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Post-emergence herbicides on weeds and productivity of garden pea under mid-hill conditions of Himalaya

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ABSTRACT

To standardize dose and time of application of post-emergence herbicides in garden pea (*Pisum sativum* var. *hortense*) under mid-hills of Himalaya, eleven treatments, *viz.* imazethapyr 100 and 150 g/ha at 20 and 40 DAS, quizalofop 25 and 37.5 g/ha at 20 DAS, isoproturon 1.0 and 1.25 kg/ha at 40 DAS, pendimethalin 1.5 kg/ha (pre-emergence), hand weeding twice (30 and 60 DAS) and unweeded check were tested during the winter (*Rabi*) season of 2005-06 and 2006-07 at Palampur. The major weed flora was constituted of *Phalaris minor, Avena fatua* and *Vicia sativa* in both the year. Post-emergence application of all the herbicides except quizalofop 25 g/ha at 20 DAS and hand weeding twice resulted in significantly lower dry weight of weeds over pre-emergence pendimethalin 1.5 kg/ha. Higher doses of all the post-emergent herbicides were superior to their lower doses. Significantly lower dry matter accumulation of all the weed species and highest weed control efficiency was obtained with imazethapyr 150 g/ha (40 DAS). Imazethapyr 150 g/ha at 40 DAS resulted in maximum plant height, dry matter accumulation, crop growth rate, relative growth rate nodule count and weight and green pod and haulm yields. Weeds in untreated check reduced pea pod yield by 56.8% over the best post-emergent herbicidal treatment (imazethapyr 150 g/ha at 40 DAS) in 2005-06 and 60.1% in 2006-07.

Key words: Dose, Garden pea, Imazethapyr, Mid-hill Himalaya Quizalofop, Time of application, Yield

Garden pea (*Pisum sativum* var. *hortense*) is one of the most important cool season crops of Himachal Pradesh. Pea crop has a great potential both for seeds as pulse (field pea) and pods as vegetable (garden pea). Weeds have been reported to cause 81% loss in its yield (Singh *et al.* 1996). The critical period for crop-weed competition in pea varied from 40-60 days after sowing (Bhyan *et al.* 2004). Manual weeding is effective but it is cumbersome, time consuming and uneconomical, while mechanical means generally lead to root injury (Casarini *et al.* 1996). In this context, the use of herbicides is the better alternative. Various pre-plant and pre-emergence herbicides have been tested under different agro-climatic conditions of Himachal Pradesh and recommended for control of weeds in pea (Singh *et al.* 1996). However, the information on post-emergence herbicides to control weeds is very scanty. Many times, the extension workers and farmers of the state demand information on post-emergence herbicides especially when due to one or the other reason they fail to apply pre-emergence herbicides.

Recently, new post-emergence herbicides, *viz.* imazethapyr and quizalofop have been introduced. However, their doses and time of application are to be standardized for effective control of weeds in pea crop under varied agro-ecological situations. To find out the effective dose and time of application of post-emergence herbicides for weed control in pea, the present investigation was carried out.

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MATERIALS AND METHODS

Field investigation was carried out during winter (*Rabi*) 2005-06 and 2006-07 at Palampur (1290.8 m altitude, $32^0$06`05`` N and $76^0$34`10`` E). Eleven treatments, *viz.* imazethapyr 100 and 150 g/ha (20 and 40 DAS), quizalofop 25 and 37.5 g/ha (20 DAS), isoproturon 1.0 and 1.25 kg/ha (40 DAS), pendimethalin 1.5 kg/ha (pre-emergence), hand weeding twice (30 and 60 DAS) and unweeded check were tested in randomized complete block design with three replications. Application of herbicides as per the treatment was made with knapsack sprayer using water 800 L/ha. Garden pea '*Palam Priya*' was treated with bavistin at 2.5 g/kg seed and sown on November 19, 2005 and November 20, 2006 on lines 40 cm apart using 80 kg seed/ha. The crop was harvested on April 4, during the first year and April 7 during the second year. The crop in its life cycle experienced 206.5 mm rainfall in the first year and 577.2 mm in the second year. The soil was silty clay loam in texture, acidic in reaction and medium in available N (290.6 kg/ha), P (16.8 kg/ha) and K (224.4 kg/ha). N, P_2O_5 and K_2O (50, 60 and 30 kg/ha, respectively) were applied as basal through urea and complex fertilizer of 12-32-16 grade. The crop was given 4 irrgations in the first year including the presowing irrigation in the first year and two in the second year. The observations on weeds (dry weight, and weed control efficiency), crop (phytotoxicity, growth, development, yield) and chemical studies (total soluble solids, ascorbic acid and protein content in seed) were recorded. Weed count and dry weight was recorded at 90 DAS, 120 DAS and at final picking. Yields were harvested from net plot in four pickings. The harvesting was done by end of March each year.

The economic threshold (economic injury levels), the weed density at which the cost of treatment equals the economic benefit obtained from that treatment, was calculated after Stone and Pedigo (1972) as below:

Economic threshold = Gain threshold/ Regression coefficient

Where, gain threshold = Cost of weed control/ Price of produce, and regression coefficient (b) is the outcome of simple linear relationship between yield (Y) and weed density/biomass (x), Y = a + bx.

The different impact indices were worked out after Walia (2003).

RESULTS AND DISCUSSION

Weeds

At 90 days after sowing (DAS), the major weed flora constituted of *Phalaris minor, Vicia sativa*, and *Avena fatua* in both the year of experimentation. Among other weeds *Lolium temulentum, Stellaria media* and *Coronopus didymus* showed their infestation. All weed control treatments were significantly superior to weedy check in reducing the dry weight of *P. minor* (Table 1). In general, *P. minor* control efficiency, increased with increase in dose. Imazethapyr at 150 g/ha (40 DAS) and quizalofop at 37.5 g/ha being at with imazethapyr at 100 g/ha (40 DAS), significantly reduced the dry weight of *P. minor* over other treatments. *P. minor* control efficiency under imazethapyr at 150 g/ha (40 DAS) and quizalofop at 37.5 g/ha was 77.1 and 76.9% during 2005-06 and 82.1 and 79.9% during 2006-07, respectively. In both the year of experimentation, imazethapyr at 150 g/ha (40 DAS) and quizalofop 37.5 g/ha (20 DAS) resulted in significantly lower dry weight of *A. fatua*. Imazethapyr 150 g/ha (40 DAS) and quizalofop 37.5 g/ha were closely followed by imazethapyr at 100 g/ ha at 40 DAS, hand weeding twice in increasing the *Avena fatua* control efficiency. Amongst all weed control treatments, pendimethalin gave least *A. fatua* control efficiency both during 2005-06 and 2006-07. Haar *et al.* (2001) also reported poor control of *A. fatua* with the application of pendimethalin. Imazethapyr at 150 g/ha (40 DAS) had highest *V. sativa* control efficiency. Being at par with imazethapyr at 100 g/ha (40 DAS) and hand weeding twice, imazethapyr at 150 g/ha (40 DAS) had significantly reduced dry weight of *V. sativa* as compared to rest of the treatments. Quizalofop at 25 and 37.5 g/ha (20 DAS) gave least *V. sativa* control efficiency. At lower rate, quizalofop did not differ significantly from weedy check in curtailing its dry weight. In both the years of experimentation, application of imazethapyr 100 and 150 g/ha (40 DAS) and hand weeding twice was most effective in reducing dry weight of other weeds. All these had hundred per cent other weeds' control efficiency. Doberzanski *et al.* (1991) observed highly effective weed control in garden pea with imazethapyr. Singh and Nepalia (1994) reported that hand weeding was quite effective in controlling weeds in pea crop. Pendimethalin at 1.5 kg/ha (pre-emergence) was next better treatment. Isoproturon at 1.0 and 1.25 kg/ha (40 DAS) and imazethapyr at 100 and 150 g/ha (20 DAS) were statistically at par with each other. Quizalofop at 25 g/ha (20 DAS) was least effective against other weeds. Significantly, lowest total weed dry weight was obtained with imazethapyr at 150 g/ ha (40 DAS). This was followed by imazethapyr at 100 g/ha (40 DAS) and hand weeding twice. Vaishya *et al.* (1999) also reported that pendimethalin 1.0 kg/ ha was inferior to hand weeding (20 and 40 DAS) in reducing dry weight.

Crop

Imazethapyr 150 g/ha (40 DAS) being statistically at par with its lower dose at 100 g/ha (40 DAS), hand weeding twice, quizalofop at 25 and 37.5 g/ha (20 DAS) and pendimethalin 1.5 kg/ha (pre-emergence) resulted in significantly taller plants over rest of the treatments (Table 2). This may be ascribed to least competition from weeds due to their effective suppression. Imazethapyr 150 g/ha (40 DAS) and hand weeding twice remaining statistically at par with imazethapyr at 100 g/ha (40 DAS), imazethapyr at 150 g/ha (20 DAS) and quizalofop at 37.5 g/ha (20 DAS) resulted in significantly higher plant dry matter accumulation as compared to other treatments. Isoproturon (40 DAS) and imazethapyr (20 DAS) at

Table 1. Effect of treatments on dry matter accumulation (g/m^2) of weeds and control efficiency at 120 DAS

Treatment	Dose (g/ha)	Time (DAS)	Dry weight (g/m^2)					Control efficiency (%)				
			P. minor	*A. fatua*	*V. sativa*	Others	Total	*P. minor*	*A. fatua*	*V. sativa*	Others	Total
Imazethapyr	100	20	17.1	15.7	15.9	4.2 (16.9)	65.5	65.0	56.3	40.9	45.2	54.0
Imazethapyr	150	20	14.7	15.0	15.2	4.2 (16.7)	61.5	69.9	58.2	43.3	45.9	56.8
Imazethapyr	100	40	12.6	13.8	6.9	1.0 (0.0)	33.3	74.3	61.5	74.5	100.0	76.6
Imazethapyr	150	40	10.0	10.8	4.9	1.0 (0.0)	25.7	79.6	69.8	81.8	100.0	82.0
Quizalofop	25	20	21.2	15.4	24.4	4.7 (20.9)	81.9	56.6	57.0	9.0	32.3	42.4
Quizalofop	37.5	20	10.6	11.1	22.2	3.5 (11.5)	55.4	78.3	69.0	17.4	62.7	61.1
Isoproturon	1000	40	15.5	15.4	16.4	4.3 (17.2)	64.4	68.4	57.1	38.8	44.2	54.7
Isoproturon	1250	40	14.8	15.1	16.1	4.2 (17.0)	63.1	69.7	57.8	40.0	44.8	55.7
Pendimethalin	1500	1	19.5	31.6	8.8	3.1 (8.7)	68.7	60.0	11.7	67.2	71.7	51.7
Hand weeding	-	30 & 60	15.9	15.3	6.8	1.0 (0.0)	37.9	67.5	57.4	74.6	100.0	73.4
Weedy check	-	-	48.8	35.8	26.8	5.6 (30.9)	142.3	0.0	0.0	0.0	0.0	0.0
LSD (P=0.05)			3.4	3.2	3.1	0.3	7.4					

*Data transformed to $(\sqrt{x+1})$ transformation. Values given in parentheses are the means of original values.

Table 2. Effect of treatments on plant height, dry matter accumulation, CGR, NAR and nodules count (no./plant) and weight (mg/plant) of pea

Treatment	Dose (g/ha)	Time (DAS)	Plant height (cm)	Plant Dry matter (g/m^2)	CGR (g/m^2/ day)	RGR (g/g/day)	Nodule count pre or post flowering		Nodule weight pre or post flowering	
							Pre-	Post-	Pre-	Post-
Imazethapyr	100	20	59.9	349.8	5.1	0.0190	42.5	25.2	44.7	25.5
Imazethapyr	150	20	61.6	368.9	5.5	0.0189	44.5	30.4	45.4	30.9
Imazethapyr	100	40	63.9	403.2	7.0	0.0234	47.9	32.9	49.2	33.4
Imazethapyr	150	40	65.4	418.2	7.4	0.0236	49.0	34.0	50.3	34.5
Quizalofop	25	20	62.0	204.1	2.4	0.0129	42.4	29.0	42.9	29.5
Quizalofop	37.5	20	62.2	403.4	7.0	0.0234	47.1	32.5	48.0	33.3
Isoproturon	1000	40	61.7	337.1	4.7	0.0180	39.3	24.1	40.1	24.3
Isoproturon	1250	40	62.2	349.9	5.1	0.0194	39.0	24.0	39.4	24.1
Pendimethalin	1500	1	62.6	340.4	4.7	0.0172	41.9	28.5	42.8	29.0
Hand weeding	-	30 & 60	64.5	407.1	7.0	0.0231	46.3	33.2	47.7	33.4
Weedy check	-	-	57.6	178.9	2.2	0.0170	33.3	22.3	33.7	22.7
LSD (P=0.05)			3.2	58.4	1.7	0.0051	1.8	1.0	2.3	1.2

CGR = Crop growth rate; RGR = Relative growth rate; NAR = Net assimilation rate

both rates were comparable to pendimethalin 1.5 kg/ ha (pre-emergence). However, quizalofop 25 g/ha (20 DAS) did not significantly increase plant dry matter accumulation over the weedy check. The enhanced growth of weeds caused intense competition with the crop for growth factors and resulted in significant decrease in plant height and dry matter production due to unchecked weed growth in peas.

Crop growth rate (CGR) and relative crop growth rate (RGR) worked out from 120 DAS to harvest were significantly highest in the treatment imazethapyr 150 g/ha (40 DAS) in both the years. The higher weed control efficiency under imazethapyr 150 g/ha (40 DAS) reduced crop weed competition and helped in significant increase in the rate of growth of the crop. However, this was statistically at par with the crop growth rate obtained under imazethapyr 100 g/ha (40 DAS), quizalofop 37 g/ha (20 DAS) and hand weeding twice treatments. Reduced crop weed competition due to effective control of weeds by various treatments resulted in better utilization of growth factors by the crop and this resulted in its better growth and development. This can be ascribed to fact that the effective control of weeds led to the favorable environment for growth and photosynthetic activity of the crop. Skrzypczak *et al.* (1994) also reported almost similar results with imazethapyr at 150 g/ha (40 DAS). Application of isoproturon at 1.25 kg/ha exhibited slight phytotoxicity in both the years, however, plants recovered by 120 DAS.

The data on nodules number at pre-flowering (90 DAS) and post-flowering (120 DAS) stage have been given in Table 2. Imazethapyr 100 and 150 g/ha (40 DAS) and quizalofop 37.5 g/ha (20 DAS) being statistically at par with hand weeding twice resulted in significantly higher number of nodules over rest of the treatments at pre-flowering stage during 2005-06.

However, in 2006-07 significantly highest number of nodules was obtained with imazethapyr 150 g/ha (40 DAS). Imazethapyr at 150 g/ha (40 DAS) remaining at par with hand weeding twice gave significantly higher number of nodules over rest of the treatments at post-flowering stage during 2005-06. In 2006-07 significantly highest number of nodules was obtained with imazethapyr 150 g/ha (40 DAS). Quizalofop at 25 g/ha both at pre- and post-flowering stage were as good as the herbicidal check pendimethalin 1.5 kg/ha. Isoproturon at both rates was least effective at both stages in both the years. Imazethapyr 150 g/ha (40 DAS) resulted in significantly higher nodules dry weight at pre-flowering stage in both the year. However, it was statistically at par with its lower dose at 100 g/ha (40 DAS), quizalofop 37.5 g/ha and hand weeding twice during 2005-06 and imazethapyr 100 g/ha (40 DAS) in 2006-07.

At post-flowering stage in both the years, imazethapyr 100 and 150 g/ha (40 DAS) resulted in significantly higher dry weight of nodules. Quizalofop at 25 g/ha (20 DAS) both at pre and post-flowering stages was as effective as pendimethalin in both the year. However, isoproturon at both the rates was least effective amongst all treatments at both the stages of observation. The higher number and dry weight of root nodules can be ascribed to the effective control of weeds which led to the favorable environment for growth and development. However, data on number of days taken for attainment of various development stages, *viz.* 75 per cent flowering and first and last picking was not significant in both the years of experimentation (data not shown).

Weed control treatments brought about significant variation in green pod yield (Table 3). All weed control treatments were significantly superior to weedy check in influencing green pod yield. Each of the herbicide at higher rate was superior to its lower rate in influencing green pod yield. Significantly highest green pod yield was obtained with imazethapyr at 150 g/ha (40 DAS) in both the years. Hand weeding twice and imazethapyr at 100 g/ha (40 DAS) being statistically similar with each other were the other superior treatments in influencing green pod yield. All the post-emergent herbicidal treatments except quizalofop at 25 g/ha were superior to standard pre-emergent herbicidal check (pendimethalin 1.5 kg/ha) in influencing green pod yield. Weeds in untreated check reduced pea pod yield by 56.8% over the best post-emergent herbicidal treatment in 2005-06 and 60.1% in 2006-07.

The grain yield was negatively associated with total weed count (r= -0.957**, significant at 1% level of significance) and total weed biomass (r= -0.953**). The linear relationship between weed count/weed dry weight (x) and grain yield (Y) of pea is given hereas under,

Weed count

$$Y = 7718 - 17.8\,x \qquad (R^2 = 0.917) \ldots\ldots\text{(i)}$$

Weed weight

$$Y = 8609 - 41\,x \qquad (R^2 = 0.908) \ldots\ldots\text{(ii)}$$

The equation (i) explains that 91.7% variation in yield due to weed count could be explained by the regression equation. The further analysis indicated that decrease in yield per unit increase in weed count (1 weed/m^2) is estimated to be 17.8 kg/ha. Similarly from the equation (ii) it may be inferred that 90.8% of variation in yield of pea due to weed dry weight could be explained by the regression equation. With every 1 g/m^2 increase in weed dry weight, the pod yield of pea was expected to fall by 41 kg/ha.

Table 3. Effect of treatments on green pod and haulm yield of pea

Treatment	Dose (g/ha)	Time of application (DAS)	Green pod yield (t/ha)	Haulms yield (t/ha)	CWC	Gt	Et		CRI	WMI	AMI	EI	WI
							Wc	Wdm					
Imazethapyr	100	20	3.70	3.95	1250	66	3.7	1.6	3.62	3.51	2.51	1.94	18.7
Imazethapyr	150	20	3.96	4.26	1809	95	5.3	2.3	4.14	3.56	2.56	2.36	13.1
Imazethapyr	100	40	4.39	4.72	1241	65	3.7	1.6	8.49	3.00	2.00	5.57	1.0
Imazethapyr	150	40	4.60	4.95	1858	98	5.5	2.4	11.51	2.94	1.94	7.81	3.7
Quizalofop	25	20	3.03	3.02	948	50	2.8	1.2	2.29	3.27	2.27	0.67	40.3
Quizalofop	37.5	20	4.21	4.54	1231	65	3.6	1.6	4.90	3.61	2.61	3.09	5.2
Isoproturon	1000	40	3.72	4.05	597	31	1.8	0.8	3.74	3.53	2.53	2.06	16.9
Isoproturon	1250	40	3.85	4.05	685	36	2.0	0.9	3.88	3.53	2.53	2.18	15.4
Pendimethalin	1500	1	3.34	3.66	2238	118	6.6	2.9	3.15	3.27	2.27	1.43	27.3
Hand weeding	-	30 & 60	4.38	4.81	4334	228	12.8	5.6	7.51	3.17	2.17	4.97	0.0
Weedy check	-	-	2.32	2.28	-	-	-	-	-	-	-	-	57.0
LSD (P=0.05)			0.16	0.25									

CWC, cost of weed control (`/ha); Gt, gain threshold; Et, Economic threshold; Wc, weed count; Wdm (weed dry weight); CRI, crop resistance index; WMI, weed management index; AMI, agronomic management index; EI, efficiency index; WI, weed index.

The economic threshold levels of weeds at the current prices of treatment application and the crop production on the basis of weed infestation (population) in wheat are given in Table 3. The economic threshold levels (number of weeds/unit area) with the weed management practices studied varies between 1.8-12.8/m^2. In terms of weed biomass the economic threshold varies from 0.9 under isoproturon 1000 g/ha to 5.6 g/m^2 under hand weeding twice. There was clear indication that any increase in the cost of treatment would lead to higher values of economic threshold, whereas an increase in price of crop produce would result in lowering the economic threshold.

Imazethapyr 150 g/ha (40 DAS) resulted in highest crop resistance index (CRI) and efficiency index (EI). This was followed by imazethapyr 100 g/ha (40 DAS), hand weeding twice and quazalofop 32.5 g/ha (20 DAS). Agronomic management index (AMI) and weed management index (WMI) were lowest under imazethapyr 150 g/ha (40 DAS) followed by imazethapyr 100 g/ha (40 DAS), hand weeding twice and pendimethalin 1500 g/ha/ quazalofop 25 25 g/ha (20 DAS). Weed index which indicates fall in yield over a weed free practice presently hand weeding twice, was minimum under imazethapyr 150 g/ha (40 DAS) followed by imazethapyr 100 g/ha (40 DAS) and quazalofop 37.5 g/ha. The effect of treatments on ascorbic acid, total soluble solids and protein content was not significant during both the years (Data not shown).

From the present investigation it may be inferred that imazethapyr at 150 g/ha (40 DAS) was the most effective herbicide for controlling of weeds. Application of imazethapyr at 150 g/ha was found more remunerative in terms of green pod and haulms yield of garden pea.

REFERENCES

Bhyan BS, Batra VK, Singh J and Thakral KK. 2004. Effect of weed competition on quality of pea seed. *Haryana Journal of Horticultural Sciences* **33**(1-2): 130-131.

Casarini B, Poldini L and Silvestri G. 1996. Experimental studies on weed control in peas grown for processing. *Industria Conserve* **3**: 15.

Doberzanski A, Polczyski J, Anyszka Z, Vlinska Z and Smolinska V. 1991. Influence of some of herbicides on weed control, legume and soil microflora. pp. 114-119 . In: *Instytu Ochrony Roslin Poznan (Poland).* (Eds. Pruszynski S and Lipa JJ). Materials of the 34th Research Session of Institute of Plant Protection Pt 2. Posters. Ponstwowe Vydawnictvo Rolmcze, Lense.

Haar MJ, Fennimore SA and Lambert CL. 2001. Economics of pronamide and pendimethalin in use in weed management during stand establishment. *Horticulture Science* **36**(4): 650-653.

Singh AK and Nepalia V. 1994. Comparative efficiency of fluchloralin and pendimethalin for weed control in field pea. *Indian Journal of Agronomy* **39**: 164-165.

Singh CM, Angiras NN and Kumar S. 1996. *Weed Management*. M.D. Publications, New Delhi.

Skrzypczak G, Pudelko J, Blecharczyik A and Voznica Z. 1994. Influence of pivot 100 SL (Imazethapyr) herbicide used in leguminous plants on rotational crops. pp. 202-205. In: *Instytu Ochrony Roslin Poznan (Poland)*. (Eds. Pruszynski S, Lipa JJ). Ponstwowe Vydawnictvo Rolmcze, Lense 202-205.

Stone JD and Pedigo LP. 1972. Development and economic injury level of the green clover worm on soybean in Iowa. *Journal of Economic Entomology* **65**: 197-201.

Vaishya RD, Rai OP and Singh RK. 1999. Weed control in pea with pre- and post-emergence herbicides. *Indian Journal of Pulses Research* **12**: 201-205.

Walia US. 2003. *Weed Management*. Kalyani Publishers, Ludhiana 396 p.