Relationships Between Sprouting In Chamise And the Physiological Condition of the Plant

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Chamise *(Adenostoma fasciculatum)* is the major component of about 7 million acres of chaparral in California, occurring in some areas in almost solid stands. Management of the species may be directed toward its removal and replacement with grass, or toward the encouragement of new sprouts for use as browse. In either case an understanding of the sprouting behavior is needed. The species often sprouts vigorously after fire, and may do so after chemical or mechanical treatment applied for its removal. To date physiological study of the plant has been meager.

The preponderance of information on sprouting response in woody plants has been obtained on species in the Eastern United States in studies relating season of top killing or removal to vigor of regrowth. A pattern of behavior appears from these reports. Killing of tops during the dormant season was less effective in depressing regrowth than if done during the growing season (Warley, et al. 1954; Cable, 1957; Ferguson, 1957). Spring to midsummer treatments were more effective than those later in the growing season in reducing regrowth (Brown, 1930; Buell, 1940; Grano, 1955; Longhurst, 1956). This latter behavior has been found to exist in chamise in California whether cut, burned, or treated with herbicides.[1] Buttery, et al. (1957) carried out studies on the season of burning as it affects follow-up chemical control of sprouting chamise, and found that late-spring burning gave the best control of chamise sprouts in conjunction with one broadcast chemical application. In studies on the seasonal application of 2,4-D and 2,4,5-T to chamise Leonard (1956) found that the most dependable sprout control was achieved by spraying in the spring following a summer or fall burn.

Explanation of this seasonal effect on sprouting has been considered by a few investigators. Low food reserves during May and June in chamise have been associated with the poor survival of sprouts which arise following treatment at this season. Stoeckler (1947) investigating sprouting in aspen in the Great Lakes Region followed the same reasoning in explaining the reduced regrowth of that species after cuttings in late June to early August, this being the period of most rapid leaf development and food reserve depletion.

Aldous (1929) measured regrowth following mowing of buck-brush and sumac in Kansas pastures. He found that the most effective time to eradicate these shrubs is about the time that they are in flower. Greatly reduced starch content was observed in plant sections taken at this stage of development, and he concluded that the low starch level was an operative factor in the response. In contrast, Wenger (1953) studied the sprouting of sweetgum in the Southeast in relation to season of cutting and carbohydrate content, and concluded that there was a pronounced trend in sprouting vigor by date of cutting but found no relationship between cutting and carbohydrate content. He speculated that a hormone system was the factor governing the seasonal trend of sprouting vigor.

The present study was initiated to determine if seasonal trends exist in the chemical constituents of chamise which may be used at the time of treatment as indicators of sprouting potential.

Procedure

The study area was located on the University of California's Hopland Field Station at an elevation of about 3000 feet. The area had been burned in 1946, and was subject to deer browsing until October, 1956, when about

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[1] *Sprouting of chamise after clearing. A paper read at the December 1956 meeting of the California Section American Society of Range Management, San Luis Obispo, California, by R. H. Blandford.*

half of the area was protected from browsing by a deer fence 8 feet high. Plots predominately of chamise were located both within and outside this fence, and were laid out in duplicate for each date of cutting for the two sites. Each plot was of sufficient size to insure that at least 12 vigorous plants of chamise were included. Obviously in a native stand, plant spacings are irregular and competitive stress from neighboring plants varies. Still it was deemed more desirable to study these plants in natural stands than to establish plantings in the manner generally used for cultivated species.

Cutting treatments consisted of removing top growth at 1-inch height above ground level from two randomly located plots both within and outside the fenced area on each of six dates at approximately 2-month intervals beginning on January 24, 1957, and ending November 19 of the same year. A brush saw attachment on a "scythette" was used to cut the plants. At each date of cutting, soil moisture, twig moisture, and measurements of sprout growth on previously cut plots, together with samples of plant tissue for chemical analysis were taken. Rainfall and temperature data were recorded at a field weather station at the same elevation located one-half mile from the plots.

Soil moisture was measured with gypsum resistance blocks placed at depths of four inches, 1, 2, 3, and 4 feet at each of four locations adjacent to the plots. Twig moisture was determined on a dry weight basis on the most recent growth of chamise plants subject to moderate browsing near the plots. The average sprout height above ground level was measured at two-month intervals following cutting, and this was continued throughout 1958.

At each cutting date six chamise plants subject to moderate browsing were uprooted and divided into stem, root, and crown fractions for analysis. Parts from three plants were pooled, giving duplicate samples of each fraction at each date of cutting. Stems one-fourth inch in diameter or larger from 3 to 11 inches above the crown were selected for this fraction. Roots of the same size from 2 to 10 inches below the crown were used, as was crown tissue from which root and stem had been removed. Within 18 hours of digging these plants, the samples were sliced on a band saw to a thickness of about one-eighth inch, and were placed in a drying oven at 75° C. where they remained for at least 48 hours. Because of distance between the plots and laboratory facilities it was impossible to reduce this time interval between uprooting the plants and drying the samples. After drying, dead tissue was cut from the samples, and bark and dirt was removed by vigorous brushing. Remaining tissue was then ground in an Intermediate Wiley mill to pass a No. 40 screen.

In the determination of sugars and starches in the brush desirable features of several methods of analyses were utilized[2]. One gram samples were extracted by blending with 125-150ml. 80 percent ethanol in a Waring Blendor. The resultant slurry was filtered by suction through No. 3 Whatman filter paper in a Buechner funnel. The residue was transferred to a 150ml. beaker and reserved for starch determination.

The filtrate was transferred to a 250ml. volumetric flask. Clarification was accomplished by adding 2—5ml. saturated neutral lead acetate, the excess of which was co-precipitated by adding saturated sodium carbonate solution. Fifty ml. of clarified solution was filtered through a sintered glass crucible with the aid of filter-cell and a Fisker vacuum filtrator. Reducing sugars were determined by estimating the extent of reduction of an alkaline ferricyanide solution by titration with cerric sulfate, using ortho phenanthroline as an indicator.

To measure total sugars a 25ml. aliquot of the clarified solution was transferred into a 50ml. volumetric flask, incubated with 5ml. of 1:1 HCl overnight at room temperature, neutralized with 6N NaOH to the phenolphthalein endpoint, made to volume and treated as for reducing sugars. From this, sucrose was calculated to equal 0.95 (percent Total Sugars—percent Reducing Sugars).

Starch content was determined by solubilization of the plant material in perchloric acid and hydrolysis of an aliquot of the filtrate with hydrochloric acid. The final measurement of resulting sugars was according to the reducing sugars method.

Protein was determined by the Kjeldahl procedure. After wet ashing with nitric and perchloric acid calcium, potassium and sodium were determined on the Perken-Elmer flame photometer. Phosphorus was determined by the ammonium vandate method. The chemical data were subjected to an analysis of variance to determine significant differences between the three plant parts and between the six dates of sampling. Plant part-date of sampling interaction was also tested.

Results and Discussion

Of the three plant fractions analyzed, the root proved to be consistent in revealing seasonal trends, and for the materials

[2] *The authors wish to acknowledge the help of Joseph Ruckman, Laboratory Technician IV, Agronomy Department, University of California, Davis, for his services in planning and carrying out the chemical determinations.*

Table 1. Percent on dry weight basis of selected components in chamise roots.

Component	Percent, when sampled on date indicated						
	Jan. 24	Mar. 27	May 27	July 15	Sept. 10	Nov. 19	Statistical Significance
Starch	13.6	14.8	14.8	6.1	8.1	11.1	**
Total mono- and disaccharides	7.0	5.7	1.7	2.3	1.9	0.8	**
Glucose	.1	.7	.9	1.3	.8	.1	**
Protein	1.8	1.4	1.3	1.7	2.2	1.7	**
Ca	.28	.15	.15	.13	.28	.17	**
K	.20	.24	.21	.23	.25	.22	*
P	.08	.11	.08	.07	.06	.10	**
Na	.02	.02	.02	.02	.02	.02	N.S.

N.S.—No statistical difference
* —Significant at the 5% level
**—Significant at the 1% level
The plant part-date sampled interaction was not significant except for calcium and phosphorus.

measured usually contained amounts nearly as high or higher than the other plant parts. There was no significant plant part-date of sampling interaction except in the case of calcium and phosphorus. Thus sampling the root gave the same seasonal trend for the content of starch, sugars, protein and potassium as sampling the crown or stem. The advantage of using root samples was partly due also to the greater certainty of including only living tissue in the sample. In chamise stems, and particularly in the crowns, dead regions were frequently interspersed among the living tissues, and could be removed only with difficulty.

The content of selected materials in the roots is presented in Table 1. The storage carbohydrate, starch, reveals the most pronounced seasonal trend. Root samples contained more starch than the crowns which in turn contained more than the stems and these differences were highly significant. All three fractions revealed the same seasonal trend. The simpler carbohydrates, though differing in amount with date, exhibited smaller differences, a result not entirely unexpected. The protein values may appear low but it should be noted that the tissues sampled were mature tissues. Protein in younger foliage is somewhat higher. Though seasonal differences in calcium, potassium, and phosphorus are significant, the amounts are not large enough to suggest that these constituents have much promise of being useful indicators of sprouting potential. No significant differences in sodium content were obtained.

The growth in height of chamise sprouts from plants cut on the several dates is shown in Figure 1, and the prevailing temperatures and moisture associated with this growth is portrayed in Table 2. Low temperatures restricted regrowth in the January plots until late March with the result that the January and March plots entered periods of rapid growth at approximately the same time. The greatest growth rate was reached between late May and mid-July. Cutting the May treatment at the beginning of this period reduced the sprout height but the rapid growth rate was obtained in much the same pattern as in the earlier treatments. Soil moisture was nearly depleted to a depth of 4 feet by July 15 as indicated by a reading of thirty-one thousand ohms resistance on the gypsum resistance blocks. Growth was very little from September until the following spring regardless of the date of cutting. It is particularly noteworthy that in September and October moisture was again available and temperatures were in the range of those of the previous May and June when growth was rapid. This suggests that a factor other than temperature and moisture is involved in the growth curtailment at the fall season.

If the growth increment for the several periods between

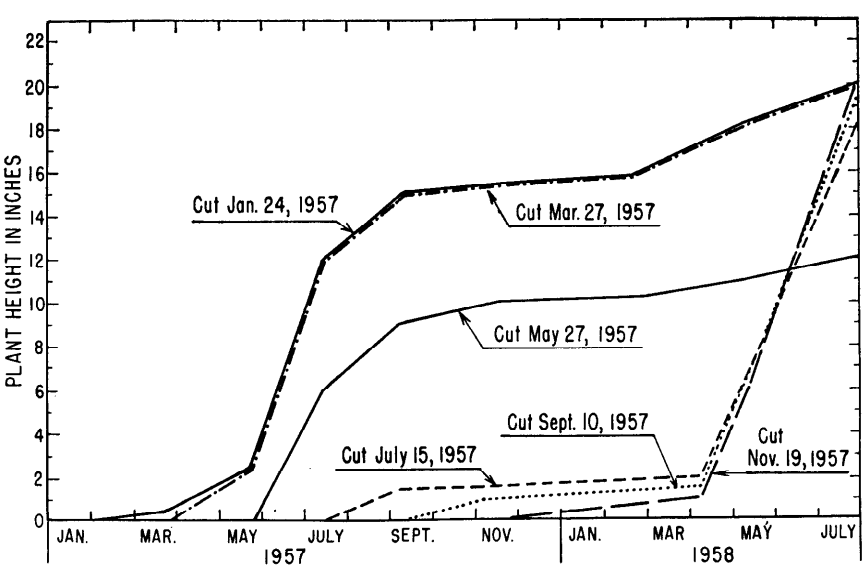

FIGURE 1. Growth curves of chamise sprouts following cutting treatments in 1957.

Table 2. Temperature and rainfall for 1957.

Month	Precipitation	Temperature Mean maximum	Temperature Mean minimum
	Inches	°F	°F
Jan.	7.5	37	25
Feb.	8.5	47	35
Mar.	6.5	48	32
Apr.	3.7	61	38
May	5.3	58	42
June	0.0	80	56
July	0.0	84	61
Aug.	0.0	81	57
Sept.	5.5	77	56
Oct.	7.1	61	44
Nov.	2.5	54	39
Dec.	7.3	44	35

treatment dates is plotted, a growth rate curve as depicted in figure 2 is obtained for 1957. The rapid depletion of starch coincides with the period of most rapid growth. The reduced growth during the autumn when moisture and temperature become more favorable may be related initially to the low stored carbohydrate level, and as the autumn progresses, to low temperatures as well. By the time growth the following spring is vigorous, carbohydrate reserves have been replenished and moisture and temperature conditions are again favorable. From these considerations it is suggested that starch level may serve as a reliable indicator of sprouting potential. Studies to pursue this relationship further are in progress.

Twig moisture, when the measurement is made on the most recent growth of the plant, also exhibits great seasonal change (Figure 3). It increases very rapidly from March to May during the early period of growth rate acceleration, and when growth rate is greatest from May to July it declines, this reduction being at the time of rapid starch depletion. The best evaluation of the effect of a date of cutting on regrowth is obtained the year following the cutting after the plots which were cut the previous autumn have passed through one spring interval favorable for regrowth. This is illustrated by sprout heights as measured on August 5, 1958. By this time the September and November treatments have equalled the January and March treatments in height of sprouting, but the May and July plots were weakened as evidenced by reduced growth. The relationship between twig moisture and regrowth suggest that treatments to reduce vigor of sprouting may be times when the twig moisture is at its peak. This may be an easily usable indicator for the scheduling of treatments. Although twig moisture parallels the growth rate curve, it is not a condition which may be considered to control that curve to the extent that carbohydrate reserves may do so.

It is probable that the date of starch depletion, of twig moisture increase, and of most rapid growth rate varies from year to year depending on the weather conditions which prevail. Observations for several years will clarify this point and indicate the amount of yearly variation. It must be recognized that the psychological condition of the plant rather than a calendar date determines the sprouting potential.

Summary

Sprout growth in chamise was measured after cutting the brush in January, March, May, July, September, and November in 1957. The physiological condition of the plant was evaluated at each date of cutting by chemical analysis of plant fractions and by determinations of growth rate, twig moisture, soil moisture, and prevailing temperatures. Growth measurements were continued throughout the year following cutting.

In this species the root fraction yielded the best samples for analysis being more free of interspersed dead tissue than either the stems or crown. Chemical analyses revealed significant seasonal trends in the content of starch, total sugars, glucose, pro-

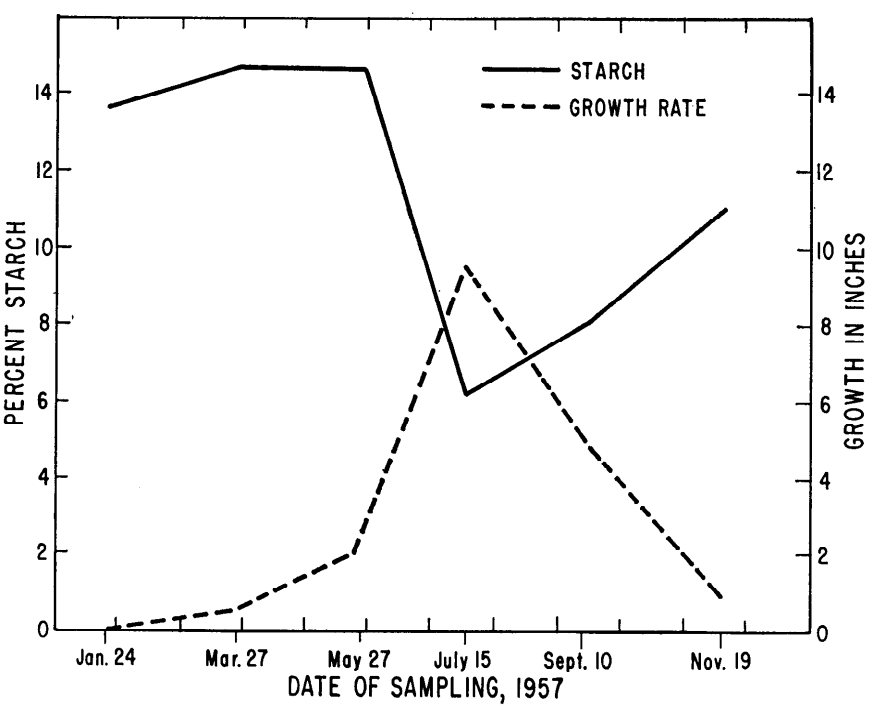

FIGURE 2. Relationship between growth rate and starch reserves.

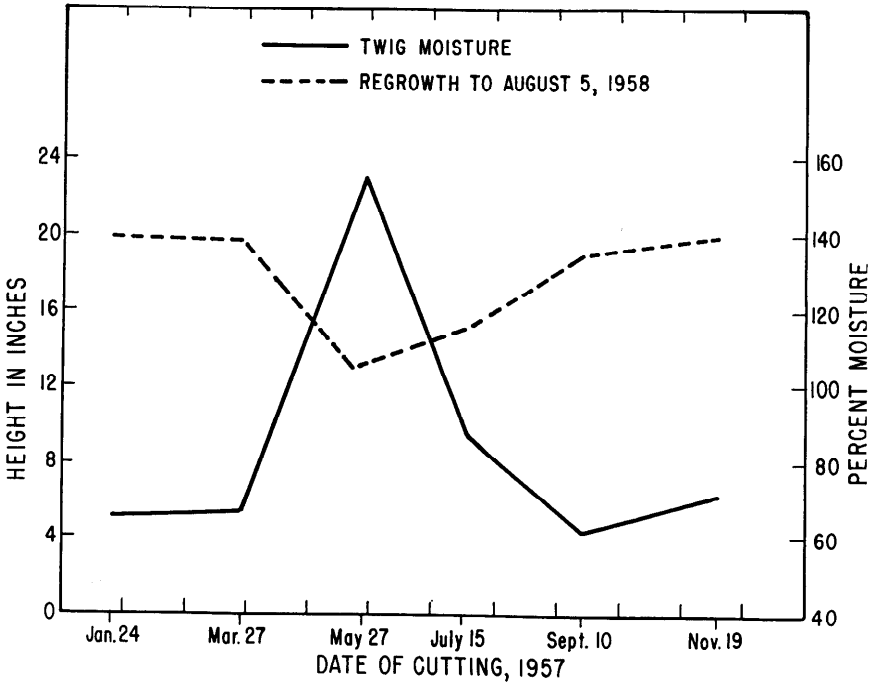

FIGURE 3. Relationship between twig moisture at time of cutting and sprout regrowth.

tein, calcium, potassium, and phosphorus. Of these, starch exhibited the greatest change. Twig moisture also reflected a pronounced seasonal difference.

A sharp rise in twig moisture immediately precedes a rapid increase in growth rate which is associated with an abrupt decline in stored starch reserves. The height of sprouts following spring growth the year after cutting was in general inversely related to twig moisture at the time of cutting and directly related to stored starch content of the root at the time of treatment.

It is suggested that twig moisture and level of stored starch reserves may be used to indicate, at the time of treatment, the subsequent sprouting potential.

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