Himachal Journal of Agricultural Research 38(1): 18-24 (2012)

Sequential application of 2, 4-D, metsulfuron, carfentrazone with clodinafop for control of weeds in wheat

Suresh Kumar, S.S. Rana, N.N. Angiras, Pankaj Chopra and Navell Chander
Department of Agronomy, Forages and Grassland Management
CSK Himachal Pradesh Krishi Vishvavidyalya, Palampur - 176 062, India.

Manuscript Received: 31.10.2011; Accepted: 14.03.2012

Abstract

2, 4-D 0.5 kg/ha, metsulfuron-methyl 3 g/ha and carfentrazone 10 g/ha each immediately after and 2, 4 and 6 days after clodinafop 60 g/ha were compared to clodinafop alone and untreated check for control of weeds in wheat. *Phalaris minor*, *Avena ludoviciana, Poa annua*, *Vicia sativa*, *Anagallis arvensis*, *Ranunculus arvensis* and *Coronopus didymus* were the important weeds associated with wheat crop. All herbicidal treatments were significantly superior to untreated check in reducing *P. minor*, *Poa annua* and *A. ludoviciana*. Except 2, 4-D and carfentrazone immediately after clodinafop, all herbicides completely killed *Phalaris minor*. 2,4-D four days after and metsulfuron immediately after clodinafop gave significantly lower count of *V. sativa* during 2005-06 and 2006-07, respectively. All treatments except clodinafop alone were superior to weedy check in suppressing *A. arvensis* and *R. arvensis*. All treatments controlled *C. didymus* effectively. Application of 2, 4-D four days after clodinafop gave maximum yield. However, all other treatments except 2, 4-D two days after metsulfuron six days after and carfentrazone four days after clodinafop during 2005 were at par with 2,4-D four days after clodinafop. Weeds reduced wheat grain yield by 38.8%.

Key words: 2, 4-D, clodinafop, metsulfuron, carfentrazone, sequential application, *Phalaris*.

Introduction

Wheat (*T. riticum aestivum*) is a major cereal crop of *rabi* season in Northern India. Besides various technological constraints, weeds pose a serious challenge in enhancing and sustaining the productivity of wheat. Weeds, on an average reduce wheat yield by 66% or even more (Kumar *et al.,* 2009; Singh and Singh, 2002). Manual weeding is difficult due to morphological similarities of grassy weeds with that of wheat. Whereas, continuous use of herbicides not only reduces their efficacy but results in emergence of resistant weed biotypes. Evolution of resistance in *Phalaris minor* against isoproturon (Walia *et al.,* 1997) is one such example. This calls for evaluation of some alternative herbicides either alone or as sequential application to get weed suppression for a longer period. Thus, clodinafop as an alternative to isoproturon against grassy weeds and 2, 4-D, metsulfuron and carfentrazone against broadleaf weeds have been taken. It is imperative to standardize their time of application as a sequential application in wheat for broader activity spectrum *vis-a-vis* to avoid chances of the development of resistant biotypes.

Materials and Methods

The field experiment was conducted at Palampur ($32^0$06'05" N latitude, $76^0$34'10" E longitude and 1290 m altitude) during *rabi* 2005-06 and 2006-07. The soil of the experimental field was silty clay loam in texture, acidic in reaction (pH 5.6) and medium is available N (318 kg N/ha), P (19.2 kg/ha) and K (226.2 kg/ha). The experiment comprised of 14 treatments *viz* clodinafop 60 g/ha (40-45 DAS, days after sowing) followed by (fb) 2, 4-D, metsulfuron and carfentrazone each immediately, 2, 4 and six days after clodinafop, clodinafop alone and unweeded check was conducted in randomized block design with three replications. Wheat variety 'HPW 89' was sown on November 30, 2005 and November 28, 2006. Except weed control, the crop was raised in accordance with the recommended package of practices. The crop was fertilized with 60 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha as basal dose. Remaining half dose of nitrogen (60 kg/ha) was applied in two equal splits, the 1/4th at tillering and 1/4th at heading. The herbicides were sprayed with knapsack sprayer fitted with flat fan nozzle using 700 l of water per hectare. Weed count and dry weight were recorded at 120 DAS and at harvest (170 DAS) from two randomly selected spots (0.25 m^2) in each plot and expressed as No./m^2 and g/m^2, respectively. The data on count and dry weight of weeds was subjected to $\sqrt{x+1}$ (square root transformation). Yields were harvested from net plot.

Results and Discussion

Effect on weeds

Phalaris minor, *Avena ludoviciana* and *Poa annua* were the main grassy weeds constituting 16.1, 13.0 and 4.2 % of the total weed flora at 120 DAS of wheat and 47.7, 3.5 and 5.5 %, respectively at harvest. The alarming increase in the proportion of *P. minor* at harvest of wheat crop showing its high competitiveness. *Vicia sativa*, *Anagallis arvensis*, *Ranunculus arvensis* and *Coronopus didymus* were important broad leaf weeds. They constituted 14.3, 19.0, 12.0 and 21.4 of the total weed flora at 120 DAS and 15.2, 9.9, 5.6 and 12.6%, respectively at wheat harvest. The decrease in the proportion of broadleaf weeds by harvest of wheat as against 120 DAS, might be owing to their senescence.

All weed control treatments were significantly superior to weedy check in reducing the count of *P. minor* until 120 DAS during both the years (Table 1). There was compete kill of this weed with clodinafop fb metsulfuron under all herbicidal treatments except 2, 4-D and carfentrazone just after clodinafop. The effective control of *P. minor* with clodinafop has been documented (Angiras *et al.*, 2008). However, this treatment was at par with other herbicidal treatments. The superiority of sulfosulfuron and fenoxaprop against *P. minor* has been reported by Walia *et al.* (2003). The superiority of all herbicidal treatments in comparison to weedy check was maintained until harvest during 2006. However, count of *P. minor* under 2, 4-D immediately after clodinafop was higher by 61% over the weedy check. All treatments significantly reduced the count of *Poa annua* during 2005. They were equally effective in reducing its count over the weedy check. Count of *Avena ludoviciana* was significantly lower under all the treatments over weedy check at harvest during 2005. Effective control of *A. ludoviciana* with clodinafop has also been reported by Malik *et al.* (2001) and Angiras *et al.* (2008). However, carfentrazone at 10 g/ha four days after clodinafop at 60 g/ha did not significantly reduce the count of this weed over weedy check during 2006.

2, 4-D at 0.5 kg/ha four days after clodinafop resulted in lowest count of *V. sativa* in wheat at 120 DAS during 2005 (Table 2). However, metsulfuron immediately or four days after clodinafop application gave significantly lower count of this weed during 2006. Clodinafop and carfentrazone appeared to be ineffective against *V. sativa* as clodinafop alone or carfentrazone after clodinafop did not significantly influence the count of this weed over weedy check at 120 DAS either during 2005-06 or 2006-07. 2, 4-D and metsulfuron two days after clodinafop also did not significantly influence the count of *Vicia sativa* over weedy check at 120 DAS during 2005. All treatments except clodinafop alone were significantly superior to weedy check in suppressing *A. arvensis* until 120 DAS during 2005. Due to senescence of the weed by harvest of wheat crop, the trends in its count were not clear at harvest during 2005. However, during 2006-07 only 2, 4-D six days after clodinafop and metsulfuron immediately, two and four days after clodinafop could significantly reduce the count of *Anagallis* over weedy check at 120 days after sowing wheat.

Count of *Ranunculus* was significantly influenced at 120 DAS during both the years (Table 3). All weed control treatments except clodinafop alone brought about significant reduction in its count during 2005. However, only metsulfuron immediately, two and four days after clodinafop could significantly reduce the count of *Ranunculus* over weedy check. All weed control treatments were significantly superior to weedy check in reducing the count of *Coronopus* at 120 DAS during 2005. 2, 4-D and metsulfuron after clodinafop were quite effective against this weed at 120 DAS during 2005 as well as during 2006. However, trend in the count of *Coronopus* at harvest during 2005 was not very conspicuous probably owing to senescence of the weed.

All weed control treatments were superior to weedy check in curtailing growth of weeds until 120 DAS during both the years. However, 2,4-D immediately after clodinafop and carfentrazone 2 and 6 days after clodinafop did not significantly influence total weed dry weight at harvest during 2005. In general, 2,4-D and metsulfuron were better than carfentrazone, irrespective of time of application after clodinafop as well as herbicidal check 'clodinafop alone' at both the stages during 2005. However, their effectivity in terms of reducing weed dry weight was more or less similar to carfentrazone after clodinafop or clodinafop alone at both stages during 2006.

Table 1. Effect of treatments on count (No./m²) of grassy weeds in wheat

Treatment	Rate (g/ha)	Time (days after clodinafop)	*Phalaris*				*Poa*		*Avena*	
			120 DAS		At harvest		120 DAS		At harvest	
			2005	2006	2005	2006	2005	2006	2005	2006
Clodinafop fb 2,4-D	60 fb*** 500	Immediately	1.6* (2.6)**	1.0 (0.0)	5.3 (28.0)	2.9 (9.3)	1.4 (1.3)	2.7 (6.7)	2.7 (8.0)	1.0 (0.0)
Clodinafop fb 2,4-D	60 fb 500	2	1.0 (0.0)	1.0 (0.0)	2.5 (6.6)	1.7 (2.7)	1.8 (2.6)	3.2 (9.3)	1.0 (0.0)	1.0 (0.0)
Clodinafop fb 2,4-D	60 fb 500	4	1.0 (0.0)	1.0 (0.0)	1.8 (2.6)	1.4 (1.3)	1.8 (2.6)	2.4 (5.3)	1.4 (1.3)	1.0 (0.0)
Clodinafop fb 2,4-D	60 fb 500	6	1.0 (0.0)	1.0 (0.0)	1.4 (1.3)	1.7 (2.7)	1.0 (0.0)	3.5 (12.0)	1.4 (1.3)	1.0 (0.0)
Clodinafop fb metsulfuron	60 fb 3	Immediately	1.0 (0.0)	1.0 (0.0)	2.7 (8.0)	3.9(14.7)	1.4 (1.3)	3.2 (9.3)	2.2 (5.3)	1.4 (1.3)
Clodinafop fb metsulfuron	60 fb 3	2	1.0 (0.0)	1.0 (0.0)	1.4 (1.3)	2.3 (5.3)	1.0 (0.0)	2.2 (4.0)	1.0 (0.0)	1.0 (0.0)
Clodinafop fb metsulfuron	60 fb 3	4	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.7 (2.7)	1.4 (1.3)	2.1 (4.0)	1.8 (2.6)	1.7 (2.7)
Clodinafop fb metsulfuron	60 fb 3	6	1.0 (0.0)	1.0 (0.0)	1.8 (2.6)	1.4 (1.3)	1.87 (2.6)	2.5 (6.7)	1.0 (0.0)	1.0 (0.0)
Clodinafop fb carfentrazone	60 fb 10	Immediately	1.0 (0.0)	1.4 (1.3)	1.0 (0.0)	1.8 (2.7)	1.6 (2.6)	2.5 (6.7)	1.4 (1.3)	1.0 (0.0)
Clodinafop fb carfentrazone	60 fb 10	2	1.0 (0.0)	1.0 (0.0)	2.2 (5.3)	1.8 (4.0)	1.4 (1.3)	2.7 (6.7)	2.3 (5.3)	1.0 (0.0)
Clodinafop fb carfentrazone	60 fb 10	4	1.0 (0.0)	1.0 (0.0)	1.4 (1.3)	1.0 (0.0)	1.0 (0.0)	3.4 (10.7)	1.0 (0.0)	1.9 (4.0)
Clodinafop fb carfentrazone	60 fb 10	6	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.8 (2.7)	1.4 (1.3)	2.9 (8.0)	1.4 (1.3)	1.4 (1.3)
Clodinafop	60		1.0 (0.0)	1.0 (0.0)	1.4 (1.3)	1.4 (1.3)	1.4 (1.3)	3.2 (9.3)	1.0 (0.0)	1.0 (0.0)
Unweeded			5.5 (29.3)	3.2 (9.3)	4.2 (17.3)	9.0 (81.3)	3.6 (12.0)	3.4 (10.7)	5.9 (37.3)	2.5 (6.7)
CD (P=0.05)			0.7	0.4	1.4	1.7	1.1	NS	1.4	0.8

*Data transformed to $\sqrt{x+1}$ root transformation;** Values in the parentheses are the means of original values;*** fb followed by

Table 2. Effect of treatments on count (No./m²) of broadleaf weeds at in wheat

Treatment	Rate (g/ha)	Time (days after clodinafop)	*Vicia*		*Anagallis*			
			120 DAS		120 DAS		At harvest	
			2005	2006	2005	2006	2005	2006
Clodinafop fb 2,4-D	60 fb*** 500	Immediately	5.1* (25.3)**	4.7 (21.3)	4.2 (17.3)	2.5 (6.7)	2.0 (5.3)	3.1 (10.7)
Clodinafopfb 2,4-D	60 fb 500	2	6.0 (36.0)	4.6 (20.0)	3.7 (13.3)	3.6 (12.0)	1.0 (0.0)	2.1 (4.0)
Clodinafop fb 2,4-D	60 fb 500	4	3.3 (10.6)	4.7 (21.3)	3.5 (12.0)	3.2 (9.3)	1.8 (2.6)	2.9 (8.0)
Clodinafop fb 2,4-D	60 fb 500	6	4.5 (20.0)	4.1 (16.0)	3.9 (14.6)	1.7 (2.7)	1.0 (0.0)	1.9 (4.0)
Clodinafop fb metsulfuron	60 fb 3	Immediately	5.1 (25.3)	3.2 (9.3)	3.3 (10.6)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)
Clodinafop fb metsulfuron	60 fb 3	2	6.1 (37.3)	3.9 (14.7)	4.0 (16.0)	1.4 (1.3)	2.6 (6.6)	1.0 (0.0)
Clodinafop fb metsulfuron	60 fb 3	4	5.5 (29.3)	3.4 (10.7)	3.7 (13.3)	1.7 (2.7)	3.0 (8.0)	1.0 (0.0)
Clodinafop fb metsulfuron	60 fb 3	6	5.2 (26.6)	3.8 (13.3)	2.9 (8.0)	2.3 (5.3)	1.0 (0.0)	1.0 (0.0)
Clodinafop fb carfentrazone	60 fb 10	Immediately	5.5 (30.6)	5.7 (32.0)	4.1 (16.0)	2.7 (8.0)	2.9 (9.3)	2.7 (6.7)
Clodinafop fb carfentrazone	60 fb 10	2	5.3 (28.0)	5.4 (28.0)	3.3 (10.6)	3.6 (12.0)	2.3 (5.3)	1.7 (2.7)
Clodinafop fb carfentrazone	60 fb 10	4	7.2 (52.0)	4.7 (21.3)	4.5 (20.0)	2.9 (8.0)	2.2 (5.3)	1.0 (0.0)
Clodinafop fb carfentrazone	60 fb 10	6	7.1 (50.6)	5.4 (28.0)	3.5 (12.0)	2.9 (8.0)	3.7 (13.3)	2.5 (6.7)
Clodinafop	60		7.5 (56.0)	5.1 (25.3)	6.7 (44.0)	3.3 (10.7)	2.9 (9.3)	2.0 (5.3)
Unweeded			6.5 (41.3)	5.4 (28.0)	7.2 (52.0)	4.1 (16.0)	1.6 (2.6)	1.7 (2.7)
CD (P=0.05)			0.9	0.6	0.9	1.6	1.6	NS

*Data transformed to square root transformation;** Values in the parentheses are the means of original values;*** fb followed by

Table 3. Effect of treatments on count (No./m²) of *Ranunculus* and *Coronopus* in wheat

Treatment	Rate (g/ha)	Time (days after clodinafop)	*Ranunculus*				*Coronopus*			
			120 DAS		At harvest		120 DAS		At harvest	
			2005	2006	2005	2006	2005	2006	2005	2006
Clodinafop fb 2,4-D	60 fb*** 500	Immediately	1.0* (0.0)**	2.7 (6.7)	1.0(0.0)	2.3(5.3)	1.0 (0.0)	2.7 (6.7)	1.0 (0.0)	1.4(1.3)
Clodinafop fb 2,4-D	60 fb 500	2	2.2 (5.3)	2.5 (6.7)	2.4(6.6)	1.8(2.7)	1.0 (0.0)	3.1 (9.3)	1.0 (0.0)	1.0 (0.0)
Clodinafop fb 2,4-D	60 fb 500	4	2.0 (5.3)	1.8 (2.7)	2.2(5.3)	1.8(2.7)	1.0 (0.0)	2.1 (4.0)	1.0 (0.0)	1.0 (0.0)
Clodinafop fb 2,4-D	60 fb 500	6	1.6 (2.6)	3.6 (12.0)	2.0(4.0)	1.4(1.3)	1.0 (0.0)	1.4 (1.3)	1.8 (4.0)	1.0 (0.0)
Clodinafop fb metsulfuron	60 fb 3	Immediately	1.0 (0.0)	1.4 (1.3)	1.0(0.0)	1.0(0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)
Clodinafop fb metsulfuron	60 fb 3	2	3.1 (9.3)	1.4 (1.3)	2.4(6.6)	1.0(0.0)	1.0 (0.0)	1.8 (2.7)	1.4 (1.3)	1.0 (0.0)
Clodinafop fb metsulfuron	60 fb 3	4	2.4 (6.6)	1.4 (1.3)	1.4(1.3)	1.0(0.0)	1.9 (2.9)	1.8 (4.0)	1.4 (1.3)	1.4 (1.3)
Clodinafop fb metsulfuron	60 fb 3	6	2.7 (8.0)	2.9 (8.0)	1.8(2.6)	1.9(4.0)	1.6 (1.9)	2.2 (4.0)	1.6 (2.6)	1.0 (0.0)
Clodinafop fb carfentrazone	60 fb 10	Immediately	3.6 (13.3)	2.7 (8.0)	2.9(8.0)	1.7(2.7)	3.5(11.7)	3.6 (12.0)	2.9 (8.0)	1.7 (2.7)
Clodinafop fb carfentrazone	60 fb 10	2	3.2 (10.6)	1.8 (2.7)	3.2(12.0)	1.0(0.0)	3.1(10.6)	3.0(8.0)	2.3 (5.3)	1.4 (1.3)
Clodinafop fb carfentrazone	60 fb 10	4	3.4 (12.0)	3.1 (9.3)	1.4(1.3)	1.9(4.0)	4.0(15.7)	3.6 (12.0)	1.4 (1.3)	1.7 (2.7)
Clodinafop fb carfentrazone	60 fb 10	6	3.1 (9.3)	2.3 (5.3)	2.0(4.0)	2.3(5.3)	3.9(16.5)	3.0 (8.0)	2.7 (8.0)	3.3 (10.7)
Clodinafop	60		5.5 (30.6)	3.6 (12.0)	2.3(5.3)	1.4(1.3)	6.2(38.1)	4.1(16.0)	2.9 (8.0)	2.2 (6.7)
Unweeded			5.2 (26.6)	2.9 (8.0)	2.9(8.0)	1.7(2.7)	7.8(61.6)	3.9 (14.7)	1.0 (0.0)	2.7 (9.3)
CD (P=0.05)			1.6	1.4	NS	NS	1.4	1.1	1.4	NS

*Data transformed to square root transformation;** Values in the parentheses are the means of original values;*** fb followed by

Effects on crop

Owing to significant reduction in the count and dry weight of weeds, all the herbicidal treatments produced higher grain yield as compared to unweeded control (Table 4). However, 2,4-D two days, metsulfuron six days and carfentrazone four days after clodinafop did not significantly increase wheat grain yield during 2005. Application of 2,4-D four days after clodinafop resulted in maximum grain yield of 3350 kg/ha and 3421 kg/ha during 2005 and 2006, respectively. However, this treatment was at par with all the herbicidal treatments except sequential application of 2,4-D two days, metsulfuron six days and carfentrazone four days after clodinafop during both the years and clodinafop alone during 2005. It is also pertinent to mention that 2,4-D four days after clodinafop was the only treatment which could significantly increase wheat grain yield over the herbicidal check 'clodinafop alone' during 2005. The other herbicidal treatments were

Table 4. Effect of treatments on total weed dry weight and grain yield of wheat

Treatment	Rate (g/ha)	Time (days after clodinafop)	Total weed dry weight (g/m^2)				Grain yield (kg/ha)	
			2005		2006			
			120 days	At harvest	120 days	At harvest	2005	2006
Clodinafop fb 2,4-D	60 fb*** 500	Immediately	2.4* (4.8)**	4.7 (23.3)	1.6 (1.6)	1.6 (1.5)	2993	3231
Clodinafopfb 2,4-D	60 fb 500	2	2.3 (4.8)	2.2 (4.0)	1.7 (1.9)	1.7 (1.8)	2331	2741
Clodinafop fb 2,4-D	60 fb 500	4	1.5 (1.7)	1.8 (2.6)	1.6 (1.5)	1.5 (1.2)	3350	3421
Clodinafop fb 2,4-D	60 fb 500	6	2.5 (5.6)	2.4 (7.6)	1.6 (1.7)	1.9 (2.7)	3134	3301
Clodinafop fb metsulfuron	60 fb 3	Immediately	2.5 (5.3)	2.0 (4.6)	1.5 (1.4)	1.2 (0.5)	3024	3291
Clodinafop fb metsulfuron	60 fb 3	2	2.6 (6.1)	2.5 (5.6)	1.5 (1.3)	1.3 (0.7)	3150	3341
Clodinafop fb metsulfuron	60 fb 3	4	1.9 (2.9)	2.2 (4.5)	1.6 (1.6)	1.4 (1.0)	2945	3120
Clodinafop fb metsulfuron	60 fb 3	6	1.6 (1.9)	1.5 (1.6)	1.8 (2.2)	1.3 (0.7)	2299	2591
Clodinafop fb carfentrazone	60 fb 10	Immediately	3.5 (11.7)	3.6 (13.0)	1.7 (2.0)	1.4 (0.8)	3155	3271
Clodinafop fb carfentrazone	60 fb 10	2	3.1 (10.6)	4.7 (23.4)	1.7 (1.8)	1.4 (1.0)	3072	3190
Clodinafop fb carfentrazone	60 fb 10	4	4.0 (15.7)	3.0 (8.2)	1.8 (2.3)	1.9 (3.3)	2268	2581
Clodinafop fb carfentrazone	60 fb 10	6	3.9 (16.5)	4.9 (15.7)	1.6 (1.5)	1.7 (2.1)	3024	3281
Clodinafop	60		6.2 (38.1)	3.3 (10.4)	2.0 (3.2)	1.6 (1.5)	2914	3251
Unweeded			7.8 (61.6)	6.6 (50.6)	3.0 (8.2)	5.3 (27.8)	2110	2031
CD (P=0.05)			1.4	2.1	0.5	0.7	420	367

*Data transformed to square root transformation; **Values in the parentheses are the means of original values; fb***: followed by

comparable to 'clodinafop alone'. Weeds in unweeded check reduced wheat grain yield by 37% over 2, 4-D 4 days after clodinafop during 2005 and by 40.6 % during 2006.

The present investigation conclusively inferred that 2, 4-D four days after clodinafop may be the better alternative to 'clodinafop alone' in tackling weed menace in wheat.

References

Angiras NN, Kumar S, Rana SS and Sharma N 2008. Standardization of dose and time of application of clodinafop-propargyl to manage weeds in wheat. Him. J. Agric. Res. **34** (2): 15-18.

Kumar S, Angiras NN, Rana SS and Sharma N 2009. Alternative methods of isoproturon application in wheat. Him. J.Agric. Res. **35** (1): 31-33.

Malik RS, Balyan RS, Malik RK and Banga RS 2001. Efficacy of new herbicides with and without surfactants on weeds in wheat. Indian J. Weed Sci. **33** (1&2):59-62.

Singh G and Singh M 2002. Bioefficacy of metsulfuron methyl in combination with isoproturon for control of grassy and non-grassy weeds in wheat. Indian J. Weed Sci. **34** (1&2):9-12.

Walia US, Brar LS and Dhaliwal BK 1997. Resistance to isoproturon in *Phalaris minor* Retz. in Punjab. Plant Prot. **12**:138-40.

Walia US, Brar LS and Jand S 2003. Integrated effects of planting methods and herbicides on *Phalaris minor* and wheat. Indian J. Weed Sci. **35** (2):169-72.