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AF Nekhat
CCS Haryana Agricultural University, Hisar, Haryana, India

AK Dhaka
CCS Haryana Agricultural University, Hisar, Haryana, India

Bhagat Singh
CCS Haryana Agricultural University, Hisar, Haryana, India

Amit Kumar
CCS Haryana Agricultural University, Hisar, Haryana, India

Axay Bhuker
Assistant Scientist, Department of Seed Science & Technology, CCS HAU Hisar, Haryana, India

Corresponding Author:
Amit Kumar
CCS Haryana Agricultural University, Hisar, Haryana, India

Influence of herbicides and their mixtures on growth, yield attributes productivity and economics of wheat

AF Nekhat, AK Dhaka, Bhagat Singh, Amit Kumar and Axay Bhuker

Abstract

Weed infestation is one of the major biotic factors limiting wheat production and productivity due to absence of well management options. Herbicides have increasingly become a key component on crop production system since offers easiest, cheapest and timely weed management option. Reduction in herbicide usage without compromising yields can lead to less environment harm and lower production cost. In order to control the broad-leaf weeds infestation in wheat, evaluation of herbicides and their mixtures were tested in a field experiment in CCS Haryana Agricultural University Research Farm area. Results promised that among herbicides and their mixtures aclonifen 500 + diflufenican 100 SC @ 1750 + 1750 g/ha and closely followed by halauxifen-methyl + florasulam + carfentrazone + surfactant @ 24.99 + 50 + 750 g/ha with maximum growth and yield attributes, biological, straw and grain yield, harvest index and weed control efficiency while minimum grain yield and weed control efficiency were recorded with application of 2,4-D NA (80 WP) and 2,4-D Ester (38 EC) @ 625 and 1316 g/ha. Hence highest net returns (Rs. 65,733 ha^{-1}) and B: C (1.82) recorded by application of aclonifen 500 + diflufenican 100 SC which were 0.13, 4.6 and 3.4 per cent higher than weed free and 47.1, 193.7 and 41.1 per cent higher than weedy check, respectively.

Keywords: Broad-leaf weeds, economics, herbicide mixtures, weed control and wheat yield

Introduction

Wheat (*Triticum aestivum L.*) is one of the most important cereal crops of the world and has great effect on the economic stability of the developing countries. Weed infestation is one of the major biotic factors limiting wheat production and productivity, losses caused by weeds depend on their type, abundance and environmental factor (Chhokar *et al*., 2012) [6]. Weeds cause 10 to 80% crop yield losses besides deteriorating quality of products and causing health and environmental hazards (Paswan *et al.,* 2017) [17]. Weeds compete with crop plant for moisture, nutrients, light and space, which serve as an alternate host for various insects and fungi by providing habitats for pathogens (Capinera, 2005) [2] thereby depriving crop for vital input. Weed-crop competition begins, when crop plants and weeds grow in close proximity and their root or shoot system overlap. The competition becomes severe due to more smothering effect, when weeds emerge earlier than the crop. Godel [7] reported that the effect of normal annual infestation of weeds on wheat and observed significant difference in number of tillers, length of ear weight of kernels and yield of crop due to weedy conditions. Weeds are the most omnipresent class of pests that interfere with crop plants through competition and allelopathy, resulting in direct loss to quantity and quality of the product (Gupta, 2004) [8] and indirectly increasing production costs including costs of labor, equipment, chemical and other management input (Singh *et al*., 2011) [21]. Numerous approaches have been in practice for handling the problem of weed infestation such as hoeing, weeding, tillage, harrowing, crop rotation biological and chemical control. Chemical weed control seems indispensable and has proved efficient in controlling weeds (Kahramanoglu and Uygur, 2010) [12] and hence currently about two-third, by volume of the pesticides used worldwide in agricultural production are herbicides. Indiscriminate use of herbicides for weed control during the past few decades has resulted in serious ecological and environmental problems, such as resistance, shifts in weed populations that are more closely related to the crops that they infest, minor weeds becoming dominant (Heap, 2007) [11] and greater environmental and health hazards (Rao, 2000) [19]. Continuous application of a similar herbicide or use of lower than recommended dose led to development of herbicide resistance (Yadav *et al*., 2013) [25]. Herbicides with differential selectivity can be applied sequentially, but it involves application in two rounds, resulting in enhancing the cost. Therefore, mixing two different herbicides and applying them simultaneously widens the spectrum of weed-control, saves time, application cost and application rate.

Therefore, a need remains to evaluate new herbicides with different modes of action to tackle the ever increasing problem of complex weed flora. For control of broad-leaf weeds in wheat, three major herbicides used in India are metsulfuron, 2, 4-D and carfentrazone (Chhokar *et al*., 2007) [5]. Also, some of the post-emergence contact herbicides like carfentrazone-ethyl, are less effective on weeds having advanced stage, as well as, unable to control the subsequent weeds emerging after application due to its lack of residual activity (half life of carfentrazone is 2-5 days) in soil (Willis *et al*., 2007) [24]. To broaden the spectrum of weed kill and to provide the long term residual weed control, the use of herbicide mixture/ combinations is advisable. Herbicide mixture besides providing control of complex weed flora will also help in managing and delaying the herbicide resistance problem.

Therefore, for sustaining food-grain production to feed ever-increasing population, ensuring food security, and effective weed management is very essential. The herbicides chosen for the study were based on their readily availability at affordable costs and also on weed species infesting the farmers' wheat fields.

Materials and methods

The field experiment was conducted at Research Area of CCS Haryana Agricultural University, Hisar, which is situated in the sub-tropical region at 29° 10' N latitude and 75° 46' E longitude with an elevation of 215.2 meter above mean sea level in Haryana State of India, to study the influence of herbicides and their mixtures on growth, yield attributes, productivity and economics of wheat during growing season of *rabi* 2018-19. Soil of experiment field was sandy loam in texture, low in nitrogen and medium in P_2O_5, K_2O and organic carbon with slightly alkaline pH of 7.6 in reaction and four years field crop history fallow-wheat, cotton-wheat, fallow-mastured and sorghum- experimental crop (wheat). The experiment was comprised of twelve post emergence herbicides (sole and their mixture) treatment combinations i.e Halauxifen-methyl ester + florasulam 40.85%WG + polyglycol 26-2N (0.25% v/v) @ 31.23 + 750 g/ha; metsulfuron-methyl 20 WP + 0.25% NIS surfactant @ 20 + 625 g/ha; carfentrazone ethyl 40DF @ 50 g/ha, 2, 4-D Na (80WP) @ 625 g/ha; 2, 4-D Ester (38 EC) @ 1316 g/ha; metsulfurone-methyl 10% WP + carfentrazone 40DF + 0.2% surfactant @ 20 + 50 + 625 g/ha; 2,4-D Na + carfentrazone @ 500 + 50 g/ha; 2,4-D Ester + carfentrazone @ 1053 + 50 g/ha; halauxifen-methyl + florasulam + carfentrazone + surfactant @ 24.99 + 50 + 750 g/ha; aclonifen 500 SC @ 2000 g/ha; diflufenican 100 SC @ 2000 g/ha; aclonifen 500 + diflufenican 100 SC @ 1750 + 1750 g/ha; weedy check and weed free, replicated thrice.

Sowing of variety WH 1105 was done by seed drill and machine as per treatments at 5-6 cm depth using 100 kg seed ha^{-1} and layout was performed. Fertilizer (NPK) was applied based on recommended dose. Nitrogen was applied at the rate of 150 kg ha^{-1} in two splits i.e. ½ at sowing and ½ at first irrigation while full dose of Phosphorus (P_2O_5) and Potassium (K_2O) were applied at the time of sowing at the rate of 60 kg ha^{-1} each. Phosphorous was applied through di-ammonium phosphate. The amount of nitrogen after deducting from the availability of diammonium phosphate was applied in the form of urea. Potash was applied through muriate of potash. Herbicides of particular doses were sprayed alone or tank mixed by knap sack sprayer fitted with flat fan nozzle with 500 liter water per hectare after 35 DAS. Other cultural practices were followed as per requirement of the treatment and crop according to recommended package of practice.

Observations related to growth component, yield attributes and were recorded adopting the standard procedure at 30, 60, 90, 120 DAS and at maturity the results were statistically analyzed.

Correlation studies calculated by the following formula:

$$r = \frac{(x - \bar{x})\ (y - \bar{y})}{\sqrt{(x - \bar{x})^2\ (y - \bar{y})^2}}$$

Where:
r = Correlation coefficient
x = Independent variable
$\bar{x}$ = Mean of independent variable
y = Dependent variable
$\bar{y}$ = Mean of dependent variable

Results and discussion

Major broad-leaf weed flora observed during the crop season in the experimental plots comprised *Chenopodium album, Rumex dentatus, Anagallis arvensis, Medicago denticulate, Melilotus indicus* and *Lathyrus aphaca* various herbicidal treatments exerted significant effect growth component, yield attributes, yield, density and dry weight of weeds, weed control efficiency, and its economics.

Effect on growth and yield attributes of wheat

Herbicides and their mixtures significantly affected the growth and yield attributes of wheat is shown in Table 1. Herbicides during the entire growing season increased the yield attributes compared to weedy check. The maximum plant height, dry matter accumulation, number of tillers, number of effective tillers, spike length, grain per spike and test weight recorded with weed controlled plot, while the minimum parameters were observed with weedy check plot. Similar results were recorded by Gupta [9] and Marwat *et al.* [14].

Significantly higher plant height, dry matter accumulation, number of tillers, number of effective tillers, spike length, grain per spike and test weight were recorded with the application of aclonifen 500 + diflufenican 100 SC @ 1750 + 1750 g/ha, followed by halauxifen-methyl + florasulam + carfentrazone + surfactant (24.99 +50 + 750 g/ha) which proved their superiority over the rest herbicides and their mixtures for growth attributes enhancement at different growth stages. Reduced weed infestation through different weed control treatments might have helped the crop to accumulate higher dry matter through higher nutrient uptake and provided higher amount of photosynthesis to developing spikelet in plants which will have been able to produce higher yield attributes and yield. Various authors reported similarly that improved yield attributes happened with reduction of weed density and weed dry weight (Singh *et al.* [23], Punia *et al*. [18], Meena *et al.* [15] and Chand and Puniya [3].

Effect on wheat yield

Wheat yield including grain, straw and biological yield and harvest index were significantly affected by different treatments compared to weedy check. Maximum yields and harvest index recorded with weed controlled plot, while the minimum parameters were observed with weedy check plot. Similar results were recorded by Gupta [9] and Marwat *et al.* [14].

Among herbicides and their mixtures, aclonifen 500 + diflufenican 100 SC @ (1750 + 1750 g/ha) was recorded with significantly higher grain, straw and biological yield and harvest index compared to other treatments except metsulfuron-methyl 10% WP + carfentrazone 40 DF + 0.2% surfactant, halauxifen-methyl + florasulam + carfentrazone + surfactant, 2,4-D Na/Ester + carfentrazone, diflufenicain 100 SC and weedy check (Table 2). Aclonifen 500 + diflufenican 100 SC @ (1750 + 1750 g/ha) was recorded with significantly higher grain yield (6282.0 kg/ha), straw yield (8239.5 kg/ha), biological yield (14521.7 kg/ha) and harvest index (43.2%) which was 50.9, 31.0, 39.0 and 8.4 per cent higher and 0.13, 0.13, 0.13 and 0.3 per cent lower than weedy check and weed free, respectively and it was closely followed by halauxifen-methyl + florasulam + carfentrazone + surfactant. Alone application of 2,4-D Na (80 WP)/Ester (38 EC) were recorded with significantly lower yield compared to other herbicides and their mixtures but it is grain yield was 26.2 - 29.0 per cent higher than weedy check.

Reduced weed infestation through different weed control treatments might have helped the crop to accumulate higher dry matter through higher nutrient uptake and provided higher amount of photosynthesis to developing spikelet in plants which will have been able to produce higher yield attributes and yield (Fig. 1). Similar findings were also reported by Singh *et al.*[23] and Punia *et al.* [18]. In addition Khaliq *et al.*[13] also reported that wheat yield have negative correlation with density and dry weight of weeds as denoted and regression accounted for 89 and 83% of variation in yield due to density and dry weight of weeds in wheat. The increase in crop yield with different doses of herbicide may be attributed to reduce weed-crop competition. Similar reports are described by Muhammad *et al.* [16] and Cheema and Khaliq [4].

Weed control efficiency

All the herbicides and their mixtures recorded with higher weed control efficiency compared to weedy check plot at all the observation stages up to maturity (Fig. 2). Similar results were reported by Shehzad *et al.*[20] and Hashim *et al.*[10] who found that maximum weed population recorded in the weedy check plot in an herbicide trial on wheat. Chhokar *et al.* [5] reported similar results and described that herbicide mixture effectively controlled weeds compared to weedy check. Among the herbicides and their mixtures, Aclonifen 500 + diflufenican 100 SC was recorded with higher weed control efficiency closely followed by halauxifen-methyl + florasolam + carfentrazon + surfactant at all observation stages, while application of 2,4-D Na (80 WP) and 2,4-D Ester (38 EC) was recorded with lower weed control efficiency. Aclonifen 500 + diflufenican 100 SC was recorded with higher weed control efficiency 79.4, 73.4 and 71.1 per cent at 30, 60 DAT and at maturity, respectively which were 79.4, 73.4 and 71.1 per cent higher than weedy check plot.

Economics

The economics of various treatments had been estimated for comparison and to find out the most economical herbicide treatment for control of broad-leaf weeds in wheat. Among all the herbicides and their mixtures tested in study (Table 2), aclonifen 500 + diflufenican 100 SC @ 1750 + 1750 g/ha was recorded with higher economics closely followed by halauxifen – methyl + florasulam + carfentrazone + surfactant @ 24.99 + 50 + 750 g/ha. Aclonifen 500 + diflufenican 100 SC @ 1750 + 1750 g/ha was recorded with higher cost of cultivation (Rs. 79,915 ha^{-1}) which was 3.7 per cent lower than weed free and 4.3 per cent higher than weedy check. Among the different herbicides and their mixtures, application of aclonifen 500 + diflufenican 100 SC @ 1750 + 1750 g/ha was recorded with maximum gross return (Rs. 145,648 ha^{-1}), net return (Rs. 65,733 ha^{-1}) and B:C (1.82) which were 0.13, 4.6 and 3.4 per cent higher than weed free and 47.1, 193.7 and 41.1 per cent higher than weedy check, respectively. Similar findings were given by Ashrafi *et al.* [1], who reported that broad spectrum herbicides gave maximum net return in wheat and minimum net return was received in weedy check. Similarly Singh and Gosh [22] described that weed control in wheat through herbicides are more economical than hand weeding.

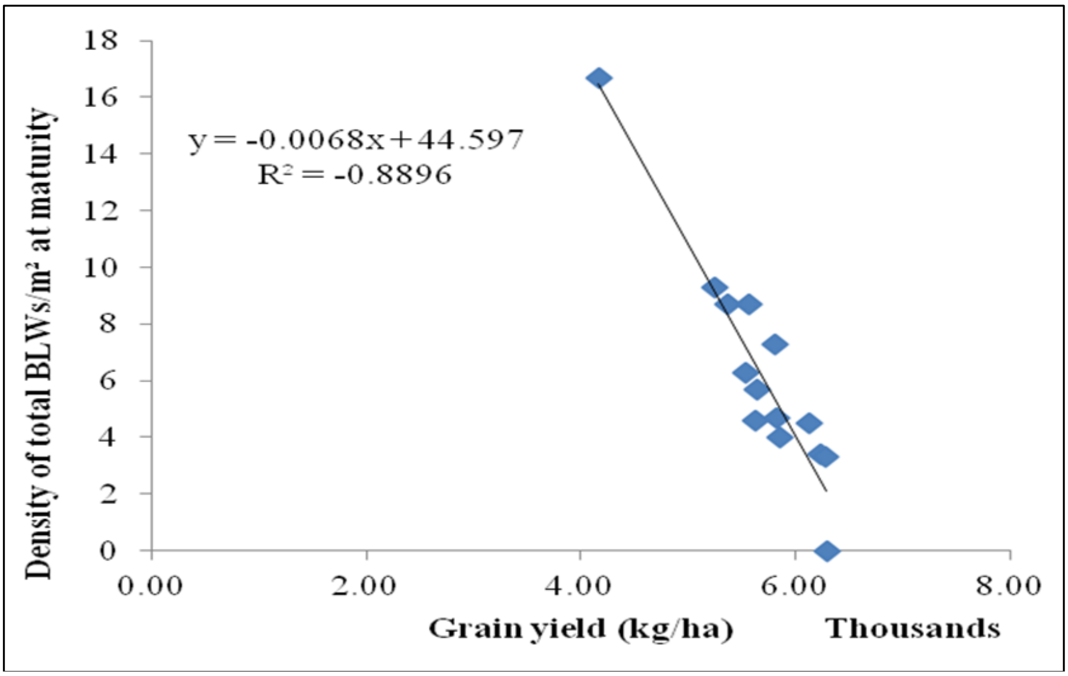

Fig. 1: Correlation of grain yield with density of BLWs at maturity

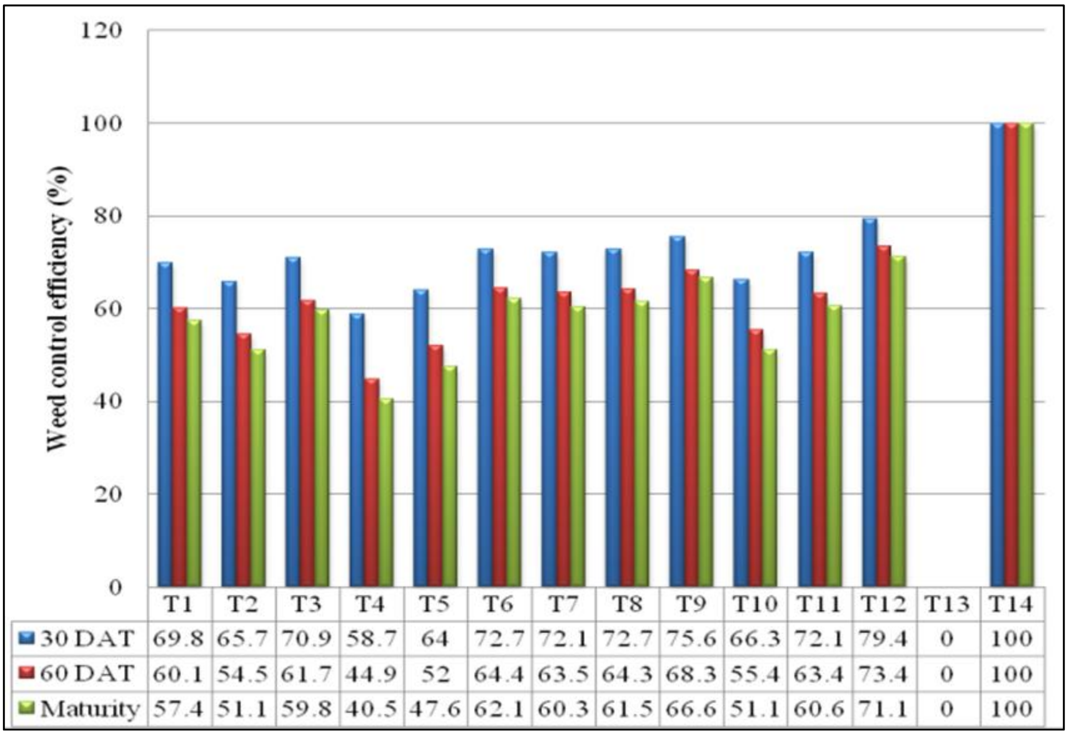

Fig 2: weed control efficiency (%)

Table 1: Effect of herbicides and their mixtures on growth and yield attributes of wheat

Treatments	Dose (g/ha)	At maturity			Effective tillers/ mrl	Spike length (cm)	Grains/ spike	Test wt. (g)
		Plant height (cm)	DMA g/mrl	Tiller/ mrl				
Halauxifen-methyl ester + florasulam 40.85%WG + polyglycol 26-2N (0.25% v/v)	31.23 + 750	107.7	323.1	106.3	99.3	10.2	51.2	40.2
Metsulfuron-methyl 20 WP + 0.25% surfactant	20 + 625	106.4	320.3	105.3	99.0	10.1	51.3	40.0
Carfentrazone-ethyl 40 DF	50	107.7	329.7	107.0	101.1	10.2	51.2	40.2
2, 4-D Na (80WP)	625	105.7	305.8	104.0	98.3	10.1	50.7	39.9
2, 4-D Ester (38 EC)	1316	106.0	308.4	105.3	98.7	10.1	51.0	40.0
Metsulfuron-methyl 10% WP + carfentrazone 40 DF + 0.2% surfactant	20 + 50 + 625	109.3	337.2	111.6	104.0	10.9	52.7	40.8
2, 4-D Na + carfentrazone	500 + 50	108.7	333.0	108.7	102.0	10.7	52.3	40.4
2, 4-D Ester + carfentrazone	1053 + 50	109.0	337.9	111.4	103.0	10.5	52.3	40.5
Halauxifen-methyl + florasulam + carfentrazone + surfactant	24.99+50+750	110.3	345.4	111.9	106.0	10.9	53.3	40.8
Aclonifen 500 SC	2000	107.3	320.6	106.0	99.0	10.1	51.3	40.1
Diflufenican 100 SC	2000	108.0	330.7	107.0	101.7	10.6	52.0	40.4
Aclonifen 500 + diflufenican 100 SC	1750 + 1750	110.7	346.3	112.0	107.7	11.0	54.7	41.6
Weedy check	--	100.0	292.7	98.7	91.7	9.4	45.0	37.0
Weed free	--	112.0	349.6	117.0	113.0	11.1	58.3	42.1
SEm±		1.5	3.3	0.9	2.2	0.2	1.2	0.4
CD at 5%		4.2	9.8	2.7	6.5	0.5	3.4	1.3

Table 2: Effect of herbicides and their mixtures on wheat yield and economics

Treatments	Dose (g/ha)	Productivity				Economics			
		Grain yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)	Cost of cultivation (`Rs.ha^{-1})	Gross returns (Rs.ha^{-1})	Net returns (Rs.ha^{-1})	B:C
Halauxifen-methyl ester + florasulam 40.85%WG + polyglycol 26-2N (0.25% v/v)	31.23 + 750	5,633.5	7,827.7	13,461.2	41.85	77,847	131,928	54,081	1.69
Metsulfuron-methyl 20 WP + 0.25% surfactant	20 + 625	5,529.8	7,914.9	13,444.7	41.13	77,357	130,193	52,836	1.68
Carfentrazone-ethyl 40 DF	50	5,619.0	7,855.8	13,474.8	41.70	77,657	131,733	54,076	1.70
2, 4-D Na (80WP)	625	5,252.5	7,416.3	12,668.8	41.46	77,357	123,360	46,003	1.59
2, 4-D Ester (38 EC)	1316	5,369.9	7,333.9	12,703.8	42.27	77,407	125,372	47,965	1.62
Metsulfuron-methyl 10% WP + carfentrazone 40 DF + 0.2% surfactant	20 + 50 + 625	6,125.3	8,266.9	14,392.2	42.56	77,907	142,713	64,806	1.79
2, 4-D Na + carfentrazone	500 + 50	5,820.7	7,709.5	13,530.2	43.02	77,857	135,177	57,320	1.74
2, 4-D Ester + carfentrazone	1053 + 50	5,853.0	7,867.1	13,720.1	42.66	77,897	136,272	58,375	1.75
Halauxifen-methyl + florasulam + carfentrazone + surfactant	24.99 +50 + 750	6,231.8	8,243.9	14,475.7	43.05	79,306	144,694	65,388	1.80
Aclonifen 500 SC	2000	5,570.7	7,950.4	13,521.1	41.2	79,077	131,087	52,010	1.66
Diflufenican 100 SC	2000	5,801.3	7,655.7	13,457.0	43.11	78,837	134,642	55,805	1.71
Aclonifen 500 + diflufenican 100 SC	1750 + 1750	6,282.0	8,239.7	14,521.7	43.20	79,915	145,648	65,733	1.82
Weedy check	--	4,163.3	6,281.5	10,444.8	39.86	76,607	98,988	22,381	1.29
Weed free	--	6,290.5	8,250.5	14,541.0	43.26	83,007	145,844	62,837	1.76
SEm±		168.5	222.1	385.3	0.24	-	-	-	-
CD at 5%		492.5	649.3	1,126.3	0.71	-	-	-	-

Conclusion

Based on field research experiment, it is concluded that among all the herbicides and their mixtures tested, application of aclonifen 500 + diflufenican 100 SC @ 1750 + 1750 g/ha at 35 DAS was found most effective against broad-leaf weeds except *Convulus arevensis* in wheat and it was also recorded with significantly lower weed density and weed dry matter accumulation and higher weed control efficiency (71.1%), net returns (65,733 Rs./ha) and B:C (1.82) at harvesting, which were 52.2 and 47.5 lower than weedy check and 71.1, 193.7 and 41.1 per cent higher than weedy check plot, respectively.

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