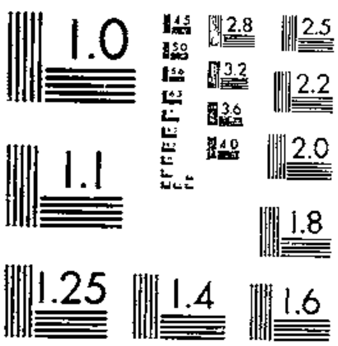
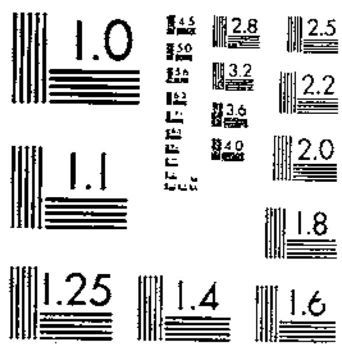
TB 1197 (1959) USDA TECHNICAL BULLETINS UPDATA
CONTROL OF DOWNY BROME IN ALFALFA AND RELATED STUDIES
BRUNS, V.F. ; HEINEMANN, W.W. ; OLDEMEYER, D.L. 1 OF 1

START



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

CONTROL OF *DOWNY BROME* *in* *ALFALFA* *and related studies*

Technical Bulletin No. 1197

UNITED STATES DEPARTMENT OF AGRICULTURE
in cooperation with the
WASHINGTON AGRICULTURAL EXPERIMENT STATIONS

CONTENTS

Washington, D. C. Issued April 1959

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C. - Price 15 cents

CONTROL OF

DOWNY BROME
in
ALFALFA

and related studies

By V. F. Bruns, agronomist, *Crops Research Division, Agricultural Research Service*, W. W. Heinemann, associate animal scientist, *Washington Agricultural Experiment Stations*, and D. L. Oldemeyer, formerly assistant agronomist, *Irrigation Experiment Station, Prosser, Wash.*[1]

Alfalfa is a major crop in the irrigated areas of central and eastern Washington. According to 1955 crop records, 95,493 acres of alfalfa produced 284,388 tons of alfalfa hay and seed with a value of $8,906,-192. Weeds are a serious problem on much of the land producing alfalfa in these areas. They may cause yearly losses of $50 or more per acre by reducing the quality and quantity of alfalfa, by damaging alfalfa stands, and by increasing operation costs.

In an effort to develop control measures for downy brome (*Bromus tectorum* L.),[2] a particularly troublesome pest in alfalfa, 18 experiments were conducted at the Irrigation Experiment Station, Prosser, Wash., from 1948 to 1957. The purpose of this publication is to summarize the information accumulated during this 10-year period.

---

[1] C. O. Stanberry, formerly associate agronomist, Washington Agricultural Experiment Stations, cooperated in the phosphorus studies. W. E. Ham, associate professor, Department of Animal Science, and D. M. Fluharty, clinical pathologist, Department of Veterinary Medicine, State College of Washington, assisted by conducting certain hematological studies on sheep.

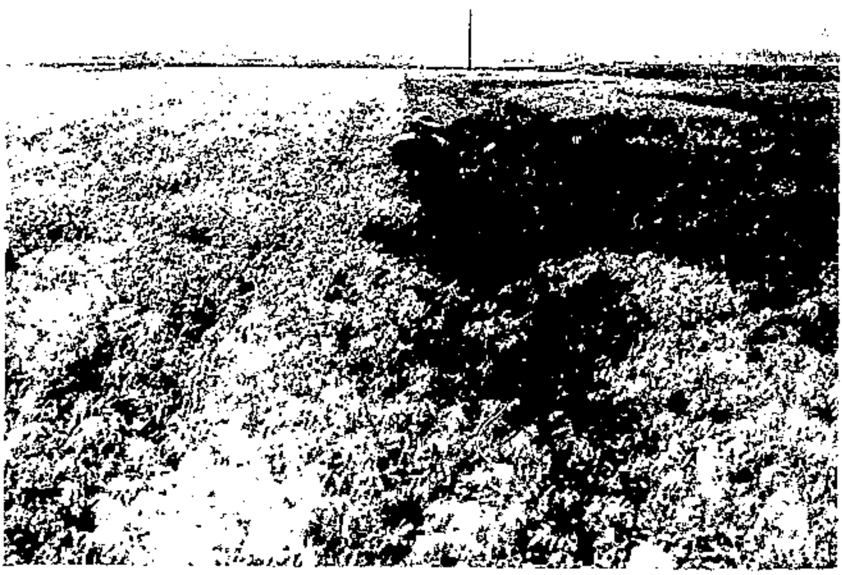
[2] The Committee on Terminology for the Weed Society of America has suggested downy brome as the standard common name for *Bromus tectorum* L. Cheat, cheatgrass, and downy chess have been common names for this species in some regions.

SOME FACTORS RELATING TO THE PROBLEM OF DOWNY BROME IN ALFALFA

Characteristics of Growth

Downy brome is an annual or winter annual that was introduced into the United States from Eurasia. It occurs abundantly in the Pacific Northwest. The stems, often in large tufts, may grow from 6 to 30 inches high from a fibrous root system (fig. 1). Many of the seeds germinate in the fall and early winter after the last cutting of alfalfa has been harvested. As alfalfa enters dormancy, the downy brome seedlings have less competition. They tend to become well established and to tiller during late fall and early winter. Generally the established plants make limited top growth during the coldest winter months but resume vigorous growth early in the spring before the alfalfa shoots emerge. New seedlings also may develop early in the spring. Because of these factors downy brome often competes vigorously with alfalfa.

Downy brome seeds usually are produced in abundance, often becoming viable before the first cutting of alfalfa is harvested (fig. 2). Stevens (*8*)[3] found in North Dakota that a single downy brome plant of average size and growing where competition was low produced 700 seeds. During the first cutting of alfalfa many of the downy brome



PN-632

FIGURE 2.—Left, uncontrolled downy brome in alfalfa; right, plots used to study herbicide control methods.

[3] Italic numbers in parentheses refer to Literature Cited, p. 29.

seeds fall to the ground and tend to remain dormant in the soil until the following fall and spring. Steinbauer and Grigsby (*7*) reported from Michigan that downy brome seeds exhibited primary dormancy for 4 or 5 weeks after maturity. During this period low constant temperatures, such as 15° C., or prechilling to 5° for 5–7 days prior to higher temperatures were required for germination. After the period of primary dormancy, germination occurred readily at 20°–25°. According to Chepil's studies (*2*) in Saskatchewan, Canada, a high percentage of downy brome seeds germinate in the fall and early spring, particularly during the first and possibly the second seasons after formation. Chepil found that the seeds had a variable period of dormancy. However, none lived at shallow depths of 3 inches or less in cultivated soil beyond 3 years.

Palatability and Nutritive Value

Matured downy brome is less palatable than alfalfa and possesses awns that may be injurious to livestock when fed as dry roughage. Platt and Jackman (*6*) noted in Oregon that the foliage of young plants was rather attractive to livestock. However, they found that when cattle or sheep were forced to eat downy brome with ripe, sharp-pointed seeds and rough beards, many of them suffered from sore mouths or sustained eye injuries, which caused serious loss of flesh and occasionally death.

According to Morrison (*4*), downy brome hay contains much smaller percentages of calcium, nitrogen, and potassium than good alfalfa hay. The latter contains nearly three times as much digestible protein and has a nutritive ratio (ratio of digestible protein to digestible nonnitrogenous nutrients, including fat, multiplied by 2.25) of 1:3.9 as compared with 1:12.6 for downy brome hay. Mature native western hay contains 22 therms of net energy per hundred pounds, whereas good alfalfa hay contains 40.1. Although no comparative values are available, it is likely that downy brome hay contains less net energy than native western hay. Thus, the physical state, the digestible protein, and the net energy content are probably the most important items contributing to the lower feed value of downy brome.

Response to Fertilizers and Cultivation

Generally grasses respond to nitrogen fertilizers, particularly in the irrigated areas of the Pacific Northwest. Moreover, in studying the effects of various fertilizers on alfalfa in Washington, Stanberry and Hausenbuiller[4] observed that downy brome tended to grow more

---

[4] STANBERRY, C. O., and HAUSENBUILLER, R. L. RECORD OF EXPERIMENTAL WORK IN SOILS. Wash. Irrig. Expt. Sta. Ann. Rpt. (Soils), 128 pp. 1950. [Unpublished. Copy on file at the Irrigation Experiment Station, Prosser, Wash.]

vigorously when phosphorus was included in the plot treatments.

The general practice of cultivating alfalfa fields with either a disk or spring-tooth harrow to control downy brome frequently has been only partially effective. Injury to alfalfa crowns and the spread of certain alfalfa diseases have resulted. Singleton and Nelson[5] tested various cultivation methods in irrigated areas of central Washington, including spring-tooth harrowing, disking, and renovating with a machine having spiked teeth on a revolving shaft, both early and late in the spring to control downy brome in alfalfa. The results were erratic and unsatisfactory.

Use of Herbicides

Because weed killers are essentially plant killers, the use of herbicides to control weeds selectively in crops usually entails certain risks. The use of herbicides to control downy brome in alfalfa, which is grown alone or in combination with grasses and other legumes, is no exception. The dosage range within which the herbicide may be applied without injury to the crop is very important.

Sheep and other livestock frequently graze on the fall growth of alfalfa and mixed forages. Alfalfa hay is used primarily as a feed for farm animals. Thus, the possible toxicity of herbicides to livestock, particularly when such compounds are used to control downy brome in alfalfa, is of prime concern.

MATERIALS AND METHODS

Phosphorus Studies

In May 1950 hay samples were collected from 81 plots in 3 experiments conducted primarily to test the effect of phosphorus, potassium, calcium, sulfur, nitrogen, and barnyard manure, alone or in combinations, on alfalfa. The alfalfa stands ranged from 3 to 7 years old. At sampling time a relatively high ratio of downy brome seed to vegetative parts existed. The alfalfa and downy brome in the samples were hand separated, weighed, and analyzed for phosphorus only.

In October 1950 downy brome was seeded uniformly in an alfalfa field with a known phosphorus deficiency. Treble superphosphate (P_2O_5 basis) was broadcast at random on 10- by 10-foot plots within 6 blocks at 0, 20, 40, 80, 160, and 320 pounds per acre. Hay samples were taken in May 1951. Downy brome and alfalfa were hand separated and oven dried for yield computations.

---

[5] SINGLETON, H. P., and NELSON, C. E. ALFALFA CULTIVATION EXPERIMENT. Wash. Irrig. Expt. Sta. Ann. Rpt. (Agron.), 294 pp. 1940. [Unpublished. Copy on file at the Irrigation Experiment Station, Prosser, Wash.]

Cultivation Treatments

Both light and heavy stands of downy brome in alfalfa were obtained in October 1950 for this study by utilizing an experimental area in which various fertilizers had been tested previously. Three treatments on plots 11 by 24 feet were randomized within 3 subblocks and repeated on 5 main blocks with different stand densities. The treatments included (1) cultivation with a spring-tooth harrow in the fall after the last cutting of alfalfa had been harvested and after downy brome had emerged, (2) cultivation with a spring-tooth harrow in the spring before alfalfa broke dormancy, and (3) the check.

Herbicides

Kinds, Rates, and Dates of Herbicide Treatments.—Each year from 1949 to 1957, inclusive, various herbicides were tested in one or more experiments for downy brome control in established alfalfa at Prosser. The herbicides varied from year to year as new compounds were added and less promising formulations were excluded. The generally accepted common names and definitions of these herbicides are as follows:

Common name of herbicide	*Definition*
Diesel oil	Diesel motor fuel
Commercial weedkiller No. 1	Special weed-killing petroleum oil
Commercial weedkiller No. 2	Weedkiller No. 1 containing 15 percent of pentachlorophenol
Commercial weedkiller No. 3	Special weed-killing petroleum oil
DNBP	4,6–Dinitro *o* secondary butylphenol
Alkanolamine salt of DNBP	Alkanolamine salt of 4,6–dinitro *o* secondary butylphenol
IPC	Isopropyl N–phenylcarbamate
CIPC	Isopropyl N–(3–chlorophenyl)carbamate
Ammonium salt of TCA	Ammonium trichloroacetate
Sodium salt of TCA	Sodium trichloroacetate
Disodium salt of endothal	Disodium salt of 3,6–endoxohexahydrophthalic acid
Sodium salt of dalapon	Sodium 2,2–dichloropropionate
Sodium salt of 2,2,3–TPA	Sodium 2,2,3–trichloropropionate
Monuron	3–(*p*–Chlorophenyl)–1,1–dimethylurea
Diuron	3–(3,4–Dichlorophenyl)–1,1–dimethylurea
DCU	Dichloral urea
MH	Maleic hydrazide
KOCN	Potassium cyanate

Each herbicide was tested at from 1 to 5 rates. The rates of application frequently varied from season to season as suggested by preceding results or information gained from other sources. All references to rates of application are based on the active ingredient of the herbicide.

The dates of application ranged from September to April. Several compounds were tested in both the fall and the spring. No fall treatment was made before the last cutting of hay had been harvested for that year. Except in 1948, no spring treatments were made after new alfalfa shoots, other than overwintering shoots, had emerged.

Emergence of downy brome seedlings in the fall was dependent largely on temperature and soil-moisture conditions. The first emergence occurred as early as mid-August in one year and as late as the first week in January in another. However, seedlings generally were 1 to 3 inches tall by late November. Fall seedlings usually were tillered and well established by late winter and early spring.

Methods of Applying Herbicides.—All herbicides were applied in sprays. When water was used as the sole diluent, spray volumes ranged from 80 to 180 gallons per acre. Small knapsack sprayers with single nozzles were used mainly. Herbicide mixtures that required agitation were applied with a small power sprayer equipped with a two-nozzle boom. Spray pressures did not exceed 30 p. s. i.

Alfalfa Stands, Soil Types, and Irrigation.—Downy brome-control experiments from 1948 to 1953 were conducted in 7- to 10-year-old nonuniform stands of alfalfa heavily infested with this weedy grass. Good, uniform, 3- to 6-year-old alfalfa stands with moderate to heavy infestations of downy brome were used for similar experiments from 1954 to 1957.

These experiments were conducted on either Sagemoor or Ritzville fine sandy loam and in fields that were irrigated by furrow- or rill-type irrigation. The 34-year average annual precipitation for this area is 7.53 inches. Most of it tends to occur during the fall and winter months.

Plot Size, Design of Experiments, and Determination of Results.—The plot size varied from year to year. However, plots either 6 by 10 or 10 by 10 feet were used most frequently. Others were 8¼ by 16½, 9 by 15, 10 by 12, and 10 by 20 feet. A randomized block design was used in all experiments except one. A split-plot arrangement was used in 1951. Plot treatments were replicated from 3 to 6 times in each experiment.

In old, nonuniform stands of alfalfa, the percentage control of downy brome effected by different treatments was estimated visually by three trained observers. In good, uniform stands of alfalfa, hay samples were cut and the downy brome and alfalfa separated by hand. Percentage composition was determined on a dry-weight basis.

Tolerance of Alfalfa, Other Legumes, and Perennial Grasses to Disodium Salt of Endothal

Disodium salt of endothal was applied on October 29, 1953, at 2, 4, 8, 16, 32, 64, and 128 pounds per acre in a uniform 3-year-old stand of vigorous and nearly weed-free alfalfa. All treatments were

486739°—59——2

randomized within 4 blocks on plots 6 by 10 feet. Samples of first-cutting alfalfa hay were taken on June 10, 1954, and yields computed on a dry-weight basis.

As an exploratory test, a 1-acre field containing aftermath growth of different species of legumes and grasses was treated with disodium salt of endothal at 8 pounds per acre in October 1953. One-meter quadrats were located throughout the area for making general observations during 1954.

Toxicity of Disodium Salt of Endothal to Sheep

Three experiments were conducted to study the possible toxicity of disodium salt of endothal to sheep.

Grazing Experiment.—Approximately 1 acre of a fall legume-grass aftermath was divided into 7 lots of equal size. Six lots were sprayed with 8 pounds of disodium salt of endothal per acre on October 23, 1953. The seventh lot was a check. Three spring ewe lambs were turned into each lot at the following intervals after treatment:

Lot	*Interval after treatment*
1	Immediately
2	1 week
3	2 weeks
4	4 weeks
5	8 weeks
6	16 weeks
7	Same day as lot 1, check

The grazing schedules for lots 4, 5, and 6 were abandoned, because after 4 weeks nearly all top growth of the forage had been killed by the treatments. The sheep were kept in the experimental lots until practically all available forage had been consumed. A total of 1.79 inches of intermittent, light rain fell during the experiment from October 23 to December 11.

Weight, condition, and certain hematological studies of samples taken at weekly intervals were utilized in evaluating the effects of the treatments on the animals.

Feeding Experiment 1.—On January 4, 1954, 18 ewe lambs (3 per treatment) were placed in individual pens and fed a daily ration of ¾ pound of chopped alfalfa hay. Corn silage, salt, and water were available to the animals. On January 13, six treatments were made by adding disodium salt of endothal in a water solution to the ¾-pound hay ration at rates of 0, 0.5, 1, 5, 10, and 20 grams. When the animals were reluctant to eat the treated hay on the first day, ensilage was withheld during the remainder of the experiment to force consumption of the alfalfa.

Feeding Experiment 2.—In 1954 a study was conducted to determine whether disodium salt of endothal might fail to break down chemically or produce physiological changes in alfalfa plants and cause the hay to be deleterious to sheep. Six ewe lambs were placed in a lot and fed first-cutting alfalfa hay from an area treated with disodium salt of endothal the previous fall at the rate of 8 pounds per acre. Six lambs comprising a check were fed alfalfa hay from a nontreated area. After these animals were fed and observed for 6 weeks, their final weights were taken and the experiment was concluded.

EXPERIMENTAL RESULTS AND DISCUSSION

Response of Downy Brome to Phosphorus

The results of the exploratory work in 1950 are summarized in table 1. They support earlier observations that the percentage of downy brome tended to be higher on plots treated with phosphorus. A decided trend toward higher percentages of phosphorus in plant tissue on a dry-weight basis from plots treated with this fertilizer was apparent. With nitrogen supplied by the alfalfa, these studies would indicate that downy brome can effectively compete for and utilize phosphorus.

TABLE 1.—*Composition of first-cutting hay from plots used to test the effect of various fertilizers* [1] *on alfalfa, 1950*

Experiment and treatment	Average number of plots	Age of alfalfa stand	Amount of downy brome	Amount of phosphorus found in—	
				Downy brome	Alfalfa
	Number	*Years*	*Percent*	*Percent*	*Percent*
Experiment 1:					
Fertilized (P_2O_5 included)	30	3	41	0.19	0.21
Check	6		30	.15	.19
Experiment 2:					
Fertilized (P_2O_5 included)	20	6	65	.18	.24
Check	4		50	.11	.20
Experiment 3:					
Fertilized (P_2O_5 included)	8	7	60	.19	.18
Fertilized (no P_2O_5 included)	9		14	.12	.11
Check	4		7	.11	.10

[1] Included phosphorus (P_2O_5), potassium, calcium, sulfur, nitrogen, and barnyard manure, alone or in combinations.

Yield data for evaluating the response of alfalfa and downy brome to different rates of phosphorus are presented in table 2. The deep-rooted alfalfa showed no apparent response to the phosphorus from October to May, and alfalfa yields were reduced, probably because of downy brome competition. The total yield and percentage of downy brome were significantly higher on treated than on untreated plots. Apparently the rather shallow-rooted downy brome plants responded readily to the phosphorus, even at the lowest rates.

TABLE 2.—*Response of alfalfa and downy brome to different rates of phosphorus (P_2O_5) applied in October 1950*

Amount of phosphorus (pounds per acre)	Yields [1] in May 1951 of—		
	Alfalfa	Downy brome [2]	
	Grams	*Grams*	*Percent*
20	92	143	61**
40	96	138	59**
80	139	200	59**
160	82	256	76**
320	71	157	69**
Check	181	52	22
Least significant difference at—			
5-percent level			14
1-percent level			20
Coefficient of variation (percent)			17

[1] Oven-dried material from 1/80 acre.
[2] Asterisks indicate that difference from the check exceeds the 1-percent level of probability.

Downy Brome Control by Cultivation

Soil conditions were relatively moist—an estimated 75 percent of field capacity—in both the fall of 1950 and the spring of 1951. Severe cultivation with a spring-tooth harrow was necessary to dislodge downy brome, especially on plots with dense stands. Cross-tillage with a spike-tooth harrow was necessary in both the fall and the spring to break up the sod clumps remaining after the initial spring-tooth harrowing.

Downy brome was controlled appreciably for a short period after the tillage operations. However, as the season advanced, new and surviving plants began to develop rapidly. As a result, marked differences in downy brome composition between treatments were no longer apparent at the first cutting of alfalfa on May 23, 1951. Furthermore, the tillage operations caused considerable damage to the alfalfa crowns.

The results from this experiment indicated that spring-tooth harrowing to control downy brome in alfalfa was not effective or practical in either the fall or the spring under the moderately moist climatic and soil conditions that prevailed.

Downy Brome Control With Herbicides

Oils and DNBP-Oil Mixtures.—Diesel oil at 160 gallons per acre, diesel oil-water emulsions in ratios of 60:100, 90:70, and 120:40, and

DNBP-diesel oil-water emulsions in ratios of 1/4:15:100,[6] 1/4:30:100, 1/4:45:100, and 1/4:60:100 gallons per acre were rather ineffective in controlling downy brome. This was true when the oil sprays were applied either on March 26, 1948, just before alfalfa shoots emerged and downy brome was in a latent stage of growth, or on April 7, after alfalfa and downy brome had started spring growth. At the same time commercial weedkillers Nos. 1 and 3 were not effective at rates lower than 90 gallons per acre. These special weed-killing oils at 90 and 120 gallons per acre effectively eliminated downy brome without seriously injuring the alfalfa, but these treatments were considered too expensive.

Diesel oil and commercial weedkillers Nos. 1 and 2, each at 20 and 40 gallons per acre, and a DNBP-diesel oil-water emulsion in the ratio of 1/4:5:35 gallons per acre temporarily controlled downy brome seedlings when applied on November 7, 1950. However, none of these treatments proved satisfactory.

The alkanolamine salt of DNBP, applied at 3, 6, and 9 pounds plus 10 gallons of diesel oil per acre on November 18, 1952, and at 6 pounds plus 10 gallons of diesel oil per acre on January 13, 1953, was not effective in controlling downy brome.

Well-established downy brome appeared exceptionally difficult to control early in the spring. Moreover, cool, moist weather conditions in late fall and early spring tended to reduce the phytotoxicity of these materials.

IPC and CIPC.—The results from three experiments with these herbicides are given in table 3. IPC and CIPC, especially at 6 and 8 pounds per acre, inhibited the emergence and development of downy brome for several weeks when applied on September 28, 1950, immediately after the last cutting of alfalfa had been harvested. However, the effectiveness of these treatments was of rather short duration. When applied in late October after many downy brome seedlings had emerged, these materials at 4 and 8 pounds per acre gave marked control until February or March, after which new seedlings and surviving plants developed rapidly. Applications in early March at the same rates were unsatisfactory. The effect of the 12-pound applications on downy brome was longer lasting but not completely adequate.

In these experiments IPC consistently appeared somewhat more effective than CIPC. However, the residual effects of both materials apparently were of insufficient duration to give the desired control of downy brome in established alfalfa.

---

[6] The DNBP formulation contained 5 pounds of DNBP per gallon.

TABLE 3.—*Control of downy brome in established alfalfa with IPC and CIPC, 1950–53*

Experiment and herbicide	Date of application	Rate per acre [1]	Average downy brome control (estimated)			
			Oct. 16, 1950	Nov. 21, 1950	Mar. 27, 1951	May 23, 1951
1950 experiment:		*Pounds*	*Percent*	*Percent*	*Percent*	*Percent*
IPC	Sept. 28, 1950	4	77	52	22	0
		6	91	67	43	8
		8	91	47	43	5
CIPC	do	4	72	35	27	2
		6	80	48	22	8
		8	82	42	20	0
			Nov. 21, 1950	Feb. 16, 1951	Mar. 27, 1951	May 23, 1951
IPC	Oct. 23, 1950	4	13	97	91	33
		8	6	99	94	83
CIPC	do	4	17	82	48	5
		8	27	93	77	8
				Mar. 27, 1951	Apr. 27, 1951	May 23, 1951
IPC	Mar. 1, 1951	4	------	9	2	0
		8	------	15	17	10
CIPC	do	4	------	6	0	0
		8	------	10	1	0
					Apr. 8, 1952	June 4, 1952 [2]
1951 experiment:						
IPC	Oct. 22, 1951	8	------	------	79	23
CIPC	do	8	------	------	73	15
IPC	Mar. 5, 1952	8	------	------	20	12
CIPC	do	8	------	------	0	31
				Feb. 2, 1953	Mar. 5, 19[illegible]	Apr. 6, 1953
1952 experiment:						
IPC	Oct. 22, 1952	12	------	85	100	88
CIPC	do	12	------	70	78	70

[1] Water at 180 gallons per acre was used as the diluent.

[2] Downy brome was hand separated from the first-cutting hay samples, and the control was computed on a dry-weight basis.

Ammonium and Sodium Salts of TCA.—One or the other of these trichloroacetates was included in four experiments, and the results are summarized in table 4.

TABLE 4.—*Control of downy brome in established alfalfa with ammonium and sodium salts of TCA, 1948 and 1950–53*

Experiment and herbicide	Date of application	Rate per acre [1]	Average downy brome control (estimated)			
						June 2, 1948 [2]
1948 experiment:		*Pounds*	*Percent*	*Percent*	*Percent*	*Percent*
Ammonium salt of TCA	Mar. 24, 1948	54.5	------	------	------	63
		109.0	------	------	------	95
		163.5	------	------	------	89
		218.0	------	------	------	95
Do	Apr. 7, 1948	54.5	------	------	------	56
		109.0	------	------	------	69
		163.5	------	------	------	76
		218.0	------	------	------	85
			Oct. 16, 1950	Nov. 21, 1950	Mar. 27, 1951	May 23, 1951
1950 experiment: Sodium salt of TCA	Sept. 28, 1950	4	12	1	1	0
		6	15	1	3	0
		8	23	28	7	0
			Nov. 21, 1950	Feb. 16, 1951	Mar. 27, 1951	May 23, 1951
Do	Oct. 23, 1950	4	2	95	68	32
		8	5	97	90	13
				Mar. 27, 1951	Apr. 27, 1951	May 23, 1951
Do	Mar. 1, 1951	4	------	17	3	0
		8	------	30	20	3
					Apr. 8, 1952	June 4, 1952 [2]
1951 experiment: Sodium salt of TCA	Oct. 22, 1951	8	------	------	78	56
	Mar. 5, 1952	8	------	------	25	37
				Feb. 2, 1953	Mar. 5, 1953	Apr. 6, 1953
1952 experiment: Sodium salt of TCA	Oct. 22, 1952	12	------	85	95	83

[1] See footnote 1, table 3.
[2] See footnote 2, table 3.

The ammonium salt of TCA, although slow acting under typical spring-weather conditions for south-central Washington, was rather effective in controlling downy brome at 109 pounds or more per acre when applied on March 24, 1948. However, at these rates the material caused excessive injury to the alfalfa. Similar treatments on April 7 also damaged the alfalfa and were less effective in controlling downy brome.

September and March applications of sodium salt of TCA at 4, 6, or 8 pounds per acre gave unsatisfactory results. October treatments, especially at 8 and 12 pounds, generally gave good control of downy brome until early spring, after which the residual action declined and growth of downy brome developed. The effectiveness of sodium salt of TCA was comparable to that of CIPC.

Disodium Salt of Endothal and Ammonium Sulfate.—On the basis of performance and latitude in rates that may be applied safely, disodium salt of endothal showed the most promise of all the herbicides tested. Data on the control of downy brome in experiments from 1950 to 1954 are given in table 5.

Best results were obtained when applications were made in late fall or early winter after many downy brome seedlings had emerged. In one experiment applications as late as January 13 gave 100-percent control of downy brome for that season. Early-fall and early-spring treatments were considerably less effective. However, the September applications inhibited emergence and development of downy brome for a much longer period than applications of IPC and the ammonium and sodium salts of TCA. The residual action of disodium salt of endothal appeared to be near optimum between late fall and the time of the first cutting of alfalfa in the spring or early summer. When disodium salt of endothal was applied at the optimum rate in late fall or early winter and failed to give at least 85- or 90-percent control of downy brome, the reason could be traced to one of three causes. They were (1) a breakdown in a commercial powdered formulation resulting from difficulties in the drying process, (2) prolonged periods (2 months) of exceptionally dry weather after treatment, or (3) excessive precipitation for 2 or 3 months after application. Under the last two conditions a more rapid breakdown or dissipation of the herbicide on or in the soil apparently occurred.

A large block of alfalfa plots in the field was sprayed with disodium salt of endothal at 8 pounds per acre late in November 1953. The results were exceptionally good and indicated further that late-fall or early-winter applications of disodium salt of endothal were most effective (fig. 3).

TABLE 5.—*Control of downy brome in established alfalfa with disodium salt of endothal and ammonium sulfate* ($(NH_4)_2SO_4$)*, alone or in combinations, 1950–54*

Experiment and herbicide	Date of application	Rate per acre [1]	Average downy brome control (estimated): Nov. 21, 1950	Mar. 27, 1951	May 23, 1951
1950 experiment:		*Pounds*	*Percent*	*Percent*	*Percent*
Disodium salt of endothal	Sept. 28, 1950	4	83	60	8
		6	78	77	23
		8	85	82	40
Disodium salt of endothal + $(NH_4)_2SO_4$	Oct. 23, 1950	[2] 4:20	99	99	85
		8:20	99	99	99
Do	Mar. 1, 1951	4:10	------	83	17
		8:10	------	92	70
		4:20	------	80	5
		8:20	------	93	80
$(NH_4)_2SO_4$	do	10	------	16	0
		20	------	7	0
Disodium salt of endothal [3]	do	4	------	92	88
				Apr. 8, 1952	June 4, 1952 [4]
1951 experiment:					
Disodium salt of endothal [3]	Oct. 22, 1951	4	------	65	41
		6	------	98	85
		8	------	98	85
Do [3]	Mar. 5, 1952	4	------	52	46
		6	------	46	54
		8	------	48	56
			Feb. 2, 1953	Mar. 5, 1953	Apr. 6, 1953
1952 experiment:					
Disodium salt of endothal	Oct. 22, 1952	4	85	80	73
		6	83	85	90
		8	88	93	95
Disodium salt of endothal + $(NH_4)_2SO_4$	do	4:20	90	90	85
		6:20	90	93	85
		8:20	98	98	98
Disodium salt of endothal + activator	do	4	88	85	85
		6	95	98	93
		8	93	95	90
Disodium salt of endothal + $(NH_4)_2SO_4$	Nov. 18, 1952	6	98	98	78
Disodium salt of endothal + activator	do	6	98	98	88
Disodium salt of endothal + $(NH_4)_2SO_4$ + activator	Jan. 13, 1953	6	93	100	100
			Dec. 15, 1953	Apr. 6, 1954	June 8, 1954
1953 experiment:					
Disodium salt of endothal	Oct. 20, 1953	4	60	55	30
		6	88	75	60
		8	98	88	78

[1] See footnote 1, table 3.
[2] Signifies ratio of disodium salt of endothal to $(NH_4)_2SO_4$ in pounds per acre.
[3] Commercial powder formulation.
[4] See footnote 2, table 3.

FIGURE 3.—Right, alfalfa plots sprayed with disodium salt of endothal at 8 pounds per acre in November 1953 to control downy brome; left foreground and background, untreated.

Applications of 6 and 8 pounds per acre appeared optimum, and 4 pounds was slightly less effective than 6 pounds. The only advantage in applying 8 over 6 pounds apparently was to insure control.

The addition of 10 or 20 pounds of ammonium sulfate $(NH_4)_2SO_4$ or a commercial activator apparently caused no marked increase in the effectiveness of disodium salt of endothal, especially at 6 and 8 pounds per acre. The $(NH_4)_2SO_4$ at 10 or 20 pounds per acre alone was ineffective in controlling downy brome.

The competitive effects of downy brome on alfalfa were illustrated frequently in these experiments. Yields of alfalfa resulting from the control of downy brome with disodium salt of endothal were increased from approximately 0.5 to 2 tons per acre, or 300 percent, in the 1951 experiment. However, this experiment was conducted on an old, thin stand of alfalfa, and such large increases would not be expected normally.

In 1954 an experiment was conducted to determine the effect of disodium salt of endothal on yields of both third- and fourth-year alfalfa, as well as downy brome. Data from this experiment are shown in table 6.

TABLE 6.—*Effect of disodium salt of endothal and sodium salt of dalapon on the botanical composition and yield of first-cutting hay when applied to control downy brome in established alfalfa, 1954–55*

Age of alfalfa and herbicide	Date of application	Rate per acre [1]	Average hay yields per acre on June 14, 1955		
			Alfalfa [2]	Downy brome	
		Pounds	*Tons*	*Tons*	*Percent*
Fourth year:					
Disodium salt of endothal	Dec. 8, 1954	6	3. 30**	0. 02	0. 6
		8	3. 26**	. 02	. 6
Sodium salt of dalapon	Mar. 8, 1955	5	2. 94**	. 18	5. 8
		10	2. 67	. 03	1. 1
Check		0	2. 23	1. 94	46. 5
Least significant difference at—					
5-percent level			0. 49		
1-percent level			. 65		
Coefficient of variation (percent)			19		
Third year:					
Disodium salt of endothal	Dec. 8, 1954	6	3. 36**	0. 05	1. 5
		8	3. 04	. 01	. 3
Sodium salt of dalapon	Mar. 8, 1955	5	3. 31**	. 04	1. 2
		10	3. 23**	. 01	. 3
Check		0	2. 65	1. 08	29. 0
Least significant difference at—					
5-percent level			0. 40		
1-percent level			. 54		
Coefficient of variation (percent)			14		

[1] Water at 120 gallons per acre was used as the diluent.
[2] See footnote 2, table 2.

The check in the fourth-year stand yielded 53.5 percent of alfalfa and 46.5 percent of downy brome, whereas the check in the third-year stand yielded 71 percent of alfalfa and 29 percent of downy brome.

In this experiment disodium salt of endothal for the first time caused a marked delay in the growth and development of alfalfa in the spring. A combination of a very mild winter and a cold spring with low soil temperatures may have been a contributing factor. Many overwintering alfalfa shoots above the soil surface were not killed on the check during the mild winter, whereas all such shoots were killed on plots treated with disodium salt of endothal. Apparently the cold, adverse weather conditions in the spring were less favorable for the development of new shoots from crown buds in the treated plots than for growth of the overwintering shoots in the check. Despite this delay in growth the treated plots in the fourth-year stand produced approximately 1 ton-per-acre more alfalfa than the check.

In the third-year stand treated plots outyielded the check by nearly 0.5 ton of alfalfa per acre. Composition of the hay on treated plots averaged 99 percent of alfalfa. Applications of 6 and 8 pounds of disodium salt of endothal per acre appeared equally effective.

In 1955 an experiment was conducted to determine the effect of disodium salt of endothal on the control of downy brome and on the seasonal yields of fourth-year alfalfa. As determined by actual separations and shown in table 7, the first-cutting hay from the check contained an average yield of 55 percent of downy brome and only 1.73 tons of alfalfa per acre. Hand weeding was difficult. As a result, hay from plots that were hand weeded contained 17 percent of downy brome, and those that were hand weeded and treated with disodium salt of endothal contained 3 percent of downy brome. Despite exceptionally wet weather during the winter, the downy brome content of hay from plots treated with disodium salt of endothal averaged no higher than 6 percent, and the first-cutting alfalfa yields were increased approximately 100 percent over the yield of the check. The alfalfa showed no symptoms of herbicide injury.

TABLE 7.—*Effect of disodium salt of endothal on the botanical composition and yield of seasonal cuttings of hay when applied on December 12, 1955, to control downy brome in fourth-year alfalfa*

Treatment	Rate per acre [1]	Average hay yields (dry weight) per acre					
		Downy brome		Alfalfa [2]			
		1st cutting on May 31, 1956		1st cutting on May 31, 1956	2d cutting on July 16, 1956	3d cutting on Sept. 11, 1956	Total
	Pounds	*Percent*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
Disodium salt of endothal	8	6	0.23	3.57**	3.18	2.01	8.76**
Disodium salt of endothal + hand weeding	8	3	.12	3.50**	2.99	2.01	8.50**
Hand weeding	0	17	.59	2.98**	3.43	2.22	8.63**
Check	0	55	2.15	1.73	3.29	2.12	7.14
Least significant difference at—							
5-percent level				0.79	(3)	(3)	0.97
1-percent level				1.11	(3)	(3)	1.35

[1] Water at 107 gallons per acre was used as the diluent.
[2] See footnote 2, table 2.
[3] Not significant.

No downy brome was present in the second and third cuttings and no significant differences in alfalfa yields were apparent. The total yield of the three cuttings of alfalfa from treated plots averaged approximately 1.5 tons per acre higher than that from the check. Thus, the competitive effects of downy brome on the first cutting of alfalfa were further demonstrated.

Sodium Salt of Dalapon and Sodium Salt of 2,2,3–TPA.—Sodium salt of dalapon showed considerable promise for controlling downy brome in established alfalfa. However, the range in rates at which this herbicide may be applied effectively and safely appeared narrow.

Applications of sodium salt of dalapon in the fall were unsatisfactory, as indicated in table 8. However, the early-spring treatments on March 4 were effective, especially at 5 and 10 pounds per acre, which averaged 90- and 98-percent control of downy brome, respectively, at the time of the first cutting of alfalfa on June 8. Except for stunting of the overwintering shoots and a slight delay in spring emergence, no serious injury to the alfalfa was observed.

TABLE 8.—*Control of downy brome in established alfalfa with sodium salt of dalapon, 1953–54*

Date of application	Rate per acre [1]	Average downy brome control (estimated) on—		
		Dec. 15, 1953	Apr. 6, 1954	June 8, 1954
	Pounds	*Percent*	*Percent*	*Percent*
Oct. 20, 1953	2.5	15	43	3
	5	48	75	54
	10	50	88	75
Mar. 4, 1954	2.5	----------	----------	50
	5	----------	----------	90
	10	----------	----------	98

[1] See footnote 1, table 3.

The effects of sodium salt of dalapon on the yields of third- and fourth-year alfalfa, as well as on downy brome, are summarized in table 6, page 17. Yields of alfalfa on plots treated with sodium salt of dalapon at 5 pounds per acre were significantly higher ($P < 0.01$) than those from the check. However, this treatment was the least effective in the fourth-year stand of alfalfa, with composition of the hay averaging 5.8 percent of downy brome. In the same stand 10 pounds was effective in controlling downy brome but caused marked injury to the alfalfa. An average alfalfa yield of 2.67 tons per acre on these plots barely missed being significantly higher ($P > 0.05$) than that from the check, but was approximately 0.6 ton per acre lower than that from plots treated with disodium salt of endothal at 6 and 8 pounds per acre in the same experiment (see table 6). In the third-year stand excellent control of downy brome was obtained, and no significant difference in alfalfa yields among the sodium salt of dalapon and disodium salt of endothal treatments resulted. Apparently the 10-pound rate of sodium salt of dalapon caused no damage to alfalfa in this stand.

On March 22, 1956, treatments were made to compare the effectiveness of sodium salt of 2,2,3-TPA in controlling downy brome in established alfalfa with that of sodium salt of dalapon. At this time new alfalfa shoots were just beginning to emerge and downy brome was beginning to resume vigorous growth.

TABLE 9.—*Effect of sodium salt of dalapon and sodium salt of 2,2,3-TPA on the botanical composition and yield of first-cutting hay when applied on March 22, 1956, to control downy brome in fifth-year alfalfa*

Herbicide	Rate per acre [1]	Average hay yields (dry weight) per acre on June 1, 1956			
		Dry matter	Alfalfa [2]	Downy brome	
	Pounds	*Percent*	*Tons*	*Tons*	*Percent*
Sodium salt of dalapon	4	37	2. 68*	0. 72	21
	6	34	3. 12**	. 15	5
	8	33	2. 98**	. 08	3
	10	34	3. 62**	. 04	1
Sodium salt of 2,2,3-TPA	4	38	2. 01	1. 76	47
	6	37	1. 97	1. 50	43
	8	38	2. 41	1. 63	40
	10	36	2. 59*	1. 25	33
Check		40	1. 80	1. 88	51
Least significant difference at—					
5-percent level			0. 76		
1-percent level			1. 03		
Coefficient of variation (percent)			20		

[1] Water at 160 gallons per acre was used as the diluent.
[2] One asterisk indicates that difference from the check exceeds the 5-percent level of probability, and two asterisks indicate that difference from the check exceeds the 1-percent level of probability.

Data on the effect of these two herbicides on the botanical composition and average yield of first-cutting hay are presented in table 9. Although the action of sodium salt of dalapon was relatively slow, the 8- and 10-pound rates ultimately gave excellent control of downy brome. Hay from these plots contained 3 percent or less of downy brome. Hay from plots treated with 6 pounds per acre contained 5 percent of downy brome. These yields may be compared with 51 percent for the check. Sodium salt of dalapon at 4 pounds per acre failed to give satisfactory control.

Sodium salt of dalapon caused no visible injury to the alfalfa in this experiment. As a result of the treatments, yields of alfalfa were increased from approximately 50 to as much as 100 percent over the yield of the check.

None of the treatments with sodium salt of 2,2,3–TPA gave satisfactory control of downy brome.

From these experiments the optimum rate of sodium salt of dalapon appeared to range between 6 and 8 pounds per acre. In the field a rate higher than 6 or 8 pounds per acre resulting from any miscalculation of dosage, error in calibration of spray equipment, or overlapping of the spray treatment could prove damaging to the alfalfa.

Monuron and Diuron.—Data from experiments with monuron in 1951 and 1952 are presented in table 10.

TABLE 10.—*Control of downy brome in established alfalfa with monuron, 1951–53*

Experiment and treatment	Date of application	Rate per acre [1]	Average downy brome control (estimated)			
					Apr. 8, 1952	June 4, 1952 [2]
1951 experiment:		*Pounds*	*Percent*	*Percent*	*Percent*	*Percent*
Monuron	Oct. 22, 1951	0.25	------	------	19	11
		.50	------	------	8	0
		1	------	------	74	7
		2	------	------	98	60
		4	------	------	100	91
Do	Mar. 5, 1952	2	------	------	3	44
1952 experiment:			Dec. 10, 1952	Feb. 2, 1953	Apr. 6, 1953	June 18, 1953
Monuron	Oct. 22, 1951	2	50	47	63	70
Re-treated	Oct. 21, 1952	2				
Monuron	Oct. 22, 1951	4	77	83	97	97
Re-treated	Oct. 21, 1952	4				
Monuron	Nov. 18, 1952	2	23	27	50	60
		4	13	40	97	95

[1] See footnote 1, table 3.
[2] See footnote 2, table 3.

In the 1951 experiment, October applications of monuron at 4 pounds per acre gave good control of downy brome without injury to the alfalfa. The lower rates were much less effective. March applications at 2 pounds were unsatisfactory. Winter and spring precipitation was below average for the area.

Monuron applied on November 18, 1952, both as initial treatments and as re-treatments, gave unsatisfactory control of downy brome at 2 pounds but excellent control at 4 pounds. However, both rates caused severe injury to the alfalfa when applied either as initial treatments or as re-treatments in this experiment. During the last part of November, December, and January the weather was mostly cloudy and wet. Precipitation of 3.62 inches for December and January was 1.5 inches greater than the 29-year average.

Monuron and diuron treatments were compared with normal spring-tooth harrowing in 1956–57, and the results are summarized in table 11. The November applications of monuron at 1.6, 2.4, and 3.2 pounds per acre were rather effective in controlling the downy brome but were injurious to the alfalfa. In spite of the herbicide injury to the alfalfa plants and the inferior quality of the hay, the yields of first-cutting alfalfa from the treated plots were higher than the yield from the check, which was suppressed markedly by competition from the downy brome. Monuron at 4 pounds per acre gave excellent control of the downy brome but caused severe injury to the alfalfa. Further herbicide injury to the alfalfa was observed prior to the second cutting in July on all plots that had been treated with monuron.

The November applications of diuron at 1.6, 2.4, 3.2, and 4 pounds per acre caused no apparent injury to the alfalfa, but none of the treatments gave satisfactory control of the downy brome. More favorable results from similar treatments have been reported from Oregon (*5*). At Prosser the 4-pound application was more effective than the others (table 11). In comparing the 4-pound application with the check, the yield of downy brome was reduced 71 percent and the yield of alfalfa was increased 63 percent. Misty, damp weather prevailed during December and snow fell during January and February after the applications. In spite of these moist conditions, precipitation perhaps was insufficient to leach the diuron into the soil before considerable photodecomposition occurred.

Although normal spring-tooth harrowing failed to give the desired downy brome control, the percentage reduction of downy brome was sufficient to increase significantly the yield of alfalfa over that of the check.

DCU, MH, and KOCN.—Applications of DCU at 5 and 10 pounds and of MH at 3 and 6 pounds per acre in the fall of 1950 inhibited appreciably the growth and development of downy brome in alfalfa until February 1951. However, none of the treatments proved satisfactory. Applications of KOCN at 20 pounds per acre in the same experiment were completely ineffective.

TABLE 11.—*Effect of monuron and diuron on the botanical composition and yield of first-cutting hay when applied to control downy brome in fifth-year alfalfa, 1956-57*

Treatment	Date of application	Rate per acre [1]	Average hay yields (dry weight) per acre on May 29, 1957 [2]			
			Amount of dry matter	Alfalfa	Downy brome	
		Pounds	*Percent*	*Tons*	*Tons*	*Percent*
Monuron	Nov. 29, 1956	1. 6	33	2. 06 a	0. 19 abc	8
		2. 4	35	1. 99 a	. 12 ab	6
		3. 2	35	1. 73 ab	. 08 ab	4
		4. 0	38	1. 27 c	. 04 a	3
Diuron	do	1. 6	36	1. 50 bc	1. 75 e	54
		2. 4	34	1. 79 ab	. 78 bcd	30
		3. 2	35	1. 83 ab	. 92 cd	33
		4. 0	34	2. 14 a	. 30 abc	12
Normal spring-tooth harrowing	Mar. 4, 1957	0	33	2. 09 a	. 67 abcd	24
Check		0	37	1. 31 c	1. 04 d	44

[1] See footnote 1, table 9.

[2] Average yields with the same letters do not differ significantly at the 5-percent level of probability (*3*); for example, alfalfa yields with the letter "b"—1.73, 1.50, 1.79, and 1.83.

Tolerance of Alfalfa, Other Legumes, and Perennial Grasses to Disodium Salt of Endothal

Data on the effect of disodium salt of endothal on the yield of first-cutting alfalfa, which was nearly free of weeds, are summarized in table 12. Within the range of 0 to 16 pounds per acre the analysis of variance indicated a significantly lower yield for the 8-pound treatment. However, a regression analysis indicated that this variation was the result of factors other than the effect of disodium salt of endothal. In the range of 16 to 128 pounds per acre the regression analysis showed a consistent decrease in yield with an increase in rate. Yield reductions were significant ($P < 0.01$) at 64 and 128 pounds of disodium salt of endothal.

TABLE 12.—*Effect of disodium salt of endothal on the yield of first-cutting alfalfa when applied on October 29, 1953*

Rate of application (pounds per acre)	Yield per acre on June 10, 1954	
	Dry matter in moisture sample	Alfalfa [1]
	Percent	*Tons*
2	27.5	2.34
4	27.5	2.45
8	26.0	2.18*
16	26.0	2.42
32	27.0	2.25
64	25.5	1.85**
128	24.0	.98**
Check	31.0	2.74
Least significant difference at—		
5-percent level		0.44
1-percent level		.60
Coefficient of variation (percent)		13.7

[1] See footnote 2, table 9.

As alfalfa broke dormancy in the spring, new growth and development of alfalfa on plots treated with disodium salt of endothal, particularly on those receiving 8 or more pounds per acre, were retarded slightly for approximately 1 week. This was anticipated because fall aftermath and overwintering shoots that had emerged at the time of application were desiccated by disodium salt of endothal treatments. However, no actual herbicide injury to the new foliage was noted. Except on plots treated at the highest rates, visible differences in growth and development tended to disappear within 1 to 2 weeks. The slightly lower percentage of dry matter in the hay from plots treated with 64 and 128 pounds per acre indicated a delay in maturity. A light infestation of downy brome developed on the check. It would seem reasonable to assume that failure to separate the downy brome from the alfalfa at the time of harvesting and sampling affected to some degree the percentage of dry matter and perhaps the yield on the check.

On the basis of this experiment disodium salt of endothal apparently caused no serious injury to or reduction in yield of alfalfa at rates several times higher than the 4, 6, and 8 pounds per acre applied experimentally for the control of downy brome in alfalfa.

In exploratory work a fall application of disodium salt of endothal at 8 pounds per acre apparently caused no permanent injury to 7 varieties of orchard grass, 3 varieties of tall fescue, Kentucky bluegrass, Tualatin tall oatgrass, Manchar and Achenback smooth bromegrass, intermediate wheatgrass, and 6 varieties of alfalfa. Whether or not perennial ryegrass, birdsfoot trefoil, perennial vetch, and Kenland red clover sustained injury was questionable. In one sample area Ladino clover was nearly eradicated by the treatment.

Toxicity of Disodium Salt of Endothal to Sheep

Grazing Experiment.—Sheep disliked the fall legume-grass aftermath that was treated with disodium salt of endothal at 8 pounds per acre and preferred to graze close to the fence lines, which had not received full coverage during the initial spray operations. All animals lost weight during the grazing experiment, as indicated in table 13. Disodium salt of endothal caused anticipated desiccation of the aftermath foliage within 7 to 10 days after treatment, and the animals were forced to graze within the given lots for rather long periods. Therefore, the ultimate lack of feed on the untreated as well as the treated areas was believed responsible for the losses in weight rather than the direct effect of the disodium salt of endothal. Otherwise, the overall condition of the animals when they were removed from the lots was good.

Differential counts were made of the stained cells in blood samples from the test animals. The percentages of neutrophils, lymphocytes, monocytes, eosinophils, and basophils remained almost entirely within Boddie's "normal range" for sheep (*1*). However, three animals had a fairly high neutrophil count, which indicates a reaction to infection, digestive disorders, or several other causes. These changes may result from mild as well as severe disorders. Whether the neutrophil reaction noted in these three sheep reflected a serious condition was doubtful. In all samples the morphology of the red blood cells remained normal.

TABLE 13.—*Weight of sheep before and after grazing on legume-grass aftermath treated with disodium salt of endothal at 8 pounds per acre on October 23, 1953*

Interval (weeks) between treatment with disodium salt of endothal and start of grazing	Length of grazing	Average weight of sheep on—		Weight loss
		Oct. 23, 1953	Dec. 11, 1953	
	Weeks	*Pounds*	*Pounds*	*Percent*
0	7	101. 7	88. 5	13
1	6	96. 3	78. 5	18
2	5	100. 5	86. 0	14
Check	7	98. 3	92. 2	6

Consumption of the treated forage apparently caused no significant changes in the hemoglobin levels. All readings were near the lower limits of or below Boddie's "normal range" for sheep. Thus, no alarming blood changes occurred that would indicate a toxic condition in the animals.

Feeding Experiment 1.—The quantities of chopped alfalfa and computed quantities of disodium salt of endothal consumed by the sheep during a 5-day period are given in table 14. Animals fed 0.5 gram of disodium salt of endothal per ¾ pound of alfalfa consumed most of the first feeding, about two-thirds of the second feeding, and about one-half of the third feeding, but none of the fourth and fifth feedings. Those fed 1 gram of disodium salt of endothal in the ration consumed approximately two-thirds of the first feeding, but practically none thereafter. About one-third of the first feeding, which contained 5 grams of disodium salt of endothal, was eaten by the sheep on the first day, but none thereafter. Less than one-third of the first feeding containing 10 grams of disodium salt of endothal was consumed during the 5 days. Sheep on the ration containing 20 grams consumed even less. The average quantity of disodium salt of endothal actually eaten during the 5 days ranged from 0.8 to 3.3 grams.

When the animals refused to eat the treated hay after 5 days, they were fed untreated alfalfa and ensilage, which they consumed readily. No alarming disorders were revealed by a check on weights and body temperatures and inspection of the eyes and mouths. Disodium salt of endothal is reported to be irritating to the mucous membranes. This may be the reason why the sheep refused to eat appreciable quantities of the treated hay, even when they were very hungry.

TABLE 14.—*Consumption by individual sheep in confinement for 5 days (Jan. 13–18, 1954) of chopped alfalfa treated with disodium salt of endothal*

Disodium salt of endothal (grams) per 0.75 pound of alfalfa	Amount of alfalfa fed	Average amount consumed of—	
		Alfalfa	Disodium salt of endothal
	Pounds	*Pounds*	*Grams*
0.5	2.25	1.81	1.2
1	.75	.57	.8
5	.75	.25	1.7
10	.75	.21	2.8
20	.75	.12	3.3
Check	3.75	3.75	0

Feeding Experiment 2.—After the sheep in this experiment were fed and observed from August 30 to October 11, 1954, their final weights were taken and the experiment was concluded. During this period no significant differences were observed in gains between 6 sheep fed first-cutting alfalfa hay from an area treated with disodium salt of endothal the previous fall at 8 pounds per acre to control downy brome and 6 sheep fed alfalfa hay from a nontreated area. The average gain of the former animals was 14.3 pounds and of the latter 13.8 pounds. All animals remained in good condition, and no visible harmful effects were noted.

These grazing and feeding experiments indicate that (1) sheep normally would not be pastured on fall aftermath treated with disodium salt of endothal, because such treatments would reduce the palatability and rapidly desiccate the existing foliage; (2) sheep are unlikely to consume toxic quantities of fall aftermath or hay treated with disodium salt of endothal; and (3) first-cutting alfalfa hay from fields treated the previous fall with disodium salt of endothal at 8 pounds per acre to control downy brome would be consumed readily by sheep without adverse effects.

SUMMARY

Downy brome (*Bromus tectorum* L.) in alfalfa presents a serious problem, because it reduces alfalfa yields, renders the hay less palatable and nutritious, and possesses awns, which are frequently injurious to livestock.

Downy brome responded markedly to applications of phosphorus on alfalfa plots, and the percentage of downy brome in the first-cutting hay after the treatments was increased significantly.

Controlling downy brome by cultivation without injury to the alfalfa has not proved entirely effective or desirable.

Two out of eighteen herbicides tested gave outstanding control of downy brome in alfalfa. Disodium salt of endothal applied at 6 or 8 pounds per acre in late fall or early winter gave effective seasonal control of downy brome and, thereby, increased alfalfa yields. Rates as high as 32 pounds per acre were applied without a significant decrease in alfalfa yields. Sodium salt of dalapon was most effective when applied in early spring, just before the alfalfa shoots began to emerge. The rate of 5 pounds per acre generally gave moderate downy brome control, whereas 10 pounds gave good control but caused occasional injury to the alfalfa. The optimum rate may be between 6 and 8 pounds per acre.

Monuron gave good control of downy brome, but it damaged the alfalfa in 2 of the 3 experiments in which this herbicide was tested. Diuron caused no injury to the alfalfa, but it failed to control the downy brome satisfactorily in the one experiment in which this herbicide was included.

Fall applications of disodium salt of endothal at 8 pounds per acre desiccated the legume-grass aftermath, and sheep disliked the treated forage. However, forced grazing of the treated aftermath caused no toxic symptoms as measured by certain hematological studies and the overall condition of the animals. Even when very hungry, the sheep refused to consume appreciable quantities of chopped alfalfa hay treated with disodium salt of endothal. They consumed readily and without adverse effects the first-cutting alfalfa hay from an area treated the previous fall with disodium salt of endothal at 8 pounds per acre.

LITERATURE CITED

(1) Boddie, G. F.
1951. diagnostic methods in veterinary medicine. Ed. 3, 389 pp., illus. Philadelphia.

(2) Chepil, W. S.
1946. germination of weed seeds. i. longevity, periodicity of germination, and vitality of seeds in cultivated soil. Sci. Agr. 26: 307–346, illus.

(3) Duncan, D. B.
1955. multiple range and multiple f tests. Biometrics 11: 1–42, illus.

(4) Morrison, F. B.
1956. feeds and feeding. Ed. 22, 1165 pp., illus. Ithaca, N. Y.

(5) Oregon Agricultural Experiment Station.
1957. better weed control with new chemicals. Oreg. Agr. Prog. 4 (2): 10–12, illus.

(6) Platt, K., and Jackman, E. R.
1946. the cheatgrass problem in oregon. Oreg. State Col. Ext. Bul. 668, 47 pp., illus.

(7) Steinbauer, G. P., and Grigsby, B. H.
1957. field and laboratory studies on the dormancy and germination of the seeds of chess (bromus secalinus l.) and downy bromegrass (bromus tectorum l.). Weeds 5: 1–4.

(8) Stevens, O. A.
1957. weights of seeds and numbers per plant. Weeds 5: 46–55.

U. S. GOVERNMENT PRINTING OFFICE: 1959

END