

Integrated weed management in lentil (*Lens culinaris*) in calcareous alluvial soils of Bihar

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ABSTRACT

A field experiment was conducted during the winter (*rabi*) season of 2012–13 and 2013–14, to study the effect of integrated weed management on weeds, nutrient removal and seed yield of lentil (*Lens culinaris* Medikus) on calcareous alluvial soils of Bihar. The experiment was laid out in a randomized block design comprising of nine weed control treatments with four replications. The results revealed that lesser weed density, weed dry matter, higher weed control efficiency and lower weed index were observed under integrated weed management (IWM) practices of pendimethalin 300 g/ha as pre-emergence (PRE) + hand weeding (HW) at 40 days after sowing (DAS) and with ready mixed application of pendimethalin 205 g/ha + imazethapyr 14 g/ha as PRE. Higher crop growth, seed yield and yield attributing characters were found with the integrated treatment of pendimethalin 300 g/ha as PRE + HW at 40 DAS and pendimethalin 205 g/ha + imazethapyr 14 g/ha as PRE. The higher net returns and benefit: cost ratio was acquired with pendimethalin 205 g/ha + imazethapyr 14 g/ha as PRE.

Key words: Herbicide, Integrated weed management, Lentil, Nutrient removal by weeds

In India, lentil is grown under irrigated as well as rainfed conditions in almost all the states during winter (*rabi*) season, but major area lies in Madhya Pradesh, Uttar Pradesh, Bihar and West Bengal. In India, lentil is grown on about 1.6 m ha area with production of 1.07 million tonnes and the productivity is 678 kg/ha. The major constraint that limits the lentil productivity is severe weed infestation. The seed yield losses due to weed infestation may vary from 20 to 30% and even increase up to 50%, if the weed management practices are not properly followed (Tanveer and Ali, 2003). The extent of yield reduction depends on the nature of crop, weed species, their density and duration of competition with the crop. In lentil, first 60 days are considered critical period for crop–weed competition (Erman *et al.*, 2008). Since weeding in India is commonly done by manually; unavailability of labour at critical time and higher cost, herbicides are considered to be an alternative to hand-weeding. Hence present investigation was carried to evaluate the influence of different integrated weed-management (IWM) practices on weed emergence,

weed growth, nutrient removal by weeds and yield of lentil.

MATERIALS AND METHODS

A field experiment was carried out on ‘KLS 218’ lentil during winter (*rabi*) seasons of 2012–13 and 2013–14 at Tirhut College of Agriculture, Rajendra Agricultural University, Dholi, (52.18 m, 25.98° N and 85.60° E), Bihar. The soil was calcareous alluvial, sandy loam, slightly alkaline (pH 7.4), low in available N (182.5 kg/ha) and medium in available P (16.6 kg/ha) and available K (122.3 kg/ha). Treatment comprised of different pre-plant incorporation (PPI), pre-emergence (PRE) and post-emergence (POE) herbicides, integration of PRE herbicide with manual weeding, ready-mix PRE herbicides, and 2 hand-weeding and weedy check for comparison. Total 9 treatments, viz. quizalofop-ethyl 50 g/ha at 30 DAS, imazethapyr 37.5 g/ha at 30 DAS, chlorimuro-ethyl 4 g/ha as pre-plant incorporation, pendimethalin 300 g/ha as pre-emergence, ready-mix of pendimethalin 154 g/ha + imazethapyr 10.5 g/ha (Valor) as pre-emergence, ready-mix pendimethalin 205 g/ha + imazethapyr 14 g/ha (Valor) as pre-emergence, pendimethalin 300 g/ha as pre-emergence + hand-weeding at 40 DAS, twice hand-weeding at 20 and 40 DAS and weedy check, were assigned in randomized block design with 4 replications. Lentil was

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sown during in the second week of November each year with a seed rate of 35 kg/ha as line sowing with 30 cm-row-spacing. An uniform dose of 20 kg N/ha, 50 kg P₂O₅/ha and 20 kg K₂O/ha was applied through, dia-ammonium phosphate and muriate of potash. Spraying of herbicides was done with the help of manually operated knapsack sprayer fitted with flat-fan nozzle by using spray volume of 500 litres/ha. The crop was grown with standard package of practices for the region. The weed density and dry-matter were recorded at 30 and 60 DAS using a quadrat of 50 cm × 50 cm randomly placed at 3 places in each plot, while weed-control efficiency (WCE) and nutrient removal by weeds were observed at 60 DAS. The data of actual weed population and dry weight were transformed by square-root transformation ($\sqrt{x + 0.5}$) due to high variance for statistical analysis. The observations on plant height and growth were collected at the time of harvest. Observations were recorded for different characters and mean values were subjected to pooled analysis. The combined analysis of 2 years revealed that the year effect was non-significant, and the mean data of 2 years were analyzed. The statistical analysis of data was done using SAS Windows Version 9.3.

RESULTS AND DISCUSSION

Weeds

The predominant weed flora recorded were *Cynodon dactylon* (L.) Pers. (1.96 and 2.44%) among grass, *Cyperus rotundus* L. (19.17 and 13.84%) among sedges; and *Anagallis arvensis* L. (5.53 and 4.70%), *Cannabis sativa* L. (8.72 and 7.62%), *Chenopodium album* L. (13.19 and 16.44%) and *Parthenium hysterophorus* L. (8.69 and 9.00%) among broad-leaf weeds.

The density of grasses at 30 DAS was effectively controlled with pre-plant incorporation of chlorimuron-ethyl 4 g/ha as compared to the other herbicides (Table 1). Behera *et al.* (2005) also reported that chlorimuron was more effective when applied before sowing. The PPI and PRE herbicides did not show any significant effect to suppress the sedges density at 30 DAS. However, these herbicides effectively reduced the germination of broad leaf weeds at early crop-growth stage. The application of pendimethalin + imazethapyr and pendimethalin as pre-emergence performed better in reducing the density of total weeds at 30 DAS as compared to PPI application of chlorimuron-ethyl. The application of POST herbicides drastically reduced the grassy weed population during 30–60 DAS of crop growth period than the other herbicidal treatments. Punia *et al.* (2011) also found similar results with imazethapyr spray. Integrated weed management with pendimethalin 300 g/ha as PRE + hand-weeding (HW) at 40 DAS significantly reduced the density of sedges at 60

Table 1. Effect of weed-management practices on weed density at different growth stages of lentil (pooled data of 2 years)

Treatment	Weed density (Nos./m ²)							
	At 30 DAS			At 60 DAS				
	Grasses	Sedges	Broad leaf	Total	Grasses	Sedges	Broadleaf-weeds	Total
Quizalofop-ethyl 50 g/ha at 30 DAS	2.46 (5.55)*	7.39 (54.10)	11.20 (124.80)	17.31 (299.10)	1.83 (2.85)	7.06 (48.90)	13.64 (185.60)	12.08 (145.40)
Imazethapyr 37.5 g/ha at 30 DAS	2.40 (5.26)	7.08 (49.60)	10.77 (115.50)	17.11 (292.30)	1.81 (2.78)	6.96 (47.90)	13.69 (187.00)	11.47 (131.10)
Chlorimuron-ethyl 4 g/ha as PPI	1.79 (2.70)	7.40 (54.30)	7.65 (58.00)	14.08 (197.80)	2.24 (4.52)	6.82 (46.00)	12.63 (158.90)	14.62 (213.20)
Pendimethalin 300 g/ha as PRE	2.31 (4.84)	7.30 (52.80)	6.38 (40.20)	11.58 (133.70)	2.86 (7.68)	7.83 (60.80)	5.84 (33.70)	14.21 (201.40)
Pendimethalin 154 g/ha + imazethapyr 10.5 g/ha as PRE	2.38 (5.16)	7.32 (53.10)	5.88 (34.10)	11.83 (139.50)	2.63 (6.42)	7.73 (58.30)	5.02 (24.80)	14.27 (203.10)
Pendimethalin 205 g/ha + imazethapyr 14 g/ha as PRE	2.33 (4.93)	7.36 (53.70)	5.20 (26.50)	11.47 (131.10)	2.54 (5.95)	7.65 (58.00)	4.34 (18.30)	13.98 (194.90)
Pendimethalin 300 g/ha as PRE + HW at 40 DAS	2.20 (4.34)	7.41 (54.40)	4.55 (20.20)	11.49 (131.50)	1.41 (1.49)	4.52 (19.90)	4.50 (19.80)	9.80 (95.50)
Two HW at 20 and 40 DAS	1.00 (0.50)	4.03 (15.70)	3.82 (14.10)	8.14 (65.80)	1.36 (1.35)	4.22 (17.30)	3.60 (12.50)	9.57 (92.00)
Weedy check	2.61 (6.31)	7.89 (61.80)	11.84 (139.70)	17.97 (322.40)	3.48 (11.61)	8.14 (65.80)	13.69 (186.80)	21.82 (475.60)
SEm±	0.25	0.35	0.66	0.75	0.30	0.42	1.51	0.71
CD (P=0.05)	0.74	1.03	1.95	2.19	0.89	1.21	4.42	2.08

*Original figures in parentheses were subjected to square-root transformation $\sqrt{x + 0.5}$ before statistical analysis
PPI, Pre-plant incorporation; PRE, pre-emergence; HW, hand-weeding; DAS, days after sowing

DAS, but imazethapyr 37.5 g/ha as POST performed better. Richburg *et al.* (1995) also reported similar results. The density of broad-leaf weeds was low in PRE herbicidal treated plots. Manjunath *et al.* (2010) also reported the positive result of ready-mixed pendimethalin + imazethapyr or pendimethalin on broad-leaf weeds like *Chenopodium album*, *Melilotus alba*, *Solanum nigrum*, etc. The lowest total weed density at 60 DAS was recorded with pendimethalin 300 g/ha as PRE + HW at 40 DAS and was at par with 2 HW (Table 1). Among the weed-management practices, pendimethalin 300 g/ha as PRE + HW at 40 DAS significantly reduced the weed biomass over weedy check and was closely followed by ready mixture of pendimethalin 205 g/ha + imazethapyr 14 g/ha as PRE (Table 2). All the weed control treatments reduced the weed density and dry biomass accumulation as com-

pared to weedy check at 30 and 60 DAS, but the performance of quizalofop-ethyl and imazethapyr as POST was inferior. Control of weeds during early stages of crop growth improved the availability of resources and helped the crop to suppress weeds at later stages.

Weed-control efficiency was maximum (83.5%) with pendimethalin 300 g/ha as PRE + HW at 40 DAS and was followed by pendimethalin + imazethapyr and pendimethalin alone as PRE (Table 2). Weed index indicates the reduction in yield. Among all the weed-control treatments, the lower weed index was recorded with integrated treatment of pendimethalin 300 g/ha as PRE + HW at 40 DAS, followed by PRE application of ready-mix pendimethalin 205 g/ha + imazethapyr 14 g/ha (Table 2). Weedy check recorded the maximum weed index due to maximum weed growth during entire crop-growth period.

Table 2. Effect of weed-management practices on weed dry-matter, weed-control efficiency, weed index and nutrient removal by weeds (pooled data of 2 years)

Treatment	Total weed biomass (g/m ²)		WCE (%)	WI (%)	Nutrient removal by weeds (kg/ha)		
	30 DAS	60 DAS			N P K		
Quizalofop-ethyl 50 g/ha at 30 DAS	3.37 (10.86)*	6.93 (47.50)	35.4	20.0	18.11	3.50	13.59
Imazethapyr 37.5 g/ha at 30 DAS	3.40 (11.06)	6.50 (41.70)	43.3	18.0	14.62	2.78	12.80
Chlorimuron-ethyl 4 g/ha as PPI	3.12 (9.23)	7.54 (56.30)	23.3	24.9	19.33	3.71	14.55
Pendimethalin 300 g/ha as PRE	2.81 (7.40)	5.57 (30.50)	56.9	14.3	10.80	1.88	7.97
Pendimethalin 154 g/ha + imazethapyr 10.5 g/ha as PRE	2.91 (7.97)	5.36 (28.20)	61.3	12.0	11.21	1.81	8.18
Pendimethalin 205 g/ha + imazethapyr 14 g/ha as PRE	2.75 (7.06)	5.27 (27.30)	61.8	8.8	10.29	1.73	7.58
Pendimethalin 300 g/ha as PRE + HW at 40 DAS	2.77 (7.17)	3.46 (11.50)	83.5	5.2	7.85	1.45	5.83
Two HW at 20 and 40 DAS	2.04 (3.66)	3.00 (8.50)	88.1	-	7.13	1.28	5.19
Weedy check	3.81 (14.02)	8.60 (73.50)	-	38.4	27.80	4.81	19.17
SEm±	0.06	0.32	-	-	1.47	0.26	1.10
CD (P=0.05)	0.18	0.92	-	-	4.28	0.75	3.22

*Original figures in parentheses were subjected to square-root transformation $\sqrt{x + 0.5}$ before statistical analysis
 PPI, Pre-plant incorporation; PRE, pre-emergence; HW, hand-weeding; DAS, days after sowing

Table 3. Effect of weed-management practices on growth, yield attributes, yield and economics of lentil (pooled data of 2 years)

Treatment	Plant height (cm)	Branches/plant	Plant biomass (g/m ²)	Pods/plant	Seeds/pod	Seed yield (t/ha)	Stover yield (t/ha)	Net returns (×10 ³ ₹/ha)	Benefit: cost ratio
Quizalofop-ethyl 50 g/ha at 30 DAS	56.3	6.41	259	45.8	1.41	1.46	2.53	21.9	2.04
Imazethapyr 37.5 g/ha at 30 DAS	57.8	6.48	261	46.4	1.43	1.50	2.55	24.8	2.27
Chlorimuron-ethyl 4 g/ha as PPI	55.5	6.14	255	45.2	1.39	1.37	2.29	20.5	2.03
Pendimethalin 300 g/ha as PRE	58.8	6.92	297	48.2	1.45	1.56	2.60	25.9	2.28
Pendimethalin 154 g/ha + imazethapyr 10.5 g/ha as PRE	59.0	7.02	361	53.8	1.46	1.60	2.61	27.1	2.35
Pendimethalin 205 g/ha + imazethapyr 14 g/ha as PRE	61.0	7.15	377	70.8	1.47	1.67	2.67	28.9	2.42
Pendimethalin 300 g/ha as PRE + HW at 40 DAS	61.5	7.17	404	74.6	1.48	1.73	2.70	27.5	2.17
Two HW at 20 and 40 DAS	62.4	7.29	487	98.4	1.56	1.83	3.10	25.2	1.88
Weedy check	48.0	5.55	255	42.3	1.28	1.12	1.93	15.3	1.86
SEm±	1.08	0.04	14.15	3.31	0.03	0.04	0.07	-	-
CD (P=0.05)	3.16	0.10	41.3	9.70	0.09	0.13	0.22	-	-

PPI, Pre-plant incorporation; PRE, pre-emergence; HW, hand-weeding; DAS, days after sowing

Tanveer and Ali (2003) also reported 20–30% loss in grain yield of lentil.

Nutrient removal by weeds

The nutrient removal by weeds under unweeded situation was maximum (Table 2). The nutrient removal by weeds in all the weed-control treatments was significantly lower compared with weedy check. The nutrient mining by weeds was the lowest when plots received 2 hand-weeding, followed by pendimethalin 300 g/ha as PRE + HW at 40 DAS (Table 2). The results are in conformity with Younesabadi *et al.* (2010).

Crop

Growth attributes: The integrated approach with pendimethalin 300 g/ha as PRE + HW at 40 DAS recorded significantly maximum plant height, branches/plant and plant dry matter accumulation and followed by ready mix application of pendimethalin 205 g/ha + imazethapyr 14 g/ha as PRE (Table 3). This might be due to lower weed infestation for longer period of time and lesser nutrient removal by weeds.

Yield attributes and yield: Maximum pods/plant and seeds/pod were recorded under hand weeding twice at 20 and 40 DAS treatment, followed by pendimethalin 300 g/ha as PRE + HW at 40 DAS and PRE application of pendimethalin 205 g/ha + imazethapyr 14 g/ha. All weed control measures exhibited significantly higher seed and stover yields than weedy check (Table 3). This might be due to the fact that the luxuriant growth of many weed species' with greater nutrient removal from the soil, thus, reduced the crop yield considerably. Among herbicidal treatments, integration of pendimethalin 300 g/ha as PRE + HW at 40 DAS and PRE application of pendimethalin 205 g/ha + imazethapyr 14 g/ha was recorded higher values of seed and stover yields. The seed yield recorded under pendimethalin 300 g/ha as PRE + HW at 40 DAS treatment was at par with that obtained 2 hand-weedings (Table 3). The efficient weed control measures reduced weed density and biomass resulting in improvement of yield-related traits and ultimately crop yield. Many reports support such role of herbicide application in improving the yield-related traits and yield of several crops through efficient weed management (Chander *et al.*, 2014; Sagvekar *et al.*, 2015).

Economics

The higher net return and benefit: cost ratio was obtained from pendimethalin 205 g/ha + imazethapyr 14 g/ha as PRE treatment, followed by integration of pendimethalin 300 g/ha as PRE + HW at 40 DAS and PRE application of pendimethalin 154 g/ha + imazethapyr 10.5 g/ha (Table 3). This might be due to lower cost involved under herbicidal treatment than hand-weeding. The lowest benefit: cost ratio among the weed control treatments was obtained under twice HW due to higher labour wage.

It may be concluded that the weed menace in lentil could be checked by integrated approach through pendimethalin 300 g/ha as PRE + HW at 40 DAS or chemical approach with ready-mix pendimethalin 205 g/ha + imazethapyr 14 g/ha as PRE.

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