



Bioefficacy and phytotoxicity of herbicides in greengram and their residual effect on succeeding mustard

S.S. Punia*, Dharambir Yadav, Anil Duhan and Mohammad Irfan

Department of Agronomy, CCS Haryana Agricultural University, Hisar, Haryana 125 004

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ABSTRACT

Weed flora of experimental field was dominated with *Echinochloa colona* during *Kharif* 2012 and *Trianthema portulacastrum* during *Kharif* 2013. Post-emergence application of imazethapyr at 70 g/ha and its ready mixture with imazamox at 60-80 g/ha although provided excellent (80-90%) control of weeds but caused 23-35% injury to greengram in initial stages in terms of yellowing of leaves and stunted crop growth up to 7 DAT which mitigated to 5-7% up to 45 DAS, without any yield reductions. Pre-emergence application of pendimethalin+ imazethapyr (ready mix) at 1000 g/ha provided season long control (75-82%) of weeds in greengram. During both years, seed yield was maximum (1.50 and 1.58 t/ha, respectively) in weed free treatment which was at par with post-emergence application of imazethapyr at 50 and 70 g/ha and imazethapyr + imazamox (ready mix) at 60 g/ha in 2012 but significantly higher than all herbicide treatments in 2013. Imazethapyr and its ready mix combination irrespective of dose did not cause any injury to succeeding mustard crop after harvest of greengram.

Key words: Crop injury, Greengram, Imazethapyr, Imazamox, Mustard, Residual carry over

Due to limited irrigation facilities in South-Western part of Haryana, greengram is the important *Kharif* season crop of this region. It is drought tolerant legume and excellent rotational crop with mustard, wheat, chickpea and barely. Weeds in greengram have been reported to offer serious competition and cause yield reduction to the extent of 49% (Parkash *et al.* 1988). Weed emergence in greengram begins almost with the crop emergence leading to crop-weed competition from initial stages. Critical period of crop-weed competition in greengram and urdbean is 20-40 days after sowing (Saraswat and Mishra 1993), hence the effective use of herbicide at these critical stages play significant role in maintaining the productivity by decreasing the weed interference. Horse purslane (*T. portulacastrum*) an annual broad-leaf weed germinates at the same time as greengram crop and completes its life cycle within 30 days (Balyan 1985). Crop type and soil properties have greatest influence on the occurrence of weed species (Andreasen *et al.* 1991). The type of irrigation, cropping pattern, weed control measures and environmental factors had a significant influence on the intensity and infestation of weeds. Although pre-emergence use of pendimethalin at 1.0 kg/ha has been found effective to control weeds in greengram but a residual herbicide is needed to control second flush of weeds emerging after rains. Keeping it in view, herbicides imazethapyr alone

or in combination with imazamox and pendimethalin as pre-mixture with imazethapyr were tested under pre- and post-emergence conditions and compared with pendimethalin alone. Based on weed dry weight, WCE was calculated.

MATERIALS AND METHODS

The present studies were conducted during *Kharif* and *Rabi* seasons of 2012 and 2013 at Department of Agronomy, CCS Haryana Agricultural University, and Hisar under irrigated conditions. The soil of the experimental field was sandy loam in texture, having pH 8.1, low in organic carbon (0.3%) and nitrogen (180 kg/ha), medium in available phosphorus (18 kg/ha) and high in potassium (370 kg/ha) content. The treatments consisting of pendimethalin at 1.0 kg/ha and pendimethalin+imazethapyr at 800-1000g/ha as pre-emergence. Post-emergence treatments included different doses of imazethapyr (ready mix) at 50, 60 and 70 g/ha, imazethapyr + imazamox (ready mix) at 60-80g/ha and compared with one or two hoeing, weed free and weedy checks were tried in randomized block design replicated thrice. Greengram cultivar 'Satya' was sown on 17 and 10 July and harvested on 5 and 8 October during 2012 and 2013, respectively. Post-emergence herbicides were applied at 23 DAS (2-3 leaf stage of weeds) by knapsack sprayer fitted with flat fan nozzle using 500 l/ha water. Crop was raised according to package of practices of the state

*Corresponding author: puniasatbir@gmail.com

university. Total rainfall received during the crop season was 215 mm during 2012 where as during 2013, total 525 mm rainfall was received during *Kharif* season. Observations on weeds were recorded at 30 and 60 DAS. Phytotoxic effect of herbicides on crop in terms of yellowing, stunting and necrosis were recorded at 15, 30 and 60 DAS. Crop yield and yield parameters were recorded at maturity. Mustard crop cultivar ‘RH 749’ was planted in second fortnight of October after harvest of greengram with shallow disking and planking in same layout as in *Kharif* 2012 and 2013. Data on number of leaves/plant at 30 DAS, number of mustard plants/m.r.l., plant height of mustard at 30 and 60 DAS and seed yield was recorded at harvest.

RESULTS AND DISCUSSION

Effect on weeds

During 2012, *Echinochloa colona* was the most dominating weed constituting 98% of total weed flora where as during 2013, *Trianthema portulacastrum* constituted 99% of weed flora. Other weeds present in experimental field were *Cyperus rotundus*, *Dactyloctenium aegyptium* and *Convolvulus arvensis*.

During 2012, all weed control treatments proved very effective against *E. colona* and population of this weed in these treatments was at par with weed free check (Table 1). During 2013, all pre-emergence herbicides treatments proved very effective against predominant weed *T. portulacastrum* as shown by density of weeds at 30 DAS (Table 1). None of the treatment proved very effective against *C. rotundus* and *C. arvensis* but pendimethalin alone or in combination showed efficacy against *D. aegyptium*. Pre-emergence application of pendimethalin or pre-plant incorporation of fluchloralin or trifluralin provided excellent control of *T. portulacastrum* L. and *E. tenella* but not *Cyperus* spp. (Kaur *et al.* 2010). During 2012, post emergence application of imazethapyr at 50-70 g/ha and imazethapyr + imazamox at 60,70 and 80 g/ha proved very effective in minimizing density and dry weight of weeds particularly *E. colona*, which was significantly less over weedy check but during 2013, post-emergence application of imazethapyr and imazethapyr + imazamox at all rates of application proved less effective in minimizing density and dry weight of *T. portulacastrum* only with some suppression as evident from density and dry weight of weeds at 30 and 60 DAS. Although post emergence application of

Table 1. Effect of different treatments on weed density in greengram during 2012 and 2013

Treatment	Dose (g/ha)	Application time	Density (no./m ²) at 30 DAS				Density (no./m ²) at 60 DAS			
			2012		2013		2012		2013	
			<i>E. colona</i>	<i>Trianthema</i>	<i>C. rotundus</i>		<i>E. colona</i>	<i>Trianthema</i>	<i>D.aegyp ticum</i>	<i>C. rotundus</i>
Pendimethalin	1000	PRE	6.1(37.3)	3.4(10.7)	5.1(26)	1.7(2.0)	4.7(22)	1.6(1.7)	1(0)	3.3(10)
Imazethapyr	50	3-4 leaf stage	3.2 (12)	5.9 (1.3)	1.4(1.3)	1.8(2.3)	1.7(2)	1.2(0.7)	1.7(2)	2.9(7.3)
Imazethapyr	60	3-4 leaf stage	-	9.4 (88.3)	-	1.6(1.7)	-	1(0)	-	2.4(4.7)
Imazethapyr	70	3-4 leaf stage	1.4(1.3)	10.5(109)	1(0)	1.7(2.0)	1.9(3.3)	1(0)	1.8(3.3)	2.0(3.7)
Imazethapyr + pendimethalin (RM)	800	PRE	3.5 (14)	1.3 (21.3)	4.5 (21.3)	2.6 (6.0)	3.4 (10.7)	2.4 (5)	1 (0)	1.6(2.3)
Imazethapyr + pendimethalin (RM)	900	PRE	2.2 (3.7)	1 (0)	4 (16.7)	2.9 (7.3)	3.4 (11.3)	2.4 (5)	1 (0)	1.8 (2.7)
Imazethapyr + pendimethalin (RM)	1000	PRE	3.0 (8.7)	1 (0)	3.1 (9.3)	1.6 (1.7)	3.8 (13.3)	2 (3.0)	1.5 (1.3)	2.9 (7.3)
Imazethapyr + imazamox(RM)	50	3-4 leaf stage	-	10.3 (106)	-	1.9 (2.7)	-	1 (0)	-	2.5 (5.3)
Imazethapyr + mazamox(RM)	60	3-4 leaf stage	3.0 (9.3)	10.4 (106)	2.0 (5.3)	1.5 (1.3)	2.3 (4.7)	1 (0)	2.9 (9.3)	2.6 (5.7)
Imazethapyr + imazamox(RM)	70	3-4 leaf stage	3.2 (9.3)	11.4 (130)	3.1 (10.7)	1.8 (2.3)	1.2 (0.7)	1.3 (1)	3.4 (11.3)	2.8 (7.0)
Imazethapyr + imazamox(RM)	80	3-4 leaf stage	1.8 (2.7)	10.8 (115)	2.3 (5.3)	2.1 (3.3)	1.2 (0.7)	1 (0)	2.9 (8)	1.9 (3.3)
One hoeing	-	20 DAS	-	1 (0)	-	1 (0)	-	2.6 (7.3)	-	1.7 (2.3)
Two hoeing	-	20 & 40 DAS	-	1 (0)	-	1 (0)	-	2.7 (8)	-	2.3 (4.7)
Weed free	-	-	1.0 (0)	1(0)	1.4(1.3)	1 (0)	1.8(2.7)	1(0)	1.2(0.7)	1(0)
Weedy check	-	-	10.5(108)	10.5 (110)	2.1(4)	1.5(2)	8.1(64)	1(0)	2.1(3.3)	2.45(5)
LSD (P= 0.05)			2.0		1.95	0.48	1.1	0.96	1.46	0.92

Transformed values ($\sqrt{x + 1}$), original values are given in parenthesis DAT: Days after treatment

Table 2. Effect of different treatments on visual weed control, crop phytotoxicity, plant height, number of pods/plant and seed yield of greengram (2012 and 2013)

Treatment	Dose (g/ha)	Application time	Visual weed control (%) 45 DAS		Crop phytotoxicity (%)				Plant height (cms)		No. of pods/plant		Seed yield (t/ha)	
			2012	2013	2012		2013		2012	2013	2012	2013	2012	2013
					30 DAS	45 DAS	30 DAS	45 DAS						
Pendimethalin	1000	PRE	30.9 (26.7)	56.8 (70)	0(0)	0(0)	0(0)	0(0)	87.5	86.9	28.3	32.3	0.91	1.40
Imazethapyr	50	3-4 leaf stage	-	63.6 (80)	-	-	0(0)	0(0)	-	85.8	-	28.5	-	1.24
Imazethapyr	60	3-4 leaf stage	73 (91.7)	67.2 (85)	16.2 (8.3)	0(0)	0(0)	0(0)	86.3	89.1	34.5	28.0	1.44	1.22
Imazethapyr	70	3-4 leaf stage	75.2 (93.3)	71.6 (90)	28.0 (23.3)	0(0)	0(0)	0(0)	85.8	85.3	34.9	30.9	1.48	1.28
Imazethapyr + pendimethalin (RM)	800	PRE	61.8 (77.7)	50.8 (60)	0(0)	0(0)	0(0)	0(0)	85.7	86.1	34.1	34.0	1.41	1.44
Imazethapyr + pendimethalin (RM)	900	PRE	63.6 (80)	60 (75)	0 (0)	0(0)	0(0)	0(0)	85.6	85.9	33.5	34.5	1.41	1.46
Imazethapyr + pendimethalin (RM)	1000	PRE	64.7 (81.7)	60 (75)	0 (0)	0(0)	0(0)	0(0)	85.6	89.9	35.0	35.0	1.43	1.50
Imazethapyr + imazamox(RM)	50	3-4 leaf stage	-	67.2 (85)	-	-	0(0)	0(0)	-	82.1	-	32.6	-	1.32
Imazethapyr + imazamox(RM)	60	3-4 leaf stage	63.6 (80)	71.6 (90)	4.3 (1.7)	0(0)	0(0)	0(0)	86.5	82.0	36.1	33.1	1.45	1.37
Imazethapyr + imazamox(RM)	70	3-4 leaf stage	64.7 (81.7)	71.6 (90)	24.8 (18.3)	12.9 (5)	0(0)	0(0)	84.2	82.4	33.3	33.0	1.37	1.42
Imazethapyr + imazamox(RM)	80	3-4 leaf stage	79.5 (95)	69.7 (88)	33.3 (35.2)	14.7 (7)	0(0)	0(0)	83.7	80.8	33.2	33.6	1.36	1.44
One hoeing	-	20 DAS	-	56.8(70)	-	-	0(0)	0(0)	-	84.6	-	34.0	-	1.48
Two hoeing	-	20 & 40 DAS	-	71.6(90)	-	-	0(0)	0(0)	-	87.2	-	36.0	-	1.56
Weed free	-	-	90(100)	90(100)	0(0)	0(0)	0(0)	0(0)	85.8	84.3	35.8	35.8	1.50	1.58
Weedy check	-	-	0(0)	0	0(0)	0(0)	0(0)	0(0)	86.9	84.9	19.7	21.3	0.22	0.34
LSD (P=0.05)			6.8	5.4	7.9	1.64	-	-	1.3	3.0	1.8	5.0	0.07	0.03

Arc Sin transformed values, original values are given in parentheses

both these herbicides caused suppression in *Trianthema* growth but pre-emergence treatments of pendimethalin alone or in combination with imazethapyr were very effective to minimize *Trianthema* population. Although, pre-emergence application of pendimethalin proved very effective and gave 80-90% control of weeds up to 15 DAS but per cent control decreased with time and it remained 27-70% up to 45 DAS. Pre-emergence use of pendimethalin + imazethapyr 2% at all application rates 800-1000 g/ha was very effective up to 45 DAS without any crop suppression. At 30 DAS, WCE was more than 70-90% in all herbicide treatments except pendimethalin at 1000 g/ha but at 60 DAS, WCE decreased in all pre-emergence treatments due to second flush of weeds appeared due to frequent rains (Table 1). At 60 DAS, maximum WCE (82-93%) was recorded with post-emergence use of imazethapyr at 70 g/ha.

Effect on crop

All weed control treatments had reflection on plant height, no. of pods per plant and seed yield of green gram. During 2012, imazethapyr + imazamox

at 70 and 80 g/ha caused 18-35% toxicity to greengram which mitigated with time and remained 5-7% up to 45 DAS resulting reduction in plant height, number of pods per plant and seed yield. Presence of weeds throughout the season caused 78-86% reduction in seed yield of green gram. During both years, seed yield was maximum (1.50 and 1.58 t/ha, respectively) in weed free treatment which was at par with post-emergence application of imazethapyr at 50 & 70 g/ha and imazethapyr + imazamox at 60 g/ha in 2012 but significantly higher than all herbicide treatments in 2013 (Table 2). During 2012, in herbicidal treatments maximum grain yield (1.48 t/ha) was obtained with post-emergence use of imazethapyr at 70 g/ha and at par with its lower dose 50 g/ha, pre-emergence use of pendimethalin + imazethapyr at 900-1000 g/ha and ready mix combination of imazethapyr + imazamox at 60 g/ha.

During 2013, maximum grain yield (1.50 t/ha) was obtained with pre-emergence use of pendimethalin + imazethapyr at 1000 g/ha which was at par with its lower dose of 900 g/ha but higher than all post-emergence treatments (Table 2).

Table 3. Residual effect of different herbicides applied in greengram on succeeding mustard crop (2012-13 and 2013-14)

Treatment	Dose (g/ha)	Application time	No. of plants/m.r.l. 20 DAS		Plant height (cm)				Phytotoxicity (%)				Seed yield (t/ha)	
					30 DAS		60 DAS		15 DAS		30 DAS			
			2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14		
Pendimethalin	1000	PRE	8.5	8.9	23.5	22.4	164.2	161.3	0	0	0	0	1.84	2.22
Imazethapyr	50	3-4 leaf stage	8.7	9.3	24.2	20.1	165.0	158.8	0	0	0	0	1.92	2.28
Imazethapyr	60	3-4 leaf stage	8.9	10.0	22.9	22.0	163.4	153.4	0	0	0	0	1.95	2.28
Imazethapyr	70	3-4 leaf stage	9.3	8.7	22.0	20.8	164.0	159.8	5	5	0	0	1.89	2.20
Imazethapyr + pendimethalin (RM)	800	PRE	9.3	8.3	23.0	22.0	162.8	160.2	0	0	0	0	1.82	2.20
Imazethapyr + pendimethalin (RM)	900	PRE	8.9	9.7	23.4	23.4	163.7	160.6	0	0	0	0	1.84	2.26
Imazethapyr + pendimethalin (RM)	1000	PRE	8.5	9.3	23.8	21.9	163.0	162.2	0	0	0	0	1.95	2.18
Imazethapyr + imazamox (RM)	50	3-4 leaf stage	8.6	9.0	23.0	20.4	162.6	157.4	0	0	0	0	1.88	2.26
Imazethapyr + imazamox (RM)	60	3-4 leaf stage	8.3	8.7	22.2	21.3	163.0	156.3	0	0	0	0	1.88	2.18
Imazethapyr + imazamox (RM)	70	3-4 leaf stage	8.7	8.7	22.3	21.5	164.2	160.8	0	5	0	0	1.88	2.24
Imazethapyr + imazamox (RM)	80	3-4 leaf stage	8.6	8.3	23.0	21.5	163.7	152.1	5	5	0	0	1.80	2.22
One hoeing	-	20 DAS	9.0	8.7	24.0	21.0	164.0	156.7	0	0	0	0	1.86	2.20
Two hoeing	-	20 & 40 DAS	9.0	8.7	24.0	22.0	162.9	157.9	0	0	0	0	1.92	2.20
Weedy free	-	-	8.7	8.7	24.4	22.4	161.7	154.0	0	0	0	0	1.88	2.24
Weed check	-	-	9.0	8.0	24.1	20.1	162.8	160.9	0	0	0	0	1.88	2.18
LSD (P=0.05)			NS	NS	NS	NS	NS	NS	-	-	-	-	NS	NS

Residual effect of herbicides

All herbicide treatments except imazethapyr at 70 g/ha and its ready mix combination with imazamox did not cause any phytotoxic effect on mustard (Table 3). Mustard crop in these treatments showed only 5% toxicity up to 15 DAS due to residues of these herbicides applied in greengram which mitigated within one month after planting as shown by non significant variation in plant height, germination percentage, number of leaves per plant and seed yield of mustard. During *Kharif* 2012, amount of rainfall was 215 mm where as during 2013, total 525 mm rainfall was received during *kharif* season so little microbial dissipation due to wet conditions might have occurred which may be responsible for no residual carrying over effect on succeeding mustard crop. These finding are not in agreement with finding of Punia *et al.* (2011) who reported poor, stunted growth of mustard grown after imazethapyr used at 100 g/ha but were in agreements with the findings of Patel *et al.* (2014).

It was summarized that pre-emergence use of pendimethalin + imazethapyr at 1000 g/ha, post emergence application of imazethapyr alone at 70 g/ha and its ready mixture with imazamox at 70 g/ha

can be safely used for weed control in greengram without any residual carry over effect on mustard crop.

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