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Research Paper

Weed control in greengram (*Vigna radiata*) and its residual effect on Indian mustard (*Brassica juncea*)

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ABSTRACT

A field experiment was conducted during the rainy (*kharif*) season of 2013 and 2014 at Agricultural Research Station, Swami Keshwanand Rajasthan Agricultural University, Bikaner, Rajasthan to study the effect of pre- and post-emergence application of herbicides on greengram [*Vigna radiata* (L.) R. Wilczek] and their carry over effect on Indian mustard [*Brassica juncea* (L.) Czern. & Coss] during succeeding winter (*rabi*) seasons of 2013–14 and 2014–15. The experiment comprised 10 weed control treatments, viz. pendimethalin 1,000 g/ha (pre-em), imazethapyr 50 g and 70 g/ha (early post-em), imazethapyr + pendimethalin (ready mix) 800, 900, and 1,000 g/ha (pre-em), imazethapyr + imazamox 60 and 70 g/ha (early post-em), 2 hand-weedings at 20 and 40 days after sowing (DAS) and weedy check applied to greengram in randomized block design with 3 replications. Two hand-weedings at 20 and 40 DAS resulted in the lowest weed count of broad-leaf and grassy weeds and weed dry matter at 60 days after sowing. It also recorded significantly the highest number of branches/plant, pods/plant, seeds/pod and seed and straw yields over the other treatments. Among different herbicidal weed-control treatments, the highest weed-control efficiency was recorded with application of imazethapyr + pendimethalin (ready mix) 900 g/ha, and lowest weed index was recorded in imazethapyr + pendimethalin (ready mix) 800 g/ha. Application of herbicides did not cause any adverse effect on succeeding Indian mustard in both the years.

Key words: Greengram, Mustard, Pendimethalin, Residual effect, Weeds

Greengram is one of the major pulse crops in India which is cultivated in arid and semi-arid region. Lack of improved cultural practices, cultivation on marginal and sub-marginal lands of poor fertility, inadequate fertilization, monsoon-dependent cultivation, heavy weed infestation, high sensitivity to pests and diseases, and non-availability of suitable varieties are the major factors responsible for low yield of rainy (*kharif*) pulses including greengram. Traditionally, weeds in greengram are controlled by manual weeding and hoeing at appropriate growth stages. Manual weeding is time-consuming and expensive and often not possible due to intermittent rains during rainy season. In the era of reduced drudgery labour is also becoming scarce, not available in time and expensive to further increase the cost of cultivation. Under such a situation, use of appropriate herbicide with suitable dose remains the pertinent choice for timely control of weeds.

Keeping in view the diverse weed flora, no single herbicide provides desired weed control, hence, herbicide mixtures or sequential use of herbicides may be more effective. Several workers have reported the effect of pendimethalin and imazethpyr on weed control and productivity of greengram/ pulses (Kaur *et al.*, 2010). These herbicides are reported to have long persistence in soil (Das, 2008) and therefore, the knowledge of their residual effect on succeeding crop in a crop sequence is essential before making any recommendation for the growers. Greengram–Indian mustard is a common crop rotation in semi-arid north-western region of India. The present study was, therefore, conducted to study the effect of pre- and early post-emergence herbicides on weed management in greengram and its carry-over effect on succeeding Indian mustard.

MATERIALS AND METHODS

A field study was conducted during the rainy (*kharif*) season of 2013 and 2014 at the research farm of Agricultural Research Station, Swami Keshwanand Rajasthan Agricultural University, Bikaner, Rajasthan. The treatments comprised pre-emergence application of pendimethalin at 1,000 g/ha and imazethapyr + pendimethalin at 800, 900 and 1,000 g/ha, post-emergence

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application of imazethapyr (ready mix/company made) at 50 and 70 g/ha, imazethapyr + imazamox (ready mix) at 60 and 70 g/ha and compared 2 hand-weedings at 20 and 40 days after sowing (is also considered as weed free at the time of calculating weed index) and weedy check in greengram. These treatments were evaluated in a randomized block design with 3 replications. The soil of experimental site was loamy sand having 0.08% organic carbon, 8.22 *p*H, 78, 22 and 210 kg/ha available N, P and K respectively. Greengram 'SML 668' was sown on 18 July 2013 and 16 July 2014 at 30 cm row- to -row spacing using seed rate of 20 kg/ha and was harvested on 11 October 2013 and 10 October 2014 respectively. Recommended dose of fertilizers (20 kg N + 40 kg P_2O_5 + 40 kg K_2O/ha) was applied basal. Pre-emergence application of pendimethalin and imazethapyr + pendimethalin was done on the next day of sowing, whereas the post-emergence application of imazethapyr and imazethapyr + imazamox was made at 25 DAS (3–4-leaf stage) as per the treatments with knap-sack sprayer. Weed density was recorded by using quadrate of 0.25 m^2 at 60 DAS in all the treatments and then converted into number of weeds/m^2. The weeds were dried in oven till a constant weight was observed and then converted into g/m^2 . The data on total weed count and weed dry matter were subjected to square-root transformation to normalize their distribution (Gomez and Gomez, 1984). Weed-control efficiency was calculated on the basis of transformed values of total weed dry weight. The residual effect of different herbicides applied in greengram was studied on the succeeding Indian mustard. In case of Indian mustard, plant population/unit area, plant height and yields were recorded at maturity.

RESULTS AND DISCUSSION

Effect on weeds

The experimental field was infested with *Amaranthus spinosus* L., *Digera arvensis* Forssk., *Trianthema portulacastrum* L., *Gisekia poedious, Mollugo verticillata* L., *Euphorbia hirta* L., *Aristida depressa* Retz., *Portulaca oleracea* L., *Cenchrus biflorus Roxb., Cleome viscose* L., *Tribulus terrestris* L., *Corchorus tridense* L., *Cyperus rotundus* L., *Eleusine verticillata* Roxb. and *Eragrostis tennela* (L.) P. Beauv. during the 2 seasons of experimentation.

The density of both broad-leaf and grassy weeds and their total dry weight recorded at 60 DAS were significantly reduced by all the weed-control treatments compared to weedy check (Table 1). However, 2 hand-weedings recorded the lowest number of broad-leaf, grassy and total weeds compared to rest of the weed-control treatments. Among different herbicides, pre-emergence application of imazethapyr + pendimethalin 1,000

Table 1. Effect of weed-control measures on weed count, weed dry weight, weed-control efficiency and weed index in greengram (pooled data of 2 years)

Treatment	Dose (g/ha)	Application time	Weed count (No./m^2) at 60 DAS			Weeds dry weight (g/m^2) at 60 DAS	Weed control efficiency (%)	Weed index (%)
			Broad leaf	Grassy	Total			
Pendimethalin	1,000	–	5.47 (29.46)	0.81 (0.17)	5.49 (29.63)	5.75 (32.5)	21.2	17.1
Imazethapyr	50	3–4-leaf stage	3.58 (12.55)	1.99 (3.45)	4.04 (15.99)	3.68 (14.8)	49.6	15.8
Imazethapyr	70	3–4-leaf stage	2.62 (6.41)	1.63 (2.16)	3.01 (8.57)	1.94 (3.3)	73.4	17.2
Imazethapyr + pendimethalin	800	–	1.56 (2.08)	0.71 (0.00)	1.56 (2.08)	1.07 (0.7)	85.3	3.7
Imazethapyr + pendimethalin	900	–	1.37 (1.40)	0.71 (0.00)	1.37 (1.40)	0.90 (0.3)	87.7	5.2
Imazethapyr + pendimethalin	1,000	–	0.98 (0.47)	0.71 (0.00)	0.98 (0.47)	1.28 (1.3)	82.5	6.1
Imazethapyr + imazamox	60	3–4-leaf stage	2.16 (4.20)	0.99 (0.49)	2.27 (4.68)	2.63 (6.7)	64.0	16.1
Imazethapyr + imazamox	70	3-4-leaf stage	1.56 (1.92)	0.71 (0.00)	1.56 (1.92)	1.13 (0.8)	84.5	17.1
2 hand-weedings	–	20 and 40 DAS	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.0)	90.3	–
Weedy check	–	–	7.81 (60.56)	2.29 (4.80)	8.11 (65.36)	7.30 (52.9)	–	31.8
SEm±	–	–	0.63	0.09	0.23	1.69	–	–
CD (P=0.05)	–	–	1.46	0.21	0.53	3.91	–	–

Original values are in parentheses, n+0.5 square root transformation; DAS, days after sowing

g/ha was the most effective in reducing the density of both broad-leaf and grassy weeds and total dry weight of weeds, followed by its lower doses (imazethapyr + pendimethalin 900 g/ha and 800 g/ha) and application of imazethapyr + imazamox 60 g/ha and 70 g/ha (Table 1). Application of pendimethalin 1,000 g/ha as pre-emergence was effective against grassy weeds, whereas imazethapyr 50 g and imazethapyr 70 g were at par and significantly reduced the density of broad-leaf weeds as compared to weedy check. Pendimethalin is a versatile pre-emergence herbicide which is rapidly absorbed by germinating weeds and inhibits cell-division and cell elongation in the root and shoot meristems of the susceptible plants/weeds. The growth of susceptible plants/ weeds is inhibited directly following absorption through hypocotyls and shoot region. The present results confirm the findings of Yadav *et al.* (2011).

Imazethapyr and imazethapyr + imazamox are imidazolinone herbicide which are absorbed both by the roots and the shoots, and can effectively control a broad spectrum of weeds (Saltoni *et al.*, 2004). These inhibit the plastid enzyme acetolactate syntheses (ALS) in plants which catalyses the first step in the biosynthesis of essential branched chain amino acids (valine, leucine, isoleucine). The ALS inhibitors thus stop cell-division and reduce carbohydrate translocation in the susceptible plants (Das, 2008). Imazethapyr and imazethapyr + imazamox are selective herbicides and are applied as post-emergence with a view to control late-emerging weeds. Results of weed density corroborate with the findings of Sasikala *et al.* (2007) and Singh *et al*. (2017). Reduction in both density and dry weight of grassy weeds with application of imazethapyr + imazamox might be due to the more effectiveness of imazamox against grassy and thick broad-leaf weeds. Hand-weeding twice removed the weeds completely and created conditions which were more favourable for crop growth, and ultimately resulted in the lowest density of later-emerged weeds and their lowest biomass during the crop-growth period. The results confirm the findings of Punia *et al.* (2011). Lower density of weeds by imazethapyr + pendimethalin in reducing weed dry matter may be ascribed to broad-spectrum activity of herbicidal combination, particularly on emergence of both broad-leaf and grassy weeds and its greater efficiency to retard cell-division of meristems causing rapid drying of weeds. In earlier study, Kanter *et al.* (1999) reported about 84.6% control of weed biomass with application of imazethapyr in chickpea. Papierniks *et al.* (2003) also reported that, imazethapyr application inhibited acetohydroxy acid synthase and the synthesis of branched chain amino acids and was effective for weed control in legumes. The highest weed-control efficiency was recorded with application of imazethapyr + pendimethalin (ready mix) 900 g/ha and the lowest weed index was recorded in imazethapyr + pendimethalin (ready mix) 800 g/ha.

Effect on greengram

All weed management options resulted in significant increase in number of branches/plant over the weedy check (Table 2). The highest number of branches/plant recorded with 2 hand-weedings was at par with all the doses of imazethapyr + pendimethalin (800, 900 and 1,000 g/ha). This might be owing to better availability of resources to the crop in absence of weeds. The lowest number of branches/plant under recorded under weedy check might be due to severe competition by weeds to crop for resources.

Table 2. Effect of weed-control measures on yield attributes, yields and economics of greengram (pooled data of 2 years)

Treatment	Dose (g/ha)	Application time	Branches/ plant	Pods/ plant	Seeds/ pod	1,000-grains weight (g)	Yield (kg/ha)		Net returns (₹/ha)	Benefit: cost ratio
							Seed	Straw (₹/ha)		
Pendimethalin	1,000	–	3.22	54.44	4.19	24.37	749	1,451	19,970	2.20
Imazethapyr	50	3–4-leaf stage	3.03	53.49	3.81	24.25	760	1,502	20,881	2.29
Imazethapyr	70	3–4-leaf stage	3.11	55.20	3.91	24.11	748	1,502	20,012	2.21
Imazethapyr + pendimethalin	800	–	3.59	62.87	4.61	24.83	870	1,613	25,203	2.47
Imazethapyr + pendimethalin	900	–	3.52	60.92	4.45	24.75	856	1,541	24,227	2.40
Imazethapyr + pendimethalin	1,000	–	3.44	59.65	4.36	24.70	848	1,546	23,672	2.35
Imazethapyr + imazamox	60	3–4-leaf stage	3.32	54.47	4.05	24.29	758	1,497	21,411	2.37
Imazethapyr + imazamox	70	3–4-leaf stage	3.30	55.54	3.95	24.40	749	1,495	20,946	2.33
2 hand-weedings	–	20 and 40 DAS	3.77	63.37	4.76	25.09	903	1,546	25,903	2.46
Weedy check	–	–	2.78	42.30	3.53	23.70	616	1,157	15,226	2.03
SEm±	–	–	0.11	2.68	0.10	0.81	22	27	–	–
CD (P=0.05)	–	–	0.32	7.70	0.29	NS	64	81	–	–

The number of pods/plant, seeds/pod and seed and straw yields were significantly increased under various weed-control treatments as compared to weedy check (Table 2) and the effect was more pronounced with 2 hand-weeding treatment, closely followed by pre-emergence application of imazethapyr + pendimethalin (800, 900 and 1,000 g/ha) and pendimethalin (1.0 kg/ha). This was attributed to minimum infestation of weeds and consequently lesser competition for growth resources. The results corroborate with the findings of Singh *et al.* (2006) and Yadav *et al.* (2014). Reduced crop-weed competition during critical phase of crop growth better regulates the complex process of yield formation owing to better availability of resources to the crop plant. Reduced crop-weed competition under different weed-control treatments might have influenced the 'source' by virtue of higher photosynthetic and metabolic activity which in turn improved growth and consequently yield components of crop. The adverse effect of weed competition under present investigation is clearly reflected under weedy check wherein dense population of weeds reduced crop growth compared to 2 hand-weedings treatment as well as other treatments and ultimately resulted in reduced number of pods/plant and seeds/pod. Among different treatments, application of imazethapyr + pendimethalin 800 g/ha resulted in higher seed and straw yields over weedy check and was at par with its higher doses and 2 hand-weedings (Table 2). Kanter *et al.* (1999) observed 63.6% higher seed yield of chickpea over unweeded check with application of imazethapyr. The reduced crop-weed competition caused significant increase in growth characters and yield, and ultimately led to the higher seed yield of greengram. The significant improvement in seed as well as straw yield as a result of 2 hand-weedings and all herbicidal weed-control treatments could be ascribed to the fact that yield of crop depends on several yield components which are interrelated. Under weedy situation, at early crop growth stage a greater part of resources present in soil and environment were depleted by weeds for their growth. The crop plant thus, faced stress which ultimately affected its growth, development and yield. Upadhayay *et al.* (2013) also reported similar results in soybean .

Economics

All weed-control treatments recorded higher net returns and benefit: cost ratio over the weedy check (Table 2). However, the highest net returns and benefit: cost ratio were obtained with 2 hand-weedings. Among different herbicidal treatments, application of imazethapyr + pendamethalin 800 g recorded the highest mean net returns (₹25,203/ha) and benefit: cost ratio (2.47), closely followed by its higher doses. Among other treatments, imazethapyr + imazemox 60 g/ha resulted in higher net returns (₹21,411/ha), with a benefit: cost ratio of 2.37 despite the higher cost involved. The higher seed yield recorded with this treatment might be responsible for higher net returns. These findings are in close vicinity with those reported by Yadav *et al.* (2014).

Residual effect on succeeding Indian mustard

Different weed-management practices or application of different herbicides applied to greengram did not cause any adverse effect on plant population, plant height and yield of succeeding mustard crop on pooled mean of 2 years (Table 3).

From the present investigation, it can be concluded that all the weed control treatments are almost equally important in controlling weeds and improving crop yield. Imazethapyr + pendamethalin 800 g/ha was superior to all with respect to yield, yield attributes and monitory returns.

Table 3. Residual effect of weed-control measures applied in greengram on succeeding Indian mustard (pooled data of 2 years)

Treatment	Dose (g/ha)	Application time	Plant stand/m row length at maturity	Plant height at maturity (cm)	Seed yield (kg/ha)	Straw yield (kg/ha)
Pendimethalin	1,000	–	7.34	149.7	1,082	2,337
Imazethapyr	50	3–4-leaf stage	7.84	151.0	1,072	2,330
Imazethapyr	70	3–4-leaf stage	8.34	151.1	1,047	2,119
Imazethapyr + pendimethalin	800	–	7.84	149.8	1,030	2,091
Imazethapyr + pendimethalin	900	–	8.34	150.4	1,023	2,084
Imazethapyr + pendimethalin	1,000	–	7.67	150.8	1,014	2,034
Imazethapyr + imazamox	60	3–4-leaf stage	7.67	152.6	1,045	2,073
Imazethapyr + imazamox	70	3–4-leaf stage	8.17	152.8	1,027	2,011
2 hand-weedings	–	20 and 40 DAS	7.50	150.4	1,073	2,121
Weedy check	–	–	7.83	149.5	1,027	2,038
SEm±	–	–	0.43	0.86	22	47
CD (P=0.05)	–	–	NS	NS	NS	NS

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