EFFECTIVE DODDER CONTROL

Steve Orloff, Mick Canevari, Jerry Schmierer,
Ron Vargas, and David Cudney [1/]

Dodder (Cuscutta spp.), a parasitic weed, is a serious problem in California forage and seed alfalfa fields. Alfalfa parasitized by dodder grows less vigorously and is often weakened to the extent that the plant dies. Thus, a severe dodder infestation can reduce stand, cause improperly cured hay, and lower forage and seed yields. A thorough review of dodder and its adverse effects have been documented elsewhere (1,10).

Dodder is widespread in California, occurring in twenty six of the alfalfa producing counties of the state (10). Historically, growers have relied primarily on postattachment applications of dinoseb or burning for dodder control (10). These control measures are costly, time consuming, and to a large degree ineffective. Greenhouse studies, and more recently field trials, have shown that trifluralin effectively controls dodder (6,8,10). As a result of these field observations, an organized statewide research program was planned and executed by the authors with these objectives: 1) to augment our understanding of dodder biology in different alfalfa production regions of California, 2) to evaluate the effectiveness of trifluralin and other dinitroaniline herbicides, and 3) to determine the proper application rates and time(s) to maximize the length of dodder control.

Materials and Methods

Field Biology Observations. The time of dodder emergence and flower initiation were studied in commercial alfalfa fields throughout the state. The seasonal attachment of dodder was investigated in the Small Plot Study referred to below. Dodder was considered attached when the haustoria penetrated the alfalfa stem and the dodder turned deep yellow-orange and thickened (photograph d).

Large Field-Scale Studies. Research trials were established in the high desert, San Joaquin Valley, Sacramento Valley, and in the Northeastern Mountain Region (Lancaster, Madera, Tracy, and Janesville , respectively). The trials were conducted in production alfalfa fields with a known history of severe dodder. Trifluralin (Treflan TR-10) was evaluated at all test sites. It was applied in the Madera and Janesville trials with a Valmar Airflo granular applicator and a Gandy Air-Spred granular applicator in the Lancaster and Tracy experiments. Trifluralin was applied prior to dodder emergence and incorporated with rainfall or irrigation water within three days at all locations. Unless otherwise noted, the experimental design for all trials was a randomized complete block with four replications. Largeseed dodder (Cuscuta indecora) was the species present in the Lancaster, Madera, and Tracy trials. Smallseed dodder (C. approximata) and field dodder (C. pentagona) were present in the Janesville study. Specific information regarding each of the trials is as follows:

Lancaster: Two trials were conducted with plot the sizes width of the border strips (40 and 25 ft) by 315 and 220 ft, respectively. Trifluralin was applied at 2 and 4 lb/A (pounds active ingredient per acre) in March, the same rates after first cutting in May, and as split applications of 2+2. The split applications included an initial application in March followed by an application after first cutting (May), a March application followed by an application after second cutting

---

1/ Farm Advisors, UC Cooperative Extension, Los Angeles, San Joaquin, Lassen, Madera Counties, and specialist, UC Riverside.

(June), and an application after first and second cuttings. Dodder control was evaluated after each cutting and percent control was calculated based on counts of dodder colonies.

Madera: Each plot was the size of the border strips (52 by 1300 ft.). Treatments for the study consisted of 2, 4, 6, 2+2, and 3+3 lbs. ai/A. The initial application was made on 1/27/86 and the second application on 4/16/86 (after first cutting) for the treatments receiving a split application. Dodder control was evaluated five times throughout the season.

Tracy: Nonreplicated strip trial plots, 100 by 300 ft., were treated leaving 50 ft wide strips adjacent to the plots untreated as the control. The treatments evaluated were 2 and 4 lbs/A applied in February (2/27/86), compared to 2 and 4 lbs applied after first cutting (4/24/86). Split applications of 2+2 lbs, applications in February and after first cutting, and February and after second cutting (5/27/86), were made. A multiple application of 2 lbs in February followed by another 2 after first cutting and again after second cutting (a total of 6 lbs/A) was also included. Percent dodder control, based on actual counts, was recorded four times during the season.

Janesville: Treatments consisting of 2 lbs/A of trifluralin and 4 lbs/A of chlorpropham (Furloe) were applied in an alfalfa seed field to plots 13.3 ft (4 rows) by 1/4 mile. Evaluations were made 49 and 106 days after treatment.

The results of these trials and a 985 trial are compiled and summarized in Table 4.

Dinitroaniline (DNA) Comparison Study (Lancaster):
Trifluralin, pendimethalin (Prowl), and prodiamine (Endurance) were applied at 2, 4, and a split application of 2+2 lbs/A in an alfalfa hay field known to be heavily infested with dodder. Plots were 25 by 25 ft with a three ft alleyway surrounding each plot to prevent dodder from growing into adjacent plots. Applications were made on 3/9/86 and 5/22/86. Dodder control, based on actual counts, was calculated after each alfalfa harvest.

DNA Residual Herbicidal Activity (Small Plot Study, Lancaster):
The procedure used in this trial was similar to that employed by Dawson (5). Alfalfa plots 3 by 6 ft were overseeded with 175 lbs/A of dodder seed. Seeds were lightly covered with soil using a hand rake. Trifluralin, pendimethalin, and prodiamine were applied at three rates (2, 4, and 6 lbs/A) on 3/6/86. Dodder control was evaluated by counting and removing attached seedlings at weekly intervals. After dodder emergence had nearly ceased in June, half of each plot was reseeded with an additional 175 lbs of dodder seed per acre to evaluate the residual dodder control with the herbicides tested.

Results and Discussion

Field Biology

Dodder emergence began in March in the central and southern areas of California, while emergence started in late May in northeastern California (Table 1.).

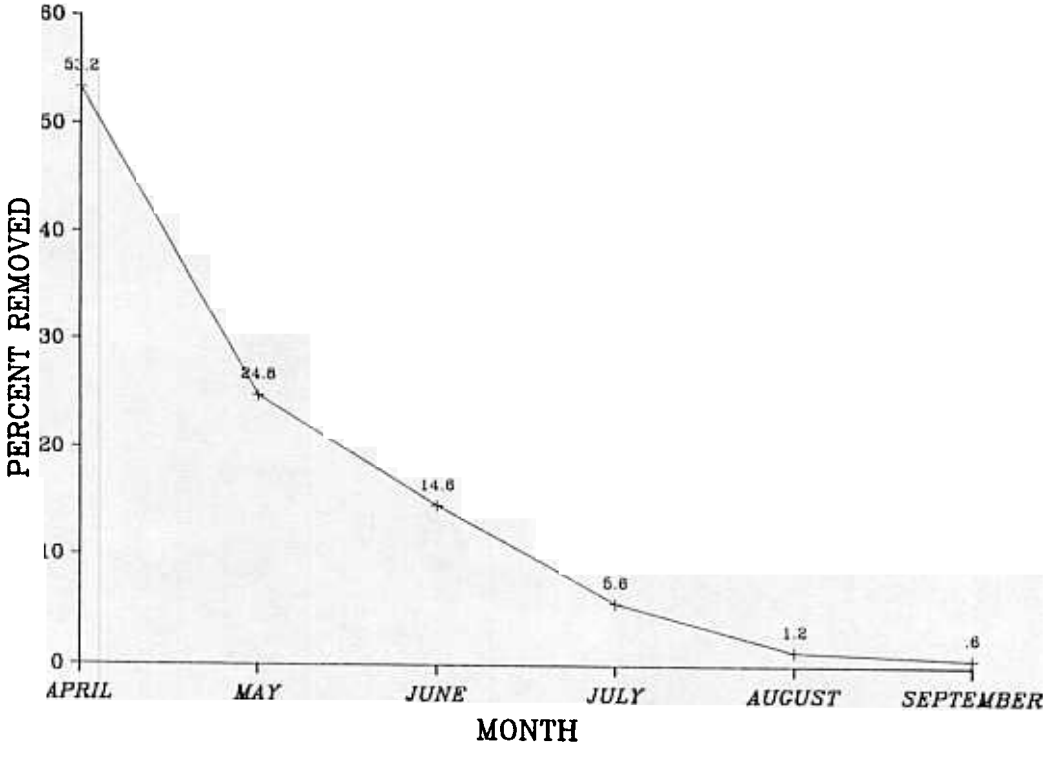
Table 1. Date of initial dodder emergence in the spring of 1986

Location (County)	Date
Lancaster (Los Angeles	March 20
Madera (Madera)	March 7
Tracy (San Joaquin)	March 16
Janesville (Lassen)	May 20-June

These observations are in agreement with the results of Hutchison and Ashton (9), where for six successive years the first dodder seedlings emerged between March 8th and March 22nd in Davis, California. Initial dodder emergence in cooler climates, such as Washington and Utah (2,4), was slightly later. This would be in accord with the Janesville site in Northern California.

The seasonal pattern of dodder attachment was monitored in the small plot study mentioned above. Although not a direct measurement of dodder emergence, counts of attached dodder do give an indication of the period of dodder emergence. Under favorable conditions, approximately one week elapses between dodder emergence and attachment (7). After an initial heavy flush of dodder emergence and attachment in the spring, the number of attached dodder declined as the season progressed (Figure 1). Similar trends were also observed in several other studies (2,4,9). Seventy eight percent of the total attached dodder plants resulted during April and May. Subsequent dodder emergence occurred following each irrigation, but the quantity never equaled the magnitude of the first spring flush.

Figure 1. Seasonal distribution of attached dodder seedlings.



This large percentage of dodder emergence in the spring is due to winter conditions preparing the dodder seeds for germination. Then, when temperature and moisture are suitable for dodder germination in the spring, there is this large flush of dodder emergence. As hard seeds are continuously germinating, dodder emergence continues throughout the season but at a significantly lower level.

The time of flower initiation was also observed (Table 2). The date was remarkably similar for the different areas of the state. This aspect of dodder biology is particularly important for contact control practices, as will be explained later in this report.

Table 2. Date of flower initiation in 1986.

Location	Date
Lancaster (Los Angeles)	June 11
Madera (Madera)	June 2
Tracy (San Joaquin)	June 11

Preemergence Dodder Control

Noticably fewer dodder seedlings emerged in the treated plots. These results are in accord with Dawson's data (6), where trifluralin reduced dodder emergence and significantly reduced attachment. The dodder seedlings that did emerge did not elongate normally and were approximately half the length of dodder in the untreated plots (Table 3). Dinitroaniline herbicides inhibit mitotic cell division which explains the reduced elongation of dodder in the treated plots.

Table 3. The effect of dinitroaniline herbicides on dodder seedling growth.

Treatment	Rate lb/A	Length (mm)	Percent Reduction
Trifluralin	2	15	46
	4	13	54
	6	11	61
Pendimethalin	2	10	64
	4	12	57
	6	11	61
Prodiamine	2	12	57
	4	12	57
	6	11	61
Check	0	28	0
L.S.D. .05		3	1

S. Orloff and D. Cudney

Early-season dodder control with trifluralin was excellent in all trials where the herbicide was applied in late winter to early spring, prior to dodder emergence. Evaluations taken approximately 3 months after treatment showed an average of nearly 93 percent control for the 2 lb/A rate (Table 4). The 4 lb rate and the split application provided 98.6 and 96.4 percent control, respectively. Four to five months after application, the 2 lb/A rate declined to 78.8 percent control, whereas, the 4 and 2+2 lb treatments still provided approximately 90 percent control. Dodder control 5.5 to 6.5 months after application was no longer commercially acceptable in four out of the seven trials.

Table 4. Summary of dodder control results from 985 and 986 large plot trials.

Treatment	Rate lbs/A	Days After Treatment (90-109)	(120-150)	(169-197)
Trifluralin (Range)	2	92.7 (81-99)	78.8 (58-99)	51.8 (30-90)
	4	98.6 (96-100)	90.8 84-99)	61.2 (30-92)
	2 + 2	96.4 (89-100)	89.8 (81-99)	66.8 (22-99)

Average of 5 to 7 Trials.
M. Canevari, D. Cudney, S. Orloff, J. Schmierer, R. Vargas

Two reasons may be postulated for the low level of dodder control at the end of the season. The residual concentration of trifluralin in the soil most likely had declined to a level that was no longer lethal to the dodder seedlings. Secondly, dodder plants that have not been controlled for the duration of the season are apt to be extremely large by mid to late summer. A high percentage of individual dodder plants may have been controlled. However, due to the rapid growth rate of dodder it is impossible to determine if an extensive mat of dodder developed from numerous plants or an individual dodder seedling. The observed wide range in percent control at the last evaluation date (i.e. 22-99) could be due to different dodder infestation levels at the test sites. Percent control of individual dodder plants was most likely similar, but by late season in fields with a very heavy dodder infestation, the control appeared to be less because the escaped dodder plants had expanded and sometimes coalesed

In areas with a relatively short growing season, such as Janesville (110 frost-free days), a single 2 lb/A application appears to be sufficient. At the end of the season, a single 2 lb application of trifluralin was still providing 95 percent control, whereas a 4 lb/A chlorpropham application resulted in only 37 percent control.

Poor dodder control occurred when the first application of trifluralin was made after first cutting (Figure 2). Bayer et al. (3), working with DCPA, also found that May applications in the high desert did not provide satisfactory dodder control. These late herbicide applications did not control the early-emerging dodder and, as is shown in Figure 1, the early spring flush of dodder is of greatest consequence. Some injury to attached dodder was noted, short and thickened shoots, but this injury did not constitute acceptable control.

Split applications of trifluralin were found to extend the period of dodder control (Figure 3). A split application of 2+2 was significantly superior to a single 2 lb application. Dodder control with a split application was similar to a single 4 lb rate until the end of the season, when the split application was slightly more effective.

Proper herbicide application timing of the split application was found to be important (Figure 4). Similar to a single late application, a split application after first and second cutting was ineffective. A split application in March and after first cutting gave better dodder control than a split application in March and after second cutting. This relates back to the seasonal pattern of dodder attachment (Figure 1). A high enough concentration of trifluralin to be lethal to emerging dodder seedlings must be present in the soil during the period of maximum dodder

Figure 2. Influence of application time on dodder control

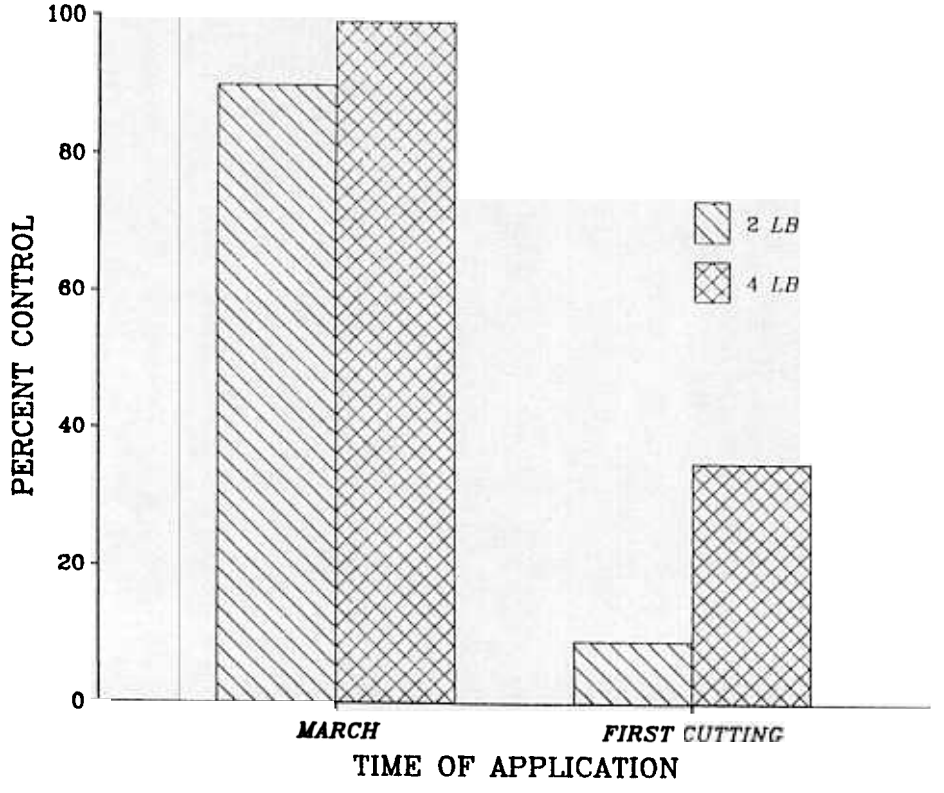
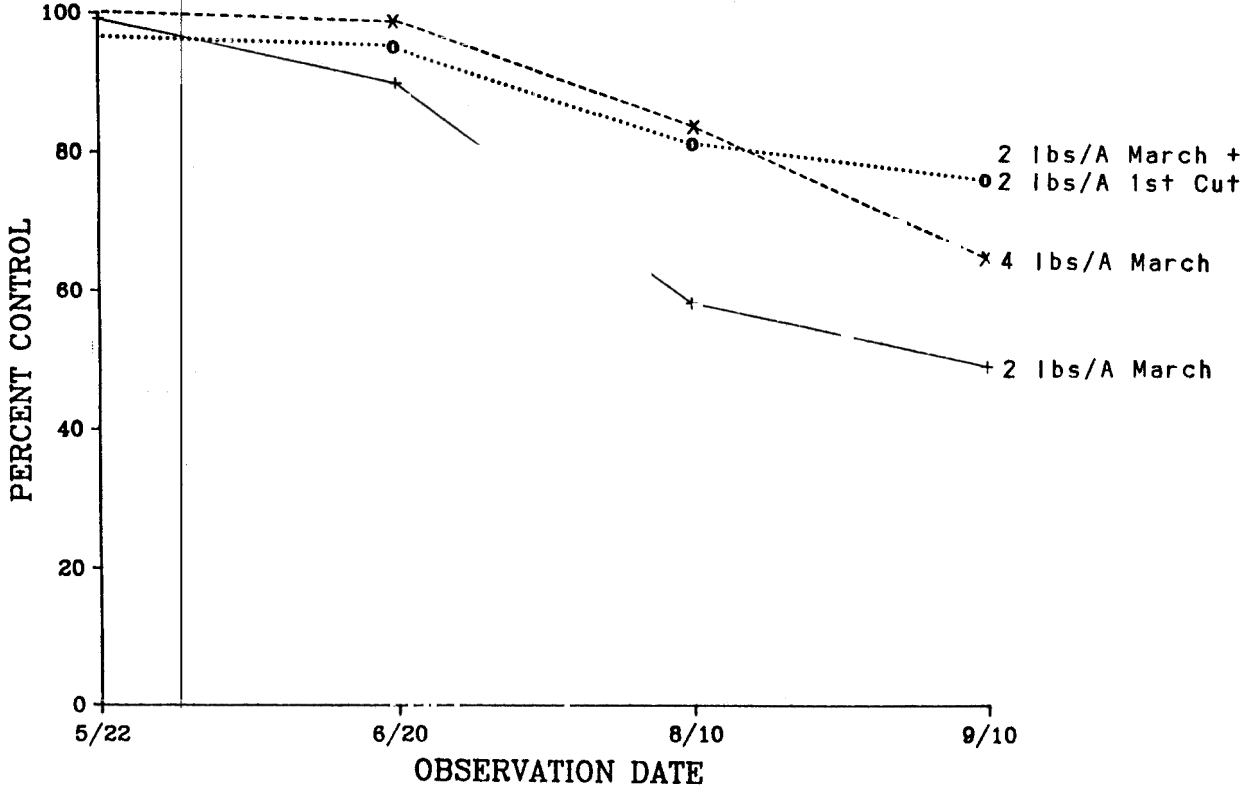
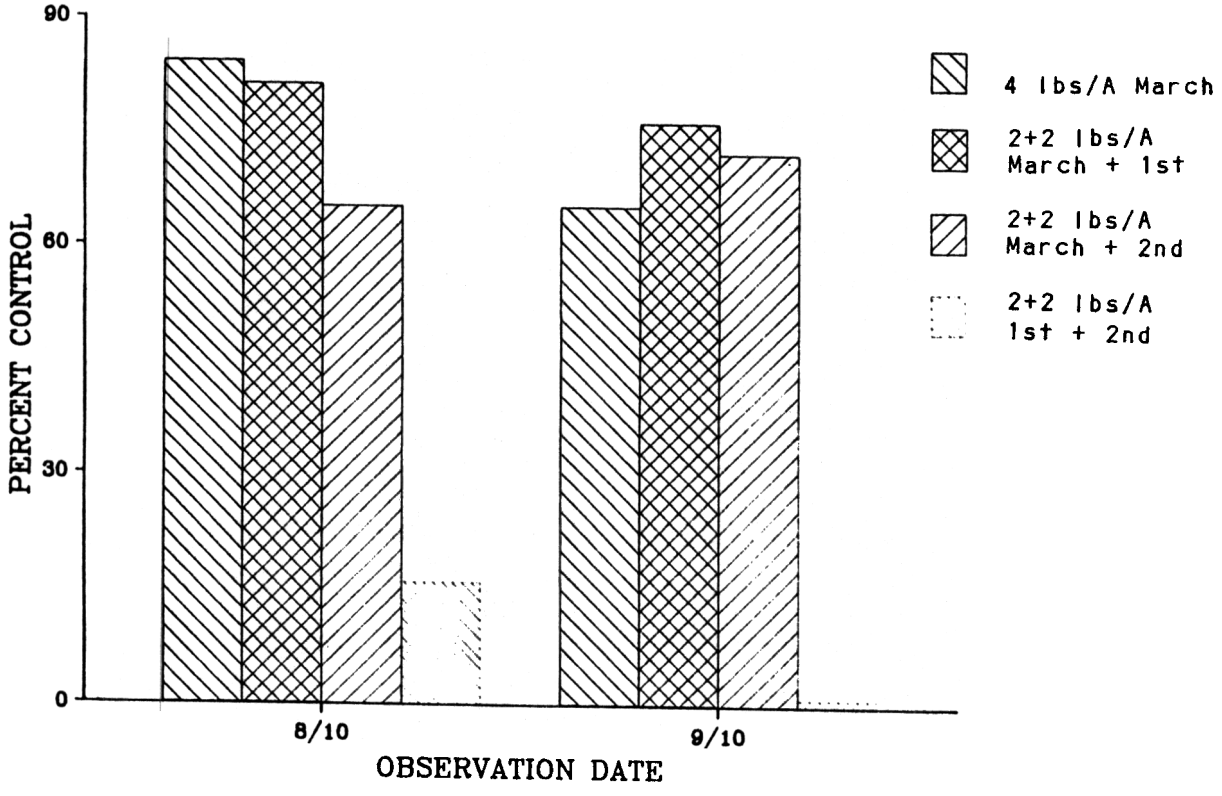


Figure 3. Comparison of single versus split applications of trifluralin for dodder control.



emergence. If the second application of a split application is too late in the season (after second cutting), the concentration of trifluralin can drop below that lethal level and newly-emerging dodder seedlings can survive.

Figure 4. Dodder control with trifluralin at different application intervals.



Trifluralin, pendimethalin, and prodiamine differed in the length of control they provided (Table 5). Attached dodder plants were cut off and removed so each rating reflects the residual control for that two month period and is not influenced by the dodder plants that were previously attached. Initially, all of the herbicides provided better than 95 percent control. However, by late-summer, control from the lower rates of trifluralin and pendimethalin diminished to a commercially unacceptable level. These results can be misleading. Control had lessened, but since most of the dodder emerges in the early spring, total dodder control for the season was good. Prodiamine, at all rates, provided full-season dodder control.

Table 5. Residual dodder control from three dinitroaniline herbicides.

Treatment	Rate lbs/A	Percent Control[1/] April-May	June-July	August-Sept.
Trifluralin	2	96	76	40
	4	100	77	65
	6	98	88	80
Pendimethalin	2	98	70	47
	4	99	73	55
	6	99	90	58
Prodiamine	2	100	84	80
	4	99	92	89
	6	98	93	97

1/ Percent control was calculated using the total number of attached dodder plants in the four replications of the untreated control plots. For each time period the total was: April-May, 255; June-July, 114; and Aug-Sept,67.
S. Orloff and D. Cudney

Similar results were encountered in a larger plot trial (Table 6). Again, all herbicides provided outstanding early-season dodder control. In this study, pendimethalin was found to be slightly more effective than trifluralin and prodiamine was still more persistent, providing full-season dodder control. These results agree with the data of Dawson[1/]. With all herbicides the length of dodder control was extended with a split application.

Table 6. Residual dodder control from single versus split applications of dinitroaniline herbicides.

Treatment	Rate lbs/A	Percent Control 5/22	6/20	8/8	9/10
Trifluralin	2	95	98	72	30
	4	99	99	85	30
	2 + 2	96	98	87	45
Pendimethalin	2	100	100	83	22
	4	100	100	93	67
	2 + 2	100	100	93	65
Prodiamine	2	100	100	95	80
	4	100	100	97	79
	2 + 2	100	100	99	94
Check		0	0	0	0
L.S.D. .05		24	19	24	25

S. Orloff and D. Cudney

1/ Personal communication (unpublished data) 1986. Irrigated Ag. Center, Prosser, WA.

These results indicate that regardless of the rate or dinitroaniline herbicide used, complete 100 percent dodder control is highly unlikely. Spot treatment will still be necessary to control the surviving dodder plants. Dodder plants should be treated prior to bloom (Table 2) to prevent replenishment of the soil reserves of dodder seed.

A trial was conducted in Lancaster to compare the effectiveness and cost of commonly used post-attachment dodder control practices. The effect of these practices on growth characteristics and yield of alfalfa was also studied. Twelve patches of dodder were burned with a propane fueled burner and another 12 patches were treated with dinoseb. Measurements were taken from each of the treated areas and from a corresponding untreated area adjacent to each plot. Dodder was controlled with both treatments, providing a large enough area was treated. The results are presented in Table 7. They reflect the combined effect of the contact control treatment and dodder parasitism of alfalfa.

Table 7. The effect of post-attachment dodder contro treatments on alfalfa growth and yield.

Treatment	Plant Height (cm) DAT 12	DAT 27	Stems/ft^2	Stems/Crown	Yield Tons/A	Stand/m^2
Dinoseb	21.8	53.0	24.4	11.1	1.01	25
Burning	12.0	48.7	21.7	9.4	0.88	23
Untreated	42.5	65.8	43.8	13.2	2.11	37

S. Orloff and D. Cudney

The alfalfa was significantly shorter in the areas where a contact dodder control treatment was used. The burned areas recovered more slowly. At the time of harvest, there were still differences in height but the differences were far less dramatic. Likewise, the number of stems per ft^2 and the number of stems per alfalfa crown were reduced. Burned areas had the fewest stems per plant, implying that perhaps in the burning operation more of the regrowth buds are damaged. Yield, the cutting after treatment, was less than half that of the untreated areas. Not only was the yield in the subsequent cutting reduced, but future harvests will also be reduced, as the stand declined approximately 35 percent by post-attachment dodder control practices.

To calculate the cost of contact dodder control treatments, dodder patches in alternating border strips of an alfalfa field were burned or treated with dinoseb. The area of each treated patch (total of 145 patches) was calculated and it was determined that the average size dodder patch after third cutting was 110 ft^2 or approximately 10 ft^2. Sample costs to spot treat dodder are given in Table 8.

Table 8. Sample costs to spot treat dodder in 1986.

Cash Costs	($) Cost/Dodder Colony[1/] Dinoseb	Burning
Labor ($5.00/hr) 1.8 min.	.15	4.7 min. .39
Material ($12.00/lb ai)	.26	$.75/gal. .38
Yield loss ($80/Ton) 1.1 ton	.22	1.23 ton .25
Total Cost	.63	1.02

[1/] Average size colony considered to be 110 ft^2.

The cost of burning for dodder control is 62 percent higher than the cost to apply dinoseb. The greatest difference occurs in the time required to treat; burning requires nearly three times as much time.

With production costs uppermost in a grower's mind, the question arises: At what dodder infestation level is it economically justified to apply a preemergence treatment of trifluralin versus post-attachment dodder control? The following assumptions were used: 1) The cost per dodder colony quoted above (burning cost was used only since the use of dinoseb has terminated), 2) a trifluralin price of $8.00/lb ai, 3) an application cost of $5.00/A, and 4) assuming 78.8 percent control for the season (the cost for spot treating surviving dodder plants is included in the analysis). A 2 lb/A trifluralin application is advisable over contact control methods when there are 27 colonies or greater per acre over the entire growing season. This is only a guide to determine which dodder control strategy is preferable. There are additional benefits of a trifluralin application, such as summer grass control, which are not included in the cost analysis. Also, the damage from burning is not limited to the following cutting but for the life of the stand since the stand was reduced by over 35 percent. Lastly, by controlling the majority of the dodder before it attacks the alfalfa, less of the dodder has the opportunity to produce seed.

Summary-An Effective Dodder Control Strategy

Field Biology

Although dodder is most troublesome in mid-summer, dodder emergence starts in early spring. The overwhelming majority of the dodder emerges early and then steadily declines for the remainder of the season.

Preemergence Control

Dinitroaniline herbicides must be applied in early spring prior to initial dodder emergence to control that early flush which is of greatest consequence. When summer grass control is required as well, the date of grass emergence will determine the time of application, rather than the dodder, since the grasses germinate earlier. Prodiamine provided the longest dodder control of the herbicides tested. A single 4 lb ai/A or a split 2+2 lb application is needed for extended full-season control in most areas.

Post-Attachment Dodder Control

Even though they were found to be costly, contact control methods must be used to control surviving dodder plants before they set seed (approximately June). Following these general principles, successful dodder control can be achieved.

At the present time, trifluralin is the only dinitroaniline herbicide registered for use in alfalfa. Two lbs/A is the current maximum rate, but Eli Lilly has submitted the 2+2 rate to the Environmental Protection Agency for registration.

Literature Cited

Ashton, F. 1976. Cuscuta spp. (Dodder): A literature review of ts biology and control. Division of Agric. Sci., Univ. of Calif., Bu 1880.

2 Allred, K.R. and D.C. Tingey. 1964. Germination and spring emergence of dodder as influenced by temperature. Weeds 12:45-48.

3. Bayer, D.E., E.C. Hoffman, and C.L. Foy. 1965. DCPA n host-parasite relations of alfalfa and dodder. Weeds 13:92-95.

4. Dawson, J.H. 1965. Prolonged emergence of field dodder. Weeds 14:373-374.

5 _____. 1966. Factors affecting dodder contro with granular CIPC. Weeds 14:255-259.

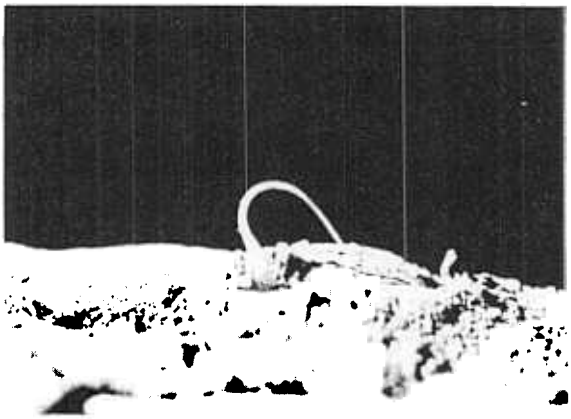
6. _____. 1967. Soil applied herbicides for dodder control: initial greenhouse evaluation. Wash. Agr. Exp. Station Bull. 691.

7. _____. 1969. Longevity of dodder control by soil-applied herbicides in the greenhouse. Weed Sci. 17:295-298.

8. _____. 1986. Dodder control in alfalfa. Proceedings, California Weed Conference. 1986. pp 149-153.

9. Hutchison, J.M. and F.M. Ashton. 1980. Germination of field dodder (Cuscuta campestris). Weed Sci. 28:330-333.

10.Orloff, S.B. 1985. Dodder: The problem and its control. Proceedings 15th California Alfalfa Symposium. December 11-12, 1985. pp 82-90.



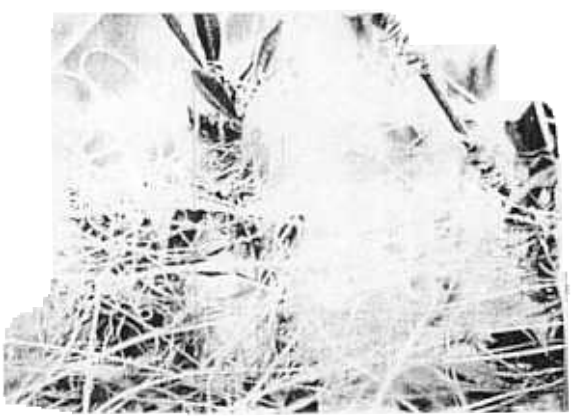
(a)

(b)

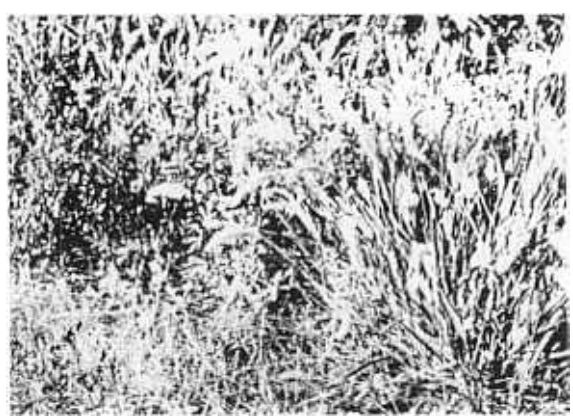
(c)

(d)

A dodder seedling emerges as an arch (a), then straightens out and rotates in search of any elongated object (b). It then wraps counterclockwise around that object (c). If that object is a suitable host plant, haustoria (suckers) penetrate the plant and dodder shoots are initiated (d). Dodder seedlings are extremely small and inconspicuous and unless the field is carefully scrutenized dodder emergence can occur unnoticed. Dinitroanilines must be applied prior to dodder emergence. Once dodder has penetrated the alfalfa, nothing short of killing the alfalfa below the



Dodder stems develop rapidly forming a dense tangled mat that supresses and even kills the alfalfa.



Dinitroaniline herbicides control both dodder (lower left) and summer grasses (right).