Short communication

Indian Journal of Weed Science **46**(3): 278–282, 2014

Residual effect of cluster bean herbicides on succeeding wheat crop

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Received: 10 April 2014; Revised: 17 July 2014

Key words: Cluster bean, *Cyamopsis tetragonoloba* Imazethapyr, Pendimethalin, Residual effect, Succeeding crop

Cluster bean (*Cyamopsis tetragonoloba* (L.) Taub.), popularly known as 'Guar', is grown during rainy season in semi-arid and arid regions of India. Cluster bean is grown for different purposes from very ancient time. A seed of cluster bean contains 28-33% gum which is used in almost all types of industries, *viz.* textiles, paper, petroleum, pharmaceuticals, food processing, cosmetics, mining explosives, oil drilling *etc*. Cluster bean adds to the fertility of soil by fixing considerable amount of atmospheric nitrogen (Naagar and Meena 2004). As per past 10 years average, guar is being cultivated in India on about 3 million ha with a production of about 1.2 million tons with year to year variation especially in the years of drought as well as on high market demand. Rajasthan contributes 83% to the area and 65% to the production. In 2012, worldwide, about 0.45 million tons of guar products were traded with export value of US$ 4,623 million out of which share of Indian export was 80.8% (0.37 million tonnes) worth US$ 3,916 million. Among all the agricultural export commodities, cluster bean has become the highest foreign exchange earner of `.212.87 billions followed by Basmati rice in the recent year of 2012-13 (NRAA 2014).

As guar is a rainy season crop and due to frequent rains, weed population increase tremendously and compete for nutrients, moisture and space with crop causing considerable yield reduction. Besides, this period coincides with the season of peak labour activity leading to scarcity of labour for weeding. All this add to high cost of production too. Proper weed control method is the prime need and it is very much essential to give the herbicide usage its due share to obtain maximum productivity. Imazethapyr is imidazolinone herbicide and may be applied pre plant incorporated, pre-emergence, ground cracking, or post-emergence for effective weed control (Wilcut *et al.* 1995). Imazethapyr applied as pre-plant incorporated or as pre-emergence controls many troublesome weeds such as coffee senna (*Cassia occidentalis* L.), common lambsquarter (*Chenopodium album* L.), morning-glory species (*Ipomoea* spp.), pigweed species (*Amaranthus* spp.) including Palmer amaranth (*Amaranthus palmeri*), prickly sida (*Sida spinosa* L.), purple and yellow nutsedge (*Cyperus rotundus* L. and C. *esculentus* L.), spurred anoda (*Anoda cristata* L.), and wild poinsettia (*Euphorbia heterophylla* L.). Imazethapyr applied as post-emergence provides broad spectrum and most consistent control when applied within 10 days of weed emergence. Imazethapyr is the only post-emergence herbicides for effective control of both yellow and purple nutsedges (Richburg *et al.* 1993). Control is most effective when imazethapyr is applied to the soil or to yellow nutsedge that is no more than 13 cm tall (Richburg *et al.* 1993). Therefore keeping these points in view, present study was carried out to find out suitable herbicide and their dose for controlling weeds in guar crop**.**

A field experiment was carried out at Bathinda during *Kharif* 2012. The soil of experimental site was sandy loam, medium in available N (275 kg/ha), P (16 kg/ha), K (221 kg/ha), medium in organic carbon content (0.67%) and slightly alkaline in reaction with pH 8.2. The experiment comprised 12 treatment combinations, *viz.* imazethapyr 40 g/ha, imazethapyr +imazamox 40 g/ha, quizalofop-ethyl 37.5 g/ha, fenoxaprop-p-ethyl 50 g/ha, pendimethalin + imazethapyr 750 + 40 g/ha, pendimethalin + (imazethapyr + imazamox 750+40 g/ha, pendimethalin + quizalofop-ethyl 750+37.5 g/ha, pendimethalin + quizalofop-ethyl 750 + 37.5 g/ha, pendimethalin + fenoxaprop-p-ethyl 750+50 g/ha, pendimethalin 750 g/ha, weeding at 3-4 weed leaf stage, weed free and weedy check. These treatments were evaluated in randomized block design with three replications. Cluster bean variety '*AG-112*' was sown 11 July 2012 at 45 x 10 cm row and plant to plant spacing with a seed rate of 20 kg/ha. Crop growth parameters, *viz.* plant height was recorded at 60 DAS. Number of pods per plant,

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hundred seed weight and seed yield were observed at harvest. Weed intensity and dry weight were recorded at 60 DAS stage of crop growth. Weed control efficiency (WCE) was computed on the basis of total dry matter of weeds at 60 DAS stage of crop growth. Phytotoxicity of different treatments on crop in terms of chlorosis, malformed plants, epinasty, hyponasty, necrosis, vein clearing and wilting, *etc*. was visually observed in each plot. The nutrient uptake by crop and weeds (kg/ha) was computed by using the following formula:

Weed intensity: All the weed control treatments resulted significantly less grassy, broad leaf weeds, sedges and total weed intensity as compared to weedy check at 60 DAS (Table 1). Pendimethalin 750 g/ha followed by imazethapyr 40 g/ha resulted significantly less grassy, broad-leaf weeds, and total weed intensity and pendimethalin 750 g/ha followed by imazethapyr + imazamox (Odyssey) 40 g/ha recorded less sedges as compared to other treatments while both these treatments were at par to each at 60 DAS. Imazethapyr 40 g/ha alone resulted in significantly less population of broad-leaf weeds, sedges and total weeds as compared to quizalofop-ethyl 37.5 g/ha, fenoxaprop-p-ethyl 50 g/ha, pendimethalin 750 g/ha, pendimethalin 750 g/ha followed by quizalofop-ethyl 37.5 g/ha and pendimethalin 750 g/ha followed fenoxaprop-p-ethyl 50 g/ha while at par to imazethapyr + imazamox (Odyssey) 40 g/ha and weeding at 3-4 weed leaf stage at 60 DAS. Imazethapyr + imazamox (Odyssey) 40 g/ha recorded less grassy weeds which was at par to imazethapyr 40 g/ha, pendimethalin 750 g/ha followed by quizalofop-ethyl 37.5 g/ha, pendimethalin 750 g/ha followed by fenoxaprop-p-ethyl 50 g/ha and weeding at 3-4 weed leaf stage while significantly higher than quizalofop-ethyl 37.5 g/ha, fenoxaprop-p-ethyl 50 g/ha, pendimethalin 750 g/ha at 60 DAS stage of crop growth.

Weed dry weight: All the weed control treatments significantly reduced dry matter accumulation of grassy, broad-leaf weeds, sedges and total weed dry matter accumulation as compared to weedy check at 60 DAS stage of crop growth (Table 1). Minimum dry matter accumulation of grassy, broad-leaf weeds, sedges and total weed dry weight were recorded with pendimethalin 750 g/ha followed by imazethapyr 40 g/ha and pendimethalin 750 g/ha followed by imazethapyr + imazamox (Odyssey) 40 g/ha which

Table 1. Effect of treatments on weed intensity and dry matter accumulation at 60 DAS

Treatment	Dose g/ha	Weed intensity (no./m^2)				Weed dry matter accumulation (g/m^2)				Weed control efficiency (%)
		Grassy	Broad-leaved	Sedges	Total	Grassy	Broad-leaved	Sedges	Total	
Imazethapyr	40	4.9 (23.5)	3.8 (14.2)	2.5 (5.5)	6.3 (43.2)	6.4 (39.7)	5.2 (28.0)	3.9 (15.7)	8.9 (83.5)	78.6
Imazethapyr +imazamox	40	4.9 (23.7)	4.8 (22.5)	2.8 (7.5)	7.3 (53.7)	6.9 (47.5)	6.1 (40.0)	4.3 (18.0)	10.2 (105)	72.0
Quizalofop-ethyl	37.5	5.8 (33.5)	8.0 (63.5)	2.9 (8.2)	10.3 (106.5)	8.4 (70.7)	11.2 (126)	4.7 (21.5)	14.7 (218)	41.5
Fenoxaprop-p-ethyl	50	7.1 (51.0)	7.9 (62.5)	2.9 (8.0)	11.1 (121.5)	8.3 (68.2)	11.4 (130)	3.8 (15.2)	14.6 (213)	43.0
Pendimethalin + imazethapyr	750+ 40	2.6 (6.5)	2.8 (7.2)	3.3 (10.0)	4.9 (23.7)	4.3 (18.0)	4.0 (15.2)	3.5 (12.2)	6.8 (45.5)	88.0
Pendimethalin + imazethapyr + imazamox	750+ 40	3.2 (10.0)	3.0 (8.2)	3.1 (8.5)	5.1 (26.7)	5.1 (25.0)	3.3 (10.2)	3.9 (14.7)	7.1 (50.0)	86.6
Pendimethalin + quizalofop-ethyl	750+ 37.5	4.2 (17.5)	6.7 (45.2)	3.4 (11.2)	8.6 (74)	6.3 (40.0)	8.8 (78.5)	4.8 (23.0)	11.8 (141)	62.6
Pendimethalin + fenoxaprop-p-ethyl	750+ 50	3.5 (12.0)	6.1 (37.5)	2.8 (7.7)	7.6 (57.2)	5.7 (33.7)	8.3 (69.0)	4.7 (22.0)	11.2 (124)	66.9
Pendimethalin	750	7.2 (52.0)	6.4 (41.2)	3.3 (10.5)	10.2 (103)	9.8 (95.7)	8.3 (70.0)	3.9 (15.0)	13.5 (180)	52.0
Weeding at 3-4 weed leaf stage	-	5.2 (27.2)	3.8 (14.2)	2.7 (7.2)	6.9 (48.7)	7.6 (57.5)	6.7 (45.0)	3.6 (12.7)	10.7 (115)	69.9
Weed free	-	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	100
Weedy	-	11.5 (132)	8.2 (67.5)	4.3 (17.7)	14.7 (218)	14.4 (14.4)	12.1 (12.1)	5.6 (32.2)	19.5 (384)	0.0
LSD (P=0.05)	-	0.75	0.69	0.67	1.25	0.97	1.15	0.78	1.31	4.77

Original values are in parentheses

were at par to each other and significantly superior to other treatments at 60 DAS stage of crop growth. An alone application of imazethapyr 40 g/ha and imazethapyr + imazamox (Odyssey) 40 g/ha resulted significantly less dry matter accumulation of grassy, broad-leaf weeds, sedges and total weed dry weight as compared to quizalofop-ethyl 37.5 g/ha, fenoxaprop-p-ethyl 50 g/ha, pendimethalin 750 g/ha, pendimethalin 750 g/ha followed by quizalofop-ethyl 37.5 g/ha, pendimethalin 750 g/ha followed by fenoxaprop-p-ethyl 50 g/ha and weeding at 3-4 weed leaf stage while at par to each other at 60 DAS stage of crop growth. Results so obtained were in close conformity with the findings of Yadav *et al.* (2011).

Weed control efficiency (WCE): The highest weed control efficiency was recorded under weed free treatment (Table 1). Among other weed control treatments, weed control efficiency was highest under pendimethalin 750 g/ha followed by imazethapyr 40 g/ha which was at par to pendimethalin 750 g/ha followed by imazethapyr +imazamox (Odyssey) 40 g/ha and significantly higher than other treatments of weed control at 60 DAS stage. An alone application of imazethapyr 40 g/ha resulted significantly higher weed control efficiency as compared to quizalofop-ethyl 37.5 g/ha, fenoxaprop-p-ethyl 50 g/ha, pendimethalin 750 g/ha, pendimethalin 750 g/ha followed by quizalofop-ethyl 37.5 g/ha, pendimethalin 750 g/ha followed by fenoxaprop-p-ethyl 50 g/ha and weeding at 3-4 weed leaf stage. Weed control efficiency increased with the application of imazethapyr was also reported by Yadav *et al.* (2011).

Nutrient uptake by weeds: All weed control treatments significantly reduced N, P and K uptake by weeds as compared to weedy check (Table 2). The minimum uptake of N, P and K was observed with pendimethalin 750 g/ha followed by imazethapyr 40 g/ha being at par with pendimethalin 750 g/ha followed by imazethapyr + imazamox 40 g/ha and significantly less than other treatments at harvest stage. Reduced nutrient uptake by weeds under the influence of different weed control measures have also been reported by Chhokar *et al.* (1997) and Yadav *et al.* (2011).

Growth parameters: Imazethapyr, imazethapyr + imazamox, quizalofop-ethyl, fenoxaprop-p-ethyl and pendimethalin at all doses and all combinations did not significantly affected plant height (data not given). At 60 DAS, minimum plant height were observed with imazethapyr 40 g/ha, imazethapyr + imazamox 40 g/ha, pendimethalin 750 g/ha followed by imazethapyr 40 g/ha, pendimethalin 750 g/ha *fb* imazethapyr + imazamox 40 g/ha and pendimethalin 750 g/ha *fb* quizalofop-ethyl 37.5 g/ha although the difference were non- significant to each other and other treatments of weed control.

Yield and yield attributing characters: All weed control treatments significantly increased the yield attributing characters and seed yield of cluster bean over weedy control (Table 2). Maximum numbers of pods per plant were observed with pendimethalin 750 g/ha followed by imazethapyr 40 g/ha and pend-imethalin 750 g/ha followed by imazethapyr + imaz-amox 40 g/ha which were at par with imazethapyr 40 g/ha, imazethapyr 40 g/ha, imazethapyr + imaza- mox 40 g/ha, weeding at 3-4 weed leaf stage and weed free and significantly higher than other treatments of weed control. 100-seed weight was significantly affected by different weed control treatments and highest was observed with pendimethalin 750 g/ha followed by imazethapyr 40 g/ha and pendimethalin 750 g/ha followed by imazethapyr + imazamox 40 g/ha which was at par with imazethapyr 40 g/ha, imazethapyr + imazamox 40 g/ha and significantly higher than quizalofop-ethyl 37.5 g/ha, fenoxaprop-p-ethyl 50 g/ha, pendimethalin 750 g/ha, pendimethalin 750 g/ha followed by quizalofop-ethyl 37.5 g/ha, pendimethalin 750 g/ha followed by fenoxaprop-p-ethyl 50 g/ha, weeding at 3-4 weed leaf stage and weed free. The maximum seed yield was observed with weed free check which was at par with pendimethalin 750 g/ha followed by imazethapyr 40 g/ha and significantly higher than rest of treatments. The increased seed yield with application of imazethapyr in clusterbean by Yadav *et al* (2011).

Phytotoxicity symptoms and crop safety: The application of imazethapyr, imazethapyr + imazamox (Odyssey), quizalofop-ethyl, fenoxaprop-p-ethyl and pendimethalin at all doses and combinations resulted no phytotoxicity symptoms on cluster bean crop at all the stages of crop growth (Table 3). No phytotoxicity symptoms of imazethapyr, quizalofop-ethyl, and pendimethalin did not result any phytotoxicity on guar crop was also reported by Yadav *et al.* (2011).

Economics: The maximum cost of cultivation was observed with weed free treatment (` 24100/ha) (Table 2). The maximum gross return (` 50,401/ha) was observed with weed free which was at par with pendimethalin 750 g/ha followed by imazethapyr 40 g/ha (‘49,150/ha) and significantly higher than other treatment of weed control. The application pendimethalin 750 g/ha followed by imazethapyr 40 g/ha result maximum net return (` 33,118/ha) and B:C ratio (2.07) which was almost significantly higher than other treatments of weed control. Imazethapyr at lower rate 100 g/ha with chlorimuron 24 g/ha also found more remunerative in groundnut as it fetched the maxi-

Table 2. Effect of different weed control treatments on yield and economics of guar and nutrients uptake by weeds and crop at harvest

Treatment	Dose g/ha	Pods/ plants (no.)	100-seed weight (g)	Seed yield (kg/ha)	Gross return (x10^3 `/ha)	Net returns (x10^3 `/ha)	B:C Ratio	Nutrients uptake by weeds (kg/ha)			Nutrients uptake by crop (kg/ha)		
								N	P	K	N	P	K
Imazethapyr	40	71.0	3.1	432.3	43.23	28.47	1.93	4.4 (18.4)	1.8 (2.5)	4.5 (19.6)	99.2	30.0	135.0
Imazethapyr +imazamox	40	71.6	3.1	424.8	42.47	27.42	1.82	4.5 (19.4)	2.1 (3.2)	4.6 (20.9)	98.0	29.1	131.8
Quizalofop-ethyl	37.5	48.0	2.9	339.2	33.92	18.70	1.23	4.8 (22.9)	2.2 (3.7)	4.9 (23.6)	85.3	22.0	122.0
Fenoxaprop-p-ethyl	50	46.5	3.0	306.9	30.70	15.89	1.07	5.1 (25.5)	2.2 (4.0)	5.2 (26.5)	82.4	22.6	119.4
Pendimethalin + imazethapyr	750+ 40	75.5	3.1	491.5	49.15	33.12	2.07	3.7 (13.4)	1.7 (2.1)	3.8 (14.0)	109.5	30.6	141.1
Pendimethalin +(imazethapyr + imazamox)	750+ 40	75.5	3.1	428.7	42.87	26.54	1.62	4.1 (16.1)	1.8 (2.4)	4.2 (16.7)	101.1	28.4	136.5
Pendimethalin + quizalofop-ethyl	750+ 37.5	54.4	2.9	359.5	35.95	19.46	1.18	4.3 (18.0)	2.1 (3.5)	4.4 (18.9)	80.7	19.8	134.9
Pendimethalin + fenoxaprop-p-ethyl	750+ 50	66.2	2.9	335.8	33.58	17.49	1.09	4.7 (21.8)	2.2 (3.7)	4.8 (22.4)	78.6	20.5	133.9
Pendimethalin	750	50.5	2.9	348.5	34.85	19.50	1.27	4.6 (21.0)	2.2 (3.9)	4.7 (21.4)	81.4	15.8	120.7
Weeding at 3-4 weed leaf stage	-	65.1	3.0	357.4	35.74	17.08	0.91	4.4 (18.8)	2.1 (3.3)	4.5 (19.3)	78.8	23.2	122.0
Weed free	-	68.3	2.9	504.0	50.40	26.30	1.09	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	117.5	32.8	142.6
Weedy	-	38.4	2.4	246.2	24.62	10.55	0.75	10.5 (110)	4.1 (15.8)	12.2 (149)	38.8	9.4	42.8
LSD (P=0.05)	-	13.37	0.21	69.92	6.99	3.79	0.24	0.22	0.16	0.26	7.02	3.21	4.04

Original values are in parentheses

Table 3. Residual effect of different weed control treatments on growth parameter, yields attributes and yields of succeeding wheat crop

Treatment	Dose g/ha	Germination (%)	Plant height (cm)	Number of tillers/m^2	Number of spike/m^2	Number of grains/ spike	1000-grain weight (g)	Grain yield (t/ha)
Imazethapyr	40	53.1(63.8)	75	305	298	46	37	5.84
Imazethapyr + imazamox	40	53.8 (65.2)	68	309	278	49	36	5.91
Quizalofop-ethyl	37.5	56.4 (69.4)	73	311	298	45	38	5.78
Fenoxaprop-p-ethyl	50	56.1(68.7)	69	302	300	43	37	5.86
Pendimethalin + imazethapyr	750+40	56.0 (68.7)	76	301	281	46	38	5.71
Pendimethalin + imazethapyr + imazamox	750+40	54.7 (66.6)	73	302	291	48	36	5.90
Pendimethalin + quizalofop-ethyl	750+37.5	55.6 (68.0)	68	320	298	45	38	5.70
Pendimethalin + fenoxaprop-p-ethyl	750+50	52.6 (63.1)	69	310	291	46	39	5.84
Pendimethalin	750	54.3 (65.9)	71	299	290	43	38	5.87
Weeding at 3-4 weed leaf stage	-	55.5 (68.0)	72	306	291	44	37	5.88
Weed free	-	53.8 (65.2)	73	310	281	45	38	5.70
Weedy	-	56.4 (69.4)	70	318	292	48	37	5.79
LSD (P=0.05)	-	NS	NS	NS	NS	NS	NS	NS

Original values are in parentheses

mum values of net monetary returns (`14,096/ha) and benefit: cost ratio (1.8) and surpassed recommended practice of weed control, *viz.* hand weeding twice which recorded the inferior values of net monetary returns (` 10,194/ha) and B: C ratio (1.4) due to more cost of labour.

Nutrient uptake by crop: All the weed control treatments recorded significant increase in N, P and K uptake by the crop compared to weedy check (Table 2). The maximum uptake of N, P and K was observed with weed free treatment at harvest stage. The application of pendimethalin 750 g/ha followed by imazethapyr 40 g/ha result significantly higher uptake of N, P and K which was at par to pendimethalin 750 g/ha followed by imazethapyr + imazamox40 g/ha and almost significantly higher than other treatments of weed control at harvest stage. Similar findings that application of imazethapyr increased uptake of nutrients in guar crop was reported by Yadav *et al.* 2011.

Residual effect on succeeding wheat crop

The application of imazethapyr, imazethapyr + imazamox (Odyssey), quizalofop-ethyl, fenoxaprop-p-ethyl and pendimethalin at all doses and combinations resulted no residual effect on growth, development and yield of succeeding wheat crop (Table 3).

SUMMARY

A field experiment was carried out at Punjab Agricultural University, Regional Research Station, Bathinda during *Kharif* 2012. Pendimethalin 750 g/ha followed by imazethapyr 40 g/ha results minimum weed intensity and weed dry matter accumulation and maximum yield attributes and yield except weed free. The application of pendimethalin 750 g/ha followed by imazethapyr 40 g/ha resulted maximum net return (` 33,118/ha) and b:c ratio (2.07) which was more than other treatments of weed control. Imazethapyr, imazethapyr + imazamox, quizalofop-ethyl, fenoxaprop-p-ethyl and pendimethalin at all doses and combinations resulted no phytotoxicity symptoms on guar crop and no residual effect on succeeding wheat crop.

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