pendimethalin + pyroxasulfone (tank mix) @ 1500 + 127.5 g ha^{-1} as pre-emergence (PRE) followed by sulfosulfuron + metsulfuron (ready mix) @ 32 g ha^{-1} as post-emergence (PoE) at 30–35 days after sowing (DAS) resulted in significantly greater plant height and a higher number of tillers compared with the other herbicide treatments. The superior performance of this treatment may be attributed to its effective control of both grassy and broad-leaved weeds during the critical period of crop–weed competition, thereby promoting better crop growth and development. The detailed description of the herbicide treatments and their effects on plant height and tiller production is presented in Tables.

Table 1 : Effect of different weed management practices on plant height (cm) of wheat during 2024–25

Treatment details		Dose (g ha^{-1})	Time of application	30 DAS	90 DAS	At Harvest
T_1	Metribuzin	200	PRE	19.5	77.6	93.9
T_2	Pendimethalin + Pyroxasulfone (TM)	1500 + 127.5	PRE	19.8	79.5	96.9
T_3	Metribuzin *fb* Mesosulfuron + Iodosulfuron (RM)	200 *fb* 14.4	PRE *fb* PoE	20.3	81.5	100.5
T_4	Metribuzin *fb* Sulfosulfuron + Metsulfuron (RM)	200 *fb* 32	PRE *fb* PoE	19.7	79.1	96.0
T_5	Metribuzin *fb* Pinoxaden + Metribuzin (TM)	200 *fb* 50 + 105	PRE *fb* PoE	19.9	80.2	98.2
T_6	Metribuzin *fb* Clodinafop + Metribuzin (RM)	200 *fb* 174	PRE *fb* PoE	19.5	78.7	95.0
T_7	Pendimethalin + Pyroxasulfone *fb* Mesosulfuron + Iodosulfuron (RM)	1500 + 127.5 *fb* 14.4	PRE *fb* PoE	20.6	84.3	103.8
T_8	Pendimethalin + Pyroxasulfone *fb* Sulfosulfuron + Metsulfuron (RM)	1500 + 127.5 *fb* 32	PRE *fb* PoE	20.3	82.1	101.4
T_9	Pendimethalin + Pyroxasulfone *fb* Pinoxaden + Metribuzin (TM)	1500 + 127.5 *fb* 50 + 105	PRE *fb* PoE	20.4	83.7	102.6
T_{10}	Pendimethalin + Pyroxasulfone *fb* Clodinafop + Metribuzin (TM)	1500 + 127.5 *fb* 174	PRE *fb* PoE	20.1	81.4	99.3
T_{11}	Weed check	–	–	19.1	76.2	90.5
T_{12}	Weed free	–	Hoeing at 30 & 60 DAS	20.5	86.6	107.0
SE(m) ±				**0.91**	**1.66**	**2.35**
CD (P = 0.05)				**NS**	**4.91**	**6.93**

Table 2 : Effect of different weed management practices on plant height (cm) of wheat during 2025–26

Treatment details		Dose (g ha^{-1})	Time of application	30 DAS	90 DAS	At Harvest
T_1	Metribuzin	200	PRE	20.6	81.2	96.2
T_2	Pendimethalin + Pyroxasulfone (TM)	1500 + 127.5	PRE	20.3	82.3	98.9
T_3	Metribuzin *fb* Mesosulfuron + Iodosulfuron (RM)	200 *fb* 14.4	PRE *fb* PoE	20.3	84.8	103.1
T_4	Metribuzin *fb* Sulfosulfuron + Metsulfuron (RM)	200 *fb* 32	PRE *fb* PoE	20.4	82.2	98.1
T_5	Metribuzin *fb* Pinoxaden + Metribuzin (TM)	200 *fb* 50 + 105	PRE *fb* PoE	19.8	83.3	100.1
T_6	Metribuzin *fb* Clodinafop + Metribuzin (RM)	200 *fb* 174	PRE *fb* PoE	20.5	81.8	97.5
T_7	Pendimethalin + Pyroxasulfone *fb* Mesosulfuron + Iodosulfuron (RM)	1500 + 127.5 *fb* 14.4	PRE *fb* PoE	20.4	88.8	106.3
T_8	Pendimethalin + Pyroxasulfone *fb* Sulfosulfuron + Metsulfuron (RM)	1500 + 127.5 *fb* 32	PRE *fb* PoE	20.9	85.5	103.5
T_9	Pendimethalin + Pyroxasulfone *fb* Pinoxaden + Metribuzin (TM)	1500 + 127.5 *fb* 50 + 105	PRE *fb* PoE	20.4	87.2	104.6
T_{10}	Pendimethalin + Pyroxasulfone *fb* Clodinafop + Metribuzin (TM)	1500 + 127.5 *fb* 174	PRE *fb* PoE	20.5	84.5	101.7
T_{11}	Weed check	–	–	20.0	78.7	92.5
T_{12}	Weed free	–	Hoeing at 30 & 60 DAS	20.6	90.3	109.2
SE(m) ±				**0.94**	**1.81**	**1.78**
CD (P = 0.05)				**NS**	**5.35**	**5.26**

Table 3 : Effect of different weed management practices on number of tillers (m^{-1} row length) of wheat during 2024–25

Treatment details		Dose (g ha^{-1})	Time of application	30 DAS	90 DAS	AT Harvest
T_1	Metribuzin	200	PRE	42.5	70.4	66.2
T_2	Pendimethalin + Pyroxasulfone (TM)	1500 + 127.5	PRE	44.0	83.3	78.2
T_3	Metribuzin *fb* Mesosulfuron + Iodosulfuron (RM)	200 *fb* 14.4	PRE *fb* PoE	44.8	89.8	84.3
T_4	Metribuzin *fb* Sulfosulfuron + Metsulfuron (RM)	200 *fb* 32	PRE *fb* PoE	44.0	78.1	73.4
T_5	Metribuzin *fb* Pinoxaden + Metribuzin (TM)	200 *fb* 50 + 105	PRE *fb* PoE	44.4	86.3	81.1
T_6	Metribuzin *fb* Clodinafop + Metribuzin (RM)	200 *fb* 174	PRE *fb* PoE	43.0	76.4	71.7
T_7	Pendimethalin + Pyroxasulfone *fb* Mesosulfuron + Iodosulfuron (RM)	1500 + 127.5 *fb* 14.4	PRE *fb* PoE	46.0	98.5	92.5
T_8	Pendimethalin + Pyroxasulfone *fb* Sulfosulfuron + Metsulfuron (RM)	1500 + 127.5 *fb* 32	PRE *fb* PoE	45.8	92.3	86.7
T_9	Pendimethalin + Pyroxasulfone *fb* Pinoxaden + Metribuzin (TM)	1500 + 127.5 *fb* 50 + 105	PRE *fb* PoE	45.8	96.2	90.4
T_{10}	Pendimethalin + Pyroxasulfone *fb* Clodinafop + Metribuzin (TM)	1500 + 127.5 *fb* 174	PRE *fb* PoE	44.6	87.6	82.2
T_{11}	Weed check	–	–	41.3	61.3	57.7
T_{12}	Weed free	–	Hoeing at 30 & 60 DAS	47.9	102.3	96.1
SE(m) ±				**1.23**	**1.86**	**1.98**
CD (P = 0.05)				**NS**	**5.50**	**5.85**

Table 4 : Effect of different weed management practices on number of tillers (m^{-1} row length) of wheat during 2025–26

Treatment details		Dose (g ha^{-1})	Time of application	30 DAS	90 DAS	At Harvest
T_1	Metribuzin	200	PRE	45.5	73.4	68.5
T_2	Pendimethalin + Pyroxasulfone (TM)	1500 + 127.5	PRE	47.2	86.6	81.8
T_3	Metribuzin *fb* Mesosulfuron + Iodosulfuron (RM)	200 *fb* 14.4	PRE *fb* PoE	48.8	90.1	85.1
T_4	Metribuzin *fb* Sulfosulfuron + Metsulfuron (RM)	200 *fb* 32	PRE *fb* PoE	47.0	79.9	75.4
T_5	Metribuzin *fb* Pinoxaden + Metribuzin (TM)	200 *fb* 50 + 105	PRE *fb* PoE	47.6	87.9	83.1
T_6	Metribuzin *fb* Clodinafop + Metribuzin (RM)	200 *fb* 174	PRE *fb* PoE	46.0	78.5	74.2
T_7	Pendimethalin + Pyroxasulfone *fb* Mesosulfuron + Iodosulfuron (RM)	1500 + 127.5 *fb* 14.4	PRE *fb* PoE	49.1	102.2	96.4
T_8	Pendimethalin + Pyroxasulfone *fb* Sulfosulfuron + Metsulfuron (RM)	1500 + 127.5 *fb* 32	PRE *fb* PoE	48.9	93.9	88.7
T_9	Pendimethalin + Pyroxasulfone *fb* Pinoxaden + Metribuzin (TM)	1500 + 127.5 *fb* 50 + 105	PRE *fb* PoE	48.9	99.5	94.0
T_{10}	Pendimethalin + Pyroxasulfone *fb* Clodinafop + Metribuzin (TM)	1500 + 127.5 *fb* 174	PRE *fb* PoE	48.0	89.2	84.2
T_{11}	Weed check	–	–	44.4	64.0	58.4
T_{12}	Weed free	–	Hoeing at 30 & 60 DAS	51.2	105.2	99.3
SE(m) ±				**1.15**	**1.59**	**1.48**
CD (P = 0.05)				**NS**	**4.70**	**4.38**

Yield attributes

Biological yield, grain yield, and straw yield were significantly influenced by different weed management practices during both years of the study. The highest biological yield, grain yield, and straw yield were recorded under the weed-free treatment, owing to the complete elimination of weed competition throughout the crop growth period. The absence of weeds ensured efficient utilization of moisture, nutrients, light, and space by the crop, resulting in superior growth and productivity. In contrast, the weedy check treatment produced the lowest biological yield, grain yield, and straw yield in both years due to severe crop–weed competition, which adversely affected crop growth and yield.

Among the herbicidal treatments, the sequential application of pendimethalin + pyroxasulfone (tank mix) @ 1500 + 127.5 g ha^{-1} as pre-emergence (PRE), followed by sulfosulfuron + metsulfuron (ready mix) @ 32 g ha^{-1} as post-emergence (PoE) at 30–35 days after sowing (DAS), recorded significantly higher biological yield, grain yield, and straw yield compared with the other herbicide combinations and sequential application treatments. The superior performance of this treatment may be attributed to effective season-long weed control, which minimized crop–weed competition and enabled better crop growth and efficient utilization of available resources. The detailed effects of different weed management practices on yield parameters are presented in the respective tables.

Table 5 : Effect of different weed management practices on biological yield, grain yield and straw yield of wheat during 2024–25 (kg ha^{-1})

Treatment details		Dose (g ha^{-1})	Time of application	Biological yield (kg ha^{-1})	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1	Metribuzin	200	PRE	8,121	3,803	4,318
T_2	Pendimethalin + Pyroxasulfone (TM)	1500 + 127.5	PRE	9,250	4,376	4,874
T_3	Metribuzin *fb* Mesosulfuron + Iodosulfuron (RM)	200 *fb* 14.4	PRE *fb* PoE	10,291	4,974	5,317
T_4	Metribuzin *fb* Sulfosulfuron + Metsulfuron (RM)	200 *fb* 32	PRE *fb* PoE	8,775	4,140	4,635
T_5	Metribuzin *fb* Pinoxaden + Metribuzin (TM)	200 *fb* 50 + 105	PRE *fb* PoE	9,729	4,637	5,092
T_6	Metribuzin *fb* Clodinafop + Metribuzin (RM)	200 *fb* 174	PRE *fb* PoE	8,520	4,001	4,519
T_7	Pendimethalin + Pyroxasulfone *fb* Mesosulfuron + Iodosulfuron (RM)	1500 + 127.5 *fb* 14.4	PRE *fb* PoE	11,329	5,597	5,731
T_8	Pendimethalin + Pyroxasulfone *fb* Sulfosulfuron + Metsulfuron (RM)	1500 + 127.5 *fb* 32	PRE *fb* PoE	10,718	5,212	5,507
T_9	Pendimethalin + Pyroxasulfone *fb* Pinoxaden + Metribuzin (TM)	1500 + 127.5 *fb* 50 + 105	PRE *fb* PoE	11,092	5,452	5,640
T_{10}	Pendimethalin + Pyroxasulfone *fb* Clodinafop + Metribuzin (TM)	1500 + 127.5 *fb* 174	PRE *fb* PoE	9,981	4,791	5,189
T_{11}	Weed check	–	–	7,713	3,562	4,151
T_{12}	Weed free	–	Hoeing at 30 & 60 DAS	11,575	5,773	5,802
SE(m) ±				**221.87**	**89.25**	**104.46**
CD (P = 0.05)				**654.91**	**263.46**	**308.35**

Table 6 : Effect of different weed management practices on biological yield, grain yield and straw yield of wheat during 2025–26 (kg ha^{-1})

Treatment details		Dose (g ha^{-1})	Time of application	Biological yield (kg ha^{-1})	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1	Metribuzin	200	PRE	8,604	4,028	4,576
T_2	Pendimethalin + Pyroxasulfone (TM)	1500 + 127.5	PRE	9,724	4,603	5,121
T_3	Metribuzin *fb* Mesosulfuron + Iodosulfuron (RM)	200 *fb* 14.4	PRE *fb* PoE	10,810	5,230	5,581
T_4	Metribuzin *fb* Sulfosulfuron + Metsulfuron (RM)	200 *fb* 32	PRE *fb* PoE	9,306	4,390	4,916
T_5	Metribuzin *fb* Pinoxaden + Metribuzin (TM)	200 *fb* 50 + 105	PRE *fb* PoE	10,240	4,895	5,345
T_6	Metribuzin *fb* Clodinafop + Metribuzin (RM)	200 *fb* 174	PRE *fb* PoE	9,024	4,238	4,786
T_7	Pendimethalin + Pyroxasulfone *fb* Mesosulfuron + Iodosulfuron (RM)	1500 + 127.5 *fb* 14.4	PRE *fb* PoE	11,858	5,866	5,992
T_8	Pendimethalin + Pyroxasulfone *fb* Sulfosulfuron + Metsulfuron (RM)	1500 + 127.5 *fb* 32	PRE *fb* PoE	11,246	5,474	5,772
T_9	Pendimethalin + Pyroxasulfone *fb* Pinoxaden + Metribuzin (TM)	1500 + 127.5 *fb* 50 + 105	PRE *fb* PoE	11,630	5,723	5,907

T_{10}	Pendimethalin + Pyroxasulfone *fb* Clodinafop + Metribuzin (TM)	1500 + 127.5 *fb* 174	PRE *fb* PoE	10,505	5,047	5,458
T_{11}	Weed check	–	–	7,798	3,584	4,214
T_{12}	Weed free	–	Hoeing at 30 & 60 DAS	12,128	6,056	6,072
SE(m) ±				**236.60**	**110.88**	**103.09**
CD (P = 0.05)				**698.60**	**327.28**	**304.30**

Conclusion

The present investigation demonstrated that weed management practices had a significant influence on the growth, development, and productivity of wheat. The weed-free treatment consistently recorded the highest plant height, number of tillers, biological yield, grain yield, and straw yield during both cropping seasons (2024–25 and 2025–26), confirming that the absence of crop–weed competition enables optimum crop growth and maximum yield. In contrast, the weedy check resulted in the lowest values for all growth and yield parameters due to severe competition from weeds for nutrients, moisture, light, and space.

Among the herbicidal treatments, the sequential application of pendimethalin + pyroxasulfone (tank mix) @ 1500 + 127.5 g ha^{-1} as pre-emergence followed by mesosulfuron + iodosulfuron (ready mix) @ 14.4 g ha^{-1} as post-emergence at 30–35 DAS (T_7) proved to be the most effective. This treatment recorded the highest plant height, greater tiller production, and superior biological, grain, and straw yields among all herbicide treatments and was statistically comparable with the weed-free treatment for several parameters. The improved crop performance was mainly due to effective control of both grassy and broad-leaved weeds during the critical period of crop–weed competition, resulting in better utilization of available resources by the wheat crop.

Based on the results of the two-year study, the sequential application of pendimethalin + pyroxasulfone followed by mesosulfuron + iodosulfuron can be recommended as an effective and practical weed management strategy for wheat under the agro-climatic conditions of Haryana. This treatment offers an efficient alternative to maintaining weed-free fields through manual weeding while ensuring improved crop growth, higher productivity, and enhanced profitability.

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