Short communication

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Weed management in lentil with post-emergence herbicides

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Lentil (*Lens culinaris* Medikus) is an important grain legume crop. In 2012, globally it was grown on 4.24 million hectare area with a total production of 4.55 million tonnes and average productivity of 1070 kg/ha (FAOSTAT 2013). Canada, India, Turkey, Australia, USA, Nepal and China are the important lentil-producing countries. Poor weed management is an important reason for low productivity of lentil. Lentil is a short-statured crop due to which weeds pose a severe competition and reduce crop yields considerably. Various pre-plant incorporation/pre-emergence herbicides such as trifluralin, pendimethalin recommended for controlling weeds in lentil, are effective only for the initial about one month period, whereas lentil is a long duration crop (145 days) and weeds emerging later also compete with crop plants. Information regarding use of post-emergence herbicides in this crop, particularly in India is meager. Therefore, the present study was undertaken.

A field experiment was conducted during *Rabi* (winter) 2009-10 at the research farm of Punjab Agricultural University, Ludhiana (30° 562 N, 75° 522 E, altitude 247 m), India. The soil of the experimental site was loamy sand (80.3% sand, 14.3% silt and 5.4% clay), having pH 8.7, organic carbon 0.29%, available P 11.5 kg/ha and available K 410 kg/ha. A total 30 cm rainfall was received during the crop growing season. Twelve treatments (Table 1) were taken in a randomized block design with three replications. The herbicides were sprayed at different timings, *i.e.* 25 and 35 days after sowing (DAS) using 375 litres of water per hectare with a Knapsack sprayer fitted with a flat fan nozzle. In the case of two hand weedings (HW), weeds were removed manually with weeding tool at 30 and 60 DAS and in weedy plots, weeds were allowed during the whole crop growing season. The crop (variety *LL-699*) was sown on 7 November, 2009 in rows 22.5 cm apart using a seed rate of 35 kg/ha. The crop was harvested on 8 April, 2010.

Dry weight of nodules and plants was determined after drying to constant weight at 65 °C. Chlorophyll content of leaves was estimated by using the method of Witham *et al*. (1971). Data on weed density were recorded 75 and 105 DAS from a randomly selected area of 50×50 cm from each plot. Weed control efficiency (WCE) was calculated as per the standard formula.

The major weed flora at the experimental site included *Oenothera drumundii, Lepidium sativum, Medicago denticulata, Anagallis arvensis, Spergula arvensis, Chenopodium album* and *Rumex dentatus* in decreasing order (Table 1). In general, imazethapyr treatments had lower weed density than those of quizalofop-ethyl. In the present study, there was infestation of broad-leaf weeds only which were not controlled by quizalofop-ethyl as this herbicide is effective mainly for annual and perennial grassy weeds only (Davis 1987). Imazethapyr 90 g/ha at 21 or 28 DAS have been reported to provide effective control of weeds in blackgram (Veeraputhiran *et al*. 2008).

Among the herbicide treatments, all treatments except quizalofop-ethyl 30 g/ha applied at 25 or 35 DAS recorded significantly lower biomass of weeds than the unweeded check at 75 DAS (Table 2). At 105 DAS and at harvest, all herbicide treatments had significantly lower biomass of weeds than the weedy check. However, none of the herbicide treatments was as effective as two hand weeding treatment for reducing the biomass of weeds at any of the three stages of observation. Our finding is in accordance with those of Meena and Jadon (2009).

Imazethapyr, when applied at 25 or 35 DAS, showed phytotoxicity in lentil at all the rates of application. Phytotoxicity increased with an increase in the rate of application and it was higher when the herbicide was applied at 25 DAS. Mishra *et al.* (2005) also reported phytotoxic effects of imazethaypyr in lentil, but with time, plants recovered. The crops are known to recover from phytotoxic effects of herbicides (Rao and Rao 2003). Quizalofop ethyl did not cause any visual phytotoxicity to lentil at any of the tested rate and time of application.

Highest number of nodules was recorded with 2 hand weeding treatment followed by imazethapyr 40 g/ha and quizalofop-ethyl 50 g/ha (Table 3). Nodule biom-

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Table 1. Weed density (no./m²) as affected by different weed control treatments in lentil

Treatment	*Oenothera drumundii*	*Lepidium sativum*	*Spergula arvensis*	*Medicago denticulata*	*Anagallis arvensis*	*Rumex dentatus*	*Chenop-odium album*	Total
75 Days after sowing								
Quizalofop-ethyl 30 g 25 DAS	6.2 (38)	3.2 (9)	2.6 (6)	3.5 (12)	2.4 (5)	2.0 (4)	1.0 (0)	8.6 (74)
Quizalofop-ethyl 30 g 35 DAS	7.0 (49)	3.2 (10)	2.9 (8)	4.1 (16)	3.2 (9)	1.0 (0)	2.0 (4)	9.8 (96)
Quizalofop-ethyl 50 g 25 DAS	6.8 (46)	4.2 (17)	1.0 (0)	2.4 (5)	2.4 (5)	1.0 (0)	2.2 (4)	8.8 (77)
Quizalofop-ethyl 50 g 35 DAS	5.5 (30)	3.5 (12)	2.4 (5)	3.2 (9)	2.4 (5)	1.0 (0)	1.4 (1)	7.9 (62)
Imazethapyr 25 g 25 DAS	6.0 (36)	2.9 (8)	1.6 (2)	3.2 (9)	1.0 (0)	1.0 (0)	1.5 (2)	7.6 (57)
Imazethapyr 25 g 35 DAS	4.9 (24)	3.5 (12)	1.4 (1)	3.2 (9)	1.0 (0)	1.0 (0)	1.0 (0)	6.8 (46)
Imazethapyr 40 g 25 DAS	4.2 (17)	1.0 (0)	1.5 (2)	3.2 (10)	1.0 (0)	1.0 (0)	1.4 (1)	5.5 (30)
Imazethapyr 40 g 35 DAS	6.0 (36)	2.4 (5)	2.4 (5)	3.3 (10)	1.0 (0)	1.0 (0)	2.0 (4)	7.7 (60)
Imazethapyr 55 g 25 DAS	2.0 (4)	1.0 (0)	1.0 (0)	2.4 (5)	1.0 (0)	1.0 (0)	1.6 (2)	3.4 (11)
Imazethapyr 55 g 35 DAS	3.5 (12)	3.2 (9)	2.4 (5)	2.9 (8)	2.0 (4)	1.0 (0)	1.6 (2)	6.3 (40)
Unweeded check	8.1 (65)	4.3 (18)	3.2 (9)	3.7 (13)	3.2 (9)	2.6 (6)	2.6 (6)	11.2 (126)
2 Hand weeding (30&60 DAS)	2.0 (4)	1.4 (1)	1.0 (0)	1.4 (1)	1.0 (0)	1.0 (0)	1.0 (0)	2.4 (6)
LSD (P=0.05)	1.1	0.9	0.7	0.8	0.6	0.5	NS	0.9
105 Days after sowing								
Quizalofop-ethyl 30 g 25 DAS	6.9 (48)	4.5 (20)	1.6 (2)	2.9 (8)	2.5 (6)	2.4 (5)	2.4 (5)	9.7 (94)
Quizalofop-ethyl 30 g 35 DAS	7.3 (53)	4.5 (20)	2.6 (6)	4.2 (17)	3.1 (9)	2.4 (5)	2.5 (6)	10.8(116)
Quizalofop-ethyl 50 g 25 DAS	5.9 (35)	5.2(27)	2.2 (4)	3.5 (12)	2.9 (8)	2.2 (4)	2.0 (4)	9.7 (94)
Quizalofop-ethyl 50 g 35 DAS	6.1 (37)	5.0 (25)	2.6 (6)	4.0 (15)	2.4 (5)	1.4 (1)	2.2 (4)	9.6 (93)
Imazethapyr 25 g 25 DAS	5.3 (28)	4.9 (24)	2.4 (5)	3.2 (9)	2.0 (4)	2.4 (5)	1.5 (2)	8.8 (77)
Imazethapyr 25 g 35 DAS	5.3 (28)	3.8(14)	1.5 (2)	3.5 (12)	1.4 (1)	1.5 (2)	2.0 (4)	8.0 (63)
Imazethapyr 40 g 25 DAS	5.1 (25)	2.9 (8)	1.6 (2)	3.7 (13)	2.4 (5)	1.4 (1)	2.2 (4)	7.6 (58)
Imazethapyr 40 g 35 DAS	6.0 (36)	3.8 (14)	1.5 (2)	3.7 (13)	1.4 (1)	2.4 (5)	1.0 (0)	8.4 (71)
Imazethapyr 55 g 25 DAS	4.5 (20)	2.0 (4)	1.4 (1)	3.2 (9)	1.6 (2)	2.2 (4)	2.5 (6)	6.8 (46)
Imazethapyr 55 g 35 DAS	4.5 (20)	2.9 (8)	1.6 (2)	3.5 (12)	2.9 (8)	2.4 (5)	1.5(2)	7.5 (57)
Unweeded check	8.5 (72)	4.7 (22)	1.2 (9)	4.2 (17)	4.2 (17)	2.9 (8)	3.5(12)	12.5(157)
2 Hand weeding (30&60 DAS)	3.3 (10)	1.3 (1)	1.0 (0)	1.4 (1)	1.4 (1)	1.4 (1)	1.0(0)	3.8 (14)
LSD (P=0.05)	0.7	0.8	0.9	0.9	1.1	2.5	1.1	1.1

Original data on density of weeds given in parentheses were subjected to square root transformation $\sqrt{x+0.5}$ before analysis

Table 2. Effect of weed control treatments on biomass of weeds and weed control efficiency (WCE) at different stages in lentil

Treatment	75 DAS		105 DAS		At harvest	
	Biomass of weeds (kg / ha)	WCE (%)	Biomass of weeds (kg / ha)	WCE (%)	Biomass of weeds (kg / ha)	WCE (%)
Quizalofop-ethyl 30 g 25 DAS	533	2.4	1200	24.3	2763	36.4
Quizalofop-ethyl 30 g 35 DAS	466	14.6	1106	30.3	2521	41.9
Quizalofop-ethyl 50 g 25 DAS	400	26.7	1186	25.2	2982	31.3
Quizalofop-ethyl 50 g 35 DAS	373	31.7	1253	21.0	2719	37.4
Imazethapyr 25 g 25 DAS	266	51.3	866	45.4	1447	66.7
Imazethapyr 25 g 35 DAS	240	56.0	733	53.8	1348	68.9
Imazethapyr 40 g 25 DAS	373	31.7	720	54.6	1447	66.7
Imazethapyr 40 g 35 DAS	320	41.4	733	53.8	1451	66.6
Imazethapyr 55 g 25 DAS	200	63.4	906	42.9	1916	55.9
Imazethapyr 55 g 35 DAS	193	64.6	893	43.7	1973	54.6
Unweeded check	546	-	1586	-	4342	-
2 Hand weeding (30 & 60 DAS)	50	90.8	366	76.9	811	81.3
LSD (P=0.05)	96		137		394	

ass in treatments of quizalofop-ethyl 30 g/ha at 35 DAS and imazethapyr 40 g/ha at 35 DAS was significantly higher than unweeded check. Maximum chlorophyll content (1.78 mg/g fresh weight of leaves) was observed in two hand weeding plots, followed by quizalofop-ethyl 30 g/ha at 35 DAS (1.48). The present findings clearly showed that quizalofop-ethyl 30 g/ha and imazethapyr 25 g/ha at both 25 and 35 DAS did not significantly affect nodulation. No adverse effect of imazethapyr on nodulation in lentil was reported by other workers (Tepe

Table 3. Effect of weed control treatments on symbiotic efficacy, growth and yield attributes and yield of lentil

Treatment	Dry weight of nodules/ plant (mg)	Chlorophyll content (mg/g fresh weight of leaves)	Plant height (cm)	Primary branches /plant	Pods/ plant	Seeds /pod	100- seed weight (g)	Grain yield (t/ha)	Harvest index (%)
Quizalofop ethyl 30 g 25 DAS	37.0	1.375	55.2	4.40	79.0	1.58	2.20	1.38	23.7
Quizalofop ethyl 30 g 35 DAS	39.0	1.485	55.5	4.60	85.6	1.63	2.16	1.42	24.1
Quizalofop ethyl 50 g 25 DAS	38.3	1.320	53.6	4.46	83.3	1.51	2.13	1.51	25.8
Quizalofop ethyl 50 g 35 DAS	27.0	0.897	55.4	4.40	83.2	1.50	2.15	1.53	26.0
Imazethapyr 25 g 25 DAS	31.0	1.200	52.3	4.41	88.4	1.73	2.26	1.71	29.0
Imazethapyr 25 g 35 DAS	32.6	1.329	53.8	4.38	86.2	1.80	2.36	1.70	28.3
Imazethapyr 40 g 25 DAS	37.3	1.007	51.4	4.36	91.0	1.76	2.40	1.75	30.1
Imazethapyr 40 g 35 DAS	40.0	1.016	53.4	4.43	89.0	1.70	2.33	1.73	30.1
Imazethapyr 55 g 25 DAS	35.0	0.991	53.0	4.46	86.0	1.65	2.20	1.64	29.8
Imazethapyr 55 g 35 DAS	28.3	0.753	54.4	4.40	84.8	1.70	2.23	1.67	30.0
Unweeded check	30.6	1.329	52.5	4.00	73.1	1.53	2.16	1.16	22.0
2 Hand weeding (30&60 DAS)	53.3	1.784	59.9	4.80	98.8	1.83	2.41	1.78	25.8
LSD (P=0.05)	9.9	0.316	3.8	NS	8.9	NS	NS	0.23	4.3

et al. 2004). Two hand weedings recorded significantly higher plant height than all other treatments (Table 3). Similarly, two hand weeding treatment registered the highest grain yield (1776 kg/ha), which was, however, on par with all imazethapyr treatments. Harvest index, in general, was higher in imazethapyr treatments than in quizalofop ethyl treatments.

Higher grain yield in case of two hand weeding treatment and imazethapyr applied at 25 or 40 g/ha at 25 or 35 DAS was due to higher number of pods/plant which might have been resulted due to better control of weeds as reflected in lower weed density (Table 1) and lower biomass of weeds and higher WCE (Table 2). Pods/plant is known to have significant positive correlation with grain yield in lentil (Singh *et al.* 2009). Harvest index, in general, was higher in imazethapyr treatments than in quizalofop-ethyl treatments.

SUMMARY

A field experiment was conducted at the Punjab Agricultural University, Ludhiana to study the effect of post-emergence herbicides imazethapyr at 25, 40 and 55 g/ha 25 or 35 DAS and quizalofop-ethyl at 30 and 50 g/ha 25 or 35 DAS along with unweeded check and two hand weedings at 30 and 60 DAS on weeds, growth and yield of lentil (*Lens culinaris* Medikus). Imazethapyr caused phytotoxicity to lentil but with time the crop recovered. Imazethapyr at 25 as well as 40 g/ha and quizalofop-ethyl at 30 g/ha, both at 25 and 35 DAS, did not adversely affect nodulation. Imazethapyr at 25 as well as 40 g/ha at either 25 or 35 DAS showed promise in improving the grain yield of lentil.

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