FRONTIERS
OF PLANT SCIENCE

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Growing asparagus in Connecticut. See page 3.

THE CONNECTICUT AGRICULTURAL EXPERIMENT STATION NEW HAVEN

Aspirin products are tested for compliance with standards

By Lester Hankin

To test the quality of aspirin products sold in Connecticut, the Department of Analytical Chemistry in cooperation with the Drug Division of the Connecticut Department of Consumer Protection, tested 68 samples of aspirin products collected at drug and food stores. The types included tablets, capsules and powders. Some contained only aspirin as the active ingredient, while others contained additional active ingredients (Table 1). The 68 samples represented 31 manufacturers or distributors and 36 different brands including generic as well as well-known brands.

Table 1. Combination of active ingredients in aspirin products tested.

Ingredients	No. samples
Aspirin	54
Aspirin + Caffeine	6
Aspirin + Caffeine + Acetaminophen	6
Aspirin + Caffeine + Salicylamide	2

Aspirin, acetaminophen and salicylamide have essentially the same analgesic action. Caffeine is a stimulant and diuretic. Some products are labeled "buffered", "time release", "coated", or "children's." Others are labelled with terms such as "super", "extra-" and "maximum strength", or "arthritis formula" to imply enhanced pain-relieving potential. Since aspirin dissolves more quickly in an alkaline medium, buffered aspirin usually contains magnesium and aluminum hydroxide to increase the rate of dissolution of the aspirin in the stomach. Coated aspirin is formulated so that the product passes through the stomach before dissolving in the more alkaline small intestine. This prevents gastric distress. Time-release products are designed to dissolve slowly to prolong the analgesic action. Children's aspirin contains a much lower dosage, usually about a third the amount found in aspirin for adults.

According to Standards set by the United States Pharmacopoeia (USP) the amount of active ingredient must be between 95 and 105% of the labelled amount. The USP sets maximum limits for the amount of non-aspirin salicylates in aspirin products. We determined the amount of non-aspirin salicylates; this shows if the product had deteriorated since manufacture. We also examined the weight variation among individual tablets, capsules and powders. Generally, 20 units (either tablets, capsules or packets of powders) are weighed, the average calculated, and each unit may not vary from the average weight by more than a specified amount, usually 5 to 10%. This is to assure that each unit contains the same amount of active ingredient.

Our testing showed all products contained the guaranteed amounts of aspirin, salicylamide and acetaminophen (Table 2). One product contained excess caffeine, but we determined that the amount was close enough to the label claim to be acceptable.

Our tests show that products implying more pain-relieving capacity, such as "maximum" or "super strength", on the average contained about 34% more aspirin than the regular product. In two cases, products from the same manufacturer labelled as "extra strength" contained about a fourth less aspirin than the regular product, but had additional active ingredients such as acetaminophen and caffeine.

No sample contained excessive non-aspirin salicylates. This shows that little or no deterioration had occurred since

Table 2. Percentage of labelled amount of active ingredients found.

Active ingredient	No. samples	% of Labelled amount, range	Average %
Aspirin	54	96-105	100
Caffeine	14	95-111	101
Acetaminophen	6	96-104	99
Salicylamide	2	98-102	100

Analgesics or pain-relieving materials have been used throughout history. Tribal medicine men stewed herbal brews that were administered with the proper incantations and exorcisms for the relief of pain. Physician-priests of all faiths later experimented and expanded the use of tranquilizing herbs. Many of the herbs that were used as pain-relievers were grown in monastery and temple gardens. Wine and other alcoholic beverages also were used to alleviate pain. Opium, the most ancient pain-reliever, can be traced back 5500 years. Morphine, derived from opium, was isolated in 1803. Salicylic acid, derived from a *Spirea* species but also found in the leaves of willow and poplar trees, has been used for the relief of pain from about the beginning of the 18th century. It is thought that Hippocrates, the father of medicine, used willow leaves for the relief of pain.

In 1859, about 125 years ago, acetylsalicylic acid, the ester of salicylic acid, was synthesized. Acetylsalicylic acid was introduced in 1899 under the name of aspirin as a therapeutic agent for mild aches and pains, for allaying fever, and for reducing swelling.

Aspirin is indeed a common non-prescription medicant and most households contain this product. Retail sales of aspirin in the United States were $726 million in 1983. This is about 1.4% of the $52.5 billion in total sales of all prescription and non-prescription drugs and toiletries.

manufacture. All products were within the required weight variation among individual units.

The range in amount of active ingredient is shown in Table 3. Children's aspirin is not included in the table. The range in values reflects potencies of regular aspirin products as well as those labelled as "extra" or "super strength."

Our tests show that aspirin products sold in Connecticut meet USP specifications. Thus, Connecticut consumers can be reassured that the products contain the correct amount of active ingredient. Complete results of our findings are published in Station Bulletin 799, Quality of Aspirin. Results are listed by brand name for comparative purposes. The Bulletin is available free by writing to Publications, Box 1106, The Connecticut Agricultural Experiment Station, New Haven, CT 06504.

Table 3. Range in amount of active ingredient.

Active ingredient	Mg, range
Aspirin	227-650
Acetaminophen *	194-250
Caffeine *	15-65
Salicylamide *	195-200

*Where labelled

New cultural methods may help restore asparagus in Connecticut

By Gordon S. Taylor and Thomas M. Rathier

At one time asparagus was an important crop in the Connecticut River Valley. The deep, well-drained soils were perfect for the tender spears that burst from the ground each spring. But both commercial and home garden plantings of asparagus have declined, mostly due to a disease called *Fusarium* crown rot. Because of increased interest in Connecticut-grown produce we are evaluating new cultural methods to help restore asparagus to Connecticut farms and gardens.

Asparagus is an herbaceous perennial; its above-ground portion, the fern, is killed by frost each autumn. Only the roots and crowns survive from one year to the next. Therefore, photosynthesis in the fern must produce adequate carbohydrates for storage in the roots for growth of the next year's crop. The tender shoots we eat would otherwise become ferns, so harvesting the spears is detrimental to the survival of the plant. Knowing when to stop cutting and allowing enough spears to become ferns is a major cultural problem.

Traditionally, asparagus has been grown from seeds sown outdoors in rows. Then, after the tops have died back, the roots are dug and stored overwinter. The roots are replanted in the early spring in well drained soil at the bottom of 10-12 inch deep trenches and the trenches are filled as the ferns grow. The third year after planting, the first small harvests are taken, with larger harvests each year until the seventh or eighth year, when yields begin to decline.

Beds which once yielded well for 15 to 20 years now last only 5 to 6 years because of the *Fusarium* disease. There are two forms of *Fusarium,* and no effective chemical control exists for either form. *Fusarium oxysporum* is a soil-borne disease closely related to the *Fusarium* species that cause vascular wilt disease in tomatoes, eggplants and peppers. It enters asparagus roots via mechanical or insect-caused injuries. *Fusarium moniliforme* is airborne and its spores can infect the plant anywhere above ground, such as the flower or stem, especially areas that are injured. From the infection site, the disease may grow down the inside of the stem and infect the crown below the soil surface. In the Northeast, *F. moniliforme* can be found in the stems of virtually every asparagus plant, including those that appear healthy. However, crown infection seems to occur only on plants that are

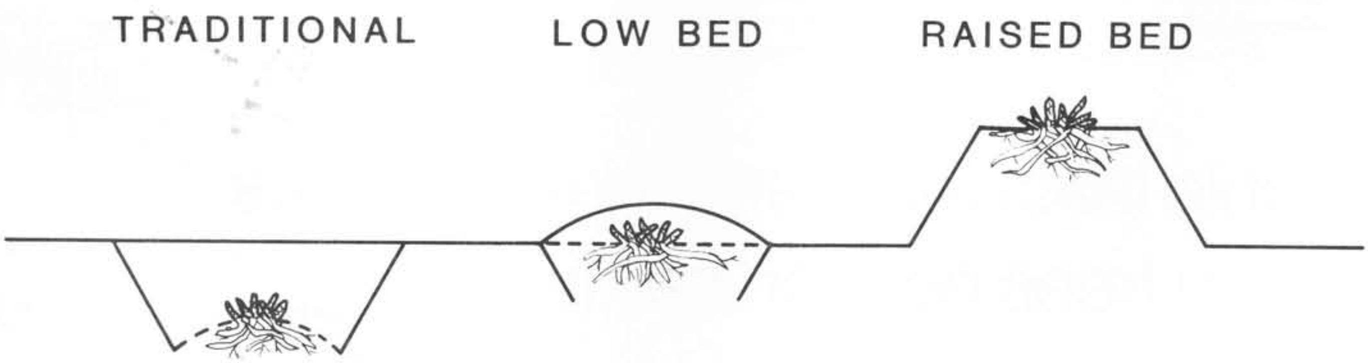

Fig. 1. Asparagus planting methods. ***Traditional*****: A 10-inch deep trench is formed, the crowns are planted 8 inches deep, and soil is added periodically as the plant grows until the trench is filled.** ***Low bed*****: A 2-inch deep trench is dug, the crowns are planted at ground level, and a 2-inch high mound is formed above the crowns to help anchor the ferns.** ***Raised bed*****: An 8-inch high by 12 inch wide raised bed is formed, the roots are placed on top, and are covered with 1-2 inches of soil.**

stressed. To prevent *F. moniliforme* from entering the crowns, growers try to avoid stress-producing conditions such as poor drainage, drought, insect damage, under or over-fertilization, weed competition, or over-harvesting. Careful monitoring of the asparagus bed throughout the growing season can help avoid such stressful conditions. The one exception is poor drainage, which allows water to remain in the soil, prevents oxygen from reaching the roots, and weakens crowns thereby promoting growth of *Fusarium*. While the soils of the Connecticut River Valley normally provide excellent drainage, those in many parts of the state do not. Because raised beds have helped make poorly drained soils suitable for other perennial crops such as strawberries, we decided to test raised beds for improving growth of asparagus.

We compared two different raised elevations (Fig. 1) with the traditional planting method. We began in April 1983 by planting crowns of 'Martha Washington' spaced 12 inches apart. In the low bed we made a shallow (2 inches deep by 8 inches wide) trench and placed one-year-old roots in the trenches so that the crowns were just below the surface of the soil. We then filled the trench to the soil line and covered it with a small (2 inches high by 8 inches wide) mound of soil to help anchor the emerging ferns. In the raised bed, we formed raised soil beds (8 inches high by 12 inches wide). We planted the roots so that the crowns were just below the top of the raised bed. In the traditional method, we planted roots with the crowns 8 inches below the soil surface. All treatments were grown in Merrimac sandy loam, a moderately drained soil, and were fertilized as needed. We monitored weeds, insects, diseases and water needs, and took action when required to avoid stressing the plants.

We observed crown survival, plant height, stem diameter and presence of *Fusarium* during the first two years. In 1983-84 the only significant difference we found was in crown survival. By April, 1984, 14.4% of the crowns planted in the traditional method were dead compared to 2.5% for the low bed, and 2.8% for the raised bed. The damage appears to have occurred between planting and complete filling of the trench. Heavy rains flooded the trenches and prevented adequate oxygen from reaching the crowns.

After the winter of 1983-84 (with average protecting snow cover), the plants in the low bed emerged sooner than in the traditional bed. This indicated that the plants in the raised beds had not been adversely affected by winter temperatures. The opposite was true after the relatively snow-free winter of 1984-85, with the plants in the traditional bed emerging sooner.

Table 1. 1985 Asparagus Yields.

Planting method	Yields (lbs per acre)				
	Apr 22	24	26	29	Total
Traditional	305 a	193 a	332 a	179 b	1009 a
Low bed	169 b	149 ab	329 a	238 a	885 ab
Raised bed	68 c	136 b	313 a	186 ab	703 b

Numbers followed by the same letter are not significantly different.

The first harvest was in the spring of 1985. Spears at least 7 inches long were cut at ground level on April 22, 24, 26, and 29. Although spears emerged later, we suspended harvesting to avoid stress. The first harvest (Table 1) shows the effect of the earlier emergence of the traditional planting. Nearly twice as much yield was obtained in the traditional planting as in the low bed and over four times as much as the raised bed on the first harvest. By the third harvest, however, the differences diminished. The two elevated plantings surpassed the traditional in the fourth harvest. The trend indicates that the differences observed in the total yields may only be due to delays in spear emergence.

We determined crown rot caused by *Fusarium* by counting the number of stalks that yellowed and died during June, July and August. The traditional method had 20 diseased stems per plot, the low bed 32, and the raised bed 35. These differences were not statistically significant.

In 1985, crown rot was determined in May, June, July, and August. The traditional method had 12 diseased stems per plot, the low bed 26, and the raised bed 34. Replicates were less variable and the differences were highly significant. Isolations from such stalks confirmed the presence of *Fusarium*. Thus, we found that elevating plants did not reduce the incidence of *Fusarium* and may even have increased it.

We will continue harvesting and monitoring the crowns for several more years to determine long-term effects of these cultural practices. In addition, we will harvest five all-male lines of asparagus from New Jersey plus three others with tolerance for *Fusarium* for the first time in 1986 and are studying ways to reduce injury from insects. We hope that results from these tests will assist in restoration of commercial asparagus culture in the Connecticut Valley.

Apple leafminers and their parasites live in trees near orchards

By Chris T. Maier

About a decade ago, tiny leafminers suddenly rose from obscurity to prominence in northeastern apple orchards when their adults became resistant to widely-used organophosphorus insecticides. Because large infestations reduce tree vigor and the quantity of marketable apples, I have been studying leafminers to develop a defense against this serious threat to the Connecticut apple industry.

My annual surveys since 1980 indicate that the apple

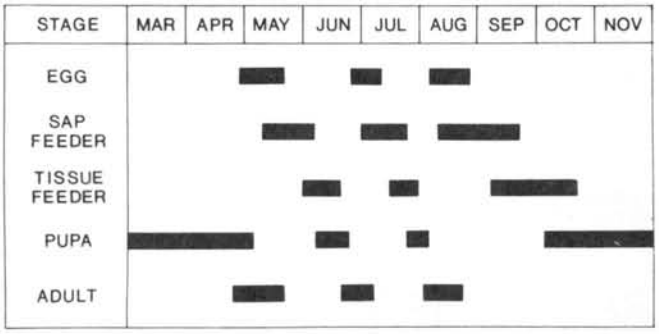

Fig. 1. Seasonal development of the apple blotch leafminer in southern Connecticut. Horizontal bars indicate when each life stage is present. Pupae overwinter in fallen apple leaves from December to March.

blotch leafminer *(Phyllonorycter crataegella)* is the leading leafminer pest of apple in Connecticut. This species comprised 90-100% of the leafminers in seven commercial orchards examined during 1983 and 1984. Growers now depend upon non-organophosphorus insecticides to control leafminers.

I have found that the apple blotch leafminer has three generations per year (Fig. 1). Adult moths (Fig. 2A) emerge in spring and lay eggs on leaves (Fig. 2B). Young, flattened caterpillars known as sap feeders live individually in shallow mines in the undersides of leaves. They lacerate leaf tissue with scissor-like mouthparts and drink the liberated fluid. At the third molt, sap feeders transform into tubular-shaped caterpillars called tissue feeders (Fig. 2C). Tissue feeders cause serious damage as they chew upward to the upper surface of leaves (Fig. 2D). My investigations at Lockwood Farm in Mt. Carmel show that a leaf of a McIntosh apple tree usually drops prematurely when 40% or more of its upper surface is mined.

My studies have shown that leafminers prefer apple, crabapple, and quince in commercial orchards. During the third and final generation of the growing season, when their density is highest, they may spread to sweet cherry, European plum, Japanese plum, or pear. Leafminers also mature on choke cherry, flowering crab-apple, pin cherry, hawthorn, shadbush, and American and European mountain ash. I have found their density on wild trees is highest near orchards, which suggests that the moths disperse from orchards to live on wild plants.

Although many natural enemies kill leafminers, insect parasites are the most effective enemies during the growing season. I have found twelve species that parasitize the apple blotch leafminer in Connecticut. The major ones, *Sympiesis marylandensis* and *Pholetesor ornigis*, are tiny wasps (Table 1). These two species represent 90-99% of the parasites I have reared from leafminers, with *S. marylandensis* the most abundant. Fortunately, enemies of these beneficial parasites are scarce.

Table 1. Relative abundance of parasites emerging from mines of the first, second, and third generation of the apple blotch leafminer.

Parasite	% of total		
	Gen. 1	Gen. 2	Gen. 3
Sympiesis marylandensis	81	85	81
Pholetesor ornigis	18	12	9
Other species	1	3	10

Although I have found that parasites may kill up to 70% of the leafminers in commercial orchards in Connecticut, parasitism is too variable to provide effective control. By contrast, parasites sometimes kill 90% of the leafminers infesting unsprayed trees in abandoned orchards or along roadsides. The difference in the level of parasitism is because insecticides kill many of the parasites in sprayed orchards.

I have found that parasites become more abundant in commercial orchards in late summer, although parasites are no longer emerging in the orchards. This increase is caused by parasites immigrating into the orchards to attack the abundant leafminers. I also discovered that *S. marylandensis* parasitizes about 30 species of leafminers in addition to the apple blotch leafminer. These non-pest leafminers feed on a wide variety of plants, including wild black cherry which is common at orchard borders. Up to 65% of the parasites emerging from mines on black cherry are *S. marylandensis* adults.

These studies of the leafminers in orchards have shown that the apple blotch leafminer is the major leafminer pest of

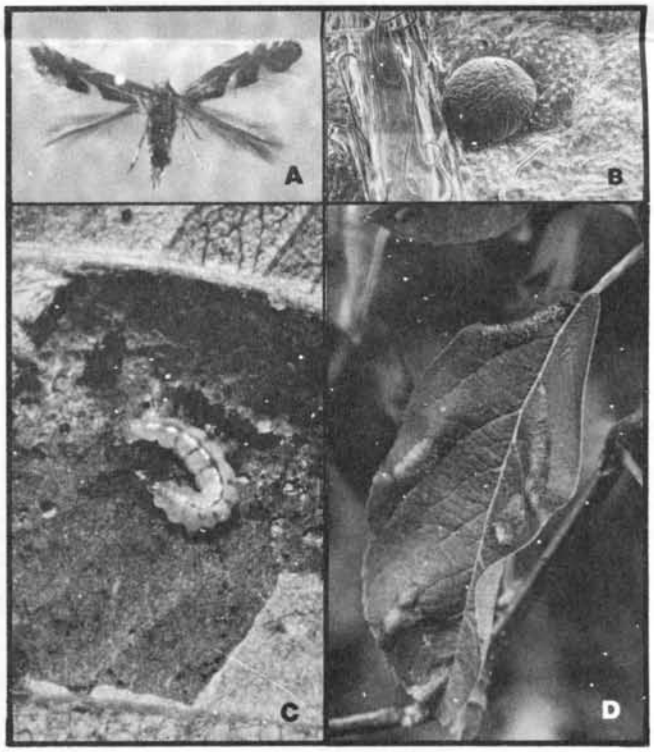

Fig. 2. Life stages and damage of the apple blotch leafminer. (A) Adult, with wingspan of ⅓-inch. (B) Scanning electron micrograph of egg. (C) Tissue feeder. The underside of a mine has been removed to expose the ⅛-inch long caterpillar. (D) Injury caused by leafminers.

apple in Connecticut. I have learned its life cycle and its host plants, and have discovered that beneficial parasites are living on the margins of orchards, which makes them available to attack leafminers in the orchards. Because the apple blotch leafminer is a threat to the Connecticut apple industry, I will continue to study this pest so that I may develop a defense that will help apple growers return leafminers to obscurity.

Does chlorine in tap water Cause damage to houseplants?

By Gregory J. Bugbee

During the summer and fall of 1984 public water in the New Haven area was treated with chlorine at 5-8 parts per million (ppm) to control bacteria that occasionally grow in distribution systems. Other water companies in several states have also occasionally increased chlorination for the same reason. Because chlorine is usually added to South Central Connecticut Regional Water Authority supplies at concentrations of less than 1 ppm, some questions were directed to the Station about the possible effects of the increased amounts of chlorine on houseplants.

A review of the literature revealed conflicting folklore but little scientific evidence. In a preliminary experiment with coleus I found no damage to growth or appearance at concentrations up to 17 ppm chlorine, but damage was evident at 55 ppm.

Therefore, in cooperation with C.R. Frink, I tested the response of 19 commonly-grown houseplants to chlorine. Plants were grown in a greenhouse during winter 1985 and irrigated with water containing 0, 2, 8, 18, 37, and 77 ppm chlorine. These chlorine concentrations were obtained by aging tap water in sunlight to obtain 0 ppm, by using water directly from the tap that contained approximately 2 ppm, and by adding 5.25% sodium hypochlorite (bleach) to tap water to obtain 8, 18, 37, and 77 ppm. Since sodium hypochlorite raises the pH of water, hydrochloric acid was added to decrease the pH to the normal 6.5 to 7.0. This water is virtually identical to drinking water in which injected chlorine gas lowers the pH and requires subsequent adjustment with sodium hydroxide to approximately pH 7.0. Water derived by either method contains chlorine predominantly in the form of hypochlorous acid, which does the disinfecting.

The houseplants are listed in Table 1. All were started from cuttings or seed and later transplanted into four-inch pots containing a standard potting medium with adequate plant nutrients. Pots were arranged on a greenhouse bench in randomized blocks with five replicates of each of the six chlorine treatments. Color coded stakes in each pot identified treatments. Plants were grown for three months and watered weekly. Liquid fertilizer was applied when found necessary by soil tests.

Most plants were slow to show any damage from chlorine. After six weeks, only geranium, petunia, marigold and kalanchoe changed in appearance and then only at the higher concentrations of 37 and 77 ppm. A yellowing of foliage was noticeable on geranium, petunia and marigold, while dropping of leaves was evident on kalanchoe.

After three months, each plant was ranked for appearance on a scale of 1 (poor) to 10 (excellent), and growth was measured by drying and weighing the harvested plants. The rankings suggest no significant adverse effects of chlorine for most of the species tested at 0, 2, 8 and 18 ppm.

The sensitivity to chlorine is shown in Table 1. Species are grouped according to the chlorine concentration that decreased growth significantly. Only geranium was affected by

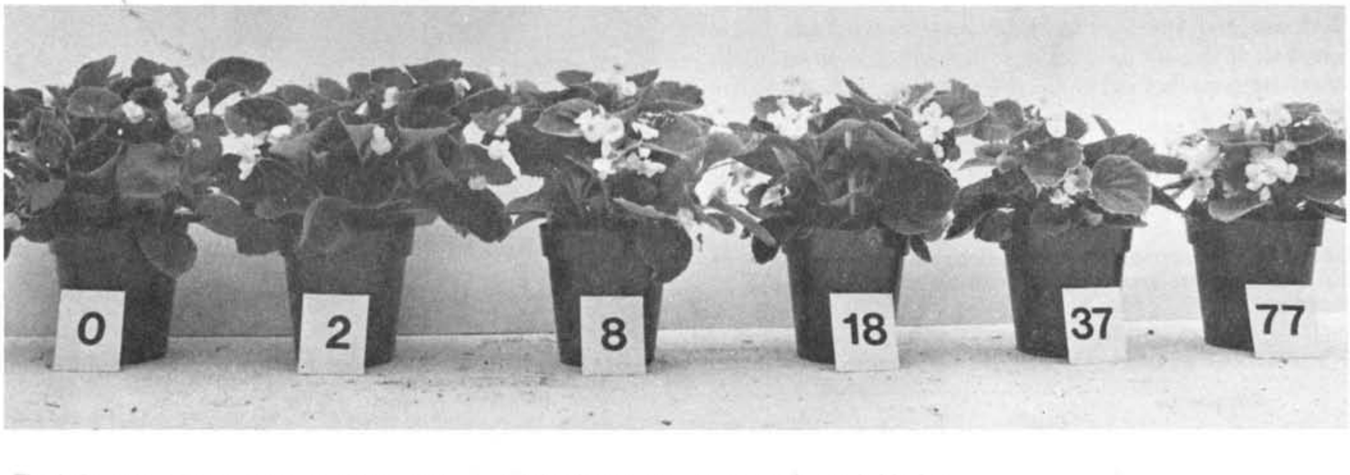

Fig. 1. Growth of Begonia irrigated with water containing increasing concentrations of chlorine.

Table 1. Plants and chlorine concentration causing growth decline as determined by Duncan's Multiple Range Test at the 5% level.

Chlorine (ppm)	Common Name	Genus/Cultivar
0-2	Geranium	*Pelargonium* cv. Ringo
3-8	none	
9-18	Kalanchoe	*Kalanchoe* cv. Tetra Vulcan
	Wandering Jew	*Tradescantia* cv. Tricolor
19-37	Begonia	*Begonia* cv. Viva
	Marigold	*Tagetes* cv. Aztec
	Petunia	*Petunia* cv. Snowdrop
38-77	Impatiens	*Impatiens* cv. Tel Star
	Madagascar Palm	*Euphorbia*
	Streptocarpus	*Streptocarpus* cv. Baby Blue
	Swedish Ivy	*Plectrantus*
77	Asparagus Fern	*Asparagus*
	Boston Fern	*Nephrolepsis* cv. Teddy
	English Ivy	*Hedera* cv. Ralf
	Fuchsia	*Fuchsia* cv. Madame Corneiliessen
	Grape Ivy	*Cissus* cv. Ellen
	Peperomia	*Peperomia* cv. Emerald Ripple
	Spathiphyllum	*Spathiphyllum*
	Spider Plant	*Chlorophytum*

chlorine concentrations less than 8 ppm. Although growth of geranium declined about 15% between 0 ppm and 8 ppm, its appearance remained good. Among the other species, only kalanchoe and wandering jew grew less at chlorine concentrations of 9-18 ppm. Growth of begonia, marigold and petunia did not decrease until chlorine was at 19-37 ppm. Figure 1 shows begonia treated with 0, 2, 8 and 18 ppm chlorine and the decline in plant size as chlorine increased to 37 and 77 ppm. Symptoms of chlorine damage included yellowing of leaves, occasional browning of leaf margins and stunted growth. The remaining 13 species were relatively tolerant to chlorine. Eight species were not harmed by chlorine at 77 ppm, and spider plant grew significantly better at 18 ppm chlorine than at zero. The appearance of all plants corresponded well to the growth data.

Thus, it appears that most houseplants will not be harmed by concentrations of chlorine likely to be present in municipal water supplies.

Food Science Night

The annual Food Science Night open house will be held in the Donald F. Jones Auditorium and the food laboratories, 123 Huntington St., New Haven, at 7:30 p.m., on Thursday November 21.

A wasp parasite helps control the spruce gall midge

By George R. Stephens

Sometimes in research the unexpected occurs. Seeking to solve a problem in one way suddenly reveals a new and different solution. What began as an experiment in conventional control of a troublesome insect ended with the discovery of an effective parasite.

In the early 1970's a new pest of white spruce was reported in Connecticut, first in Fairfield County and soon after in New Haven County. The new pest was a tiny fly, the spruce gall midge, *Mayetiola piceae*. Within 10 years it was found over most of the state. Although known throughout the natural range of white spruce in Canada and the Lake States, the midge was not considered a serious pest of forest-grown white spruce. In Connecticut, however, damage was occurring on both Christmas trees and ornamentals. Light infestation produced only a scattering of small blister-like galls on new shoots. However, heavy infestation caused masses of galls with swelling, stunting and deformation of new shoots, and, in severe cases, death of needles and shoots. This severe infestation rendered ornamentals unsightly and Christmas trees unsalable.

By the mid-1970's, knowledge of the biology of the midge and of insecticides had been integrated by this Station into suggestions for control, and the matter seemed closed. By 1980, however, growers complained that the system of control was not working.

The weak link in the control system seemed to be the insecticides. So I began tests in 1980 to learn which compounds were effective against the midge, and in 1983 I began a large-scale test of timing of the most promising insecticides. Some of those insecticides were more effective in controlling the midge than no treatment; others failed to control the midge. In 1984, however, something surprising happened: I found no difference between the insecticide treatments and no treatment. The insecticides had not failed to work; I had discovered another solution in the form of a tiny wasp emerging from midge-infested twigs. The wasp parasite was as effective as insecticides! But to come to this discovery I had to experiment for four years with insecticides and observe how they controlled the midge.

During 1980-82 I tested a promising systemic insecticide, aldicarb, but found when applied to the soil beneath the tree it did not control the midge. Therefore, in 1982, I began to test foliar sprays. When applied in late April several insecticides controlled the midge, but timing seemed important.

Therefore, in April 1983 at Christmas tree farms in Guilford and Middlefield I rated white spruce trees for infestation and selected trees already infested with the midge for one or two applications of nine insecticide sprays. The first applica-

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tion was in late April when white spruce buds were swelling, bud scales were loosening and adult midges were emerging from their galls. The second application was in early May, 9 or 10 days after the first application, when new growth was expanded half to three-fourth inch.

In mid-November I examined the trees when the caps on new galls had turned white and were clearly visible. Each tree was ranked on a scale of 0 to 5 — where 0 represented no visible infestation and 5 represented severe infestation with stunted, deformed shoots and abundant dead needles and twigs.

Although none of the insecticides completely controlled the midge, I noted interesting things happened to the unsprayed trees. Infestation of unsprayed trees in 1983 increased nearly 40 percent over 1982 at Guilford and Middlefield. On the other hand, infestation of sprayed trees decreased 16 percent at Guilford and 19 percent at Middlefield. Infestation of trees sprayed early decreased 14 percent at Guilford and 35 percent at Middlefield. Spraying late decreased infestation only 4 percent at Guilford and increased it 20 percent at Middlefield. Spraying at both times reduced infestation 33 percent at Guilford and 43 percent at Middlefield. Four insecticides, chlorpyrifos, diazinon, dimethoate, and trichlorfon, worked well. Although my late spraying corresponded to the previously suggested time for control, earlier spraying or spraying both early and late was more effective.

In April 1984 I began another experiment. I selected and rated infested trees for treatment with the four most effective insecticides in the 1983 test applied to foliage once or twice at three different times. Application was made in mid-April when white spruce buds were unswollen, bud scales tight and before adult midges emerged; in late April corresponding to the early application of 1983; and in early May corresponding to the late application of 1983.

In mid-April, prior to treatment, infestation on 1983 growth averaged 1.8 at Guilford and 1.5 at Middlefield. In November infestation on 1984 growth averaged 0.4 at Guilford and 0.2 at Middlefield. However, there were no differences in infestation between sprayed and unsprayed trees, or between the frequency or timing of applications of insecticides. Although infestation before treatment in 1983 was slightly higher than in 1984, the lack of response to treatment and the very low level of new infestation in 1984, even on unsprayed trees, indicated that some other factor was influencing the midge population.

I had found the answer the previous year when I applied dormant oil spray in April to prevent emergence of adult midges. To monitor the results, I placed sprayed and unsprayed twigs in special emergence traps in the laboratory. The treatment failed to be effective, but soon, along with adult midges, I found tiny parasitic wasps emerging. At Guilford the proportion of parasites was not great, about 25 percent, but at Middlefield it was 66 percent. In 1984, the parasite populations had increased enough to make biological control as effective as the insecticides being tested.

Abundant parasitic wasps were again seen emerging from twigs infested with midge in 1983 and 1984. If I assume that each parasitic wasp that emerged killed a midge that otherwise would have emerged, and if I also assume no parasites died in the galls, then I can easily express parasitism as the percentage of wasps out of the total wasps and midges that emerged in the spring. At Guilford parasitism of the midge infestations of 1983 and 1984 was 83 and 95 percent the following spring. At Middlefield the parasitism was 98 and 83 percent. Now, it was apparent why the sprays of 1984 were not as effective as in 1983. Although the trees were infested with midge in 1983, so many were killed by the wasps that only a few midges were available to infest trees in 1984.

Although the wasp appears to be *Mesopolobus* sp., little is known about it. The adult female wasp lays an egg in or near a midge larva and develops in the gall, emerging with adult midges. How many generations occur each year or when the wasp attacks the spruce gall midge is unknown. The wasp may be the same as one reported in Canada that keeps midge populations in check within the natural range of white spruce. Unfortunately, the identity of the Canadian parasitic wasp was not given. While its effect is apparent, its life cycle, and origin remain to be determined.

Although the original question of which insecticides can control the spruce gall midge has been answered, this parasite has, I expect, made them unnecessary.

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