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Evaluation of herbicides in berseem (*Trifolium alexandrinum* L.) for fodder and seed production

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Abstract
An investigation was conducted to study the effect of different herbicides on weed growth, green fodder and seed yields of berseem during the winter season of 2014-15 to 2016-17 at Central Research Farm of ICAR-Indian Grassland and Fodder Research Institute, Jhansi, India. Two herbicides in seven treatment combinations *viz*., oxyfluorfen @ 0.02, 0.03, and 0.04 kg/ha at 0-3 days after sowing, imazethapyr @ 0.05, 0.075 and 0.100 kg/ha at 20 days after sowing, oxyfluorfen @ 0.03 kg/ha (0-3 days after sowing) followed by imazethapyr @ 0.100 kg/ha after first cut were evaluated with weed free and weedy check treatments. Application of imazethapyr @ 0.100 kg/ ha at 20 days after sowing effectively reduced the density of *Coronopus didymus, Rumex dentatus, Spergula arvensis, Anagalis arvensis, Chenopodium album* and other kind of weeds and recorded the lowest weed dry weight (3.29, 3.24 and 3.15 g/m^2) at first, second and third cut of berseem. When compared to other treatments, application of imazethapyr @ 0.100 kg/ha at 20 days after sowing gave highest weed control efficiency, crop resistance index, herbicide efficiency index, weed management index and lower weed index.Weed free treatment recorded significantly highest green fodder (428.89 q/ha), seed (3.81 q/ha) and straw yield (28.05 q/ ha) of berseem. However, among the different herbicides treatments, post-emergence application of imazethapyr @ 0.100 kg/ha recorded the significantly highest green fodder (404.45 q/ha), seed (3.50 q/ha) and straw (25.79 q/ha) yields of berseem and resulted in highest net returns (Rs. 59,336/ha), benefit cost ratio (1.35) and economic efficiency (Rs. 371/ha/day).

Keywords: Berseem, Crop resistance index, Green fodder, Imazethapyr, Oxyfluorfen, Weed index

Introduction

Berseem (*Trifolium alexandrinum* L.) is one of the prominent *Rabi* season legume fodder crops. It is popu-larly known as the '*King'* of fodder crops. It occupies about 54% (1.9 million ha) of the total cultivated *Rabi* fodder cropped area. It is adapted to cool and moderately cold climate. The optimum temperature required at the time of sowing of berseem is 25^{0}C. In irrigated condition of northern India, it is available for 6-7 months from November to May. The crop gives 4 to 8 cuts during winter season and provides nutritious, succulent and palatable fodder. The green fodder of berseem on dry matter basis contains 17-22% crude protein, 42-49% neutral detergent fibre, 35-38% acid detergent fibre, 24-25% cellulose and 7-10% hemicellulose with 70% dry matter digestibility (Kumar *et al.,* 2012). The initial growth of berseem is drastically hampered by many seasonal weeds like *Anagalis arvensis, Chenopodium album, Eclipta alba, Melilotus alba, Melilotus indica, Physalis minima, Sonchus asper*, *Spergula arvensis* and associated weeds like *Cichorium intybus, Coronopus didymus, Medicago denticulata, Rumex dentatus* and *Trifolium resupinatum.* It has also been observed that interference of seasonal and associated weed flora reduces 23-28% green fodder and 38-44% seed yields of berseem (Wasnik *et al.,* 2017). In addition to green fodder and seed yield reduction, the weeds like *Coronopus didimus* when mixed with berseem in cattle feed produces bad odor in milk and enhances its perishability. Hence, timely weed management is necessary to get optimum quality green fodder and seed yields. Since long time hand weeding is a popular and traditional method of weed management among the farmers. But it is cumbersome and labour intensive (Pathan and Kamble, 2012). In order to achieve highest weed control efficiency with minimum labour cost, the use of pre and post-emergence herbicides and their complex combination has been advocated in different crops including fodder crops. The present study was carried out to record the effect of various weed control measures on weed and crop growth in relation to berseem fodder and seed yields.

Materials and Methods

***Experimental location and soil*:** The field trials were conducted at Central Research Farm of ICAR-Indian Grassland and Fodder Research Institute, Jhansi during three consecutive years in *Rabi* season of 2014-15 to 2016-17.The farm is geographically situated at an altitude of 270 m above mean sea level on 25°27' N latitude and 78°33' E longitude. The region falls under Agro-climatic zone VIII Central Plateau and Hills region [Bundelkhand Agro climatic Zone (6)] of the Uttar Pradesh. The soil of experimental field was sandy clay loam in texture having neutral pH (7.3) in reaction, high in organic carbon (0.94%), low in available nitrogen (159.0 kg/ha) and medium in available phosphorus (11.9 kg/ ha) and potassium (158.0 kg/ha).

***Treatments*:** Two herbicides in seven treatment combinationss *viz*., oxyfluorfen @ 0.02, 0.03, and 0.04 kg/ha at 0-3 days after sowing, imazethapyr @ 0.05, 0.075 and 0.100 kg/ha at 20 days after sowing , oxyfluorfen @ 0.03 kg/ha (0-3 days after sowing) followed by imazethapyr @ 0.100 kg/ha (after first cut) were compared with weed free (hand weeding) and weedy check treatments (zero weeding).The field experiment was conducted in randomized block design (RBD) and each treatment and control was replicated thrice. Herbicides were applied through a manually operated knapsack sprayer fitted with flat fan nozzle using 500 litres water/ ha.The oxyfluorfen was applied three days after sowing of the crop, while imazethapyr was applied 20 days after sowing of the crop and after first cut. Berseem cultivar 'Wardan' was sown at the seed rate of 20 kg/ha in the last week of October keeping row to row spacing of 40 cm. The required doses of nitrogen, phosphorus and potassium were supplied through urea, single superphosphate and muriate of potash @ 20 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha, respectively at the time of sowing.

***Crop and weed observations*:** When the crop attained sufficient growth to obtain the green fodder, the first cutting was taken at 55 days after sowing and subsequent two cuttings were taken at 25-30 days interval. The green fodder yield obtained after the three cuttings was weighed plot-wise using digital hanging scale and was converted to quintals per hectare. To recover the highest seed yield after three cuttings, the crop was left for seed production and harvested in the first week of May. At the time of first, second and third cut a quadrate of one square meter were randomly placed in each plot to record the data on weed density and dry weight. Benefit cost ratio indicates the returns one gets after investing one rupee for different weed control treatments. B: C ratio was calculated by dividing the net returns by the cost of cultivation. The economic efficiency in terms of Rs. /ha/day was worked out by dividing the net returns by crop duration in each treatment.

***Imazethapyr residue analysis in berseem*:** Imazethapyr was applied @ 0.05, 0.075 and 0.100 kg/ha as post-emergence twenty days after sowing of berseem crop. To determine the residue level of herbicide in harvested berseem green fodder, plant samples were collected at 35, 45 and 55 days after herbicide application. The residue analysis was done as per the method described by Sondhia and Gogoi (2005). Extractions of herbicide from green fodder were carried out with acidic methanol solvent in Erlenmeyer. After extraction, samples were cleaned up through column chromatography. Glass columns (10 cm x 2 cm id) were packed with celite (1g) and activated charcoal (0.25 g) between anhydrous sodium sulphate (2 g) at each end. The concentrated extract was added at the top of the column after pre-washing with methanol and eluted with methanol and water (60:40). Elutes were collected in conical flask and evaporated on a rotary vaccum evaporator at 45^0C. Finally, residues were dissolved in 4 ml methanol and filtered through Nylon 0.45 mm filter paper. An aliquot (20 µl) of the samples and standard was injected using micro syringe in high performance liquid chromatography (HPLC). A Shimadzu make HPLC with photodiode array detector (HPLC-PDA) was used for estimation of imazethapyr, which was separated on a Phenomax C-18 (ODS) column (250 x 4.6 mm) and detected at 250 nm wavelength. The mobile phase used for the analysis was mixture of methanol and water (70:30) at flow rate of 1 ml/minute.

***Statistical analysis*:** The data recorded for growth and yield parameters were statistically analyzed as per Gomez and Gomez (1984) for randomized block design to test the significance of the overall differences among the treatments by 'F' test and conclusion was drawn at 5% probability level. Weeds data on weed density and dry weight were subjected to square root transformation $\sqrt{(X+0.5)}$ to normalize their distribution. The different weed indices like weed control efficiency (WCE), weed index (WI), crop resistance index (CRI), herbicides efficiency index (HEI) and weed management index (WMI) were calculated by using the formulae given by Rana and Kumar (2014).

Results and Discussion

***Weed flora in experiment field*:** In berseem during various growth stages fifteen major weed species were predominant which competed with the crop for light, water and nutrients. The weed species consists of one sedges (*Cyperus rotundus*), two grass species (*Poa annua* and *Phalaris minor*) and thirteen broadleaf weeds *viz*., *Anagalis arvensis, Chenopodium album, Cichorium intybus, Coronopus didymus, Eclipta alba, Medicago denticulate, Melilotus alba, Melilotus indica, Physalis minima, Rumex dentatus, Sonchus asper, Sonchus oleraceus, Spergula arvensis* and *Trifolium resupinatum.* Among all the weed species, *Coronopus didymus, Rumex dentatus*, *Spergula arvensis, Trifolium resupinatum and Medicago denticulate* were the most dominant weeds in berseem field. Earlier in berseem cultivation presence of similar kind of weed flora were also reported (Tiwana *et al.,* 2002; Kewat *et al.,* 2005; Singh *et al.,* 2010; Priyanka *et al.,* 2017).

***Weed density and dry weight*:** Weed dry weight is the actual indicator of the weed pressure in the field and competition between weeds and crop. All the weed control treatments caused significant reduction in the total density and dry weight of weeds over weedy check. The highest density (16.26, 14.73, 11.92 and 14.42 /m^2) and dry weight (7.56, 6.81, 5.63 and 6.72 g/m^2) of weeds at first, second and third cut and mean of all the three cuts was recorded in weedy check treatment (Table 1). However, amid the herbicides, the most effective dose of imazethapyr @ 0.100 kg/ha with excellent control of weeds recorded the lowest density (4.66, 4.43, 4.14 and 4.42/ m^2) and dry weight (3.29, 3.24, 3.15 and 3.23 g/m^2) of weeds at first, second and third cut and mean of all the three cuts, respectively. In general, irrespective to dose application of imazethapyr @ 0.100 kg/ha was superior to oxyfluorfen and oxyfluorfen followed by imazethapyr in curtailing the weed density and weed dry weight. Long lasting effects of imazethapyr at first, second and third cut helped in reducing the weed dry matter, which might be due to broad-spectrum activity of herbicide on both narrow and broad-leaf weeds particularly on initial growth stage of plants as a result of which weeds died rapidly. These results were in conformity of Kumar and Shivadhar (2008) in berseem and Meena *et al*. (2011) in soybean.

***Weed indices*:** Weed control efficiency, calculated on the basis of dry weight of weeds, was highest in case of application of imazethapyr @ 0.100 kg/ha (77.52%, mean of all the three cuts) followed by imazethapyr @ 0.075

Table 1. Effect of different weed control measures on weed density and dry weight in berseem

Treatments	Dose (kg/ha)	Time of application (DAS)	Weed density (No./m^2)				Weed dry weight (g/m^2)			
			I Cut	II Cut	III Cut	Mean	I Cut	II Cut	III Cut	Mean
Oxyfluorfen	0.02	0-3	*14.69 (214.83)	13.84 (190.67)	10.93 (118.50)	13.25 (174.67)	*6.18 (37.18)	5.54 (32.29)	4.79 (21.92)	5.53 (30.46)
Oxyfluorfen	0.03	0-3	14.32 (204.17)	13.62 (184.50)	10.52 (109.67)	12.93 (166.11)	5.96 (34.49)	5.50 (26.92)	4.56 (19.80)	5.38 (27.07)
Oxyfluorfen	0.04	0-3	13.92 (192.83)	13.24 (174.33)	9.67 (92.50)	12.42 (153.22)	5.47 (28.92)	4.92 (23.17)	4.30 (17.50)	4.92 (23.19)
Imazethapyr	0.05	20	6.26 (38.17)	5.91 (34.00)	5.32 (27.33)	5.84 (33.17)	4.73 (21.39)	4.55 (19.75)	4.02 (15.19)	4.45 (18.78)
Imazethapyr	0.075	20	5.46 (29.00)	5.14 (25.50)	4.69 (21.00)	5.12 (25.17)	3.92 (14.40)	3.84 (13.76)	3.52 (11.40)	3.76 (13.19)
Imazethapyr	0.100	20	4.66	4.43	4.14	4.42	3.29	3.24	3.15	3.23
Oxyfluorfen *fb*	0.03 *fb*	0-3 *fb*	(20.83)	(18.67)	(16.17)	(18.56)	(9.83)	(9.50)	(8.95)	(9.43)
Imazethapyr	0.100	after	14.51	7.75	5.23	9.97	6.05	4.38	3.39	4.74
		first cut	(209.67)	(59.33)	(26.33)	(98.44)	(35.65)	(18.21)	(10.51)	(21.46)
Weed free	-	-	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
Weedy check	-	-	16.26 (263.33)	14.73 (216.17)	11.92 (141.00)	14.42 (206.83)	7.56 (56.17)	6.81 (45.53)	5.63 (30.79)	6.72 (44.16)
SEm±	-	-	0.18	0.18	0.14	0.09	0.12	0.18	0.08	0.08
CD (P=0.05)	-	-	0.55	0.55	0.42	0.28	0.35	0.53	0.24	0.25

*Values are $\sqrt{(x + 0.5)}$ transformed and original values are in parenthesis, DAS: Days after sowing; fb: Followed by

Table 2. Effect of different weed control measures on weed indices of berseem cultivation

Treatments	Dose (kg/ha)	Time of application (DAS)	Weed control efficiency (%)				Weed Index (%)	CRI	HEI	WMI
			I Cut	II Cut	III Cut	Mean				
Oxyfluorfen	0.02	0-3	33.80	29.08	28.82	30.57	38.38	1.51	0.13	0.29
Oxyfluorfen	0.03	0-3	38.59	40.88	35.71	38.39	33.92	1.74	0.24	0.39
Oxyfluorfen	0.04	0-3	48.52	49.12	43.17	46.93	30.15	2.10	0.37	0.41
Imazethapyr	0.05	20	61.91	56.63	50.67	56.41	24.29	2.68	0.61	0.45
Imazethapyr	0.075	20	74.36	69.79	62.98	69.04	15.36	3.97	1.13	0.48
Imazethapyr	0.100	20	82.49	79.14	70.93	77.52	8.27	5.77	1.81	0.49
Oxyfluorfen *fb* Imazethapyr	0.03 *fb* 0.100	0-3 *fb* after first cut	36.53	60.01	65.86	54.13	18.69	2.30	0.64	0.47
Weed free	-	-	100.00	100.00	100.00	100.00	0.00	-	-	-
Weedy check	-	-	0.00	0.00	0.00	0.00	43.81	-	-	-
SEm±	-	-	-	-	-	-	-	-	-	-
CD (P=0.05)	-	-	-	-	-	-	-	-	-	-

Table 3. Effect of different weed control measures on growth and yield attributes parameters of berseem

Treatments	Dose (kg/ha)	Time of application (DAS)	No. of tillers/m^2				Plant height at harvest (cm)	Individual head wt. (g)	Seed wt./ head (g)	Test weight (g)
			I Cut	II Cut	III Cut	Mean				
Oxyfluorfen	0.02	0-3	316.83	423.92	348.50	363.08	47.61	0.31	0.19	2.82
Oxyfluorfen	0.03	0-3	342.75	433.00	366.00	380.58	48.67	0.31	0.19	2.86
Oxyfluorfen	0.04	0-3	362.50	447.83	383.83	398.05	50.22	0.32	0.20	2.99
Imazethapyr	0.05	20	375.17	473.00	399.17	415.78	50.83	0.35	0.23	3.03
Imazethapyr	0.075	20	384.92	485.67	407.50	426.03	53.22	0.37	0.24	3.07
Imazethapyr	0.100	20	399.50	499.17	421.33	440.00	56.10	0.40	0.28	3.18
Oxyfluorfen *fb* Imazethapyr	0.03 *fb* 0.100	0-3 *fb* after first cut	336.00	477.42	396.42	403.28	51.78	0.36	0.23	3.04
Weed free	-	-	412.00	514.00	438.75	454.92	57.59	0.43	0.33	3.37
Weedy check	-	-	304.17	409.75	333.00	348.97	42.67	0.30	0.16	2.79
SEm±	-	-	3.81	4.39	4.37	4.91	0.86	0.02	0.02	0.10
CD (P=0.05)	-	-	11.51	13.27	13.21	14.84	2.60	0.05	0.05	0.31

kg/ha (Table 2). The reason of good control of weeds on post-emergence application of imazethapyr, because it inhibited the maximum germinated seedlings of grassy and broad-leaf weeds at initial growth stage of crop and thereby it helped in registering the highest weed control efficiency.

The weed index which showed the percent reduction in seed yield of berseem due to the presence of weeds in comparison to weed free plot was highest in weedy check plot (43.81%). Whereas in herbicidal treatments, the lowest value of weed index (8.27%) was obtained with application of imazethapyr @ 0.100 kg/ha at 20 days after sowing. Pathan *et al.* (2013) and Rana *et al.* (2019) also reported lower weed index due to application of imazethapyr in berseem and blackgram. Lowest crop resistance and herbicides efficiency index (1.51 and 0.13) were recorded with pre-emergence application of oxyfluorfen @ 0.02 kg/ha (Table 2). Among various imazethapyr applied treatments highest crop resistance index (5.77), herbicides efficiency index (1.81) and weed management index (0.49) were registered with post-emergence application of imazethapyr @ 0.100 kg/ha.

***Effect on crop growth*:** No visible phytotoxicity symptom of imazethapyr was observed on berseem even at a dose of 0.100 kg/ha, indicating a high degree of selectivity for berseem. The data on number of tillers and

Table 4. Effect of different weed control measures on yield and economics of berseem

Treatments	Dose (kg/ha)	Time of application (DAS)	Yield (q/ha) Green fodder I Cut	II Cut	III Cut	Total	Seed	Straw	Cost and returns (Rs /ha) Cost of cultivation	Net returns	B:C ratio	Economic efficiency (Rs./ha/day)
Oxyfluorfen	0.02	0-3	47.49	148.61	133.87	329.97	2.35	17.21	42574	32663	0.77	204
Oxyfluorfen	0.03	0-3	49.41	155.11	140.99	345.51	2.52	19.39	42877	37255	0.87	233
Oxyfluorfen	0.04	0-3	51.75	161.74	147.34	360.83	2.66	21.44	43244	41297	0.95	258
Imazethapyr	0.05	20	54.05	167.53	149.09	370.66	2.88	21.97	43169	46044	1.07	288
Imazethapyr	0.075	20	56.39	175.85	154.83	387.06	3.22	23.26	43639	52973	1.21	331
Imazethapyr	0.100	20	59.45	181.41	163.59	404.45	3.50	25.79	44041	59336	1.35	371
Oxyfluorfen *fb* Imazethapyr	0.03 *fb* 0.100	0-3 *fb* after first cut	50.15	173.94	153.65	377.74	3.10	22.25	44438	48937	1.10	306
Weed free	-	-	62.74	190.06	176.10	428.89	3.81	28.05	55022	56453	1.03	353
Weedy check	-	-	43.52	142.35	124.60	310.47	2.14	14.75	41757	27526	0.66	172
SEm±	-	-	1.07	1.42	2.29	5.32	0.07	0.70	-	-	-	-
CD (P=0.05)	-	-	3.23	4.28	6.93	16.09	0.20	2.12	-	-	-	-

Current market price of berseem: Green fodder: Rs. 100/q; Seed: Rs. 158/kg; Straw: Rs. 300/q

plant height remain unaffected with increase in imazethapyr concentration up to 0.100 kg/ha (Table 3). The highest number of tillers/m^2 at first, second and third cut (412.00, 514.00 and 438.75/m^2) and mean of all the three cut (454.92 /m^2) and plant height at harvest (57.59 cm) was recorded in weed free treatment. In case of herbicidal treatment the highest number of tillers/m^2 at first, second and third cut (399.50, 499.17 and 421.33/m^2) and mean of all the three cuts (440.00/m^2) and plant height at harvest (56.10 cm) was noticed with post-emergence application of imazethapyr @ 0.100 kg/ha followed by imazethapyr @ 0.075 kg/ha. This result was in line with the findings of Priyanka *et al.* (2017).

***Effect on crop yield attributes and yield*:** The data revealed that individual head weight (0.43 g), seed weight/head (0.33 g) and test weight (3.37 g) were highest with weed free plot but the difference between weed free treatment and imazethapyr @ 0.100 kg/ha applied treatment were found to be non-significant (Table 3). The significantly highest quantity of green fodder (428.89 q/ha), seed (3.81q/ha) and straw yield (28.05 q/ha) of berseem were recorded in weed free treatment followed by post-emergence application of imazethapyr @ 0.100 kg/ha (Table 4).This was probably possible due to efficient control of weeds; higher weed control efficiency coupled with lower depletion of nutrients by weeds resulted in more favourable environment for growth and development of crop plants. Similar findings were also noticed by Pathan *et al.* (2013) and Jha *et al.* (2014). The lowest green fodder (310.47 q/ha), seed (2.14 q/ha) and straw yield (14.75 q/ha) of berseem were noticed in weedy check plot. This might have happened due to poor crop growth as a result of less availability of resources like light, moisture, and nutrients to crop by the overwhelming canopy of weeds created competitive environment between crop and weeds which prevented the crop to flourish. Lowest green fodder, seed and straw yield of berseem in weedy condition were also reported earlier by Kauthale *et al.,* (2016), Sinare *et al.,* (2017) and Kumar *et al.,* (2018).

***Economics*:** All the weed control treatments registered higher net returns and benefit cost ratio than the weedy check (Table 4). Among all the weed management practices, highest net returns (Rs. 59,336 /ha), benefit cost ratio (1.35) and economic efficiency (Rs. 371/ha/day) were obtained in treatment of post-emergence application of imazethapyr @ 0.100 kg/ha followed by imazethapyr @ 0.075 kg/ha. Whereas the lowest net returns (Rs. 27526/ha), benefit cost ratio (0.66) and

Table 5. Imazethapyr residue analysis in berseem green fodder at different harvesting time

Treatments	Dose (kg/ha)	Time of application (DAS)	Sample analyzed days after herbicide application	Herbicide residue mean on dry weight basis(µg g^{-1})	Safe limit*
Imazethapyr	0.050	20	35	0.57	
			45	0.04	Yes
			55	0.02	
Imazethapyr	0.075	20	35	0.78	
			45	0.40	No
			55	0.18	
Imazethapyr	0.100	20	35	1.72	
			45	1.33	Yes
			55	0.67	

*Safe limit = <1.50 µg g^{-1} (dry weight basis)

economic efficiency (Rs. 172/ha/day) were observed in weedy check treatment. Net return per rupee investment was more in weedy check treatment due to involvement of lower cost of cultivation for seed production. Kumar and Shivadhar (2008) and Priyanka *et al.,* (2017) also observed the economic viability of application of imazethapyr @ 0.100 kg/ha over rest of the treatments.

***Imazethapyr residue analysis*:** When two herbicides in different concentration alone and in combination were tested in berseem, it was found that imazethapyr @ 0.075 and 0.100 kg/ha performed well with agronomical parameters, however, for its judicious utilization its residue level needs to be tested before recommendation in berseem. The concentration of imazethapyr residues were minimum (0.02, 0.18 and 0.67µg g^{-1}) in treatment where imazethapyr were applied @ 0.05, 0.075 and 0.100 kg/ha and the berseem green fodder samples were analyzed for herbicide residues after 55 days of herbicide application (Table 5). As normally the first cut of berseem is taken at 55 days after sowing for green fodder, at this stage of maturity, the residue level of imazethapyr were also below the maximum residue limits (MRLs) as set by European countries (1.5µg g^{-1} on dry weight basis, by codex, 2018). It was true even for the best treatment application of imazethapyr @ 0.100 kg/ha, when residue analysis of berseem green fodder was done at 55 days after herbicide application. Whereas the concentration of imazethapyr residues were 0.57, 0.78 and 1.72 µg g^{-1} in treatments when imazethapyr were applied @ 0.05, 0.075 and 0.100 kg/ha, respectively and the berseem green fodder samples were analyzed for herbicide residues after 35 days of herbicide application. Thus on 20 day post-mergence application of imazethapyr @ 0.100 kg/ha, the green berseem fodder harvested after 35 days of application was not within safe limit for animal feeding and there was a need to wait upto 45 days.

Conclusion

The present study revealed that post-emergence application of imazethapyr @ 0.100 kg/ha at 20 days after sowing suppressed the weed population in berseem and recorded the highest green fodder, seed and straw yield and net returns, benefit cost ratio and economic efficiency over the other herbicide treatments. Hence, imazethapyr may be considered as an herbicide for weed control in berseem seed production as its persistency was in safe limit even when berseem was harvested for green fodder after 55 days of herbicide application. But there is concern regarding its persistency in berseem green fodder when harvested after 35 days of herbicide application (@ 0.100 kg/ha), which needs further study.

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