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Effect of herbicides on growth parameters, yield attributes, yield and economics of lentil (*Lens culinaris* Medik) in *vertisols* of Chhattisgarh

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Abstract
The present investigation entitled "Effect of herbicides on growth parameters, yield attributes, yield and economics of lentil (*Lens culinaris* Medik) in *Vertisols* of Chhattisgarh" was carried out during *rabi* season of 2020-21 at the Research Farm, Indira Gandhi Krishi Vishwavidyala, Raipur (C.G.). The soil of the experimental field was neutral in reaction and had low nitrogen, medium phosphorus and high potassium contents. The experiment was laid out in randomized block design with three replications. The treatments consisted of 15 different herbicide treatments *viz.* T_1 - Oxadiargyl 80 g ha^{-1} 0-3 DAS, T_2 - Metribuzin 350 g ha^{-1} 0-3 DAS, T_3 - Topramezone 19.35 g ha^{-1} 2-3 Leaf stage of weed, T_4 -Topramezone 25.8g ha^{-1} 2-3 Leaf stage of weed, T_5 - Topramezone 32.25 g ha^{-1} 2-3 Leaf stage of weed, T_6- Topramezone (directed application) 28.5 g ha^{-1} 5-6 Leaf stage of weed, T_7- Fluzifop-p-butyl 13.4% + fomesafen 11.1% 250 g ha^{-1} 2 to 3 leaf stage of weed, T_8 - Metribuzin fb Topramezone 350-25.8 g ha^{-1} 0-3DAS & 2-3 Leaf stage of weed, T_9 - Metribuzin fb Metribuzin 350-350 g ha^{-1} 0-3 DAS & 5-6 Leaf stage of weed, T_{10}- Fluzifop-p-butyl 13.4% + Fomesafen 11.1% (directed application) 250 g ha^{-1}5-6 Leaf stageweed, T_{11}- Sodium acifluorfen16.5% + coldinafopproparzyl 8% (directed application) 187.5 g ha^{-1} 2 to 3 leaf stage of weed, T_{12} - Mertibuzin (directed application) 350 g ha^{-1} 2 to 3 leaf stage of weed, T_{13} - Metsulfuron (directed application) 4 g ha^{-1} 2 to 3 leaf stage of weed, T_{14} - Hand weeding twice 20 & 40 DAS, T_{15} - Unweeded control. Results revealed that significantly higher plant height (cm), number of branchesplant^{-1}, number of nodulesplant $^{-1}$, yield attributes, yield (kg ha^{-1}), stover yield (kg ha^{-1}) and harvest index (%) were obtained under hand weeding twice at 20 and 40 DAS (T_{14}), but it was at par with Metribuzin *fb* Metribuzin 350-350 g ha^{-1} 0-3 DAS & 5-6 Leaf stage of weed (T_9), Metribuzin 350 g ha^{-1} 0-3 DAS(T_2) and Sodium acifluorfen16.5% + coldinafopproparzyl 8% (directed application) 187.5 g ha^{-1} 2 to 3 leaf stage of weed (T_{11}). The minimum values of above character were observed under unweeded control plot (T_{15}). The highest cultivation cost and gross monetary returns were noticed with hand weeding twice at 20 and 40 DAS. Maximum net returns and higher B: C ratio was noticed under Metribuzin fb Metribuzin 350-350 g ha^{-1} 0-3 DAS & 5-6 Leaf stage of weed (T_9) followed by Metribuzin 350 g ha^{-1} 0-3 DAS(T_2)..

Keywords: Herbicides, parameters, economics, *vertisols*, *Lens culinaris* Medik

Introduction
Lentil (*Lens culinaris* Medik) is one of the world's oldest and most important pulse. It is always eaten as a dry crop. Dehulled lentil grains have a protein content of 24-26 percent, a fat content of 1.3 percent, an ash content of 2.2 percent, a fibre content of 3.2 percent, and a carbohydrate content of 57 percent. Calcium (68 mg/100g), phosphorus (300 mg/100g), and iron (7 mg/100g) are all abundant. Lentils are a high-protein, low-calorie crop. India (18.00 mha), Canada (12.17 mha), Turkey (2.43 mha), Iran (1.68 mha), Australia (1.62 mha), Bangladesh (1.24 mha), Syria (1.11 mha) and the United States (1.04 mha) are the world's most important lentil-growing countries. Turkey ranked third in the world in terms of both output and region, with India and Canada following closely behind (FAOSTAT, 2014) [7]. Lentil cultivation covers 1362720 ha in India during 2019, with a yield of 901 kg ha^{-1} and an output of 1227820 tonnes (FAOSTAT, 2019) [8]. During 2018-19, 15 lakh hectares of land were planted with lentils. A remarkable achievement is the highest ever output of 15 lakh tonnes at a productivity level of 1088 $kgha^{-1}$. Madhya Pradesh (0.68 Mt), Uttar Pradesh (0.50 Mt), West Bengal (0.15 Mt), Bihar (0.14 Mt), Jharkhand (0.06 Mt), and Rajasthan (0.06 Mt) are the top six lentil-producing states (0.03 Mt). Lentil cultivation covers 0.16 mha in Chhattisgarh, and lentil contributes 1.04 percent of India's total output (Anonymous, 2019) [2]. A variety of factors have been identified as contributing to the low yield of lentil and weed problem has been identified as being of primary importance.

The losses caused by weeds exceed the losses from any other category of agricultural pests like insect diseases etc. Weed has been discovered to cause unnoticed and silent losses. Weed damage is primarily measured by the presence and intensity of the weed. Weeds remain a lot of nutrients and compete with other plants for moisture, space, and most importantly, nutrients. Weed control practises are ineffective because they deprive the crop of essential nutrients, soil, moistureand space, resulting in poor crop growth and yield. In the presence of weeds, lentil yields are decreased by 80 percent (Mohamed *et al*.,1997) exceed the losses from [12].

Materials and Methods

The experiment "Effect of herbicides on growth parameters, yield attributes, yield and economics of lentil (*Lens culinaris* Medik) in *Vertisols* of Chhattisgarh" as conducted at Research cum Instructional Farm of IGKV, during rabi season of 2020-21. The climate of the region is sub-humid The soil of the experimental field was vertisols with low, medium and high in N, P and K, respectively and neutral in reaction. The test variety was JL-3. The experiment was laid out in Randomized Block Design having three replications and fifteen treatments *viz*., T_1 - Oxadiargyl 80 g ha^{-1} 0-3 DAS, T_2 - Metribuzin 350 g ha^{-1} 0-3 DAS, T_3 - Topramezone 19.35 g ha^{-1} 2-3 Leaf stage of weed, T_4 -Topramezone 25.8g ha^{-1} 2-3 Leaf stage of weed, T_5 - Topramezone 32.25 g ha^{-1} 2-3 Leaf stage of weed, T_6- Topramezone (directed application) 28.5 g ha^{-1} 5-6 Leaf stage of weed, T_7- Fluzifop-p-butyl 13.4% + fomesafen 11.1% 250 g ha^{-1} 2 to 3 leaf stage of weed, T_8 - Metribuzin fb Topramezone 350-25.8 g ha^{-1} 0-3DAS & 2-3 Leaf stage of weed, T_9 - Metribuzin fb Metribuzin 350-350 g ha^{-1} 0-3 DAS & 5-6 Leaf stage of weed, T_{10}- Fluzifop-p-butyl 13.4% + Fomesafen 11.1% (directed application) 250 g ha^{-1}5-6 Leaf stageweed, T_{11}- Sodium acifluorfen 16.5% + coldinafopproparzyl 8% (directed application) 187.5 g ha^{-1} 2 to 3 leaf stage of weed, T_{12} - Mertibuzin (directed application) 350 g ha^{-1} 2 to 3 leaf stage of weed, T_{13} - Metsulfuron (directed application) 4 g ha^{-1} 2 to 3 leaf stage of weed, T_{14} - Hand weeding twice20 & 40 DAS, T_{15} - Unweeded control. Lentil variety "IL - 3" was sown on November 15, 2020 and harvested on March 10, 2021. During crop growth period various growth parameter like plant height $plant^{-1}$, number of branches $plant^{-1}$, number of nodules $plant^{-1}$ yield attributing characters like pods $plant^{-1}$, seed pod^{-1}, seed index, seed yield, stover yield and economics were taken as per schedule and requirement of investigation.

Results and discussion

Plant height (cm)

Data regarding the plant height (cm) of lentil as influenced by different herbicide treatments measured at 25, 50, 75 DAS and at harvest are presented in Table1. Results revealed that the plant height increased with passage of time. Various weed management practices had significant influenced on plant height at all the stages of observation, except at 25 DAS, where the differences in plant height were non significant. The significantly tallest plants of lentil were found with the treatment hand weeding twice at 20 and 40 DAS (T14) as compared to others but it to at par with treatments Metribuzin *fb* Metribuzin 350-350 g ha-1 0-3 DAS & 5-6 Leaf stage of weed (T9),Metribuzin @350gha^{-1} at 0-3 DAS (T2), Sodium acifluorfen16.5%+ clodinafop proparzyl 8% (directed application) @ 187.5gha^{-1} at 2-3 leaf stage of weed (T11) at 50, 75 DAS and at harvest. The lowest plant height was observed under unweeded control plot at all the time interval of observations. Jaiswal and Khajanji (2005) [9] also reported that one hand weeding at 40 DAS produced significantly superior growth of plant height compared with the weedy check.

Table 1: Plant height (cm) of lentil at different time interval as influenced by various herbicide treatments

	Treatment	Plant height (cm)			
		30 DAS	60 DAS	90 DAS	At harvest
T1	Oxadiargyl 80g/ha at 0-3 DAS	8.00	20.67	37.9	56.76
T2	Metribuzin 350g/ha at 0-3 DAS	10.00	23.27	39.87	59.22
T3	Topramezone 19.35g/ha at 2-3 Leaf stage of weed	9.00	22.00	39.07	58.09
T4	Topramezone 25.8g/ha at 2-3 Leaf stage of Weed	8.67	21.60	38.83	57.22
T5	Topramezone 32.25g/ha at 2-3 Leaf stage of weed	8.33	21.00	38.33	57.22
T6	Topramezone (directed application) 25.8g/ha at 5-6 Leaf stage of weed	9.37	22.83	39.67	58.72
T7	Fluzifop-p-butyl 13.4% + Fomesafen 11.1% 250g/ha at 2-3 Leaf stage of weed	8.17	20.83	38.00	57.00
T8	Metribuzin 350g/ha *fb* Topramezone 25.8g/ha at 0-3 DAS & 2-3 Leaf stage of weed	8.83	21.83	39.00	58.00
T9	Metribuzin 350g/ha *fb* Metribuzin 350g/ha at 0-3 DAS &5-6 Leaf stage of weed	10.50	23.57	39.93	59.67
T10	Fluzifop-p-butyl 13.4% + fomesafen 11.1% (directed application) 250g/ha at 5-6 Leaf stage of weed	9.33	22.67	39.43	58.63
T11	Sodium acifluorfen 16.5%+ clodinafop proparzyl 8% (directed application) 187.5g/ha at 2-3 leaf stage of weed	9.67	23.00	39.75	59.12
T12	Mertibuzin (directed application) 350g/ha at 2-3 leaf stage of weed	8.50	21.33	38.67	57.32
T13	Metsulfuron (directed application)4g/ha at 2-3 leaf stage of weed	9.17	22.43	39.23	58.32
T14	Hand weeding twiceat 20 & 40 DAS	10.97	24.67	40.00	61.96
T15	Unweeded control	7.80	17.33	34.17	54.89
	S.Em±	0.55	0.63	0.89	1.10
	CD (P = 0.05)	NS	1.84	2.60	2.89

Number of branches plant-1

The data on the number of branches per plant of lentil at 30, 60, 90 DAS and at harvest are presented in Table 2. Number of branches per plant increased with advancement in crop age up to 90 DAS. Differences in number of branches due to different treatments were significant at all the stages of crop growth, except at 30 DAS. At 30 DAS, number of branches per plant showed nonsignificant differences due to different herbicide treatments. While, at 60, 90 DAS and at harvest, the significantly highest number of branches per plant was observed under hand weeding twice at 20 and 40 DAS (T14), and it was at par with Metribuzin *fb* Metribuzin 350-350 g ha-1 0-3 DAS & 5-6 Leaf stage of weed (T9),Metribuzin @350gha^{-1} at 0-3 DAS (T2), Sodium acifluorfen16.5%+

clodinafop proparzyl 8% (directed application) @ 187.5gha^{-1} at 2-3 leaf stage of weed (T11). Whereas, the lowest number of branches per plant was observed under unweeded control during all the dates of observation. The increase in number of branches might be due to better utilization of moisture, sunlight, space and nutrients in above treatments resulted in proper translocation of food material to the reproductive parts. Similar results have been reported by Ahlawat *et al.*(1979) [1] and Turk and Tahawa (2002).

Number of nodules plant -1

The data related to number of nodules plant was recorded at 30 and 60 DAS and presented in Table 3 The results showed that there was nonsignificant differences in number of nodules per plant at 30 and 60 DAS due to different herbicide treatments. However the maximum number of nodules was produced under hand weeding twice at 20 and 40 DAS (T14) and minimum number of nodules was noted in unweeded control plot (T15). The might be due to fact that there were severe crop-weed competition resulted in poor growth and development of crop leads to poor root growth. Similar results were noted by Dawood (1994) [4] and Mahanta *et al*. (2007) [10].

Table 2: Number of branches per plant of lentil at different time interval as influenced by various herbicide treatments

	Number Of Branches Plant-1				
	Treatment	**30 DAS**	**60 DAS**	**90 DAS**	**At harvest**
T1	Oxadiargyl 80g/ha at 0-3 DAS	2.07	4.07	6.03	5.96
T2	Metribuzin 350g/ha at 0-3 DAS	2.57	5.77	7.83	7.22
T3	Topramezone 19.35g/ha at 2-3 Leaf stage of weed	2.21	5.03	6.93	6.70
T4	Topramezone 25.8g/ha at 2-3 Leaf stage of Weed	2.17	4.73	6.63	6.47
T5	Topramezone 32.25g/ha at 2-3 Leaf stage of weed	2.13	4.30	6.33	6.22
T6	Topramezone (directed application) 25.8g/ha at 5-6 Leaf stage of weed	2.36	5.60	7.33	7.03
T7	Fluzifop-p-butyl 13.4% + Fomesafen 11.1% 250g/ha at 2-3 Leaf stage of weed	2.10	4.17	6.20	6.03
T8	Metribuzin 350g/ha *fb* Topramezone 25.8g/ha at 0-3 DAS & 2-3 Leaf stage of weed	2.20	4.87	6.80	6.59
T9	Metribuzin 350g/ha *fb* Metribuzin 350g/ha at 0-3 DAS &5-6 Leaf stage of weed	2.63	6.00	7.97	7.40
T10	Fluzifop-p-butyl 13.4% + fomesafen 11.1% (directed application) 250g/ha at 5-6 Leaf stage of weed	2.33	5.47	7.20	6.97
T11	Sodium acifluorfen 16.5%+ clodinafop proparzyl 8% (directed application) 187.5g/ha at 2-3 leaf stage of weed	2.47	5.67	7.60	7.15
T12	Mertibuzin (directed application) 350g/ha at 2-3 leaf stage of weed	2.15	4.67	6.47	6.40
T13	Metsulfuron (directed application)4g/ha at 2-3 leaf stage of weed	2.27	5.17	7.03	6.85
T14	Hand weeding twiceat 20 & 40 DAS	3.00	6.67	8.37	8.00
T15	Unweeded control	2.00	3.00	5.77	5.22
	S.Em±	0.31	0.36	0.35	0.30
	CD (P = 0.05)	NS	1.05	1.02	0.87

Table 3: Number of nodules plant-1of lentil at 30 and 60 as influenced by various herbicide treatments

	Treatment	**Number of nodules plant-1**	
		30 DAS	**60 DAS**
T1	Oxadiargyl 80g/ha at 0-3 DAS	5.67	12.11
T2	Metribuzin 350g/ha at 0-3 DAS	6.82	14.17
T3	Topramezone 19.35g/ha at 2-3 Leaf stage of weed	6.46	13.40
T4	Topramezone 25.8g/ha at 2-3 Leaf stage of weed	6.33	13.00
T5	Topramezone 32.25g/ha at 2-3 Leaf stage of weed	5.83	12.67
T6	Topramezone (directed application)25.8g/ha at 5-6 Leaf stage of weed	6.70	14.00
T7	Fluzifop-p-butyl 13.4% + Fomesafen 11.1% 250g/ha at 2-3 Leaf stage of weed	5.75	12.33
T8	Metribuzin350g/ha *fb* Topramezone25.8g/ha at 0-3 DAS & 2-3 Leaf stage of weed	6.40	13.20
T9	Metribuzin 350g/ha *fb* Metribuzin350g/haat0-3 DAS &5-6 Leaf stage of weed	6.97	14.33
T10	Fluzifop-p-butyl 13.4% + fomesafen11.1% (directed application) 250g/ha at 5-6 Leaf stage of weed	6.58	13.83
T11	Sodium acifluorfen16.5%+ clodinafop proparzyl 8% (directed application) 187.5g/ha at 2-3 leaf stage of weed	6.77	14.05
T12	Mertibuzin (directed application) 350g/ha at 2-3 leaf stage of weed	6.12	12.87
T13	Metsulfuron (directed application) 4g/ha at 2-3 leaf stage of weed	6.52	13.67
T14	Hand weeding twiceat 20 & 40 DAS	7.13	14.83
T15	Unweeded control	5.40	12.00
	S.Em±	0.15	0.48
	CD (P= 0.05)	NS	NS

Number of pods plant-1

The data on number of pods plant^{-1} of lentil as influenced by different herbicide treatments are presented in Table 4 significant result was observed for number of pods plant^{-1}.The significantly higher number of pods plant^{-1}was recorded in plot where hand weeding was applied twice at 20 and 40 DAS (T14) (36.67) than other treatments but it was at par with Metribuzin *fb* Metribuzin 350-350 g ha^{-1} 0-3 DAS & 5-6 Leaf stage of weed (T9), Metribuzin @350gha^{-1} at 0-3 DAS (T2) and Sodium acifluorfen16.5%+ clodinafop proparzyl 8% (directed application) @ 187.5gha^{-1} at 2-3 leaf stage of weed (T11). The minimum number of pods per plant (20.33) was recorded in unweeded control (T15) due to high crop - weed competition during critical period, resulting poor vegetative and reproductive growth of plants. The treatment could very well be explained in the light of competition stress and clean

cultivation. The plant got proper aeration during their growth phase. Dawood (1994) [4] and Mahanta (2007) [10] reported that the two hand weeding significantly increased the value of yield attributes.

Number of seeds pod-1

The data on number of seeds pod^{-1} of lentil as influenced by different herbicide treatments are presented in Table 4. There was non-significant result was observed for number of seeds pod^{-1}. Although, the maximum number of seeds pod^{-1} (1.67) was obtained in treatment two hand weeding at 20 and 40 DAS (T14). The minimum number of seeds pod^{-1} (1.00) was recorded in unweeded control (T15). The treatment could very well beexplained in the light of competition stress and clean cultivation. Dawood (1994) [4] and Mahanta (2007) [10] obtained that the two hand weeding significantly increased the value of yield attributes and yield.

Seed index (100 seed weight)

The weight of hundred seeds is also an important attribute to yield and data are presented in Table 4. The effect of various treatment on seed index was non- significant. Although, the highest seed index (3.33g) was obtained in treatment two hand weeding at 20 and 40 DAS (T14). The lowest seed index (2.70g) was recorded in unweeded control (T15).

Seed yield (kg ha-1)

The data on seed yield (kg ha^{-1}) of lentil as influenced by different herbicide treatments are presented in Table 4. Different herbicide treatments resulted significant influenced on seed yield (kg ha^{-1})of lentil. Among the herbicide application of Metribuzin *fb* Metribuzin 350-350g ha-1 0-3 DAS & 5-6 Leaf stage of weed (T9) was recorded maximum seed yield (990.00) followed by Metribuzin @ 350gha^{-1} at 0-3 DAS (T2) (930.00) and Sodium acifluorfen16.5%+ clodinafop proparzyl 8% (directed application) @ 187.5gha^{-1} at 2-3 leaf stage of weed (T11). The minimum seed yield was recorded in unweeded control (T15) (485.25). Weed removal at early stage in the season, reduced crop weed competition had the lowest possible limit and provided almost weed free environment. It may probably the reason for higher seed yield in hand weeding treatment. The present finding are closely reported with the findings of Turk and Tawaha (2002) [16], Elkoco *et al*. (2005) and Maleki *et al*. (2010) [11].

Stover yield (kg ha-1)

Among the herbicide application of Metribuzin *fb* Metribuzin 350-350 g ha^{-1} 0-3 DAS & 5-6 Leaf stage of weed (T9) was recorded maximum stover yield followed by Metribuzin @350gha^{-1} at 0-3DAS (T2) and Sodium acifluorfen16.5%+ clodinafop proparzyl 8% (directed application) @ 187.5gha^{-1} at 2-3 leaf stage of weed (T11). The minimum stover yield was recorded in unweeded control (T15) over all other treatments. Hand weeding twice gave comparatively higher grain and straw yield of lentil than chemical treatments (Singh and Choudhary, 1982).

Harvest index

The data on the harvest index were gathered on the basis of grain yield and total biological yield and the mean data have been presented in Table 4 The non- significant differences were observed among the various herbicide treatments for harvest index. However, treatment hand weeding twice at 20 and 40 DAS (T14) had the highest harvest index value (32.91%) followed by Metribuzin *fb* Metribuzin 350-350 g ha^{-1} 0-3 DAS & 5-6 Leaf stage of weedT9 (32.84%), while the lowest harvest index was registered under T15 (23.49%).

Table 4: Yield attributes and yield of lentil as influenced by various herbicide treatments

	Treatments	Number of pods plant^{-1}	Number of seeds pod^{-1}	100 seed Weight (g)	Seed yield (kg/ha)	Stover yield (Kg/ha)	Harvest index (%)
T_1	Oxadiargy l80g/ha at 0-3 DAS	23.67	1.03	2.73	519.72	1638.41	24.08
T_2	Metribuzin350g/ha at 0-3 DAS	33.33	1.50	3.27	950.00	1982.00	32.40
T_3	Topramezone19.35g/ha at 2-3 Leaf stage of weed	27.00	1.30	3.10	713.83	1810.25	28.28
T_4	Topramezone 25.8g/ha at 2-3 Leaf stage of weed	25.67	1.20	3.00	623.02	1745.42	26.30
T_5	Topramezone 32.25g/ha at 2-3 Leaf stage of weed	24.33	1.13	2.87	568.50	1680.60	25.27
T_6	Topramezone (directed application) 25.8g/haat 5-6 Leaf stage of weed	31.33	1.43	3.20	758.35	1876.67	28.75
T_7	Fluzifop-p-butyl 13.4% + Fomesafen 11.1% 250g/ha at 2-3 Leaf stage of weed	24.00	1.10	2.77	541.13	1658.67	24.60
T_8	Metribuzin 350g/ha *fb* Topramezone 25.8g/ha at 0-3 DAS & 2-3 Leaf stage of weed	26.00	1.23	3.07	700.00	1780.67	28.22
T_9	Metribuzin 350g/ha *fb* Metribuzin 350g/ha at 0-3 DAS &5-6 Leaf stage of weed	34.00	1.53	3.30	970.00	1983.42	32.84
T_{10}	Fluzifop-p-butyl 13.4% + fomesafen11.1% (directed application) 250g/ha at 5-6 Leaf stage of weed	29.33	1.37	3.17	740.17	1850.59	28.56
T_{11}	Sodium acifluorfen16.5%+ clodinafop proparzyl 8% (directed application) 187.5g/ha at 2-3 leaf stage of weed	32.00	1.47	3.23	923.33	1973.58	31.87
T_{12}	Mertibuzin (directed application) 350g/ha at 2-3 leaf stage of weed	25.00	1.17	2.97	600.00	1701.67	26.06
T_{13}	Metsulfuron (directed application) 4g/ha at 2-3 leaf stage of weed	28.33	1.33	3.13	720.33	1845.33	28.49
T_{14}	Hand weeding twiceat 20 & 40 DAS	36.67	1.67	3.33	1016.67	2098.25	32.91
T_{15}	Unweeded control	20.33	1.00	2.70	485.25	1580.30	23.49
	S.Em±	1.62	0.17	0.23	38.18	51.48	-
	CD (P= 0.05)	4.70	NS	NS	110.60	149.13	-

Economics: Economics is the final metric to evaluate the best treatments which are economically sound and that can be acceptable to the farmers. Different parameters of economics like cost of cultivation (Rsha^{-1}), gross return (Rsha^{-1}), net return (Rsha^{-1}) and B:C ratio for different weed management practices for were computed and presented in table 5.

Cost of cultivation (Rsha^{-1})

The data pertaining to cost of cultivation showed that highest cost of cultivation was recorded under treatment T14: Hand weeding twice (36471 Rsha^{-1}) followed by T5- Topramezone 32.25gha^{-1} 2-3 Leaf stage of weed (31141 Rsha^{-1}) however lowest cost of cultivation was found in T15: Unweeded control (23831Rs ha^{-1}).

Gross return (Rsha^{-1})

Higher gross return was found in treatment T14: Hand weeding twice (55917 Rsha^{-1}) followed by T9: Metribuzin *fb* Metribuzin 350-350gha^{-1}0-3DAS &5-6 Leaf stage of weed (54450 Rsha^{-1}) and lowest was recorded in T15: Unweeded control (26689 Rsha^{-1}).

Net return (Rsha^{-1})

Highest net returns was received by T9: Metribuzin *fb* Metribuzin 350- 350g/ha 0-3 DAS &5-6 Leaf stage of weed (27467 Rsha^{-1}) followed by T2: Metribuzin 350g/ha 0-3 DAS (25269 Rsha^{-1}) and lowest in T5: Topramezone 32.25gha^{-1} 2-3 Leaf stage of weed (126 Rsha^{-1}).

B:C ratio

Highest B:C ratio was obtained in treatment T9: Metribuzin *fb* Metribuzin 350-350g/ha 0-3 DAS &5-6 Leaf stage of weed (2.02) followed by T2: Metribuzin 350g/ha 0-3 DAS (1.98) and lowest in treatment T5: Topramezone 32.25gha^{-1} 2-3 Leaf stage of weed (1.00). Total dry matter production of a plant often reflects its potentiality for its biomass production. Whereas, mobilization forwards the seed development is an important factor for realization of economic yield and serves as the yardstick resulting in maximum gross return which was produced in T9- hand Weeding twice at 20 and 40 DAS and this treatment also gave maximum net return, additional return over weedy check and benefit cost ratio. This was due to lower cost of cultivation associated with higher seed yield than other herbicidal treatments. It was conformity with the findings of Yaduraju and Mishra (2005) [17], Chaudhary (2011) [3], Tiwari *et al*. (2006) [15].

Table 5: Economics of lentil as influenced by various herbicide treatments

	Treatments	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio
T1	Oxadiargyl 80g/ha at 0-3 DAS	25759	28585	2826	1.11
T2	Metribuzin 350g/ha at 0-3 DAS	25881	51150	25269	1.98
T3	Topramezone 19.35g/ha at 2-3 Leaf stage of weed	28481	39261	10780	1.38
T4	Topramezone 25.8g/ha at 2-3 Leaf stage of weed	29665	34266	4601	1.16
T5	Topramezone 32.25g/ha at 2-3 Leaf stage of weed	31141	31268	126	1.00
T6	Topramezone (directed application) 25.8g/ha at 5-6 Leaf stage of weed	29665	41708	12044	1.41
T7	Fluzifop-p-butyl 13.4% + Fomesafen 11.1% 250g/ha at 2-3 Leaf stage of Weed	26667	29762	3095	1.12
T8	Metribuzin *fb* Topramezone 350- 25.8g/ha at 0-3 DAS & 2-3 Leaf stage of weed	30767	38500	7733	1.25
T9	Metribuzin *fb* Metribuzin 350-350g/ha a t0-3 DAS & 5-6 Leaf stage of weed	26983	54450	27467	2.02
T10	Fluzifop-p-butyl 13.4% + fomesafen 11.1% (directed application) 250g/ha at 5-6 Leaf stage of weed	26667	40709	14042	1.52
T11	Sodium acifluorfen16.5%+ clodinafop proparzyl 8% (directed application) 187.5g/ha at 2-3 leaf stage of weed	26261	50783	24522	1.93
T12	Mertibuzin (directed application) 350g/ha at 2-3 leaf stage of weed	25881	33000	7119	1.28
T13	Metsulfuron (directed application) 4g/ha at 2-3 leaf stage of weed	25229	39618	14389	1.57
T14	Hand weeding twice at 20 & 40 DAS	36471	55917	19446	1.54
T15	Unweeded control	23831	26689	2858	1.12

Concussion

Results revealed that significantly higher plant population(m^{-1} row length), plant height (cm), number of branches plant^{-1}, number of nodules plant $^{-1}$, yield attributes, seed yield (kg ha^{-1}), stover yield (kg ha^{-1}) and harvest index (%) were obtained under hand weeding twice at 20 and 40 DAS (T14), but it was at par with Metribuzin *fb* Metribuzin 350-350 g ha^{-1} 0-3 DAS & 5-6 Leaf stage of weed (T9), Metribuzin 350 g ha^{-1} 0-3 DAS(T2) and Sodium acifluorfen1 6.5% + coldinafopproparzyl 8% (directed application) 187.5 g ha^{-1} 2 to 3 leaf stage of weed (T11). The minimum values of above character were observed under unweeded control plot (T15). The highest cultivation cost and gross monetary returns were noticed with hand weeding twice at 20 and 40 DAS. Maximum net returns and higher B: C ratio was noticed under Metribuzin *fb* Metribuzin 350-350 g ha^{-1} 0-3 DAS & 5-6 Leaf stage of weed (T9) followed by Metribuzin 350 g ha^{-1} 0-3 DAS(T2).

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