Killing Ribes with 2,4-D and 2,4,5-T

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FOR many years the United States Bureau of Entomology and Plant Quarantine has been directly concerned with methods for destroying noxious plants that harbor important plant diseases and insect pests. Chemical methods have been used effectively in controlling white pine blister rust by killing *Ribes*, the host plants of this disease.

This report summarizes results from greenhouse and field tests from 1944 to 1948 in killing *Ribes* with 2,4-D and 2,4,5-T. It describes the methods and equipment that were most effective in field practice, and points out some of the factors now known to affect the killing action of these herbicides. Although *Ribes* is not common on range lands, the results of these studies might be of some value to range men concerned with the use of chemicals in the control of other noxious woody plants.

Location and Scope of Work

Greenhouse work was done at Berkeley, Calif., where the United States Bureau of Entomology and Plant Quarantine uses laboratory and greenhouse facilities maintained in cooperation with the University of California (College of Agriculture, School of Forestry). Field plots were established in white pine areas of California, Oregon, Washington, Idaho, Montana, Colorado, and Wyoming. About 500 greenhouse tests and 1364 field tests were made on 29 species of *Ribes* to study the toxic action of growth-regulating substances applied as sprays, dusts, and aerosols. The principal studies were methods of treating intact plants and the cut surfaces of stems and root crowns, developmental work on equipment and crew methods, and formulations of 2,4-D, spreader, sticker, and marker.

During 1946, in the Sierra Nevada of California, 328 acres of sugar pine land bearing heavy populations of *Ribes roezli* were sprayed in a series of tests with 40,950 gallons of aqueous 2,4-D in 220 man-days. In the 1947 and 1948 control operations in California, 690,239 gallons of aqueous 2,4-D and 3766 man-days were used to spray *Ribes* on 2796 acres of forest land. During 1948 a limited quantity of 2,4,5-T became available, and it was used for the first time in control operations for killing *R. viscosissimum* and *R. lacustre* in Idaho. The spray now being most widely used for the selective treatment of *Ribes* contains 6.7 ounces (500 p.p.m.) of 2,4-D acid plus 24 ounces of titanium dioxide marker (Titanox B-30) and 1 fluid ounce of spreader (Tergitol No. 7) in 100 gallons of water.

Costs

Cost of the 2,4-D spray work averaged about $1 per acre for the chemical and about $1\frac{1}{3}$ man-days per acre for labor. At present the price of 2,4,5-T is about double that of 2,4-D. The bulk of this work was done with high-pressure sprayers mounted on trucks and operated by a crew of 4 to 6 men.

Comparative tests of grubbing and spraying show that chemical methods are from 2 to 8 times faster than pulling or digging for work in areas where the *Ribes* population is 200 plants or more per acre.

The larger the population the greater is the advantage of a chemical method.

Methods of Applying 2,4-D and 2,4,5-T

Ribes and other woody plants closely associated with them have been killed by 2,4-D and 2,4,5-T herbicides applied as follows: 1) Spraying leaves and stems of intact plants with generous volumes of dilute aqueous solutions or with low volumes of oil or aqueous concentrates, 2) applying oil concentrates to the basal portions only of intact or scarified stems, 3) decapitating the plants at or near the ground line and applying liquid or dry herbicide direct to the root crown or to the short stub ends of cut-off stems, and 4) dusting the stems and leaves of intact plants.

Equipment Used for Field Work

For the selective or broadcast spraying of intact plants with dilute aqueous sprays, the low-pressure (40–60 p.s.i.) knapsack unit, and medium (75–150 p.s.i.) and high-pressure (150–600 p.s.i.) truck-mounted power sprayers were used. For applying oil or aqueous concentrates as a fine mist, we tested in the field the high-pressure (300–1000 p.s.i.) knapsack unit known as the Hi-Fog gun, power-operated turbine-type mist makers or blowers, or more recently the helicopter.

For applying oil concentrates to the basal stems of intact plants or for applying the herbicide to the root crowns of decapitated plants, the Hi-Fog gun, a small hand sprayer (8- to 32-ounce capacity), or a pocket size (4- to 8-ounce) oil can having a screw-on spout or removable top was used.

Intact plants were dusted with hand-operated and power-operated dusters of conventional design. Field tests were made with compressed air from a storage tank and with propellant gases in bomb-type containers to provide finely atomized 2,4-D and 2,4,5-T concentrates. So far these types of equipment have not been used in large scale field work.

Of the equipment just mentioned, the helicopter and the Hi-Fog gun are well adapted to work on land not under cultivation or difficult of access where large areas must be treated or searched to destroy noxious plants.

Hi-Fog Gun

The Hi-Fog gun is manufactured under patent by Banta and Driscoll Company, Los Angeles, Calif. It was used during the 1947 and 1948 field seasons in Idaho, Oregon, and California. This knapsack unit is convenient for applying low volumes of herbicides in aqueous or oil solution at pressures ranging from 300 to 1000 pounds per square inch. When a fine orifice (0.016 inch in diameter) is used in the nozzle tip, the 2,4-D or 2,4,5-T concentrate is delivered as a fine mist or fog approximating an aerosol in particle size. The Hi-Fog gun model D weighs 26 pounds when empty and holds $3\frac{1}{5}$ quarts. The unit takes in the liquid herbicide and simultaneously develops pressure by means of an hydraulic pump built into the head of a short, heavy-walled cylinder fitted closely with a movable piston. Back of the piston the cylinder carries a permanent cushion charge of nitrogen gas at 300 pounds pressure.

Tests conducted with the Hi-Fog gun showed that it is especially well adapted to the treatment of crown sprouts in respray work and to initial spraying of medium to large *Ribes* of scattered distribution, especially those in brush or along streams or rocky terrain where laying and moving hose lines is troublesome. The construction of the Hi-Fog gun precludes the use of an insoluble marker, such as titanium dioxide, and the small volumes employed call for careful work by skillful and dependable operators. A temporary

marker good for about 3 minutes can be provided by adding from 2 to 5 percent of emulsifiable spray oil to an aqueous 2,4-D or 2,4,5-T concentrate.

Helicopter Tests

The first tests of the helicopter for spraying *Ribes* with 2,4-D were made on the Sierra National Forest, California, June 21–25, 1948. A Bell model 47B-3, equipped with a 44-nozzle boom, was effectively flown within 30 feet of the ground at elevations of 5200–6000 feet. The maximum load carried was 20 gallons. Thirty-eight acres were sprayed with 575 gallons of herbicide at ground speeds of about 30 miles per hour. Eighteen plots, each from 1 to 5 acres, were treated with 16 dosages of the following 2,4-D formulations: Isopropyl ester in Diesel oil, aqueous isopropyl ester plus a sticker-spreader, aqueous alkanolamine, or aqueous ammonium salt plus summer oil plus sticker-spreader. Dosages per acre ranged from 5 to 30 gallons and from 3.4 to 53.4 ounces of 2,4-D acid.

Observations 6 weeks after treatment showed that 2,4-D ester in Diesel oil was generally more toxic to *Ribes* and associated brush than the esters or salts diluted with water. Oil solutions apparently settle and wet the vegetation with greater uniformity than aqueous solutions. The apparent kill could be correlated with the dosage of 2,4-D used. Sixteen ounces of 2,4-D acid in 5 gallons of solution per acre caused significant damage to *R. roezli* and *R. nevadense* and to other susceptible plants. Damage to *Ribes* was spotty whenever they were screened by other vegetation. This screening effect was noticeable when associated brush had a density of $\frac{3}{10}$ or more. In general, the apparent kill of *Ribes* and of susceptible brush correlates closely with the density of spray deposit recorded by test plates. Disks of filter paper gave an excellent record of spray deposit for aqueous solutions dyed red; glass plates were best for recording oil solutions. Most uniform coverage was obtained on plots where slope and ground obstructions permitted spraying from two opposing directions.

Factors Affecting the Toxicity of 2,4-D and 2,4,5-T to Ribes

Ribes species vary markedly in their susceptibility to phenoxy compounds. Several species—*R. americanum*, *R. bracteosum*, *R. petiolare*, and *R. roezli*—were killed at favorable periods of the growing season by aqueous sprays containing 250 p.p.m. of 2,4-D acid; others—*R. lacustre*, *R. montigenum*, and *R. triste*—were not significantly damaged by 2,4-D sprays unless excessive dosages were used. Tests with 2,4,5-T are as yet incomplete, but it appears that most *Ribes* species can be killed by 2,4,5-T herbicides; some species may require the use of oil diluents and concentrations of 2000 p.p.m. or more of 2,4,5-T for satisfactory kill.

Unless varietal forms of *Ribes* species are involved, the percentage of resistant individuals within a population of a highly susceptible species does not usually exceed 5 percent. With the exception of the black currants, all of which are highly susceptible to 2,4-D, the classification of currants and gooseberries by subgenera or by gross morphologic criteria does not consistently indicate susceptibility to the phenoxy compounds.

In using dilute aqueous sprays thorough coverage of all leaves, stems, and adventitious buds down to the ground is necessary for uniform and high-percentage kill. When 2,4,5-T is applied to plants not readily damaged by 2,4-D, it seems to be especially important to use a generous volume of dilute solution and to obtain thorough coverage of all growing points. Workmen must be especially careful to spray the ends of all branches and to

direct the spray over the plant from at least two opposing sides. Tall, straggling plants are more difficult to spray properly than are low, compact plants. Fully foliated plants generally will be killed more readily than will plants with sparse foliage.

2,4-D sprays applied to aerial parts of intact *Ribes* are not effective unless applied during the period of active vegetative growth. Mature plants are most susceptible to 2,4-D and 2,4,5-T from the time that leaves are fully expanded and stems have started to elongate until the fruits are about two-thirds grown.

Light, temperature, and relative humidity affect the apparent rate of killing action of 2,4-D, but the final bush kill remains about the same for *Ribes* plants sprayed at the same stage of seasonal development. Rain seems to have little or no effect on the toxicity of ester formulations of 2,4-D on sprayed plants. Heavy rains within an hour or so of spray work may reduce the killing power of dilute aqueous solutions of the highly soluble ammonium and amine salts. The white marker used in sprays for *Ribes* eradication shows most clearly when sprayed onto dry foliage.

Age of *Ribes* plants, character of the soil, and vegetative associates all have a bearing on the ease with which the plants can be treated and killed with 2,4-D. Any soil, climatic, or vegetational factor that reduces available moisture, or modifies the soil temperature so as to hasten seasonal development, will tend to shorten the period of high susceptibility to 2,4-D. Thus in scheduling practical spray work, plants on south and southwest slopes, especially on shallow and rocky soils, should be sprayed earlier in the season than those on deep, moist soils in flat sites or on north and northeast slopes. In heavy brush *Ribes* grows more slowly and becomes resistant to 2,4-D earlier in the season than it does in open sites where there is little or no competition from deep-rooted vegetation.

Extensive field tests on the formulations of 2,4-D in relation to ultimate toxicity show that the salts and esters of 2,4-D at equivalent concentrations of the acid are about equally toxic. Thus considerations of cost, availability, bulk, and toxicity to associated crop plants can be given fullest consideration in the light of special needs of the field job.

Crown sprouts and partly killed bushes also must be sprayed during the seasonal period of high susceptibility. This period begins about 2 weeks later in the spring than for plants not previously sprayed, and continues as long as the sprouts show vigorous growth. Since living root crowns do not all sprout at the same time, it is good field practice to delay respray work until about midpoint in the growing season. Crown resprouts and partially killed plants can usually be attributed to one or more of the following: 1) Failure to treat during the susceptible period of growth, 2) failure to get complete spray coverage of all stems and leaves, 3) genetic and varietal differences of individuals in a population of susceptible *Ribes*, 4) sublethal dosage, and 5) general low susceptibility of the *Ribes* species to the phenoxy sprays.

Basal stem treatments using an ester concentrate of 2,4-D or 2,4,5-T in Diesel oil have been economic and effective on erect plants especially those having relatively few stems near the ground. Results of these treatments do not appear to be affected by the growth stage of the plant to the same extent as the dilute aqueous sprays.

The viability of *Ribes* seed is destroyed by low concentrations of 2,4-D. The seeds are hard-coated and will retain their viability through several weeks of immersion in many of the inorganic acids, alka-

lies, and plant poisons. For example, immersion of unplumped *R. roezli* seed for 24 hours in aqua regia containing about 15,000 p.p.m. of total acid reduced germination of seed to 79 percent from a normal of 90 percent. By contrast, 24 hours immersion of dry, unplumped *R. roezli* seeds in 1000 p.p.m. of 2,4-D acid resulted in only 14 percent germination, and 200 p.p.m. for 48 hours prevented germination. Immersion of dry *R. roezli* seeds in 60 p.p.m. of 2,4-D for 4 days reduced germination to 1 percent from a normal of about 90 percent. Results of other germination tests show that the sensitivity of *Ribes* seeds to various growth-regulating substances correlates closely with the sensitivity of the mature plant to the killing action of the same chemicals.