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RESEARCH ARTICLE

Efficacy of herbicides and their time of application on field dodder (*Cuscuta*) in lucerne

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ABSTRACT

Parasitic weed *Cuscuta* is a serious problem in lucerne and other crops has negative impacts on the growth and yield of lucerne. Hence, effective control of *Cuscuta* in lucerne is necessary to reduce yield losses. Considering the seriousness of the problem, an experiment was conducted during *Rabi* seasons of the 2020-21 and 2021-22 on loamy sand soil at the farm of AICRP-Weed Management, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat. Pre-emergence application (PE) of pendimethalin 680 g/ha; pendimethalin + imazethapyr 640 g/ha; and pendimethalin + imazethapyr 800 g/ha were found phytotoxic to lucerne crop. The post-emergence application (PoE) of fluazifop-p-butyl + fomesafen 250 g/ha was also found phytotoxic to lucerne crop and showed burning effect on leaves of lucerne. Among different treatments, pendimethalin 680 g/ha applied at 10 days after sowing (DAS) significantly reduced the length and fresh weight of *Cuscuta* at 60 DAS with higher *Cuscuta* control efficiency (99.44%) and green fodder yield of lucerne at 60 DAS without any phytotoxic effect on lucerne.

Keywords: *Cuscuta*, Fluazifop-p-butyl + fomesafen, Lucerne, Pendimethalin, Pendimethalin + imazethapyr, Phytotoxicity

INTRODUCTION

Lucerne/Alfalfa (*Medicago sativa* L.) is an important forage crop with high yields and nutritional value for the dairy industry across the world. The high protein and low lignin contents of the species make it highly desirable within the animal feedstock industry (Noroozi *et al*. 2022). In India, lucerne is predominantly cultivated in subtropical and tropical climatic conditions as a major *rabi* fodder crop and is estimated to cultivated under 1.0 Mha area (Chauhan *et al*. 2017). Gujarat state is having the highest area under lucerne cultivation followed by Rajasthan, Maharashtra, Punjab, Haryana, Madhya Pradesh, Uttar Pradesh, Tamil Nadu and Karnataka (Roy *et al*. 2020). Weeds have serious impacts on the economical production of lucerne as they severely decrease the forage yield and nutritive value. Dodder (*Cuscuta* spp.) also reduces the quality lucerne seed.

Dodder, also known as *Akashbel* or *Amarbal*, is a parasitic angiosperm belonging to the family *Cuscutaceae*. It is a serious parasitic weed in lucerne, which reduces crop yield and can kill its host plant. Dodders are obligate parasitic plants consisting of yellow twining stems that produce small clusters of white flowers. Dodder is a holo-parasitic plant that attaches to the stems and leaves of broad-leaved crops in many agricultural regions of the world. Dodder does not produce chlorophyll, therefore, it exhibits no photosynthetic activity and acquires essential resources such as moisture, nutrients and carbohydrates by attaching to the aerial tissues of host plants through haustoria due to the lack of roots and leaves Garcia *et al*. (2014). Mishra (2012) reported that *Cuscuta* caused detrimental effect on lucerne seed yield (85.5-95.3% loss), even at density of 0.25 plants/m^2 (1 plant/4m^2). Lucerne is a very sensitive host to dodder infection because of slow germination and establishment. Heavy contamination of dodder without control leads to significant yield losses ranging between 50 and 80% (Arregi *et al*. 2001 and Saric-Krsmanovic *et al*. 2015). Manual removal and frequent inter-row cultivation before the parasite attaches the host plant are the usual control measures but they are laborious and often not effective methods. Therefore, effective and selective herbicide is required to control the *Cuscuta* without damaging its host plant. Hence, the present study was undertaken with an objective to identify the effective herbicides for control of *Cuscuta* in lucerne.

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MATERIALS AND METHODS

A field experiment was carried out during *Rabi* seasons of 2020-21 and 2021-22 on loamy sand soil at the farm of AICRP-Weed Management, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat State. The experiment was laid out in randomized block design with three replications and nine treatments, *viz*. pre-emergence application (PE) of pendimethalin 38.7% CS (pendimethalin) 680 g/ha, pendimethalin 680 g/ha at 10 days after seeding (DAS), pendimethalin 30% + imazethapyr 2% EC pre-mixed (PM) (pendimethalin + imazethapyr) 640 g/ha PE, pendimethalin + imazethapyr (PM) 800 g/ha PE, post-emergence application (PoE) of imazethapyr10% SL (imazethapyr) 50 g/ha, imazethapyr 35% + imazamox 35% WG (PM) (imazethapyr + imazamox) 70 g/ha PoE, fluazifop-p-butyl 11.1% + fomesafen 11.1% SL (PM) (fluazifop-p-butyl + fomesafen) 250 g/ha PoE, propaquizafop 2.5% + imazethapyr 3.75% ME (PM) (propaquizafop + imazethapyr) 125 g/ha PoE and weedy check. The recommended seed rate of 15 kg/ha of lucerne cv. "*Anand Lucerne 2*" was manually sown in previously open furrows, with the help of kudali, keeping the row spacing of 30 cm. The crop was sown on 9th November, 2020 and 1st November 2021 and was harvested on 9th May 2020 and 2021. Seeds of *Cuscuta* (5 g/18m^{-2} plot area) were mixed with lucerne seeds at the time of sowing. After sowing, the seeds were covered with soil manually and irrigation was given for better germination of the seeds. Herbicides were applied as per the treatment by using battery operated knapsack sprayer fitted with flat-fan nozzle by mixing in 500 and 375 litre of water/ha for pre-emergence and post emergence application of herbicide, respectively. Visual phytotoxicity (%) of herbicides applied in lucerne was recorded based on 0-10 scale at 10 and 20 days after herbicide application (DAHA). Observation on fresh weight and length of *Cuscuta* were taken randomly from 0.25 m^2 quadrat from net plot area in each treatment and fresh weight was converted into g/m^2 and length was converted into (m/m^2) at 60 DAS. Green forage yield of lucerne was harvested from net plot area of each treatment at 60 DAS and converted into t/ha. Data on various observations recorded during the experimental period was statistically analysed as per the standard procedure and weed data were transformed by square root transformation ($\sqrt{x+1}$) and transformed data were subjected to ANOVA analysis (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Effect on *Cuscuta*

Pendimethalin 680 g/ha at 10 DAS, pendimethalin + imazethapyr 640 g/ha PE and pendimethalin + imazethapyr 800 g/ha PE significantly reduced the length, fresh weight at 60 DAS and seed yield of *Cuscuta* as compared to other treatments (**Table 1**). Pendimethalin 0.5-1.5 kg/ha PE was reported to control *Cuscuta* in niger (Mishra *et al*. 2005) with higher *Cuscuta* control efficiency and more than 94% decrease in seed yield of *Cuscuta*. Fluazifop-p-butyl + fomesafen 250 g/ha PoE recorded higher seed yield of *Cuscuta* and it was at par with propaquizafop + imazethapyr 125 g/ha PoE, imazethapyr 50 g/ha PoE, pendimethalin 680 g/ha PE and imazethapyr + imazamox 70 g/ha PoE. Other herbicidal treatments recorded significantly lower fresh weight, length and seed yield of *Cuscuta* as compared to control plot. Imazethapyr inhibits amino acid biosynthesis, causing plant mortality and this mode of action has been found to be particularly effective in suppressing growth of *Cuscuta* in lucerne. Noroozi *et al*. (2022) observed that imazethapyr 100 g/ha provided significant reduction in the density (90%) and biomass (98%) of dodder in alfalfa.

Phytotoxicity

Mean data on phytotoxicity of applied herbicides on lucerne indicated that application of pendimethalin 680 g/ha PE, pendimethalin + imazethapyr 640 g/ha PE and pendimethalin + imazethapyr 800 g/ha PE were found phytotoxic to lucerne crop and poor germination was observed in treated plot as compared to untreated check. Liu *et al*. (1990) reported that pendimethalin inhibited the cell division and formation of spindle microtubulus in the cells of germinated *Cuscuta* seedlings. However, pendimethalin PE was found phytotoxic to berseem and lucerne. Fluazifop-p-butyl + fomesafen 250 g/ha PoE was also found phytotoxic to lucerne crop and showed burning effect on leaves of lucerne but recovered after 10 days of application (**Table 3**).

Effect on lucerne

Lucerne plant stand (at 15 DAS) and plant height (at 60 DAS) was significantly lowest with pendimethalin + imazethapyr at both 800 or 640 g/ha (**Table 2**). Further, pendimethalin 680 g/ha also showed significantly lower plant stand and plant height as compared to other herbicidal treatments. Mishra (2012) also observed that pendimethalin 750

Table 1. Length, Fresh weight and seed yield of *Cuscuta* as influenced by different treatments

Treatment*	Length of *Cuscuta* (m/m^2) at 60 DAS			Fresh weight of *Cuscuta* (g/m^2) at 60 DAS			*Cuscuta* control efficiency (%)			Seed yield of *Cuscuta* (g/m^2)		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Mean	2020-21	2021-22	Pooled
Pendimethalin 680 g/ha PE	9.86 (96.3)	9.46 (88.7)	9.66 (92.5)	8.57 (72.7)	6.36 (39.7)	7.47 (56.2)	85.04	94.11	89.58	51.8	20.5	36.2
Pendimethalin 680 g/ha at 10 DAS	1.00 (0.00)	3.52 (11.4)	2.26 (5.72)	1.00 (0.00)	2.71 (6.43)	1.85 (3.22)	100	99.05	99.53	0.00	8.57	4.28
Pendimethalin + imazethapyr (PM) 640 g/ha PE	1.00 (0.00)	4.69 (21.0)	2.84 (10.5)	1.00 (0.00)	3.89 (14.2)	2.44 (7.08)	100	97.89	98.95	0.00	8.77	4.38
Pendimethalin + imazethapyr (PM) 800 g/ha PE	1.00 (0.00)	2.99 (8.13)	1.99 (4.07)	1.00 (0.00)	2.43 (5.13)	1.71 (2.57)	100	99.24	99.62	0.00	8.70	4.35
Imazethapyr 50 g/ha PoE	15.5 (245)	13.4 (180)	14.4 (213)	13.7 (189)	11.5 (132)	12.6 (161)	61.11	80.42	70.77	45.6	28.1	36.8
Imazethapyr + imazamox 70 g/ha PoE	18.1 (333)	14.1 (201)	16.1 (267)	16.5 (275)	13.1 (175)	14.8 (225)	43.41	59.20	51.31	43.5	26.6	35.1
Fluazifop-p-butyl + fomesafen 250 g/ha PoE	15.7 (255)	13.8 (189)	14.7 (222)	14.5 (211)	18.6 (349)	16.6 (280)	56.58	48.22	52.40	45.4	35.1	40.3
Propaquizafop + imazethapyr 125 g/ha PoE	11.3 (129)	10.5 (109)	10.9 (119)	10.5 (108)	9.64 (92.4)	10.0 (100)	77.78	86.29	82.04	45.8	28.0	36.9
Weedy check	24.2 (588)	26.3 (692)	25.3 (640)	22.0 (486)	25.8 (674)	24.0 (580)	-	-	-	92.4	69.2	80.8
LSD (p=0.05)	3.60	2.10	1.61	2.34	1.89	1.17	-	-	-	9.37	8.63	4.93

Note: Data subjected to $(\sqrt{x+1})$ transformation. Figures in parentheses are means of original values. ; *PE = pre-emergence application; PoE = post-emergence application; DAS = days after seeding

Table 2. Plant stand, plant height and green fodder yield of lucerne as influenced by different treatments

Treatment*	Reduction in seed yield of *Cuscuta* over control (%)			Plant stand (no./m row length) at 15 DAS			Plant height (cm) at 60 DAS			Green fodder yield (t/ha) at 60 DAS		
	2020-21	2021-22	Mean	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
Pendimethalin 680 g/ha PE	43.94	70.38	57.16	25.2	46.9	36.0	48.6	52.4	50.5	13.0	8.13	10.6
Pendimethalin 680 g/ha at 10 DAS	100.00	87.62	93.81	39.7	78.7	59.2	60.3	63.6	62.0	22.8	12.2	17.5
Pendimethalin + imazethapyr 640 g/ha PE	100.00	87.33	93.66	9.07	28.1	18.6	38.40	37.9	38.2	7.00	8.90	7.95
Pendimethalin + imazethapyr 800 g/ha PE	100.00	87.43	93.71	8.13	24.6	16.4	36.13	32.7	34.4	6.57	8.53	7.55
Imazethapyr 50 g/ha PoE	50.65	59.39	55.02	41.1	78.4	59.8	52.5	56.4	54.5	20.0	11.7	15.8
Imazethapyr + imazamox 70 g/ha PoE	52.92	61.56	57.24	41.5	77.9	59.7	53.5	57.5	55.5	22.7	9.83	16.3
Fluazifop-p-butyl + fomesafen 250 g/ha PoE	50.87	49.28	50.07	40.3	78.9	59.6	42.2	46.2	44.2	12.7	3.70	8.18
Propaquizafop + imazethapyr 125 g/ha PoE	50.43	59.54	54.99	42.4	80.9	61.7	51.3	54.2	52.7	19.4	11.8	15.6
Weedy check	-	-	-	43.3	79.9	61.6	59.2	59.9	59.5	18.9	3.90	11.4
LSD (p=0.05)	-	-	-	5.58	10.0	4.45	5.66	4.73	2.86	6.51	2.42	2.69

*PE = pre-emergence application; PoE = post-emergence application; DAS = days after seeding

Table 3. Phytotoxicity of applied herbicides on lucerne (mean of two years)

Treatment	Phytotoxicity Score (0-10 scale)		Remarks
	10 DAHA	20 DAHA	
Pendimethalin 680 g/ha PE	3	1	Poor germination
Pendimethalin 680 g/ha at 10 DAS	0	0	-
Pendimethalin + imazethapyr 640 g/ha PE	4	2	Poor germination and Stunted growth
Pendimethalin + imazethapyr 800 g/ha PE	4	2	Poor germination and Stunted growth
Imazethapyr 50 g/ha PoE	0	0	-
Imazethapyr + imazamox 70 g/ha PoE	0	0	-
Fluazifop-p-butyl + fomesafen 250 g/ha PoE	4	0	Burning of leaves
Propaquizafop + imazethapyr 125 g/ha PoE	0	0	-
Weedy check	0	0	-

*PE = pre-emergence application; PoE = post-emergence application; DAS = days after seeding; DAHA = days after herbicide application

g/ha PE significantly reduced the lucerne plant population leading to decreasing green fodder yield of lucerne. Significantly higher green fodder yield (17.5 t/ha) at 60 DAS was recorded with pendimethalin 680 g/ha at 10 DAS but remained at par with imazethapyr + imazamox 70 g/ha PoE, propaquizafop + imazethapyr 125 g/ha and imazethapyr 50 g/ha PoE. Mishra (2012) observed that pendimethalin applied at 14 DAS was safe for lucerne emergence as compared to its application at 7 DAS and pendimethalin 14 DAS was also effective in reducing *Cuscuta* emergence leads to recorded maximum green fodder yield of lucerne.

Conclusion

Pendimethalin 680 g/ha applied at 10 DAS significantly reduced the length and fresh weight of *Cuscuta* at 60 DAS with higher *Cuscuta* control efficiency (99.44%) and green fodder yield of lucerne at 60 DAS without any phytotoxic effect on lucerne. Hence, pendimethalin 680 g/ha application at 10 DAS may be used for managing *Cuscuta* in lucerne.

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