Early-season flooding for insect pest control

Shawn Steffan [1], Merritt Singleton [2], Jayne Sojka [3], Juan Zalapa [4], Tim Dittl [5], and Rebecca Harbut [4]

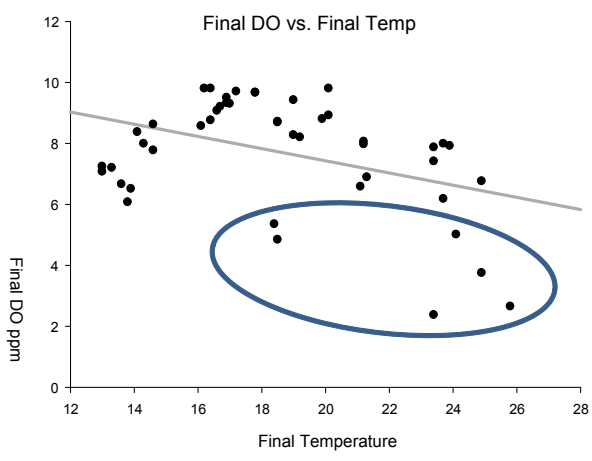
[1] USDA-ARS Vegetable Crop Research Unit, Madison, WI
[2] Dept. of Entomology, University of Wisconsin, Madison, WI
[3] Lady Bug IPM, Pittsville, WI
[4] Dept. of Horticulture, University of Wisconsin, Madison, WI
[5] Ocean Spray, Inc., Babcock, WI

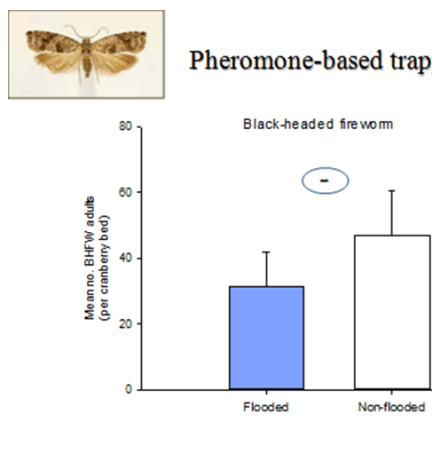
For over 100 years, the cranberry industry has been interested in the potential for spring floods to suppress arthropod populations. One critical element of this strategy is the trade-off between lethality for insects and harm to the cranberry plant. The basic question underlying our research, therefore, was the following:
Can a late spring flood effectively suppress arthropod pests without harming the cranberry harvest?
If so, under what conditions?

In collaboration with Wisconsin pest management consultants and growers, we set up a large-scale experiment in central Wisconsin in 2011. This work involved 23 pairs of flooded/unflooded beds (46 beds total, among 11 commercial growers), and we included not only arthropod metrics (Sparganothis fruitworm, cranberry fruitworm, and black-headed fireworm densities), but also plant metrics (chlorophyll, upright growth, flowers/upright, harvestable crop) and surface water metrics (temperature, dissolved oxygen, and pH).

In parallel, we conducted a submergence tolerance study in a greenhouse setting, where we could concurrently manipulate the effects of water temperature (cool, warm regimes) and submergence duration (0, 48, and 96 hrs) on three different cranberry varieties ('Stevens', 'Ben Lear', and 'GH1').

From our field data, we showed that springtime surface waters in Wisconsin were generally well-oxygenated and cool (8.2 ppm at flooding, and then 7.7 ppm as water drained; 64-65 deg. Fahrenheit). As water temperature rose, dissolved oxygen (DO) declined. At the majority of the marshes, DO levels were not worrisome, although there was some evidence of hypoxia (see blue circled data points below), and we suspect this is due to elevated microbial oxygene demand in older beds.





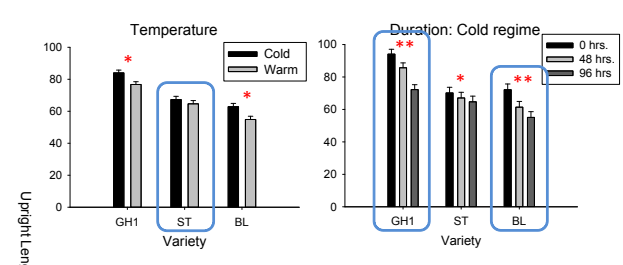
After 30-40 hours of flooding, the floodwaters warm up and lose dissolved oxygen. At week 2 post-flood, black-headed fireworm trap-catch (pheromone-baited traps) was significantly lower in flooded beds than in the non-flooded beds. Sparganothis fruitworm and cranberry fruitworm trap-catch numbers in flooded versus non-flooded beds (which received insecticide treatments) were equivalent, suggesting that the effects of the flood were similar to that of insecticide treatments alone.

In terms of the cranberry plant, there was evidence of flood-induced stress. By week 1, chlorophyll was reduced in the leaves of flooded beds, and by week 4, flowers per upright were significantly fewer in the flooded beds: 3.83 flowers per upright in flooded beds vs. 4.16 flowers per upright in non-flooded (see table below). By harvest, however, there was no difference in harvestable crop between flooded (204.3 grams/sq. ft.) and non-flooded beds (203.0 g/sq. ft.).

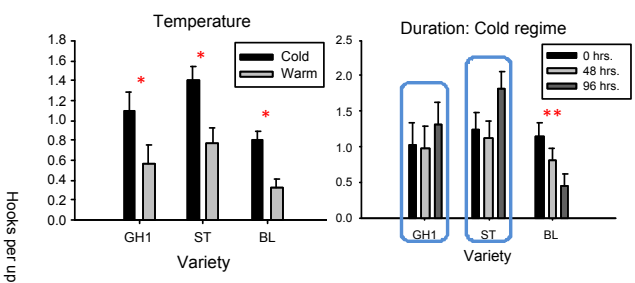
	Flooded	Non-flooded	*P*
Week 1: Chlorophyll (SPAD)	**9.40**	**10.84**	**0.029**
Week 2: Upright lengths (mm)	45.36	46.65	0.342
Week 3: Hooks/upright	2.58	2.72	0.420
Week 4: Hooks + Flowers/upright	**3.83**	**4.16**	**0.016***

In the greenhouse trials, we learned that over the long term, cranberry sods can sustain complete submergence for 96 hrs, whether the water is cool or warm, as long as dissolved oxygen levels remain above approximately 40% saturation (~5 ppm). However, 7 days after treatment (see figure below; Greenhouse trials: upright length at 7 DAT), there were significant differences between controls (0 hours submergence) and 96 hours of submergence. For each variety, being submerged for the longer duration significantly reduced the growth of uprights. After 7 weeks, though, this trend was non longer evident. The response of both 'Stevens' and 'GH1' were similar among the 0, 48, and 96 hour submergence duration regimes (see Greenhouse trials: hooks per upright at 49 DAT). Notably, there was a significant difference between cold and warm effects, where warm water caused a greater reduction in upright growth 49 days after treatment (DAT). Interestingly, the 'Ben Lear' sods suffered much more, even in the cold water regime, but this can be explained by the markedly depleted oxygen levels in the 'Ben Lear' water. Here we suspect there was elevated microbial activity reducing available oxygen.

Greenhouse trials:
upright length at 7 DAT

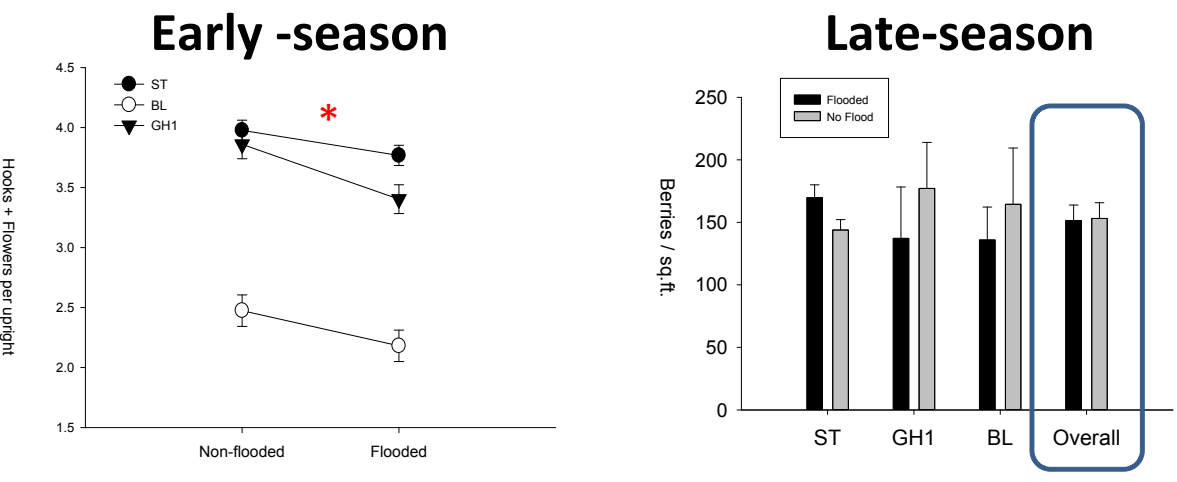


Greenhouse trials:
hooks per upright at 49 DAT

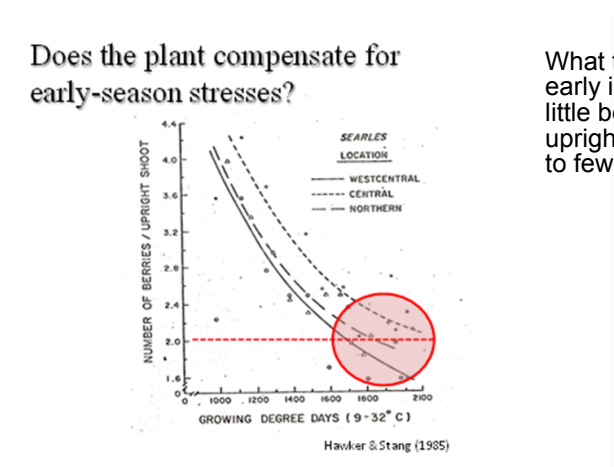


For the 'Stevens' and 'GH1' sods, the cold water regime was quite similar to water temperatures and dissolved oxygen levels in the field. This allowed us to focus on the cold water regime in the greenhouse to assess how well these plants could sustain prolonged submergence. After being submerged for 96 hrs and then being allowed to grow under natural conditions for 7 weeks, there was no difference (in terms of hooks or flowers per upright) between these plants and those that had not been submerged at all. This suggests that as long as dissovled oxygen levels are not too low (< 40% saturation), cranberry sods ('Stevens' and 'GH1') can remain submerged for prolonged periods (48-96 hrs) in the springtime without suffering significant injury.

In the field, we observed a similar trend in which there was early evidence of flood-induced plant stress, yet by harvest (Sept/Oct), the difference between flooded and non-flooded beds was non-existent. Note in the figure below that early in the season (left panel, "Early-season"), there were fewer hooks and flowers per upright, but by harvest (right panel, "Late-season"), there was no significant difference between flooded and non-flooded beds.



Why might this be? Does the plant possibly compensate by re-allocating resources? An old study done in Wisconsin (using 'Searles') shows how cranberries are "shed" all season, eventually reaching about 2 fruit/upright by harvest (see figure below, from Hawker & Stang, 1985).



What this suggests is that stressors, like spring flooding, might reduce flowers/upright early in the season (from an average of about 4/upright to 3/upright), but this may have little bearing on harvest because the sods will only mature approximately 2 berries/upright. This, as long as spring flooding does not reduce the number of berries/upright to fewer than 2, there may not be a significant problem with early-season flooding.

References Cited:

Hawker, G.M., and E.J. Stang (1985) Characterizing vegetative growth and fruit development in cranberry (*Vaccinium macrocarpon* Ait.) by thermal summation. Acta Horticulturae 165: 311-324.