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Effect of herbicides on weed dynamics and profitability of lentil (*Lens culinaris* Medik) in vertisols of Chhattisgarh

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Abstract
The present investigation entitled "Effect of herbicides on weed dynamics and profitability 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- Fluazifop-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}- Fluazifop-p-butyl 13.4% + Fomesafen 11.1% (directed application) 250 g ha^{-1} 5-6 Leaf stageweed, T_{11}- Sodium acifluorfen16.5% + clodinafop propargyl 8% (directed application) 187.5 g ha^{-1} 2 to 3 leaf stage of weed, T_{12} - Metribuzin (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. The lowest weed density, dry matter production of weeds and highest weed control efficiency (WCE) were recorded under hand weeding twice at 20 and 40 DAS, followed by Topramezone 32.25 g ha^{-1} 2-3 Leaf stage of weed (T_5).
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: Weed flora, weed dry matter, weed control efficiency, weed index, B:C ratio

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/100 g), phosphorus (300 mg/100 g), and iron (7 mg/100 g) 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) [10]. 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) [11]. 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 kg ha^{-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, moisture and space, resulting in poor crop growth and yield. In the presence of weeds, lentil yields are decreased by 80 percent (Mohamed *et al*., 1997) [18]. Weed control is the most important factor in ensuring a high yield at harvest in the lentil crop (Erman *et al*., 2008) [9]. Yield losses of 20 to 30 percent are typical, and if proper packaging and practises aren't followed, yield losses can hit 50 percent (Tanveer and Ali, 2003) [24]. Weeds have been found to reduce lentil yields by 40-66 percent (Singh and Chowdhury, 1982; Gautam and Singh, 1981; Yaduraju and Mishra, 2005 and Singh *et al*., 2015) [23, 12, 28, 22]. To maximise lentil grain yield, weed competition must be minimised using management methods such as herbicides. Herbicide management practises help to minimise the expense of weed control in a number of situations by controlling weeds rapidly and efficiently. Since lentils are a long-term crop with critical weed competition ranging from 40 to 60 DAS, early weed control herbicides are often ineffective in achieving higher yields, even when farmers use pre-emergence herbicides. Weed control at later stages of the crop growth cycle can be aided by using pre-emergence and post-emergence herbicides in series, as well as applying post-emergence herbicides.

Materials and methods

The experiment "Effect of herbicides on weed dynamics and profitability of lentil (*Lens culinaris* Medik) in Vertisols of Chhattisgarh" was conducted at Research cum Instructional Farm of IGKV, during rabi season of 2020-21. The climate of the region is sub-humid to semi-arid. 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- Fluazifop-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}- Fluazifop-p-butyl 13.4% + Fomesafen 11.1% (directed application) 250 g ha^{-1}5-6 Leaf stageweed, T_{11}- Sodium acifluorfen16.5% + clodinafop propargyl 8% (directed application) 187.5 g ha^{-1} 2 to 3 leaf stage of weed, T_{12} - Metribuzin (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. All the herbicides were sprayed as per their time of application by knapsack sprayer using a flat fan nozzle at 500 l/ha volume by diluting with water. The economics of treatments was computed on the basis of prevailing market prices of inputs and outputs under each treatment.

Weed flora composition

Weed flora was observed before and after the application of treatments. The important weed species in the experimental field were *Medicago denticulata*, *Cichorium intybus*, *Chenopodium album*, *Cynodon dactylon*, *Echinochloa colona* and *Physalis minima* etc.

Weed density (Total number m^{-2})

The weed density of different weed species were studied on 30, 60 and 90 DAS. The weed investigation in each plot was conducted at random from four randomly selected sites, and quadrate was used for this purpose. Green weeds were the only ones sampled. Weeds were counted and the total population of weeds was calculated. The data was transformed in order to conduct statistical analysis.

Weed dry weight (g m^{-2})

Weed dry matter was measured in lentil at 30, 60, and 90 DAS. Weeds and roots that had grown in the quadrate were carefully eradicated. The weed plants' roots were removed and the shoots were oven dried for 36 to 48 hours at 60 °C. The dry matter of the weeds was measured after complete oven drying for each treatment.

Weed control efficiency (%)

The weed control efficiency was calculated on the basis of reduction in dry matter production of weeds in treated plots in comparison with weedy check and expressed in percentage as suggested by Mani *et al*. (1973) [29].

$$WCE\ (\%) = \frac{DWC - DWT}{DWC} 100$$

Where,
WCE - Weed control efficiency (%)
DWC = Dry weight of weeds in unweeded control plot (g)
DWT =Dry weight of weeds in treated plot (g)

Weed index (%)

Weed index is defined as the reduction in yield due to the presence of weeds in comparison with weedy check plot and expressed in percentage as suggested by Gill and Vijayakumar (1969).

$$W.I.\ (\%) = \frac{X-Y}{X} X\ 100$$

Where,
WI = Weed index
X= Seed yield from hand weeded plot
Y- Seed yield from the treatment for which weed index is to be worked out.

Economics

The cost of inputs and outputs that were prevailing at the time of their use was considered for working out the economics of various treatment combinations. A net return ha^{-1} was calculated by deducting the cost of cultivation from gross income $hectare^{-1}$ and benefit cost ratio was worked as follows.

$$B: C\ ratio = \frac{Gross\ Returns}{Cost\ of\ cultivation}$$

Results and discussion

Weed density (Total number of weeds m^{-2})

The data on total weed density were recorded at 30, 60, and 90 DAS and data are presented in Table 1

At 30 DAS ssignificantly lower of weeds was recorded under hand weeding twice at 20 and 40 DAS (T_{14}) as compared to other treatments but it was at par with Topramezone 32.25g ha^{-1} 2-3 Leaf stage of weed (T_5), Metribuzin *fb* Topramezone 350-25.8 g ha^{-1}0-3 DAS & 2-3 Leaf stage of weed (T_8) and

Topramezone 25.8 g ha^{-1} 2-3 Leaf stage of weed (T_4). The higher density of weeds was recorded under unweeded control (T_{15}).

At 60 and 90 DAS, significantly lower density of weeds was recorded under hand weeding twice at 20 and 40 DAS (T_{14}) as compared to other treatments but it was at par with Topramezone 32.25 g ha^{-1} 2-3 Leaf stage of weed (T_5), Fluazifop-p-butyl 13.4% + fomesafen 11.1% 250 g ha^{-1}2-3 Leaf stage of weed (T_7) and Metribuzin *fb* Metribuzin 350-350gha^{-1}0-3DAS &5-6 Leaf stage of weed (T_9). The higher density of weeds was recorded under unweeded control (T_{15}).

It was depicted from the data, (Table 1) that the total weed species and weed density in the T_{15}- Unweeded control was significantly higher compared to other weed management practices throughout the period of investigation. This was due to know any weed management practices applied to control weeds which freely proliferated and compete with the crop for available nutrient, moisture and sunlight resulting in reduction of crop yield. Similar results were observed by Singh and Singh (1983) [21], Kumar and Kolar (1989) [15], Punia *et al*. (2003) [19] and Dibakar *et al*. (2003) [7].

Weed dry weight (gm^{-2})

The data on total dry matter production of weeds, at 30, 60, and 90 DAS as influenced by different herbicide treatments are presented in Table 2.

At 30 DAS ssignificantly lower production of total weed dry matter was recorded under hand weeding twice at 20 and 40 DAS (T_{14}) as compared to other treatments but it was at par with Topramezone 32.25gha^{-1} 2-3 Leaf stage of weed (T_5),Metribuzin *fb* Topramezone 350-25.8gha^{-1}0-3DAS & 2-3 Leaf stage of weed (T_8)andTopramezone 25.8gha^{-1} 2-3 Leaf stage of weed (T_4). The higher production of total weed dry matter was recorded under unweeded control (T_{15}).

At 60 and 90 DAS, significantly lower production of total weed dry matter was recorded under hand weeding twice at 20 and 40 DAS (T_{14}) as compared to other treatments but it was at par with Topramezone 32.25gha^{-1} 2-3 Leaf stage of weed (T_5), Fluazifop-p-butyl 13.4% + fomesafen 11.1% 250gha^{-1}2-3 Leaf stage of weed (T_7) and Metribuzin *fb* Metribuzin 350-350gha^{-1}0-3DAS &5-6 Leaf stage of weed (T_9). The higher production of total weed dry matter was recorded under unweeded control (T_{15}).

Production of total dry matter by all species were observed significantly maximum under T_{15}-unweeded control and significantly minimum production of dry matter under treatment T_{14}- hand weeding twice at 20 and 40 DAS, throughout the period of investigation. Anupam *et al.* (2009) [3], Kumar and Kolar (1989) [15] and Bhowmik *et al*. (2010) [4] also reported similar results from their study.

Table 1: Total weed density of weeds in lentil as influenced by various herbicide treatments.

S. N.	Treatments	Total Weed density (total no. m^{-2})		
		30 DAS	60 DAS	90 DAS
T_1	Oxadiargyl 80g/ha at0-3 DAS	5.78 (33.00)	6.82 (46.00)	6.94 (49.00)
T_2	Metribuzin 350g/ha at0-3 DAS	5.52 (30.00)	6.39 (40.33)	6.57 (44.00)
T_3	Topramezone19.35g/ha at2-3 Leaf stage of weed	4.34 (18.33)	5.18 (26.33)	5.87 (34.00)
T_4	Topramezone 25.8g/ha at2-3 Leaf stage of weed	4.02 (15.67)	4.88 (23.33)	5.55 (30.33)
T_5	Topramezone 32.25g/ha at2-3 Leaf stage of weed	3.54 (12.00)	3.49 (11.67)	3.98 (15.33)
T_6	Topramezone (directed application) 25.8g/ha at5-6 Leaf stage of weed	6.96 (49.67)	4.53 (20.00)	5.02 (24.67)
T_7	Fluazifop-p-butyl 13.4% + Fomesafen 11.1% 250g/ha at 2-3 Leaf stage of weed	5.27 (27.33)	3.72 (13.33)	4.34 (18.33)
T_8	Metribuzin *fb* Topramezone 350-25.8g/ha at0-3DAS & 2-3 Leaf stage of weed	3.76 (13.67)	4.70 (21.67)	5.31 (27.67)
T_9	Metribuzin *fb*Metribuzin 350-350g/ha at0-3DAS &5-6 Leaf stage of weed	7.31 (53.00)	3.98 (15.33)	4.53 (20.00)
T_{10}	Fluazifop-p-butyl 13.4% + fomesafen 11.1% (directed application) 250g/ha at 5-6 Leaf stage of weed	7.63 (56.33)	4.34 (18.33)	4.81 (22.67)
T_{11}	Sodium acifluorfen16.5%+ clodinafop propargyl 8% (directed application) 187.5g/ha at2-3 leaf stage of weed	4.81 (22.67)	5.40 (28.67)	6.04 (36.00)
T_{12}	Metribuzin (directed application) 350g/ha at2-3 leaf stage of weed	5.08 (25.33)	5.61 (31.00)	6.23 (38.33)
T_{13}	Metsulfuron (directed application) 4g/ha at2-3 leaf stage of weed	4.60 (20.67)	5.05 (25.00)	5.70 (32.00)
T_{14}	Hand weeding twice at20 & 40 DAS	3.44 (10.66)	3.24 (10.00)	3.76 (13.67)
T_{15}	Unweeded control	7.71 (59.00)	9.14 (83.00)	12.14 (147.00)
	SEm±	0.12	0.25	0.15
	CD (P=0.05)	0.34	0.63	0.40

Table 2: Weed dry weight of weeds in lentil as influenced by various herbicide treatments.

S. N.	Treatments	Weed dry weight (gm^{-2})		
		30 DAS	60 DAS	90 DAS
T_1	Oxadiargyl 80g/ha at0-3 DAS	3.67 (13.00)	7.15 (50.67)	11.42 (137.85)
T_2	Metribuzin 350g/ha at0-3 DAS	3.61 (12.50)	6.99 (48.33)	10.74 (128.01)
T_3	Topramezone19.35g/ha at2-3 Leaf stage of weed	2.86 (7.67)	6.48 (41.50)	10.24 (104.33)
T_4	Topramezone 25.8g/ha at2-3 Leaf stage of weed	2.67 (6.65)	6.07 (36.33)	9.59 (86.00)
T_5	Topramezone 32.25g/ha at2-3 Leaf stage of weed	2.31 (4.87)	4.52 (20.00)	7.20 (51.67)
T_6	Topramezone (directed application) 25.8g/ha at5-6 Leaf stage of weed	5.05 (25.05)	5.83 (35.91)	9.48 (89.50)
T_7	Fluazifop-p-butyl 13.4% + Fomesafen 11.1% 250g/ha at2-3 Leaf stage of weed	2.52 (7.40)	5.14 (25.97)	8.18 (66.44)
T_8	Metribuzin *fb* Topramezone 350-25.8g/ha at0-3DAS & 2-3 Leaf stage of weed	2.51 (5.80)	5.41 (28.76)	8.31 (68.67)
T_9	Metribuzin *fb*Metribuzin 350-350g/ha at0-3DAS &5-6 Leaf stage of weed	3.80 (14.00)	5.96 (35.00)	9.59 (92.00)
T_{10}	Fluazifop-p-butyl 13.4% + fomesafen 11.1% (directed application) 250g/ha at5-6 Leaf stage of weed	4.95 (24.00)	5.56 (30.48)	8.61 (73.67)
T_{11}	Sodium acifluorfen16.5%+ clodinafop propargyl 8% (directed application) 187.5g/ha at2-3 leaf stage of weed	3.34 (10.66)	6.84 (44.33)	10.75 (115.09)

T_{12}	Metribuzin (directed application) 350g/ha at2-3 leaf stage of weed	3.47 (11.58)	6.84 (46.33)	10.92 (118.77)
T_{13}	Metsulfuron (directed application) 4g/ha at2-3 leaf stage of weed	3.02 (8.65)	6.20 (37.84)	9.79 (95.30)
T_{14}	Hand weeding twice at20 & 40 DAS	2.17 (4.23)	4.30 (18.00)	6.44 (41.00)
T_{15}	Unweeded control	5.21 (26.62)	10.02 (100.00)	15.01 (225)
	SEm±	0.20	0.15	0.24
	CD (P=0.05)	0.47	0.48	0.69

Weed control efficiency

The data on weed control efficiency (%) at successive stages of growth i.e. 30, 60 and 90 DAS as affected by different weed control treatments have been summarized and presented in Table 3.

Data exhibited that at initial stage of plant growth i.e. at 30 DAS, T_{14}- recorded the highest weed control efficiency (84.12%) which was followed in order by T_5 - Topramezone 32.25 g ha^{-1} 2-3 Leaf stage of weed(81.71%), T_8 - Metribuzin fb Topramezone 350-25.8 g ha^{-1} 0-3DAS & 2-3 Leaf stage of weed (78.81%),T_4 -Topramezone 25.8g ha^{-1} 2-3 Leaf stage of weed (75.02%). At 60 DAS, weed control efficiency was found to be increased and the highest value (82.00%) was obtained under T14 (hand weeding twice at 20 and 40 DAS), followed by T_5 - Topramezone 32.25 g ha^{-1} 2-3 Leaf stage of weed(80.00%), T_7- Fluazifop-p-butyl 13.4% + Fomesafen 11.1% (directed application) 250 g ha^{-1}5-6 Leaf stage of weed (74.03%), T_8 - Metribuzin *fb* Topramezone 350-25.8 g ha^{-1} 0-3DAS & 2-3 Leaf stage of weed (71.24%).

At 90 DAS, the highest weed control efficiency was recorded under T14 (81.78%) which was followed by T_5 - Topramezone 32.25 g ha^{-1} 2-3 Leaf stage of weed(77.04%), T_7- Fluazifop-p-butyl 13.4% + Fomesafen 11.1% (directed application) 250 g ha^{-1}5-6 Leaf stage of weed (70.47%), T_8 - Metribuzin fb Topramezone 350-25.8 g ha^{-1} 0-3DAS & 2-3 Leaf stage of weed (69.48%).

Herbicidal application killed the weed seeds and weeds effectively and reduced the weed dry mass as compared to the control this resulted in increased weed control efficiency. Similar results were also reported by Singh and Singh (1983) [21], Kumar and Kolar (1989) [15], Punia *et al*. (2003) [19], Venkatesha *et al*. (2008), Khedkar *et al*. (2009), Amaregonda *et al*. (2013) [1], Sangeetha *et al*. (2013) [20] and Jha *et al*. (2014).

Weed index (%)

The data on weed index have been summarized and presented in Table 4. Weed index had remarkably influenced by different new herbicides application. Maximum weed index was recorded under T_{15}- unweeded control (52.27). Where, minimum weed index was recorded under T9- Metribuzin *fb* Metribuzin 350-350g/ha 0-3DAS &5-6 Leaf stage of weed, T_2-Metribuzin 350g/ha 0-3 DAS and T_{11}-Sodium acifluorfen 16.5%+ clodinafop propargyl 8% (directed application) 187.5g/ha 2-3 leaf stage of weed, (5.59, 6.56 & 9.18) respectively.

Weed index indicate the reduction in yield due to weed competition as compared to the maximum attained seed yield. The maximum weed index recorded under where no weed management practices are applied. Ultimately causes reduction in seed yield also reported maximum weed index under untreated control. Similar results were also reported by Singh and Singh (1983) [21], Kumar & Kolar (1989) [15], Punia *et al*. (2003) [19] and Jha *et al*. (2014) [13].

The maximum weed index under T15 (Unweeded control) was observed because of fact that there was lowest seed yield reported under weedy check which causes by high infestation of weeds.

Table 3: Weed control efficiency (%) as influenced by different weed management practices in Lentil at 30, 60 and 90 DAS

	Treatments	**Weed control efficiency (%)**		
		30 DAS	**60 DAS**	**90 DAS**
T_1	Oxadiargyl 80g/ha at 0-3 DAS	51.16	49.33	38.73
T_2	Metribuzin350g/ha at 0-3 DAS	53.04	51.67	43.11
T_3	Topramezone19.35g/ha at 2-3 Leaf stage of weed	71.17	58.50	53.63
T_4	Topramezone 25.8g/ha at 2-3 Leaf stage of weed	75.02	63.67	61.78
T_5	Topramezone 32.25g/ha at 2-3 Leaf stage of weed	81.71	80.00	77.04
T_6	Topramezone (directed application) 25.8g/ha at 5-6 Leaf stage of weed	5.90	64.49	60.22
T_7	Fluazifop-p-butyl 13.4% + Fomesafen 11.1% 250g/ha at 2-3 Leaf stage of weed	72.20	74.03	70.47
T_8	Metribuzin 350g/ha *fb* Topramezone 25.8g/ha at 0-3 DAS & 2-3 Leaf stage of weed	78.21	71.24	69.48
T_9	Metribuzin 350g/ha *fb*Metribuzin 350g/ha at0-3 DAS &5-6 Leaf stage of weed	47.41	65.00	59.11
T_{10}	Fluazifop-p-butyl 13.4% + fomesafen11.1% (directed application)250g/ha at 5-6 Leaf stage of weed	9.84	69.52	67.26
T_{11}	Sodium acifluorfen16.5%+ clodinafop propargyl 8% (directed application) 187.5g/ha at 2-3 leaf stage of weed	59.94	55.67	48.85
T_{12}	Metribuzin (directed application) 350g/ha at 2-3 leaf stage of weed	56.51	53.67	47.21
T_{13}	Metsulfuron (directed application) 4g/ha at 2-3 leaf stage of weed	67.51	62.16	57.64
T_{14}	Hand weeding twice at 20 & 40 DAS	84.12	82.00	81.00
T_{15}	Unweeded control	0.00	0.00	0.00

Table 4: Weed index (%) of lentil as influenced by various herbicide treatments.

	Treatments	**Weed index (%)**
T_1	Oxadiargyl 80g/ha at 0-3 DAS	38.72
T_2	Metribuzin 350g/ha at 0-3 DAS	6.56
T_3	Topramezone 19.35g/ha at 2-3 Leaf stage of weed	29.79
T_4	Topramezone 25.8g/ha at 2-3 Leaf stage of weed	48.88
T_5	Topramezone 32.25g/ha at 2-3 Leaf stage of weed	44.08
T_6	Topramezone (directed application)25.8g/haat 5-6 Leaf stage of weed	25.41
T_7	Fluazifop-p-butyl 13.4% + Fomesafen 11.1% 250g/ha at 2-3 Leaf stage of weed	46.77

T_8	Metribuzin 350g/ha *fb* Topramezone 25.8g/ha at0-3 DAS & 2-3 Leaf stage of weed	31.12
T_9	Metribuzin 350g/ha *fb* Metribuzin 350g/ha at 0-3 DAS &5-6 Leaf stage of weed	4.59
T_{10}	Fluazifop-p-butyl 13.4% + fomesafen11.1%(directed application) 250g/ha at 5-6 Leaf stage of weed	27.20
T_{11}	Sodium acifluorfen16.5%+ clodinafop propargyl 8% (directed application) 187.5g/ha at 2-3 leaf stage of weed	9.18
T_{12}	Metribuzin (directed application)350g/ha at 2-3 leaf stage of weed	40.98
T_{13}	Metsulfuron (directed application) 4g/ha at 2-3 leaf stage of weed	29.15
T_{14}	Hand weeding twiceat 20 & 40 DAS	-
T_{15}	Unweeded control	52.27

Economics

Economics of lentil production in terms of gross return, net return and benefit: cost ratio was calculated for different treatments. The data reveals that highest gross return (₹ 55917 ha^{-1}) were reported under T_{14}: Hand weeding twice at 20 &40 DAS. Whereas, maximum net realization (₹ 27467 ha^{-1}) and benefit: cost ratio (1.98) were recorded under T_9: Metribuzin 350g/ha *fb*Metribuzin 350g/haat 0-3 DAS & 5-6 Leaf stage of weed.A higher gross return in Metribuzin 350g/ha *fb* Metribuzin 350g/haat 0-3 DAS & 5-6 Leaf stage of weed (T_9) is due to more seed yield than other treatment. The lowest gross realization (₹ 28585rs ha^{-1}), net realization (₹ -126 ha^{-1}) and B: C ratio (1.00) were recorded under T_{15}: Unweeded control. Similar results were reported by, Punia *et al*. (2003) [19] and Dibakar *et al*. (2003) [7].

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	Fluazifop-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	Fluazifop-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 propargyl 8% (directed application) 187.5g/ha at 2-3 leaf stage of weed	26261	50783	24522	1.93
T12	Metribuzin (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

Conclusion

The results of the experiment further concluded that the lowest weed density, dry matter production of weeds and highest weed control efficiency (WCE) were recorded under hand weeding twice at 20 and 40 DAS, followed by Topramezone 32.25 g ha^{-1} 2-3 Leaf stage of weed (T_5).

Hand weeding twice 20 & 40 DAS DAS was found economically beneficial as compare to other treatments. The highest gross return was found in Hand weeding twice 20 & 40 DAS treatment, however net return and B:C ratio was higher in Metribuzin 350g/ha *fb*Metribuzin 350g/haat 0-3 DAS & 5-6 Leaf stage of weed.

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