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Fig. 1. An enlarged, distorted sand cherry fruit (left) and leaves (right), both as a result of infection by the leaf curl and pockets fungus

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Summary

A single dormant spray controls leaf curl and pockets of sand cherries and plums in South Dakota. Lime-sulphur, 31-33° Baume′, diluted 1 part to 9 parts of water, is a suitable spray material; it may be applied in the fall after the leaves drop or in the spring by April 1.

Leaf curl and pockets of sand cherries and plums is caused by the fungus, *Taphrina communis*. Its essential feature in relation to control is that it overwinters only as spores, some of which are lodged on the overwintering buds of the host plant.

Covering the entire plants with a single spray of lime-sulphur in the fall or spring while the buds were dormant achieved satisfactory control on the sand cherry. Fall sprays were successful in 1942, 1943 and 1944; spring sprays were highly successful in 1943 and 1944 and partially successful in 1942. Combinations of fall and spring sprays seemed slightly superior to either one alone, but are probably not justified. The fungus was spread readily in 1943 from relatively few infections in the experimental block. Such spread indicates the necessity for spraying every year.

Leaf Curl and Pockets Control by a Lime-Sulphur Dormant Spray

By W. F. Buchholtz *and* C. M. Nagel[1]

A very common fruit disease in South Dakota is leaf curl and "pockets" of plums and related fruits, including the western sand cherry, cultivated forms of which are collectively known as the "Hansen bush cherry." This disease is cause for concern because of the frequent high percentage of dropped, infected fruits, particularly of plums, and is the basis for many inquiries because of the peculiar appearance of the inflated fruits and distorted leaves and branches typical of the disease.

The western sand cherry *(Prunus Besseyi)* is a native of South Dakota. It is hardy enough to be grown anywhere in the state and constitutes a relatively certain supply of fruit wherever grown. Because it is small and therefore easily sprayed, the sand cherry was chosen as an appropriate experimental plant on which to determine the feasibility of spraying for leaf curl and pockets control.

Possibility of control was investigated on the basis of resemblance of this to similar diseases of other species of the plum family, notably peach leaf curl, which can be controlled by a single dormant spray. It is clear from the results presented here that control of leaf curl and pockets of sand cherry, and presumably of plums, can likewise be accomplished by a single spray in the fall or in the early spring while the buds are dormant.

Symptoms of Leaf Curl and Pockets

Leaves, current season's twigs and fruits are affected by this disease. The infected leaves and young twigs on which they occur grow abnormally fast and irregularly and thereby become enlarged and distorted, as shown in Fig. 1. Infected fruits become enlarged, their pits fail to develop and their centers become hollow, so that the term "pockets" is appropriate for sand cherries as well as plums. Sand cherry fruits so afflicted usually are long and pointed (Fig. 1), but frequently become irregularly round and wrinkled.

The development of enlarged and distorted leaves, twigs and fruits begins in the spring soon after the leaf and flower buds open and parallels the development of normal leaves and fruit up to the appearance of the layer of spore sacs in mid-June. Thereafter most of the enlarged fruits drop and many of the distorted twigs and clusters of leaves disintegrate and die. A few infected leaves and twigs remain alive until frost, but all are dead by the following spring.

The enlarged, distorted leaves, twigs and fruits are somewhat lighter than normal green in color and gradually acquire a reddish tinge. As the causal fungus approaches maturity, the surface of infected parts is covered by a layer of spore sacs, which are apparent to the unaided eye as a grayish sheen.

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Cause of Leaf Curl and Pockets

A microscopic examination of the surface layer of infected, distorted leaves, twigs and fruits in mid-June reveals a layer of spore sacs which contain spores of the fungus, *Taphrina communis*. Its appearance, together with the symptoms it induces, indicates its similarity to other members of this genus which cause similar maladies on other members of the plum family (i.e., peach leaf curl). Their development has been extensively studied.

The spores are ejected from the spore sacs in late June. Some of them lodge on the young buds which are developing in the axil of every normal leaf and from which will develop the following season's crop of leaves, young twigs and fruit. The spores remain dormant with the bud during late summer, fall and winter. In the following spring when the buds begin to unfold, infection of the very young developing leaves, twigs and fruits takes place. The fungus permeates the outer tissues and stimulates them to abnormally rapid and irregular growth. The development of the fungus culminates in the new crop of spore sacs on the surface in mid-June. The seasonal development of *Taphrina communis* is shown in Fig. 2.

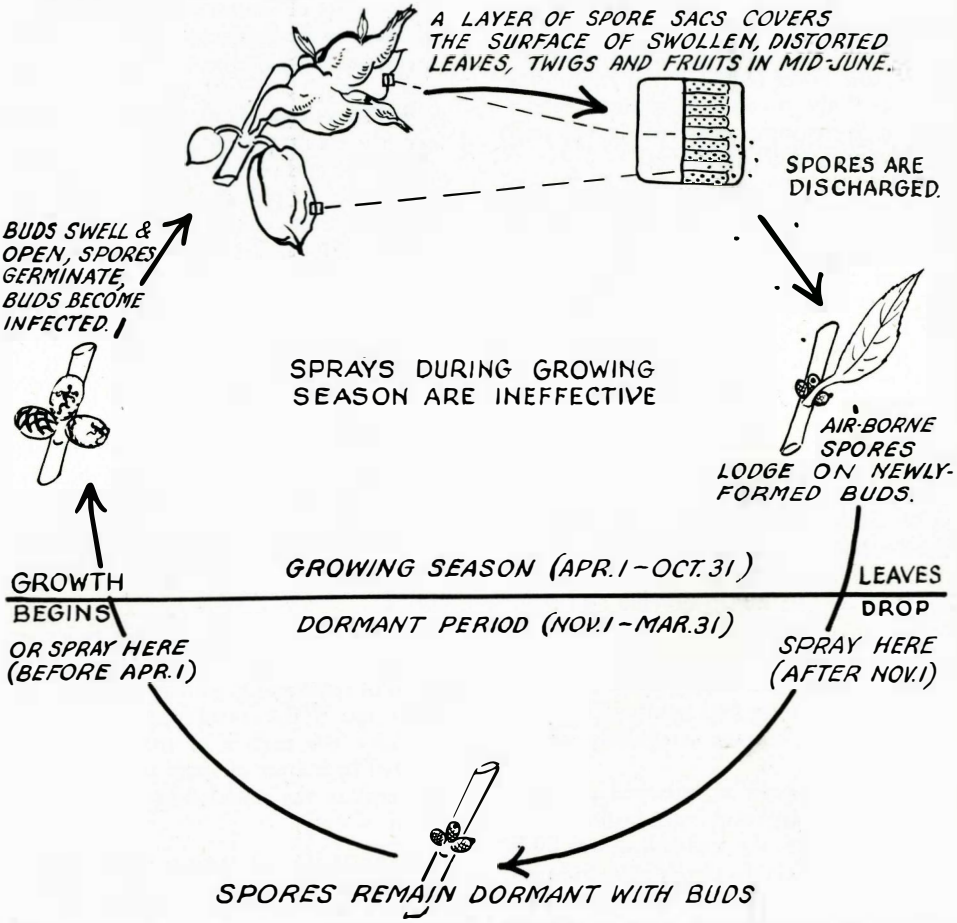

Fig. 2. Seasonal development of the leaf curl and pockets fungus in relation to its control by a dormant spray.

Three characteristics of *Taphrina communis* need emphasis because they are in effect the basic principles of its control: (1) Its spores overwinter only on the surface of dormant buds; they do not penetrate the dormant bud. A fungicide, to be effective, needs only to kill these surface-borne spores. (2) Virtually all infections occur as the buds are opening; there is no "spread" from these first infections. A thorough spray while the buds are dormant can prevent all infection; sprays after the buds have begun to open are too late to prevent any infection. (3) Infected twigs die. Therefore there is no resumption of growth by infected twigs the following season and there are no "hold-over" infections. Since all infections are new ones, all are controllable by a dormant spray.

The experimental evidence which supports these principles is subsequently presented.

Control by Spraying

It is well known that a single dormant spray controls peach leaf curl, which is a very similar disease; in fact, such a spray is common practice in commercial peach growing. For this area two instances of successful plum pockets control are on record. In Montana,[2] nearly perfect control was achieved by a dormant spray with lime-sulphur in April and early May. In Minnesota[3] a degree of control was similarly attained, but freedom from infection was not accomplished by a single dormant spray.

The objective of the spray experiments conducted at the South Dakota Agricultural Experiment Station was to determine whether or not *Taphrina communis* could be controlled by a single spray or a series of sprays. After the 1942 results were available, it was obvious that on the sand cherry a single dormant spray in November was effective, but there was still doubt about the time at which a spring spray was effective. The experiments in 1943 and 1944 indicated that single sprays in March and April were as effective as a fall spray.

All the spray applications were of lime-sulphur, 31-33° Baume′,[4] diluted 1 part in 9 parts of water. The single exception was the spray application of May 16, 1942, which was the same lime-sulphur diluted 1 to 39 parts of water. All sprays were applied with a four-gallon pump tank sprayer. All three years' experiments were on the same planting of sand cherries, which was four rows wide and divided into two replicates of seven blocks or spray treatments each.

The spray dates for the 1942 experiment were: November 14, 1941; April 1 and May 16, 1942; and combinations of these dates. For the 1943 experiment, they were November 7, 1942; March 11, March 23, and April 9, 1943; and combinations of November 7, 1942, with March 11 and March 23, 1943. For the 1944 experiment they were November 17, 1943; and April 1, April 11, and April 22, 1944. In 1942 and 1943 there was one unsprayed block in each of the two replications; in 1944 there were three in each replication.

The infected leaves, twigs and fruits were counted each year in mid-June. In 1942 and 1943, no distinction was made in the records between infected leaves and twigs and infected fruits; in 1944, they were recorded separately. The data thus accumulated appear in tables 1, 2, 3, and 4.

Effectiveness of Fall Sprays

Fall sprays were effective each year (November 14, 1941; November 7, 1942; November 17, 1943). In the 1942 experiment (Table 1), only the plots sprayed in the fall of 1941 were relatively free of infection. In 1943 there was a dry spring and very

[2]Swingle, D. B., and Morris, H. E. Plum pocket and leaf gall on American plums. Montana Agr. Exp. Sta. Bul. 123. 1918.

[3]Stakman, E. C., and Tolaas, A. G. The control of brown rot of plums and plum pocket. Minnesota Horticulturist. **45**:182-186. 1918.

[4]31-33° Baume′ is the concentration of lime-sulphur available at most drug stores.

little leaf curl and pockets, even in the unsprayed plots, but there was evidence of control by the spray applied the previous fall (Table 2). In the 1944 experiment, the fall spray was applied on November 17, 1943, and thorough coverage of the plants was impossible because many branches were covered by snow to a depth of 12 to 15 inches. Even so, there was 84 percent control (Table 3).

Effectiveness of Spring Sprays

In 1943 and 1944, early spring sprays also accomplished effective control, as good if not better than the fall sprays. In the first experiment, in 1942, the spring spray on May 16 was ineffective, which was expected, since by then the buds were fully opened, some stem growth had taken place and flower petals had fallen. Better control was expected from the April 1 spray, and subsequent results have justified that expectation. The data from plots sprayed on April 1, and plots sprayed on April 1 and again on May 16, indicated 40 and 54 percent control, respectively (Table 1), and it may be significant that the plots sprayed on November 14 and again on April 1 were the only plots in which no infected leaves, twigs or fruits were found.

The tentative conclusion reached after evaluating the 1942 results was that the first spring spray on April 1 probably was not early enough. Consequently, the 1943 spring sprays were on March 11, March 23, and April 9. All achieved effective control (Table 2). In 1943, during a late spring, the spray applications were made on April 1, April 11, and April 22. All were effective (Table 3). Despite the results in 1942, the data for 1943 and 1944 indicate that spring sprays are effective for leaf curl and pockets control.

Combination of Fall and Spring Sprays

Combinations of fall and early spring sprays in the 1942 and 1943 experiments (Tables 1 and 2) resulted in almost perfect control (100, 99 and 100 percent). However, single fall or spring sprays were 88 percent or more effective, usually 95 percent or more. Since absolute freedom from disease in any given season does not necessarily preclude infection the succeeding year (see following paragraph), there probably is no need to apply two dormant sprays for leaf curl and pockets control, even in the commercial orchard.

Other Facts Pertinent to Leaf Curl and Pockets Control

Taphrina communis *Spreads Readily Into Blocks of Disease-Free Plants*

Relative lack of infection in a block of plants apparently does not insure freedom from infection the following year. In the last two columns of Table 3 are indicated whether (+) or not (—) the disease was present in the various plots in the previous two years. It is particularly significant that sprays had virtually eliminated leaf curl and pockets from 12 of the 14 plots in 1943, and there were very few infections in the two unsprayed plots. Yet in 1944, after a cold, wet spring, there was a generally heavier infection than the year before. Furthermore, there were as many or more (136.0) visible infections on plants in unsprayed plots that had been relatively free of infection as a result of spraying the two previous years, as in plots that had been unsprayed all three years (80.5).

It is clear that there was considerable spread of *Taphrina communis* from a very few infections in 1943, and equally to plants in all plots, whether they were previously free of infection or not.

Although it can not be surmised what would happen to plants absolutely free of

infection and well isolated, such a situation is not likely to occur very often in areas where the disease is common, and, therefore, spraying will need to be an annual precaution.

Infected Twigs Die

Taphrina communis does not overwinter on infected sand cherry twigs in South Dakota. In November, 1942, 100 infected twigs were tagged for further observation. In May, 1943, 86 tags were recovered, and all 86 infected twigs were dead. The bark at their bases was healthy and in no case had it given rise to adventitious growth. This evidence, plus the successful control by spraying and the evidently indiscriminate infection of unsprayed bushes whether infected or not the previous year (Table 3), is against the likelihood of hold-over infections in living plant parts, and well indicates that each infection is of the current season.

Can Pockets Be Controlled on Plum as Well as on Sand Cherry?

The results of these spray experiments apply for plums as well as sand cherries. The fungus causing pockets of plum is evidently the same as the one on sand cherry. On the sand cherry, leaf and stem infections and fruit infections are caused by the same fungus, and both types of infection were controlled by the spray (Table 4). Furthermore, excellent control of plum pockets by a dormant spray was achieved in Montana, and likewise a reasonable degree of control in Minnesota. It appears that the South Dakota sand cherry leaf curl and pockets fungus is identical to the Montana plum pockets fungus.

The sand cherry was chosen as the subject for control experiments because it is small and therefore easily sprayed, and was available in large numbers in a block suitable for experimentation. The results should be applicable to plums.

Effect of Weather on the Amount of Leaf Curl and Pockets

Cool, wet weather at the time the buds are swelling and beginning to grow is reputed to favor infection by the leaf curl and pockets fungi. March and April of 1941 were, in general, wet,[5] and although no counts were made, leaf curl and pockets infections were observed to be abundant. In 1942, March was wet and the second warmest on record, which may have resulted in early swelling of buds and partial failure of the April 1 spray. Early April was dry and warm, but there was a normal amount of leaf curl and pockets, probably as a result of infection in March, though less than in 1941. March was cold and dry in 1943, and April was warm and very dry; leaf curl and pockets almost disappeared from the experimental plots. In 1944, March was cold and dry but April was cool and moist and there was again an appreciable amount of infection.

Since 1941 the occurrence of leaf curl and pockets at Brookings has been favored by cool, wet weather in March or April, at the time the buds are swelling and beginning to open. An occasional period of unusually warm weather in March may result in early infection, so that spraying on the first warm day in March is obviously a sound practice.

[5]Climatological Data, U. S. Department of Commerce Weather Bureau, Huron, South Dakota.

Tables

Table 1. The Amount of Leaf Curl and Pockets on Sand Cherries Sprayed in November, 1941, and April and May, 1942

Spray dates	Infected buds*	Bushes with infected buds	Bushes in plot	Control, percent
Nov. 14	1.0†	1.0	50.0	99
Nov. 14, April 1	0	0	49.0	100
Nov. 14, May 16	7.5	3.0	42.0	95
April 1	77.0	20.0	46.0	40
April 1, May 16	59.5	20.0	45.5	54
May 16	143.0	29.5	57.5	None
Not sprayed	129.0	28.5	52.5	----

*Buds from which developed an infected twig (with leaves) or infected fruits. Since these infections took place before the buds were opened, the term "infected buds" is used in Tables 1 and 2.

†All data are averages of two plots.

Table 2. The Amount of Leaf Curl and Pockets on Sand Cherries Sprayed in November, 1942, and March and April, 1943

Spray dates	Infected buds*	Bushes with infected buds	Bushes in plot	Control, percent
Nov. 7	5.0†	3.0	50.0	88
Nov. 7, March 11	0.5	0.5	49.0	99
Nov. 7, March 23	0	0	42.0	100
March 11	1.0	1.0	46.0	98
March 23	1.5	0.5	45.5	97
April 9	2.5	1.5	57.5	94
Not sprayed	41.5	11.5	52.5	----

*See footnote in Table 1.

†All data are averages of two plots.

Table 3. The Amount of Leaf Curl and Pockets on Sand Cherries Sprayed in November, 1943, and April, 1944

Spray dates	Leaves, twigs, fruits infected*	Bushes with infected parts	Bushes in plot	Control, percent	Plots with or without infections in 1943	Plots with or without infections in 1942†
November 17	18.5‡	4.5	39.0	84	— —	— —
April 1	0.5	0.5	38.5	99	— —	+ +
April 11	13.5	5.5	43.0	88	— —	+ —
April 22	7.5	4.0	37.5	93	— —	+ +
Not sprayed	80.5	16.5	47.0	....	+ +	+ +
Not sprayed	123.5	22.0	43.0	....	— —	— +
Not sprayed	136.0	24.0	48.5	....	— —	— —

*In 1944, each distorted twig (with leaves) or swollen fruit was counted as 1.

†All three years' spray experiments were on the same sand cherry block. Each year the relative freedom (—) or abundance (+) of disease on plants in a plot depended on whether or not that particular plot had been effectively sprayed.

‡All data are averages of two plots.

Table 4. A Comparison of Control of Leaf and Twig Infection and Fruit Infection by Spraying in 1944

	Number plant parts infected	
	Leaves and twigs	Fruits
Sprayed	6.4*	3.6*
Not sprayed	93.3†	20.0†
Control, percent	93	82

*Average of 8 plots.

†Average of 6 plots.