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Efficacy and economics of imidazolinone herbicides in cluster bean and their residual effect on mustard

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ABSTRACT

A field experiment was carried out at two different locations, research area of CCS HAU Hisar and farmer's field (Kheri Batter) to study efficacy and economics of imidazolinone herbicides in cluster bean during *Kharif* 2013 and their carryover effect on mustard was observed during *Rabi* 2014. Significantly higher herbicide efficiency index (HEI) was observed under PE application of pendimethalin + imazethapyr 1000 g/ha and tank mixture 500 g + imazethapyr 50 g/ha at 30 DAS and these two treatments also provided better control of weeds at 60 DAS without any phytotoxic effect on cluster bean at both the locations. At 30 DAS, less dry weight of weeds was recorded under pendimethalin 1000 g/ha as PE, but at 60 DAS, due to new emergence of weeds, percent weed control reduced due to more dry weight of weeds, thus HEI was lower under pendimethalin 1000 g/ha PE. At 60 DAS, PoE application of imazethapyr 100 g/ha *fb* propaquizafop 62.5 g/ha provided the highest HEI which was at par with pendimethalin + imazethapyr (ready and tank mixture), but at Hisar, HEI of imazethapyr + imazamox at all the doses was lower due to heavy infestation of *T. portulacastrum* as compared to other herbicidal treatments. The lowest weed index (WI) was observed under pendimethalin 500 g + imazethapyr 50 g/ha (tank mixture) as PE which was significantly at par with pendimethalin + imazethapyr (RM) 1000 g/ha as PE and imazethapyr 75 and 100 g/ha *fb* propaquizafop 62.5 g/ha, but significantly higher WI was recorded under imazethapyr + imazamox due to lower efficacy against *T. portulacastrum*. The highest biological yield, seed yield, maximum net returns and increase over weedy check were obtained under pendimethalin 500 g + imazethapyr 50 g/ha (tank mixture) as PE and pendimethalin + imazethapyr (RM) 1000 g/ha as PE, but both were statistically similar to each other and similar to PoE imazethapyr 100 g/ha *fb* propaquizafop 62.5 g/ha at both the locations. No injury was visible at 2 WAS, 4 WAS and later stages on mustard.

INTRODUCTION

The imidazolinone herbicides are known to be very effective in controlling annual and perennial broad-leaved and grass weeds in crops. These herbicides inhibit acetolactate synthase (ALS) which is essential for nucleic acid synthesis, *viz*. leucine, valine and isoleucine (Stidham and Singh 1991). The potential of imidazolinones in legume crop production increases globally for farmers due to this flexibility in time and mode of application. Numerous PE and PoE herbicide tank and ready mixtures are available for legume production. Cluster bean (*Cyamopsis tetragonoloba* L.) commonly known as *guar* is considered as a drought tolerant, deep taproot legume and rotational crop grown during *Kharif* season in arid and semiarid regions. Growing *guar* can be used as a forage or green manure, as an industrial crop grown mainly for *guar* gum and meal remaining after gum extraction can be used as protein supplement for animals. According to Joshi and Arora (1993), cluster bean has gained much importance in recent past due to its multifarious industrial uses. The 80% of World of cluster bean production is contributed by India as a largest cluster bean producer and it is mainly cultivated under rainfed or restricted irrigation condition. Haryana is the 2nd largest producer of cluster bean after Rajasthan. Being a rainy season crop, a large number of weeds come up and compete

with cluster bean for the limited water, nutrients and space, thereby reducing the crop yield considerably (Daulay and Singh 1982). Critical period of crop weed competition in cluster bean has been identified as 20-40 DAS and presence of weeds beyond this result in competition between weeds and crop caused 53.7% reduction in seed yield (Saxena *et al*. 2004). Severity of yield loss depends on the weed infestation and its duration. So cluster bean is poor competitor with weeds and weed management is essential to maximize yield. Persistence of herbicide in the soil is mainly governed by soil temperature and soil moisture. However, the carry over effect of these herbicides in cropping system is not much known, so there is a need to test the persistence of herbicides in the field.

MATERIALS AND METHODS

Field experiments were conducted at CCSHAU, Hisar, which is characterized by the semi-arid climate with hot and dry summers and extremely cold winters and farmer's field at Khari Batter, Bhiwani during the *Kharif* and *Rabi* seasons of 2013-14. Mean weekly maximum temperature fluctuated between 36.5 and 16.4^{O}C and minimum between 3.2 and 27.1^{O}C from June 2013 to April 2014. The major part of the annual rainfall is received during monsoon season *i.e*. June to mid-September. The crop received 594.3 and 500.5 mm of rainfall in the growing season at Hisar and Kheri Batter, respectively. Texture of soil at Hisar was sandy loam with pH 7.8 and organic carbon 0.3% and at Kheri Batter was loamy sand with pH 8.2 and organic carbon 0.24%. Soils were deficient in available N (112 and 103.7 kg/ha), medium in P (14.4 and 12 kg/ha) and sufficient in K (427 and 240 kg/ha) at Hisar and Kheri Batter, respectively. The experiments were laid out in a randomized block design (RBD) with 16 treatments and 3 replications. Treatment comprised of imidazolinone herbicides and their mixture *viz*. pendimethalin (1000 g/ha, PE), pendimethalin 500 g + imazethapyr 50 g/ha (tank mixture) PE, pendimethalin + imazethapyr (ready mixture) 1000 g /ha PE, imazethapyr + imazamox PoE at 43.75, 52.5, 61.5 and 70 g/ha at 3 WAS (weeks after sowing) alone and followed by (*fb*) propaquizafop 62.5 g/ha (6 WAS), imazethapyr (50, 75 and 100 g/ha *fb* propaquizafop 62.5 g/ha applied at 3 *fb* 6 WAS, weedy check and weed free. HG-563 variety of Cluster bean and RH-749 mustard variety was taken. At both the locations, crop was sown with the recommended seed rate (20 kg/ha) and spacing (30 × 15 cm) and fertilizer rate (20: 40: 20, N: P_2O_5: K_2O kg/ha) using seed-cum-fertilizer drill. All experimental data were analyzed using software S.P.S.S version 7.5.

Weed index and herbicide efficiency index was

$$WI\ (\%) = \frac{\text{Yield from weed free plot - Yield from particular treatment}}{\text{Yield from weed free plot}} \times 100$$

$$HEI\ (\%) = \frac{\text{Yield from treatment - Yield from control}}{\text{Yield from control}} \times 100 / \frac{\text{Dry matter of weeds in a treatment}}{\text{Dry matter of weeds in control}} \times 100$$

calculated with the help of equations:

RESULTS AND DISCUSSION

Weed index

At Hisar, the highest WI was observed under weedy plot (0.39%) due to more weed competition which was at par with alone application of imazethapyr + imazamox 43.75 g/ha at 3 WAS. Among herbicidal treatments, lowest WI was observed under pendimethalin 500 g + imazethapyr 50 g/ha as PE (0.0%) which was significantly similar to pendimethalin + imazethapyr (RM) 1000 g/ha as PE (0.01%) and imazethapyr 75 and 100 g/ha *fb* propaquizafop 62.5 g/ha (0.07 and 0.04, respectively), but significantly higher WI was recorded under imazethapyr + imazamox due to heavy infestation of *T. portulacastrum*and herbicide was less effective to that weed (**Table 1**). But at farmer's field (Kheri Batter), there was less infestation of *T. portulacastrum*, thus pendimethalin + imazethapyr (TM and RM), imazethapyr 100 g/ha *fb* propaquizafop 62.5 g/ha and imazethapyr + imazamox 70 g/ha at 3 WAS *fb* propaquizafop 62.5 g/ha at 6 WAS were significantly at par with each other (**Table 1**).

Herbicide efficiency index

At 30 DAS, maximum HEI was observed under pendmethalin 500 g + imazethapyr 50 g/ha PE (14.8%) which was statistically similar to the pendimethalin + imazethapyr 1000 g/ha PE (10.4%) and both the treatments were statistically higher as compared to other herbicidal treatments because pre-emergence application of herbicides provided effective control of weeds. At 60 DAS, maximum HEI was recorded under imazethapyr 100 g/ha 3 WAS *fb* propaquizafop 62.5 g/ha (7%) which was at par with pemdimethalin + imazethapyr 1000 g/ha PE (6%) and pendimethalin 500 g + imazethapyr 50 g/ha (tank mixture) PE (5.7%) because these two pre-emergence herbicidal treatments provided season long control of multiple weed flora in clusterbean (**Table 1**). HEI of imazethapyr + imazamox was lower due to lower efficacy of imazethapyr + imazamox against *T. portulacastrum* in sandy loam soils.

Table 1. Herbicide efficiency index under different weed control treatments applied in cluster bean

Treatment	Weed Index (%)		Herbicide efficiency Index (%) at 30 DAS		Herbicide efficiency Index (%) at 60 DAS	
	Hisar	Farmer field	Hisar	Farmer field	Hisar	Farmer field
Pendimethalin (1000 g/ha) PE	0.29	0.19	2.3	2.2	1.2	1.7
Imazethapyr + imazamox (43.75 g/ha) 3 WAS	0.30	0.33	0.3	1.0	0.4	1.5
Imazethapyr + imazamox (52.5 g/ha) 3 WAS	0.25	0.26	0.7	1.5	1	1.8
Imazethapyr + imazamox (61.5 g/ha) 3 WAS	0.23	0.27	0.7	1.6	1	3.2
Imazethapyr + imazamox (70 g/ha) 3 WAS	0.16	0.17	2.2	2.5	2.4	4.6
Imazethapyr + imazamox *fb* propaquizafop (43.75 *fb* 62.5 g/ha) 3 WAS *fb* 6 WAS	0.25	0.27	0.6	1.2	1.2	2.9
Imazethapyr + imazamox *fb* propaquizafop (52.5 *fb* 62.5 g/ha) 3 WAS *fb* 6 WAS	0.22	0.22	0.9	1.5	2	3.9
Imazethapyr + imazamox *fb* propaquizafop (61.5 *fb* 62.5 g/ha) 3 WAS *fb* 6 WAS	0.17	0.16	1.4	2.1	3.5	5.0
Imazethapyr + imazamox *fb* propaquizafop (70 *fb* 62.5 g/ha) 3 WAS *fb* 6 WAS	0.12	0.10	2.4	2.8	5.3	6.4
Imazethapyr *fb* propaquazafop (50 *fb* 62.5 g/ha) 3 WAS *fb* 6 WAS	0.22	0.16	1.3	1.7	3.1	4.5
Imazethapyr *fb* propaquazafop (75 *fb* 62.5 g/ha) 3 WAS *fb* 6 WAS	0.15	0.07	2.6	2.3	5.5	6.5
Imazethapyr *fb* propaquazafop (100 *fb* 62.5 g/ha) 3 WAS *fb* 6 WAS	0.00	0.04	3.4	4.9	7	9.5
Pendimethalin + imazethapyr (500 + 50 g/ha) PE	0.00	0.00	13.7	14.4	6	8.3
Pendimethalin + imazethapyr (1000 g/ha) PE	0.09	0.01	11.7	10.7	5.7	7.3
Weed free	0.00	0.00	-	-	-	-
Weedy check	0.55	0.39	-	-	-	-

Table 2. Comparative economics of different weed control treatments applied in cluster bean

Treatment	Hisar					Farmer field				
	Seed yield (t/ha)	Gross returns (x10^3 `)	Total cost of cultivation (x10^3 `)	Net returns (x10^3 `)	Increase over weedy check (x10^3 `)	Seed yield (t/ha)	Gross returns (x10^3 `)	Total cost of cultivation (x10^3 `)	Net returns (x10^3 `)	Increase over weedy check (x10^3 `)
Pendimethalin (1000 g/ha) PE	1.24	81.60	32.38	49.22	22.40	1.11	76.60	32.38	44.22	26.66
Imazethapyr + imazamox (43.75 g/ha) 3 WAS	1.02	61.84	32.10	29.74	2.94	1.10	76.12	32.10	44.02	26.47
Imazethapyr + imazamox (52.5 g/ha) 3 WAS	1.13	67.92	32.28	35.64	8.83	1.19	79.97	32.28	47.69	30.13
Imazethapyr + imazamox (61.5 g/ha) 3 WAS	1.11	74.24	32.45	41.79	14.98	1.21	84.74	32.45	52.30	34.74
Imazethapyr + imazamox (70 g/ha) 3 WAS	1.27	81.92	32.63	49.29	22.48	1.32	90.66	32.63	58.03	40.47
Imazethapyr + imazamox *fb* propaquizafop (43.75 *fb* 62.5 g/ha) 3 WAS *fb* 6 WAS	1.11	69.84	33.10	36.74	9.93	1.19	81.13	33.10	48.02	30.47
Imazethapyr + imazamox *fb* propaquizafop (52.5 *fb* 62.5 g/ha) 3 WAS *fb* 6 WAS	1.20	68.88	33.29	35.59	8.78	1.24	84.06	33.29	50.77	33.21
Imazethapyr + imazamox *fb* propaquizafop (61.5 *fb* 62.5 g/ha) 3 WAS *fb* 6 WAS	1.29	81.92	33.46	48.46	21.66	1.31	89.78	33.46	56.33	38.78
Imazethapyr + imazamox *fb* propaquizafop (70 *fb* 62.5 g/ha) 3 WAS *fb* 6 WAS	1.38	87.36	33.64	53.72	26.91	1.38	93.84	33.64	60.20	42.65
Imazethapyr *fb* propaquazafop (50 *fb* 62.5 g/ha) 3 WAS *fb* 6 WAS	1.29	83.20	32.99	50.21	23.40	1.22	86.49	32.99	53.50	35.95
Imazethapyr *fb* propaquazafop (75 *fb* 62.5 g/ha) 3 WAS *fb* 6 WAS	1.42	89.28	33.33	55.95	29.14	1.34	91.33	33.33	58.00	40.45
Imazethapyr *fb* propaquazafop (100 *fb* 62.5 g/ha) 3 WAS *fb* 6 WAS	1.47	91.52	33.84	57.68	30.87	1.57	103.63	33.84	69.79	52.24
Pendimethalin + imazethapyr (500 + 50 g/ha) PE	1.53	95.28	32.61	62.67	35.86	1.57	104.14	32.61	71.52	53.97
Pendimethalin + imazethapyr (1000 g/ha) PE	1.51	94.64	32.38	62.26	35.45	1.44	97.34	32.38	64.96	47.41
Weed free	1.53	96.56	46.35	50.21	23.40	1.58	104.76	46.35	58.41	40.86
Weedy check	0.93	57.68	30.87	26.81	0	0.71	48.42	30.87	17.55	0
LSD (p=0.05)	0.28	-	-	-	-	0.19	-	-	-	-

Yield and economics of cluster bean

Among herbicidal treatments, highest seed yield was recorded under pendmethalin 500 g + imazethapyr 50 g/ha (tank mixture) PE at both the locations that was statistically at par with imazethapyr + imazamox 70 g/ha at 3 WAS *fb* propaquizafop 62.5 g/ha at 6 WAS, weed free treatment, imazethapyr 100 g/ha 3 WAS *fb* propaquizafop 62.5 g/ha at 6 WAS and pemdimethalin + imazethapyr 1000 g/ha PE (**Table 2**). Among herbicides, the lowest number of pods/ plant, seeds/pod, biological yield and seed yield was observed with pendimethalin 1000 g/ha PE and imazethapyr + imazamox 43.7 g/ha at 3 WAS respectively. In the present study, higher net returns and increase over weedy check were recorded with pendimethalin 500 g + imazethapyr 50 g/ha (tank mixture) PE, imazethapyr 100 g/ha 3 WAS *fb* propaquizafop 62.5 g/ha at 6 WAS, pendimethalin + imazethapyr (RM) 1000 g/ha PE at both the locations (**Table 2**). These results corroborate with the finding of Meena *et al*. (2011) where application of imazethapyr 100 g/ha significantly reduced the

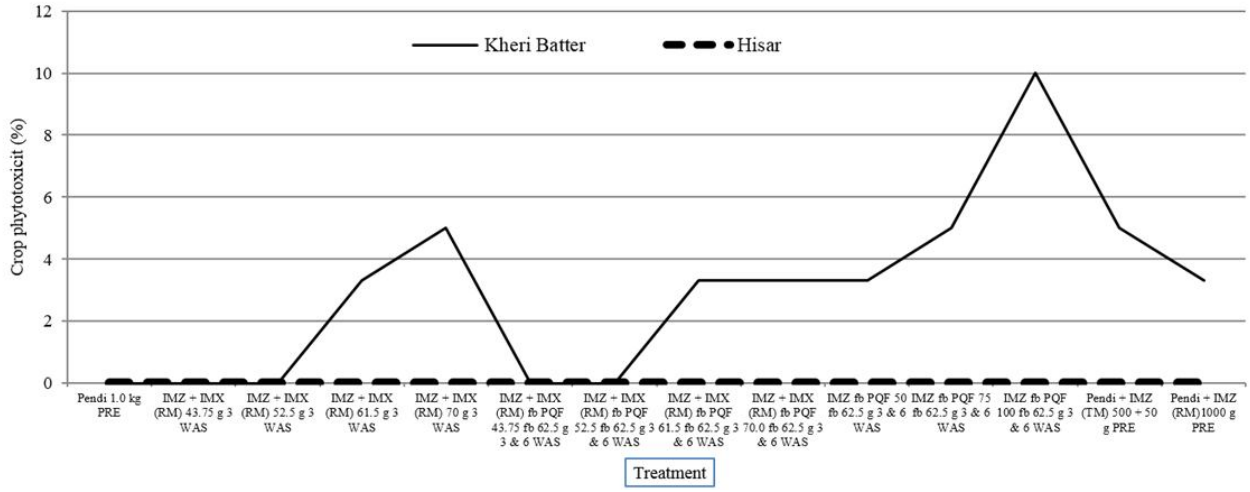

Figure 1. Phtotoxity of different herbicides applied in cluster bean on succeeding mustard crop at 2 weeks after sowing (WAS)

density of weeds and provided higher net returns and B:C ratio in soybean as compared to imazethapyr 150 g/ha or 50 g/ha.

Persistence of the herbicides applied in cluster bean may affect the yield of mustard in the next cropping season and persistence of imazethapyr at higher rate has been reported by farmers in sandy loam soil. But in the present experiment, crop suppression of 0-10 scale was observed under imazethapyr + imazamox 61.5 and 70 g/ha at 3 WAS applied alone and *fb* propaquizafop 62.5 g/ha at 6 WAS, imazethapyr 50, 75 and 100 g/ha 3 WAS *fb* propaquizafop 62.5 g/ha at 6 WAS, pendimethalin 500 g + imazethapyr 50 g/ha PE and pendimethalin + imazethapyr 1000 g/ha PE at farmer field (Kheri Batter) only due to light texture soil but the difference were non-significant, however there was no crop suppression observed under any treatment at 4 WAS and later stages, probably due to microbial degradation mediated by higher temperature (36.5^{O}C observed during the *Kharif* season 2013-14) or leaching of these herbicides because of heavy rainfall (500-580 mm) occurred between time of herbicide application and planting of mustard in 2013-14 (**Figure 1**).

From present study, it may be concluded that imidazolinone herbicides mixture and their sequential application were found effective in controlling weeds, increasing HEI (%) and net return in cluster bean under both the soil texture, but under sandy loam conditions imazethapyr + imazamox was less effective against predominance of existing weed *T. portulacastrum*.

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