Flooding Cranberry Beds in the 1990's to Control Blackheaded Fireworm

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Background and Introduction

Growers have been using deep, brief floods in late spring to control blackheaded fireworm since the mid 1800's. The only alternatives to flooding in the 1800's were kerosene emulsion, Paris green (an inorganic insecticide), and the botanical insecticides tobacco and pyrethrum. Flooding was widely regarded as the best control method.

After the turn of the century up to 1915, bulletins from USDA and Massachusetts Experiment Station recommended waiting until June to reflood, and extending the flood for 4-8 hrs for maximum larval mortality. This severe measure was probably practiced in response to a serious and chronic outbreak of blackheaded fireworm in Massachusetts. In the following decades, agronomists and plant physiologists questioned the safety of the method and investigated the problems caused by excessive flooding. They documented symptoms of stress and correlated the injury with low oxygen content of flood water. Perhaps in response to these concerns, in 1945, entomologists in Massachusetts recommended limiting the duration of a flood to 10 hours twice in June. Although pyrethrum was still in use, DDT was then newly available. When first introduced, DDT was the most effective compound for general insect control and had relatively low toxicity to plants and mammals. For the first time, a compound had been discovered which performed better than flooding.

During the 1950's, and 60's, many new types of synthetic organic insecticides were developed and are still in use today. These compounds controlled fireworm effectively without danger to plants, and seemed to be a permanent alternative to flooding.

Management options have changed once again in the 1990's. We are witnessing a decline in the number of synthetic organic compounds registered for cranberry instead of an increase. Reliance on fewer available products increases the possibility of excessive use of particular compounds. Excessive use, in turn, can lead to insecticide resistance. Cultural control methods such as flooding should be reevaluated with the hope of once again increasing pest management options. Since the earliest writing on the subject, there has not been any published quantitative assessment of the technique. The purposes of this investigation are (i) to quantify the effect of water of different temperature and dissolved oxygen (DO) content on survival of submerged blackheaded fireworm larvae, and (2) to evaluate reflooding as a control measure.

Laboratory Experiments

Methods and Materials

Blackheaded fireworm larvae were established on cut cranberry foliage and allowed to construct silken shelters. Samples were submerged in water of high (8.2- 13.1 ppm) DO at two temperatures, 36°F and 50°F, for different lengths of time. Other samples were submerged in water of low (5.1-7.1 ppm) DO at 50°F for different lengths of time. After submersion, the number of living and dead insects were counted.

Results

The trend in survival of larvae over time was similar for the two temperature treatments (Fig. 1). As the time of submersion increased to nine days, survival decreased to approximately 40%.

The effect of DO on survival of larvae is illustrated in Figure 2. About 90% of larvae survived submersion in water of high DO for three days, while only about 10% survived in water of low DO for the same length of time. At low, springtime temperatures, DO concentration had a comparatively large effect on survival of larvae while temperature had little effect.

Field Experiments

Methods and Materials

Three marshes (designated Marsh A, B, and C) were selected as sites for field trials in 1991 from a total of six volunteer sites. All three were located near Warrens. At each site two beds were chosen based on their proximity to one another, high density of blackheaded fireworm eggs, and the ability to flood one bed independently. In April, 100 eggs in each bed were located and their locations marked. Twenty-four hours prior to and 24 hours after flooding, three 0.1 m2 (about 1 ft2) areas from each bed were pruned to ground level. The foliage samples were examined under a microscope for living and dead larvae.

The beds which could be independently flooded at each site were flooded 3- 10 inches above the foliage to kill blackheaded fireworm larvae. Timing of flood was based on maximum hatch of eggs and minimum bud break of plants. Water temperature and DO were monitored at mid-afternoon and dawn each day. Duration of flood was based on dormancy of the plants.

Marsh A was flooded in the morning of 11 May and water withdrawn after 50 hours. Marsh B was flooded in the afternoon on 12 May and water removed after 31 hours. Marsh C was flooded in the evening of 13 May and water withdrawn after 24 Hours. For a summary of DO and temperature measurements during the trials, see Table 1.

Data were analyzed by computing the corrected percentage reduction (CPR) in larval density, which is intended to measure mortality of insects in the treated plots apart from population changes not caused by the treatment. CPR ranges from 0% (no reduction) to 100% (complete elimination of larvae).

Results

The egg hatch patterns and times of treatment are represented in Figure 3. Shoot elongation occurred during the end of hatch, when temperatures rose into the high 80’s. The beds were flooded before hatch was completed to avoid greatest damage to the plants.

On Marsh A there was an approximate 90% decrease in larval density in the treated bed but very little change in the untreated bed (Table 2). Larval density was reduced very little on Marsh B whereas density increased greatly on the untreated bed because of continued egg hatch (Table 2). The same pattern was apparent on Marsh C. The CPR was high for all sites indicating a significant mortality of larvae during the flood (Table 2).

Conclusions

The ability of flood water to kill blackheaded fireworm larvae depends on the concentration of dissolved oxygen. The lower the oxygen content, the greater the larval mortality in a certain time period. The longer larvae remain submerged, the greater the mortality.

Although flooding generally will not eliminate fireworm populations, it does cause considerable mortality in the field. Reflooding may be most effective as a preventative treatment when population densities are near or below economic injury level, or as a supplement to insecticides or other control measures. This should result in a reduced need for insecticide applications.

Ideally, modern use of reflooding should be done with full knowledge of its effects on plant health and crop yield. Although there is some information on the tolerance of cranberry plants to flooding, current knowledge does not allow us to predict the effect of flooding on cranberry plant health and fruiting during the transition from late dormancy to early growth. The timing and duration of a flood will need to be based on a balance of risks and benefits: the risk of reduced yield if flooding is attempted, the risk of reduced yield if no action is taken, the expected benefit provided by pest suppression, and the relative cost of control alternatives.

In an era of increased pest and environment monitoring in integrated pest management programs, we believe reflooding can have a role in controlling blackheaded fireworm. In some cases flooding may be adequate by itself; in other cases it may be necessary to combine flooding with other pest management approaches.

Table 1. Flood water temperature (°F) and Dissolved Oxygen concentration (ppm) during field trials.

Day	Time	Measurement	Location Marsh A	Marsh B	Marsh C
1	afternoon	Temp.	72	---	---
		DO	8.5	---	---
2	dawn	Temp.	68	70	61
		DO	6.0	7.2	4.1
	afternoon	Temp.	79	81	81
		DO	8.0	7.2	7.2
3	dawn	Temp.	72	---	---
		DO	4.2	---	---

Table 2. Mean density of blackheaded fireworm larvae found in 0.1 m2 samples and derived corrected percentage reduction (CPR) of larval density resulting from flood treatment.

Site	Bed	Larval Density Before Flood	After Flood	CPR
Marsh A	flooded	36.3	3.7	89.4
	control	7.7	9.7	
Marsh B	flooded	4.0	3.0	93.1
	control	0.7	7.7	
Marsh C	flooded	43.3	12.0	78.7
	control	14.0	31.3	

Figure 1. Water temperature
and survival of larvae

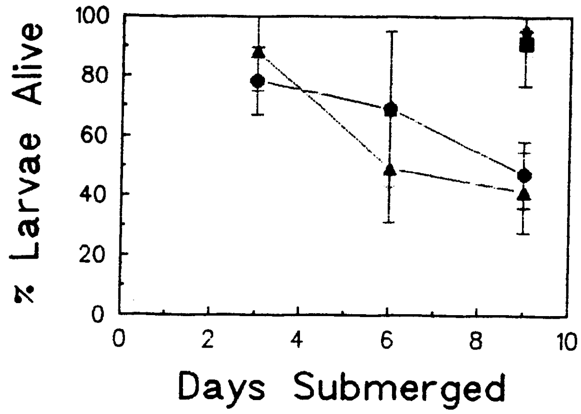

Figure 1. Percent of blackheaded fireworm larvae alive after submergence in water at 36°F (circles) or 50° F (triangles). Percent survival of unsubmerged larvae after 9 days at either temperature is in the top right corner. all symbols are averages and the vertical bars are standard deviations.

Figure 2. Dissolved oxygen content
and survival of larvae

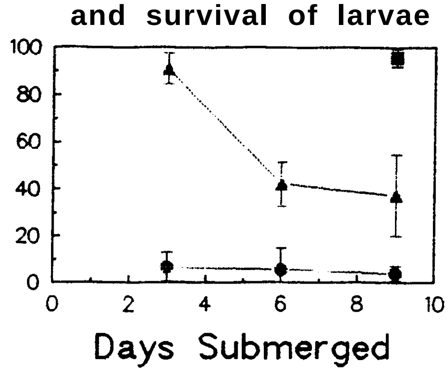

Figure 2. Percent of larvae alive after submergence in water at 50º F and with high (8.2-13.1 ppm, triangles) or low (5.1-7.1 ppm, circles) DO content. Percent survival of unsubmerged larvae after 9 days at 50°F is in the top right corner. All symbols are averages and bars are standard deviations.

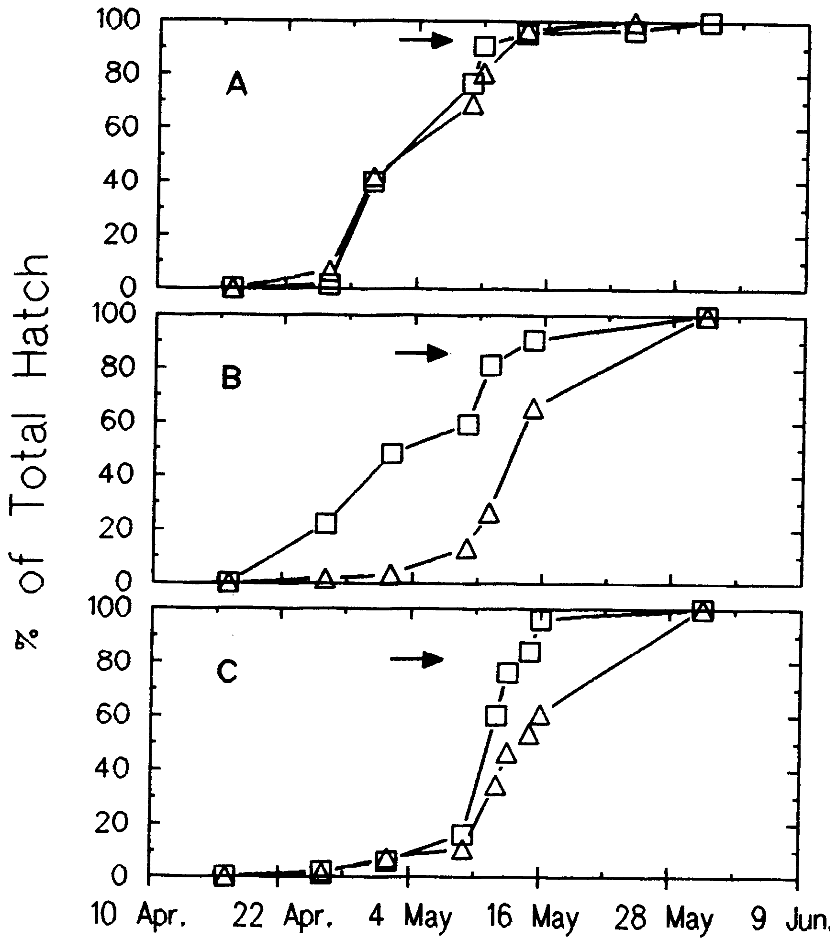

Figure 3. Percent of monitored eggs which successfully hatched in each bed during April and May. A is percent hatch at Marsh A, B at Marsh B, and C at Marsh C. Data from flooded beds are designated by squares, those from unflooded beds by triangles. Arrows indicate percent hatch at the start of reflood.