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Research Paper

Effect of sowing management and herbicides application on weeds and yield of berseem (*Trifolium alexandrinum*)

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ABSTRACT

A field experiment was conducted during winter (*rabi*) seasons of 2020–2021 and 2021–2022 at research farm of College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh to study the impact of planting time and herbicides application on weeds and berseem (*Trifolium alexandrinum* L.) yield. Experiment was conducted in a split plot design with 20 treatments comprising of 4 dates of sowing, viz. October 15th, October 30th, November 15th and November 30th in main plots and these were superimposed with 5 weed control treatments i.e. Pyroxasulfone 125 g/ha as pre emergence; Pyroxasulfone 125 g/ha at 14 DAS; Oxyfluorfen 100 g/ha + Imazethapyr 15 g/ha after first cutting; Oxyfluorfen 100 g/ha + Imazethapyr 15 g/ha after first and second cutting, replicated thrice. Berseem variety JB 05-9 was sown in the experimental field with recommended package of practices. There was predominance of dicot weeds as compared to monocot in berseem at Jabalpur, Madhya Pradesh. Among the dicot weeds, *Medicago truncatula* Gaertn. (37.48%) and *Cichorium intybus* (L.) (27.74%) were predominant. However, other weeds like *Cyperus rotundus* (L.) (13.79%), *Anagallis arvensis* (L.) (11.21%) and *Chenopodium album* (L.) (9.78%) were also present in good numbers. Sowing of berseem in the thermal regimes of 15th October and application of Oxyfluorfen 100 g/ha + Imazethapyr 15 g/ha after first and second cutting was most effective treatment for curbing the growth of weeds as it attained the minimum density and dry weight of weeds during both the years. However, sowing of 15th October with application of Oxyfluorfen 100 g/ha + Imazethapyr 15 g/ha after first cutting recorded the superior values of growth parameters, yield attributing traits, green fodder yield, dry matter yield and seed yield and found more remunerative as it fetched the higher NMR and B:C ratio as compared to other combinations.

Key words: Economics, Green fodder yield, Herbicides, Seed yield, Sowing time

Berseem (*Trifolium alexandrinum* L.), known as king of the fodder crop is one of the most important winter (*rabi*) season leguminous fodder crop in India. It is well known green forage crop to stimulate milk production in dairy animals. Due to its excellent and quick re-growing ability and long durational nutritious green fodder availability (November to April), the crop is grown under irrigated condition (Kauthale *et al*., 2016). After Egypt and Pakistan, India is having the highest area under berseem cultivation (Muhammad *et al*., 2014). In India, it is grown in approximately 2 million hectare area (Prajapati *et al.,* 2015). The crop cultivated under irrigated condition provides highly palatable, succulent and nutritious green fodder (800–850 q/ha) in 5–6 cuttings. It contains about 62% total digestible nutrients and about 20–21% crude protein (Yadav *et al*., 2015). Due to slow growth of crop, weeds adversely affect the crop growth and yield in berseem. Weeds compete with main crop for essential plant nutrients, light, moisture and space. They not only deteriorate fodder quality but also decrease fodder and seed yield. Weeds infestation decreases yields of fresh fodder and seed to the tune of 20 to 30% and 13 to 37% respectively as reported by Jha *et al*., (2014). Berseem suffers from strong crop weed competition at initial 30–40 DAS (days after sowing), or at the time up to 1st cutting and results in low quality fodder. At later cuttings, the weeds are smothered by heavy branching and faster growth of berseem. Apart from these, weeds like *Cichorium intybus* (L.), *Rumex dentatus* (L.) and *Sonchus asper* (L.) Hill pose problems in harvesting of the berseem crop for seed. The problem of weeds in berseem is very much severe due to lack of appropriate weed control methods. Therefore, it is very important to control the berseem weeds for enhancement of fodder and seed yield. With this

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background the present study was planned to evaluate the impact of planting management and herbicide application on weeds and yield of berseem.

MATERIALS AND METHODS

An experiment was conducted during winter (*rabi*) seasons of 2020–2021 and 2021–2022 at research farm of College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh. The soil of the experimental field is sandy clay loam, medium in organic carbon (0.61%), available nitrogen (365.20 kg N/ha) and phosphorus (17.97 kg P_2O_5/ha) but high in available potassium (308.12 kg K_2O/ha) and neutral in reaction (7.24 *p*H). The concentration of soluble salts (0.35 ds/m) was below the harmful limit. Experiment was conducted in a split plot design with 20 treatments comprising of 4 dates of sowing, viz. D_1, October 15th; D_2, October 30th; D_3, November 15th; and D_4, November 30th as a main plots treatments superimposed with 5 herbicidal weed control, i.e. W_1, Pyroxasulfone 125 g/ha as pre emergence; W_2, Pyroxasulfone 125 g/ha at 14 DAS; W_3, Oxyfluorfen 100 g/ha + Imazethapyr 15 g/ha after first cutting; W_4, Oxyfluorfen 100 g/ha + Imazethapyr 15 g/ha after first and second cutting; and W_5, control as a sub plot treatments, replicated thrice. Berseem variety JB 05–9 was sown in the experimental field with recommended package of practices. Full doses of nitrogen (20 kg/ha), P_2O_5 (80 kg/ha) and K_2O (40 kg/ha) was applied as basal through urea, single super phosphate (SSP) and muriate of potash (MOP). Different observations on weeds and crop parameters were recorded during the course of investigation. Dominant weed flora, species wise weed density and their dry weight were recorded under all the treatments at 30, 60 and 90 DAS. From this data, the total weed density and relative density was calculated. Herbicides were sprayed with manually operated knapsack sprayer fitted with flat fan nozzle at spray. Pre-emergence herbicides were sprayed 2-DAS prior to emergence of weed as well as crop and post-emergence herbicides were applied immediately after harvest of 1st cut for fodder. First two cuts were taken for green forage and after harvesting of second cut for fodder, the crop was left for seed production. Harvesting of seed was done in the month of May. From each plot, representative fresh plant sample was taken in each cut to estimate the dry matter content for computing dry matter yield of fodder. The weed count (monocot and dicot) and their dry weight were recorded from each plot by using a quadrate method (1.0 × 1.0 m) at harvest of last cut for seed. The weed count and weed dry weight values were transformed for statistical analysis. The weed control efficiency (WCE) was calculated as per the standard formula suggested by Mani *et al*., (1968). Soil fertility status (*p*H, EC, OC, N, P and K) was determined using the standard methods described in AOAC (1995). The growth and yield observations were recorded at every cut and samples were analyzed in laboratory using standard analytical methods. The pooled data for two years was statistically analyzed.

RESULTS AND DISCUSSION

Dominant weed flora

The dominant weeds in the experimental field were mainly comprised of *Chenopodium album, Cichorium intybus* (L.), *Medicago truncatula Gaertn., Cyperus rotundus* (L.), *Anagallis arvensis* (L.) and *Cuscuta pentagona* Engelm. Species wise data were recorded from weedy check plots (Fig.1). Among the dicot weeds, *Medicago truncatula* (37.48%) and *Cichorium intybus* (27.74%) were predominant as they attained higher values of relative density of weeds. However, other weeds like *Cyprus rotundus, Anagallis arvensis, Chenopodium album* (L.) and *Cuscuta pentagona* marked their presence in good numbers (13.79, 11.21, 9.78 and 5.59%, respectively). Almost similar weed flora associated in berseem was also reported by Agrawal *et al.,* (2001), Kewat *et al.,* (2002), Jha *et al.,* (2014) and Kantwa *et al.,* (2019).

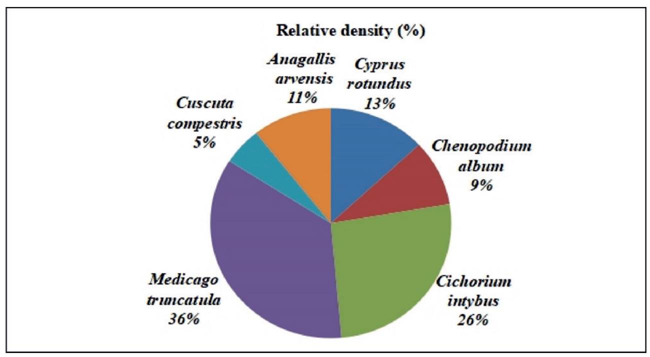

Fig. 1. Relative density of different weeds in berseem

Density and dry weight of weeds

The total weed population and weed biomass was significantly affected by date of sowing (Table 1). The minimum weed density and biomass was noted in early date of sowing on 15th October and it increased when sowing was delayed up to 30th November during both the years. The highest weed control efficiency was obtained under 15th October and the lowest under 30th November. This was owing to the emergence of more weeds in delayed sowing, but early sown crop was having shading effect for reduced weed growth. Similar results have been reported by Mishra (2012), Sahu *et al*., (2020a), Tanisha *et al*., (2022) and Patel *et al*., (2023). The application of various herbicides significantly influenced the density and dry weight of weeds in berseem. Density and biomass of *Chenopodium album, Cichorium intybus*, *Medicago truncatula*, *Cyprus*

Table 1. Effect of sowing dates and weed control practices on total weed density and dry weight of berseem (mean of 2020–2021 and 2021–2022)

Treatment	Total weed density (m^2)			Total dry weight (g/m)		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Date of sowing						
D_1, October 15th	6.92 (47.46)	9.01 (80.14)	11.40 (129.87)	3.76 (7.76)	5.03 (24.81)	8.04 (64.10)
D_2, October 30th	7.57 (56.76)	9.81 (95.64)	12.22 (148.82)	4.38 (10.94)	5.67 (31.69)	8.86 (78.05)
D_3, November 15th	8.20 (66.27)	10.32 (106.39)	12.68 (160.19)	5.03 (24.81)	6.20 (37.91)	9.54 (90.52)
D_4, November 30th	8.83 (77.56)	10.92 (118.51)	13.40 (179.34)	5.73 (32.31)	6.74 (44.91)	10.52 (110.20)
CD (P=0.05)	0.32	0.41	0.57	0.19	0.20	0.47
Herbicidal weed control						
W_1, Pyroxasulfone 125 g ai/ha as pre-emergence	7.71 (59.19)	11.72 (136.85)	14.86 (220.39)	4.34 (18.37)	7.22 (51.69)	11.50 (131.72)
W_2, Pyroxasulfone 125 g ai/ha at 14 DAS	6.13 (37.09)	9.42 (88.21)	13.02 (168.87)	3.14 (9.31)	5.63 (31.24)	9.72 (94.19)
W_3, Oxyfluorfen 100 g ai/ha + Imazethapyr 15 g ai/ha after first cutting	7.84 (61,81)	7.97 (63.22)	10.76 (115.25)	5.11 (25.79)	4.20 (17.10)	7.03 (48.91)
W_4, Oxyfluorfen 100 g ai/ha + Imazethapyr 15 g ai/ha after first and second cutting	7.94 (62.14)	7.95 (62.76)	6.82 (46.45)	5.13 (25.83)	4.25 (17.61)	4.74 (22.05)
W_5, Control	9.79 (95.44)	13.02 (168.27)	16.66 (276.60)	5.90 (34.31)	8.24 (67.32)	13.21 (174.10)
CD (P=0.05)	0.43	0.39	0.55	0.26	0.28	0.45

Figures in parenthesis are the original values and have been transformed (√ X+0.5) before statistical analysis. DAS, Days after sowing.

rotundus, *Anagallis arvensis* and *Cuscuta pentagona* was maximum under the control plots where no herbicide was applied. However, identical reduction in density and dry weight of weeds was observed when weeds were controlled chemically. The effect of different herbicides revealed that application of oxyfluorfen 100 g/ha + imazethapyr 15 g/ha after first and second cutting was most effective for inhibiting germination of annual weeds. The weed control efficiency based on dry matter production of different treatments was also maximum under oxyfluorfen 100 g/ha + imazethapyr 15 g/ha after first and second cutting (77.44 and 87.63%) *fb* oxyfluorfen 100 g/ha + imazethapyr 15 g/ha after first cutting (78.23 and 72.59%), respectively *fb* pyroxasulfone 125 g/ha at early post emergence (61.24 and 49.24%) and pyroxasulfone 125 g/ha as pre-emergence (26.49 and 26.73%) over the control treatment at 60 and 90 DAS. Effective control of weeds by application of oxyfluorfen 100 g/ha + imazethapyr 15 g/ha after first and second cutting was owing to more absorption, translocation of herbicide at the site of action and more mortality of susceptible weed species. The application of imazethapyr at first and second cutting interferes with the process of protein synthesis efficient to restricted growth, necrosis and killing of weed species over a period of time. Similar results were also reported by Chopra and Saini (2018), Sahu *et al*., (2022) and Yadav *et al.,* (2023a).

Growth characteristics

The height of crop weed significantly reduced under late sowing at all cuttings and harvest. The average height at harvest was 52.57, 48.73, 46.18 and 40.89 cm in the sowing time of 15th October, 30th October, 15th November and 30th November, respectively. This might be owing to the fact that the crop sown during normal sowing time received high temperature which favoured the better germination and had better early emergence and plant growth during both the years. The total sunshine hours received during early growth were about 2 to 3 times more (Table 2 and 3) under 15th and 30th October sowing than 15th November and 30th November during both the years. More sunshine hours and suitable temperature in timely sown crop could

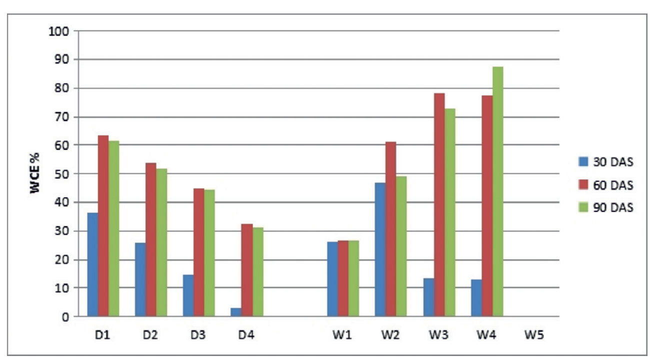

Fig. 2. Effect of sowing time and herbicides application on weed control efficiency

Table 2. Effect of sowing dates and weed control practices on growth characteristics of berseem at various stages (mean of 2020–2021 and 2021–2022)

Treatment	Plant height (cm)				Number of branches/plant			
	First cutting 55 DAS	Second cutting 85 DAS	Third cutting 105 DAS	At harvest	First cutting 55 DAS	Second cutting 85 DAS	Third cutting 105 DAS	At harvest
Date of sowing								
D_1, October 15th	60.52	66.41	57.89	52.57	4.75	6.40	5.46	4.99
D_2, October 30th	49.50	62.77	54.30	48.73	4.13	5.72	4.93	4.47
D_3, November 15th	45.01	57.10	49.23	46.18	3.59	5.17	4.50	4.04
D_4, November 30th	41.85	49.72	44.10	40.89	3.09	4.48	3.99	3.53
CD (P=0.05)	1.93	2.99	2.30	2.18	0.16	0.16	0.38	0.17
Herbicidal weed control								
W_1, Pyroxasulfone 125 g ai/ha as pre-emergence	49.44	53.26	47.41	43.15	3.94	4.43	3.86	3.40
W_2, Pyroxasulfone 125 g ai/ha at 14 DAS	52.61	62.40	53.73	46.86	4.29	5.12	4.65	4.18
W_3, Oxyfluorfen 100 g a i/ha + Imazethapyr 15 g ai/ha after first cutting	48.78	68.37	62.75	58.52	3.90	6.80	6.18	5.71
W_4, Oxyfluorfen 100 g ai/ha + Imazethapyr 15 g ai/ha after first and second cutting	49.23	68.40	60.04	56.81	3.86	6.83	5.97	5.51
W_5, Control	46.06	42.56	32.97	30.11	3.47	4.03	2.94	2.48
CD (P=0.05)	2.64	3.06	2.86	2.63	0.21	0.22	0.28	0.25

DAS, Days after sowing.

have brought higher photosynthetic efficiency. Thus, the initial better growth favoured development throughout life span of the crop. The number of branches per plant were also decreased significantly due to delayed sowing in both the years. The number of branches per plant were higher at all cutting stages and harvest when crop sown on 15th October over the crop sown 30th October, 15th November and 30th November. This might be owing to the fact that 15th October and 30th October sown crop received maximum length of growing periods. Favourable temperature and other climatological parameters for the growth character facilitated better cell division and cell elongation in comparison to 15th November and 30th November sown crop. and Sahu *et al.,* (2020) and Singh *et al.,* (2021) also found that the delay in sowing time caused adverse effect on plant growth by shortening the vegetative phase, creating unfavourable thermal sequence under delayed sowing with consequent effect on growth behaviour and phonological development, thereby, reducing the total biomass under delayed sowing. Similar results have also been reported by Amanullah *et al*., (2005) and Mohamed *et al*., (2017).

Leaf-stem ratio

The total leaf stem ratio of berseem was significantly influence due to various sowing dates and weed control practices Among the different dates of sowing the total leaf stem ratio was maximum when berseem was shown on 15th October (0.63%) and proved significantly superior as compared to late sowing on 30th October (0.61%), 15th November (0.54 %) and 30th November (0.50%). Among various weed control treatments, application of oxyfluorfen 100 g ai/ha + imazethapyr 15 g ai/ha after first cutting produced significantly highest total leaf stem ratio (0.62%) *fb* oxyfluorfen 100 g ai/ha + imazethapyr 15 g ai/ha after first and second cutting (0.61%); pyroxasulfone 125 g ai/ha as early post emergence (0.59%); pyroxasulfone 125 g ai/ha as pre-emergence (0.54%); and weedy check plots (0.49%) (Yadav *et al.,* 2023).

Yield attributing characters and yield

Results (Table 3 and 4) showed that the yield attributing characters like number of capsules per plant and number of seed/capsules were affected significantly due to chemical weed control. However, test weight remained unaffected under different weed control treatments as this character governed by genetic factors. Among the treatments, minimum number of capsules and seed per capsules were recorded under weedy check plots (38.11 and 224.81), respectively during both the years. Thin and lanky crop plants under severe weed stress could not assimilate and partitioned enough photosynthate for capsule and seed formation under control treatment. The number of capsules

Table 3. Effect of sowing dates and weed control practices on green fodder yield, dry matter yields and leaf-stem ratio of berseem (mean of 2020–2021 and 2021–2022)

Treatment	Green fodder yield (t/ha)				Dry matter yield kg/ha (t/ha)				Total leaf stem ratio (%)
	First cutting 55 DAS	Second cutting 85 DAS	Third cutting 105 DAS	Total	First cutting 55 DAS	Second cutting 85 DAS	Third cutting 105 DAS	Total	At harvest
Date of sowing									
D_1, October 15th	16.99	21.33	19.32	57.64	2.45	3.33	2.79	8.58	0.63
D_2, October 30th	15.45	18.38	17.04	50.86	2.18	2.84	2.45	7.47	0.61
D_3, November 15th	13.93	16.07	14.91	44.91	1.91	2.37	2.07	6.36	0.54
D_4, November 30th	12.63	13.30	13.80	39.74	1.72	1.91	1.88	5.53	0.50
CD (P=0.05)	0.60	0.84	0.69	2.13	0.08	0.06	0.09	0.25	0.02
Herbicidal weed control									
W_1, Pyroxasulfone 125 g ai/ha as pre-emergence	15.31	14.34	12.56	42.21	2.171	2.15	1.75	6.07	0.54
W_2, Pyroxasulfone 125 g ai/ha at 14 DAS	16.37	17.67	16.81	50.85	2.317	2.712	2.384	7.41	0.59
W_3, Oxyfluorfen 100 g ai/ha + Imazethapyr 15 g ai/ha after first cutting	14.49	20.96	21.56	57.01	2.019	3.221	3.1	8.34	0.62
W_4, Oxyfluorfen 100 g ai/ha + Imazethapyr 15 g ai/ha after first and second cutting	14.63	20.94	19.62	55.18	2.044	3.186	2.799	8.02	0.61
W_5, Control	12.94	12.46	10.80	36.19	1.803	1.819	1.477	5.09	0.49
CD (P=0.05)	0.79	1.29	0.80	2.88	0.78	0.11	0.145	0.11	0.03

DAS, Days after sowing.

and seeds per capsules were significantly more in plots receiving application of oxyfluorfen 100 g/ha + Imazethapyr 15 g/ha after first cutting (457.91 and 41.32) and oxyfluorfen 100 g/ha + Imazethapyr 15 g/ha after first and second cuttings (402.41 and 40.53) over alone application of pyroxasulfone 125 g/ha. Better growth and development under these treatment resulted into more number of flowers and fertilization under weed free situation which led to more number of capsules and more number of seed per capsule. These results are in accordance with the findings of Shah *et al.,* (2020).

Green fodder, dry matter and seed yield are the resultant of complete phenomena which not only depend on the genetic constitution of the crop plant but also on the production technology adopted therein and prevailing environmental condition. Weed caused enormous damage to the crop depending upon the associated weed species, their relative density, duration of crop-weed completion and their cumulative effect reflected in terms of reduced crop yield. The perusal of data on green fodder, dry matter and seed yield under different chemical control treatment (Table 3 and 4) reveled that significantly higher green fodder, dry matter and seed yield were obtained under oxyfluorfen 100 g/ha + Imazethapyr 15 g/ha after first cutting treatment followed by oxyfluorfen 100 g/ha + Imazethapyr 15 g/ha after first and second cuttings as compared to pyroxasulfone 125 g/ha as early post emergence and pyroxasulfone 125 g/ha as pre emergence which were attributed to superior values of growth and yield attributes. The lesser yield under pyroxasulfone 125 g/ha as pre-emergence and post emergence (42.21and 50.58) could be due to poor values of growth and yield parameters under same degree of weed competition. Tiwari *et al.,* (2011), Jha *et al.*, (2014), Kantwa *et al.*, (2019) and Yadav *et al.*, (2023) also reported chemical weed control as an effective way to achieve weed free environment for better growth and development of yield attributes trails and finally higher green fodder yield, dry-matter yield and seed yield of berseem.

Economics

The study on economics of sowing time indicated that sowing on 15th October fetched significantly higher net returns to the extent of ₹95,813/ha followed by 30th October (₹79,703/ha) over 15th November (₹59,869/ha) and 30th November (₹45,026/ha). Similarly, benefit cost (B:C) ratio was also higher under 15th October sowing (2.58) over to delayed sowings 30th October (2.31), 15th November (1.99) and 30th November (1.74). Thus, sowing of berseem on 15th October and 30th October is definitely a profitable concern to the farmers over 15th November and 30th November sowings. It is attributed to higher green matter and seed yield coupled with proportionate increase in profit under timely sowing of berseem i.e. 15th October whereas reverse was true in case of later sowing dates. The application of oxyfluorfen 100 g/ha + Imazethapyr 15 g/ha after first cut-

Table 4. Effect of sowing dates and weed control practices on yield attributes, seed yield and economics of berseem (mean of 2020–2021 and 2021–2022)

Treatment	Seeds/ capsule	Test weight (g)	Seed yield (t/ha)	Haulm yield (t/ha)	Gross monetary returns (×10³ ₹/h)	Net monetary returns (×10³ ₹/ha)	Benefit cost ratio
Date of sowing							
D_1, October 15th	41.77	3.51	0.39	3.56	156.45	95.813	2.58
D_2, October 30th	40.63	3.25	0.36	3.79	140.34	79.703	2.31
D_3, November 15th	39.45	3.18	0.31	2.81	120.51	59.869	1.99
D_4, November 30th	38.23	2.96	0.26	2.54	105.66	45.026	1.74
CD (P=0.05)	NS	NS	0.11	1.162			
Herbicidal weed control							
W_1, Pyroxasulfone 125 g ai/ha as pre-emergence	39.29	2.94	2.70	24.19	112.56	51.40	1.84
W_2, Pyroxasulfone 125 g ai/ha at 14 DAS	40.33	3.22	3.24	29.43	138.93	77.77	2.27
W_3, Oxyfluorfen 100 g ai/ha + Imazethapyr 15 g ai/ha after first cutting	41.32	3.72	4.52	39.96	158.01	97.71	2.62
W_4, Oxyfluorfen 100 g ai/ha + Imazethapyr 15 g ai/ha after first and second cutting	40.53	3.55	4.07	35.34	148.78	86.50	2.39
W_5, Control	38.11	2.69	2.13	21.04	95.42	37.11	1.64
CD (P=0.05)	NS	NS	0.15	1.72	-		

DAS, Days after sowing.

ting gave significantly higher net return (₹97,716/ha) followed by oxyfluorfen 100 g/ha + Imazethapyr 15 g/ha after first and cuttings (₹86,500/ha) over alone application of pyroxasulfone 125 g/ha as pre-emergence (₹51406/ha) and pyroxasulfone 125 g/ha as early post emergence (₹77,773/ha). In case of B:C ratio, the treatment oxyfluorfen 100 g/ha + Imazethapyr 15 g/ha after first cutting (2.62) gave maximum B:C ratio than oxyfluorfen 100 g/ha + Imazethapyr 15 g/ha after first and second cutting and alone application of pyroxasulfone 125 g/ha as pre emergence and early post emergence, because of more profit per rupee of investment. But reverse trend in case of oxyfluorfen 100 g/ha + Imazethapyr 15 g/ha after first and second cut. Kewat *et al.,* (2002) and Pathan *et al.,* (2013) also reported similar results.

Based on a 2-years field study, it can be concluded that sowing on 15th October and application of oxyfluorfen 100 g/ha + imazethapyr 15 g/ha after first cutting was found the best interaction to reduce the weed growth and attaining higher green fodder yield, seed yield and haulm yield, and B:C ratio in berseem.

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