ENVIRONMENTAL PROTECTION AGENCY

OFFICE OF ENFORCEMENT

EVALUATION OF 2,4-D DAMAGE IN THE LOWER YAKIMA VALLEY, WASHINGTON VINEYARDS

March 1979

National Enforcement Investigations Center
Denver, Colorado

and

Region X
Seattle, Washington

INTRODUCTION

The lower Yakima Valley, located in south-central Washington at the confluence of the Yakima and Snake Rivers with the Columbia River (Figure 1), is an area of diverse agricultural crops. Numerous crops are grown, with wheat being the principal one. Also of considerable importance in the region are grapes, both wine and domestic varieties.

Grape vineyards in the lower Yakima Valley have been damaged, allegedly, by the herbicide 2,4-D (2,4-dichlorophenoxyacetic acid) for the past 20 years. Greater damage has occurred since 1969, especially during the 1974 grape-growing season[1]. There are at least three possible sources of the herbicide contamination:

1. Low-volatile and amine 2,4-D used on grains in Washington is translocated to sensitive grape crops when weather conditions favor herbicide drift.
2. Illegal use of high-volatile 2,4-D in the State of Washington.
3. High-volatile 2,4-D drift entering Washington from treated croplands in Oregon.

Whenever any agricultural pesticide is sprayed on a field by either a groundrig or aircraft, there is an initial drift of some active ingredient away from the target area. This takes the form of droplet drift at the time of spraying, with the smaller size droplets being carried downwind rather than depositing in the target area. Following the application, and generally extending over several hours, more pesticide may be carried from the target area through evaporation if the active ingredient is volatile. This latter transport is termed vapor drift.

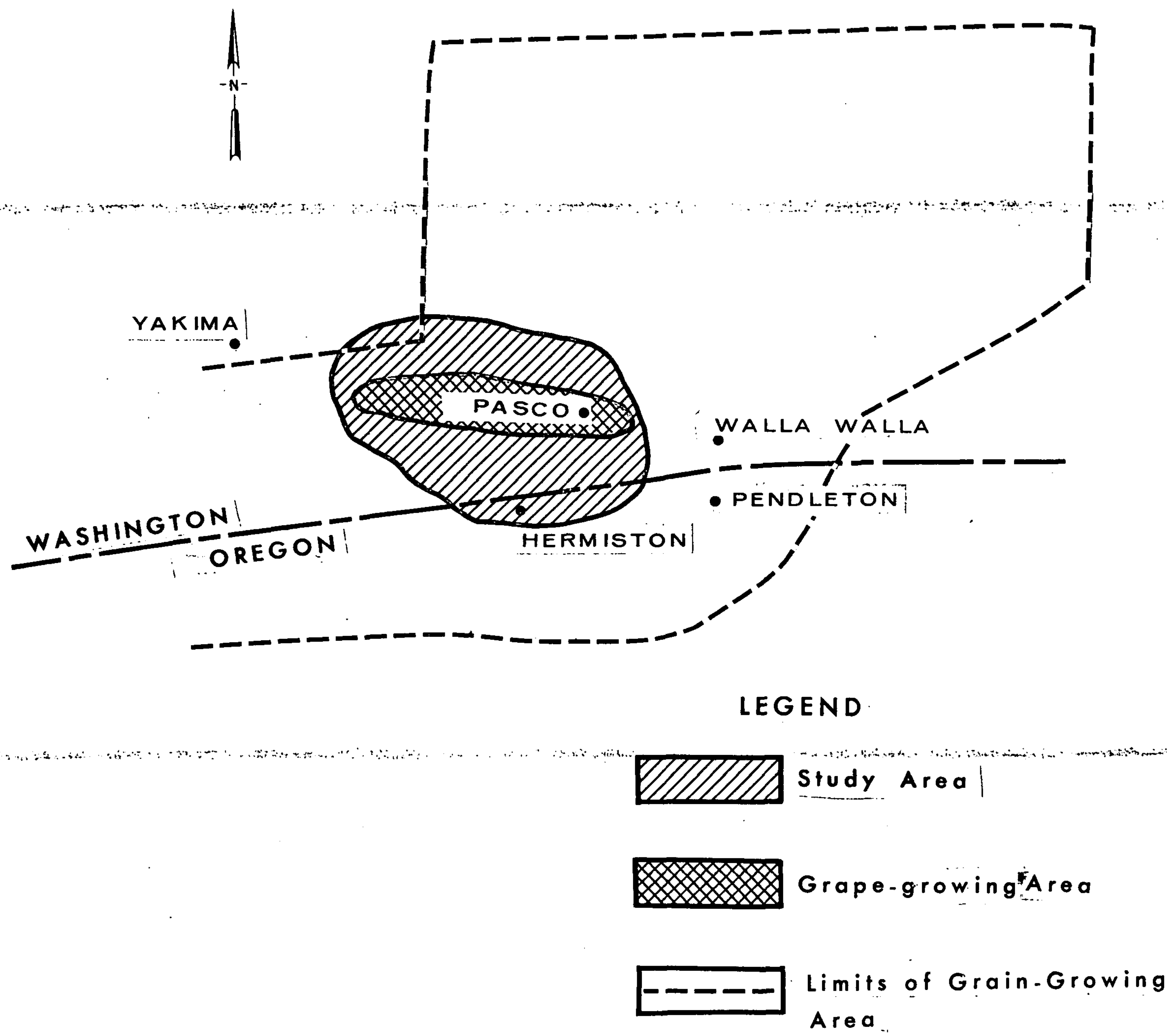

Figure 1. Grape-growing Region of Washington State and Surrounding Study Area

Spray deposition studies done in Canada[2] showed that, for high volatile 2,4-D butyl esters, about 35% of the applied chemical evaporated from the ground and drifted downwind as vapor. For the less volatile octyl formulation, the figure for vapor drift was around 12%. Initial droplet drift from the esters, as well as from the non-volatile amine formulation, was about 3-5%. Maximum drift distances were not calculated but probably exceed 40 km (25 mi.).

Applying these research findings to the situation in the lower Yakima Valley, it appears that vapor drift from high volatile (butyl ester) 2,4-D applications is potentially very high. The only known use of high volatile 2,4-D in the study area is in Oregon.

Although the vineyard damage is apparent, the cause of the damage is controversial. Studies by researchers at Washington State University[3] allege that one mechanism of damage is airborne translocation associated with the use of high-volatile 2,4-D to control weeds in north-central Oregon grain-growing areas. However, Oregon State University researchers[4] found it unlikely that high-volatile 2,4-D is translocated from Oregon into Washington in sufficient amounts to cause such damage. Oregon investigators believe it is more likely that vineyard damage in Washington is due to low or non-volatile 2,4-D, other herbicides, or the illegal use of high-volatile 2,4-D within Washington State.

Washington State Department of Agriculture has used the Washington State University research results to develop herbicide-control regulations. Presently, restrictions on 2,4-D use that are enforced in Washington State are as follows:

1. High volatile 2,4-D is banned (since 1974).
2. The use of low-volatile 2,4-D is prohibited in areas immediately surrounding the grape growing region between April 5 and October 31.
3. Application of 2,4-D is not permitted when weather conditions favor drift that could damage susceptible non-target crops.
4. Spray-booms must be equipped with state-approved nozzles to lessen the chance of drift. Minimum allowable oriface diameter is 9mm (0.036 in.)

Despite these restrictions, concentrations of 2,4-D continue to be found in air samples collected by Washington State University in and near Washington vineyards. EPA Region X, Seattle, Washington, requested the National Enforcement Investigations Center (NEIC) to (a) determine if 2,4-D or other herbicide applications are causing damage to vineyards in the lower Yakima Valley, (b) determine, if possible, the mode of translocation and the source of herbicides causing damage to the vineyards, and (c) evaluate appropriate control measures.

SUMMARY

The field study was conducted from April 20 to May 5, 1978, and included: (1) environmental sampling of soil, water and vegetation (grape leaves) for herbicide residue analysis; (2) ambient air sampling to determine aerial concentrations of 2,4-D; (3) determining the amounts, types, and locations of herbicide use in the study area during the field study; and (4) recording weather conditions of the study area via a network of meteorological stations. In addition, an unsuccessful aerial gas tracer study was conducted to provide additional information on air movements from Oregon into Washington.

Grape leaves in the lower Yakima Valley of Washington State were contaminated with as much as 0.28 μg/g of 2,4-D by April 21, 1978. A second visit in late June, 1978 revealed extensive herbicide damage in several vineyards, but the 1978 grape yield remained good. Growers believe prospects for another good crop in 1979 are poor because the herbicide damage of 1978 will reduce overall plant vigor next season.

Apparently, 2,4-D drifted by air into the vineyards prior to the NEIC study. Because of incomplete records of application in Oregon and the fact that no 2,4-D was found in air samples collected by the NEIC, the specific source of the 2,4-D drift remains unknown.

Droplet drift into vineyards from any 2,4-D application in Oregon or Washington could be reduced also if applicators were required to: (1) spray only under the lightest winds, not under weather inversions, (2) reduce hydraulic pressure on sprayers, (3) apply more total solution volume, (4) use thickeners, or (5) use low pressure nozzles.

STUDY METHODS

Ambient air, soil, water and vegetation samples were collected from seventeen stations in the lower Yakima Valley [Figure 2 and Table 1]. Seven sampling stations (2,4,5,6,9,10 and 15) were located in vineyards. The remaining 10 stations were sited in the vicinity of Pasco, which is the center of the grape growing area.

To adequately define meteorological conditions in the survey area, data were obtained for wind speed, wind direction, horizontal wind direction variation, stability, mixing depth, temperature, humidity, and barometric pressure. In addition to three meteorological stations established by the NEIC [Figure 2], data were also obtained from the National Weather Service and Battelle Northwest Laboratories, Richland, WA and Portland General Electric, Portland, OR for the period from April 16 to May 6, 1978. Weather forecast support was provided by the Portland, OR and Yakima, WA National Weather Service offices. This information was used in planning an SF_6 (sulfur hexafluoride) gas tracer study; however, a malfunction in sampling equipment prevented usable results from being obtained.

Table 1
Sampling Station Locations

1. Murch-Land vineyard near Grandview, WA
2. Wandling Farm near Mabton, WA
3. Washington State University (WSU) Experimental Farm near Prosser, WA
4. Parcell home near Benton City, WA
5. Bacchus-Dionysis vineyard near Pasco, WA
6. Conner vineyard near Pasco, WA
7. Neff farm near Ice Harbor Dam, WA
8. Fire station near Hoffman Ranch at Eureka, WA
9. Snake River vineyard near Ice Harbor Dam, WA
10. Lutke vineyard near Kennewick, WA
11. 1 mi. south of Cemetery Road on Travis Road near Kennewick, WA
12. Clodfelter Farm near Kennewick, WA
13. Blair Ranch in Horse Heaven Hills near Kennewick, WA
14. Lynch Ranch near Touchet, WA
15. Cripe vineyard near Hermison, OR
16. Carty Meterological Tower near Boardman, OR
17. Pebble Springs Meteorological Tower near Arlington, OR

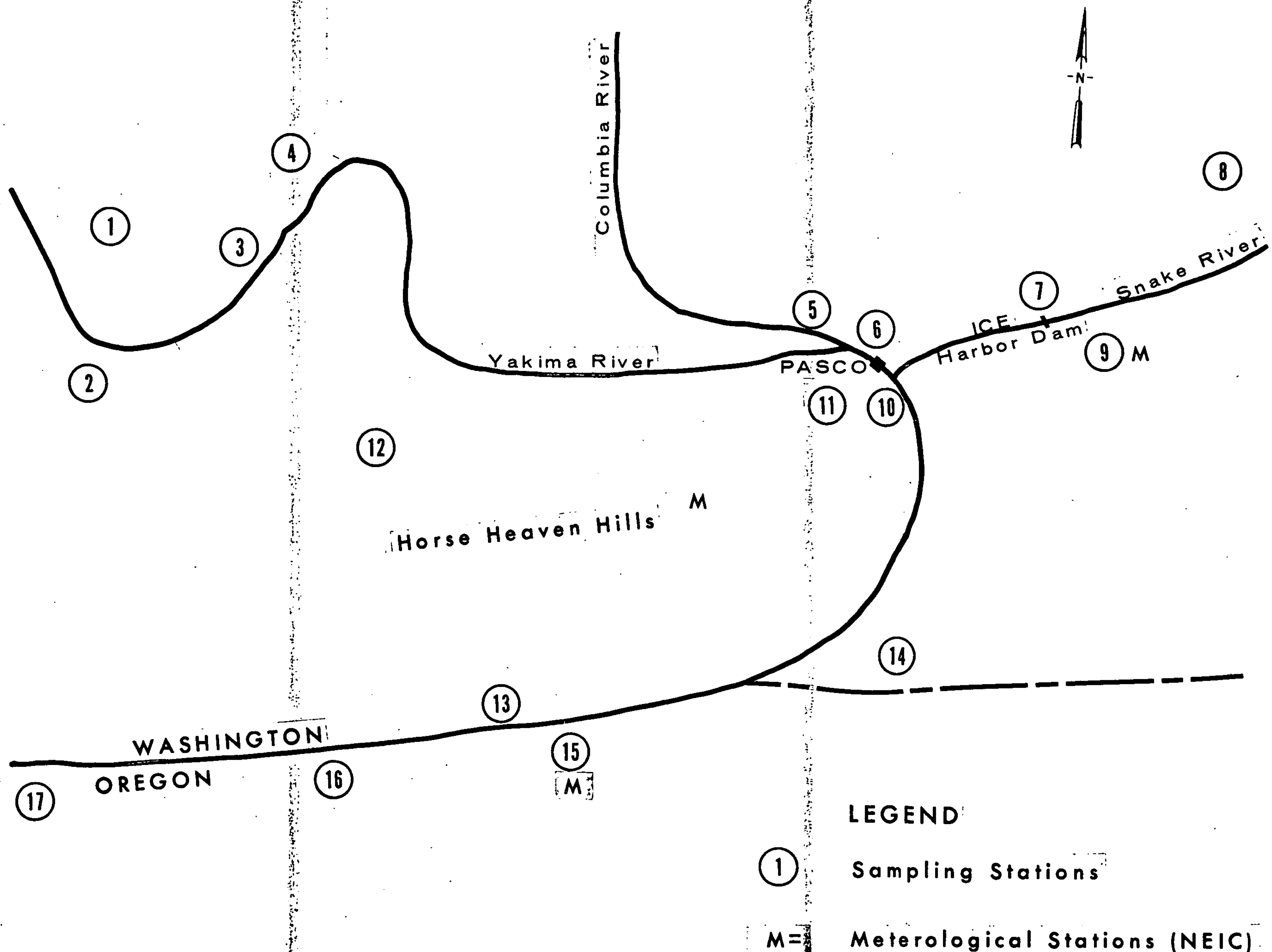

Figure 2, Sampling Stations

At the seven vineyards included in the study area, samples of irrigation water, soil and vegetation were collected for analysis of 2,4-D and dicamba. Air samples were collected by use of a porous polystyrenedivinyl-benzene copolymer resin, Amberlite XAD-2*, a solid absorbent which selectively retains organic compounds in air while allowing water vapor to pass through the collection column. Twice daily (on an 8- and 16-hour schedule) the resin columns were retrieved, wrapped in aluminum foil, packed in separate plastic bags, labeled and shipped to the NEIC laboratory for analysis of phenoxy herbicides.

To determine the types, amounts and locations of herbicide applications during the period of April 15 to May 5, 1978, a questionnaire was prepared and distributed to aerial applicators operating in east-central Washington and Oregon [Fig. 7]. However, because limited data were received from the questionnaire, a subsequent review of state pesticide use records was conducted, in October, 1978. Senior officials within the Washington and Oregon state agricultural departments were also contacted at that time.

STUDY RESULTS

In March, 1978, during a reconnaissance of the lower Yakima Valley, woody portions of selected grapevines and soil samples were collected from vineyards, allegedly affected by 2,4-D. A grapevine sample collected on April 1, 1978 contained 0.06 µg/g of 2,4-D. One soil sample, collected on March 15, 1978, contained residues of a benzoic acid herbicide (0.005 µg/g dicamba). At no other time during the reconnaissance in March or the full-scale study in April and May did an analysis reveal detectable levels of dicamba.

---

*Mention of commercial products does not constitute endorsement by the U.S. Environmental Protection Agency.

Vegetation (grape leaves), soil, irrigation water, and ambient air were collected from the vineyards during the April 20 to May 5, 1978 study. Grape leaves contained from <0.13 to 0.28 μg/g 2,4-D (Table 2) with no other pesticide residues being found. Analytical methods used did not specifically identify the type of 2,4-D on the grape leaves (e.g. high, low or non-volatile); however, 2,4-D at an intermittent concentration of 0.1 μ/g over a 60 hour time period is known to damage grape plants[5]. No 2,4-D or other phenoxy-type herbicides were found in air, soil or irrigation water samples.

To determine the possible means by which 2,4-D was translocated to vineyards, published literature was reviewed.

Pesticide studies conducted in Canada[6] and Washington state[3] reaffirmed that 2,4-D contact with exposed plant surfaces, via air (not soil or water) is the most effective method to apply the herbicide and kill plants. Soil incorporation or mixing with irrigation water are methods not used in WA or OR. Based on these facts, it was concluded that airborne deposition of the 2,4-D appears to be the most likely way that the vineyards of the Yakima Valley become contaminated.

In late June, 1978, damage to grape leaves was noted during a visit to several vineyards in the Pasco, WA area, with local grape-growers (Figures 3,4,5,6). Figure 4 shows a grape vine alledgedly contaminated with 2,4-D; however, other herbicides cause similar malformations. These vineyard owners stated that 1978 crop prospects ranged from fair to good, but that 1979 crop production may suffer because of a loss of plant vigor during the 1978 growing season.

Fig. 3. Normal near-mature Concord grape leaf.

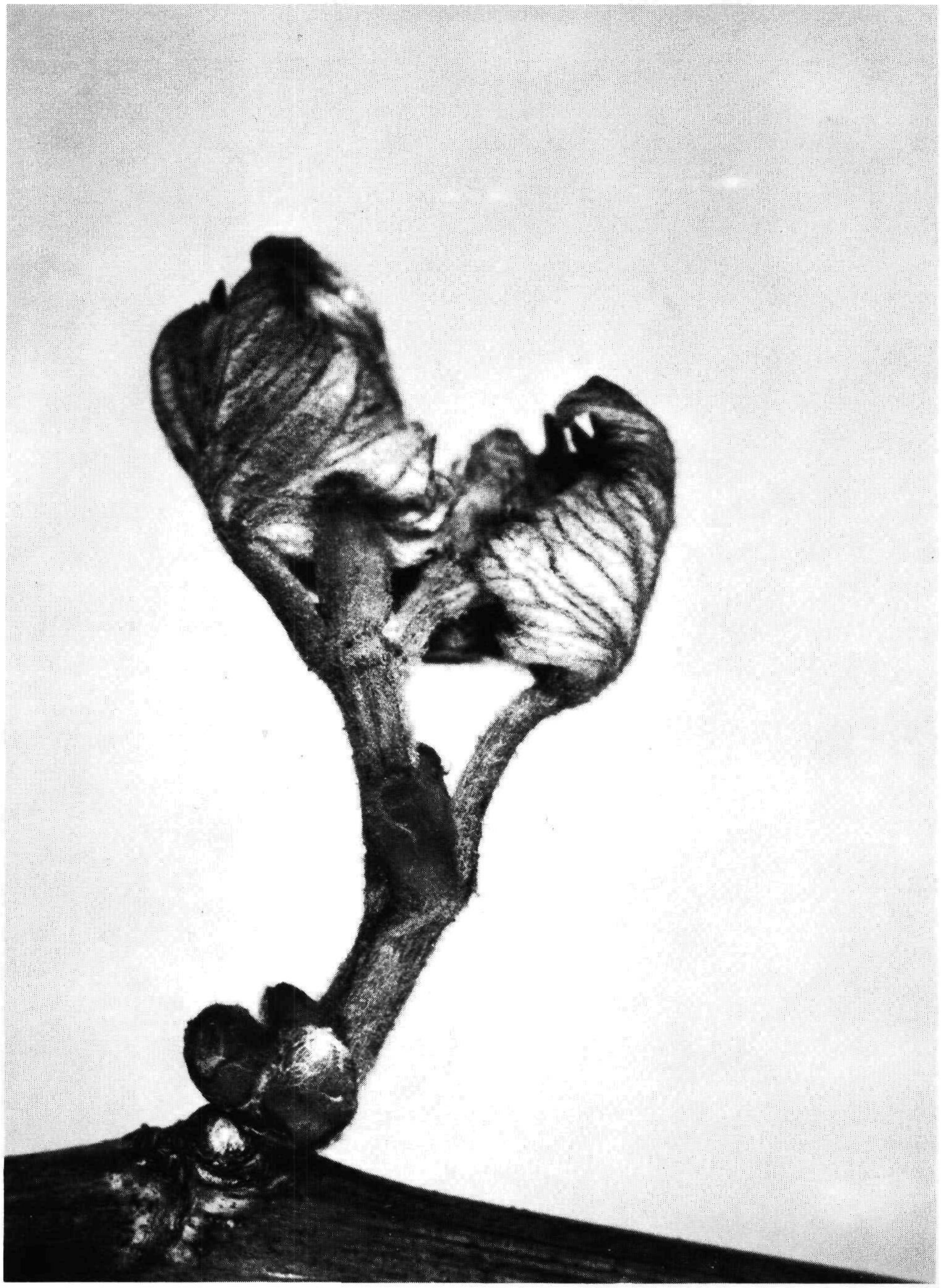

Fig. 4. Emerging Concord grape shoot contaminated with 2,4-D.

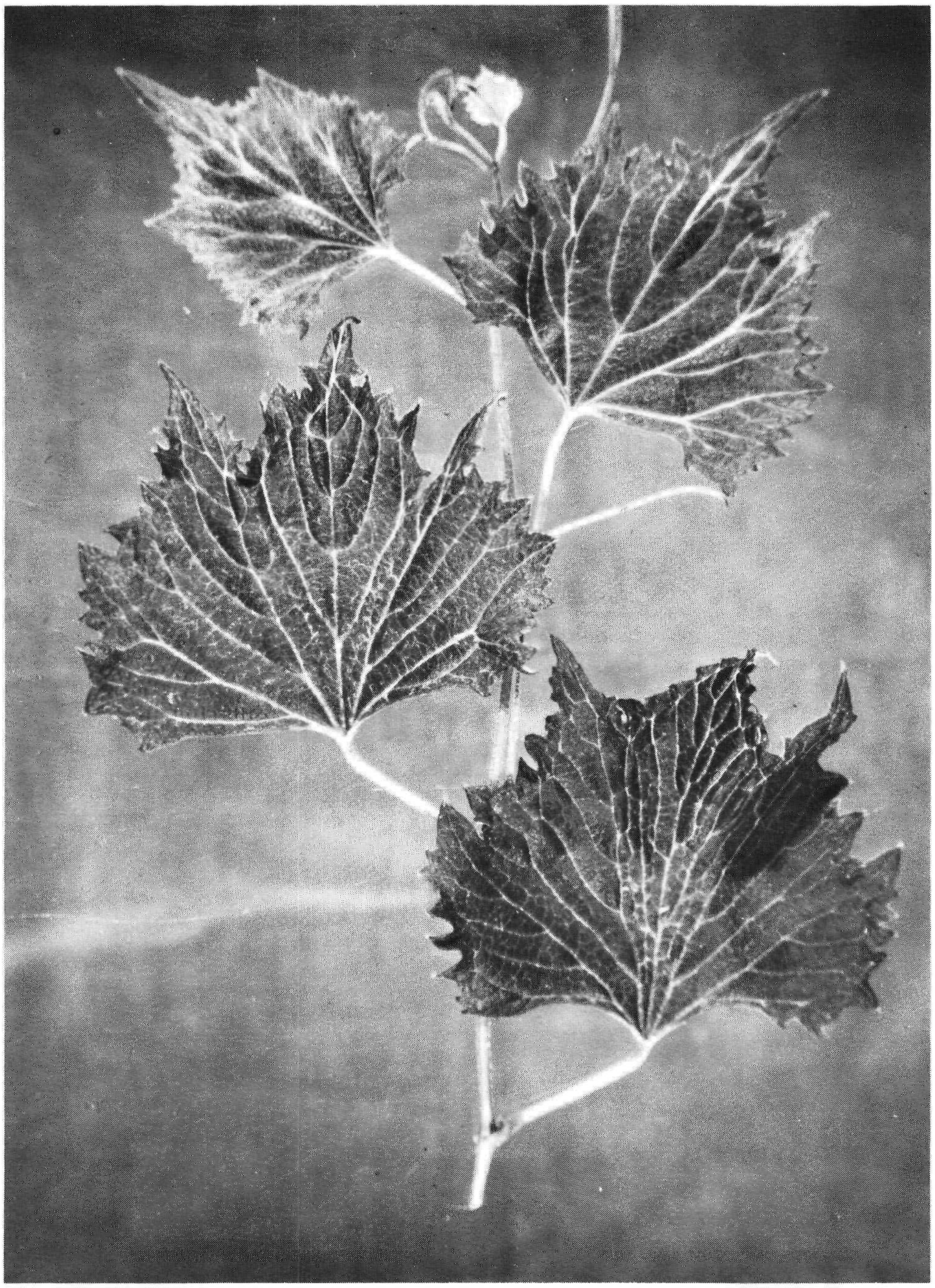

Fig. 5. Typical 2,4-D symptoms on Concord grape leaves.

Fig. 6. Poor set of wine grapes caused by aerial 2,4-D contamination. (Courtesy of W.J. Clore)

Table 2

Results of Analyses of Vegetation Samples for 2,4-D*

Date	Time	2,4-D**
4/1/78	--	0.06*
4/21/78	0640	0.28
4/21/78	0730	0.11*
4/21/78	0937	0.15
4/21/78	1000	0.09
4/22/78	1430	<0.13
5/2/78	0715	0.10
5/2/78	0800	0.03
5/2/78	0840	0.05
5/2/78	1021	0.11
5/3/78	0900	0.08

*Confirmed by GC/MS

**Expressed as μg/g of the methyl ester

Information provided to the NEIC by several grape-growers following the 1978 harvest indicated that yields were good, probably the best within the last 5 years. The apparent anomoly between severe plant damage and a good crop yield is not clearly understood.

Principal formulations of 2,4-D used as reported by aerial applicators [Fig. 7] and by review of state records in both Washington and Oregon were the low-volatile amine (Washington) and the high-volatile butyl ester (Oregon). Commercial applicators reported crops treated with 2,4-D and other closely related produces included wheat, corn, clover, alfalfa and barley, while a variety of other herbicides were used on peas, corn, barley, alfalfa, mint and wheat, the latter being the principal crop treated with 2,4-D in 1978.

The questionnaire completed by applicators revealed 2,4-D was sprayed on 8 to 1860 hectare (20 to 4,600-acre) fields at a rate of 28 to 94 liters/hectare (3 to 10 gallons/acre) using 0.3 to 1.8 liter/hectare (0.25 to 1.5 pt/acre) active ingredients. In Washington, the state data were detailed enough to determine that 16,000 hectares (39,000 acres) were treated with approximately 643,000 liters (170,000 gallons) of 2,4-D during the April 20 to May 5, 1978 study; treated sites were as close as 8 Km (about 5 miles) to vineyards. Data supplied by Oregon provided information only on total amounts sprayed on a daily basis within the Oregon Columbia Basin wheat growing area; the specific locations and number of treated acres were not made available.

Additionally, the data revealed that: (1) in Washington and Oregon most spraying of herbicidal material occurred after April 20, and (2) about 4,800 Kg (10,500 lbs) of high volatile 2,4-D was sprayed on Oregon wheat fields during the course of the NEIC study. The use of high volatile 2,4-D is not permitted in Washington.

While the high volatile 2,4-D has a propensity to drift[2], no 2,4-D was found in air samples during the NEIC study (April 20 to May 5, 1978); therefore, the NEIC was unable to determine the specific source of 2,4-D found earlier in Yakima Valley vineyards.

In order to estimate the possible downwind hazard resulting from pesticide drift and in particular to determine ways by which the hazard can be reduced, it is essential to distinguish between droplet and vapor migration from the target area.

Recommendations

Because drift of 2,4-D may cause herbicide damage in vineyards, it is appropriate to maintain controls on 2,4-D applications in Oregon and Washington sites upwind from Yakima Valley vineyards. Applicators in both states should be advised to spray 2,4-D only under the lightest winds, particularly when upwind of susceptible grape vineyards. Spraying should not occur under inversion conditions, when the upward dilution of the drift cloud is much reduced. Applicators should also be advised that drift from 2,4-D applications is effectively diminished by: (1) reducing the hydraulic pressure on sprayers; (2) applying more total solution volume; (3) using thickeners and (4) using low pressure nozzles.

FIGURE 7

Example of Herbicide Application Record
Questionnaire Sent to all Aerial Applicators in
North-central Oregon and South-central Washington

HERBICIDE APPLICATION RECORD

Applicator (Firm) _______________________Date______Time_____to___________

Location of Field (Hwy/Route-Nearest Town & Distance) ______________________

Area of Field (Acres)_________Application-Aerial/Ground Herbicide Applied___

Application Rate (Gal/Acre)____________________ Crop Treated _______________

REFERENCES

1. Personal Communication from C. Brown, Washington State Department of Agriculture. March, 1978.

2. Maybank, J., et al. 1977. Spray Drift and Swath Deposit Pattern from Agricultural Pesticide Application: Report of the 1976 Field Trial Program. SRC Rept. No. P77-1, Jan., 1977.

3. Anon. 1977. Studies of 2,4-D Drift Problems in the Lower Yakima Valley-1976. Report No. 77-13-32. Washington State University. 27 pp.

4. Farwell, S.O., F. W. Bowes and D. F. Adams, 1977. Evaluation of XAD-2 as a Collection Sorbent for 2,4-D Herbicides in Air. J. Environ. Sci. Health B12(1): 71-83.

5. Weigle, J.L., et al. 1970. 2,4-D as an Air Pollutant: Effects on Market Quality of Several Horticultural Crops. HortScience 5(4):213-214.

6. Maybank, J., et al. 1978. Spray Drift from Agricultural Pesticide Applications. J. Air Pollut. Conf. Assoc. 28(10):1009-1014.