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Evaluation of herbicides in irrigated linseed (*Linum usitatissimum* L.) under mid-hills of Himachal Pradesh

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Abstract

A field experiment consisting of twelve weed control treatments was conducted during *rabi* 2005-06 to 2007-08 in randomized block design at Experimental Farm of Oilseed Section, CSK HPKV, Palampur to evaluate the new herbicides for controlling weeds in linseed. The results revealed that clodinafop alone (60, 80 and 100 g ha^{-1}) and tank mix application of clodinafop (60 and 80 g ha^{-1}) with 2,4-D (0.5 kg ha^{-1}) being at par with hand weeding twice recorded significantly lowest total dry matter accumulation of weeds by significantly reducing the population of *Phalaris minor* and *Avena ludoviciana* and other weeds. Application of either clodinafop 80 g ha^{-1} alone or in combination with 2,4-D 0.5 kg ha^{-1} recorded significantly maximum plant stand, plant height, primary & secondary branches, capsules/plant and thus significantly highest seed yield (210 and 253% higher over unweeded check) with weed control efficiencies of 95-97%. These treatments were followed by statistically similar treatments of tank mix application of clodinafop 60 g ha^{-1} with 2,4-D 0.5 kg ha^{-1} and alone application of clodinafop 100 g ha^{-1} for recording significantly higher linseed yield. Significantly higher net retruns and B:C ratio was achieved either with application of clodinafop (80 and 100 g ha^{-1}) alone or with its tank mix application at doses of 60 and 80 g ha^{-1} with 2,4-D 0.5 kg ha^{-1}.

Key words: Weed control, clodinafop, 2,4 D, isoproturon, economics, production, linseed.

Introduction

Linseed is an important winter season oilseed crop, being initially slow growing having less leaf canopy and erect nature of its plants, virtually exerts no smothering effect on weeds. Weeds can cause upto 66% yield losses and can further aggravate if weeds are not controlled with in a specific period of time (Sandhu *et al.*, 1996). Due to increased cost of manual weeding, its low efficiency and non-availability of labour during critical period of growth, use of post-emergence herbicide could be alternative for weed control. Among herbicides, isoproturon is recommended for weed control in this crop but its continuous use may result in the development of resistant biotypes like *P. minor* in wheat (Walia and Brar, 2006). This necessitates the use of some other herbicide molecules which are quite effective against associated weeds along with resistant and other weeds. Moreover, for wider spectrum weed control, it is desirable to incorporate the strength by mixing two herbicides into one complementary mixture. Considering the above facts, the present investigation was planned to assess the efficacy of different post emergence herbicides for controlling weeds in linseed.

Materials and Methods

A field experiment was conducted for three consecutive years at the Experimental Farm of Oilseed Section, CSK HPKV, Palampur during *rabi* 2005-06 to 2007-08. The experiment consisting of 12 treatments was laid out in randomized block design with three replications. Treatments constitute isoproturon (1.0 kg/ha), three doses of sulfosulfuron (10, 20 and 30 g ha^{-1}), three doses of clodinafop (60, 80 and 100 g ha^{-1}) and tank mixture of isoproturon + 2,4-D (1.0 + 0.5 kg ha^{-1}), clodinafop + 2,4-D (60 and 80g ha^{-1} + 0.5 kg ha^{-1}), two hand weedings (20-25 and 40-45 DAS) and weedy check (Table 1). The soil of the experimental site was silty clay loam in texture, acidic in nature, medium in available nitrogen (345 kg N ha^{-1}), phosphorus (13 kg P_2O_5 ha^{-1}) and potassium (205 kg K_2O ha^{-1}). Linseed variety 'Him Alsi-2' was sown in rows 23 cm apart on second week of October in each year with all the recommended package of practices except weed control treatments. Harvesting was done during mid of May in each year. All the herbicides were applied in standing crop as post emergence application (*i.e.* 30-35 DAS) with knapsack sprayer using flat fan nozzle at a spray volume of 750 liters per hectare. Total amount of

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rainfall received during crop seasons (Oct.-May) of 2005-06, 2006-07 and 2007-08 was 496.6, 779.9 and 468.5 mm, respectively. Data pertaining to weed density for dominant weeds and weed dry matter of total weeds were recorded at maximum dry matter stage (150 DAS) using 0.50 m x 0.50 m quadrate. The performance of different treatments was studied in terms of their effect on types of weed flora, weed density, weed biomass and their subsequent effect on linseed growth, yield attributes, grain yield and economics.

Results and Discussion

The experimental field was mainly infested with grassy weeds, among them the. *Phalaris minor* Retz. and *Avena ludoviciana* Dur. were the dominant ones. The *Vicia sativa* L. was the only major broad leaf weed present in the experimental field. However, some other weeds *viz. Lolium temulentum* L., *Poa annua* L., *Cynodon dactylon* L. and *Coronopus didymus* (L.) Sm. were also present to some extent.

Effect on weeds

All the weed control treatments were significantly superior in reducing the density of different weeds and dry matter accumulation of total weeds over weedy check. There was considerable increase in the efficacy of each herbicide either applied alone or in combination with the corresponding increase in their dose of application (Table 1).

Table 1. Effect of different treatments on count of different weed species (No. m^{-2}) and total weed dry matter accumulation (g m^{-2}) in linseed (Means of three years)

Treatments	Dose (g ha^{-1})	Weed Count (No. m^{-2})				Total weed dry weight (g m^{-2})	WCE (%)
		P. minor	*A. ludoviciana*	*V. sativa*	Other sp.		
Hand weeding at 20-25 & 40-45 DAS	-	2.50	6.33	2.80	3.50	16.42	94.64
Isoproturon	1000	5.00	8.00	12.70	3.00	43.02	85.95
Isoproturon + 2,4-D	1000+500	4.67	5.17	4.07	2.70	41.57	86.42
Sulfosulfuron	10	2.67	5.00	9.27	1.63	31.33	89.77
Sulfosulfuron	20	1.33	5.33	9.00	1.40	27.70	90.95
Sulfosulfuron	30	1.33	3.83	9.50	1.20	24.75	91.97
Clodinafop	60	1.00	4.23	8.60	0.83	17.93	94.14
Clodinafop	80	1.17	3.87	8.73	0.73	14.62	95.22
Clodinafop	100	1.00	3.10	8.50	0.63	12.79	95.82
Clodinafop + 2,4-D	60+500	1.00	3.00	4.73	0.87	10.80	96.47
Clodinafop + 2,4-D	80+500	1.17	3.10	4.53	0.67	10.10	96.70
Weedy check	-	344.33	83.00	42.73	14.03	306.11	--
CD (P=0.05)		3.67	3.63	1.70	0.38	7.96	

Among different herbicidal treatments, all the treatments except isoproturon 1.0 kg ha^{-1} resulted in significantly lowest population of *P. minor* and *A. ludoviciana*. Best control of these weeds by clodinafop in gobhi sarson was also reported by Sharma *et al.* (2007). Similarly, Kightley *et al.* (1997) also found best control of these weeds in linseed by amidosulfuron, another herbicide of same sulfonylureas group to which sulfosulfuron belongs. Tank mix application of isoproturon + 2,4-D (1.0 + 0.5 kg ha^{-1}) being at par with hand weeding twice recorded significantly lower population of *V. sativa* and were followed by tank mix application of clodinafop (60 and 80 g ha^{-1}) with 2,4-D (0.5 kg ha^{-1}). Superiority to control weeds in linseed with tank mix application of isoproturon + 2,4-D and with hand weeding twice done at 20-25 and 40-45 DAS was also reported by Husain *et al.* (2003) and Khare *et al.* (1996), respectively. Significantly maximum reduction in the densities of other weeds were achieved with the application of clodinafop alone (60, 80 and 100 g ha^{-1}) and tank mix application of clodinafop (60 and 80 g ha^{-1}) with 2,4-D (0.5 kg ha^{-1}) over rest of herbicides.

With respect to dry matter accumulation of total weeds, clodinafop alone (60, 80 and 100 g ha^{-1}), tank mix application of clodinafop (60 and 80 g ha^{-1}) with 2,4-D (0.5 kg ha^{-1}) being at par with hand weeding twice recorded significantly lowest values (Table 1). Application of clodinafop alone (80 and 100 g ha^{-1}) and tank mix application of clodinafop (60 and 80 g ha^{-1}) with

Table 2. Effect of different treatments on growth, yield attributes, seed yield of linseed and weed index (means of three years)

Treatments	Dose (g ha^{-1})	Plant stand (000/ha)	Plant height (cm)	Primary branches (No./Plant)	Secondary branches (No./Plant)	Capsules/ plant (No.)	Seeds/ Capsule (No.)	Seed Yield (kg ha^{-1})				Weed Index (%)
								2005-06	2006-07	2007-08	Mean	
Hand weeding at 20-25 & 40-45 DAS	-	1135.67	72.53	6.03	3.53	44.38	7.82	1344	1122	687	1051	33.77
Isoproturon	1000	1117.67	71.77	5.98	3.00	44.12	7.69	893	917	787	866	45.43
Isoproturon + 2,4-D	1000+500	1103.33	67.63	6.02	3.07	43.73	7.39	1018	1048	849	972	38.75
Sulfosulfuron	10	1186.00	66.07	5.68	3.43	42.33	7.33	1125	1121	679	975	38.56
Sulfosulfuron	20	1182.67	63.37	6.43	3.43	44.06	7.50	1207	1213	504	975	38.56
Sulfosulfuron	30	1278.00	65.80	5.47	2.83	44.97	7.44	1006	1014	566	862	45.68
Clodinafop	60	1265.33	70.23	7.23	3.37	47.80	7.47	1370	1348	781	1166	26.52
Clodinafop	80	1335.00	73.73	7.69	3.67	51.78	7.53	1756	1607	815	1393	12.22
Clodinafop	100	1255.33	73.90	7.69	3.97	52.13	7.68	1463	1402	1099	1321	16.76
Clodinafop + 2,4-D	60+500	1279.67	71.30	7.62	3.97	51.64	7.62	1405	1325	1250	1327	16.38
Clodinafop + 2,4-D	80+500	1284.67	71.80	7.71	3.63	53.43	7.72	1756	1641	1365	1587	-
Weedy check	-	799.67	61.27	3.54	2.27	24.34	5.54	656	483	211	450	71.64
CD (P=0.05)		52.13	6.03	0.68	0.38	3.96	0.60	126	106	41	236	

2,4-D (0.5 kg ha^{-1}) proved better amongst all weed control treatments and on average of three years these reduced the dry wt. of total weeds to the extent of 95-97%. Other better treatments in that order were hand weeding twice (95%), application of clodinafop 60 g ha^{-1} (94%), sulfosulfuron 30 g ha^{-1} (92%) and sulfosulfuron 20 g ha^{-1} (91%).

Effect on crop

All the weed control treatments recorded significantly higher plant stand, plant height (except sulfosulfuron) and produced significantly more number of primary and secondary branches, capsules/plant, seeds/capsule and consequently higher seed yield. Sulfosulfuron had stunting effect on plant height. Similarly, Freer (1991) recorded stunting of growth in linseed with the application of another herbicide metsulfuron of same sulfonylurea group to which sulfosulfuron is related. Among different herbicides, application of clodinafop 80 g ha^{-1} alone or in combination with 2,4-D 0.5 kg ha^{-1} had recorded significantly maximum plant stand, primary & secondary branches, capsules/plant and thus contributed significantly highest seed yield. However, plots receiving highest dose of clodinafop (*i.e.* 100 g ha^{-1}) and tank mix application of clodinafop 60 g ha^{-1} + 2,4-D 0.5 kg ha^{-1} also behaved statistically similar to these treatments in recording significantly higher number of primary & secondary branches, capsules/plant and the next best for recording significantly higher plant stand and averaged mean seed yield (Table 2). The percent increase in the mean seed yield through the application of clodinafop 80 g ha^{-1} alone or in combination with 2,4-D 0.5 kg ha^{-1} was 210 and 253 per cent, respectively over unweeded check. Weed competition reduced the mean grain yield by 71.6% in unweeded plot. Such loss was 33.8% under hand weeding twice practice. Like wise, yield losses caused due to weed competition in clodinafop 80 g ha^{-1} alone and tank mix application of clodinafop 60 g ha^{-1} + 2,4-D 0.5 kg ha^{-1} treated plots in comparison to maximum yielded plot *i.e.* clodinafop (80 g ha^{-1}) + 2,4-D (0.5 kg ha^{-1}) was 12.22 and 16.38%, respectively.

Effect on economics

Application of clodinafop (80 and 100 g ha^{-1}) alone being at par with its tank mix application at doses of 60 and 80 g ha^{-1} with 2,4-D 0.5 kg ha^{-1} recorded significantly higher net returns and B:C ratio. Similar trend was found for recording significantly higher gross returns except for tank mix application of clodinafop + 2,4-D (60 g ha^{-1} + 0.5 kg ha^{-1}), where it was the next best (Table 3). Numerically, highest net returns (Rs. 21270/ha) achieved with involvement of lower cost of cultivation (Rs. 9901/ha) resulted in getting highest B:C ratio (2.15) with tank mix application of clodinafop+ 2,4-D (80 g ha^{-1} + 0.5 kg ha^{-1}) and was followed by clodinafop 80 g/ha application with net returns and B:C ratio of Rs. 18414/ha and 1.96, respectively.

Table 3. Effect of different treatments on economics of linseed production (Mean of three years)

Treatments	Dose (g ha^{-1})	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio
Hand weeding at 20-25 & 40-45 DAS	-	12468	21020	8552	0.69
Isoproturon	1000	8610	17178	8568	1.00
Isoproturon + 2,4-D	1000+500	8755	19594	10839	1.24
Sulfosulfuron	10	9735	19432	9698	1.00
Sulfosulfuron	20	11246	19492	8246	0.73
Sulfosulfuron	30	12705	17658	4953	0.39
Clodinafop	60	9242	23327	14084	1.52
Clodinafop	80	9542	27956	18414	1.96
Clodinafop	100	9763	27180	17417	1.78
Clodinafop + 2,4-D	60+500	9350	26389	17039	1.82
Clodinafop + 2,4-D	80+500	9901	31171	21270	2.15
Weedy check	-	7883	9015	1132	0.12
CD (P=0.05)		311	4710	4764	0.46

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