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Effect of Dormant-season Applications of 2,4-D on Pruned and Nonpruned Tokay Grapes

Robert J. Weaver and Oliver A. Leonard

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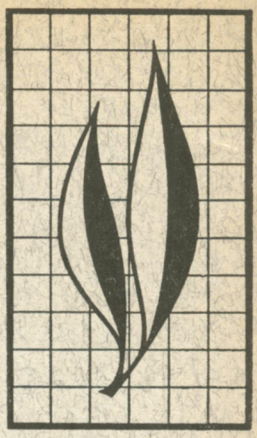

In one experiment, Tokay grapevines pruned in December were sprayed 16 days later with either a water- or oil-soluble amine of 2,4-D at various concentrations. Spray was applied to vine plus soil, base of trunk plus soil, and soil only. An ester form at 10,000 ppm was applied to soil only. Spray treatments using the water-soluble amine were repeated on another series of vines in February. All treatments were repeated on unpruned vines.

Both oil- and water-soluble forms at 2,500 or 10,000 ppm, sprayed on pruned vines plus soil in December markedly delayed bud break. Fewer formative effects were found following the February treatments. Cluster appearance, crop weight, berry size, Balling reading, total acid, and pruned brush weight were not significantly affected except that some clusters had a few shot berries.

Sprayed, nonpruned vines were not significantly affected with respect to number of shoots, brush weight, crop weight, or fruit quality; however, a few formative effects were produced by some treatments.

Two tests with drop applications of 2,4-D at concentrations of 10 to 500,000 ppm were made during the dormant season. In one test, treatments were applied to pruning cuts, buds, or internodes of the spurs. Greatest delay in bud break and severest injury to shoots resulted from application to the pruning cut. Internode treatment showed least damage and delay. In a second test, 2,4-D at 1,000 ppm was applied to pruning cuts at various intervals after pruning. A delay of 11 days resulted in much less injury than occurred when treatments were applied immediately after pruning.

THE AUTHORS:

Robert J. Weaver is Professor of Viticulture and Viticulturist in the Experiment Station, Davis.

Oliver A. Leonard is Lecturer in Botany and Botanist in the Experiment Station, Davis.

Robert J. Weaver and
Oliver A. Leonard

Effect of Dormant-season Applications of 2,4-D on Pruned and Nonpruned Tokay Grapes[1]

INTRODUCTION

Application of 2,4-D (2,4-dichlorophenoxyacetic acid) to soil, for weed control in vineyards, appears to be relatively safe (Leonard, Bayer, and Weaver, 1961), but application to foliage during the growing season can result in considerable damage to the vines. Uptake by foliage can be avoided, however, by applying spray during the dormant season. Our experience has shown that oil-soluble forms of 2,4-D incorporated into herbicidal mixtures of amitrole plus either diuron or simazine give relatively dependable weed control in dormant applications in vineyards. The dosage is usually 1 pound 2,4-D per acre (about ⅓ pound for vine-row treatments).

Still to be determined was the possibility of damage from uptake of 2,4-D by bark, buds, and pruning wounds. A previous experiment (Weaver, Leonard, and McCune, 1961*b*) indicated such a possibility, when 2,4-D sprays at 2 and 8 ppm were applied to Tokay grapes soon after pruning. The sprays resulted in malformed leaves early in the growing season. This observation also suggested a hazard to recently pruned vines by spray drift.

The present investigation was designed to assess the possible damage to growing vines from applications of oil- and water-soluble forms of 2,4-D applied to vines at various intervals after pruning and at dosages far in excess of those actually used in vineyards.

MATERIALS AND METHODS

Experiments were conducted on two blocks of irrigated Tokay grapes about 300 yards apart, at the University of California, Davis. The vines, on their own roots, were five years old, cordon-trained, and spur-pruned (Winkler, 1931). The blocks received normal vineyard care.

Two types of tests were carried out. Spray treatments were applied to soil, trunks, and whole vines on one block; vines were pruned both before and after the spray applications. Drop applications (with a pipette) were made to pruning cuts, buds, or internodes in the other block.

Sprays were applied to three-vine plots, each having an area of 8×18 feet, and were replicated three times. The applications were made with a compressed-air sprayer, at rates of 50 to 60 gallons per acre, with pressures of 20 to 30 psi. The spray wand was equipped with a single 8003E Teejet tip.

[1] Submitted for publication May 4, 1965.

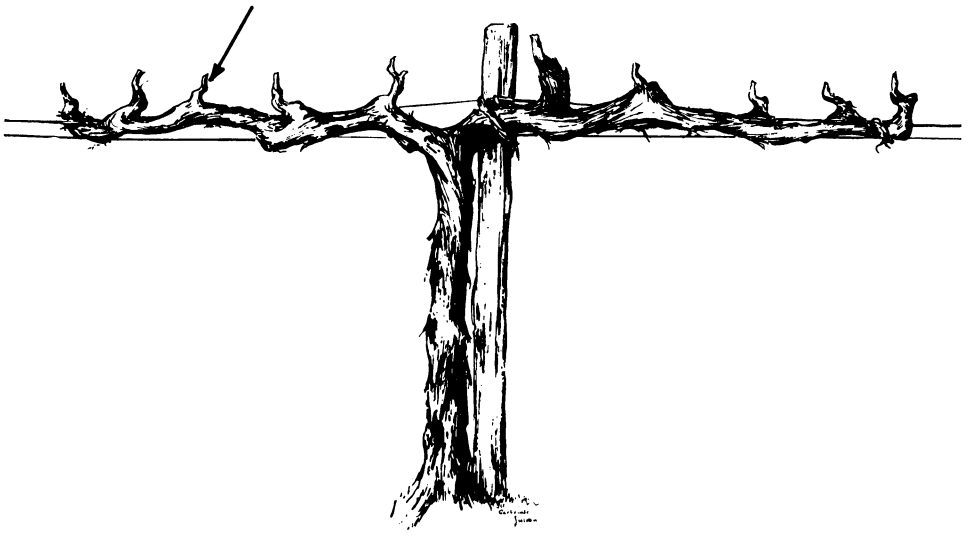

Fig. 1. Drawing shows cordon-trained Tokay vine and spur. Arrow indicates treated arm.

Three types of coverage were used for the spray tests: (1) only the soil was sprayed; (2) soil plus bases of trunks were sprayed; (3) soil plus entire vines were sprayed.

Three forms of 2,4-D were used:[2] (1) water-soluble amine (alkanolamine salt); (2) oil-soluble amine (N-oleyl 1,3 propylene diamine salt); and (3) ester (butoxy ethanol ester). A sticker-spreader[3] was used at 0.2 per cent by volume, with water as the diluent. Concentrations of 2,4-D were 0 (control), 625, 2,500, and 10,000 ppm with water- and oil-soluble amines, and 10,000 ppm as the ester. The amine forms were applied to the soil, bases of the trunks, and entire vines; the ester was applied only to the soil.

Shoot counts on the spurs were made in the spring to determine the effect of 2,4-D on development. Shoots less than ½ inch long were not counted.

At harvest, crop weights were obtained for each vine. A 30-pound sample was used for fruit analysis. Average weight of berries was determined by weighing 100 or 200 in duplicate. A Balling hydrometer was used to find percentage of total soluble solids in the juice. Total acidity was determined by diluting 10 ml of juice to 50 ml with distilled water, and titrating with 0.113 N/NaOH, using phenolphthalein as an indicator. Results are expressed as gm of tartaric acid per 100 ml of juice.

Test 16 days after pruning. This test was conducted on pruned and nonpruned vines on December 26, 1961, 16 days after pruning. The nonpruned vines were pruned about March 15, 1962. On the day of treatment, the air temperature was about 45° F, the humidity high, there was very little wind, and the soil was moist. About 50 per cent of the ground was covered with a 1- to 2-inch growth of miner's lettuce (*Montia perfoliata*), red maids (*Calandrinia ciliata*), common groundsel (*Senecio vulgaris*), white-stem filaree (*Erodium moschatum*), and annual bluegrass (*Poa annua*).

Test 73 days after pruning. A second test on pruned and nonpruned vines was made on February 21, 1962. The nonpruned vines were pruned

[2] The water-soluble amine (Formula 40) was from the Dow Chemical Company; the oil-soluble amine (Dacamine) from Diamond Alkali Company; and the ester (LV-4) from Amchem Products, Incorporated.

[3] The sticker-spreader (X-77) was from Colloidal Products Corporation.

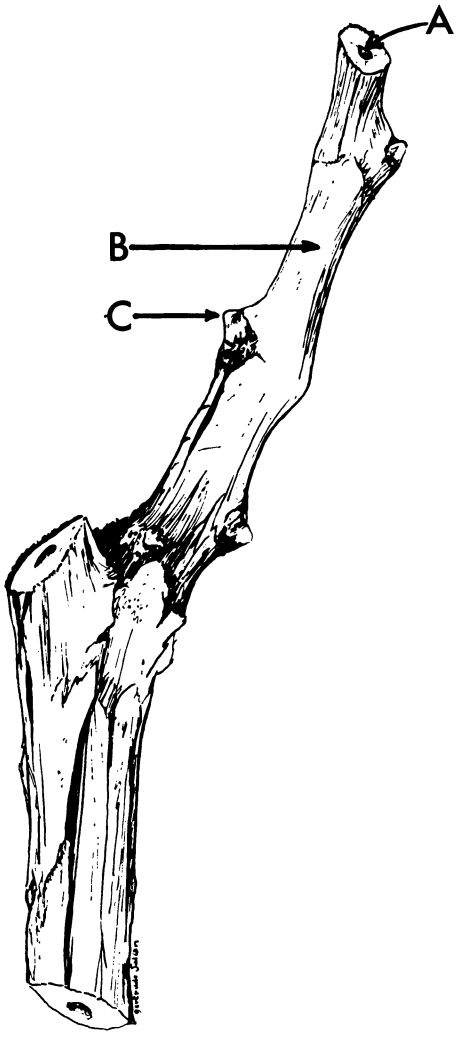

Fig. 2. Diagram of pruned spur, showing location of the 2,4-D applications at: (A) cut end of spur; (B) internode; (C) second bud.

about March 15, 1962. Only the water-soluble form of 2,4-D was used. The day was clear, the soil wet, and there was a slight wind. The plant cover was the same as it was 16 days after pruning, but now it covered nearly 100 per cent of the ground.

Drop-application tests. The alkanolamine form of 2,4-D in aqueous solution was applied with a pipette to pruning cuts, buds, or internodes of mature Tokay grapes at the rate of 0.05 ml of solution to each application point. Rings of transparent tape were used with the internode treatments to prevent running.

In the first test, on January 4, 1962, one cane near the middle of the east cordon on each vine was pruned to a spur of two to three buds (fig. 1). 2,4-D was applied to the cut apical ends of the spurs within an hour after pruning (fig. 2), at rates of 0 (control), 1, 10, 100, 1,000, 10,000, 100,000, and 500,000 ppm. On other vines, similar amounts were applied to the second bud from the apical end of the spur, and in a third series, to the internode between the first and the second bud from the apex. There were six replicate vines per treatment. No bleeding occurred after pruning.

In the second test, six vines were spur-pruned on January 4. The pruning wounds were treated with 0.05 ml of 1,000 ppm 2,4-D on January 4 immediately after pruning, and 1, 4, 11, and 49 days after pruning. A different vine was used for each treatment date, and one vine served as a control.

RESULTS

Spray tests to soil, soil plus trunks, and soil plus whole vines. Nonpruned vines sprayed in either December or February were not significantly affected with respect to number of shoots and crop weight, fruit quality, and brush weights (tables 1, 2). Very few 2,4-D symptoms were produced on non-pruned vines by treatment (fig. 3). No symptoms resulted from treatments applied either to the soil or to the soil and bases of the trunks. The oil-soluble amine applied to the soil plus entire vine at a concentration of 10,000 ppm produced only an occasional symptom. The water-soluble amine caused slight

TABLE 1

EFFECT OF 2,4-D ON SHOOT GROWTH OF PRUNED AND NONPRUNED TOKAY GRAPEVINES

Condition of vine, type and month† of treatment	Conc. of 2,4-D (ppm)	Av. no. shoots per vine on: April 10	Av. no. shoots per vine on: April 20
	Water-soluble amine		
Pruned—vines + soil sprayed in:			
December (1961).....	0	19.9	21.2
	625	17.3	22.8
	2,500	7.8*	15.0
	10,000	6.3*	11.6
February (1962).....	0	15.9	21.1
	625	16.9	20.5
	2,500	16.2	18.3
	10,000	13.1	18.8
	Oil-soluble amine		
December (1961).....	0	19.9	21.2
	625	15.4*	21.0
	2,500	12.1*	17.7
	10,000	4.4*	10.9*
	Water-soluble amine		
Pruned—base of trunk + soil sprayed in:			
December (1961).....	0	18.1	21.9
	625	18.3	21.1
	2,500	16.8	22.4
	10,000	17.3	21.0
February (1962).....	0	15.9	21.3
	625	17.8	22.2
	2,500	17.8	20.0
	10,000	15.4	18.6
	Oil-soluble amine		
December (1961).....	0	18.1	21.9
	625	17.1	20.9
	2,500	18.7	20.8
	10,000	18.8	23.5
	Water soluble-amine		
Pruned—soil sprayed in:			
December (1961).....	0	18.2	20.6
	10,000	18.4	21.8
February (1962).....	0	15.9	21.3
	10,000	13.6	19.3
	Oil-soluble amine		
December (1961).....	10,000	18.4	20.3
	Ester		
December (1961).....	10,000	18.0	20.3
	Water-soluble amine		
Not pruned‡—vines + soil sprayed in:			
December (1961).....	0	....	10.4
	625	....	7.7
	2,500	....	10.4
	10,000	....	7.4
February (1962).....	0	....	8.6
	625	....	10.4
	2,500	....	9.8
	10,000	....	9.3
	Oil-soluble amine		
December (1961).....	0	....	10.4
	625	....	9.9
	2,500	....	10.3
	10,000	....	10.4

* Significantly different from the controls (0 ppm) at 5 per cent level.

† December treatment 16 days after December pruning; February treatment 73 days after December pruning.

‡ These vines were pruned about March 15, 1962.

symptoms on one vine that was similarly treated.

Pruned vines were not affected by either soil or soil plus base-of-trunk applications of 2,4-D (tables 1 and 2), and no formative effects developed on any of these vines.

Pruned vines were affected by many of the 2,4-D treatments applied to the soil plus entire plant, as indicated by a decreased number of shoots per vine (table 1), stunting of shoots, and for-

TABLE 2

EFFECT OF 2,4-D SPRAYS ON WEIGHT OF PRUNINGS AND FRUIT OF TOKAY GRAPES AND ON FRUIT QUALITY AT HARVEST

Condition of vine, type and month† of treatment	Conc. of 2,4-D (ppm)	Av. wt. (lb.) per vine of:		Degrees Balling	Total acid (per cent tartaric)
		Prunings	Fruit‡		
	Water-soluble amine				
Pruned—vines + soil sprayed in:					
December (1961)	0	6.3	67.4	17.1	0.62
	625	7.6	78.7	16.9	0.62
	2,500	8.6	69.7	18.6	0.61
	10,000	8.6	59.5	19.8*	0.64
February (1962)	0	8.1	90.8	15.9	0.69
	625	7.6	81.1	16.0	0.62
	2,500	8.1	87.8	18.1*	0.63
	10,000	7.8	75.1	17.7*	0.61
	Oil-soluble amine				
December (1961)	0	6.3	67.4	17.1	0.62
	625	8.6	79.6	17.3	0.61
	2,500	7.8	51.7	19.0*	0.63
	10,000	7.6	49.6	18.1	0.75*
	Water-soluble amine				
Pruned—vines and base of trunk + soil sprayed in:					
December (1961)	0	7.5	63.9	18.1	0.65
	625	7.0	80.8	16.5	0.75
	2,500	8.4	82.3	16.4	0.66
	10,000	8.1	91.2	17.5	0.63
February (1962)	0	8.1	90.8	15.9	0.69
	625	7.9	87.8	16.7	0.64
	2,500	7.9	86.0	16.0	0.60
	10,000	8.8	90.0	15.7	0.68
	Oil-soluble amine				
December (1961)	0	7.5	63.9	18.1	0.65
	625	7.4	72.7	17.4	0.61
	2,500	7.5	86.1	16.6	0.65
	10,000	9.6	78.6	15.2	0.62
	Water-soluble amine				
Pruned—soil sprayed in:					
December (1961)	0	8.1	85.2	15.6	0.66
	10,000	7.8	88.1	16.3	0.64
February (1962)	0	8.1	90.8	15.9	0.69
	10,000	7.8	71.0	18.1	0.65

TABLE 2—(*Continued*)

Condition of vine, type and month† of treatment	Conc. of 2,4-D (ppm)	Av. wt. (lb.) per vine of:		Degrees Balling	Total acid (per cent tartaric)
		Prunings	Fruit‡		
	Oil-soluble amine				
December (1961)	10,000	8.3	77.1	17.4*	0.58*
	Ester				
December (1961)	10,000	8.0	83.5	16.7	0.63
	Water-soluble amine				
Not pruned—vine + soil sprayed in:					
December (1961)	0	8.1	92.5	14.7	0.76
	625	9.8	97.6*	16.7	0.69
	2,500	7.3	97.1*	15.8	0.68
	10,000	8.0	93.6	16.3	0.73
February (1962)	0	7.1	86.1	17.1	0.73
	625	7.5	90.8	15.9	0.65
	2,500	7.3	88.5	15.6	0.70
	10,000	7.7	89.6	14.7	0.70
	Oil-soluble amine				
December (1961)	0	8.1	92.5	14.7	0.76
	625	7.8	87.0	16.7	0.64*
	2,500	8.2	95.6	15.7	0.71
	10,000	6.9	90.7	16.2	0.69

* Significantly different from the controls (0 ppm) at 5 per cent level.
† December treatment 16 days after pruning; February treatment 73 days after December pruning.
‡ Fruit harvested October 4, 1962.

mative effects on foliage (fig. 3). The effect on the vines was similar with the water- and oil-soluble forms of 2,4-D, but varied greatly with concentration used and with the time lapse between pruning and spraying. Formative effects were far greater from sprays applied 16 days after pruning than from sprays applied 73 days after pruning.

Pruned vines sprayed in December with 625 ppm 2,4-D (either amine) developed a few leaves with mild formative effects; by September, however, these were difficult to find, and most clusters appeared normal. Formative effects were more numerous and severe with 2,500 ppm, and some were still evident in September. More abnormal clusters were also present. Applications of 10,000 ppm greatly retarded shoot emergence in April; elongation of the sprayed shoots was only about one-half that of the controls on May 8. The clusters were slightly twisted and somewhat elongated. Although many abnormal leaves were present in September, the growth was mainly normal; many of the clusters appeared to be injured, however, and some were dead.

Pruned vines sprayed in February showed some abnormal leaves that were still evident in September, especially with the 10,000-ppm treatment. At this concentration, also, an appreciable number of clusters had shot berries.

The treatments apparently had no effect on weight of crop, berry size, degrees Balling, percentage of total acid, or weight of prunings in the autumn (table 2). Some clusters from the whole-

vine treatments were damaged, but the injury did not significantly reduce crop level. Damaged clusters would, however, be useless for table grapes.

Weed control, as determined on February 1 from the December 16 sprays, was very poor with the water-soluble amine and moderate with the oil-soluble amine. No control was evident with the water-soluble amine except at a concentration of 10,000 ppm, in which case it was about 35 per cent; control with the oil-soluble amine was about 30 per cent with a 2,500-ppm treatment and 90 per cent with treatments using 10,000 ppm. With ester at 10,000 ppm control was about 70 per cent.

Spray drift was not a significant factor in producing formative effects on control vines, whether pruned or nonpruned at the time of spraying.

Three out of 45 plants sprayed with three oil-soluble forms of 2,4-D (amine, butoxy ethanol ester, or isooctyl ester) at the base of the trunks and soil on January 16 developed limited formative effects as recorded on June 24. On one of these plants, which was treated with isooctyl ester at 25,000 ppm, the entire effect was on a single basal shoot (fig. 4) which had developed symptoms and evidently stopped growing for a period. When brush was collected in October, a sharp change from malformed leaves to normal ones was evident. The other two plants with formative effects were from treatments with 125,000 ppm—one with oil-soluble amine and the other with butoxy ethanol ester. One of the two vines was a replant with a trunk less than 1 inch in diameter.

Drop-application tests. In the first test, the first buds broke on the controls about April 1. Influence of 2,4-D on bud break was recorded on April 5 and May 8 (table 3). Only buds fully broken, with green color, and at least ½ inch long were considered. Bud growth was inhibited most by treatment of the pruning cuts; next, by treatment of the buds; and finally, by treatment of the internodes. On April 5, all bud growth was inhibited by the 1,000-ppm pruning-cut treatments, the 100,000-ppm bud treatments, and the 500,000-ppm internode treatments. On May 8, the 1,000-ppm pruning-cut treatments showed the first bud still inhibited, but 50 per cent of the second buds had started to grow. May 8 results of the bud and the internode treatments were similar to those of April 5 with respect to the concentration of 2,4-D required for bud inhibition.

The effect of 2,4-D treatment on shoot injury was recorded April 16 and May 14 (table 4). In each case the record was based on the shoot closest to the point of application, and is an average effect of the replicates. The injury in all cases was greatest with the pruning-cut treatments, much less with bud treatments, and least with the internode treatments. In the pruning-cut treatments the most severe injury was usually on the bud nearest the cut stump (fig. 5).

The occurrence of formative effects was considered a bioassay of how far 2,4-D had moved. In general, the movement was confined to the treated spurs and connecting arm. However, with some treatments, 2,4-D moved into the cordons; when this occurred, movement was outward in the cordons (with one exception).

Most movement occurred with pruning-cut applications. For example, in one out of six instances, 2,4-D at 10 ppm moved basally in the spurs about 4 inches. In four out of six instances, at 1,000 ppm, 2,4-D moved into the arm out of the treated spur; in two instances, at 10,000-ppm concentration, 2,4-D moved out of the treated spur and arm into the next arm on the cordon—20 inches away. In one of the treatments in which 500,000 ppm were used, 2,4-D moved out of the treated spur and arm and then inward in the cordon into the next arm; this was the

Fig. 3. Tokay grapevines sprayed with 10,000 ppm oil-soluble amine of 2,4-D. (A) Control. Pruned in December; not sprayed. (B) Pruned in December; sprayed in December. (C) Control. Not pruned in December; not sprayed; pruned in March. (D) Not pruned in December;

sprayed in December; pruned in March. Note that shoots of nonsprayed vines pruned in December (A) were longer than those of nonsprayed vines pruned in March (C). 2,4-D caused severe stunting and many formative effects on pruned vines (B), but had little effect on vines that were not pruned until March (D).

TABLE 3

NUMBER OF SHOOTS ON SIX REPLICATE VINE SPURS OF TOKAY GRAPE FOLLOWING APPLICATION OF 2,4-D TO VARIOUS SPUR AREAS

Conc. of 2,4-D (ppm)	Area treated*								
	Pruning-cut at:			Bud			Internode at:		
	Bud 1†	Bud 2	Total	1	2	Total	Bud 1	Bud 2	Total
	No. of shoots on April 5								
0	6	6	12	6	6	12	6	6	12
1	6	6	12	6	6	12	5	5	10
10	4	4	8	6	6	12	5	6	11
100	1	1	2	4	6	10	6	6	12
1,000	0	0	0	2	3	5	6	6	12
10,000	0	0	0	3	5	8	6	4	10
100,000	0	0	0	0	0	0	3	1	4
500,000	0	0	0	0	1	1	0	0	0
	No. of shoots on May 8								
0	6	6	12	6	6	12	6	6	12
1	6	6	12	6	6	12	5	5	10
10	6	6	12	6	6	12	6	6	12
100	5	3	8	6	6	12	6	6	12
1,000	0	3	3	5	5	10	6	6	12
10,000	0	0	0	5	6	11	6	6	12
100,000	0	0	0	0	0	0	6	5	11
500,000	0	0	0	0	1	1	0	0	0

* Vines pruned January 4; 2,4-D applied within one hour following pruning.
† Bud no. 1 is apical bud and bud no. 2 is the next one basal to it.

TABLE 4

INJURY TO SHOOTS ON TOKAY GRAPE SPURS FOLLOWING APPLICATIONS OF 2,4-D*

Concentration of 2,4-D (ppm)	Degree of injury† following application to:					
	Pruning cut		Bud		Internode	
	April 16	May 14	April 16	May 14	April 16	May 14
0	1	1	1	1	1	1
1	1	1	1	1	1	1
10	3	4	1	1	1	1
100	4	4	2	2	1	1
1,000	5	5	2	2	1	1
10,000	5	5	3	4	3	2
100,000	5	5	5	5	4	3
500,000	5	5	5	5	5	5

* Vines pruned January 4; 2,4-D applied within one hour following pruning.
† 1 = normal growth; 2 = very slight blistering and/or abnormal venation of leaves; 3 = medium injury—many formative effects, but shoots not greatly stunted; 4 = severe injury—shoot much stunted, many formative effects; 5 = buds or shoots appear dead.

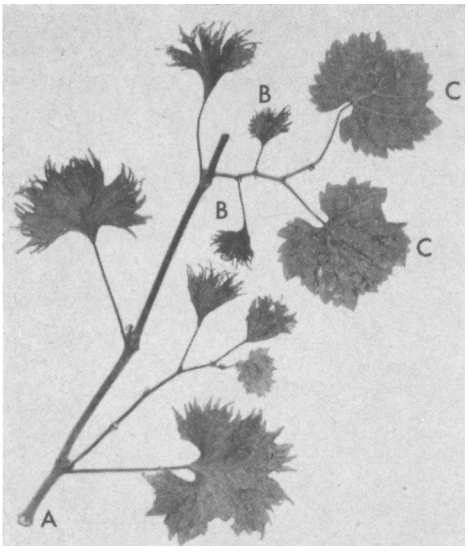

Fig. 4. Shoot developing at base of trunk 300 days after base was sprayed with 25,000 ppm of 2,4-D (isooctyl ester) — about 25 pounds per acre. Shoot was collected in November. Base of shoot, (A). Note two basal leaves (B) on one lateral branch show marked formative effects, and two apical leaves (C) are nearly normal. The sharp contrast between (B) and (C) indicates that the effect of 2,4-D can be quite localized.

only case in which inward movement was detected.

Very little movement occurred from the bud treatments. 2,4-D applied to the buds at 100,000 ppm resulted in some callus formation on the treated arm but not beyond it. In the 500,000-ppm treatment no movement occurred in four out of the six cases; in the others, movement did occur out of the treated arms into the cordons.

With the exception of that at 500,000 ppm, the internode treatments resulted in very little movement. In five out of six cases the movement was out of the treated arms into the cordons and then outward. The actual movement was variable, in some instances skipping an arm. The treatment resulted in callusing and cracking of the spurs.

Degree of shoot growth confirmed that treatment of pruning cuts resulted in greatest injury (fig. 6), and treatment of internodes the least (table 5). Concentrations of 1,000, 100,000, and 500,000 ppm were required to kill shoots with pruning-cut, bud, and internode treatments, respectively; fruit yield on the treated spurs was affected in the same order. It is interesting that in order to inhibit fruit production, 1,000 times as much 2,4-D was required by bud application as by pruning-cut applications. With internode application the difference was even greater—5,000 times as much.

Observations on April 5 showed that, in the second test, the number of shoots that had developed on spurs of control vines and vines treated January 4, 5, 8, 15, and February 22 were 26, 9, 7, 18, 24 and 23, respectively. Thus, treatment of the spurs at the time of pruning and one day later markedly delayed bud break, but treatment after 11 days or more had no appreciable effect.

On April 16, control shoots were about 10 inches long. Shoots on the spurs treated at the time of pruning or one day later were dead. Spurs treated four days after pruning had shoots with moderate to severe formative effects; those 11 days after pruning, slight to moderate; those 49 days after pruning, only slight.

DISCUSSION

Recently made pruning cuts offer the best mode of entrance for 2,4-D into the aerial portions of dormant grapevines. This was indicated in previous work in which Tokay vines were sprayed in the dormant season, for three successive years, with 2,4-D at 2 and 8 ppm (Weaver, Leonard, and McCune, 1961*b*). In only one year were malformed leaves present early in the season, and in that case the vines had been sprayed two days after pruning. In the

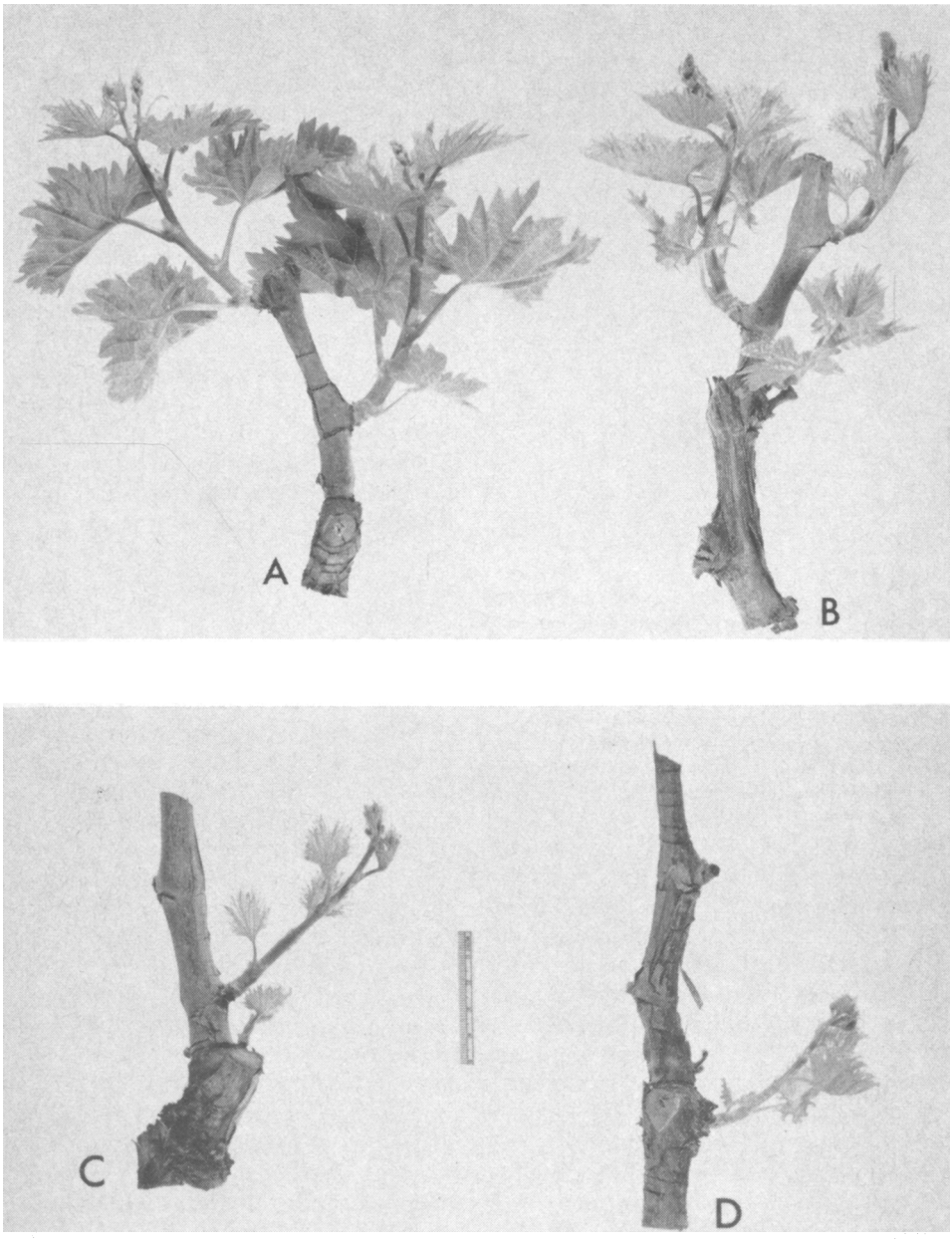

Fig. 5. Spurs of Tokay vines 98 days after pruning cuts were treated with the water-soluble amine form of 2,4-D at: (A) 0 ppm (control); (B) 10 ppm; (C) 100 ppm; and (D) 1,000 ppm. Note that apical buds were dead with 100- and 1,000-ppm treatments and that the water sprouts showed abnormal venation.

present experiments a delay in treatment following pruning greatly reduced the effect of 2,4-D on the vines. Vines pruned on December 10 were injured far more by sprays applied 16 days later than they were by similar sprays applied 73 days later. In tests on the direct application of 2,4-D to pruning cuts it was found that symptoms were related to the time lapse be-

TABLE 5

INJURY TO SHOOTS AND EFFECT ON FRUIT WEIGHT AND BERRY SIZE FOLLOWING APPLICATION OF 2,4-D* TO DORMANT SPURS OF TOKAY GRAPE

Location of application	Concentration of 2,4-D (ppm)	Injury rating on shoots†	Fruit weight on spur‡ (gm)	Av. weight per berry (gm)
Pruning cut	0	1	1,404	4.26
	1	1	1,322	4.44
	10	3	24	3.96
	100	3	0	0
	1,000	5	0	0
	10,000	5	0	0
	100,000	5	0	0
	500,000	5	0	0
Bud	0	1	1,404	4.26
	1	1	1,341	4.72
	10	1	1,545	4.52
	100	2	651	4.40
	1,000	2	620	3.90
	10,000	2	947	3.88
	100,000	5	0	0
	500,000	5	0	0
Internode	0	1	1,409	4.26
	1	1	1,318	4.70
	10	1	1,492	4.94
	100	1	1,060	4.58
	1,000	1	1,244	4.84
	10,000	4	1,347	4.86
	100,000	4	351	2.76
	500,000	5	0	0

*Vines pruned January 4; 2,4-D applied within one hour following pruning.
† 1 = normal growth—many shoots 3 to 4 feet long; 2 = slight formative effects; 3 = shoots ½ to 2 feet long; 4 = shoots 1 to 6 inches long; 5 = shoots dead.
‡ Fruit harvested September 10.

tween application and pruning; the greatest effect was produced by treatment of the fresh cuts. However, freshly pruned control vines were not affected by the small amounts of drift that occurred in carrying out the experiment. Evidently, drift need not be a serious factor when applications are carefully made.

Internodes and unbroken stem tissue offer much more resistance to 2,4-D entry than do buds or cut surfaces. Several lines of evidence support this conclusion. When the bases of the trunks and soil were sprayed with 10,000 ppm of 2,4-D no formative effects were created; in contrast, the same concentration of 2,4-D applied to entire pruned vines produced severe formative effects. Most 2,4-D no doubt entered through the pruning cuts. Furthermore, nonpruned vines had only a few malformed leaves even when the entire vines were sprayed. Uptake was probably through the bud scales, which allowed small quantities of 2,4-D to enter. When high concentrations of 2,4-D are applied, the level of 2,4-D may reach either physiological or herbicidal proportions. However, the exact mode of entry of herbicides and growth regulators into buds is still to be investigated.

The oil-soluble amine was no more injurious to the pruned vines than was the water-soluble amine, but it was more injurious when the nonpruned vines were completely sprayed. Neither the oil-soluble amine nor the esters was injurious when only the bases of the trunks were treated. The latter result is important since good winter weed control was obtained only with the oil-soluble forms.

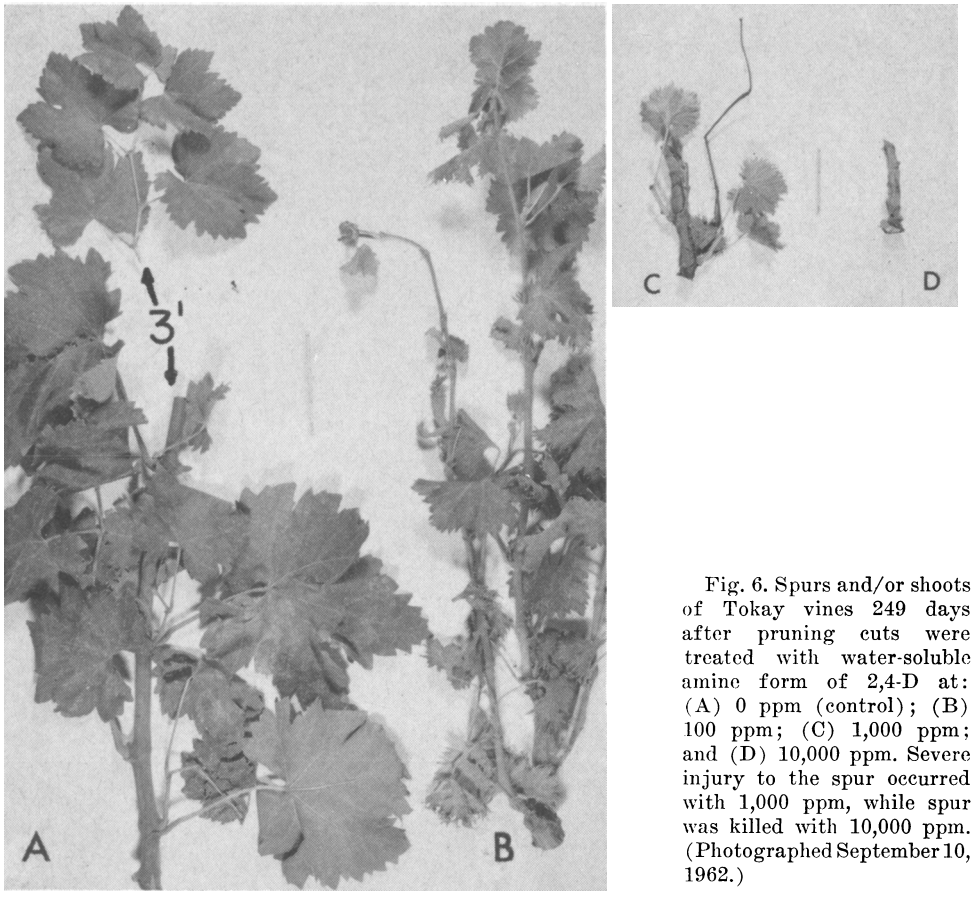

Fig. 6. Spurs and/or shoots of Tokay vines 249 days after pruning cuts were treated with water-soluble amine form of 2,4-D at: (A) 0 ppm (control); (B) 100 ppm; (C) 1,000 ppm; and (D) 10,000 ppm. Severe injury to the spur occurred with 1,000 ppm, while spur was killed with 10,000 ppm. (Photographed September 10, 1962.)

Pronounced formative effects on Tokay grapes, resulting from sprays during the growing season, were often associated with a decrease in crop (Weaver, Leonard, and McCune, 1961*b*). In the present experiments, however, when formative effects occurred very early in the growing season as a result of winter applications of 2,4-D to the entire vines (after pruning), yields were not decreased. Nevertheless, some clusters with many shot berries were produced, although the analysis did not indicate any effect on either the degrees Balling or percentage of total acid in the fruit from such vines. Typical 2,4-D injury to Tokay clusters, such as occurred in these experiments, has been previously reported (Weaver, Leonard, and McCune, 1961*a*).

Movement of 2,4-D from the treated dormant spurs to other parts of the vines was related to point of application and dosage. In general, very little movement occurred except with the pruning-cut applications. This is not surprising since our work shows that most 2,4-D enters the vine through pruning cuts and wounds. The movement was, in all instances except one, from the treated arm outward in the cordons. The first arm adjacent to the treated arm was the one generally affected; however, this arm was skipped in some cases, and the next arm affected. Downward movement in the spur and arm was to be expected, since it has been shown that 2,4-D applied to cuts in other woody species migrates downward (Leonard and Murphy, 1965). Once it reaches the cordons, the

water containing the 2,4-D is carried outward in certain channels of flow in the xylem. For example, if those channels happen to be associated with the first arm adjacent to the treated arm, that is where the 2,4-D would go. The one instance of inward flow is less easily explained. Possibly the 2,4-D was contaminated in some manner by rain, at the point of application.

Leonard, Weaver, and Glenn (unpublished data) failed to induce formative effects on the cordons by application of herbicidal dosages of 2,4-D to single vegetative shoots. Only the treated shoots showed effects. Only phloem transport was indicated in foliage application tests with C^{14}-labeled 2,4-D on shoots of Tokay (Leonard and Weaver, 1961). In view of these results, it is suggested that the single instance of inward transport in the current tests was not a result of phloem movement.

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