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Efficacy of imazethapyr applied alone and its mixture with other herbicides in green gram and their residual effect on mustard

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ABSTRACT

An experiment on evaluation of herbicides in greengram and their residual effect on succeeding mustard crop was conducted at Research farm of Department of Agronomy, CCSHAU, Hisar during *Kharif* 2013 and *Rabi* 2013-14. Weed flora of the experimental field was dominated by *Echinocloa colona* (78%), *Cyperus rotundus* (18%) and other weeds (4%) at 30 DAS. Pre-emergence application of ready mix (RM) imazethapyr + pendimethalin at 1000 g/ha provided good control (80%) of *Echinocloa colona* up to 30 DAS. At 60 DAS, imazethapyr + imazamox (RM) at 80 g/ha applied at 3-4 leaf stage provided maximum control of weeds, which was at par with two hoeings employed at 20 and 40 DAS. Post-emergence use of imazethapyr + imazamox (RM) at 60-80 g/ha exhibited 70-80% control of weeds with slight crop suppression which mitigated within 10-15 days after spray resulting maximum crop growth and seed yield. Early post-emergence application of imazethapyr at 50, 60 and 70 g/ha although caused mild injury to greengram in terms of yellowing of leaves and stunted crop growth up to 30, but it diminished within two weeks. Maximum seed yield (1078 kg/ha) of green gram was obtained with two hoeings at 20 and 40 DAS followed by imazethapyr + imazamox (RM) at 80 g/ha and imazethapyr at 70 g/ha applied at 3-4 leaf stage. All herbicides, irrespective of their dose and time of application, did not cause any injury to succeeding mustard crop due to high rainfall (594 mm) during crop growing season that resulted in to enhanced microbial degradation of herbicides.

Key words: Greengram, Herbicide efficacy, Herbicide persistence, Imazethapyr, Mustard, Phytotoxicity

The reduction in yield and quality of crop depends upon the weed species their duration and degree of infestation. Being a short duration crop, greengram is subjected to heavy infestation of weeds such as *Trianthema portulacastrum, Digera arvensis, Dactyloctenium aegyptium, Echinocloa colona, Cyperus rotundus, Corchorus aestuans, Mollugo* spp., *Cleome viscosa* and *T. terrestris* in Haryana state (Punia *et al.* 2013). In greengram, weed flora is more complex during *Kharif* season because of frequent rains, high temperature and wider row spacing. Singh *et al.* (1996) reported that yield of greengram was decreased by 35% where the crop was not weeded for first 30 days after sowing (DAS). Cultural and mechanical weed control can be practiced, but is not always feasible due to their high cost, non-availability of labour at appropriate time, prevailing weather conditions, long window of weed emergence in the growing season and continuous moisture during rainy season. So, chemical method of weed management offers good scope for harvesting a good crop of green- gram. Arvadiya *et al.* (1996) however, observed that pre-emergence application (PE) of pendimethalin at 1.0 kg/ha and two HW (20 and 40 DAS) gave similar yield. Bajpai *et al.* (1988) reported that application of pendimethalin at 1.0 kg/ha showed marked reduction in intensity of *E. colona, Phyllanthus niruri, Ageratum conyzoides* and other broad-leaved weeds. Singh and Kumar (2008) found that post-emergence application of imazethapyr at 75 and 100 g/ha reduced the density and dry biomass of broad as well as narrow leaved weeds significantly as compared to PPI, PE and PoE herbicides under study in soybean. Mishra and Bhanu (2006) reported that imazethapyr at 0.10 kg/ha (as PPI or PoE) was most effective against *E. geniculata* and pre-plant incorporation (PPI) of imazethapyr was superior to its post-emergence (PoE) application in increasing seed yield. Singh *et al.* (2014) reported that application of imazethapyr at 75 and 100 g/ha at 25 DAS gave good control of weeds and the weed control efficiency was comparable to that of two HW. Application of imazethapyr at 75 and 100 g/ha at 15 DAS resulted in 144.6 and 146.4% higher grain yield respectively over unweeded control.

Finding the duration of herbicide persistence at applied rate will be helpful for determining the toxicity of herbicide to sensitive crop. Jourdan *et al.* (1998) studied imazethapyr bioactivity and movement in soil

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and found that under low soil moisture and low temperature, a high level of imazethapyr residue was retained in the top 10 cm for 3 months. Punia *et al.* (2011) reported that post-emergence application of imazethapyr at 80 and 100 g/ha although caused mild injury to cluster bean but caused severe injury to succeeding mustard crop, but on the other hand, Sangwan *et al.* (2016) evaluated the performance of imazethapyr and its mixture with pendimethalin and imazamox in cluster bean and their residual effect on succeeding mustard crop, but no residual carry over effect of these herbicides was observed on succeeding mustard crop due to high rainfall and temperature during the crop season. Hence, the present experiment was planned to evaluate the efficacy of imazethapyr applied alone and in combination with pendimethalin or imazamox in greengram and their residual effect on succeeding mustard.

MATERIALS AND METHODS

An experiment was conducted at CCSHAU, Hisar during *Kharif* 2013 and *Rabi* 2013-14. The soil of the experimental field was sandy-loam in texture with 55% sand, 34% silt and 11% clay, slightly alkaline in reaction with pH 8.1, medium in fertility with 0.6% organic carbon, sufficient in N content (320 kg/ha), medium in P (17 kg/ha) and sufficient in K (317 kg/ha). The experiment was conducted in a randomized block design with three replications and 15 treatments. Treatments consisted of PE application of pendimethalin 1.0 kg/ha, ready mix (RM) of pendimethalin + imazethapyr (Valor) 0.8, 0.9 and 1.0 kg/ha and PoE application of imazethapyr 50, 60 and 70 g/ha, imazethapyr + imazamox (Odyssey) 50, 60, 70 and 80 g/ha along with weed free and weedy check. Greengram variety '*MH-421*' was drilled on July 22 June, 2013 in a plot size of 5.4 x 10 m, keeping row to row distance of 30 cm by using seed rate of 20 kg/ha and harvested on 23 September, 2013. Application of PE and PoE herbicides in different treatments were done by using flat-fan nozzle mounted on a backpack sprayer with a spray discharge of 250 l/ha at 42 p.s.i. pressure. Weed density and weed dry weight were recorded by randomly placing a quadrant (0.25 m^2) in each plot at 30 and 60 DAS. Plant material was dried at 65 ^{0}C for 48 hours before determining dry weight and this was used for calculating weed control efficiency (WCE). Per cent control of weeds was recorded at 15, 30, 45 and 60 DAS by visually comparing with weedy check. Visual crop injury to greengram due to different herbicides was quantified visually at 15, 30, 45 and 60 DAT (days after treatment) on 0-100 scale where 0 = no effect and 100 = complete mortality. Succeeding mustard var. '*RH30*' was sown after slight disking the field without disturbing the original layout. The weed density data with zero value were subjected to square root transformation and per cent data of weed control and visual crop injury were subjected to arcsine transformation in order to normalize their distribution. To evaluate the comparative performance of various treatments, data were subjected to one way ANOVA. The significance difference among treatments was tested by calculating LSD at p=0.05 level of significance.

RESULTS AND DISCUSSION

Weed density

The major weeds appeared in the experimental field were *E. colona* and *C. rotundus* (**Table 1**). Other weeds although low in density such as *Dactylocteinum aegyptium, Corchorus olitorius, Celosia argentia, Trianthema portulacastrum, Digera arvensis etc*. also infested the field. At 30 DAS, *E. colona* was the major weed infested the experimental area with relative density (RD) of 8% but at 60 DAS, *C. rotundus* with RD of 62% was the major weed. At 30 DAS, among herbicide treatments, ready mix combination of pendimethalin with imazethapyr at 900 and 1000 g/ha was the most effective treatment resulting in significant reduction of *E. colona* in comparison to weedy check (**Table 1**). At 60 DAS, all doses of imazethapyr alone and imazethapyr + imazamox (RM) used at 3-4 leaf stage provided excellent control of *E. colona*, but the plots treated with imazethapyr + imazamox 80 g/ha proved significantly superior to all other herbicidal treatments at all the stages (**Table 1**). Among the herbicide treatments, the lowest weed density (8.3/m^2) was recorded with imazethapyr + pendimethalin (RM) at 1000 g/ha applied as PE followed by its lower doses at 800 and 900 g/ha at 30 DAS (**Table 1**). At 60 DAS, effect of PoE application of imazethapyr + imazamox (RM) was visible as density of *C. rotundus* with use of this herbicide mixture was significantly reduced. There was no control of *C. rotundus* by PE application of pendimethalin at any stage (**Table 1**).

Dry weight of weeds

Among herbicidal treatments, significantly lower weed dry weight (7.4 g/m^2) was recorded with PE application of imazethapyr + pendimethalin (RM) at 1000 g/ha followed by imazethapyr + pendimethalin (RM) at 900 g/ha (**Table 1**). At 60 DAS, significantly lower dry weight of weeds (25 g/m^2) was recorded with two hoeing given at 20 and 40 DAS, which was

significantly less over all other treatments. Although all herbicide treatments caused significant reduction in dry weight but ready mix formulation of imazethapyr + imazamox applied at 3-4 leaf stage at 80 g/ha was more effective than other treatments as dry weight of weeds in this treatment was 78 g/ha which was significantly less than the other herbicides (**Table 1**).

Per cent control of weeds

At 15 DAS, highest weed control (85%) was recorded with imazethapyr + pendimethalin (RM) at 1000 g/ha applied as PE. At 30 DAS, highest weed control (85%) was recorded with PE application of imazethapyr + pendimethalin (RM) at 1000 g/ha, which was at par with PE application of imazethapyr + pendimethalin (RM) at 800 and 900 g/ha (81 and 83%, respectively) (**Figure 1**). At 60 DAS, 90% control of *E. colona* was recorded with imazethapyr + imazamox at 80 g/ha followed by early post-emergence use of imazethapyr + imazamox (RM) at 60 and 70 g/ha (**Figure 1**). Although none of herbicide combination proved effective against *C. rotundus* but post-emergence application imazethapyr at 60 and 70 g/ha and its ready mix combination with imazamox at 60, 70 and 80 g/ha controlled 50% population of this weed (**Figure 2**). Although PE application of imazethapyr + pendimethalin (RM) at 1000 g/ha gave 46.7% control of *C. rotundus* up to 15 DAS but control decreased to only 28.3% at 60 DAS.

Plant dry weight and visual phytotoxicity (%) on green gram

At 30 DAS, the highest dry matter accumulation was recorded with imazethapyr + pendimethalin (RM) at 1000 g/ha (7.7 g/plant), which was at par

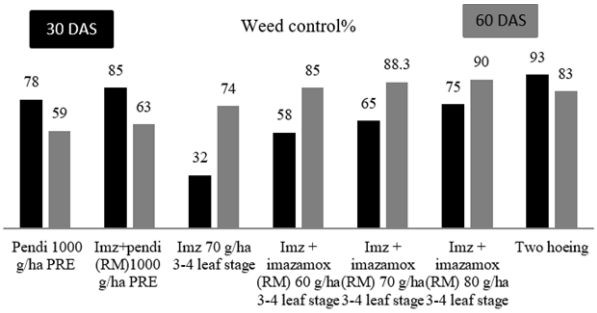

Figure 1. Per cent control of *E. colona* due to different weed control treatments at 30 and 60 DAS

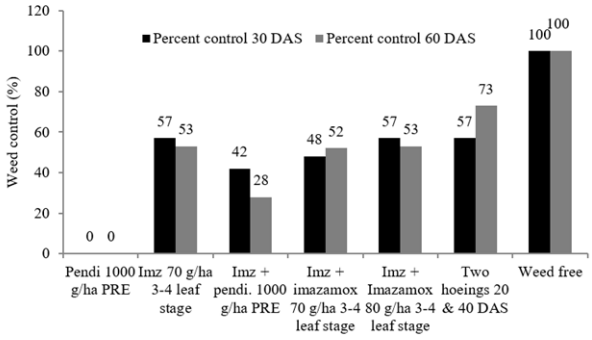

Figure 2. Per cent control of *C. rotundus* due to different weed control treatments at 30 and 60 DAS

Table 1. Effect of different herbicidal treatments on weed density and dry weight in green gram

Treatment	Dose (g/ha)	Application time	Weed density (no./m^2)				Weed dry weight (g/m^2)	
			Echinocloa colona		*Cyperus rotundus*			
			30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS
Pendimethalin	1000	PE	8.4 (69.0)	4.9 (22.7)	5.4 (30.0)	9.1 (81.3)	3.5 (11.3)	14.3 (203.0)
Imazethapyr	50	3-4 leaf stage	11.6 (132.3)	2.9 (7.3)	4.6 (20.3)	8.3 (68.3)	4.6 (20.2)	11.5 (131.7)
Imazethapyr	60	3-4 leaf stage	11.1 (122.3)	2.7 (6.3)	4.3 (17.3)	7.6 (56.7)	4.3 (17.2)	10.8 (115.0)
Imazethapyr	70	3-4 leaf stage	10.8 (115.7)	2.7 (6.0)	3.8 (13.7)	6.9 (46.7)	4.2 (16.7)	10.2 (103.3)
Imazethapyr + pendimethalin (RM)	800	PE	6.9 (46.7)	5.7 (32.0)	3.7 (12.7)	8.1 (65.0)	3.3 (9.8)	14.2 (200.3)
Imazethapyr + pendimethalin (RM)	900	PE	5.0 (24.0)	5.1 (25.3)	3.3 (9.7)	7.0 (48.0)	3.2 (9.1)	13.6 (185.0)
Imazethapyr + pendimethalin (RM)	1000	PE	4.4 (18.7)	3.8 (13.3)	3.1 (8.3)	6.4 (40.0)	2.9 (7.4)	13.1 (170.2)
Imazethapyr + imazamox (RM)	50	3-4 leaf stage	9.1 (82.3)	2.9 (7.7)	5.0 (24.0)	7.9 (56.7)	4.0 (15.4)	12.1 (145.8)
Imazethapyr + imazamox (RM)	60	3-4 leaf stage	8.9 (78.7)	2.8 (6.7)	3.2 (19.3)	6.8 (45.0)	4.0 (15.1)	10.5 (108.8)
Imazethapyr + imazamox (RM)	70	3-4 leaf stage	7.6 (57.3)	2.3 (4.3)	4.4 (18.3)	6.1 (36.7)	4.0 (14.9)	10.0 (99.8)
Imazethapyr + imazamox (RM)	80	3-4 leaf stage	5.5 (29.3)	2.1 (3.3)	4.3 (17.3)	4.9 (23.3)	3.5 (11.0)	8.9 (78.0)
One hoeing	-	20 DAS	1.6 (1.7)	1.9 (2.7)	3.1 (8.3)	6.9 (47.3)	1.8 (2.3)	9.5 (90.0)
Two hoeings		20 and 40 DAS	1.5 (1.3)	1.5 (1.3)	2.3 (4.3)	4.2 (16.7)	1.8 (2.2)	5.1 (25.0)
Weedy check	-	-	12.1 (145.0)	6.8 (45.0)	5.8 (32.3)	9.2 (84.0)	6.3 (38.3)	19.0 (360.0)
Weed free	-	-	1.0 (0)	1.0 (0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)
LSD (p= 0.05)			0.3	0.3	0.4	0.4	0.3	0.5

Data in parentheses was subjected to square root transformation

with pendimethalin at 1000 g/ha, imazethapyr + pendimethalin at 800 and 900 g/ha (**Table 2**). At 60 DAS, maximum dry matter (28.9 g/plant) was recorded with two hoeings employed at 20 and 40 DAS, which was at par with imazethapyr + pendimethalin (RM) at 900 and 1000 g/ha applied as PE and pendimethalin at 1000 g/ha. At harvesting, maximum dry matter was recorded with imazethapyr + imazamox (RM) at 80 g/ha (42.0 g/plant), which was at par with imazethapyr + imazamox (RM) at 50- 70 g/ha applied at 3-4 leaf stage and two hoeing given at 20 and 40 DAS (**Table 2**).

None of PE herbicides caused toxicity to green gram crop. Higher doses of imazethapyr (60 and 70 g/ha) and its ready mix combination with imazamox applied at 3-4 leaf-stage caused 11.3-23.3% toxicity to green gram, which mitigated within 15 days after application as it evident by visual phyto-toxicity recorded at 45 and 60 DAS. At 30 DAS, higher visual phyto-toxicity (23.3%) on crop was recorded with imazethapyr + imazamox (RM) at 80 g/ha applied at 3-4 leaf stage which was at par with imazethapyr + imazamox (RM) at 60 and 70 g/ha (**Table 2**).

Yield and yield attributes

Maximum number of pods/plant (37.1) and seeds/pod (11.8) were recorded in weed free treatment closely followed by two hoeings at 20 and 40 DAS (**Table 3**). Among herbicidal treatments, maximum number of pods/plant (34.6) were

Table 2. Dry weight of plant and Visual phyto-toxicity (0-100 scale) on greengram due to different weed control treatments at different intervals

Treatment	Dose (g/ha)	Application time	Dry weight of plant (g/m^2)			Phyto-toxicity (%)			
			30 DAS	60 DAS	Harvest	15 DAS	30 DAS	45 DAS	60 DAS
Pendimethalin	1000	PE	6.7	27.0	34.5	0	0.00	0	0
Imazethapyr	50	3-4 leaf stage	5.0	14.1	32.5	0	0.00	0	0
Imazethapyr	60	3-4 leaf stage	4.7	17.9	33.0	0	11.3	0	0
Imazethapyr	70	3-4 leaf stage	4.4	18.7	36.9	0	16.9	0	0
Imazethapyr + pendimethalin (RM)	800	PE	6.2	22.2	32.4	0	0.00	0	0
Imazethapyr + pendimethalin (RM)	900	PE	7.0	27.8	34.1	0	0.00	0	0
Imazethapyr + pendimethalin (RM)	1000	PE	7.7	28.0	36.5	0	0.00	0	0
Imazethapyr + imazamox(RM)	50	3-4 leaf stage	4.9	19.0	39.2	0	17.4	0	0
Imazethapyr + imazamox(RM)	60	3-4 leaf stage	4.7	22.1	41.0	0	20.3	0	0
Imazethapyr + imazamox(RM)	70	3-4 leaf stage	4.1	23.5	41.5	0	21.0	0	0
Imazethapyr + imazamox(RM)	80	3-4 leaf stage	3.7	24.6	42.0	0	23.3	0	0
One hoeing		20 DAS	4.8	27.4	33.0	0	0.00	0	0
Two hoeings	-	20 & 40 DAS	4.9	28.9	40.7	0	0.00	0	0
Weedy check	-	-	4.0	17.9	23.9	0	0.00	0	0
Weed free	-	-	7.8	29.7	42.4	0	0.00	0	0
LSD (p=0.05)			1.6	3.4	3.8		4.2		

Table 3. Effect of different herbicides on yield and yield attributes of greengram

Treatment	Dose (g/ha)	Application time	Pods/ Plant (no.)	Seeds/ Pod (no.)	Biological yield (t/ha)	Seed yield (kg/ha)	HI (%)	B: C ratio
Pendimethalin	1000	PE	25.3	8.5	2.44	492	20.4	1.38
Imazethapyr	50	3-4 leaf stage	31.4	8.3	2.96	721	24.2	2.04
Imazethapyr	60	3-4 leaf stage	31.9	8.9	3.22	837	25.3	2.33
Imazethapyr	70	3-4 leaf stage	32.8	9.9	3.26	915	27.7	2.51
Imazethapyr + pendimethalin (RM)	800	PE	25.2	8.1	2.52	565	22.7	1.55
Imazethapyr + pendimethalin (RM)	900	PE	27.5	8.7	2.70	580	22.7	1.58
Imazethapyr + pendimethalin (RM)	1000	PE	30.3	9.4	3.00	780	26.6	2.07
Imazethapyr + imazamox(RM)	50	3-4 leaf stage	31.2	10.3	2.93	764	25.8	2.14
Imazethapyr + imazamox(RM)	60	3-4 leaf stage	32.4	10.6	3.27	849	26.0	2.35
Imazethapyr + imazamox(RM)	70	3-4 leaf stage	33.3	10.9	3.30	880	27.1	2.40
Imazethapyr + imazamox(RM)	80	3-4 leaf stage	34.6	11.0	3.37	995	29.0	2.67
One hoeing	-	20 DAS	34.7	10.0	3.89	1013	26.7	1.86
Two hoeings		20 & 40 DAS	36.0	10.9	3.93	1078	27.8	2.47
Weedy check	-	-	19.6	6.9	1.54	290	19.0	0.91
Weed free	-	-	37.1	11.8	4.10	1143	28.1	1.74
LSD (p=0.05)			6.2	1.1	0.34	36	1.0	-

Table 4. Number of plants / m. r. l., number of pods/plant and seed yield of mustard as affected by residual carryover effect of different herbicides applied in green gram

Treatment	Dose (g/ha)	Application time	No. of plants / m. r. l.	No. of pods/ plant	Seed yield t/ha
Pendimethalin	1000	PE	11.0	299.3	2.48
Imazethapyr	50	3-4 leaf stage	11.7	306.7	2.47
Imazethapyr	60	3-4 leaf stage	6.7	306.7	2.50
Imazethapyr	70	3-4 leaf stage	9.0	303.3	2.52
Imazethapyr + pendimethalin (RM)	800	PE	9.3	301.7	2.47
Imazethapyr + pendimethalin (RM)	900	PE	10.7	298.3	2.50
Imazethapyr + pendimethalin (RM)	1000	PE	12.0	306.7	2.50
Imazethapyr + imazamox(RM)	50	3-4 leaf stage	7.3	306.7	2.45
Imazethapyr + imazamox(RM)	60	3-4 leaf stage	10.3	306.7	2.48
Imazethapyr + imazamox(RM)	70	3-4 leaf stage	10.0	310.0	2.47
Imazethapyr + imazamox(RM)	80	3-4 leaf stage	10.7	323.3	2.45
One hoeing		20 DAS	9.7	313.3	2.48
Two hoeing	-	20 and 40 DAS	10.3	313.3	2.50
Weedy check	-	-	7.3	306.7	2.52
Weed free	-	-	10.0	303.3	2.47
LSD (p=0.05)			NS	NS	NS

recorded with imazethapyr + imazamox (RM) at 80 g/ ha, which were significantly higher than all PE herbicides and maximum number of seeds/pod (11) were recorded with imazethapyr + imazamox (RM) at 80 g/ha which was at par with all other 3 doses of imazethapyr + imazamox at 50-70 g/ha and imazethapyr alone at 70 g/ha applied at 3-4 leaf stage (**Table 3**). Weed free treatment by virtue of providing a favourable environment registered maximum seed yield (1.14 t/ha), which was significantly higher over all other treatments (**Table 3**). Post-emergence application of imazethapyr at 70 g/ha at 3-4 leaf stage also increased the seed yield (0.91 t/ha), significantly which was at par with the imazethapyr + imazamox (RM) at 70 g/ha. The maximum harvest index (29%) and B:C ratio (2.67) were recorded with imazethapyr+ imazamox (RM) 80 g/ha applied at 3-4 leaf stage closely followed by imazethapyr at 70 g/ha applied at 3-4 leaf stage (**Table 3**).

Residual effect of herbicides applied in green gram on succeeding mustard crop

Number of plants/meter row length (m.r.l.), no. of pods/plant and seed yield of mustard did not differ significantly by residual carryover effect of different herbicides applied in greengram due to enhanced microbial degradation of these herbicides due to occurrence of heavy rainfall between time of herbicide application and planting of mustard in *Kharif* 2013-14 (**Table 4**).

From the present study, it can be inferred that of two hoeings at 20 and 40 DAS or PoE application of imazethapyr + imazamox at 80 g/ha or imazethapyr alone at 70 g/ha should be adopted for the control of weeds in green gram without any adverse effect on succeeding mustard crop.

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