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TB84: Controlling the Saratoga Spittlebug in Young Red Pine Plantations by Removal of Alternate Hosts

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CONTROLLING THE SARATOGA SPITTLEBUG IN YOUNG RED PINE PLANTATIONS BY THE REMOVAL OF ALTERNATE HOSTS

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INTRODUCTION

The Saratoga spittlebug, *Aphrophora saratogensis* (Fitch), is a major pest of young red pine (*Pinus resinosa* Ait.) and jack pine (*Pinus banksiana* Lamb.) plantations in the Lake States, Ontario, and more recently in the Northeast. This native insect was first described in 1851. It was not until the early 1940's when large areas reforested with red pine or jack pine were infested, that this insect was recognized as being an important pest.

Red pine has been the preferred species in the reforestation of blueberry-sweetfern "barrens" of eastern Maine. These plantations, at times, have been infested by spittlebug to an extent requiring the implementation of chemical control programs. Seedling mortality is often apparent after several seasons of heavy spittlebug feeding (cover photo). Moreover, the growth of red pine in young plantations supporting only moderate spittlebug populations is reduced.

Adults attack the needle bearing twigs of their pine hosts. Red pine is the most severely damaged though jack pine is also attacked, but with less effect on growth and survival (Anderson 1947). Feeding adults can be found on eastern white pine (*Pinus strobus* L.), particularly when it is growing in close proximity to red pine, but recognizable damage is rare.

The life history of the Saratoga spittlebug is described by Ewan (1961). Adults feed by piercing the bark and sucking plant liquids from their pine hosts. Susceptible red pines are generally less than 15 feet in

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height. Since a doubling in height usually means a tripling in the length of needle bearing branches, pines exceeding 15 feet in height are not significantly damaged (Ewan 1961).

There are two main causes of seedling damage (Ewan 1961), firstly, depending on the number of insects, feeding adults withdraw liquids in quantities sometimes sufficient to cause wilting. Secondly, the feeding scars block conduction in xylem tissues which again cause wilting. Damage to seedlings is very similar to that caused by drought.

Appraising seedling damage in the early stages of a spittlebug infestation is not easily accomplished. According to Ewan (1961), the effects of a summer's feeding by adult spittlebugs may not be evident until the following season. Thus, several years of light to medium feeding may go unnoticed. The first obvious, external symptom of feeding damage is flagging (twig foliage turning red or yellow). Flagging usually indicates two or three years of heavy spittlebug feeding and severe damage to the seedlings (Ewan 1961).

Although insecticides are successful in controlling the Saratoga spittlebug, the biology of the insect raises the possibility of an alternative method of control. The spittlebug requires an alternate host to complete its nymphal development. A variety of herbaceous and low woody plants, common on reforested sites, serve as the necessary alternate hosts. Early instars prefer stems of the more succulent, herbaceous vegetation while fourth and fifth instars are much more abundant on woody stems, sometimes several feet from a pine seedling (Secrest 1944, Anderson 1947, Ewan 1961). Woody plants are a prerequisite for a high spittlebug population and sweetfern, *Comptonia peregrina* (L). Coult. is the preferred alternate host (Secrest 1944, Anderson 1947, Ewan 1961, Kennedy and Wilson 1971, Wilson 1971). The severity of spittlebug damage is highly correlated with the abundance of sweetfern, and although sweetfern may not be essential for an outbreak of spittlebug, other woody alternate hosts must be extremely abundant (Kennedy and Wilson 1971).

Secrest (1944) suggested spittlebug damage could be avoided by not planting red pine in open, burned-over areas that supported substantial amounts of sweetfern, or by planting the pines under over-topping hardwoods which shade out intolerant plants like sweetfern. Graham and Knight (1965) mentioned adjusting the density of a plantation, to shade out the alternate hosts of the spittlebug, as an effective silvicultural tool. The elimination or reduction of alternate host plants in a plantation also should reduce the occurrence of epidemic populations of spittlebugs.

In the culture of blueberries on the "barrens" of eastern Maine, sweetfern and other alternate hosts of the spittlebug have been successfully controlled with herbicides. The objective of this study was to investigate the feasibility of using herbicides to control nymphal host plants of the spittlebug in red pine plantations.

In 1974 and 1975 experimental sites were selected, herbicidal treatments were applied, and a nymphal sampling technique was designed to evaluate the effects of herbicidal control of the alternate host plants on nymphal populations of the Saratoga spittlebug.

METHODS

Treatments

Two separate herbicidal treatments were employed. The first treatment involved applying a herbicide to all woody and herbaceous understory vegetation in young red pine plantations. The intent was to eliminate, as much as possible, all available alternate hosts. The second treatment limited herbicidal application to sweetfern, the preferred nymphal host. Untreated control areas were established for comparison.

Selection of Experimental Units

1974. In the spring of 1974, three small red pine plantings were located in T. 30 M.D.; two additional plantings were located in Deblois. These plantings varied in size from approximately one-half acre to less than two acres. All were stocked with red pine seedlings, three to six feet in height, spaced roughly 10 by 10 feet. All of the plantings were spittlebug susceptible due to a combination of dry site, numbers of alternate hosts, high current estimates of spittlebug populations, and current symptoms of spittlebug damage (flagging). Each planting was selected for a different treatment, including control or no treatment, affording a gross comparison of treatment effectiveness.

1975. Three additional units were located within a large plantation in T. 30 M.D. Criteria for selection as an experimental unit were much the same as in 1974. The following guidelines were established;

1. Pines should not exceed 12 feet in height.
2. An abundance of alternate hosts, including sweetfern, must be present.
3. Spittlebug populations should be fairly high, based on feeding scars (Kennedy and Wilson 1971) and numbers of eggs.
4. Areas of extensive spittlebug damage should be avoided.

The 1975 units or blocks differed in design from the 1974 versions; each consisted of three adjacent one by two chain (one-fifth acre) treatment plots. In total, three experimental blocks containing nine treatment plots were established in 1975.

Application of Treatments

The three treatments (treatment of all undergrowth, treatment of only sweetfern, and control) were randomly assigned. An ester of 2,4-D (having a low volatility) (2,4-dichlorophenoxyacetic acid, butoxyethanol ester) and water were applied with a knapsack sprayer equipped with a Tee Jet Spraying Systems flat spray nozzle number 8003. The rate of application was approximately two pounds of 2,4-D per acre. A surfactant (Triton B 1956®) was used to improve spray effectiveness.

The herbicide was applied as uniformly as possible considering the type of equipment. Care was taken to avoid wetting red pine foliage while spraying as close to the seedling as possible.

The 1974 plots were sprayed in June soon after leaf expansion of the sweetfern. They were resprayed seven to ten days later to assure no areas were missed. A third application took place later in the growing season in an attempt to kill the more hardy sweetfern clones and the late blooming lambkill (*Kalmia angustifolia* L.). The 1974 plots were sprayed only in 1974.

The 1975 plots were also sprayed early in the growing season in an attempt to kill the hosts before the spittlebug nymphs completed their development. Missed areas were resprayed 15 days after the first application. The treated plots were not entirely resprayed so as to simulate a practical control technique.

Nymphal Sampling Technique

Fifth instar nymphs were sampled during early July. The sampling technique involved locating quarter milacre sample plots on sites in the understory judged to be highly favorable for spittlebug nymphs. Table 1 contains a list of common hosts found in the "pine barrens" of eastern Maine. Using randomly selected pine seedlings, sample plots were located on a site containing ample stems of the preferred host, sweetfern, and within a radius of five or six feet of the seedling pine. The first favorable site encountered from among randomly selected seedlings was chosen as a sample plot. All stems of the host plants present were examined, and numbers of nymphs were recorded. Three samples were taken per treatment plot. Since separate treatment plots were adjacent, some adjustment for nymphal migration was necessary. This was accomplished by restricting sampling sites to the center portion of the treatment plots.

Table 1. Common Alternate Hosts of the Saratoga Spittlebug in Maine

Host Category	Common Name	Scientific Name[1]
Preferred Host	Sweetfern	*Comptonia peregrina* (L.) Coult.
Secondary Hosts[2]	Blueberry	*Vaccinium angustifolium* Ait.
	Goldenrod	*Solidago* spp.
	Lambkill	*Kalmia angustifolia* L.
	Blackberry, Raspberry	*Rubus* spp.
	Orange Hawkweed	*Hieracium aurantiacum* L.
	Wintergreen	*Gaultheria procumbens* L.
	Strawberry	*Fragaria virginiana* Duchesne
	Wild-Raisin	*Viburnum cassinoides* L.
	Gray Birch	*Betula populifolia* Marsh.
	Black Chokeberry	*Pyrus melanacarpa* (Michx.) Willd.

[1] Scientific names taken from Fernald, M. L. 1950. Gray's field manual of botany, 8th ed. American Book Co., N. Y. 1632 pp.

[2] Includes a wide variety of herbaceous and woody plants.

Understory vegetation in the herbicidally treated areas, although brown and dying, was still discernible at the time of sampling. Dead and dying stems within these sample plots were examined in the same fashion as those in untreated areas. In sampling one year after herbicidal treatment, sample plots were located in any new growth or surviving vegetation, particularly sweetfern.

Analysis

The nymphal sampling data were compared by analysis of variance. A square root transformation, $\sqrt{x + 0.5}$, was applied to the raw data to stabilize the variance (Snedecor and Cochran 1967).

RESULTS AND DISCUSSION

Effects of Herbicidal Treatments on Spittlebug nymphs During the Season of Application

The analysis of nymphal samples collected during the 1974 field season and from the 1975 plots indicates little, if any, reduction in nymphal populations of the Saratoga spittlebug. Table 2 presents an analysis of variance summary table of the first year's data. The F-test for treatments is non-significant. The blocks F-test is highly significant

($P < 0.01$) indicating variability among experimental sites. Based on the fiist season's results, the elimination of alternate hosts does not reduce nymphal populations.

The herbicide killed the tops of the herbaceous and woody vegetation in roughly two weeks and sweetfern tops were thoroughly brown at the time of sampling. However, the root systems, particularly sweetfern, remained active enough to allow the nymphs to complete their development. Later instar nymphs were found feeding almost entirely on sweetfern.

Effects of Herbicidal treatments on Spittlebug Nymphs One Growing Season After Application

Experimental units treated in 1974 and 1975 were again sampled in July of 1975 and 1976 respectively. Table 3 presents an analysis of variance summary table for these data.

Referring to Table 3, the F-test for treatments is highly significant ($P < 0.01$). A Duncan's Multiple Range Test (Table 4) indicates nymphal numbers in treated plots are significantly lower than in control plots. The removal of alternate hosts was beginning to cause a decline in nymphal populations. Plotting the years X treatments interaction data (Tables 3 & 5), the resulting graph (Figure 1) illustrates nymphal responses to herbicidal treatments over a one year period. Populations in the treated areas declined, while control increased slightly. Based on these results, the elimination of alternate hosts reduced nymphal populations during the year following herbicidal application.

Again referring to Table 3, the highly significant F-test for blocks is partly a result of a declining spittlebug population over a three year period and initial population variation among experimental blocks.

Considering the treatments, spraying all undergrowth and spraying only sweetfern, Duncan's Multiple Range Tests of treatment and years X treatment (interaction) means for two years show no significant differences (Tables 4 & 5). Again, referring to Figure 1, the treatments appear to have nearly equal effctiveness in reducing nymphal numbers.

Effects of Herbicide on the Preferred Host of Spittlebug Nymphs

The broadleaved, alternate host plants of the Saratoga spittlebug are all susceptible to 2,4-D. The question arises, how long will it take plants such as sweetfern to reestablish themselves after spraying.

Table 2. Spittlebug Nymphal suppression with 2, 4-D during the Season of Application (transformed data).

Analysis of Variance Summary Table for a RCB Design

Source of Variation	Degrees Freedom	Sum. of Squares	Mean Squares	F Value
Blocks	3	50.888	16.963	19.620***
Treatments	2	0.957	0.479	0.553
Error	6	5.187	0.865	
Subsamples	24	27.603	1.150	
Total	35	84.636		

*** Significant at the 1% level

Table 3. Spittlebug Nymphal Suppression with 2, 4-D One Season After Application (transformed data)

Analysis of Variance Summary Table for a RCB Design

Source of Variation	Degrees Freedom	Sum. of Squares	Mean Squares	F Value
Blocks	3	28.461	9.487	17.170***
Treatments	2	30.441	15.220	27.545***
Error	6	3.315	0.552	
Years	1	9.136	9.136	2.656
Yr X Trmts	2	22.523	11.261	3.274*
Error	9	30.954	3.439	
Subsamples	48	49.770	1.037	
Total	71	174.600		

*** Significant at the 1% level
* Significant at the 10% level.

Table 4. Treatment Means for Spittlebug Nymphal Suppression with 2, 4-D One Season after Application (transformed data).

Herbicide Treatment	Mean Number of Nymphs/Sample*
All Undergrowth	2.629a
Sweetfern Only	2.325a
Control	3.831b

* Any two means not followed by the same letter are significantly different using a Duncan's Multiple Range Test at the 10% level.

Table 5. Years X Treatments (interaction) Means for Spittlebug Nymphal Suppression with 2, 4-D (transformed data).

	Mean Number of Nymphs/Sample* Treatment		
Year	All Undergrowth	Sweetfern Only	Control
1	3.403a	3.054a	3.397a
2	1.855b	1.597b	4.265a

* Any two means not followed by the same letter are significantly different using a Duncan's Multiple Range Test at the 10% level.

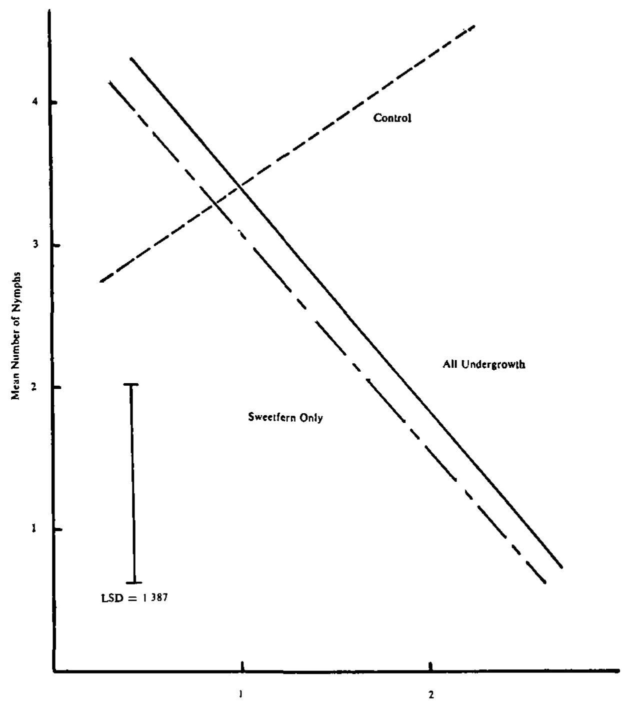

Figure 1. Years X Treatment (Interaction) Means for Spittlebug Nymphal Suppression with 2,4-D (transformed data)

The 1974 herbicidal treatment areas received several applications of 2, 4-D, and apparently all the broadleaved hosts were killed. The following season a check was made to estimate the extent of sweetfern reestablishment. One hundred clones of brown-topped sweetfern (stems were easily located) were inspected in each plot, and the number of clones with any new shoots tallied.

Results (Table 6) indicated that one year after herbicidal application, where all undergrowth was treated, nine percent of the sweetfern clones sampled showed some new growth. Where sweetfern only was sprayed, six percent sent up some new shoots. A greater percentage of sweetfern survived in the plots treated in 1975 when checked late in the growing season. An average of approximately 20% survived where all undergrowth was sprayed and 15% where only sweetfern was treated. These 1975 plots received only one complete application of 2,4-D. Despite being less than completely successful in eliminating sweetfern, the number of stems available as nymphal feeding sites was greatly reduced. In all probability, 90 to 95% of the available feeding sites were destroyed both years. Knapsack sprayers had limitations and high volume equipment might have been more effective. No attempt was made to evaluate the mortality incurred by other host plants.

CONCLUSIONS

Silvicultural control of the Saratoga spittlebug is an effective technique for protecting susceptible pines from serious damage. This method seldom produces a drastic, sudden reduction in insect populations as is common with some insecticidal applications. Nevertheless, the elimination of a substantial portion of the alternate hosts lessens the chance a given plantation will ever support an epidemic spittlebug population.

Table 6. Percentage of Sweetfern Clones Showing New Growth after Herbicidal Treatment

Year	Treatment: All Undergrowth	Treatment: Sweetfern Only
1974 areas, sampled 1 yr. after treatment (received more than 1 application of herbicide).	9%	6%
1975 areas, received only 1 application of herbicide (average of 3 treatment plots).	19%	15%

Experimental results indicate herbicidal treatment of alternate hosts affords little spittlebug control during the year of application. However, the following season does bring a noticeable reduction in nymphal numbers. No significant differences could be detected between two types of treatments, spraying all understory growth and spraying only sweetfern. The herbicide 2,4-D does an adequate job of killing sweetfern and other hosts, but may require more than one application to be effective on dense, well established vegetation.

Silvicultural control has the advantages of not requiring the precise timing needed with insecticides and the possibility of improving growth rates of seedlings by weeding out undesirable plant competition. Any large scale application of herbicides would require tractor drawn equipment. This is feasible in plantations since seedlings are spaced with enough interval to allow passage of equipment. Timing not being critical, treatments could be applied from mid-June through July to produce noticeable reductions in the spittlebug population the second season following spraying.

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