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Pre- and post-emergence herbicidal effect on weeds, fodder yield and quality of berseem in lowland region of Western Himalayas

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ABSTRACT

A field experiment was carried out during winter seasons of 2013-14 and 2014-15 at G.B. Pant University of Agriculture and Technology, Pantnagar to study the effect of pre- and post- emergence herbicides on weeds, fodder yield and quality of berseem (*Trifolium alexandrinum* L.). The experimental results indicated that pre emergence application of pendimethalin (1000 g/ha) followed by imazethapyr (100 g/ha) just after 1st cut produced significantly higher green and dry fodder yields, crude protein and net returns but alone application of pendimethalin at 1000 g/ha had the highest B:C ratio. The pooled values indicated that the lowest weed population was observed at application of pendimethalin + imazethapyr (1666 + 100 g/ha). The fresh and dry weight of weeds were recorded significantly lower under oxyflourfen + imazethapyr at 425 + 100 g/ha (just after 1st cut) in both the years, while pooled weed control efficiency was found significantly highest under oxyflourfen + imazethapyr at 425 + 100 g/ha (just after Ist cut). It is therefore, concluded that the application of pendimethalin + imazethapyr at 1000 + 100 g/ha may be recommended for effective weed control as well as higher fodder yield, its quality and net profit in berseem growing areas of lowland *(Tarai)* region of Western Himalayas.

INTRODUCTION

Berseem (*Trifolium alexandrinum* L.) also known as a Egyptian clover is the most important winter forage crop in north, north-west, and central parts of India under irrigated conditions. The green fodder of berseem is very nutritious with 20-24% crude protein, rich in calcium and phosphorus and 70% digestible dry matter. The quantity and quality of milk is improved by feeding berseem fodder. The weed control is essential in early growth stage of berseem mainly because of slow crop growth and green fodder yield may reduce by 20 to 30% (Joshi and Bhilare 2006, Alfred 2012). The major weed of the berseem namely *Cichorium intybus* (dicot) but other weeds like *Coronopus didymus, Rumex dentatus, Medicago dentriculata, Poa annua, Phalaris minor, Anagalis arvensis, Leudugia octoradosis, Parthenium hysterophorus, Euphorbia geniculata* and *Cyperus rotundus* were dominated and weeds reduce not only the fodder quality (Jain1998) but also compete for light, space and nutrients (Thakur *et al.* 1990).

Normally farmers do not adopt the weed control measures in berseem in *Tarai* region and also hills of Uttarakhand. Some of the progressive farmers apply pre-emergence herbicides like pendimthalinan at 0.5 to 0.75 kg/ha and fluchloralin at 0.60 to 1.20 kg/ha to control the weeds. Recently some post-emergence herbicides were available but their bio-efficacy is yet to be evaluated in berseem. Therefore, the present investigation was carried out to study the effect of pre- and post-emergence herbicides on weeds, fodder yield and quality of berseem in lowland *(Tarai)* region of Western Himalayas.

MATERIALS AND METHODS

A field study was carried out during *Rabi* seasons of 2013-2014 and 2014-2015 at Forage Agronomy block of Instructional Dairy Farm, Nagla, G.B. Pant University of Agriculture and Technology, Pantnagar. The experimental site was silty clay loam having 7.2 pH, 0.86 % organic carbon, 278.48, 27.80 and 232 kg/ha available N, P, and K, respectively. The field experiment consisted of 10 treatments *i.e.* pendimethalin (PE) (1000 g/ha) 2 DAS, pendimethalin (PE) (1333 g/ha) 2 DAS, pendimethalin (PE) (1666 g/ha) 2 DAS, oxyflourfen (PE) (425 g/ha), imazethapyr (POE) (1000 g/ha)(just after 1st and 2nd cut), oxyflourfen + imazethapyr (425 + 1000 g/ha) (just after 1st cut), pendimethalin + imazethapyr (1000 + 1000 g/ha) (just after 1st cut), pendimethalin + imazethapyr (1333 + 1000 g/ha) (just after 1st cut) and pendimethalin + imazethapyr (1666 + 1000 g/ha) (just after 1st cut) was laid out in a completely block

design and replicated thrice. The required amount of herbicides was applied using 375 l/ha of water with knap-sack sprayer fitted with a flat-fan nozzle. Berseem variety '*Mescavi'* was sown at 30 kg/ha seed rate in rows spaced at 30 cm apart and fertilized with 30, 26.2 and 33.3 kg/ha nitrogen, phosphorus and potash, respectively at the time of sowing. The first cutting was taken manually with the help of sickle at 55 days after sowing (DAS) followed by subsequent two cuttings at an interval of 30 days. After 3rd cut, the crop was left for seed production. The crop samples were taken from 1.0 m^2 area before each cutting for growth, leaf and stem ratio (L:S), fodder yield and crude protein. The recommended agronomic practices were adopted as and when required for irrigation and plant projection. The growth parameters of berseem were recorded at each cut and then averaged. The weed dry matter was recorded by using a quadrate sampler of 0.5x0.5 m size at the time of each cutting. The weed control efficiency (WCE) was calculated as DMC-DMT/ DMC (Mani *et al*. 1973), where, DMC is dry matter production by weeds in control plot and DMT is dry matter production by weeds in treated plots.

RESULTS AND DISCUSSION

Crop growth attributes

The plant height, L:S ratio of berseem were affected significantly by different pre- and post-herbicides during both the years (**Table 1**). In 2013-14, the tallest plants were recorded with the application of pendimethalin + imazethapyr at 1000 + 1000 g/ha) that was significantly higher with oxyflourfen + imazethapyr at 425 + 1000 g/ha, while in 2014-15, the plant height of berseem was recorded significantly higher under weedy check followed by chemical weed control by pendimethalin (1000 g/ha) and also pendimethalin + imazethapyr (1333 + 1000 g/ha). The pooled values showed the tallest plants under control treatment that remained significantly at par with alone application of pendimethalin (1000 g/ ha) and also pendimethalin + imazethapyr (1333 + 1000 g/ha). The application of pendimethalin at 1666 g/ha had the shortest plants of berseem at harvest for seed yield. It may be due to toxic effect of herbicide on plant growth. It indicated that higher dose of pendimethalin and also oxyflourfen had adverse effect and delayed germination of berseem, hence the early germination of berseem under control contributed higher plant height. The maximum number of plants/m row length in 2013-14 was counted under pendimethalin + imazethapyr (1000 + 1000 g/ha) that had significantly higher values than application of oxyflourfen (425 g/ha), imazethapyr (1000 g/ha) just after 1st and 2nd cut, oxyfluorfen + imazethapyr (425 + 1000 g/ha) and also control. In 2014-15, the number of plants/m row length were found significantly higher at application of pendimethalin (1000 g/ha) followed by pendimethalin + imazethapyr (1333 + 1000 g/ha). The lowest number of plants were found at application of higher dose of pendimethalin (1666 g/ha), pendimethalin + imazethapyr (1333 + 1000 g/ha) as well as application of oxyflourfen (425 g/ha). It was observed that both treatments had adverse effect on germination of both berseem and weeds. Application of herbicides did not have significant effect on straw yield of berseem (after seed yield), however application of pendimethalin + imazethapyrat 1000 + 1000 g/ha just after 1st cut gave maximum values followed by oxyflourfen at 425 g/ha during both years.

Fodder and seed yield

The green and dry fodder yield differed significantly by herbicides during both the years (**Table 1**). Significantly higher green forage yield was recorded under pendimethalin + imazethapyr at 1000 + 1000 g/ha) and remained significantly superior to control, and oxyfluorfen + imazethapyr at 425 + 1000 g/ha during 2013-14 but in 2014-15, significantly higher green fodder yield was achieved at application pendimethalin + imazethapyr of 1333 + 1000 g/ha. It was significantly equal to pendimethalin (1000 g/ha). The dry fodder yield had almost similar trend of green fodder yield during both the years. The lowest green and dry fodder yield were recorded under either alone application of oxyflourfen or combined with imazethapyr during both the years mainly due to poor germination and reduced number of plants/m row length. The higher values attributed to taller plants and more number of plants/ha supported by higher weed control efficiency and better crop growth. Application of imazethapyr at 1000 g/ha just after 1st and 2nd cut produced maximum green and dry fodder yield (Pathan *et al*. 2013). Similarly, Prajapati *et al*. (2015) reported that imazethapyr at 1500 g/ha applied immediate after 1st and 2nd cut gave higher green and dry fodder yield of berseem.

Seed yield was recorded significantly highest with application of pendimethalin + imazethapyr at 1000 + 1000 g/ha during both the years but it remained at par with pendimethalin + imazethapyrat 1333 + 1000 g/ha and alone application of pendimethalin at 1000 g/ha in 2013-14. The seed yield however was very poor in both the years mainly due to poor weather conditions including heavy rainfall during post-flowering that caused lodging of plants and poor seed formation. Pathan *et al*. (2013) reported higher berseem seed yield at application of imazethapyr at 1000 g/ha just after 1st and 2nd cut, while Prajapati *et al.* (2015) found higher seed yield

Table 1. Effect of pre- and post-emergence herbicides on growth, green and dry forage yield, seed yield and straw yield of berseem in 2013-14 and 2014-15

Treatment	Pl height (cm)		No of plants/m row		Green forage yield (t/ha)		Dry forage yield (t/ha)		Seed yield (kg/ha)		Straw yield at harvest (t/ha)	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-1.4	2014-15	2013-14	2014-15	2013-14	2014-15
Pendimethalin (PE) (1000g/ha) 2 DAS	39	55	70	86	21.6	46.0	3.00	5.92	52	107	4.06	4.12
Pendimethalin (PE) (1333 g/ha) 2 DAS	38	51	69	73	21.2	43.8	2.90	5.23	42	59	4.18	3.96
Pendimethalin(PE) (1666 g/ha) 2 DAS	39	49	69	67	20.6	38.9	2.80	4.86	40	52	3.95	3.90
Oxyflourfen (PE) (425 g/ha)	36	58	43	67	15.1	39.6	2.10	4.70	40	57	4.22	4.30
Imazethapyr (PoE) (1000 g/ha)(Just after Ist&IInd cut)	39	54	55	77	20.6	44.2	2.80	5.53	41	73	4.08	4.09
Oxyflourfen + imazethapyr (425 + 1000 g/ha)(Just after Ist cut)	34	53	39	74	13.0	42.6	1.80	5.18	41	70	3.87	3.72
Pendimethalin + imazethapyr (1000 + 1000 g/ha) (just after Ist cut)	40	52	74	82	22.1	47.4	3.20	6.13	55	133	4.53	4.49
Pendimethalin + imazethapyr (1333 + 1000 g/ha) (just after Ist cut)	38	55	70	73	21.8	42.6	3.00	5.38	53	88	4.14	4.11
Pendimethalin + imazethapyr (1666 + 1000g/ha) (just after Ist cut)	38	54	68	67	21.4	43.7	3.00	5.48	49	78	4.08	4.08
Weedy check	38	59	66	79	19.8	40.3	2.70	4.86	40	63	3.80	3.92
LSD (p=0.05)	03	06	06	08	1.9	4.8	0.30	0.48	9	18	ns	ns

PE-pre-emergence: PoE-post-emergence; LSD - Least Significant difference at the 5% level of significance: DAS - Days after sowing

under application of oxyflourfen at 425 g/ha followed by imazethapyr immediately after 1st cut. Kauthale *et al*. (2016) reported that combination of oxyflourfen 0.1 kg/ha + imazethapyr 0.1 kg/ha immediately after harvest of first cut produced highest seed and straw yield of berseem. It indicated that oxyflourfen though had negative impact on germination of both crop and weeds but crop grew well in later stages due to poor plant population and resulted into better straw yield.

Fodder quality

The L:S ratio and crude protein are the main indicators of fodder quality. The L:S ratio did not differ significantly by different herbicides during both the years (**Table 2**), however the highest L:S ratio was measured under pendimethalin + imazethapyr at 1666 + 1000 g/ha followed by pendimethalin + imazethapyr at 1333 + 1000 g/ha, pendimethalin + imazethapyr at 1000 + 1000 g/ha) and imazethapyr at 1000 g/ha just after 1st cut and 2nd cut in 2013-14,while in 2014-15, the highest value was recorded under oxyflourfen at 425 g/ha followed by pendimethalin + imazethapyr at 1666 + 1000 g/ha), imazethapyr at 1000 g/ha just after 1st cut and 2nd cut and pendimethalin + imazethapyr at 1000 + 1000 g/ha).

The crude protein was affected significantly by herbicides during both the years (**Table 2**). In 2013-14, it was noticed significantly highest under pendimethalin + imazethapyr at 1000 + 1000 g/ha) that was significantly equal to pendimethalin + imazethapyr at 1333 + 1000 g/ha), pendimethalin + imazethapyr at 1666 + 1000 g/ha) and alone application of pendimethalin at 1000 g/ha. The highest crude protein production was noticed under pendimethalin + imazethapyr at 1000 + 1000 g/ha) (after 1st cut) followed by pendimethalin + imazethapyr at 1000 + 1000 g/ha) (after 1st cut and 2nd cut). The pooled values had the highest crude production pendimethalin + imazethapyr at 1000 + 1000 g/ha) (after 1st cut) followed by pendimethalin at 1000 g/ha. The higher crude protein production is the result of higher dry matter and crude protein percentage. Pathan *et al*. (2013) reported higher crude protein production under oxyflourfen (425 g/ha) followed by imazethapyr (1000 g/ha) just after 1st cut). Kauthale *et al*. (2016) also reported the highest dry matter and crude protein production under combined application of oxyflourfen 0.1 kg/ha + imazethapyr 0.1 kg/ha immediately after the first cut.

Density and biomass

Major weeds like *Cichorium intybus, Coronopus didymus, Rumex dentatus, Medicago dentriculata, Poa annua, Phalaris minor, Anagalis arvensis, Leudugia octoradosis, Parthenium hysterophorus, Euphorbia geniculata* and *Cyperus rotundus* were recorded in per square meter as an index of weed control efficiency of weed management practices. The highest weed population was recorded at weedy check followed by pendimethalinat 1000 g/ha during both the years, while the lowest weed population was counted at oxyflourfen+ imazethapyr (425 + 1000 g/ha) (just after 1st cut) followed by pendimethalin + imazethapyr at 1000 + 1000 g/ha) (just after 1st cut) in 2013-14 but in 2014-15, it was under pendimethalin (1666 g/ha) followed by pendimethalin + imazethapyr at 1666 + 1000 g/ha). The pooled values indicated that pendimethalin + imazethapyr at 1666 + 1000 g/ha) had

the lowest weed population followed by oxyflourfen+ imazethapyr (425 + 1000 g/ha) (just after 1st cut) and oxyflourfen (425 g/ha). It indicated that higher dose of pendimethalin and oxyflourfen were very effective in suppressing the weed population, however proved toxic to crop germination. Significantly maximum fresh weed weight was recorded under weedy check during both years. Significantly lowest fresh weed weight was recorded under oxyflourfen+ imazethapyr at 425 + 1000 g/ha (just after 1st cut) in both the years but, it was significantly equal to imazethapyr at 1000 g/ ha (immediate after 1st and 2nd cut), pendimethalin + imazethapyr at 1000 + 1000 g/ha) (after 1st cut), pendimethalin + imazethapyr at 1333 + 1000 g/ha (after 1st cut) in 2014-15. Pathan and Kamble (2012) observed that application of oxyflourfen at 100 g/ha *fb* imazethapyr at 1000 g/ha immediately after 1st cut recorded significantly the lowest total weed count/m^2 and its total dry weight. Jain (1998) and Tamrakar *et al.* (2002) also supported the above findings.

Weed control efficiency (WCE)

The herbicides had significant effect on weed control efficiency during both the years (**Table 2**). In 2013-14, the highest WCE was recorded at application of oxyfluorfen + imazethapyr at 425 + 1000 g/ha (just after 1st cut) followed by pendimethalin + imazethapyr at 1000 + 1000 g/ha) (after 1st cut) and pendimethalin + imazethapyr at 1666 + 1000 g/ha) (after 1st cut). In 2014-15, the highest WCE was recorded under pendimethalin + imazethapyr at 1333 + 1000 g/ha) (after 1st cut) and it was found significantly similar to oxyfluorfen + imazethapyrat 425 + 1000 g/ha (just after 1st cut), pendimethalin + imazethapyr at 1666 + 1000 g/ha) (after 1st cut), pendimethalin + imazethapyr at 1000 + 1000 g/ha)(after 1st cut) and imazethapyr at 1000 g/ha (just after Ist and IInd cut) (**Table 2**). Application of oxyflourfen (PE) was found more toxic not only to berseem but also for weeds, thereby the emergence of weeds and berseem reduced drastically. Application of oxyflourfen followed by POE application of imezathapyr helped to reduce weed population further and improved weed control efficiency. Pathan *et al.* (2013) found similar weed control efficiency in both weed free and oxyflourfen at 425 g/ha *fb* imazethapyr PoE at 1000 g/ha (immediately after 1st cut). Among herbicidal treatments, the weed dry weight was significantly less (48.73 g/0.25m^2) due to application of pendimethalin + imazethapyr at 500 g/ha applied immediate after 1stcut resulting in higher weed control efficiency (43.53%) (Prajapati *et al.* 2015). Among herbicides, imazethapyr at 100 g/ha at 3 weeks after sowing and butachlor 1500 g/ha as pre-emergence were significantly superior in controlling weed flora (weed control efficiency 69.7-77.3 and 68.7-75.8%) and recorded higher green fodder yield (86.0 and 82.1 t/ha) in berseem than other treatments (Priyanka *et al.* 2018).

Economics

Application of pendimethalin + imazethapyr at 1000 + 1000 g/ha) (after 1st cut) had significantly higher gross returns, but was at par with pendimethalin + imazethapyr at 1333 + 1000 g/ha) (after 1stcut) and pendimethalin + imazethapyr at 1666 + 1000 g/ha) (after 1st cut) during 2013-14, but in 2014-15, pendimethalin + imazethapyr at 1333 + 1000 g/ha) (after 1st cut) gave the highest gross returns (**Table 3**), however remained at par with pendimethalin + imazethapyr at 1000 + 1000 g/ha) (immediately after 1st

Table 2. Effect of pre- and post-emergence herbicides on L:S ratio, crude protein and weed population and weed control efficiency of berseem in 2013-14 and 2014-15

Treatment	L:S ratio		Crude protein (yield (t/ha)		No of Weeds/m^2		Fresh weed weight (g/m^2)		Dry weed weight (g/m^2)		Weed control efficiency (%)	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Pendimethalin (PE) (1000g/ha) 2 DAS	2.23	2.72	0.58	1.14	595	683	473	297	42.3	48.50	30.07	31.70
Pendimethalin (PE) (1333 g/ha) 2 DAS	2.22	2.49	0.56	1.00	538	398	391	291	43.5	45.17	27.69	36.42
Pendimethalin(PE) (1666 g/ha) 2 DAS	2.30	2.43	0.55	0.96	526	292	365	271	37.7	39.93	33.18	43.89
Oxyflourfen (PE) (425 g/ha)	2.29	3.03	0.41	0.93	336	400	340	259	37.5	37.53	46.17	47.37
Imazethapyr (PoE) (1000 g/ha)(just after Ist&IInd cut)	2.34	2.85	0.55	1.08	448	507	391	242	53.0	25.10	31.11	64.85
Oxyflourfen + imazethapyr (425 + 1000 g/ha)(just after Ist cut)	1.95	2.75	0.34	0.99	212	494	194	235	24.2	22.50	64.31	68.42
Pendimethalin + imazethapy (1000 + 1000 g/ha) (just after Ist cut)	2.50	2.67	0.63	1.20	303	515	267	253	29.0	23.83	50.48	66.53
Pendimethalin + imazethapy (1333 + 1000 g/ha) (just after Ist cut)	2.58	2.42	0.58	1.04	271	469	302	244	45.3	22.47	44.79	69.26
Pendimethalin + imazethapy (1666 + 1000g/ha) (just afterIst cut)	2.89	2.99	0.58	1.06	331	329	283	262	46.7	23.73	47.37	66.65
Weedy check	2.01	2.57	0.54	0.95	651	709	565	389	58.8	71.20	-	-
LSD (p=0.05)	ns	ns	0.07	-	-	-	63	54	09	5.81	6.67	8.34

PE-pre-emergence; PoE-post-emergence; LSD - Least Significant difference at the 5% level of significance: DAS - Days after sowing

Table 3. Effect of pre- and post-emergence herbicides on economics of berseem in 2013-14 and 2014-15

Treatment	Gross returns (x10^3 `/ha)		Net returns (x10^3 `/ha)		B:C ratio	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Pendimethalin (PE) (1000g/ha) 2 DAS	45.16	108.46	31.76	93.46	2.37	6.23
Pendimethalin (PE) (1333 g/ha) 2 DAS	43.81	103.45	30.31	88.25	2.25	5.80
Pendimethalin(PE) (1666 g/ha) 2 DAS	41.89	93.36	28.29	77.97	2.08	5.06
Oxyflourfen (PE) (425 g/ha)	37.63	95.52	24.28	80.42	1.82	5.32
Imazethapyr (PoE) (1000 g/ha)(just after Ist&IInd cut)	42.62	104.82	29.37	89.82	2.22	5.98
Oxyflourfen + imazethapyr (425 + 1000 g/ha)(just after Ist cut)	34.22	100.51	20.62	85.11	1.52	5.52
Pendimethalin + imazethapy (1000 + 1000 g/ha) (just after Ist cut)	47.87	112.86	33.87	96.86	2.42	6.05
Pendimethalin + imazethapy (1333 + 1000 g/ha) (just after Ist cut)	45.79	101.64	31.94	86.00	2.31	5.49
Pendimethalin + imazethapy (1666 + 1000g/ha) (just afterIst cut)	44.56	103.83	30.66	88.08	2.21	5.59
Weedy check	40.56	96.29	27.71	81.79	2.16	5.64
LSD (p=0.05)	3.64	8.39*	3.64	8.39*	0.27	0.55*

PE-pre-emergence; PoE-post-emergence application; LSD - Least Significant difference at the 5% level of significance: DAS - Days after sowing; Rates (`/q): Green forage yield= ` 100/-, Berseem seed=14000/-straw= 400/-

and 2nd cut). Application of oxyflourfen at 425 g/ha and pendimethalin + imazethapyr at 1666 + 1000 g/ha) (after 1st cut) had phytotoxic effect on both weeds and crop, therefore the plant population of berseem reduced and finally produced lower green fodder yield. Kauthale *et al.* (2016) also found the highest net returns with combined application of oxyflourfen 0.1 kg/ha + imazethapyr 0.1 kg/ha immediately after harvest of first cut.

The net returns was recorded significantly higher at pendimethalin + imazethapyr at 1000 + 1000 g/ha) (after 1st cut) that remained equal to pendimethalin (1000 g/ha), pendimethalin + imazethapyr at 1333 + 1000 g/ha) (after 1st cut) and pendimethalin + imazethapyr at 1666 + 1000 g/ha) (after 1stcut) in 2013-14, while in 2014-15, it was significantly higher under pendimethalin + imazethapyrat 1333 + 1000 g/ha (after 1st cut) and remained at par with pendimethalin + imazethapyr at 1000 + 1000 g/ha) (immediate after 1st and 2nd cut). Similarly, the B:C ratio was also observed significantly higher at pendimethalin at 0.3 kg/ha + imazethapyr at 0.1 kg/ha (after 1st cut) that was significantly superior to pendimethalin at 0.5 kg/ha and oxyflourfen at 0.1 kg/ha in 2013-14 but in 2014-15, the highest B:C ratio was found at application of pendimethalin at 0.3 kg/ha that was significantly similar to pendimethalin at 0.4 kg/ha) and also pendimethalin at 0.3 kg/ha + imazethapyr at 0.1 kg/ha after 1st cut. The higher B:C ratio was the result of higher number of plants/ha, green and forage yield, seed yield and weed control efficiency (**Table 3**).

The experimental results indicated clearly that application of pendimethalin + imethapyr at 1000 + 1000 g/ha (just after 1st cut) and alone pre-emergence application of pendimethalin at 1000 g/ha gave higher green and dry fodder yield, seed yield, L:S ratio, crude protein, gross returns, net returns and B:C ratio mainly because of reduced weed population and higher weed control efficiency, Therefore, application of pendimethalin + imethapyr at 1000 + 1000 g/ha (just after 1st cut) or alone pendimethalin at 1000 g/ha may be recommended for weed control in berseem cultivation in *Tarai* region of Western Himalayas.

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