RESEARCH ARTICLE

NUTRIENT UPTAKE BY WEEDS AND PEA (*PISUM SATIVUM* L.) AS INFLENCED BY DIFFERENT HERBICIDE COMBINATIONS

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Abstract: A field experiment was carried out during the winter season of 2012-13 and 2013-14 at Palampur to evolve an effective herbicide combination on nutrient depletion by weeds in pea (*Pisum sativum* L.). In the present study, pendimethalin 1000 g/ha *fb* HW (45 DAS)andpendimethalin 1000 g/ha (Pre)*fb* imazethapyr + imazamox 60 g/ha (45 DAS) resulted in significantly lower total weed dry weight over other herbicidal treatments.All the herbicide combinations were comparable to weed free in reducing the GR_w between 90-120 DAS. Pendimethalin 1000 g/ha *fb* HW (45 DAS), pendimethalin 1000 g/ha *fb* imazethapyr + imazamox 60 g/ha (45 DAS) were as effective as weed free in reducing NPK uptake by weeds. Weeds in weedy check removed 49.3 kg/ha N, 19.7 kg/ha P and 44.7 kg/ha K depriving thereby the crop for that much amount of nutrients. Most of the treatments were results in significantly higher crop dry matter accumulation. Significantly higher green pod yield and NPK uptake by crop were obtained in weed free, pendimethalin 1000 g/ha *fb* HW **(**45 DAS) and pendimethalin 1000 g/ha *fb* imazethapyr + imazamox 60 g/ha (45 DAS) treatments.Herbicide combinations in general were better than sole application of herbicides in effectively reducing the NPK uptake by weeds and increasing NPK uptake by crop.

Keywords: Hand weeding, Imazethapyr, Nutrient uptake, Peas, Pendimethalin

INTRODUCTION

A strong competition is going on between weeds and crop plants for nutrients, and that is the most critical factor in the first period of the vegetation. Plants compete mainly for the sufficient amount of macronutrients, for nitrogen, phosphorus, and potassium. Most weed species can take up nitrogen and potassium from soil at a higher degree than crop plant living in association with it. Pea is one crop, which builds up the soil fertility by atmospheric nitrogen fixation through the root nodules. Pea has great potential as an exceptionally nutritive and very rich protein food. However, it has higher requirement of phosphorus for symbiotic nitrogen fixation. Among different production factors, weeds pose serious threat to the productivity of garden pea. However, weeds are the major threat in harnessing the full potential of applied and native plant nutrients. They remove considerable amount of nutrients and adversely affect the yield of the crop (Kumar *et al*., 2005; Dubey *et al*.1999). Weeds have been reported to cause 56.8-81(%) losses in its yield (Rana *et al.,*2013; Singh *et al.,*1996) under different agro-climatic conditions. ln Himachal Pradesh, pea crop has been reported to be infested with a variety of weeds *viz*., *Phalaris minor, Avena ludoviciana, Loliumtemulentum, Vicia sativa and Anagallis arvensis* (Rana *et al.,* 2013). In order to achieve enhanced crop production and higher benefits from applied inputs, there must be a strong weed management strategy.They can be controlled by manual, mechanical and chemical methods. Manual method of weed control is labour intensive, cumbersome and time consuming. Whereas, mechanical methods of weed control are reported to cause injury to root system (Casarini *et al.,* 1996). Various pre-plant incorporation and pre-emergence herbicides have been tested and recommended under different agro-climatic conditions of Himachal Pradesh (Singh *et al.,*1996). However, the information on post-emergence herbicides to control weeds is scanty. Many a times extension workers and farmers of the state demand information on post emergence herbicides particularly when they fail to advocate/apply pre-emergence herbicides due to one or the other reason. Post-emergence herbicides are also required when pre-emergence fail to give satisfactory weed control. New post-emergence herbicides *viz.*, imazethapyr alone and in combination with imazamox (odissey) have been introduced. Therefore, the present investigation was carried out for having an effective management strategy for season long control of weeds in pea under mid hill conditions of Himachal Pradesh.

MATERIAL AND METHOD

Pea variety ‘Palam Priya’ was sown during the second fortnight of October for two consecutive years (2012-12 and 2013-14) with recommended package of practices except weed control. Twelve weed control treatments *viz.,* pendimethalin 1500 g/ha pre emergence, pendimethalin 1000 g/ha (Pre)*fb* imazethapyr 100 g/ha (45 DAS), imazethapyr 100 g/ha (Pre)*fb* imazethapyr 100 g/ha (45 DAS), imazethapyr + pendimethalin 1200 g/ha pre emergence, imazethapyr + pendimethalin 1500 g/ha pre emergence, imazethapyr + pendimethalin 1000 g/ha (Pre)*fb* imazethapyr 100 g/ha (45 DAS),

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imazethapyr + imazamox 60 g/ha (45 DAS), imazethapyr + imazamox 90 g/ha (45 DAS), pendimethalin 1000 g/ha (Pre)*fb* imazethapyr + imazamox 60 g/ha (45 DAS), pendimethalin1000 g/ha (Pre)*fb* 1HW (45 DAS), weed free and weedy check were tested in a Randomized Block Design with three replications. Soil of the test site was silty clay loam in texture, acidic in reaction, medium in available nitrogen(322.9 kg/ha) and K (276.4 kg/ha) and high in available P (25.8 kg/ha).Observation on weed density and biomass were recorded at 60, 90, 120 DAS and at harvest using quadrat of 0.5 m x 0.5 m, placed at two random spot. The crop was harvested on April 20 during the first year and April 24 during the second year. Yields were harvested from net plot in four picking. Weed biomass data showed variation and were subjected to square root transformation [$(\sqrt{x+1})$].Weed control index was worked out based on weed dry weight.

$$\text{Weed Control index (\%)} = \frac{\text{Wc} - \text{Wt}}{\text{Wc}} \text{X } 100$$

Where,

Wc- Weed dry weight (g/m^2) in control plot and

Wt- Weed dry weight (g/m^2) in treated plot.

$$\text{Weed index (\%)} = \frac{\text{X} - \text{Y}}{\text{X}} \text{X } 100$$

Where,

X - Yield from weed free treatment

Y - Yield of particular treatment for which WI is to be worked out.

$$\text{GRw } (g/m^2/\text{day}) = \frac{W_2 - W_1}{t_2 - t_1}$$

$$\text{RGRw } (g/g/\text{day}) = \frac{\text{Log}_e W_2 - \log_e W_1}{t_2 - t_1}$$

Where, W_2 and W_1 are the total dry weight at times t_2 and t_1, respectively.

RESULT AND DISCUSSION

Effect on weeds

The major weed flora of the experimental field was composed of *Phalaris minor* (28.8%), *Alopecurus myosuroides* (21.3%),*Avena ludoviciana* (15.8%), *Lolium temulentum* (12.1%) and *Vicia sativa* (16.7%).Among other weeds, *Stellaria media*, *Poa annua, Anagallis arvensis* and *Coronopus didymus* showed their little infestation.

Data pertaining to progressive dry matter accumulation by weeds have been presented in Table 1. The data revealed that in general, dry matter accumulation increased consistently up to 120 DAS, thereafter it declined gradually. The decline in weed dry weight was owed to withering of weeds. Data on weed dry weight at maximum dry matter stage *i.e.* 120 DAS have been given in Table 1. Weed control treatments significantly decreased total weed dry weight as compared to weedy check. Removing the weeds whenever they appear under the weed free treatment resulted in complete elimination of weed competition as it resulted in lowest total weed dry weight. Pendimethalin 1000 g/ha *fb* HW (45 DAS)being at par withpendimethalin 1000 g/ha (Pre)*fb* imazethapyr + imazamox 60 g/ha (45 DAS) resulted in significantly lower total weed dry weight over other herbicidal treatments. The superiority of pendimethalin *fb* HW in controlling weeds has been reported by Kumar and Singh (1994). Imazethapyr + imazamox 60 g/ha (45 DAS), imazethapyr + pendimethalin 1000 g/ha *fb* imazethapyr 100 g/ha (45 DAS), imazethapyr + pendimethalin 1200 g/ha pre emergence**,** imazethapyr + imazamox 90 g/ha (45 DAS) and pendimethalin 1000 g/ha *fb* imazethapyr 100 g/ha (45 DAS) behaving statistically alike were the next better treatments. Owing to synergetic, enhancement or additive effects, herbicidal combinations in general were better than sole application of herbicides in effectively reducing the total weed dry weight.

Species-wise better control of weeds under the herbicide mixture or sequence application, weed control index under them was comparable to weed free. Application of herbicide alone gave poor control of weeds, therefore had lower weed control index.

The data on effect of treatments on nutrient uptake by weeds has been embodied in Table 3. Owing to significant reduction in dry weight, all weed control treatments significantly reduced N, P and K uptake by weeds as compared to weedy check. Pendimethalin 1000 g/ha *fb* HW (45 DAS), pendimethalin 1000 g/ha *fb* imazethapyr + imazamox 60 g/ha (45 DAS) were as effective as weed free in reducing N, P and K uptake by weeds. In general, all herbicide combinations proved superior to alone application of herbicides in reducing the N, P and K uptake by weeds. Weeds in weedy check removed 49.3 kg/ha N, 19.7 kg/ha P and 44.7 kg/ha K depriving thereby the crop for that much amount of nutrients. Similar results have been reported by Wagner and Nadasy (2007).

Effect on crop

The trend in progressive dry matter accumulation by pea crop under different weed control treatments has been shown graphically in Fig. 1. Dry matter accumulation increased consistently with the advancement of crop growth. The data on total dry matter accumulation by pea crop at final harvest as influenced by different treatments have been given in Table 2. A cursory glance at the data depicts that the plant dry weight increased consistently with advancement in crop growth with maximum rate at 90 to 120 DAS. Pendimethalin 1000 g/ha *fb* HW (45 DAS) and weed free remaining statistically at par with pendimethalin 1000 g/ha (Pre)*fb* imazethapyr + imazamox 60 g/ha (45 DAS), imazethapyr + pendimethalin 1000 g/ha *fb* imazethapyr 100 g/ha (45 DAS), imazethapyr + imazamox 90 g/ha (45 DAS),

imazethapyr + imazamox 60 g/ha (45 DAS), imazethapyr + pendimethalin 1200 g/ha pre emergence and pendimethalin 1000 g/ha *fb* imazethapyr 100 g/ha (45 DAS) resulted in significantly higher dry matter accumulation over rest of the treatments. The reduction in population and dry weight of weeds under these treatments and higher weed control index created favourable micro-environment for growth and development of pea crop and thus increased the dry matter accumulation of pea.

Data pertaining to crop growth rate (CGR) and relative growth rate (RGR) of pea crop have been embodied in Table 2. Weed control treatments did not significantly influence the CGR and RGR of pea. This showed that rate of growth of pea remained unaffected irrespective to variation in population and dry weight of weeds. However, data on number of days taken for attainment of various development stages *viz*., emergence count, 50% flowering, first picking and maturity was not significant in both the years of experimentation (Data not shown).

Table 1. Effect of weed control treatments on total weed dry weight (g/m^2) at different crop stage and weed control index (%)

Treatment	Dose (g/ha)	Time of application	Weed dry weight (DAS)				Weed control index (DAS)			
			60	90	120	At harvest	60	90	120	At harvest
Pendimethalin	1500	Pre emergence	8.3 (68.3)	11.0 (120.5)	12.1 (145.6)	10.1 (100.3)	58.2	55.4	50.2	49.2
Pendimethalin *fb* imazethapyr	1000 *fb* 100	Pre *fb* post (45 DAS)	7.6 (57.6)	9.4 (87.5)	10.7 (114.1)	8.6 (73.1)	64.7	67.7	61.0	63.0
Imazethapyr *fb* imazethapyr	100 *fb* 100	Pre *fb* post (45 DAS)	7.6 (56.5)	11.4 (129.1)	12.3 (149.3)	11.2 (124.8)	65.4	52.3	48.9	36.7
Imazethapyr + pendimethalin	1200	Pre emergence	6.2 (37.3)	9.4 (87.5)	10.2 (104.0)	10.2 (104.0)	77.1	67.7	64.4	47.3
Imazethapyr + pendimethalin	1500	Pre emergence	6.2 (37.9)	9.3 (84.8)	11.2 (124.8)	10.2 (102.4)	76.8	68.6	57.3	48.1
Imazethapyr + pendimethalin *fb* imazethapyr	1000 *fb* 100	Pre *fb* post (45 DAS)	4.2 (17.1)	8.3 (67.7)	10.2 (102.4)	7.1 (50.1)	89.5	75.0	65.0	74.6
Imazethapyr + imazamox	60	Post (45 DAS)	4.8 (22.4)	8.5 (70.9)	9.8 (96.0)	8.3 (68.8)	86.3	73.8	67.2	65.1
Imazethapyr + imazamox	90	Post (45 DAS)	6.3 (40.0)	8.9 (78.9)	10.5 (109.3)	9.6 (91.7)	75.5	70.8	62.6	53.5
Pendimethalin *fb* imazethapyr + imazamox	1000 *fb* 60	Pre *fb* post (45 DAS)	2.1 (4.3)	7.9 (61.3)	8.8 (76.3)	7.0 (47.5)	97.4	77.3	73.9	75.9
Pendimethalin *fb* 1HW	1000	Pre *fb* HW (45 DAS)	1.0 (0.0)	6.6 (43.2)	8.1 (65.1)	6.2 (37.9)	100.0	84.0	77.7	80.8
Weed free	-	-	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	100.0	100.0	100.0	100.0
Weedy check	-	-	12.8 (163.2)	16.5 (270.4)	17.1 (292.8)	14.1 (197.3)	0.0	0.0	0.0	0.0
SE(m+-)			0.48	0 .33	0.41	0.37	-	-	-	-
CD (P=0.05)			1.0	0.7	0.9	0.8	-	-	-	-

Table 2. Effect of weed control treatments on total crop dry matter accumulation (g/m^2), crop growth analysis, yield and weed index

Treatment	Dose (g/ha)	Time of application	Crop dry matter (At harvest)	CGR (g/m^2/day) 90-120 DAS	RGR_c (mg/g/day) 90-120 DAS	Grain yield (t/ha)			WI (%)	Straw yield (t/ha)		
						2012-13	2103-14	Mean		2012-13	2103-14	Mean
Pendimethalin	1500	Pre emergence	343.7	4.049	21.45	6.57	6.57	6.6	9.9	2.11	1.75	1.9
Pendimethalin *fb* imazethapyr	1000 *fb* 100	Pre *fb* post (45 DAS)	351.1	3.975	20.73	6.29	6.49	6.4	12.3	2.07	1.87	2.0
Imazethapyr *fb* imazethapyr	100 *fb* 100	Pre *fb* post (45 DAS)	346.7	3.852	20.02	6.21	6.37	6.3	13.7	2.03	1.71	1.9
Imazethapyr + pendimethalin	1200	Pre emergence	353.3	4.025	21.31	5.97	6.25	6.1	16.2	2.11	1.83	2.0
Imazethapyr + pendimethalin	1500	Pre emergence	344.4	4.074	21.55	6.13	6.41	6.3	14.0	2.03	1.79	1.9
Imazethapyr + pendimethalin *fb* imazethapyr	1000 *fb* 100	Pre *fb* post (45 DAS)	389.6	3.901	20.04	6.09	6.81	6.5	11.5	1.99	1.99	2.0
Imazethapyr + imazamox	60	Post (45 DAS)	384.4	3.778	19.31	6.01	6.69	6.4	12.9	2.11	1.91	2.0

Imazethapyr + imazamox	90	Post (45 DAS)	385.2	3.827	19.68	6.53	6.81	6.7	8.5	2.15	1.95	2.1
Pendimethalin *fb* imazethapyr + imazamox	1000 *fb* 60	Pre *fb* Post (45 DAS)	396.3	4.114	21.54	7.01	7.25	7.1	2.2	2.23	2.07	2.2
Pendimethalin *fb* 1HW	1000	Pre *fb* HW (45 DAS)	400.0	4.136	21.32	7.17	7.33	7.2	0.5	2.27	2.11	2.2
Weed free	-	-	403.7	4.296	21.16	7.21	7.37	7.3	0.0	2.35	2.11	2.2
Weedy check	-	-	188.9	1.012	3.20	4.34	4.74	4.5	37.7	1.87	1.71	1.8
SE(m+-)			27.24	0.80	5.58	0.26	0.43	0.32	-	0.10	0.11	0.07
CD (P=0.05)			56.8	1.686	NS	0.56	0.90	0.7	-	0.21	0.22	0.2

Table 3. Effect of weed control treatments on nutrient uptake by weeds and crop (kg/ha)

Treatment	Dose (g/ha)	Time of application	Weeds			Crop								
			N	P	K	N			P			K		
						Pods	Straw	Total	Pods	Straw	Total	Pods	Straw	Total
Pendimethalin	1500	Pre emergence	20.1	7.0	21.7	57.2	42.6	99.8	7.9	7.6	15.5	41.4	42.6	84.0
Pendimethalin *fb* imazethapyr	1000 *fb* 100	Pre *fb* post (45 DAS)	14.1	4.6	14.6	58.4	43.1	101.5	7.8	7.5	15.3	42.8	48.0	90.9
Imazethapyr *fb* imazethapyr	100 *fb* 100	Pre *fb* post (45 DAS)	25.8	9.6	27.5	56.7	42.2	99.0	7.6	6.8	14.5	38.2	43.4	81.6
Imazethapyr + pendimethalin	1200	Pre emergence	19.8	6.2	18.7	54.4	45.2	99.6	9.4	7.9	17.3	40.0	45.2	85.2
Imazethapyr + pendi methalin	1500	Pre emergence	17.4	5.8	18.4	57.1	44.2	101.3	8.3	6.6	14.9	40.4	45.4	85.8
Imazethapyr + pendimethalin *fb* imazethapyr	1000 *fb* 100	Pre *fb* post (45 DAS)	8.2	2.5	8.7	62.0	47.8	109.8	10.2	8.6	18.8	42.9	51.8	94.7
Imazethapyr + imazamox	60	Post (45 DAS)	11.0	3.7	12.2	61.6	46.5	108.1	8.7	7.0	15.7	42.8	49.7	92.5
Imazethapyr + imazamox	90	Post (45 DAS)	15.3	4.6	15.3	62.7	46.8	109.5	10.2	8.5	18.7	44.3	50.1	94.4
Pendimethalin *fb* imazethapyr + imazamox	1000 *fb* 60	Pre *fb* post (45 DAS)	7.4	2.2	7.3	67.4	49.7	117.1	13.0	10.4	23.4	54.4	54.5	108.9
Pendimethalin *fb* 1HW	1000	Pre *fb* HW (45 DAS)	5.8	1.4	5.7	68.9	51.4	120.2	13.2	10.6	23.7	54.2	56.3	110.5
Weed free	-	-	0.0	0.0	0.0	70.0	52.1	122.1	14.0	10.6	24.6	55.3	57.0	112.2
Weedy check	-	-	49.3	19.7	44.7	45.5	43.4	88.9	5.7	7.4	13.1	26.5	43.5	70.1
SE(m+-)			2.32	0.51	2.17	2.4	2.13	3.18	0.97	1.20	1.88	3.35	2.96	4.39
CD (P=0.05)			4.9	1.1	4.5	5.1	4.5	6.6	2.0	2.5	3.9	7.0	6.2	9.2

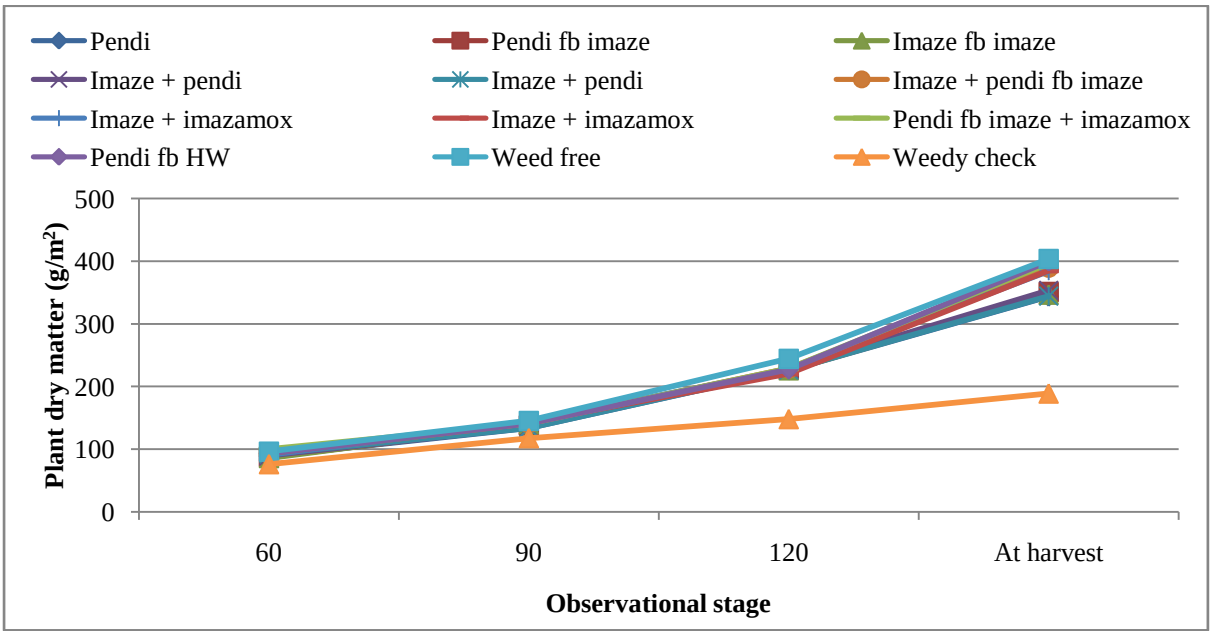

Fig 1. Effect of weed control treatments on progressive dry matter accumulation by pea at different stages of observation

Weed control treatments brought about significant variation in green pod yield (Table 2). All weed control treatments were significantly superior to weedy check in influencing green pod yield. Significantly higher green pod yield was obtained in weed free, pendimethalin 1000 g/ha *fb* HW **(**45 DAS) and pendimethalin 1000 g/ha *fb* imazethapyr + imazamox 60 g/ha (45 DAS) treatments. Imazethapyr + imazamox 90 g/ha (45 DAS) and imazethapyr + pendimethalin 1000 g/ha *fb* imazethapyr 100 g/ha (45 DAS) being statically similar with each other were the next superior treatments in influencing green pod yield. Similarly observation with respect to pendimethalin *fb* HW on yield attributes and yield were recorded (Vaishya *et al.*,1999; Tripathi *et al.*,1993; Kumar and Singh 1994). As indicated by weed index, un-interrupted growth of weeds in the weedy check reduced pea yield by 37.7% over weed free.Significantly higher straw yield was obtained with weed free and pendimethalin 1000 g/ha *fb* HW (45 DAS). However, they behaved statically alike to pendimethalin 1000 g/ha *fb* imazethapyr + imazamox 60 g/ha (45 DAS), imazethapyr + pendimethalin 1000 g/ha *fb* imazethapyr 100 g/ha (45 DAS), imazethapyr + imazamox 90 g/ha (45 DAS) and imazethapyr + imazamox 60 g/ha (45 DAS). Unchecked weed growth reduced the straw yield to the extent of 18.2% as compared to best treatment *i.e*. pendimethalin 1000 g/ha *fb* imazethapyr + imazamox 60 g/ha (45 DAS).

The data on effect of treatments on N, P and K uptake by pea have been embodied in Table 3. All the weed control treatments significantly increased the N, P and K uptake by pea over weedy check. Because of the higher pea pod and straw yield, weed free remaining at par with pendimethalin 1000 g/ha *fb* HW (45 DAS), pendimethalin 1000 g/ha *fb* imazethapyr + imazamox 60 g/ha (45 DAS), imazethapyr + pendimethalin 1000 g/ha *fb* imazethapyr 100 g/ha (45 DAS), imazethapyr + imazamox 90 g/ha (45 DAS), imazethapyr + imazamox 60 g/ha (45 DAS), pendimethalin 1000 g/ha *fb* imazethapyr 100 g/ha (45 DAS), imazethapyr + pendimethalin 1500 g/ha pre emergence and imazethapyr + pendimethalin 1200 g/ha pre emergence resulted in significantly higher N uptake by crop. Imazethapyr 100 g/ha (Pre)*fb* imazethapyr 100 g/ha (45 DAS), imazethapyr + pendimethalin 1200 g/ha pre emergence and pendimethalin 1500 g/ha pre emergence were less effective treatment in influencing N uptake than other treatments.

Weed free remaining at par with pendimethalin 1000 g/ha *fb* HW (45 DAS), pendimethalin 1000 g/ha *fb* imazethapyr + imazamox 60 g/ha (45 DAS), imazethapyr + pendimethalin 1000 g/ha *fb* imazethapyr 100 g/ha (45 DAS) and imazethapyr + imazamox 90 g/ha (45 DAS) resulted in significantly higher P and K uptake by crop. In general, all herbicide combinations were superior to alone application of herbicides in improving the N, P and K uptake by crop. The superiority of herbicide combination in influencing N, P and K uptake by pea crop has been documented Ramia *et al.*,(2013). Weed free resulted in 37.3, 87.8 and 60.0 per cent higher N, P and K uptake over weedy check, respectively.

Application of pendimethalin 1000 g/ha (Pre)*fb* imazethapyr + imazamox 60 g/ha (45 DAS) reducing nutrient uptake by weeds, increased by pea and behaved statistically alike with weed free and pendimethalin 1000 g/ha *fb* HW (45 DAS). Thus, combination of herbicides (tank mixed or sequential) is the better option for the control of mixed weed flora to obtain higher yield in pea crop.

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