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Effect of weed management on crop growth and economics of lentil (*Lens culinaris* Medic.)

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Abstract
A field experiment was conducted to study the effect of weed management on weed growth and yield of lentil during *rabi* seasons of 2021-22 at Agricultural Research Farm, Lovely Professional University, Jalandhar, Punjab. randomized block design assigning nine treatments comprising of T_1 (Weedy Check), T_2 (Hand weeding (30 DAS)), T_3 (Hand weeding twice (30 and 60 DAS)), T_4 (Pendimethalin (30% EC) @ 1000 g a.i. ha^{-1}), T_5 (Quizalofop ethyl 15% EC @ 50 g a.i. ha^{-1}), T_6 (Imazethapyr 10% SL @ 100 g a.i. ha^{-1}), T_7 (Proxasulfone 85% (Zidua SC) @ 60 g a.i. ha^{-1}), T_8 (Clodinafop-propargyl 15% WP @ 40 g a.i. ha^{-1}) and T_9 (Eucalyptus mulch @ 5500 kg ha^{-1}) and were replicated thrice. The results reported that the higher crop growth characters *viz.* plant height, number of branches plant^{-1}, leaves plant^{-1}, nodules plant^{-1}, dry matter accumulation along with net returns and B:C ratio were recorded under herbicidal application of Imazethapyr 10% SL @ 100 g a.i. ha^{-1} which was statistically at par with Clodinafop-propargyl 15% WP @ 40 g a.i. ha^{-1} over rest of the treatments. However, plant stand were failed to show any significant effect due to above treatments.

Keywords: Herbicide, imazethapyr, clodinafop-propargyl, gross returns and number of branches

Introduction
Lentil (*Lens culinaris* Medic.) is grown as seeds/grain for human use and straw for animal feed all throughout the world. Lentil has a protein content of 25%, a fat content of 0.7 percent, a mineral content of 2.1 percent, a fibre content of 0.7 percent and a carbohydrate content of 60%. It also contains significant levels of calcium, iron, phosphorus, potassium, zinc, and magnesium, as well as vitamins such as niacin, riboflavin, thymine and ascorbic acid (Anonymous, 2004) [1].

Lentil is grown on approximately 1.51 million hectares in India, yielding 1.56 million tonnes with an average productivity of 1032 kg ha^{-1}. Lentil is the most important pulse crop in Punjab during the *rabi* season, and it is primarily farmed in rainfed settings. It is planted in Punjab on around 1.5 thousand hectares and yields 1.0 lakh tonnes per hectare, with an average productivity of 410.7 kg ha^{-1} (Punjab Agriculture Statistics, 2018) [9]. It's possible that the low average yield is related to inadequate crop management. Manipulation of soil to generate appropriate plant stand, selection of proper variety and adoption of suitable weed management strategy at key times of crop-weed competition are all important steps in determining a crop's yield potential.

Weeds have been identified as one of the most important causes contributing to the low lentil yield. Weeds have been observed causing losses in an unobserved and silent manner. The severity of cannabis damage is mostly determined by the weed's composition and intensity. It can diminish crop production by up to 96.5 percent depending on the plant type and crop weed competition (Punia *et al.,* 2003; Verma *et al*., 2015) [8, 11]. Weeds use a lot of nutrients and compete with other plants for moisture, space, and, most importantly, nutrients. Poor weed control measures deprive the crop of essential nutrients, soil, moisture, and space, resulting in poor crop growth and production. The stress is mainly due to presence of dominant grassy weed *viz. Cyperus rotundus* and broad leaved *viz. Chenopodium album*, *Anagalis arvensis*, *Melilotus* spp. and *Lathyrus aphaca* etc. (Mahanta *et al.,* 2003) [7].

Weed control technique that is both effective and cost-efficient. The important phase for weed removal in lentils is the first 50-60 days after planting (Dungarwal *et al*., 2003) [4]. The traditional and most successful methods of weed removal in pulses include hand weeding and hoeing. These approaches result in workers arriving on time and earning greater compensation. When compared to hand weeding, selective herbicides may provide more effective and cost-efficient weed management.

Lentil, as a leguminous crop, has limited use of the herbicidal umbrella available on the market. Furthermore, the continued use of limited recommended herbicides may pollute the environment and encourage weeds to develop resistance to these chemicals. Furthermore, using pesticide alone is insufficient to guarantee a weed-free environment for crops during the growing season.

Mulching works on the premise of starving weeds by preventing light penetration until the reserve food source in the roots has been depleted. Mulching materials used in lentils include paddy straw, sawdust, hay or manure, rockwool and polythene films (black, silver, transparent, or biodegradable), among others (Scott, 2007 and De, 2014) [10, 3]. However, there is a scarcity of knowledge on herbicidal weed management with mulching under lentil production in Punjab. In light of the above-mentioned facts of insufficient knowledge and limited relevant research, the current study was conducted to determine the influence of weed control on crop growth and economics of lentil under Phagwara conditions.

Material and Methods

The experiment was conducted during *rabi* seasons of 2021-22 at Agricultural Research Farm, Lovely Professional University, Jalandhar, Punjab situated at latitude of 25º 18' North and longitude of 83º 03' East, with altitude of 128.93 meters above the mean sea level. The experiment was laid out in randomized block design assigning nine treatments comprising of T_1 (Weedy Check), T_2 (Hand weeding (30 DAS)), T_3 (Hand weeding twice (30 and 60 DAS)), T_4 (Pendimethalin (30% EC) @ 1000 g a.i. ha^{-1}), T_5 (Quizalofop ethyl 15% EC @ 50 g a.i. ha^{-1}), T_6 (Imazethapyr 10% SL @ 100 g a.i. ha^{-1}), T_7 (Proxasulfone 85% (Zidua SC) @ 60 g a.i. ha^{-1}), T_8 (Clodinafop-propargyl 15% WP @ 40 g a.i. ha^{-1}) and T_9 (Eucalyptus mulch @ 5500 kg ha^{-1}) and were replicated thrice. The soil of the experimental field was sandy loam in texture having slightly alkaline in reaction (pH 7.8), low in organic carbon (0.34%), available nitrogen (200.6 kg ha^{-1}), phosphorus (16.3 kg ha^{-1}) and medium in available potassium (186.5 kg ha^{-1}). Recommended dose of nitrogen, phosphorous and potassium (30:60:40 kg ha^{-1}) through urea, SSP and MOP, respectively were applied as basal dose. Nitrogen was applied 50% as basal and remaining in two equal splits. The total rainfall experienced during the crop growth season was 190.2 mm in during 2021-22. LL 931 variety of lentil was used for sowing of experiment. Application of herbicides was done as per treatment. Other crop management practices were followed as per the recommendation of the area. The data relating to each character were analyzed as per the procedure of analysis of variance and significance was tested by "F" test (Gomez and Gomez, 1984) [5].

Results and Discussions

Effect of weed management on crop growth

The data pertaining to plant stand at 20 DAS and at harvest of lentil are presented in Table 1. The maximum plant stand at 30 DAS (32.17 m^{-2}) and (29.50 m^{-2}) at harvest were observed under (T_8) Clodinafop-propargyl 15% WP @ 40 g a.i. ha^{-1} over rest of the treatments.

The data showed (Table 2-4) that plant height, number of branches and number of leaves were continued to increase with the advancement of crop age and this increase was rapid during early crop growth period and thereafter, a slow rate of increase was observed. The maximum plant height, number of branches and number of leaves were observed under (T_3) Hand weeding twice (30 and 60 DAS) at all growth stages during course of experimentation. Among the herbicidal treatments, the maximum values of these characters were recorded under application of (T_6) Imazethapyr 10% SL @ 100 g a.i. ha^{-1} which was statistically at par with (T_8) Clodinafop-propargyl 15% WP @ 40 g a.i. ha^{-1}, (T_9) Eucalyptus mulch @ 5500 kg ha^{-1} and (T_5) Quizalofop ethyl 15% EC @ 50 g a.i. ha^{-1} over rest of the treatments. Similar trend was also noted at 60, 90 DAS and at harvest stage. However, least values were observed under (T_1) weedy check at all growth stages.

Perusal of the data (Table 5) revealed that significantly higher number of nodules plant^{-1} (9.98) was observed under (T_3) Hand weeding twice (30 and 60 DAS) at all growth stages. In case of herbicidal treatments, significantly higher number of nodules plant^{-1} (9.65) was noted under (T_9) Eucalyptus mulch @ 5500 kg ha^{-1} which was statistically at par with (T_6) Imazethapyr 10% SL @ 100 g a.i. ha^{-1} over rest of the treatments. Similar trend was observed at 90 DAS and at harvest stage. However, least number of nodules plant^{-1} was observed with (T_1) weedy check (control) at all growth stages during course of experimentation.

Perusal of the data (Table 6) revealed that (T_3) Hand weeding twice (30 and 60 DAS) exerted significant improvement in dry matter accumulation (5.66 g plant^{-1}) as compared to other treatments at all the growth stages. Dry matter content as influenced by herbicidal treatments was recorded at 30, 60, 90 DAS and at harvest stage. Data analysis at 30 DAS revealed that (T_6) Imazethapyr 10% SL @ 100 g a.i. ha^{-1} observed significantly higher dry matter accumulation (5.63 g plant^{-1}) which was statistically at par with (T_8) Clodinafop-propargyl 15% WP @ 40 g a.i. ha^{-1}, (T_9) Eucalyptus mulch @ 5500 kg ha^{-1}, (T_5) Quizalofop ethyl 15% EC @ 50 g a.i. ha^{-1}, respectively over rest of the treatments. Similar trend was observed at 60, 90 DAS and at harvest. However, least dry matter accumulation was observed under (T_1) weedy check treatment at all growth stages.

The excellent control of weeds under these treatments led to optimal utilization of resources by the crop plant, therefore, these treatments have long stature plants. These results are in close conformity with the finding of Kumar *et al* (2014) [6].

This might be due to minimum weed infestation for longer period of time in these treatments. The results confirmed with the finding of Baldev *et al.* (2011) [2] who reported that Imazethapyr 10% SL @ 100 g a.i. ha^{-1} favourably influenced the growth attributes of lentil field in comparison of weedy check.

Table 1: Plant stand (no. m^{-2}) of lentil as influenced by weed management practices

Treatments	Plant stand (No. m^{-2})	
	20 DAS	At harvest
T_1	28.67	26.77
T_2	29.43	26.73
T_3	29.77	27.07
T_4	30.67	27.97
T_5	30.40	27.70
T_6	30.97	28.30
T_7	31.83	28.40
T_8	32.17	29.50
T_9	31.67	29.00
S.Em±	1.64	1.62
LSD (p=0.05%)	NS	NS

Table 2: Plant height (cm) of lentil as influenced by weed management practices at periodic intervals

Treatments	Plant height (cm)			
	30 DAS	60 DAS	90 DAS	At harvest
T_1	6.98	16.93	29.25	27.04
T_2	8.38	20.34	32.66	30.31
T_3	9.95	24.14	36.46	34.25
T_4	7.95	19.30	31.62	29.27
T_5	9.48	23.00	35.32	33.11
T_6	9.90	24.02	36.34	33.99
T_7	8.76	21.25	33.57	31.36
T_8	9.78	23.73	36.05	33.70
T_9	9.59	23.26	35.58	33.37
S.Em±	0.32	0.92	1.42	1.37
LSD (p=0.05%)	0.97	2.87	4.25	4.11

Table 3: Number of branches plant^{-1} of lentil as influenced by weed management practices at periodic intervals

Treatments	Number of branches plant^{-1}		
	60 DAS	90 DAS	At harvest
T_1	2.25	3.23	3.74
T_2	5.57	6.15	6.66
T_3	6.04	6.92	7.43
T_4	4.49	5.10	5.61
T_5	5.71	6.33	6.84
T_6	5.95	6.73	7.24
T_7	5.63	6.24	6.75
T_8	5.85	6.53	7.04
T_9	5.74	6.39	6.90
S.Em±	0.10	0.16	0.18
LSD (p=0.05%)	0.31	0.49	0.56

Table 4: Number of leaves plant^{-1} of lentil as influenced by weed management practices at periodic intervals

Treatments	Number of leaves plant^{-1}		
	30 DAS	60 DAS	90 DAS
T_1	4.85	16.36	16.69
T_2	6.60	22.86	23.32
T_3	7.78	29.94	30.54
T_4	6.35	17.55	17.90
T_5	7.13	25.47	25.98
T_6	7.60	27.32	27.87
T_7	6.78	24.18	24.66
T_8	7.40	24.71	25.20
T_9	7.18	28.95	29.53
S.Em±	0.09	0.97	0.99
LSD (p=0.05%)	0.26	2.91	3.01

Table 5: Number of nodules plant^{-1} of lentil as influenced by weed management practices at periodic intervals

Treatments	Number of nodules plant^{-1}		
	60 DAS	90 DAS	At harvest
T_1	5.45	8.61	8.85
T_2	7.62	12.04	12.28
T_3	9.98	15.76	16.00
T_4	5.85	9.24	9.48
T_5	8.49	13.41	13.65
T_6	9.11	14.39	14.63
T_7	8.06	12.73	12.97
T_8	8.24	13.02	13.26
T_9	9.65	15.24	15.48
S.Em±	0.25	0.36	0.42
LSD (p=0.05%)	0.78	1.12	1.28

Table 6: Dry matter accumulation plant^{-1} (g) of lentil as influenced by weed management practices at periodic intervals

Treatments	Dry matter accumulation plant^{-1}			
	30 DAS	60 DAS	90 DAS	At harvest
T_1	3.97	49.43	107.04	128.03
T_2	4.76	59.27	128.34	153.50
T_3	5.66	70.47	152.61	182.53
T_4	4.52	56.28	121.87	145.76
T_5	5.39	67.11	145.33	173.82
T_6	5.63	70.10	151.80	181.56
T_7	4.98	62.01	134.27	160.60
T_8	5.56	69.23	149.91	179.30
T_9	5.45	67.86	146.94	175.76
S.Em±	0.14	0.24	4.98	5.37
LSD (p=0.05%)	0.46	0.78	15.69	16.94

Effect of weed management on economics

Relative economics of lentil as influenced by weed management practices are presented in Table 7. Data revealed that maximum cost of cultivation and gross returns were observed under (T_3) Hand weeding twice (30 and 60 DAS) during course of investigations. It may be due to high grain and straw yield as a result of high weed control efficiency coupled with lesser cost of production under these treatments. However, significantly higher net returns and B:C ratio were was observed under (T_6) Imazethapyr 10% SL @ 100 g a.i. ha^{-1} which was statistically at par with (T_8) Clodinafop-propargyl 15% WP @ 40 g a.i. ha^{-1} over rest of the treatments. However, least net returns and B:C ratio was observed under (T_1) weedy check treatment. This might be due to lower cost involved under chemical weeding. The investigation thus revealed that hand weeding or herbicidal control of weeds may be equally effective in producing higher yield and hence generating higher income (Baldev *et al.*, 2011) [2].

Table 7: Economics (₹ ha^{-1}) of lentil as influenced by weed management practices

Treatments	Economics (₹ ha^{-1})			B:C ratio
	Cost of cultivation	Gross returns	Net returns	
T_1	24600	30542	5942	0.24
T_2	27600	54428	26828	0.97
T_3	30600	71046	40446	1.32
T_4	24830	54507	29677	1.20
T_5	24830	60033	35203	1.42
T_6	24830	69441	44611	1.80
T_7	26790	57088	30298	1.13
T_8	24644	67652	43008	1.75
T_9	25600	62729	37129	1.45
S.Em±	-	1343	1079	0.14
LSD (p=0.05%)	-	4037	3247	0.45

Conclusions

From the above overall study, it is recommended that to obtain higher growth with net returns of lentil should be grown under application of Imazethapyr 10% SL @ 100 g a.i. ha^{-1} under ago-climatic conditions of Phagwara region of Punjab.

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