Bulletin 467
May 1989

Edited by Joe J. Hanan

research bulletin

Published by the Colorado Greenhouse Growers' Assoc., Inc. in cooperation with Colorado State University

Colorado State University

THE TOBACCO BUDWORM ON BEDDING PLANTS IN COLORADO

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Pheromone trapping of tobacco budworms worked poorly. Unfortunately, insecticidal control is limited — although effective control can be achieved with Talstar®, Orthene®, Mavrik® and *B. Thuringiensis* var. *Kurstaki.* Fortunately, serious damage was confined to the Denver Metro area where mild micro-climate conditions favor overwintering. Overwintering survival and subsequent damage should be related to winter severity.

Introduction

The tobacco budworm (geranium budworm), *Heliothis virescens,* is an extremely serious pest of agriculture throughout the southern U.S. and Mexico. Losses in the tens of millions annually occur to such crops as cotton and tobacco. In Colorado, it has historically been considered an occasional migrant of little economic importance. In recent years, however, serious injury to bedding plants has occurred in the Denver Metro area. Geranium and petunia have been most heavily damaged, but a wide variety of other flowering plants (e.g. nicotiana, calendula, dandelion) are fed upon. The ovaries and other reproductive parts are preferred and are destroyed during feeding.

On geranium, eggs are laid by the female moth directly on the developing buds. Eggs hatch within a few days and the larvae feed by tunneling into the bud. Such feeding prevents flowering. As the larvae become full-grown, dozens of buds may be destroyed in a single evening. Occasionally, expanded petals may be fed upon. No leaf feeding was observed. Pupation occurs in the soil, reportedly 1 to 2 inches deep.

Multiple, overlapping generations of the insect occur, at intervals of 4 to 6 weeks during the summer. Populations develop to high levels in late summer, due, in part, to the increasing amount of favored food available as the growing season progresses.

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Overwintering

The tobacco budworm is considered to be a subtropical species whose overwintering ability is limited by winter conditions. Based on numerous studies, the species should not be capable of overwintering outdoors in any areas of Colorado. If so, then Colorado infestations are dependent upon migrations of the insect from areas in Mexico and the extreme southern U.S. However, injury intensity over the past few seasons suggests that overwintering does occur.

A network of pheromone traps was established along the Front Range, between Pueblo and Fort Collins. Unfortunately, very few moths were caught, apparently due to poor quality of the attractant from the source supplier. Further use of pheromone traps should involve a comparison of the various lures available. A second study involved a survey and mapping of injury throughout the eastern part of the state. This involved visits to petunia and geranium plantings at various locations the first week of September. The observations showed the center of infestation is clearly limited to the Metro area (**Table 1**). More important, some southern locations were not infested. This would rule out migration. This is strong, indirect, evidence that overwintering does occur.

Overwintering in the Metro area would likely result from two sources: 1) geraniums brought into sheltered areas (garages, etc.) before frost would allow for pupae survival. Indeed, the first reported budworm damage in 1988 did involve overwintered geraniums. And 2), the outside overwintering sites would involve particularly mild winter

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micro-climates in pupation sites. Unusually mild winters that prevent deep soil freezing would contribute to overwintering survival. Deep snow cover prior to periods of deep soil freezing (typically late December-early February) would also protect overwintering pupae. Furthermore, overwintering survival would be expected next to heated buildings, or due to the fact that the Metro "heat island" provides approximately four degrees F. If this latter source of overwintering pupae does exist, the severity of infestations should be directly related to the previous winter severity.

Chemical control trials

Three trials were conducted to evaluate insecticide treatments of preventing budworm injury to geraniums and petunias. Plots were located in established outdoor flower plots in Arvada (Site 1) and in Northern Denver near Cherry Creek and the South Platte (Site 2).

At Site 1, a bed of geraniums was divided into individual 2.5 × 4 foot plots. Plot design was randomized complete block design with four replications. Sprays were made with a hand-operated, compressed air sprayer. Initial treatments were applied August 10 and again August 24. Evaluations, consisting of counting the number of damaged buds from five bud clusters per plot, were made August 20 and Sept. 6.

Two trials were conducted at Site 2 on petunias. In the first trial, beds of about 15 sq.ft. area were utilized. Sprayed treatments were applied August 10 and August 24. Evaluations on August 20 counted the number of damaged flowers per plot. Because of high pest pressure, the Sept. 6 evaluations counted all blossoms per plot. The second trial subdivided a linear bed into 3 × 5 foot plots with one treatment on August 24 and evaluation on Sept. 6. The latter counted all flowers in the center 1.5 foot swath of the plot. Plot design for both trials was a randomized complete block with four replications.

Budworm pest pressure was intense at both sites. Damage to untreated geranium buds exceeded 75% with almost complete cessation of blooming of untreated petunias on the Sept. 6 evaluation. Infestation tended to be less on geranium compared to petunia, perhaps due to the insect habit of laying eggs on newly emerged geranium buds, and for much of the feeding to occur within the geranium bud. Only Talstar® gave adequate control (75 to 90%) on geranium. Unfortunately, Talstar® is not available in homeowner packages, and its use on outdoor ornamentals in Colorado

Table 1: Survey of budworm damage in Eastern Colorado.

Lamar	no injury	**Pueblo**	no injury
Rocky Ford	no injury	**Limon**	little or no injury
Castle Rock	no injury	**Longmont**	little or no injury
Poncha Springs	no injury	**Fort Collins**	little or no injury
Colo. Springs	no injury	**Greeley**	no injury
Brighton	little-moderate	**Englewood**	moderate-heavy
Arvada	heavy injury	**Denver**	little-heavy injury
Aurora	little-heavy		

Table 2: Chemical control of tobacco budworm on bedding plants. Evaluations undertaken at two sites in the Metro region in 1988. Figures are percent increase in flowering, or decrease in injury, relative to an untreated check.

Treatment and rate	% bud injury reduction 20 Aug	% bud injury reduction 6 Sept	% flower injury reduction 20 Aug	% flowering increase 6 Sept
	Site 1			
Orthene Systemic Insect Control, 3 tbsp/gal.	-6	-23		
Lindane, Borer, Leafminer & Bark Beetle Spray, 1 Tbsp/gal.	-25	-22		
Talstar 10WP, 2.4 oz/10 gal	-75	-91		
			Site 2a	
Orthene Systemic Insect Control, 3 Tbsp/gal.			-52	+336
Lindane Borer, Leafminer, & Bark Beetle Spray, 1 Tbsp/gal.			-43	+192
Talstar 10WP, 2.4 oz/10 gal.			-90	+1240
			Site 2b	
Chipco Sevin SL, 1 qt/100 gal				+231
Caterpillar Attack, 4 tsp/gal				+505
Mavrick Aqua-flo 5 fl.oz/100 gal.				+579
Talstar 10WP 2.4 oz/10 gal.				+744

is due only to a 24C registration (to be reviewed in Dec., 1989) (**Table 2**).

Talstar® was also superior on petunia, resulting in dramatically increased flowering. Adequate budworm control was also achieved with Orthene®, Mavrick® and *B. thuringiensis* var. *kurstaki* (Caterpillar Attack®). These are more generally available than Talstar®. This improved control was probably related to increased exposure of larvae on petunia where they fed upon the entire flower and crawl about the foliage after egg laying. On petunia, control by Lindane® was more erratic, and Sevin® resulted in only a two-fold increase in flowering compared to the untreated check. No phytotoxicity was observed in any treatment.

The difficulties in successfully controlling tobacco budworm on bedding plants is not surprising, considering how difficult it has been to control on other agricultural crops such as cotton. Indeed, the importance and rapid development of insecticide resistance by the budworm, and other *Haliothis* species, has been a major driving force in developing new insecticides. At present, the pyrethroid insecticides (e.g. Talstar®, Mavrick®, Tempo®, etc.) have provided the best control in field crops. However, there has been disturbing indications of resistance to pyrethroid insecticides.

Varietal resistance

At two locations, large geranium/petunia plantings of mixed varieties infested with budworm were available. These allowed observation for possible varietal resistance to budworm feeding injury. In Aurora, a large petunia planting was rated Sept. 6 for injury using a 0 (no injury) to 3 (maximum injury). Ratings are given in **Table 3**.

At a second site in north Denver, four beds of mixed geraniums were evaluated for incidence of bud tunneling. Casual observations indicated that essentially all of the standard geraniums were badly injured. One variety, 'Snowmass', however, appeared to have much less injury than the other cultivars. More obvious was a consistent, high degree of resistance among the ivy leaf geraniums. These exhibited sustained high flower production and no apparent budworm injury. Based on the 1988 observations, development of budworm resistant cultivars is likely to be a promising control approach, and it should be given priority in developing a budworm management program.

Summary

1. Egg laying and budworm feeding habits vary with the particular host. Eggs are laid on unopened buds of geraniums and most larval feeding involves tunneling into the buds. On petunias (and probably nicotiana), eggs are laid on the leaves. Some foliage feeding occurs with tunneling of unopened buds, but larvae will also feed readily on flowers.
2. Pheromone trapping worked poorly at trapping adult males, apparently due to problems with lure attractiveness. Studies should compare lures from the various suppliers.
3. Serious damage was confined to the Metro area. More southerly areas were not infested. This is indirect evidence that problems occur from overwintering populations rather than migrations originated in the southern U.S. and Mexico.
4. Overwintering is likely related to mild, micro-climate winter conditions in the Metro area. These allow the insect to overwinter during favorable seasons. Survival and subsequent damage should be related to winter severity.
5. Budworm control on geranium was less successful than that on petunia. This is likely due to budworm feeding habits on the two species. Effective insecticide control options are limited, particularly on geraniums.
6. A range of resistance to budworm injury may exist in petunias and geranium, especially ivy leaf geraniums. Identification of resistant cultivars should be a major research emphasis.

Supported in part by the Colorado Greenhouse Growers Association.

Table 3: Varietal resistance observations on petunias, 1988, in Aurora, based on a scale of 0 (no injury) to 3 (maximum injury).

	3 greatest injury	
Apollo	Candy Apple	Fire Frost
Happiness	Challenger Red and Blue	Challenger Salmon
Rose Cloud	Orchid Daddy	Red Cloud
Salmon Cloud	Flamenco	Plum Apple
Plum Pink	Ultra Rose Star	Ultra Salmon
	Ultra Crimson Star	
	2 moderate injury	
Blue Frost	Cherry Frost	Velvet Frost
Sparkler	Viva	Glacier
Challenger Red	Challenger Blue	Challenger Pink
Challenger Burgundy	Fiesta	Blue Cloud
Pink Cloud	Orchid Cloud	California Girl
Plum Blue	Razzle Dazzle	Pink Joy
Rose Joy	Purple Joy	Ultra Plum
Ultra Red Star	Ultra Red	Ultra Rose
	1 little injury	
Rainy Days Blue	Challenger Red	Gary Paris
Summer Sun	Snow Cloud	Blue Joy
Telstar		
	0 no injury at site	
	Starlight Joy	

Abstracts from the American Society for Horticulture Science Annual Meeting, 1988, Michigan State University

EFFECTS OF CARBON DIOXIDE ENRICHMENT ON RUBISCO ACTIVITY IN ROSE LEAVES DURING THE WINTER AND SPRING PRODUCTION PERIOD

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Winter production of cut-flower roses generally includes enrichment of the atmosphere to 1000 ppm CO_2. This has been shown to result in increased production of 15 to 25%. For most greenhouse crops, the use of long-term CO_2 enrichment results in declining photosynthetic rates and reduced Rubisco activity; hence lower photosynthetic efficiency. This study characterizes the effects of winter and spring (January to May) CO_2 enrichment on Rubisco activity and photosynthetic rates for the cut-flower rose cultivar 'Red Success'. Preliminary results suggest that the long-term decline in photosynthetic rates and Rubisco activity found with other species does not occur with greenhouse roses in production. The results will be discussed in terms of leaf age, duration of exposure and light levels; and differences between previously reported effects on other species.

NATURAL LIGHT UNIFORMITY IN GREENHOUSES

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Many research projects on production in greenhouses require measurements of light levels at the top of the canopy. These values can be obtained from calculations when both the outside radiation and the transmission of the covering material is known, and precise information about the positions of structural members is available. However, the effects of material aging and additional structure (e.g., training wires, lamps and ballasts, etc.) are not easily accommodated for in mathematical models. This study reports on the use of a mobile track system to measure linear averages of light levels at the top of the canopy in three types of greenhouses. These data are reported for cloud and sunny days, and compared to data obtained from stationary sensors at the same height. The data are analysed in terms of the number of stationary sensors required for agreement with the track system, the object being to provide minimum sensor requirements for accurate light level measurements in different greenhouses.

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Fort Collins, Colorado 80523
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