Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(6): 1568-1571
Received: 08-09-2018
Accepted: 10-10-2018

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Performance of pendimethalin *fb* imazethapyr against complex weed flora in lentil under rice–lentil system

AK Mauriya, Vinod Kumar, Radhey Shyam and Rahul Kumar Verma

Abstract
A field experiment was conducted during *Rabi* season of 2014-15 and 2015-16 at farmer's field of seven villages of Bhagalpur, Bihar to find most effective herbicides for weed management in lentil. Best result was found in application of pendimethalin 1.0 kg/ha as pre-emergence *fb* imazethapyr25 g/ha at 20 DAS closely followed by imazethapyr25 g/ha at 20 DAS where in the lowest weed biomass was recorded at 40 DAS with maximum weed control efficiency, tallest plant, maximum branches/plant, highest plant dry matter accumulation, highest pods/ plant, seeds/plant, test weight, grain yield, maximum net return and B:C ratio than pendimethalin 1.0 kg/ha as pre-emergence and farmers' practice (weedy check).

Keywords: Herbicide, Imazethapyr, Pendimethalin, Pre- and Post-emergence

Introduction
Lentil (*Lens culinaris* Medik.) is an important *Rabi* legume crop. 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 (Kumar *et al.* 2016) [5]. In Bihar, lentil is generally grown under rainfed conditions after rice with a very low productivity i.e. 480 kg/ha (Chaudhary, 2013) [2]. There are number of reasons of low productivity in lentil out of which, weeds are serious negative factor responsible for reduction in the yield to a tune of 84% (Mohamed *et al.* 1997) [7]. Lentil is a short-statured crop having small and weak canopy so create a severe competition against weeds. It gets heavily infested with all type of upland weeds. The prominent weed species infesting lentil crop are *Chenopodium album*, *Cynodon dactylon*, *Vicia sativa*, *Melilotus Alba*, *Anagallis arvensis* and *Fumaria parviflora*. Broad-leaved weeds may become dominant in the early stages of crop growth because of their fast growth and deep root system. The concept that high input in high yield also means is high risk, if weeds are not controlled. A weed free crop environment is therefore important both for increasing yield and income for the security of crop.

In lentil, first 60 days are considered critical period for crop–weed competition (Erman *et al.* 2008) [4]. With the advancement of agro techniques, chemical weed control has become an effective and cheap alternative to control weeds. Generally for weed control in lentil, herbicides like pendimethalin as pre-emergence (PE) and fluchloralin as pre-plant incorporation (PPI) have been recommended for use. But both these herbicides have narrow windows of application. Therefore, it is essential to have alternative herbicide which may be used as post-emergence (POE) if a farmer missed early application. Recently, imazethapyr, a new imidazolinone herbicide, has been introduced for the control of complex weed flora in pulse crops like blackgram and lentil (Duary *et al.* 2016; Singh *et al.* 2014) [3, 11], But there are scanty reports on follow up application of herbicides available in the market. Hence, the present study was undertaken to evaluate the efficacy of pendimethalin as pre-emergence along with imazethapyr as post-emergence on weed growth and productivity of lentil.

Materials and Methods
On-farm trials were carried out on lentil during the winter (*Rabi*) season of 2014–15 and 2015–16 at farmer's field of seven villages of Bhagalpur, Bihar (*i.e.* Bandhaw, Mohanpur, Barahri, Birnaudh, Raghopur, Ghyanshyam Chak, Khankitta and Shankarpur) to validate, refine and popularize the technology developed at Bihar Agricultural University Sabour, Bhagalpur (Bihar) for enhancing the productivity and profitability of lentil. Participatory Rural Appraisal (PRA) was done to identify causes of low yield of lentil and high cost of production. The soils of the experimental plot was sandy loam to loamy in texture, with average pH 7.7, organic carbon 0.42%, available N 191.6 kg/ha, P_2O_5 18.1 kg/ha, K_2O 183 kg/ha same fields

were selected during the experimental year to follow homogeneity test and rice was taken as preceding crop was in the previous season where experiment was conducted. The experiment comprised four treatments *viz.* pendimethalin 1.0 kg/ha as pre- emergence, imazethapyr 25 g/ha at 20 DAS, pendimethalin 1.0 kg/ha as pre-emergence *fb* imazethapyr 25 g/ha at 20 DAS and farmer's practice (No hand weeding and No use of herbicide). Treatments were arranged in randomized block design (RBD) with fifteen replications in which each farmer was treated as one replication. The area of each experimental field was 0.1 ha. Lentil variety *'KLS 218'* was sown during the third week of December during both the years with the seed rate of 35 kg/ha at 30 cm row spacing and harvested in second week of March. Lentil seed were treated with carrier based *Rhizobium* and PSB culture, each at the rate of 20 g per kg seed and mixed well to ensure the inoculums to stick on to the surface of the seeds, thereafter, the treated seeds were dried in shade for six hour and used for sowing. Recommended dose of fertilizer *i.e.* 20:50:20 NPK kg/ha were applied uniformly through, dia-ammonium phosphate and muriate of potash as basal. Uniform spray of all herbicides was done with the help of manually operated knapsack sprayer fitted with flat-fan nozzle by using spray volume of 400 litres/ha. Data on density and dry weight of weeds were recorded at 40 days after sowing by placing a quadrat of 1.0 m × 1.0 m. The data on weeds were subjected to square root transformation before statistical analysis to normalize their distribution. The economics of treatments was computed on the basis of prevailing market prices of inputs and outputs under each treatment. Benefit: cost ratio (B:C ratio) was expressed as ratio of net returns to cost of cultivation.

Results and Discussion

Effect on Weeds

The grassy weed observed in lentil fields was *Cyperus rotundus,* however among broad leaved weeds *Polypogon Monspeliensis, Chenopodium album, Rumex dentatus, Vicia sativa, Vicia hirsuta, Medicago denticulata, Anagallis arvensis* and *Coronopus didymus* were dominant.

The density of all weeds at 40 DAS was effectively controlled in all the treatments as compared to farmer practice (Table 1). The lowest narrow and broad leaved weeds were recorded with pendimethalin 1.0 kg/ha as PE*fb*imazethapyr25 g/ha at 20 DAS but it was found statistically at par with imazethapyr25 g/ha. Pre-emergence application of pendimethalin 1.0 kg/ha also significantly reduced the weeds density/ m^2 but not found as effective as imazethapyr 25g/ha at 20 DAS. This might be due to fact that pendimethalin, a pre-emergence herbicide, inhibit emergence of weeds to improve germination of crop however imazethapyr suppressed the weed at early stage of crop growth and improved the availability of resources and helped the crop to suppress weeds at later stages. Punia *et al.* (2011) [8] also reported pendimethalin 300 g/ha as PE + hand-weeding (HW) at 40 DAS significantly reduced the density of sedges at 60DAS, but imazethapyr 37.5 g/ha as POE performed better. Richburg *et al.* (1995) [9] also reported similar results. Manjunath *et al.* (2010) [6] recorded the positive result of ready-mixed pendimethalin + imazethapyr or pendimethalin on broad-leaf weeds like *Chenopodium album, Melilotus Alba* and *Solanumnigrum* etc. The maximum weed-control efficiency (87.70%) was with pendimethalin1.0 kg/ha *fb* imazethapyr 25 g/ha followed by imazethapyr alone (Table 1) when compared with farmer practice. Tanveer and Ali (2003) [12] also reported 20–30% loss in grain yield of lentil due to weeds. A negative correlation was observed between weed density and grain yield (Fig. 1 and 2). The regression equation clearly showed that decrease of grain yield was more pronounced with the infestation of narrow leaved weeds as compared to broad leaved weeds at later stage.

Table 1. Effect of herbicides on weed density, weed dry-matter in lentil (mean data of 2 years)

Treatment	Stage of application	Weed density / m^2 at 40 DAS		Weed dry wt. (g/m^2) at 40 DAS	Weed Control Efficiency (%)
		NLW	BLW		
Pendimethalin 1.0 kg/ha	PE	2.14 (4.13)	3.72 (13.47)	7.20 (51.60)	69.6
Imazethapyr 25g/ha	20 DAS	1.65 (2.47)	1.91 (3.20)	4.78 (22.60)	86.7
Pendimethalin 1.0 kg/ha *fb*Imazethapyr25 g/ha	PE *fb* 20 DAS	1.57 (2.20)	1.76 (2.67)	4.61 (20.87)	87.7
Farmer's practice (No HW and No use of herbicide)	-	3.17 (9.53)	7.38 (54.3)	13.03 (169.53)	-
LSD (p=0.05)		0.27	0.28	0.38	-

Figure in parenthesis are the original values. The data was transformed to SQRT √x+0.5 before analysis
HW: Hand weeding, NLW: Narrow leaved weed and BLW: Broad leaved weed

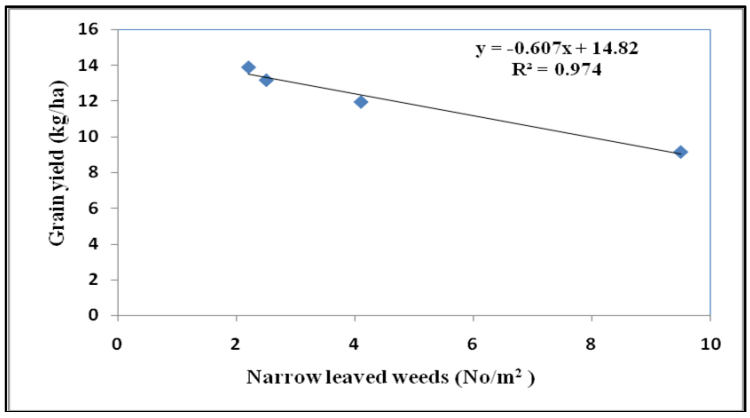

Fig 1: Regression analysis of narrow leaved weeds and grain yield of lentil at 40 DAS

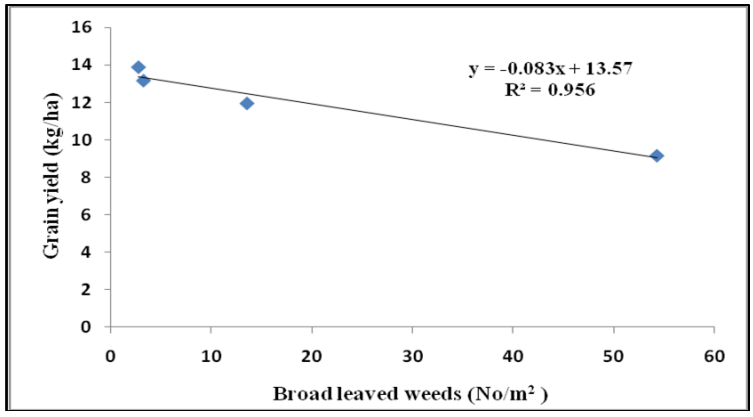

Fig 2: Regression analysis of broad leaved weeds and grain yield of lentil at 40 DAS

Effect on Crop

The follow up application approach of pendimethalin 1.0 kg/ha with imazethapyr25 g/ha recorded significantly maximum branches/ plant, pods/plant, seeds/pod and test weight and followed by imazethapyr25 g/ha at 20DAS (Table 2). All weed control measures exhibited significantly higher seed yields than farmer practice. 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 treatments, application of pendimethalin 1.0 kg/ha + imazethapyr 25 g/ha was recorded higher values of seed yields. The seed yield recorded under pendimethalin 1.0 kg/ha as pre-emergence *fb* imazethapyr 25g/ha at 20 DAS was at par with imazethapyr 25g/ha at 20 DAS. 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; Sagvekari *et al.*2015) [1, 10]. The higher net return was obtained from pendimethalin 1.0 g/ha *fb* imazethapyr 25 g/ ha followed by imazethapyr 25 g/ha. However highest benefit: cost ratio (3.95) was imazethapyr25 g/ha.

Table 2. Effect of herbicide on yield attributes, seed yield, harvest index and economics of lentil (mean of 2 years)

Treatment	Stage of application	Yield attributes				Seed Yield (t/ha)	Cost of cultivation (Rs./ha)	Gross return (Rs/ha)	Net return (Rs./ha)	B:C ratio
		Branches/plant	Pods/plant	Seeds/pod	Test wt. (g)					
Pendimethalin 1.0 kg/ha	PE	5.8	63.7	1.45	22.1	1.20	18,821	70,010	51,190	3.72
Imazethapyr 25g/ha	20 DAS	6.7	72.4	1.65	22.6	1.32	19,401	76,651	57,251	3.95
Pendimethalin 1.0 kg/ha *fb* Imazethapyr 25g/ha	PE *fb* 20 DAS	7.1	73.5	1.65	22.6	1.39	20,846	81,248	60,403	3.89
Farmer's practice (No HW and No use of herbicide)	-	4.3	39.8	1.25	21.1	0.92	17,202	54,450	37,249	3.17
LSD (p=0.05)		0.4	3.2	0.22	0.6	0.09	-	-	-	-

Results of the present study comprising fifteen number of on-farm trials conducted at farmers' fields in various villages of district Bhagalpur, Bihar reveals that pendimethalin 1.0 kg/ha as pre-emergence *fb* imazethapyr 25 g/ha at 20 DAS as well as imazethapyr 25 g/ha at 20 DAS alone can keep the weed density and dry weight reasonably at lower level and enhance the productivity of lentil resulting in higher economic returns than others. These OFR trials will motivating the other farmers of the locality and nearby to adopt it in larger area of the state to boost the confidence level of the farmers.

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