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Management of dodder in lucerne and Egyptian clover

J.S. Mishra*

Directorate of Weed Science Research, Jabalpur, Madhya Pradesh 482 004

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ABSTRACT

Field dodder (*Cuscuta campestris*), the most damaging annual obligate stem parasite is a serious problem in forage legumes lucerne (*Medicago sativa* L.) and Egyptian clover (*Trifolium alexandrinum* L.). Studies were conducted to investigate the interference of *C. campestris* densities in lucerne and the efficacy of herbicides for its control in lucerne and Egyptian clover. Even at *Cuscuta* density of 0.25 plants/m^2 (1 plant/4m^2) caused detrimental effect on lucerne seed yield (85.5-95.3% loss). A high dose of pendimethalin (1000 g/ha) applied pre-emergence reduced *Cuscuta* emergence but was phytotoxic to lucerne as compared to lower doses and application at 14 days after sowing (DAS). Application of imazethapyr 100 g/ha and pendimethalin 750 g/ha at 14 DAS significantly improved green fodder yield of lucerne but failed to control *Cuscuta* infestation at reproductive stage resulting in poor seed yield. Method of seeding did not influence the population and green fodder yield of Egyptian clover and *Cuscuta* emergence. Post-emergence (at 14 DAS) application of pendimethalin 500-750 g/ha effectively controlled *Cuscuta campestris* in Egyptian clover and produced the maximum green fodder and seed yields.

Key words: Berseem, *Cuscuta*, Herbicides, Interference, Lucerne, Pendimethalin

Lucerne (alfalfa) (*Medicago sativa* L.) and Egyptian clover (berseem) (*Trifolium alexandrinum* L.) are the major forage crops grown worldwide. In India, these crops are extensively grown in irrigated areas during winter season. Field dodder (*Cuscuta campestris* Yuncker) is a serious problem in these forage legumes and lucerne was reported to be highly susceptible to *Cuscuta* than the Egyptian clover (Farah and Al-Abdulsalam 2004). Seeds of *Cuscuta* are ideally suited to be transported as a contaminant of alfalfa and clover seeds (Dawson *et al*. 1994). During the seed production of these crops, *Cuscuta* seeds are harvested with the crop seed and being similar in size and density to the forage legume seed, it is extremely difficult to separate from the crop seed and consequently, *Cuscuta* is often seeded with forage legumes (Dawson *et al*. 1994). Infestation of *C. campestris* caused more than 50% reduction in forage and seed yields of alfalfa (Cudney *et al*. 1992). Movsesyan and Azaryan (1974) reported that *C. campestris* can be poisonous to animals if it exceeds 5% of the total roughage.

Manual removal and frequent inter-row cultivation before the parasite attaches the host plant are the usual control measures. However, these methods are laborious and often not effective. As dodder is able to compete with lucerne and is not readily controlled by herbicide, knowledge of density dependent effects of dodder interference in lucerne for the successful implementation of the economic threshold concept is needed to develop an integrated weed management programme. Dinitroaniline herbicides (trifluralin, pendimethalin and prodiamine) provide pre-emergence dodder control without injury to alfalfa (Orloff *et al*. 1989). However, Barevadia *et al*. (1998) reported that application of pendimethalin at 0.50 kg/ha as pre-emergence and at 4 days after sowing (DAS), and fluchloralin at 0.50 kg/ha as pre-plant incorporation and at 4 DAS showed severe phytotoxicity to lucerne seedlings. Therefore, efficacy of pendimethalin with different rates and timing of application and newer herbicides, known to have activity against *Cuscuta* and safe to alfalfa and clover needs to be evaluated. The objectives of the present study were to investigate (i) the interference of *C. campestris* densities and (ii) the efficacy of herbicides for its control in lucerne and Egyptian clover.

MATERIALS AND METHODS

Four field experiments were conducted during winter seasons of 2005-06 and 2006-07 at the Directorate of Weed Science Research, Jabalpur (23^0 90' N, 79^0 58' E, 412 m above mean sea level). In all the four experiments, crops were grown with a recommended package of practices other than weed control. *Cuscuta* seeds were treated with concentrated sulfuric acid for 30 min before broadcasting them in the field to break seed dormancy and to facilitate germination. Fifty *Cuscuta* seeds/m^2 were uniformly broadcasted near the soil surface (2-3 cm depth) in each plot (except in *Cuscuta* free plots) before sowing of lucerne and Egyptian clover. Lucerne (*cv.* Anand 2)

***Corresponding author:** jsmishra31@gmail.com
Present address: *Directorate of Sorghum Research, Rajendranagar, Hyderabad, Andhra Pradesh 500 030*

was sown in rows 20 cm apart in first week of November during both the years with a seed rate of 15 kg/ha. The seed was treated with *Rhizobium melilotii* culture which helps in nitrogen fixation after the establishment of the seedlings. The soil was clay loam (Typic chromusterts), low in available nitrogen (242 kg/ha), medium in available phosphorus (37 kg/ha), and high in available potassium (315 kg/ha), with organic carbon 0.54% and pH 7.1. Pendimethalin was applied with a knapsack sprayer fitted with flat fan nozzle at a spray volume of 500 l/ha. Number of *Cuscuta campestris* and clover emerged/m^2 were recorded at 30 DAS. All the weeds except *Cuscuta* were removed from the plots manually as and when required. Total 3 cuttings were taken for green fodder yields. The first cutting was done at 60 DAS and subsequent 2 cuttings were done at 30 days intervals when the crop attained the height of around 45 cm from the ground. The cuttings were done at about 5-7 cm height for better quick growth. The total fodder yield includes the weight of *Cuscuta* vines as it was difficult to remove it from the host plants. The crops were left for seed production after the 3rd cutting and given light irrigations until flowering and seed setting. These were harvested in the last week of May.

Interference of *Cuscuta campestris* in lucerne

Treatments consisting of varying densities of *Cuscuta* (0, 0.25, 0.5, 1, 2, 4, and 8 plants/m^2) were replicated thrice in a randomized block design. The *Cuscuta* densities of 0.25 and 0.50/m^2 were maintained by keeping 1 and 2 plants/4 m^2 area, respectively. The plot size was 4 m^2 leaving 1m wide discards between plots. *Cuscuta* densities as per the treatments were maintained at 20 days after sowing by removing the excess plants.

Bio-efficacy of pendimethalin against *Cuscuta campestris* in lucerne in relation to dose and time of application

This experiment was conducted to evaluate the efficacy of pendimethalin as influenced by its dose and time of application. Treatments consisted of three doses of pendimethalin (0.50, 0.75 and 1.0 kg/ha) and 3 timing of application (1, 7 and 14 days after sowing) were replicated thrice in a factorial randomized block design. *Cuscuta* infested and *Cuscuta* free checks were also kept for comparison. The experiment was laid out in micro plots (4 m^2).

Bio-efficacy of herbicides against *Cuscuta campestris* in lucerne

Different herbicides (pendimethalin, fluchloralin, imazethapyr, butachlor and pretilachlor) along with 1 hand weeding at 30 days after sowing, *Cuscuta* infested and *Cuscuta* free checks were evaluated for their relative efficacy against *Cuscuta campestris* in lucerne. Treatments were replicated thrice in a randomized block design.

Bio-efficacy of pendimethalin against *Cuscuta campestris* in Egyptian clover in relation to method of sowing, dose and time of application

An experiment was conducted to evaluate the efficacy of pendimethalin as influenced by method of sowing, dose and time of application. Treatments consisted of two methods of sowing (dry and wet seeding), three doses of pendimethalin (0.50, 0.75 and 1.0 kg/ha) and 3 timing of application (1, 7 and 14 days after sowing) were replicated thrice in a split-plot design. *Cuscuta* infested and *Cuscuta* free checks were also kept for comparison. Egyptian clover (*cv*. Vardan) was sown by broadcasting in the first week of November during both the years with a seed rate of 30 kg/ha. In dry bed method, seed was broadcasted, mixed and covered with half to one cm fine soil. Sprinkler irrigation was given after sowing for proper germination. In case of wet sowing, plots were flooded with 5-6 cm deep water and puddled before broadcast sowing.

RESULTS AND DISCUSSION

Interference of *Cuscuta campestris* in lucerne

It was observed that increasing densities of *Cuscuta campestris* did not influence the initial (at 30 DAS) plant population of lucerne. Total green fodder yield declined significantly with increasing *Cuscuta* densities (Table 1). *Cuscuta* density of 2 plants/m^2 during 2005-06 and a single plant/m^2 during 2006-07 caused significant reduction (15.87 and 15.10%, respectively) in green fodder yield of lucerne as compared to *Cuscuta* free treatment. Seed yield of lucerne declined drastically (95.3 and 85.45%, respectively during 2005-06 and 2006-07) even at *Cuscuta* density of 0.25 plants/m^2 (1 plant/4 m^2). Increasing density of *Cuscuta* up to 1 plant/m^2 increased its seed production capacity. However, further increase in *Cuscuta* densities resulted in significant decline in its seed production capacity. This might be due to the fact that higher *Cuscuta* densities resulted in to restricted growth of host plant leading to reduced supply of resources and poor growth of the parasite.

Bio-efficacy of pendimethalin against *Cuscuta campestris* in lucerne in relation to dose and time of application

Increasing dose of pendimethalin from 500 to 1000 g/ha though significantly reduced the *Cuscuta* emergence but also caused phytotoxicity to lucerne crop and reduced its population significantly (Table 2). Total fodder yield did not vary significantly during 2005-06, however, during 2006-07, application of pendimethalin at 1000g/ha

Table 1. Interference of *Cuscuta* in lucerne

Treatment (*Cuscuta* density/m^2)	Number of lucerne emerged/m^2 at 30 DAS		Green fodder yield* (t/ha) (total of 3 cuttings)		Seed yield of lucerne (kg/ha)		Seed yield of *Cuscuta* (kg/ha)	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
0	161	172	22.49	23.17	246.67	352.20	0	0
0.25	141	168	20.14	21.85	11.64	51.23	349	396
0.50	167	170	21.85	21.66	11.81	46.15	424	425
1	138	153	20.75	19.67	9.61	26.30	483	464
2	128	169	18.92	18.32	4.82	21.85	391	407
4	157	178	17.83	16.14	2.96	12.04	361	368
8	150	159	16.67	15.63	3.05	10.68	193	208
LSD (P=0.05)	NS	NS	2.99	2.16	19.8	15.32	68	57

DAS-Days after sowing, *Including weight of *Cuscuta* vines.

Table 2. Efficacy of pendimethalin against *Cuscuta campestris* in lucerne

Treatment	Number of lucerne emerged/m^2 at 30 DAS		Number of *Cuscuta* emerged/m^2 at 30 DAS *		Green fodder yield (t/ha) (total of 3 cuttings)		Seed yield (kg/ha)	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
Dose of pendimethalin (g/ha)								
500	122	158	0.85 (0.22)	2.93 (8.08)	25.35	26.47	461	23.33
750	119	142	0.78 (0.11)	2.88 (7.79)	24.40	26.81	352	49.57
1000	76	111	0.74 (0.05)	1.88 (3.03)	24.16	22.09	359	158.33
LSD (P=0.05)	12	15	0.09	0.30	NS	1.07	35	17.5
Time of application of pendimethalin (DAS)								
1 (pre-emergence)	83	124	0.85 (0.22)	2.42 (5.36)	22.88	22.86	351	15.56
7	110	135	0.79 (0.12)	2.98 (8.38)	24.82	24.31	406	48.78
14	124	152	0.72 (0.02)	2.29 (4.74)	26.13	28.20	415	166.89
LSD (P=0.05)	12	15	0.09	0.30	2.61	1.08	35	15.8
Cuscuta-infested	142	165	(2.5)	(5.03)	13.05	22.53	0	5.67
Cuscuta-free	144	163	(0)	(0)	31.78	30.09	512	850

*Square root transformed ($\sqrt{x+0.5}$); figures in parentheses are original values, DAS-Days after sowing.

caused significant reduction compared to its lower doses (750 and 500 g/ha). Significantly maximum seed yield (461 kg/ha) was obtained at lower level of pendimethalin (500 g/ha) probably due to lower level of *Cuscuta* infestation during 2005-06. However, during 2006-07 application of pendimethalin at 1000 g/ha produced the maximum seed yield of lucerne due to better control on *Cuscuta* emergence. Application of pendimethalin at 14 DAS was safe for lucerne emergence as compared to its application as pre-emergence at 7 DAS and also effective in reducing *Cuscuta* emergence. The maximum fodder and seed yields of lucerne were also recorded with pendimethalin applied at 14 DAS.

Bio-efficacy of herbicides against *Cuscuta campestris* in lucerne

Application of herbicides significantly reduced the *Cuscuta campestris* emergence in lucerne as compared to the *Cuscuta*-infested control treatment (Table 3). Among different herbicides, pendimethalin 750 g/ha as pre-emergence, pendimethalin 750 g/ha at 14 DAS and imazethapyr 100 g/ha at 14 DAS were the most effective and significantly better than fluchloralin 1000 g/ha as pre-plant incorporation, pretilachlor 750 g/ha and butachlor 1000 g/ha as pre-emergence in reducing *Cuscuta* emergence during both the years. Liu *et al*. (1990) reported that pendimethalin inhibited the cell division and formation of spindle microtubules in the cells of germinated *Cuscuta* seedlings. Imazethapyr 100 g/ha at 14 DAS was significantly better than its pre-emergence application in reducing *C. campestris* emergence. All the above herbicides, though they significantly reduced the initial *Cuscuta* population could not check the growth of remaining *Cuscuta* plants, which ultimately infested the lucerne plants severely, especially after 3rd cutting when left for seed production, and reduced the seed yield considerably. All the herbicides except imazethapyr as pre-emergence caused slight reduction in lucerne plant population at 30 DAS as com-

Table 3. Efficacy of herbicides against *Cuscuta* in lucerne

Treatment	Number of *Cuscuta* emerged/m^2 at 30 DAS *		Number of lucerne emerged/m^2 at 30 DAS		Green fodder yield (t/ha) (total of 3 cuttings)		Seed yield of lucerne (kg/ha)		Seed yield of *Cuscuta* (kg/ha)	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
Pendimethalin 750 g/ha (PE)	1.12 (0.75)	1.33 (1.22)	128	137	9.26	10.74	23.21	7.38	462	521
Pendimethalin 750 g/ha (14 DAS)	1.18 (0.89)	1.80 (2.74)	159	161	13.87	13.99	25.67	9.58	436	592
Fluchloralin 1000 g/ha (PPI)	2.06 (3.74)	2.39 (5.21)	163	170	12.34	12.62	22.00	10.53	382	363
Imazethapyr 100 g/ha (PE)	2.65 (6.52)	3.22 (9.87)	189	196	10.21	11.69	16.89	7.04	263	168
Imazethapyr 100 g (14 DAS)	1.15 (0.82)	1.78 (2.67)	172	179	13.90	14.26	18.12	8.42	302	296
Butachlor 1000 g/ha (PE)	2.14 (4.08)	2.84 (7.57)	175	169	10.63	11.30	15.36	7.97	289	224
Pretilachlor 750 g/ha (PE)	2.23 (4.47)	2.54 (5.95)	159	162	10.33	11.29	10.50	5.26	265	200
1 hand weeding at 30 DAS	2.66 (6.58)	3.39** (11.0)	185	197	10.50	11.08	12.78	9.22	310	312
Cuscuta free	0.71 (0.00)	0.71 (0.00)	182	197	14.86	15.10	192.5	209.6	-	-
Cuscuta infested	2.58 (6.16)	3.35 (10.72)	186	195	9.63	10.75	10.62	5.19	406	420
LSD (P=0.05)	0.36	0.48	46	51	1.71	1.62	15.55	17.38	93	101

PE-pre-emergence; PPI-pre-plant soil incorporation; DAS-days after sowing.
*Square root transformed ($\sqrt{x+0.5}$); figures in parentheses are original values, **Population before hand weeding.

Table 4. Efficacy of pendimethalin against *Cuscuta campestris* in Egyptian clover

Treatment	Number of Egyptian clover emerged/m^2 at 30 DAS *		Number of *Cuscuta* emerged/m^2 at 30 DAS *		Green fodder yield (t/ha)								Seed yield (kg/ha)	
					I cutting		II cutting		III cutting		Total			
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
Method of sowing														
Dry seeding	169	176	1.01 (0.52)	1.26 (1.09)	5.73	10.08	13.16	20.81	25.44	17.30	43.47	47.95	638	854
Puddle broadcast	165	172	0.95 (0.40)	1.24 (1.04)	5.71	9.93	15.82	25.13	22.10	16.21	42.79	51.19	433	837
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	93	NS
Dose of pendimethalin (g/ha)														
500	169	178	1.04 (0.58)	1.38 (1.40)	6.05	10.12	15.55	22.91	22.93	16.76	45.76	49.23	477	831
750	168	173	1.00 (0.50)	1.23 (1.01)	5.91	11.23	13.92	24.72	22.06	19.63	41.84	55.64	619	854
1000	165	171	0.90 (0.31)	1.14 (0.80)	5.20	8.67	14.08	21.29	22.22	13.87	41.71	43.83	511	850
LSD (P=0.05)	NS	NS	0.07	0.15	0.70	1.35	1.47	2.29	NS	1.34	3.87	3.39	39	NS
Time of application of pendimethalin (DAS)														
1 (pre-emergence)	138	116	0.84 (0.21)	1.30 (1.19)	4.46	11.78	13.84	21.57	22.29	16.94	42.08	45.66	526	809
7	20	45	0.78 (0.11)	1.20 (0.94)	1.13	9.04	8.16	23.61	18.17	15.31	27.37	47.78	370	847
14	343	362	1.32 (1.24)	1.26 (1.09)	11.61	9.19	21.51	23.75	26.74	18.01	59.85	55.27	710	880
LSD (P=0.05)	25	28	0.09	NS	0.75	1.43	2.20	1.92	1.53	2.03	3.33	4.4	50	NS
Cuscuta- infested	347	378	(3.81)	(1.96)	11.82	14.53	22.63	25.06	23.91	18.59	58.35	58.18	516	734
Cuscuta-free	330	385	(0)	(0)	11.35	15.61	23.06	27.38	27.86	24.13	62.27	67.12	812	908

*Square root transformed ($\sqrt{x+0.5}$); figures in parentheses are original values, DAS-Days after sowing.

pared to untreated plots, but pendimethalin 750 g/ha as pre-emergence significantly reduced the lucerne plant population leading to lowest fodder yield. Barevadia *et al*. (1998) also reported that application of pendimethalin at 0.50 kg/ha as pre-emergence and at 4 DAS, and fluchloralin at 0.50 kg/ha as pre-plant incorporation and at 4 DAS showed severe phytotoxicity to lucerne seedlings. Post-emergence application of imazethapyr and pendimethalin yielded 14.26 and 13.99 t/ha green fodder and was at par with *Cuscuta*-free control (15.10 t/ha). However, post-emergence application of these herbicides checked the *Cuscuta* spread for a certain period but thereafter, it re-generated from the isolated haustoria within the host stem and soon infested the crop causing severe damage. None of the herbicides and hand weeding at 30 DAS proved effective in checking *Cuscuta* growth, especially during reproductive stage of the lucerne. It was observed that after 3rd cutting for fodder when the lucerne crop was left for seed production, its vegetative growth was reduced and *Cuscuta* grew very vigorously making a mat over lucerne and resulted in very poor seed yields.

Bio-efficacy of pendimethalin against *Cuscuta campestris* in Egyptian clover in relation to method of sowing, dose and time of application

Method of seeding had no significant influence on population and green fodder yield of Egyptian clover as well as on *Cuscuta* emergence (Table 4). Seed yield of clover during 2005-06 was significantly higher in dry seeding as compared to puddle broadcast seeding. Increasing doses of pendimethalin from 500 to 1000 g/ha did not influence the clover plant population, but irrespective of the pendimethalin doses, there was around 50% reduction in clover population as compared to untreated control because of the phytotoxic effect of pendimethalin when applied as pre-emergence or at 7 DAS. *Cuscuta* emergence decreased significantly with increase in pendimethalin doses. The highest fodder yield was obtained with 500g/ha during 2005-06 and 750 g/ha during 2006-07. Pre-emergence application of pendimethalin at 750 g/ha produced the maximum seed yield of clover during 2005-06, however, during 2006-07, the differences among herbicide doses were not significant. Application of pendimethalin at 7 DAS caused severe phytotoxicity on clover followed by its pre-emergence application. Post-emergence application at 14 DAS was safe for the clover crop and produced the maximum green fodder yields during both the years. Application of pendimethalin at 14 DAS produced the maximum seed yield of clover, but the differences were significant during 2005-06 only.

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