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Herbicidal Management of *Cuscuta spp.* in Berseem (*Trifolium alexandrinum* L.) Crop

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To correlate the efficiency of herbicides towards control of Dodder (*Cuscuta spp*.) in green forage and seed yield of berseem crop.
Study Design: Randomized block design (RBD).
Place and Duration of Study: Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) during the *Rabi* season of 2019-20.
Methodology: The experiment consisted of three replications and ten treatments, in which oxyfluorfen was applied as pre-emergence herbicide and pendimethain was applied as pre-emergence and early post-emegence herbicide while imazethepyr, imazamox 35 % + imazethapyr 35 % (ready mix) and sodium acifluorfen 16.5 % + clodinafop-propargyl 8 % (ready mix) were applied as post-emergence herbicides in different proportion along with control.
Results: No cuscuta infestation was observed during the experimentation period under any

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treatments (T_1, T_2, T_3). Highest cuscuta length (41.20 cm), threads (3.00/m^2), and dry weight (0.49 g/m^2) were recorded just before 1st cutting with treatment (T_7). Just before 2nd cutting, the highest cuscuta length (46.32 cm), threads (4.00/m^2), and dry weight (0.74 g/m^2) were recorded with treatment (T_5) and before 3rd cutting, the highest cuscuta length (53.11 cm), threads (5.00/m^2), and dry weight (1.06 g/m^2) recorded under control (T_{10}). No cuscuta infestation after herbicide application in all treatments. The significantly highest total green forage and seed yield of 60.12 ton/ha and 0.35 ton/ha were recorded under the pre-emergence application of oxyfluorfen 250 g/ha (T_3) as compared to the rest of the treatments.

Conclusion: The selective action of oxyflourfen, pendimethalin, and imazethapyr on berseem and non-selective control of weeds, including *cuscuta spp.,* resulted in minimal weed competition during critical growth stages. This created a favourable environment for berseem, leading to improved growth, yield quality, and overall crop productivity. The effective herbicidal treatments played a vital role in enhancing berseem yield.

Keywords: Berseem; herbicide; Cuscuta spp; threads.

1. INTRODUCTION

Berseem (*Trifolium alexandrinum* L.) is a prominent winter season forage crop in India, covering an extensive area of 1.9 million hectares with a yield ranging from 60 to 110 tons per hectare [1]. Although not native to Chhattisgarh, it has been gaining popularity among farmers due to its ability to provide high-quality green forage with a protein content of 15-25%, along with valuable minerals (11-19%) and carotene [2]. Berseem faces significant competition from weeds during its initial growth stages, especially within the first 30-40 days after sowing (DAS), and sometimes even up to the first cutting. This is due to its initially slow growth rate, coupled with the least leaf area and branching expansion. In subsequent cuttings, the weeds are naturally suppressed by the dense branching and rapid growth of berseem [3]. However, it is important to note that during earlier stages, weeds can cause significant losses in both fodder yield (estimated at 23-30%) and seed yield (estimated at 50%) [4,5]. In India, Cuscuta, commonly known as dodder, presents challenges in various oil seeds such as niger (*Guizotia abyssinica* L.) and linseed (*Linum usitatissimum* L.), as well as pulses like blackgram (*Vigna mungo* L.), greengram (*Vigna radiata* L.), lentil (*Lens culinaris* L.), and chickpea (*Cicer arietinum* L.). It particularly affects rice-fallow areas and fodder crops like lucerne (*Medicago sativa* L.) and berseem (*Trifolium spp*.) in states such as Andhra Pradesh, Chhattisgarh, parts of Madhya Pradesh, Orissa, Gujarat, and West Bengal, both in rainfed and irrigated conditions. Dodder (*Cuscuta spp*.) is classified as a "declared noxious weed" in 25 countries, which prohibits the importation and movement of its seeds and plant material. In the United States, it stands as the only weed seed whose transportation is banned in all states [6]. The presence of cuscuta poses significant challenges in crop seed production, as its intertwining nature makes it difficult to separate its seeds when crops are sorted out during grading, leading to a reduction in both yield and quality. Consequently, this result in increased harvesting and cleaning expenses [6].

2. MATERIALS AND METHODS

The experiment was conducted at the Research cum Instructional Farm, IGKV, Raipur (C.G.), during the *rabi* season of 2019-20. The physico-chemical properties of the experimental field are given in Table 1. Berseem multicut *cv* SS-51 seeds were sown at a rate of 25 kg/ha, with a sowing depth of 2-3 cm. The sowing was performed using a tractor drawn seed cum fertilizer drill, maintaining a row to row spacing of 20 cm. To ensure proper seeding, the seeds were mixed with sand in a 1:1 ratio. To achieve a consistent plant population across all treatments, gap filling was carried out 10 days after sowing (DAS). At the time of sowing, the required amount of fertilizer (20 kg of nitrogen, 50 kg of Phosphorus, and 20 kg of Potassium per hectare) was applied as a basal dose using a seed cum fertilizer drill. The experiment was set up in a randomized block design with three replications. Details of the treatments and their scheduling can be found in Table 2. For herbicide application, a knapsack sprayer fitted with a flat fan nozzle was used to spray the required quantity of herbicides. The observations on number of threads, length of threads and dry weight of cuscuta was observed before the 1st, 2nd and 3rd cut (*i.e.* 55, 85 and 115 DAS, respectively) of berseem. For counting number of

threads, a quadrat of 0.25 m^2 (0.5 m x 0.5 m) was placed randomly at four places in each plot and then cuscuta threads were counted. The data thus obtained, was averaged out and expressed in number/m^2. For measuring the length of threads, 5 threads were randomly selected and then with the help of a metre scale lengths were measured. Thereafter, the average length of threads (cm/thread) was worked out by dividing the summation of 5. The cuscuta threads were collected randomly from 4 places with the help of a quadrat of 0.25 m^2 in each plot. The collected stems were placed into individual paper bags and then dried in an oven at 60°C until a constant weight was achieved. Thereafter, the dry weight of cuscuta stems was recorded and reported in g/m^2 after conversion.

3. RESULTS AND DISCUSSION

3.1 Herbicidal Effect on *Cuscuta spp.*

The data on number of cuscuta threads/m^2, length of cuscuta threads (cm/threads) and dry weight of cuscuta threads (g/m^2) was recorded before 1st, 2nd and 3rd cutting (*i.e.* 55, 85 and 115 DAS, respectively) of berseem and presented in Tables 3, 4 and 5, respectively.

The initial occurrence of cuscuta within the experimental plot was noted after 30 days of sowing (DAS) berseem, with the herbicide being applied solely following the first and second cuttings. The data shows that there was no infestation of cuscuta throughout the experimentation under the treatments *viz.* pendimethalin1000 g/ha applied as pre-emergence (PE) (T_1), pendimethalin 1000 g/ha applied at 10 DAS as early post-emergence (EPoE) (T_2) and oxyfluorfen 250 g/ha applied as pre-emergence (PE) (T_3). Similarly pendimethalin 0.5-1.5 kg/ha applied as pre-emergence effectively controlled cuscuta in niger as reported by Mishra et.al. [12], in blackgram by Mishra et.al. [13], in linseed by Mahere et.al. [14], and in onion by Rao and Rao [15]. Liu et al. [16] reported that pendimethalin inhibits the cell division and formation of spindle microtubules in the cells of germinated cuscuta seedlings. It clearly showed that herbicides disturbed mitosis, cytokinesis and production of microtubules on shoot tips and effectively controlled cuscuta in berseem.

Just before 1st cutting of berseem, the highest average length (41.20 cm) of cuscuta thread with the highest average number of threads (3.00/m^2) and dry weight of cuscuta (0.49 g/m^2) were recorded under the treatment imazamox 35 % + imazethapyr 35 % (ready mix) 70 g/ha applied just after 1st cutting as post emergence (PoE) (T_7). Just before 2nd cutting of berseem, the highest average length (46.32 cm) of cuscuta thread with the highest average number of threads (4.00/m^2) and dry weight of cuscuta (0.74 g/m^2) were recorded under the treatment imazethapyr 40 g/ha applied just after 2nd cutting as post emergence (PoE) (T_5). While before 3rd cutting, the highest average length (53.11 cm) of cuscuta thread with the highest average number of threads (5.00/m^2) and dry weight of cuscuta (1.06 g/m^2) was recorded under the treatment control (T_{10}). However, under all the herbicidal treatments, the infestation of cuscuta was not observed after the application of herbicides. Yadav et. al.[17] reported that the combined application of oxyfluorfen at 100 g a.i./ha and imazethapyr at 15 g a.i./ha after the first and second cutting effectively suppressed the growth of *Cuscuta reflexa* and other weeds. Similarly Zaroug et.al. [18] reported that post-attachment application of stomp (pendimethalin) at 0.36 kg a.i/feddan(approximately 0.42 hectare) and goal (oxyfluorfen) at 0.1 kg a.i/feddan controlled field dodder by 86%-100%, 76%-85%, respectively in onion.

Table 1. Physico-chemical properties of the experimental field

Particulars	Values	Class	Method used
Mechanical composition			
Sand (%)	16	Clayey	International Pipette method [7]
Silt (%)	36		
Clay (%)	47		
Chemical composition			
pH (1:2:5 soil: water)	7.4	Slightly alkaline	Glass electrode pH meter [8]
Available N (Kg/ha)	189.64	Low	Alkaline permanganate method [9]
Available P (Kg/ha)	12.30	Medium	Olsen's calorimeter method [10]
Available K (Kg/ha)	257.60	Medium	Flame photometer method [11]

Table 2. Treatment details

Treatment no.	Treatments	Dose (g/ha)
1	Pendimethalin (PE*)	1000
2	Pendimethalin (EPoE*) at 10 DAS	1000
3	Oxyfluorfen (PE)	250
4	Imazethapyr (PoE*) just after 1st cutting	40
5	Imazethapyr (PoE) just after 2nd cutting	40
6	Imazethapyr (PoE) just after 1st cutting *fb** Imazethapyr (PoE) just after 2nd cutting (applied twice)	40
7	Imazamox 35 % + Imazethapyr 35 % (ready mix) (PoE) just after 1st cutting	70
8	Imazamox 35 % + Imazethapyr 35 % (ready mix) (PoE) just after 2nd cutting	70
9	Sodium acifluorfen 16.5% + Clodinafop-propargyl 8% (ready mix) (PoE) just after 1st cutting	187.5
10	Control	--

Where PE-pre-emergence, EPoE- early post-emergence, PoE- post-emergence, fb-followed by

Table 3. Herbicidal effect on number of threads of *cuscuta spp*. in berseem

Treatment	Number of threads of cuscuta/m^2		
	Before 1st cut (55 DAS)	Before 2nd cut (85 DAS)	Before 3rd cut (115 DAS)
T_1-Pendimethalin (PE) 1000 g/ha	Nil	Nil	Nil
T_2-Pendimethalin (EPoE) 1000 g/ha at 10DAS	Nil	Nil	Nil
T_3-Oxyfluorfen (PE) 250 g/ha	Nil	Nil	Nil
T_4-Imazethapyr (PoE) 40 g/ha just after 1st cutting	2.67	Nil	Nil
T_5-Imazethapyr (PoE) 40 g/ha just after 2nd cutting	2.00	4.00	Nil
T_6-Imazethapyr (PoE) 40 g/ha just after 1st cutting *fb* Imazethapyr (PoE) 40 g/ha just after 2nd cutting	2.00	Nil	Nil
T_7-Imazamox 35% + Imazethapyr 35% (ready mix) (PoE) 70 g/ha just after 1st cutting	3.00	Nil	Nil
T_8-Imazamox 35% + Imazethapyr 35% (ready mix) (PoE) 70 g/ha just after 2nd cutting	2.33	3.67	Nil
T_9-Sodium acifluorfen 16.5% + Clodinafop-propargyl 8 % (ready mix) (PoE) 187.5 g/ha just after 1st cutting	2.67	Nil	Nil
T_{10}-Control	2.67	3.33	5.00

Where PE-pre-emergence, EPoE- early post-emergence, PoE- post-emergence, fb-followed by

3.2 Total Green Forage Yield and Seed Yield

Total green forage yield was also affected significantly by different herbicidal treatments as shown in Table 6. The total green forage yield was the lowest (35.97 tons/ha) under control (T_{10}) when weeds were allowed to grow throughout the crop season and it increased substantially when herbicides were applied as per the plan of experimentation in berseem. The significantly highest total green forage yield, amounting to 60.12 tons/ha was observed in the application of oxyfluorfen at 250 g/ha as pre-emergence (T_3) and it was found at par with pendimethalin at 1000 g/ha as pre-emergence (PE) (T1) and early post-emergence (EPoE) at 10 days after sowing (DAS) (T2). All treatments, including the mentioned ones, showed significant superiority over the control (T10). The weed-free condition created a favourable environment for the crops by eliminating competition from weeds for light, nutrients, and moisture. This led to enhanced crop growth, increased nutrient

uptake, and consequently, a higher green forage yield. Wasnik et. al. [19] observed that the application of oxyfluorfen at 0.04 kg a.i./ha resulted in the highest recorded yields of green fodder (360.83 q/ha), seed (2.66 q/ha), and straw (21.44 q/ha) among the pre-emergence herbicides tested. Kauthale et al. [20] found that employing oxyflourfen at 0.10 kg/ha pre-emergence, followed by post-emergence application of imazethapyr at 0.10 kg/ha immediately after the first cut's harvest, resulted in significantly increased green fodder yields. Similar results were also found by Kumar et .al. [21], Pathan et. al. [22], kantwa et. al.[23].

Table 4. Herbicidal effect on length of thread of *cuscuta spp.* in berseem

Treatment	Length of thread (cm/thread)		
	Before 1st cut (55 DAS)	**Before 2nd cut (85 DAS)**	**Before 3rd cut (115 DAS)**
T_1-Pendimethalin (PE) 1000 g/ha	Nil	Nil	Nil
T_2- Pendimethalin (EPoE) 1000 g/ha at 10 DAS	Nil	Nil	Nil
T_3-Oxyfluorfen (PE) 250 g/ha	Nil	Nil	Nil
T_4-Imazethapyr (PoE) 40 g/ha just after 1st cutting	40.32	Nil	Nil
T_5-Imazethapyr (PoE) 40 g/ha just after 2nd cutting	38.70	46.32	Nil
T_6-Imazethapyr (PoE) 40 g/ha just after 1st cutting *fb* Imazethapyr (PoE) 40 g/ha just after 2nd cutting	39.20	Nil	Nil
T_7-Imazamox 35% + Imazethapyr 35% (ready mix) (PoE) 70 g/ha just after 1st cutting	41.20	Nil	Nil
T_8-Imazamox 35% + Imazethapyr 35% (ready mix) (PoE) 70 g/ha just after 2nd cutting	39.56	44.61	Nil
T_9-Sodium acifluorfen 16.5% + Clodinafop-propargyl 8 % (ready mix) (PoE) 187.5 g/ha just after 1st cutting	39.00	Nil	Nil
T_{10}-Control	38.34	45.23	53.11

Where PE-pre-emergence, EPoE- early post-emergence, PoE- post-emergence, fb-followed by

Table 5. Herbicidal effect of dry weight of *cuscuta spp.* in berseem

Treatment	Dry weight of cuscuta (g/m^2)		
	Before 1st cut (55 DAS)	**Before 2nd cut (85 DAS)**	**Before 3rd cut (115 DAS)**
T_1-Pendimethalin (PE) 1000 g/ha	Nil	Nil	Nil
T_2- Pendimethalin (EPoE) 1000 g/ha at 10 DAS	Nil	Nil	Nil
T_3-Oxyfluorfen (PE) 250 g/ha	Nil	Nil	Nil
T_4-Imazethapyr (PoE) 40 g/ha just after 1st cutting	0.44	Nil	Nil
T_5-Imazethapyr (PoE) 40 g/ha just after 2nd cutting	0.31	0.74	Nil
T_6-Imazethapyr (PoE) 40 g/ha just after 1st cutting *fb* Imazethapyr (PoE) 40 g/ha just after 2nd cutting	0.34	Nil	Nil
T_7-Imazamox 35% + Imazethapyr 35% (ready mix)(PoE) 70 g/ha just after 1st cutting	0.49	Nil	Nil
T_8-Imazamox 35% + Imazethapyr 35% (ready mix)(PoE) 70 g/ha just after 2nd cutting	0.37	0.65	Nil
T_9-Sodium acifluorfen 16.5% + Clodinafop-propargyl 8 % (ready mix) (PoE) 187.5 g/ha just after 1st cutting	0.43	Nil	Nil
T_{10}-Control	0.41	0.60	1.06

Where PE-pre-emergence, EPoE- early post-emergence, PoE- post-emergence, fb-followed by

Table 6. Total green forage and seed yield of berseem

Treatment	Total Green forage yield (tons/ha)	Seed yield (tons/ha)
T_1-Pendimethalin (PE) 1000 g/ha	56.73	0.23
T_2- Pendimethalin (EPoE) 1000 g/ha at 10 DAS	55.21	0.25
T_3-Oxyfluorfen (PE) 250 g/ha	60.12	0.35
T_4-Imazethapyr (PoE) 40 g/ha just after 1st cutting	45.17	0.18
T_5-Imazethapyr (PoE) 40 g/ha just after 2nd cutting	44.25	0.13
T_6-Imazethapyr (PoE) 40 g/ha just after 1st cutting *fb* Imazethapyr (PoE) 40 g/ha just after 2nd cutting	51.59	0.21
T_7-Imazamox 35% + Imazethapyr 35% (ready mix)(PoE) 70 g/ha just after 1st cutting	46.95	0.19
T_8-Imazamox 35% + Imazethapyr 35% (ready mix)(PoE) 70 g/ha just after 2nd cutting	42.32	0.16
T_9-Sodium acifluorfen 16.5% + Clodinafop-propargyl 8 % (ready mix) (PoE) 187.5 g/ha just after 1st cutting	36.30	0.05
T_{10}-Control	35.97	0.04
SEm±	1.83	0.01
CD (P=0.05)	5.43	0.04

Where PE-pre-emergence, EPoE- early post-emergence, PoE- post-emergence, fb-followed by

The effect of different treatments on the seed yield of berseem is presented in Table 6. The lowest seed yield (0.04 tons/ha) was found under control (T_{10}). Whereas, the significantly highest seed yield (0.35 tons/ha) was recorded under the pre-emergence application of oxyfluorfen 250 g/ha (T_3) as compared to the rest of the treatments. It was followed subsequently by the early post-emergence application of pendimethalin1000 g/ha at 10 DAS (T_2), pre-emergence application of pendimethalin1000 g/ha (T_1) and post-emergence application of imazethapyr 40 g/ha applied twice just after 1st and 2nd cutting (T_6) (0.25, 0.23 and 0.21 tons/ha, respectively). Prajapati et. al. [24] reported significantly higher seed yield with the application of oxyflourfen 0.10 kg/ha + imazethapyr 0.15 kg/ha (immediately after 1st cut) i.e. 0.67 tons/ha compared to remaining herbicidal treatments. Similar results were also reported by Tamrakar et al. [25], Tiwana et al. [26], Pathan and Kamble [27], and Pathan et al. [28].

4. CONCLUSION

The selective mode of oxyflourfen, pendimethalin, and imazethapyr towards berseem and their non-selective mode against weed flora contributed to the effective control of *cuscuta spp.* (dodder) and other grassy and broad-leaved weeds. As a result, there was minimal competition from weeds during the critical crop growth period, ensuring that the crop had sufficient access to moisture, space, sunlight, and nutrients. This favourable environment led to improved growth and development of the crop, ultimately enhancing yield quality parameters and overall yield.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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