Controlling Big Sagebrush with Growth Regulators

DONALD N. HYDER

Range Conservationist, Squaw Butte-Harney Range and Livestock Experiment Station,[1] *Burns, Oregon*

THE possibility of using chemical sprays to kill big sagebrush (*Artemisia tridentata*) in a range improvement program is both interesting and promising. This paper presents the information gained from spraying big sagebrush with 4 formulations at 1, 2, and 3 pounds of acid equivalent per acre on 9 dates during the months of April, May, June, and July, 1950.

This one-year study was planned to evaluate the possibility of practical control of big sagebrush by spraying, and to evaluate the scope of research needed as a basis for recommendations. The results and interactions reported may be of importance to an understanding of past results and to the planning of future trials.

Review of Literature

A limited study was conducted at Squaw Butte, Burns, Oregon, by W. A. Sawyer and J. A. Singley during 1946. Sodium salt of 2,4-D was applied in 200 gallons of water per acre at acid equivalent rates of 1 to 8 pounds per acre inclusive on May 1, May 15, June 1, and June 15. The most favorable dates of application were June 1 and May 15. Significance was not found among rates of application (unpublished data). It was observed that mature sagebrush was affected more seriously than immature brush.

In Wyoming spraying on May 25 was more favorable than June 15, 1949 (Hull and Vaughn, 1951). In general 2,4-D butyl ester gave better results than did mixtures of 2,4-D and 2,4,5-T. Application of 1.5 pounds of acid gave 70 percent kill and 3 pounds gave 81 percent. The age and size of the sagebrush plants did not appear to influence the mortality rate.

Cornelius and Graham (1951) reported active growth of big sagebrush from May 1 to August 1, and concluded that the average period of most active growth, and the period during which spraying would be most effective, may be expected between May 1 and June 10. Butyl ester of 2,4-D applied on June 30, 1948, resulted in a high mortality.

Results from 1949 applications in Colorado (Colorado A. & M. College, et al, 1950) indicated that 2,4-D butyl ester was more effective than a 2:1 mix of 2,4-D and 2,4,5-T, and sodium salt of 2,4-D was least effective. The mix was superior to 2,4-D in 1950, and 2,4,5-T was superior to the mix (Colorado A. & M. College, et al, 1951). Spraying during 1950 with 2,4,5-T on May 27 was more effective than May 11 or June 15; however, 2,4-D was most effective when applied on June 15. A kill of 72 percent was attained with an application of 2 pounds of 2,4,5-T on May 27. On that date 57 percent of the sagebrush was killed with

[1] Squaw Butte-Harney Range and Livestock Experiment Station is jointly operated by the Bureau of Land Management, U. S Department of the Interior, and Oregon Agricultural Experiment Station, Oregon State College, Corvallis, Oregon. This report is published as technical paper No. 730 with approval of the Director, Oregon Agricultural Experiment Station.

a 2-pound application of 2,4-D. Spraying on a "swale" site was more effective than on either a side-hill or ridge-top.

Unpublished studies (Timmons, 1951) in Montana and Utah indicate rather similar results, but with a few noticeable variations. An interesting possibility is that of effective applications during the late-seed stage of big sagebrush.

Materials and Methods

Description of the Area

Squaw Butte range land is located about forty miles west of Burns in Harney County, southeastern Oregon. Elevation of the station range land varies from 4,600 to 5,200 feet above sea level.

This big sagebrush semi-desert range is predominately a sagebrush-bunchgrass type intermixed with juniper types. The forage is provided by bunchgrasses with very few palatable shrubs or forbs. Foremost among the grasses are bluebunch wheatgrass (*Agropyron spicatum*), Idaho fescue (*Festuca Idahoenisis*), Sandberg bluegrass (*Poa secunda*), Thurber needlegrass (*Stipa thurberiana*), squirreltail (*Sitanion hystrix*), and June grass (*Koeleria cristata*).

The average annual precipitation during the 14 years, 1937–1950 inclusive, was 11.58 inches with variation from 5.41 inches during 1949 to 15.93 inches during 1941. Although there was extreme variation between months and years, the precipitation was somewhat more concentrated during the winter months. Average monthly precipitation was highest during June, but June was the month of heaviest precipitation only twice during the 14 years. July and August were the months of lightest precipitation by average.

Design of Experiment

The experiment was conducted as a factorial in three randomized blocks located to attain a near maximum difference between the blocks.

Block number one was located on a bottom site in a dense stand of old mature sagebrush with an understory dominated by sagebrush seedlings. The soil is fine loamy sand and supports an average of 109 sagebrush per 500 square feet. Mature sagebrush was about four feet high with a few plants as high as seven feet.

Block number two was established about fifty yards from number one on the same bottom site. The original stand of sagebrush on this area was grubbed during 1935, and now supports an average of 130 young mature sagebrush per 500 square feet and a thin understory of grass.

Block number three was established on a south exposed site with a shallow, rocky soil. The site supports an average of 31 old mature sagebrush per 500 square feet and a good understory of bluebunch wheatgrass and Thurbers needlegrass. The sagebrush on this site stands about two and one-half feet high.

Plots were 10 by 50 feet in size and placed adjacent to each other within each block.

Treatments

One hundred and thirty-five treatments were assigned to plots at random within each block.

Four chemical formulations and a check were included as follows:

1. A 1:1 mix of isopropyl esters of 2,4-D and 2,4,5-T was prepared with 2 gallons of stove oil emulsified in water and made up to a total spray volume of 10.9 gallons per acre. The stove oil was emulsified in water with a neutral detergent.

2. Sodium salt of 2,4-D was prepared with 2 gallons of stove oil emulsified in water and made up to a total spray volume of 10.9 gallons per acre.

3. Butyl ester of 2,4-D was mixed with

water to a total spray volume of 10.9 gallons per acre.

4. Butyl ester of 2,4-D was prepared with 2 gallons of stove oil emulsified in water and made up to a total spray volume of 10.9 gallons per acre.

5. Check. Not sprayed.

Rates of application were 1, 2, and 3 pounds of acid equivalent per acre.

Spray applications were made on the following 9 dates: April 18, May 2, May 16, May 24, May 30, June 8, June 15, June 20, and July 6, 1950.

Application of the Spray

Applications were made with a hand sprayer at a pressure of about 25 pounds per square inch. The fan-type spray from a single Teejet 8001 nozzle was well suited to spraying the plots.

Distribution was accomplished by observing the time required to disseminate the amount of spray required for a single plot. Each plot was covered lengthwise in both directions spraying downward upon the vegetation and soil with no special attempt to cover individual sagebrush thoroughly. The sprayer was washed with water after each material.

Some difficulty was encountered in dissolving the sodium salt of 2,4-D. The small amount of precipitate which remained after thorough mixing was permitted to settle, and the clear solution was poured off to prevent frequent spray stoppage.

Dates of application were not at consistent intervals because calm days were selected for spraying. Spray drift did not appear to be a serious source of error.

Collection of Data

All living sagebrush were counted on each plot prior to spraying in 1950 and again during the spring growth period of 1951. Since a plant was considered alive if a single live branch remained, the percentage-kill data does not fully evaluate the effectiveness of the chemicals in reducing the demand of sagebrush for soil moisture and nutrients.

Complementary data was taken on precipitation, atmospheric temperature, humidity, and plant development. Soil temperature and soil moisture readings were taken on a number of plots in block number one. Soil moisture readings were taken with a Bouyoucos Soil Moisture Meter (Bouyoucos, 1950).

Results

The poor and inconsistent effectiveness of 2,4-D sodium salt (Table 1) is given initial consideration. The manner in which the sodium salt solution was prepared may have lowered its effectiveness.

To permit unrestricted consideration of the effectiveness of the 3 ester formulations, the results from their respective plots were segregated and analyzed. The subsequent reduction in coefficient of variation was from 30.2 percent with all plots, to 9.6 percent with ester-treated plots.

All main effects and interactions, except the interaction of formulation by rate, were significant in analysis of variance. Those significant sources of variation gave F values larger than the corresponding tabular values at a probability level of 0.01.

Difference among Blocks

Average sagebrush mortality was 77, 71, and 69 percent respectively for blocks 1, 3, and 2. The least significant difference at 0.05 probability is 3 percent.

Two factors are of major importance in considering the "very significant" difference among blocks. Those two factors are age of the sagebrush and site exposure. The observed difference between blocks one (old mature sagebrush, bottom site) and two (young mature sage-

brush, bottom site) was the age of the sagebrush, and the difference between blocks one and three (old mature sagebrush, south exposed site) was site quality and exposure.

The effectiveness of the chemicals was higher on the south exposed site when applied on May 2 and 16 but dropped off more quickly and consistently than on the bottom site. This difference in mortality between blocks one and three is supported by plant development data which indicates that plant growth was earlier but of somewhat shorter duration on the south exposed site than on the bottom site.

TABLE 1

Percent mortality of sagebrush resulting from the application of four separate "growth regulator" formulations at different dates

FORMULATION*	DATE OF APPLICATION									AVERAGE MORTALITY
	April	May				June			July	
	18	2	16	24	30	8	15	20	6	
No. 1	85	89	92	88	87	74	74	51	32	75
No. 2	21	39	31	35	28	32	48	24	12	30
No. 3	66	84	82	85	77	83	78	51	29	70
No. 4	69	85	86	87	75	82	72	66	30	72

* The formulations were as follows:
1. A 1:1 mix of isopropyl ester of 2,4-D and 2,4,5-T.
2. Sodium salt of 2,4-D.
3. Butyl ester of 2,4-D in water.
4. Butyl ester of 2,4-D in an oil emulsion.

Apparently, young mature sagebrush was more resistant to the growth regulators than old mature sagebrush, but not consistently so. The mortality of young sagebrush resulting from spraying on May 30 and June 8 was higher than that of old sagebrush (Fig. 1).

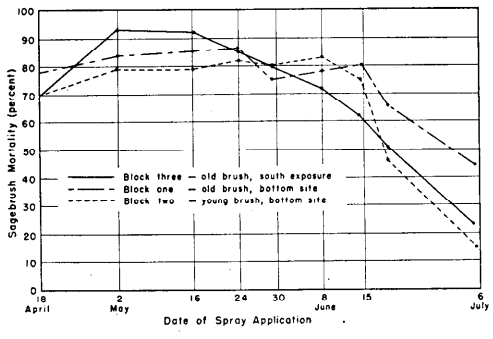

FIGURE 1. Average percent mortality of big sagebrush on the separate blocks resulting from 1, 2, and 3 pound applications of 1:1 mix of isopropyl esters of 2,4-D and 2,4,5-T in oil emulsion, 2,4-D butyl ester in water, and 2,4-D butyl ester in an oil emulsion.

Difference among Formulations

Average sagebrush mortality was 75, 72, and 70 percent respectively for the 1:1 mix of isopropyl esters of 2,4-D and 2,4,5-T in oil emulsion, butyl ester of 2,4-D in oil emulsion, and butyl ester of 2,4-D in water (Table 1). The least significant difference at 0.05 probability is 3 percent.

The 1:1 mix was significantly better than the butyl ester of 2,4-D; although the higher cost of 2,4,5-T at the present time may offset that advantage. Table 1 shows that the advantage was not consistent through all dates of application, but was of a seasonal nature which contributed to the "very significant" inter-

action of formulation by date. The 1:1 mix was consistently better than the butyl ester formulations during April and May applications, but was generally lower in effectiveness during June and July applications.

No significant advantage was gained by including stove oil as a part of the carrier of butyl ester of 2,4-D. The periodic reversion in mortality between the water and oil emulsion carriers is interesting. Of special interest is the large difference on June 20 when the oil emulsion attained a mortality of 66 percent as compared with 51 percent for the water carrier. The data is too limited to justify any conclusion; although, the outstanding difference on June 20 was uniform among the blocks.

Rate of Spray Application

Average sagebrush mortality was 63, 74, and 81 percent respectively for 1, 2, and 3 pounds of acid equivalent per acre. The least significant difference at 0.05 probability is 3 percent.

Of more importance is the average mortality for the separate rates during the first 3 applications in May; namely 77, 89, and 93 percent respectively for the 1, 2, and 3 pound rates.

Date of Spray Applications

The most favorable dates of application were May 2, May 16, and May 24 (Fig. 2).

The percent of sagebrush killed on June 8 and June 15 is interesting when considered with the percent of available soil moisture. Available soil moisture at the 6-inch level increased from 37 percent on June 5 to 66 percent on June 19. The precipitation received during early June increased the soil moisture level as deep as 12 inches below the surface, and apparently sustained growth activity of the sagebrush. This indicates the possibility of extending the period of application during favorable years.

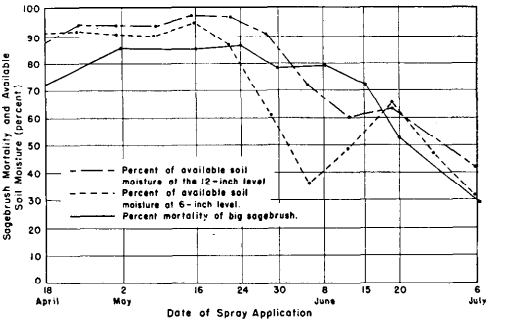

FIGURE 2. Percent mortality of big sagebrush by dates of application with available soil moisture in percent. (Average mortality resulting from 1, 2, and 3 pound applications of 1:1 mix of 2,4-D and 2,4,5-T in oil emulsion, 2,4-D butyl ester in oil emulsion, and 2,4-D butyl ester in water.)

DISCUSSION AND CONCLUSIONS

Since variation among blocks may be due to factors other than age and site, no facts can be drawn concerning age and site from the data presented. However, the writer believes that age and site are factors which caused a difference in the effectiveness of the spray applications, and that the differences among blocks are not misleading with respect to those two sources of variation.

The indication that site and exposure may influence the effectiveness of the growth regulators was also reported from Colorado (Colorado A. & M. College, et al, 1951). In the present study spring growth activity resumed at an earlier date on a south exposed site than on a bottom site and was of shorter duration. The exposure, shallower soil, degree of slope, and denser understory of grass on the south exposed site would tend to decrease the amount of moisture retained in the soil and to increase its rate of depletion. Since the effectiveness of the

chemicals was higher on the south exposed site when applied on May 2 and May 16, then dropped off more quickly than on the bottom site, the difference in sagebrush mortality between blocks one and three (Fig. 1) seems reasonable. The importance of spraying early in the growing season on large areas with changing slope and exposure is emphasized. It is probably better to spray too early than too late—the first three weeks of May is indicated.

That young plants may be more difficult to kill than old plants during the early season growth period (Fig. 1) supports the earlier observation at Squaw Butte in 1946. A similar observation was made in Colorado (Colorado A. & M. College, et al, 1950). However, Hull and Vaughn (1951) do not report differences in effectiveness due to age. Age is a probable source of variation in the effectiveness of growth regulators that may fluctuate with season, rate of application, and other factors. Such a possibility may be of benefit in selecting a rate of application, date of spraying, and the sites which will make the most economical improvement following spraying.

The poor and inconsistent effectiveness of 2,4-D sodium salt is not an isolated case (Colorado A. & M. College, et al, 1950). A preliminary trial in 1946 at Squaw Butte with 2,4-D sodium salt showed very inconsistent results. Although the difficulty encountered by the writer in dissolving sodium salt may have been a cause of poor and inconsistent results in the present study, another possible cause is apparent. Freed (1951) reported that for the control of annual weeds the ester formulations of 2,4-D are probably more effective than salt (amine or sodium) formulations because they are more able to wet plants and be absorbed by them. This difference in ability to wet plants and be absorbed by them seems equally true with respect to big sagebrush.

A 1:1 mix of isopropyl esters of 2,4-D and 2,4,5-T was more effective in killing big sagebrush than butyl ester of 2,4-D. Since 2,4,5-T is more costly than 2,4-D, its effectiveness on big sagebrush does not appear sufficient to justify its use at the present.

A highly significant interaction between formulations and dates of application emphasizes the importance of comparing formulations throughout the period or periods when favorable mortality might result rather than rely upon results attained from a single date of application. The most effective formulation on a given date may not be the best even 2 weeks later or earlier.

An oil emulsion with 2,4-D butyl ester was not better than water, each at 10.9 gallons of solution per acre. However, there is an indication that the oil emulsion spray remained effective at a later date than did water.

A rate of application of 1 to 2 pounds of acid equivalent per acre seems necessary for a suitable sagebrush kill. However, the degree of mortality which is most desirable and economical is speculative. It may be better to rely upon a one-pound rate of application repeated at intervals of 10 to 15 years rather than heavier applications.

The most favorable period of spray application included the applications on May 2, 16, and 24. A significant reduction of 7 percent in mortality occurred between May 24 and May 30 (Fig. 2). One and fifty-four hundredths inches of precipitation during the first 17 days of June apparently extended the period during which the growth regulators effectively killed big sagebrush. It appears that the period during which physiological changes rapidly increase plant resistance would have occurred between June 8 and

June 20 under continuously favorable moisture conditions.

Soil moisture was an important factor in determining the conclusion of the period during which growth regulators effectively killed big sagebrush. The possibility of using a plant development index of the soil moisture level was considered. Sandberg bluegrass appears to be a promising indicator. On May 23 Sandberg bluegrass growing on the bottom site was in early flower and was beginning to lose green color. Its development on the south exposed site was about a week earlier. It is tentatively concluded that a noticeable loss of green color in the leaves of Sandberg bluegrass can be used as an indication of the conclusion of the period during which spray applications will result in maximum effectiveness. However, during those years when late May and early June precipitation is well above average, spraying can probably be continued until about the middle of June.

Practical application of growth regulators for the control of big sagebrush is assured, if total spray volume can be sufficiently reduced to bring costs in balance with benefits.

Summary

1. This study of big sagebrush control was conducted at the Squaw Butte-Harney Range and Livestock Experiment Station about forty miles west of Burns, Oregon, on sagebrush-bunchgrass range having an elevation of 4,600–5,200 feet and a mean annual precipitation of 11.58 inches.

2. Four separate formulations of 2,4-D and 2,4,5-T were applied at 1, 2, and 3 pounds of acid equivalent per acre on 9 dates during April, May, June, and July 1950.

3. The treatments were applied as a factorial in 3 randomized blocks. Two of the blocks were located on a bottom site but segregated by a sharp demarcation in age of the sagebrush, and the third block was located on a south exposed site supporting old mature sagebrush.

4. Living sagebrush plants were counted on all plots during the spring of 1950 prior to spraying and again during the spring of 1951. The reduction in number of living plants was expressed in percent of the initial count for an evaluation of mortality.

5. The average mortality of old mature sagebrush was 77 percent, and the mortality of young mature sagebrush on a similar site was 69 percent.

6. Sagebrush mortality was greater on the south exposed site following May 2 and May 16 treatments, but dropped off more quickly and consistently than on the bottom site.

7. A 1:1 mix of isopropyl esters of 2,4-D and 2,4,5-T in an oil emulsion caused an average mortality of 90 percent when applied on May 2, 16, and 24; whereas, 2,4-D butyl ester in an oil emulsion killed 86 percent, 2,4-D butyl ester in water killed 84 percent, and 2,4-D sodium salt in an oil emulsion killed 35 percent.

8. The most favorable period of spray application included the applications on May 2, 16, and 24, 1950.

9. Early June precipitation apparently extended the period during which the growth regulators effectively killed big sagebrush.

10. An average mortality of 77, 89, and 93 percent was caused by applications of 1, 2, and 3 pounds of acid equivalent per acre respectively when applied during May. Those average results include all the formulations used except 2,4-D sodium salt.

11. A noticeable loss of green color in the leaves of Sandberg bluegrass may be a valuable indicator of the conclusion of

the period during which spray applications will result in maximum effectiveness.

ACKNOWLEDGMENTS

The author gratefully acknowledges the assistance and advice given by Virgil Freed, Associate Chemist, Department of Agricultural Chemistry, Oregon State College, Corvallis, Oregon.

LITERATURE CITED

BOUYOUCOS, GEORGE JOHN. 1950. A practical soil moisture meter as a scientific guide to irrigation practices. Jour. Agron. 24(2): 104–107.

COLORADO A. &. M. COLLEGE, ET AL. 1950. Sagebrush range improvement by eradication, reseeding, management. Northwestern Colorado fifth annual range improvement field day. July 21 (mimeographed).

———. 1951. Sagebrush to grass. Northwestern Colorado sixth annual range improvement field day. July 20 (mimeographed).

CORNELIUS, DONALD R. AND CHARLES A. GRAHAM. 1951. Selective herbicides for improving California forest ranges. Jour. Range Management. 4(2): 95–100.

FREED, VIRGIL H. 1951. Herbicides and their use. Oregon State College, Corvallis, Oregon. February. (mimeographed).

HULL, A. C., JR. AND W. T. VAUGHN. 1951. Controlling big sagebrush with 2,4-D and other chemicals. Jour. Range Management 4(3): 158–164.

TIMMONS, F. L. 1951. Western weed control conference newsletter No. 3. October 5. Utah Agr. Expt. Sta., Logan, Utah. (mimeographed).