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Research Communication

Effect of sequential application of herbicides on weed control indices and productivity of rainy-season greengram (*Vigna radiata*) in north Indian plains

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ABSTRACT

A field experiment was conducted at New Delhi during rainy season (July–October) of 2013, to determine the effect of sequential application of herbicides on weed growth and weed- control indices, productivity and profitability of greengram [*Vigna radiata* (L.) Wilczek]. The experiment had 12 weed-control treatments, viz. pendimethalin @ 1 kg/ha pre-emergence (PE), pendimethalin @ 1 kg/ha PE followed by (fb) 1 hand-weeding (HW) at 30 days after sowing (DAS), pendimethalin @ 0.75 kg/ha PE fb imazethapyr @ 50 g/ha post-emergence (PoE) at 30 DAS, pendimethalin @ 0.75 kg/ha PE fb imazethapyr @ 75 g/ha PoE at 30 DAS, imazethapyr @ 50 g/ha PoE at 20 DAS, imazethapyr @ 75 g/ha at PoE at 20 DAS, pendimethalin @ 0.75 kg/ha PE fb quizalofop @ 50 g/ha PoE at 30 DAS, pendimethalin @ 0.75 kg/ha PE fb quizalofop @ 75 g/ha PoE at 30 DAS, quizalofop @ 50 g/ha PoE at 20 DAS, quizalofop @ 75 g/ha PoE at 20 DAS, weed free and weedy check. The treatments were randomly allocated in a randomized complete block design with 3 replications. The sequential application of herbicides was found to be more effective than their 1 time application in decreasing weed dry weight. pendimethalin @ 1 kg/ha PE fb 1 HW at 30 DAS resulted in the highest seed yield (1.1 t/ha), weed-control efficiency (75.2%), herbicide-efficiency index (4.5%), benefit: cost ratio (2.91), net return (₹41,167/ha) and lowest weed dry weight (6.0 g/m^2) and weed index (8.3%). However, this treatment did not differ significantly from pendimethalin @ 0.75 kg/ha PE fb imazethapyr @ 75 g/ha PoE at 30 DAS indicating that sequential application of herbicides could be an efficient option to manage weeds in greengram, particularly under labour-constrained conditions.

Key words: Greengram, Herbicide, Sequential application, Weed management

Greengram is the third most important pulse crop in India. In the country, it is cultivated on 3.77 million ha (mha), producing 1.52 million tonnes (mt) of grain annually with a very low productivity of 0.4 t/ha (DAC, 2013). Considering the shortage of pulses in the country productivity of this crop needs to be increased, but weeds cause severe yield losses in greengram ranging from 30 to 85% depending on type of weeds, variety, season, soil type, rainfall and duration and time of weed competition (Malik *et al*., 2000; Punia *et al*., 2004). Weed infestation is severe in the rainy season due to continuous rains and slow initial growth of crop. Greengram is more sensitive to weed competition in the first 4–5 weeks after emergence (Kumar *et al.*, 2005). Pre-emergence application of herbicides, such as, pendimethalin is effective in reducing weed growth only during initial growth period, but crop suffers considerably during later part of the crop growth. Thus, late-season emerging weeds need to be controlled effectively to achieve higher yield of greengram. Sequential application of pendimethalin and imazethapyr has been found useful in blackgram (Rao *et al*., 2010) which is quite akin to greengram. Hence present study was conducted to determine the effect of sequential application of herbicides on weed suppression and productivity and profitability of greengram under north Indian plains condition.

The field experiment was conducted during the rainy (*kharif*) season of 2013 at the ICAR–Indian Agricultural Research Institute, New Delhi, (28° 38'23" N, 77° 09'27" E, 228.6 m above mean sea-level). Soil of the experimental field was sandy loam, slightly alkaline (*p*H 7.6), with electric conductivity of 0.32 dS/m, low in organic C (0.38%), medium in available K (260 kg/ha), and low in available P (9.2 kg/ha) and available N (259 kg/ha). The crop received 469.6 mm precipitation in 27 rainy days during the crop season. Although a sufficient rainfall occurred during

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crop period, irrigations were given during long dry spells. The mean maximum temperature was 32.8°C, while the mean minimum temperature 20.85°C during the crop growth. This field experiment had 12 weed-control treatments including pendimethalin @ 1 kg/ha pre-emergence (PE), pendimethalin @ 1 kg/ha PE followed by (fb) 1 hand-weeding (HW) at 30 days after sowing (DAS), pendimethalin @ 0.75 kg/ha PE fb imazethapyr @ 50 g/ha at 30 DAS, pendimethalin @ 0.75 kg/ha PE fb imazethapyr @ 75 g/ha at 30 DAS, imazethapyr @ 50 g/ha at 20 DAS, imazethapyr @ 75 g/ha at 20 DAS, pendimethalin @ 0.75 kg/ha PE fb quizalofop @ 50 g/ha at 30 DAS, pendimethalin @ 0.75 kg/ha PE fb quizalofop @ 75 g/ha at 30 DAS, quizalofop @ 50 g/ha at 20 DAS, quizalofop @ 75 g/ha at 20 DAS, weed-free condition and weedy check laid-out in a randomized complete block-design with 3 replication. A uniform recommended dose of 30 kg N/ha and 26 kg P/ha through diammonium phosphate and 40 kg K/ha through muriate of potash was applied basal. In this experiment 'Pusa Ratna' cultivar of greengram was used. The crop was sown in lines, spaced 30 cm apart, using a seed rate of 15 kg/ha. Depth of seeding was kept as 3–4 cm. The crop was sown manually on 31 July 2013. Herbicides were applied with the help of a manually-operated knapsack sprayer fitted with flat-fan nozzle at spray volume of 500 litres/ha. The crop was sprayed with dimethoate (Rogor) to control insect-pest particularly white flies (*Bemisia tabaci*), the vector for yellow mosaic virus. In all, 3 sprays were done as and when early symptoms of white flies were noticed. Data on weeds were recorded at 50 DAS in 2 quadrates (0.25 m^2) from 2 randomly selected spots in individual plots. Weeds were counted species-wise and were cut from the base for recording their total dry weight and then converted into per square metre. Weed samples were sun-dried before oven drying at 70°C until constant weight was obtained. Data on weed dry weight were subjected to square-root transformation before statistical analysis to normalize their distribution. Weed-control efficiency (WCE), weed index (WI) and herbicide efficiency index (HEI) were calculated using the standard formulae. The experimental crop was finally harvested on 15 October 2013 after taking 3 picking of pods. The crop was sun-dried for 3 days and manual threshing was done separately for each experimental plot. The yield from all the pickings and finally harvested and threshed crop was combined to arrive at yield/ha. Economics of the treatments was computed taking into account the prevailing market prices of inputs and crop outputs. The analysis of variance of data under randomized block design was carried out using SAS 9.2 software and treatments were compared by computing 'F-test'. LSD values at P=0.05 were used to determine the significance of differences between treatment means.

Different weed-control treatments exhibited a significant influence on seed, stover yield and harvest index (Table 1). The weed-control treatments pendimethalin @ 1 kg/ha PE fb 1 HW at 30 DAS resulted in the highest seed (1.1 t/ha) and stover yields (1.85 t/ha). Raman and Krishnamoorthy (2005) also reported that pre-emergence application of pendimethalin at 1.0 kg/ha fb 1 HW at 20–30 DAS was most effective method in controlling weeds and resulted in the highest seed yield of greengram. Malik *et al.* (2005) also reported that application of pendimethalin at 1.5 kg/ha fb 1 HW at 30 DAS resulted in higher greengram seed yield than pendimethalin at 1.5 kg/ha or 1 HW at 30 DAS alone. Among sequential herbicide application treatments, pendimethalin @ 0.75 kg/ha PE fb imazethapyr @ 75 g/ha at 30 DAS recorded higher seed and stover yields, but was found at par with rest of the sequential application treatments. The highest value of harvest index was recorded with pendimethalin @ 1 kg/ha PE, which was however, closely at par with all the treatments, barring the treatments involving sequential application of herbicides. Harvest index was the lowest in weedy check plot. The higher seed and stover yields in treatments involving sequential application of herbicides, pre-emergence application of herbicides fb 1 HW and weed-free conditions could be owing to better weed control which ultimately increased the values of yield attributes. Chhodavadia *et al*. (2013) also reported the similar findings.

Minimum weed index was recorded with pendimethalin @ 1 kg/ha PE fb 1 HW at 30 DAS which was followed by pendimethalin @ 0.75 kg/ha PE fb imazethapyr @ 75 g/ha @ 30 DAS (15%). The major weed flora in the experimental field included *Cyperus rotundus* L., *Digitaria sanguinalis* (L.) Scop, *Dactyloctenium aegyptium* (L.) P. Beauv., *Trianthema portulacastrum* L. and *Digera arvensis* Forsk. These 5 species were more or less evenly spread in almost all the parts of the experimental area. Among the herbicide treatments, the lowest weed dry weight was recorded with pendimethalin @ 1 kg/ha PE fb 1 HW at 30 DAS that was closely similar to weed dry matter found in plots treated with pendimethalin @ 0.75 kg/ha PE fb imazethapyr @ 75 g/ha @ 30 DAS. This could likely be due to inhibition of germination as well as growth of weeds owing to paralysis of vital metabolic processes like cell-division, protein synthesis etc. The weed-control efficiency (WCE) and herbicide-efficiency index (HEI) were the highest under pendimethalin @ 1 kg/ha PE fb 1 HW at 30 DAS and pendimethalin @ 0.75 kg/ha PE fb imazethapyr @ 75 g/ha @ 30 DAS was the next best treatment. This may have occurred due to the fact that initial weed growth was sup-

Table 1. Effect of weed-control treatments on seed yield, stover yield, harvest index, weed index and weed dry weight, weed-control efficiency, herbicide-efficiency index, and economics of greengram

Treatment	Seed yield (t/ha)	Stover yield (t/ha)	Harvest index (%)	Weed index (%)	Total weed dry weight (g/m^2)	Weed-control efficiency (%)	Herbicide-efficiency index (%)	Gross returns (× 10^3 ₹/ha)	Net returns (× 10^3 ₹/ha)	Benefit: cost ratio
Pendimethalin @ 1 kg/ha pre-emergence (PE)	0.79	1.25	38.7	34.2	11.5 (131.0)	33.7	0.89	37.4	23.9	1.77
Pendimethalin @ 1 kg/ha PE fb 1 HW (30 DAS)	1.10	1.85	37.3	8.3	6.0 (35.8)	75.2	4.57	52.2	41.1	2.91
Pendimethalin @ 0.75 kg/ha PE fb imazethapyr @ 50 g/ha (30 DAS)	0.99	1.77	35.9	17.5	8.4 (70.0)	68.6	2.15	47.2	33.3	2.40
Pendimethalin @ 0.75 kg/ha PE fb imazethapyr @ 75 g/ha (30 DAS)	1.02	1.80	36.2	15.0	8.0 (64.0)	68.7	2.41	48.6	34.6	2.49
Imazethapyr @ 50 g/ha (20 DAS)	0.77	1.25	38.1	35.8	10.1 (101.6)	57.6	1.11	36.5	23.3	1.78
Imazethapyr @ 75 g/ha (20 DAS)	0.80	1.37	36.9	33.3	9.7 (93.1)	60.6	1.28	38.0	24.8	1.88
Pendimethalin @ 0.75 kg/ha PE fb quizalofop @ 50 g/ha (30 DAS)	0.89	1.70	34.4	25.8	8.7 (75.7)	58.1	1.79	42.6	28.7	2.07
Pendimethalin @ 0.75 kg/ha PE fb quizalofop @ 75 g/ha (30 DAS)	0.93	1.75	34.7	22.5	8.2 (67.1)	61.7	2.12	44.4	30.5	2.19
Quizalofop @ 50 g/ha (20 DAS)	0.71	1.15	38.2	40.8	10.3 (105.7)	34.5	0.93	33.6	20.5	1.56
Quizalofop @ 75 g/ha (20 DAS)	0.75	1.27	37.1	37.5	10.0 (100.1)	36.0	1.08	35.6	22.4	1.70
Weed-free	1.20	2.05	36.9	0.0	0.7 (00)	100	-	57.0	40.4	2.43
Weedy check	0.46	1.00	31.5	61.7	16.9 (281.8)	00	-	22.2	9.5	0.75
SEm±	0.04	0.05	0.6	2.3	0.2	1.8	0.30			
CD (P=0.05)	0.11	0.16	1.8	6.8	0.6	3.5	0.90			

PE, Pre-emergence; DAS, days after sowing; fb, followed by; HW, hand-weeding

Weed dry weight data were subjected to $(\sqrt{x + 0.5})$ transformation before statistical analysis. Figures in parentheses are the original values

pressed by the injurious effect of pre-emergence herbicide and subsequent grassy weed flushes were controlled by the PoE application of imazethapyr at 30 DAS. The lowest WCE and HEI were recorded with pendimethalin @ 1 kg/ha PE that were, however, at par with the WCE and HEI recorded in quizalofop @ 50 g/ha and quizalofop @ 75 g/ha @ 20 DAS treatments. Dubey *et al.* (2012) reported similar results of higher WCE of imazethapyr. Among different weed-control treatments, pendimethalin @ 1 kg/ha PE fb 1 HW at 30 DAS fetched the highest net monetary returns and benefit : cost ratio closely followed by pendimethalin @ 0.75 kg/ha PE fb imazethapyr @ 75 g/ha at 30 DAS.

The results of study indicate that pre-emergence application of pendimethalin @ 1 kg/ha fb 1 HW at 30 DAS and pendimethalin @ 0.75 kg/ha PE fb imazethapyr @ 75 g/ha @ 30 DAS were equally effective in managing weeds and improving greengram productivity, and thus, sequential application of herbicides can be an efficient option in controlling weeds in greengram, particularly under labour-scarce conditions.

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