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Soil microbes, nutrient removal, productivity and profitability of lentil (*Lens culinaris* Medikus) influenced by weed management practices

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ABSTRACT

A field experiment was conducted during winter (Rabi) seasons of 2012-13, 2013-14 and 2014-15 in sandy loam soils of Central Brahmaputra Valley Zone (CBVZ) of Assam to study the effect of pre-emergence herbicides and their combination with hand weeding on weed growth, soil microbes, nutrient removal by both crop and weed, grain yield and economics of lentil (Lens culinaris Medikus ssp. culinaris) under irrigated conditions. Pendimethalin + imazethapyr (combo formulation) 1.0 kg ha^{-1} as pre-emergence (PE) + hand weeding (HW) at 40 days after sowing (DAS) and pendimethalin 1.0 kg ha^{-1} PE + HW at 40 DAS controlled weeds effectively and recorded 79.63 and 74.75 per cent weed control efficiency (WCE), respectively. These two integrated weed management practices exhibited significant superiority to pendimethalin as well as the combo formulation. After the initial suppression, the adverse effect of herbicides on soil microbial population was decreased from 25 DAS onwards, and microbial population gradually increased through the crop growing period. The increase in symbiotic N-fixing (NFB) and phosphate solubilizing bacteria (PSB) at harvest over initial values ranged from 106.1 to 151.9 per cent and from 115.4 to 146.1per cent, respectively. Uptake of N, P and K by crop was maximum under the combo formulation + HW (45.42, 3.32 and 5.54 kg ha^{-1}, respectively). Pendimethalin 1.0 kg ha^{-1} + HW accrued in an uptake of 43.33 kg N ha^{-1}, 3.17 kg P ha^{-1} and 5.28 kg K ha^{-1}. However, nutrient (N, P, K) removal by weeds was minimum under these two treatments. These two weed management practices accrued in significantly higher (pooled) grain yields (1107.89 and 1056.72 kg ha^{-1}, respectively) as compared to all other treatments. The benefit-cost ratio (BCR) under these two was 2.53 and 2.63, respectively. Considering the easy availability of pendimethalin in Assam, the technology 'pendimethalin 1.0 kg ha^{-1} PE + HW at 40 DAS' was tested for effective weed management, maximizing lentil production and farmers' acceptability in farmers' fields during Rabi 2015-16 through four Krishi Vigyan Kendras (KVK) in Upper Brahmaputra Valley (UBV), Central Brahmaputra Valley (CBV), Lower Brahmaputra Valley (LBV) and North Bank Plain (NBZ) Zones of the state. The yield increase over farmer's practice (1 HW at 25-30 DAS) was 23.2, 46.6, 8.1 and 8.4 per cent in UBV, CBV, LBV and NBP, respectively.

***Keywords*:** B:C ratio, grain yield, lentil, nutrient removal, soil microbes and weed management

Lentil (*Lens culinaris* Medikus) is an important pulse crop of India cultivated on 1.27 million ha^{-1} area with total production of 0.97 million tons and a productivity of 765 kg ha^{-1} (2015-16). This crop is grown in 27180 ha^{-1} with production and productivity of 19645 t and 723 kg ha^{-1}, respectively in Assam. Weeds are salient competitors/removers of natural and man-made resources such as nutrients, water and light, which could have been otherwise for boosting up crop productivity (Singh and Sheoran, 2008). Yield reduction caused by weeds exceeds the losses due to any other agricultural pests. In Assam, manual weeding is the only proposition practised by the farmers in pulses. On small-scale farms, in developing countries > 50 % of labour- time is devoted to weeding manually (Akobundu, 1996). Therefore, weed management by using herbicides is the only alternative for maximizing productivity and profitability of lentil production. Since, PE application of herbicide may not be so effective in providing broad spectrum weed management, combination of PE herbicide and manual weeding may be more worthwhile. Keeping these in view, the present investigation was undertaken to test the performance of two PE herbicides using varying doses alone or in integration with HW for providing effective weed control during critical period of crop-weed interference in lentil. While using herbicides, it is of utmost significance that one should keep a sight on soil health sustainability.

MATERIALS AND METHODS

A field study was conducted during winter (*Rabi*) seasons of 2012-13, 2013-14 and 2014-15 at Regional Agricultural Research Station, Assam Agricultural University, Shillongani, Nagaon, Assam (92.65^{0}E longitude, 26.21^{0}N latitude and 50.2 m above MSL). The technology generated was tested through KVKs for farmers' acceptability in four agro-climatic zones of the state during *Rabi* 2015-16. Seven weed management treatments (Table 1) were evaluated in randomized block design with four replications. The soil was sandy-loam, having 0.79% organic C, 280.6 kg ha^{-1} of available N, 22.1 kg ha^{-1} of available P_2O_5 and 137.4 kg ha^{-1} of available K_2O. Lentil variety 'HUL 57' was sown on November 1, 25 and 17 in respective years of study using

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a seed rate of 30 kg ha^{-1} at 25 cm row to row distance. The crop was harvested on March 3, 23 and 16 in respective years. Recommended dose of fertilizers (15 kg N +35 kg P_2O_5 + 15 kg K_2O ha^{-1}) was applied as basal. One sprinkle irrigation was given at pod formation stage. The mean maximum and minimum temperature recorded were in the range of 18.0 to 33.5 ^{0}C and 8.0 to 21.0 ^{0}C, respectively (mean of three years); mean relative humidity ranged from 72 to 100 per cent (morning) and 43 to 100 per cent (evening) during the crop growth period. Range of evaporation rate per day was 1.0 to 3.0 mm, while rainfall was 7 mm in 2012-13, 51.2 mm in 2013-14 and 24.5 mm in 2014-15. Pre-emergence application of herbicides was done on next day of sowing. Weed population was recorded at 80 DAS. The weeds were dried in oven till constant weight was observed and then, WCE was calculated using standard formula. The soil and plant analyses for nutrient were done by using standard methods. The soil samples were drawn and analysed after harvesting of the crop. The economics was calculated based on prevailing market prices of inputs and outputs.

The enumeration of soil microbial population was done on agar plates containing appropriate media following serial dilution technique and pour-plate method (Pramer and Schmidt, 1966). Yeast mannitol agar medium was used for counting symbiotic NFB and for that of PSB, Pikovskaia's agar medium was used. The pH of the medium was maintained at 6.8 ± 0.2 for NFB and 7.4 for PSB, and the medium was sterilized at 15 lbs stream pressure for 20 minutes. Plates were incubated at 30^{0}C. The counts were recorded at the fifth day of incubation as number of cells/g soil. For microbial counts, soil samples were collected just before sowing and at 25, 50, 75 DAS and at harvest.

RESULTS AND DISCUSSION

Effect on weeds

The major weed flora in the experimental field comprised *Vicia sativa* L., *Cynodon dactylon* (L.) Pers., *Celotia argentea* L. and *Leucas aspera* (Willd.) Link. The highest weed population (35.24/m^2) and dry matter (27.49 g/m^2) were recorded in weedy check; whereas, the lowest weed population (8.9/m^2) and total weed biomass (5.6 g/m^2) were under PE application of the combo formulation of pendimethalin and imazethapyr 1.0 kg ha^{-1} + HW at 40 DAS, which was followed by PE pendimethalin 1.0 kg ha^{-1} + HW at 40 DAS (Table 1 and 2). The highest WCE (79.63%) was with the combo formulation of pendimethalin and imazethapyr + HW (Table 3) closely followed by pendimethalin + HW (74.75%). Gupta *et al*. (2013) reported that pendimethalin 1.0 kg ha^{-1} PE reduced weed population and dry matter accumulation to a notable level in urdbean (*Vigna mungo* L.). Papiernik *et al*. (2003) recommended use of imazethapyr in legumes. However, the combo herbicide 0.75 kg ha^{-1} PE + HW also registered notable WCE (69.69%). The PE herbicides alone were inferior to that of the respective integrated weed management practices because the application of herbicide might have reduced the population and dry matter accumulation of weeds at early phase of crop growth, but at the latter stage more weeds had emerged. This was probably due to low persistence of these herbicides in soil that reduced their activity for longer period. The higher efficacy of the herbicides + HW might be owing to better control of weeds initially followed by eradication of the second flash of weeds by HW at 40 DAS. Tripathi *et al*. (2008) also reported the effectiveness of PE herbicides in integration with manual weeding to check weed growth.

Effect on soil microbes

Pre-emergence application of herbicides exerted considerable detrimental effect on symbiotic NFB and PSB and accrued in reduction of microbial count in all soil samples collected at 25 DAS (Table 4, 5). But the harmful effect of herbicides did not last long and that was reflected through stimulation of bacterial population in the rhizosphere soil thereafter (Sebiomo *et al*. 2011). Initial suppression of microbial population might be due to toxic effect of herbicides in soil environment (Dutta *et al*. 2016). In case of both the bacteria, the pattern of decline in population and subsequent recovery followed the similar trend. The PE herbicides alone or in integration with HW did not differ considerably so far as the population of both the bacteria observed at any stage of crop growth was concerned. However, at 25 DAS, their population was maximum and it was the minimum at harvest of the crop under weedy check. This might be due to the harmful effects of root exudates secreted by the complex weed flora in the soil of rhizosphere (Dutta *et al*. 2016).

Nutrient removal by weeds and crop

Removal of major nutrients (N, P, K) by weeds from soil was significantly affected by weed management treatments (Table 6). Pendimethalin 1.0 kg ha^{-1} PE + HW at 40 DAS and the combo formulation of pendimethalin and imazethapyr 1.0 kg ha^{-1} PE + HW at 40 DAS resulted in significantly lower removal of the nutrients as compared to other treatments. The highest removal of N, P and K was recorded in weedy check plot. Therefore, it was well augmented that weeds should be controlled at early stage of crop growth. Any delay in weed control might have accrued in robbing off nutrients by weeds and depriving the crop of its share (Wu *et al*.

Table 1: Effect of weed management treatments on weed population (number m^{-2})

Treatment	2012-13	2013-14	2014-15	Mean
Pendimethalin + imazethapyr 0.75 kg ha^{-1} as PE	21.33	26.00	18.67	22.01
Pendimethalin + imazethapyr 1.0 kg ha^{-1} as PE	18.00	23.67	16.00	19.22
Pendimethalin 1.0 kg ha^{-1} as PE	19.67	25.00	17.33	20.66
Pendimethalin + imazethapyr 0.75 kg ha^{-1} as PE + HW at 40 DAS	10.00	13.33	11.67	11.67
Pendimethalin + imazethapyr 1.0 kg ha^{-1} as PE + HW at 40 DAS	12.00	8.67	6.00	8.90
Pendimethalin 1.0 kg ha^{-1} as PE + HW at 40 DAS	9.00	12.00	8.33	9.77
Weedy check	33.67	40.33	31.67	35.24
SEm (±)	**1.68**	**1.85**	**1.22**	**1.74**
LSD (0.05)	**4.98**	**5.51**	**3.62**	**5.17**

Table 2: Effect of weed management treatments on weed dry matter (g m^{-2})

Treatment	2012-13	2013-14	2014-15	Pooled
Pendimethalin + imazethapyr 0.75 kg ha^{-1} as PE	13.87	20.15	15.97	16.68
Pendimethalin + Imazethapyr 1.0 kg ha^{-1} as PE	12.20	17.66	14.28	14.71
Pendimethalin 1.0 kg ha^{-1} as PE	13.65	18.94	12.75	15.12
Pendimethalin + imazethapyr 0.75 kg ha^{-1} as PE + HW at 40 DAS	7.40	9.33	8.24	8.33
Pendimethalin + imazethapyr 1.0 kg ha^{-1} as PE + HW at 40 DAS	4.22	6.90	5.65	5.60
Pendimethalin 1.0 kg ha^{-1} as PE + HW at 40 DAS	5.37	8.54	6.90	6.94
Weedy check	26.18	31.42	24.86	27.49
SEm (±)	**1.20**	**1.69**	**1.33**	**1.55**
LSD (0.05)	**3.54**	**5.03**	**3.94**	**4.63**

Table 3: Effect of weed management treatments on weed control efficiency (%)

Treatment	2012-13	2013-14	2014-15	Mean
Pendimethalin + imazethapyr 0.75 kg ha^{-1} as PE	47.02 (43.27)	35.87 (36.60)	35.76 (36.68)	39.54 (38.83)
Pendimethalin + imazethapyr 1.0 kg ha^{-1} as PE	53.40 (46.95)	43.79 (41.41)	42.56 (40.63)	46.48 (42.98)
Pendimethalin 1.0 kg ha^{-1} as PE	47.86 (43.75)	39.72 (39.02)	48.72 (44.25)	44.99 (42.35)
Pendimethalin + imazethapyr 0.75 kg ha^{-1} as PE + HW at 40 DAS	71.73 (58.21)	70.31 (56.98)	66.85 (54.88)	69.69 (56.67)
Pendimethalin + imazethapyr 1.0 kg ha^{-1} as PE + HW at 40 DAS	83.88 (67.48)	78.04 (62.21)	77.27 (51.65)	79.63 (60.42)
Pendimethalin 1.0 kg ha^{-1} as PE + HW at 40 DAS	79.49 (63.79)	72.82 (58.80)	72.24 (58.23)	74.75 (60.27)
Weedy check	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)
SEm (±)	**3.04**	**2.17**	**1.76**	**2.90**
LSD (0.05)	**9.11**	**6.50**	**5.28**	**8.67**

Data in parenthesis represent angular transformed values.

2010). Weeds could be controlled effectively and economically by the above mentioned two practices, reflecting lower nutrient removal by weeds. Pre-emergence herbicides controlled weeds in early stages of lentil and weeds emerged at latter stages were not controlled well. Therefore, a combination of PE herbicide and 1 HW showed lower nutrient removal by weeds than that of herbicides alone. The findings are in conformity with that of Kumar *et al*. (2016).

Weeds management practices led to significantly higher N, P and K uptake by crop over weedy check (Table 7). Favourable crop growth conditions owing to

Table 4: **Effect of weed management treatments on microbial population of symbiotic N-fixing bacteria (mean of 3 years)**

Treatment	Bacteria (10^7 cfu g^{-1} of soil)				
	Initial	25 DAS	50 DAS	75 DAS	At harvest
Pendimethalin + imazethapyr 0.75 kg ha^{-1} as PE	36.25	22.46	47.23	61.26	83.16
Pendimethalin + imazethapyr 1.0 kg ha^{-1} as PE	39.42	20.12	45.12	58.57	81.24
Pendimethalin 1.0 kg ha^{-1} as PE	34.23	25.62	51.41	65.22	86.23
Pendimethalin + imazethapyr 0.75 kg ha^{-1} as PE + HW at 40 DAS	37.12	24.32	50.22	63.14	85.46
Pendimethalin + imazethapyr 1.0 kg ha^{-1} as PE + HW at 40 DAS	35.24	23.13	48.16	61.42	83.42
Pendimethalin 1.0 kg ha^{-1} as PE + HW at 40 DAS	39.14	27.14	52.26	67.63	90.67
Weedy check	36.47	38.42	40.51	57.00	78.56
SEm (±)	**2.20**	**1.93**	**3.61**	**2.05**	**1.22**
LSD (0.05)	**NS**	**5.74**	**NS**	**6.13**	**3.66**

Table 5: **Effect of weed management treatments on microbial population of phosphate solubilizing bacteria (mean of 3 years)**

Treatment	PSB (10^4 cfu g^{-1} of soil)				
	Initial	25 DAS	50 DAS	75 DAS	At harvest
Pendimethalin + imazethapyr 0.75 kg ha^{-1} as PE	25.46	10.48	27.41	48.12	59.41
Pendimethalin + imazethapyr 1.0 kg ha^{-1} as PE	23.23	8.47	25.12	45.41	57.16
Pendimethalin 1.0 kg ha^{-1} as PE	26.42	12.52	31.47	53.43	58.12
Pendimethalin + imazethapyr 0.75 kg ha^{-1} as PE + HW at 40 DAS	25.78	11.13	29.58	52.13	61.06
Pendimethalin + imazethapyr 1.0 kg ha^{-1} as PE + HW at 40 DAS	27.42	10.67	28.61	51.25	59.07
Pendimethalin 1.0 kg ha^{-1} as PE + HW at 40 DAS	29.12	15.91	35.17	57.62	66.13
Weedy check	24.60	18.22	29.43	36.12	48.20
SEm (±)	**2.33**	**0.90**	**2.28**	**3.56**	**1.98**
LSD (0.05)	**NS**	**2.69**	**NS**	**NS**	**5.86**

lower crop-weed competition resulted in higher nutrient uptake. The highest nutrient uptake by the crop was favoured by the combo formulation of pendimethalin and imazethapyr 1.0 kg ha^{-1} + HW closely followed by pendimethalin 1.0 kg ha^{-1} + HW.

Crop yield and economics

All weed management practices exhibited significantly higher grain yields than weedy check (Table 8). The luxuriant growth of weeds with higher nutrient removal from soil reduced the crop yield considerably in weedy plots. Amongst herbicidal treatments, integration of pendimthalin 1.0 kg ha^{-1} PE + HW and combo herbicide (pendimethalin + imazethapyr) 1.0 kg ha^{-1} PE + HW recorded higher values of grain yield. The efficient weed control measures reducing weed density and biomass and increasing nutrient uptake by crop might have led to better vegetative and reproductive growth and ultimately resulting in higher crop yield. Sagvekar *et al.* (2015) also reported similar findings in *Rabi* groundnut.

The highest net return was obtained from ready-mix pendimethalin + imazethapyr 1.0 kg ha^{-1} followed by HW (Table 9). This was closely followed by pendimethalin 1.0 kg ha^{-1} + HW. However, this treatment gave the highest BCR. This was owing to lower cost of pendimethalin as compared to the combo herbicide. This finding corroborates the findings of Kumar *et al.* (2016).

It may be concluded that the weed menace in lentil could be checked effectively by integrated approach through pendimethalin 1.0 kg ha^{-1} PE + HW at 40 DAS or ready-mix pendimethalin + imazethapyr 1.0 kg ha^{-1} PE + HW at 40 DAS. However, considering the easy availaibility of pendimethalin in the markets of Assam,

Table 6: Effect of weed management treatments on nutrient removal (kg ha^{-1}) by weeds

Treatments	N removal			Mean	P removal			Mean	K removal			Mean
	2012-13	2013-14	2014-15		2012-13	2013-14	2014-15		2012-13	2013-14	2014-15	
Pendimethalin + imazethapyr 0.75 kg ha^{-1} as PE	39.06	56.74	44.97	46.92	5.55	8.06	6.39	6.67	6.52	9.47	7.51	7.83
Pendimethalin + imazethapyr 1.0 kg ha^{-1} as PE	34.36	49.73	40.21	41.43	4.88	7.06	5.71	5.89	5.73	8.30	6.71	6.91
Pendimethalin 1.0 kg ha^{-1} as PE	38.44	53.33	35.90	42.56	5.46	7.58	5.10	6.05	6.42	8.90	59.93	71.03
Pendimethalin + imazethapyr 0.75 kg ha^{-1} as PE + HW at 40 DAS	20.83	26.27	23.20	23.44	2.96	3.73	3.30	3.33	3.48	4.39	3.87	3.91
Pendimethalin + imazethapyr 1.0 kg ha^{-1} as PE + HW at 40 DAS	11.88	19.43	15.91	15.74	1.69	2.76	2.26	2.24	1.98	3.24	2.66	2.63
Pendimethalin 1.0 kg ha^{-1} as PE + HW at 40 DAS	15.12	24.05	19.43	19.53	2.15	3.42	2.76	2.78	2.52	4.01	3.24	3.26
Weedy check	73.72	88.48	70.01	77.40	10.47	12.57	9.94	10.99	12.30	14.77	11.68	12.92
SEm (±)	**3.63**	**1.67**	**2.80**	**2.24**	**0.40**	**0.83**	**0.37**	**0.63**	**0.85**	**0.65**	**1.22**	**1.06**
LSD (0.05)	**10.84**	**5.01**	**8.37**	**6.70**	**1.24**	**2.59**	**1.11**	**1.96**	**2.60**	**1.92**	**3.65**	**3.18**

Table 7: Effect of weed management treatments on nutrient removal (kg ha^{-1}) by lentil

Treatments	N removal			Mean	P removal			Mean	K removal			Mean
	2012-13	2013-14	2014-15		2012-13	2013-14	2014-15		2012-13	2013-14	2014-15	
Pendimethalin + imazethapyr 0.75 kg ha^{-1} as PE	36.97	33.69	32.00	34.22	2.71	2.47	2.34	2.50	4.51	4.11	3.90	4.17
Pendimethalin + imazethapyr 1.0 kg ha^{-1} as PE	43.53	36.29	35.88	38.56	3.19	2.66	2.63	2.82	5.31	4.43	4.38	4.70
Pendimethalin 1.0 kg ha^{-1} as PE	41.14	35.19	36.09	37.47	3.01	2.57	2.64	2.74	5.02	4.29	4.40	4.57
Pendimethalin + imazethapyr 0.75 kg ha^{-1} as PE + HW at 40 DAS	50.36	36.70	36.83	41.30	3.69	2.69	2.70	3.02	6.14	4.48	4.49	5.04
Pendimethalin + imazethapyr 1.0 kg ha^{-1} as PE + HW at 40 DAS	52.20	38.84	42.00	44.33	3.90	2.86	3.02	3.27	6.35	4.92	4.88	5.40
Pendimethalin 1.0 kg ha^{-1} as PE + HW at 40 DAS	51.49	38.40	40.08	43.33	3.77	2.81	2.93	3.17	6.28	4.68	4.89	5.28
Weedy check	28.70	29.38	28.75	28.94	2.10	2.15	2.10	2.12	3.50	3.58	3.51	3.53
SEm (±)	**2.19**	**1.72**	**1.20**	**1.39**	**0.15**	**0.23**	**0.08**	**0.17**	**0.25**	**0.64**	**0.09**	**0.16**
LSD (0.05)	**6.57**	**NS**	**3.62**	**4.17**	**0.50**	**NS**	**0.24**	**NS**	**0.78**	**NS**	**0.29**	**0.51**

Table 8: Effect of weed management treatments on grain yield of lentil (kg ha^{-1})

Treatment	2012-13	2013-14	2014-15	Pooled
Pendimethalin + imazethapyr 0.75 kg ha^{-1} as pre-emergence	901.67	821.67	780.50	834.61
Pendimethalin + imazethapyr 1.0 kg ha^{-1} as pre-emergence	1061.67	885.00	875.17	940.45
Pendimethalin 1.0 kg ha^{-1} as pre-emergence	1003.34	858.33	880.34	914.00
Pendimethalin + imazethapyr 0.75 kg ha^{-1} as pre-emergence + HW at 40 DAS	1228.34	895.00	898.34	1007.22
Pendimethalin + imazethapyr 1.0 kg ha^{-1} as pre-emergence + HW at 40 DAS	1314.17	973.33	1036.17	1107.89
Pendimethalin 1.0 kg ha^{-1} as pre-em + HW at 40 DAS	1255.83	936.67	977.67	1056.72
Weedy check	700.00	716.67	701.17	705.95
SEm(±)	**29.77**	**19.63**	**31.97**	**23.50**
LSD (0.05)	**88.46**	**58.28**	**94.94**	**69.82**

Table 9 : Effect of weed management treatments on economics

Treatment	GR(Rs)	Cost (Rs)	NR(Rs)	B : C
Pendimethalin + imazethapyr 0.75 kg ha^{-1} as pre-em	54250	24598	29652	2.20
Pendimethalin + imazethapyr 1.0 kg ha^{-1} as pre-em	61129	24918	36211	2.45
Pendimethalin 1.0 kg ha^{-1} as pre-em	59410	24570	34840	2.42
Pendimethalin + imazethapyr 0.75 kg ha^{-1} as pre-em + HW at 40 DAS	65469	26138	39331	2.50
Pendimethalin + imazethapyr 1.0 kg ha^{-1} as pre-em + HW at 40 DAS	72013	28458	43555	2.53
Pendimethalin 1.0 kg ha^{-1} as pre-em + HW at 40 DAS	68687	26110	42577	2.63
Weedy check	45887	22412	23475	2.05

the practice involving pendimethalin 1.0 kg ha^{-1} PE + HW was tested in farmers' fields during *Rabi* 2015-16 for popularizing the technology through four KVKs in UBV, CBV, LBV and NBP zones of Assam (Table 10). The yield increase over farmers' practice (1 HW at 25-30 DAS) was 23.2, 46.6, 8.1 and 8.4% in UBV, CBV, LBV and NBP zones, respectively.

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Table10: **Grain yield and BCR of lentil in on-farm trials conducted through KVKs**

Treatments	KVK, Nagaon			KVK, Jorhat			KVK, Darrang			KVK, Chirang		
	Grain yield (q ha^{-1})	% yield increase	B:C	Grain yield (q ha^{-1})	% yield increase	B:C	Grain yield (q ha^{-1})	% yield increase	B:C	Grain yield (q ha^{-1})	% yield increase	B:C
Pendimethalin 1.0 kg ha^{-1} pre-em fb hand weeding at 40 DAS	9.34	46.62	2.50	8.77	23.17	2.33	6.97	8.4	2.21	10.00	8.11	3.01
Farmer's practice (1 hand weeding at 25-30 DAS	6.37		2.16	7.12		1.74	6.43		2.04	9.25		2.97