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Efficacy of Pre- and Post-emergence Herbicides on Weed Flora and Yield of Wheat (*Triticum aestivum* L.)

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Abstract

A field experiment was conducted during (*Rabi*) season of 2019-20 and 2020-21 to evaluate the efficacy of pre- and post-emergence herbicides against complex weed dynamic in wheat. Twelve treatments consisted with ten herbicidal treatments, pre-emergence application of Metribuzin 750 g/ha, Oxyfluorfen 120 g/ha, Atrazin 1000 g/ha and Pendimethalin 750 g/ha post-emergence application of Metasulfuron 750 g/ha, 2,4D Amino salt 1000 g /ha, 2,4-D Ethylin ester 750 g/ha, 2,4-D (Dimethyl) 1000 g/ha, Sulfosulfuron1000 g/ha, Isoproturon 1000 g/ha, hand weeding at 30 and 60 days after sowing (DAS) and weedy check, were tested in randomized block design with three replications. Hands weeding at 30 and 60 DAS recorded significantly reduced weed density and weed dry matter at 30, 60 and 90 DAS stages with weed control efficiency of 85.24% and 85.37% at 30 DAS, respectively. However, application of Oxyfluorfen resulted in maximum grain yield of 4.39 and 4.43 t/ha, respectively in both the years compared to other herbicide applications. Thus, it may be concluded that for higher productivity and weed control, application of Oxyfluorfen 120 g/ha was found to be the best practice among the various herbicidal combinations.

Key words: *Triticum aestivum*, Hand weeding, Oxyfluorfen, Weed control efficiency, Yield

Wheat (*Triticum aestivum* L.) is widely grown as winter cereal and is the backbone of food security in India. Many factors affect the yield; weed infestation is one of the major causes of reduced yield. Weeds compete with crop species for water, nutrients and light leading to stunted plant growth and reduction in crop yield [1]. Wheat occupies a predominant position among winter cereals and is cultivated extensively across diverse agro-climatic zones. The productivity of wheat, however, is influenced by various biotic and abiotic factors, among which weed infestation remains one of the most detrimental. Weeds are aggressive, unwanted plants that compete with the main crop for essential growth resources such as light, water, space, and soil nutrients [2]. This competition is particularly severe during the early stages of crop establishment when wheat plants are less competitive. Weed interference not only suppresses crop growth but also affects physiological processes such as photosynthesis, nutrient uptake, and translocation, leading to poor tillering and reduced biomass accumulation. As a result, both grain yield and quality are adversely impacted. In addition to direct competition, weeds can also harbor pests and diseases, further aggravating crop stress [3]. Studies have shown that unchecked weed growth can cause yield losses ranging from 15% to as high as 50%, depending on the intensity and type of weed flora present. Effective weed management is, therefore, a critical component of modern wheat production systems. Integrating cultural, mechanical, and chemical methods through an integrated weed management (IWM) approach is essential to minimize weed competition and sustain wheat productivity. Ensuring timely weed control not only improves crop growth and resource-use efficiency but also contributes significantly to the stability of national food supply and farmers' income [4].

Therefore, suitable weed management practices are vital to produce optimum yields. Among different weed management practices, chemical weed control is preferred due to less labour availability [5]. Though the chemical method is being discouraged worldwide, farmers in countries like India cannot ignore its immediate effect and economic returns. The application of herbicide is more effective as the weeds even within the rows are killed which escape, because of morphological similarity to wheat. Now a day's high yielding agriculture relies on herbicides as integral part of weed control practices. The application of herbicides has become one of the most effective and efficient methods for controlling weeds in wheat cultivation. Unlike manual or mechanical weeding, which often fails to eliminate weeds growing close to crop rows due to their morphological resemblance to wheat plants, herbicides ensure uniform weed control across the entire field, including intra-row spaces. Many weed species, such as *Phalaris minor* and *Avena ludoviciana*, closely resemble wheat during early growth stages, making them difficult to distinguish and remove manually [6]. Herbicide application ensures effective weed control by exploiting physiological and biochemical differences between crops and weeds, allowing selective elimination even when physical distinctions are minimal.

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In modern agriculture, herbicides have emerged as an integral component of high-yielding and resource-efficient crop production systems. Their timely and judicious use not only reduces weed density and competition but also conserves labor, time, and soil moisture [7]. The adoption of selective herbicides compatible with wheat physiology allows farmers to manage complex weed flora without causing crop injury. Consequently, herbicide-based weed management contributes significantly to enhanced nutrient-use efficiency, better crop establishment, and improved yield stability. However, continuous reliance on herbicides also necessitates careful management to prevent the development of herbicide resistance and adverse environmental effects [8]. Therefore, integrating herbicide use with other agronomic and cultural practices forming part of an Integrated Weed Management (IWM) strategy is essential for sustainable and long-term weed control in wheat ecosystems.

In recent years, pre and post herbicide have been developed and found promising tool in weed management. Sulfosulfuron, pendimethalin are promising herbicide for control of narrow and broad leaves weeds in wheat crops. The effectiveness of these herbicides has also been reported by some other workers [9]. The oxyflorfen some broadspectrum herbicides like sulfosulfuron and metribuzin was needed for effective weed control [10]. Hence, the present experiment was carried out to evaluate the efficacy of pre- and post-emergence herbicides against diverse weed flora, and yield of wheat.

MATERIALS AND METHODS

The study was conducted in the winter (*Rabi*) seasons of 2019-20 and 2020-21 at the Zonal Agriculture Research station, Chhindwara (M.P.). The experiment was designed using a randomized block design with 12 treatments. The treatment details of the experiment are time of application, viz., pre-emergence application of T_1: weedy check, T_2: Hand weeding at 30 and 60 days after sowing (DAS), T_3: Metribuzin 750 g/ha, T_4: Oxyfluorfen 120 g/ha, T_5: Atrazin 1000 g/ha, T_6: Pendimethalin 750 g /ha post-emergence application of T_7: Metasulfuron 750 g/ha, T_8: 2,4D Amino salt 1000 g/ha, T_9: 2,4-D Ethylin ester 750 g/ha, T_{10}: 2,4-D (Dimethyl) 1000 g/ha, T_{11}: Sulfosulfuron 1000 g/ha and T_{12}: Isoproturon 1000 g/ha. The soil of the research field was clay in texture pH of 7.2, medium in organic carbon (0.64%), available N (370 kg/ha), medium in available P (16.45 kg/ha) and high available K (295 kg/ha). Wheat (JW-3211) was sown on 28th November 2019 and 28th November in 2020 by using seed rate of 100 kg/ ha at 5 cm depth with rows 22.5 cm apart. The recommended dose of fertilizer was applied at the rate of 120-60-40-20-20 kg N, P, K, $ZnSO_4$ and $FeSO_4$/ha. All the Preemergence herbicide were sprayed uniformly as per the treatment one day after sowing of the crop. The post-emergence herbicides were sprayed uniformly as per the treatments at 20-25 DAS when the weeds attained 2-4 leaf stage. The determined quantity of herbicide was applied to each treatment using a knapsack sprayer, with a spray volume of 750 litres of water per hectare. In the hand weeding treatment, there was twice at 20 and 40 DAS with manual weeding when weeds appear in the field. Total number of weeds per square meter was noted in each plot in quadrate of 1 × 1 m^2 at 30, 60 and 90 DAS. The weeds were uprooted from m^2 area randomly each time and oven dried of weeds at 70°C till a constant weight. These were weighed and expressed in g m^2 of weed biomass. The statistical analysis was carried out using Analysis of Variance [11] and mean comparisons were based on the least significant difference (LSD) at 0.05 probability. Weed control efficiency in terms of weed dry matter would be worked out based on the following formula [12].

$$\text{WCE (\%)} = \frac{\text{DMC} - \text{DMT}}{\text{DMC}} \times 100$$

Where;
DMC = Dry matter of weeds in the Un weeded check (control)
DMT = Dry matter of weeds in the treated plot.

RESULTS AND DISCUSSION

The dominant weed species observed in the experimental field were *Chenopodium album, Avena fatua, Cynodon dactylon, Cyperus rotundus, Anagallis arvensis, Convolvulus arvensis, Fumaria parviflora, Lathyrus aphaca, Melilotus alba, Physalis minima, Rumex dentatus, Vicia hirsute* and *Eclipta alba.*

Table 1 Total weed population and weed dry weight at 30, 60 and 90 DAS as influenced by weed management practices in wheat (2019-20 and 2020-21

Treatments	Total weed population (No/m^2)						Weed dry weight (g/m^2)					
	30 DAS		60 DAS		90 DAS		30 DAS		60 DAS		90 DAS	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Weed control	24.28	24.01	69.54	70.24	56.33	56.67	18.63	19.00	64.55	63.38	86.29	86.43
Hand weeding	11.09	11.34	24.21	24.98	34.00	34.40	2.74	2.77	36.64	35.37	63.22	63.34
Metribuzin (PE)	23.92	18.54	37.36	48.94	27.33	27.44	7.35	7.61	18.35	18.38	25.02	25.52
Oxyfluorfen (PE)	5.57	5.09	12.11	12.50	17.00	18.00	1.51	1.76	4.09	4.26	4.29	4.43
Atrazin (PE)	6.90	7.20	15.56	16.09	17.67	18.22	1.86	2.15	9.87	8.25	6.09	6.14
Pendimethalin (PE)	7.39	7.63	17.10	17.87	19.33	19.44	2.05	2.41	10.61	10.03	11.42	11.63
Metasulfuron (PoE)	19.56	23.59	48.28	38.12	51.67	51.89	5.58	5.22	18.98	19.09	64.06	64.09
2,4D Amino salt (PoE)	18.32	19.85	19.69	20.22	45.00	45.47	5.95	5.64	45.49	45.49	19.22	19.34
Sulfosulfuron ((PoE))	12.77	13.02	32.01	32.31	32.67	33.22	6.35	6.71	54.52	54.6	66.69	67.03
2,4-D Zura (Dimethyl) (PoE)	13.59	13.90	40.80	41.23	43.00	43.67	4.45	4.71	48.62	48.83	80.66	80.98
2,4-D Ethylin ester (PoE)	8.10	8.47	19.36	19.86	22.33	23.11	2.36	2.45	11.99	12.09	14.19	14.29
Isoproturon (PoE)	17.77	18.02	28.90	29.53	33.33	33.67	6.02	5.7	56.61	56.76	71.06	71.09
LSD (p=0.05)	1.82	1.20	1.78	2.54	3.96	3.83	1.35	0.71	5.09	4.31	4.58	3.31

Total weed population

Application of herbicides reduced the total number of weeds at 30, 60, 90 DAS compared to the weedy check (24.28 & 24.01, 69.54 & 70.24 and 56.33 & 56.67 m^2). Application of pre-emergence Oxyfluorfen 120 g/ha recorded lowest weed population at 30, 60, 90 DAS followed by Atrazin 1000 g/ha as compared to rest of the treatments during the 2019-20 and 2020-21 (Table 1). The variation might be due to the application of different doses and weedicides on different treatments. The minimum weed population might be due to oxyfluorfen used as pre-emergent herbicide and this was not allowed more weed growth in the same plots or treatment. The oxyfluorfen control weeds by inhibition action of essential enzymes protex during weed growth [13-14].

Dry weight of weeds

During 2019-20 and 2020-21 dry weight of weeds significantly influenced by pre and post emergence herbicides and the maximum weed dry weight at 30, 60 and 90 days after sowing (DAS) was recorded in the treatment weed control (unweeded). Minimum weed dry weight was recorded in the treatment Oxyfluorfen 120 g/ha (Table 1). The minimum weed population might be due to Oxyfluorfen used as pre-emergent herbicide and this was not allowed more weed growth in the same plots or treatment at different growth stages. The minimum weed density was responsible for accumulation of weed dry weight in oxyfluorfen. The oxyfluorfen control weeds by inhibition action of essential enzymes during weed growth [13-14].

Table 2 Weed control efficiency at 30, 60 and 90 DAS and grain yield as influenced by weed management practices in wheat (2019-20 and 2020-21)

Treatments	Weed control efficiency (%)						Grain yield (t/ha)	
	30 DAS		60 DAS		90 DAS			
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Weed control	-	-	-	-	-	-	3.27	3.28
Hand weeding	85.23	85.36	43.22	44.17	26.72	26.70	3.66	3.72
Metribuzin (PE)	60.50	59.90	71.55	70.97	70.98	70.45	3.89	3.91
Oxyfluorfen (PE)	91.83	90.67	93.63	93.25	95.00	94.85	4.39	4.43
Atrazin (PE)	89.95	88.62	84.68	86.95	92.92	92.87	4.35	4.29
Pendimethalin (PE)	88.93	87.25	83.54	84.15	86.74	86.52	4.22	4.27
Metasulfuron(PoE)	70.00	72.47	70.57	69.85	25.74	25.83	3.29	3.31
2,4D Amino salt (PoE)	68.01	70.26	29.51	28.21	77.70	77.60	4.04	4.07
Sulfosulfuron ((PoE))	65.86	64.64	15.52	13.84	22.70	22.43	3.85	3.88
2,4-D Zura (Dimethyl) (PoE)	76.06	75.16	24.66	22.94	6.51	6.29	3.79	3.84
2,4-D Ethylin ester (PoE)	87.27	87.04	81.40	80.90	83.53	83.44	4.16	4.19
Isoproturon (PoE)	67.64	69.95	12.28	10.43	17.63	17.73	3.64	3.70
LSD (p=0.05)	-	-	-	-	-	-	0.62	0.61

Weed control efficiency

At various phases of crop growth higher weed control efficiency was recorded with pre-emergence except metribuzin followed by post-emergence (91.8 & 90.6, 93.6 & 93.2, and 95.0 & 94.8 % at 30, 60 and 90 DAS respectively) during 2019-20 and 2020-21 (Table 2). It is due to the fact that oxyfluorfen pendimethalin and atrazin control both monocot and dicot weeds. Oxyfluorfen (PE) might be due to the oxyfluorfen reduce the weed growth at every crop growth period and control most of weeds by inhibition action of enzyme. Removing the weeds whenever they appear in the weed free treatment resulted in total control of weeds only by manual weeding. However, this is not feasible due to labour scarcity and un-economical. The lower weed control efficiency was noticed under weedy check treatment, because of higher weed competition stress Gugulothu *et al.* [15].

Yield

The weed control treatments resulted significant increase in grain yield as compared to unweeded control (3.27, 3.28 t/ha). The highest grain yield of wheat (4.39 and 4.43 t/ha) was recorded by the treatment Oxyfluorfen (PE) which remained at par with post-emergence application atrazin (4.35 and 4.29 t/ha) during both of the years (Table 2). This exhibited an increase of grain yield 34.2 and 35.0 % over unweeded control. The higher yield might be due to effective weed control which kept the crop almost weed free during entire crop growth period that markedly reduced the competition for the moisture, space, nutrients, light leading to enhanced crop growth by utilizing greater moisture and nutrients from soil layers [16].

CONCLUSION

The results of the study clearly demonstrated that effective weed management significantly influenced weed population, weed dry weight, weed control efficiency, and ultimately the grain yield of wheat. The dominant weed flora observed in the experimental field included *Chenopodium album*, *Avena fatua*, *Cynodon dactylon*, *Cyperus rotundus*, *Anagallis arvensis*, *Convolvulus arvensis*, *Fumaria parviflora*, *Lathyrus aphaca*, *Melilotus alba*, *Physalis minima*, *Rumex dentatus*, *Vicia hirsuta* and *Eclipta alba*. Among the weed management practices, the pre-emergence application of Oxyfluorfen at 120 g/ha consistently recorded the lowest weed population and dry weight across all growth stages (30, 60, and 90 days after sowing) during both years of experimentation (2019–20 and 2020–21). This was attributed to its broad-spectrum herbicidal activity and inhibition of essential enzymes required for weed growth. Oxyfluorfen treatment also exhibited the highest weed control efficiency (above 90%) throughout the crop growth period, followed closely by Atrazin and Pendimethalin. These treatments effectively suppressed both monocot and dicot weeds, reducing competition for essential growth resources such as moisture, nutrients, and light. Consequently, Oxyfluorfen recorded the maximum grain yield (4.39 and 4.43 t/ha), showing a significant increase of over 34% compared to the weedy check. Manual weeding was also effective but less feasible due to high labor requirements and cost constraints. Overall, the study concludes that pre-emergence application of Oxyfluorfen (120 g/ha) proved to be the most efficient and economically viable herbicide for achieving superior weed control and enhancing wheat productivity under the given agro-climatic conditions. Adoption of such integrated and timely herbicide applications can play a crucial role in sustaining higher wheat yields by minimizing weed competition throughout the crop growth period.

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