strains of subclover. Additional field testing is continuing to confirm or reject the encouraging results of this study.

Conclusions

The evaluations of Spanish subclover and early-maturing Australian cultivars in both San Luis Obispo and San Diego counties in southern California indicate that subclover can be grown in this difficult region. The impressive showing of four of the five Spanish introductions over the best Australian performer, Geraldton, has encouraged us to look to the possible increase and release of the best-adapted germplasm. The poor showing by both the Daliak and Nungarin cultivars, which have largely replaced Geraldton commercially, should help to emphasize the need for more extensive testing of Australian introductions to determine their adaptation to the more variable California conditions.

Numerous Australian subclover cultivars have been introduced over the last several decades, but most have had low hard seed content and limited success outside the higher rainfall zones of northern California. The finding and testing of hardseeded subclover strains is believed to be the first step in extending this highly versatile range and pasture plant to parts of California with less favorable amounts and seasonal distribution of annual rainfall.

The encouraging results of these Spanish hardseeded strains justify the continued evaluation of subclover germplasm for hardseededness. The goal is to improve pasture and range animal productivity without using large inputs of high-energy nonrenewable fossil fuels.

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J. Kegg

Although the gypsy moth is primarily a pest of forest and shade trees, lab tests suggest the larvae will readily feed on foliage of numerous California fruit and nut trees.

The potential of gypsy moth as a pest of fruit and nut crops

Jeffrey C. Miller ❑ Paul E. Hanson ❑ Robert V. Dowell

The gypsy moth is a well-known pest of deciduous forests and landscape trees in northeastern United States. Most of the studies and available information on the feeding habits of larvae are therefore based on the flora of that region. However, as the gypsy moth, *Lymantria dispar* (L.), is introduced into new areas such as California, different plants become available as potential hosts (*California Agriculture*, March 1977, July 1982, and March-April 1984).

The repeated recovery of gypsy moth males from pheromone-baited traps in many locations between Canada and southern California has created concern that larvae may be feeding not only on forest and urban landscape trees but also on some crops.

Laboratory studies on gypsy moth larvae and host plant suitability of western species have been under way in Oregon since 1983. One objective is to observe the feeding behavior, development, and survival of larvae on the foliage of select fruit and nut crops grown in California. Such information could help determine where best to place pheromone-baited traps and suggest which crops could be at risk to some degree of damage to the foliage. It could also indicate those crops in which management programs may need to include contingency plans for gypsy moth, should it become established.

One requirement for this study was that it be conducted in an out-of-state laboratory where other gypsy moth studies were in progress. Since the laboratory of the senior author satisfied this need, the study was conducted at Oregon State University.

The development of gypsy moth larvae was tested on the foliage of 24 varieties or species of fruit and nut crops obtained from commercial nurseries in California. The trees were kept in their original potted condition and grown in a greenhouse to maintain foliage similar to that which would be available to gypsy moth larvae during the spring. Cool temperatures (55° to 64°F) were maintained to minimize the occurrence of "greenhouse" foliage. The plants could not be grown outside because of unsuitable weather conditions for many of the species and because the ongoing gypsy moth eradication effort in Oregon could interfere with obtaining leaves free of insecticide.

Larvae were not placed on leaves while on the plant because of research protocol deemed appropriate in studying an organism that was under quarantine regulations. Instead, a sprig of foliage from a test plant was cut and its stem or petiole was placed in a tube of water. Tests comparing the use of clipped and of attached foliage were conducted with Oregon white oak and Douglas-fir. Since no differences in larval feeding, development, or survival were observed, the clipped foliage technique was regarded as suitable for conducting feeding tests.

Immediately following clipping, the foliage "bouquet" was placed in a 1-pint container with three gypsy moth larvae. This procedure was repeated at least four times (12 larvae) for each foliage type. Two types of foliage were tested if appropriate. Year-old leaves were tested separately from current-season leaves of the evergreen species; otherwise only new leaves (within two to nine weeks after bud break) were tested.

Each test was begun with caterpillars that were within eight hours of hatching from the egg (first instars). If these caterpillars survived, they were fed only the leaves of that plant species until pupation. Fresh foliage was provided every day or every other day. If caterpillars did not feed on the foliage or died before molting, another test was conducted using caterpillars within eight hours of the second molt (second instars). These caterpillars had been raised on an artificial diet. This procedure was repeated using caterpillars into the fifth instar if necessary.

Development of the caterpillars was monitored daily. We observed survival of each instar on each foliage type, time to pupation, and weight of live, male and female, two- to three-day-old pupae. Degrees of suitability were defined according to survival of the first instars to pupation, the rate of larval development, and pupal weights. The higher each of these variables, the higher the ranking of the plant as potentially suitable for survival of the gypsy moth. On the basis of these observations, we placed plants in one of three categories, ranging from most to least suitable: Class I, II, or III (see table 1).

Results from the feeding trials suggested that the leaves of some fruit and nut crops were relatively very suitable for the development of gypsy moth larvae, while others were totally unsuitable.

Class I plants

The most suitable plants tested were apple, apricot, blueberry, filbert, pear, pistachio, and plum. Larvae readily settled out of a wandering phase and fed extensively on the foliage of these plants. Development of first instars to pupation also was the most rapid on these plants, often requiring only 35 to 40 days at room temperature (72°F). Survival of first instars to pupation was very high, ranging between 90 and 100 percent. Also, the weights of male and female pupae were the highest, ranging from 900 to 1400 mg for females and 425 to 600 mg for males.

Variability in the data among plants ranked in Class I precluded any further differentiation in their relative suitability for larvae. However, the results were significantly different ($p<0,05$, ANOVA) from those for plants in Class II.

Class II plants

Plants that ranked as relatively poor in host suitability included almond, avocado, citrus (grapefruit, orange, lemon, and tangerine), nectarine, peach, pomegranate, red raspberry, and walnut. First instars failed to molt while feeding on the foliage of these plants. In certain cases, the first instars fed very slightly but found the leaves unacceptable; the larvae eventually starved to death.

Second instars, however, did feed and successfully molt through the remaining instars on the foliage of each plant. Development of second instars to pupation generally required 45 to 60 days. Survival of second instars (first instars had been reared on an artificial diet for three days) ranged from 70 to 100 percent, and pupal weights were less than 750 mg in females and 350 mg in males.

All of the evergreen species used in this study were in Class II. Among these species, all but the test on lemon demonstrated that differences in leaf age strongly influenced larval fitness. For example, new and old citrus leaves differentially affected larval growth and survival. In general, second instars fed on new leaves but not on old leaves. In fact, old leaves of grapefruit, tangerine, and Valencia orange were totally unsuitable for larval development. However, second instars fed and molted when given new or old foliage from lemon (Meyer) while fourth instars were the youngest larvae surviving on old foliage of navel orange.

TABLE 1. Survival, relative larval growth rate, and relative pupal weight of gypsy moth larvae fed foliage of various California fruit and nut crops

Foliage source	Survival to pupation by instar*	Comments†
CLASS I PLANTS		
Apricot	First	Growth fast; pupae heavy
Apple	First	Growth fast; pupae heavy
Blueberry	First	Growth fast; pupae heavy
Filbert	First	Growth fast; pupae heavy
Pistachio	First	Growth fast; pupae heavy
Plum	First	Growth fast; pupae heavy
CLASS II PLANTS		
Almond	Second	Growth slow; pupae light
Avocado	New, all died Old, second	No feeding by any instar Growth slow; pupae light
Citrus:		
Grapefruit	New, second Old, all died	Growth slow; pupae light No feeding by any instar
Lemon	New, second Old, second	Growth slow; pupae light Growth slow; pupae light
Navel orange	New, second Old, fourth	Growth slow; pupae light Growth slow; pupae light
Valencia orange	New, second Old, all died	Growth slow; pupae light No feeding by any instar
Tangerine	New, second Old, all died	Growth slow; pupae light No feeding by any instar
Nectarine	(Fourth?)	Failed through third instar
Pear	First	Growth slow; pupae light
Pomegranate	Second	Growth slow; pupae light
Red raspberry	Second	Growth slow; pupae light
Peach	Third	Growth slow; pupae light
Walnut (English and black)	Second or third	Mixed results in larval survival; growth slow; pupae light
CLASS III PLANTS		
Grape:		
Concord	All died	Minor feeding by fifth instar
Thompson Seedless	All died	No feeding by any instar
Cabernet Sauvignon	All died	No feeding by any instar
Kiwi	All died	Minor feeding by fifth instar
Tomato	All died	No feeding by any instar

* First through fifth instars as indicated. New = current season's growth of foliage; old = previous years' growth.
† Fast = <40 days; slow = >40 days. Heavy = females >400 mg; light = female <400 mg.

On avocado, the age of leaves had an opposite effect. All larvae died on new foliage, while second instars were able to survive through pupation on old foliage.

Class III plants

Four of the crops tested were totally unsuitable for larval development, even for fifth instars, which were the least discriminating and most voracious of the instars tested. For example, leaves from three grape varieties were not only unsuitable for development, but larval feeding was essentially absent. The only attempt by larvae to eat grape foliage was by fifth instars on Concord grape. In this case, the feeding was very slight, indicating the foliage was not acceptable to the caterpillar. Similarly, caterpillars did not develop or even attempt to feed upon the foliage of tomato or kiwi.

Conclusions

The results indicate a relatively high rate of host plant acceptance; 29 percent of those tested were very suitable and 79 percent were suitable to some degree to gypsy moth larvae. Only 5 of 24 plant species (21 percent) were rejected entirely. Although these observations are based on studies conducted with greenhouse-grown plants and clipped foliage, the results indicate which varieties or species of plants are relatively suitable for the development of gypsy moth larvae. Our findings do not predict that the most suitable plants will be infested if a population of gypsy moths is present but rather suggest which plants may be more likely to be affected by an established population.

Although the gypsy moth is primarily considered to be a pest of forest and shade trees, our results suggest that it could become a pest of several important fruit and nut crops in California. The gypsy moth could achieve pest status in these crops by causing feeding damage or by being present in viable life stages that would result in the levying of quarantine restrictions. In California, the crops listed in table 1 as Class I and II plants occupied over 705,000 acres, representing a total value exceeding $975 million in 1985.

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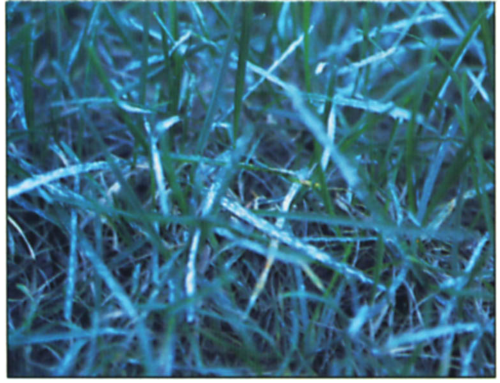

Powdery mildew on bluegrass can easily be identified by the white powdery appearance of the fungus on leaf blades.

Chemical control of powdery mildew on Kentucky bluegrass

Howard D. Ohr ❑ Margaret K. Murphy ❑ Emmylou M. Krausman
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Several products effectively control this relatively minor disorder.

Powdery mildew of Kentucky bluegrass occurs during cool months in heavily shaded areas with poor air circulation. Although the disease is of relatively minor importance in Kentucky bluegrass (*Poa pratensis* L.), it is sometimes necessary to initiate control measures. Caused by the fungus *Erysiphe graminis* DC. ex Mérat, powdery mildew is characterized by the white, powdery appearance of the fungus on the leaf blades. Because of the limited occurrence of the disease, opportunities to test chemicals for control are also limited.

We began a trial in January 1986 on the north side of a multi-story building in San Bernardino, southern California. The area was approximately 8 by 200 feet, allowing four randomized blocks with one replication of each of six treatments in each block. The replications were 8 by 10 feet each.

Fungicides were applied three times at two-week intervals as drenches in 2 gallons of water followed by a 1-gallon water wash. Each nontreated control plot received 2 gallons of water followed by the wash. Chemicals used were Award (penconazole), Bayleton (triadimefon), Chipco 26019 (iprodione), MF-690 (no common name), and Systhane (myclobutanil). Visual evaluations were made before each treatment and two weeks after the final treatment.

TABLE 1. Effect of fungicide drenches for powdery mildew control in Kentucky bluegrass

Fungicide, rate/1,000 square feet	Visual ratings on days after first application on January 14, 1986*			
	Init†	14	28	42
Bayleton-25W, 2 oz	6.3	2.4 a	0.5 a	1.3 a
Systhane-40W, 5 oz	8.3	5.3 ab	0.8 a	1.3 a
Award-50W, 3.5 oz	8.0	5.5 ab	1.8 a	1.5 ab
MF-690-50W, 3 oz	7.3	6.3 ab	7.0 b	4.3 abc
Control	7.0	6.5 ab	6.5 b	4.8 bc
Chipco 26019-50W, 4 oz	8.5	8.5 b	8.8 b	6.6 c

* Ratings on a scale of 0 to 10; 0 = no disease; 10 = plants dead. Ratings followed by different letters are significantly different at the 5% level by Duncan's multiple range analysis.
† There were no significant differences among ratings at initial evaluation.

Results

Fourteen days after the initial application, Bayleton was the only significantly effective treatment (table 1). At the 28-day evaluation, Bayleton, Systhane, and Award were statistically better than the other treatments. MF 690 and Chipco 26019 demonstrated no notable effectiveness against powdery mildew. In the final evaluation two weeks after the last application (42 days from the beginning), the Bayleton and Systhane treatments showed the best powdery mildew control, followed by the Award treatments. MF 690 was only marginally better than no treatment, and Chipco 26019 was the least effective treatment tested.

Bayleton and Chipco 26019 are the only fungicides tested that are currently registered for this use in California.

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