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CRANBERRY ENTOMOLOGY IN WISCONSIN: SPOTTED WING DROSOPHILA (SWD), SPARGANOTHIS PHENOLOGY, AND THE BUG FLOODS

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In 2012, the USDA-ARS cranberry entomology program addressed a variety of issues: flea beetle biology and control (see Bosak et al. report in these Proceedings), pheromone-based mating disruption (see the Deutsch et al. report), the threat posed by a new invasive insect species (SWD), the biology of an age-old pest (Sparg), and the arthropod community removed during the spring floods. This report will focus on the latter three elements.

Drosophila suzukii, commonly known as SWD, is a recent arrival in the US (Hauser, 2011). It has been confirmed as a potential pest of the major fruit crops grown in the US (Lee et al., 2011). In anticipation of future infestations, management programs are being erected to combat this pest (Beers, Van Steenwyk, Shearer, Coates, & Grant, 2011). One of the most troubling aspects of this fly is that it is attracted to and can penetrate unripe, hard fruit. This effectively broadens the window of fruit susceptibility, and allows the fly to "hitch a ride" within the food transportation system by hiding in ripening fruit. It has arrived in Wisconsin, has been detected in all major fruit-growing regions, and can be expected to be a regular visitor. While SWD has not been found in Wisconsin cranberries, one question has remained: is the cranberry a potential host for SWD?

Photo courtesy C. Hammond, DATCP

We investigated this question by exposing gravid (mated) females to cranberries in no-choice assays (the females had no choice as to what food source could serve as hosts for their eggs—only cranberries were offered). We found that SWD does not like cranberries very much. Following multiple replicated trials using ripe, under-ripe, and over-ripe organic Wisconsin cranberries, SWD females would not (or could not) insert eggs into under-ripe or ripe cranberries. This suggests that healthy, current-year fruit should be safe from attack. Among the over-ripe, decaying cranberries (harvested, frozen, thawed, refrigerated)

Saw-like female ovipositor

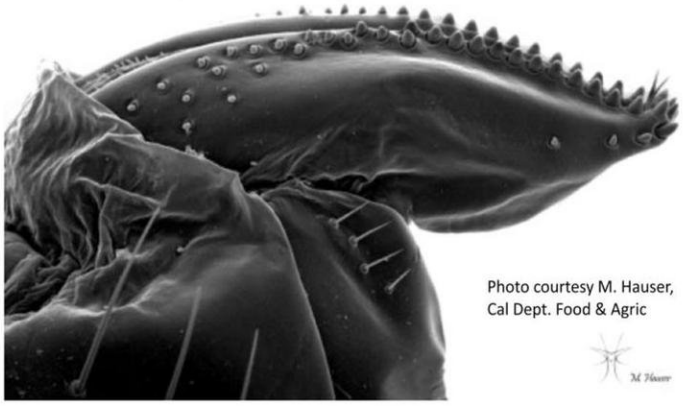
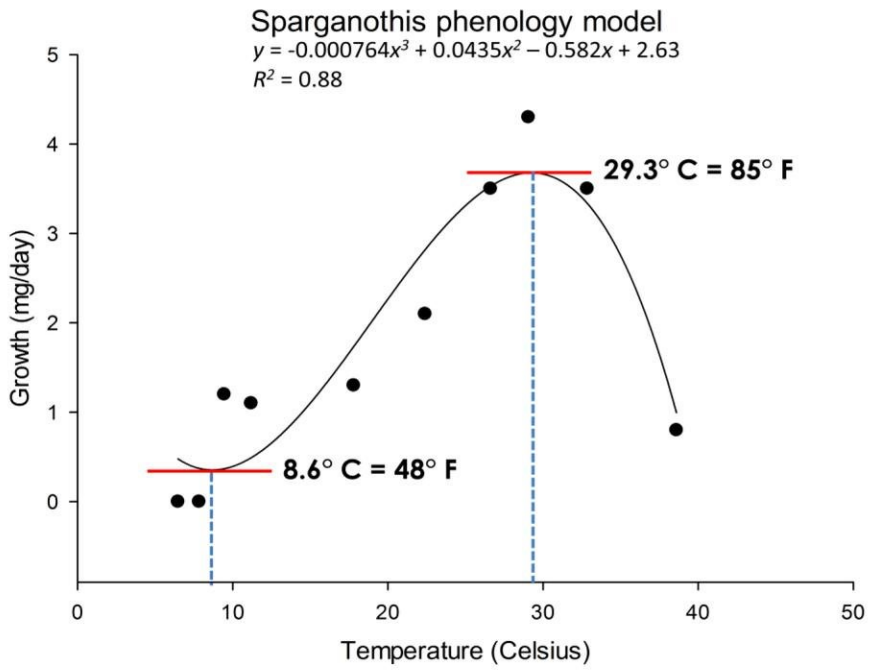


Photo courtesy M. Hauser, Cal Dept. Food & Agric

just two eggs were found among many berries, but no mature larvae were detected, and no adults emerged. Fortunately, rotten fruit usually do not make it into harvests because they generally do not float. While none of the SWD larvae in our study successfully developed within the highly acidic flesh of fresh cranberries, other studies using physically damaged cranberries have shown that SWD could reach adulthood. These berries represented wounded, decaying fruit, not the sort of berries that would get harvested. Again, current-year cranberries (that are not damaged or rotting) appear to be safe from SWD attack. Conversely, last-year's decaying bounty of unharvested cranberries may be vulnerable. SWD populations will likely be found each spring and summer in fruit-growing regions, but the risk to cranberry production seems minimal.

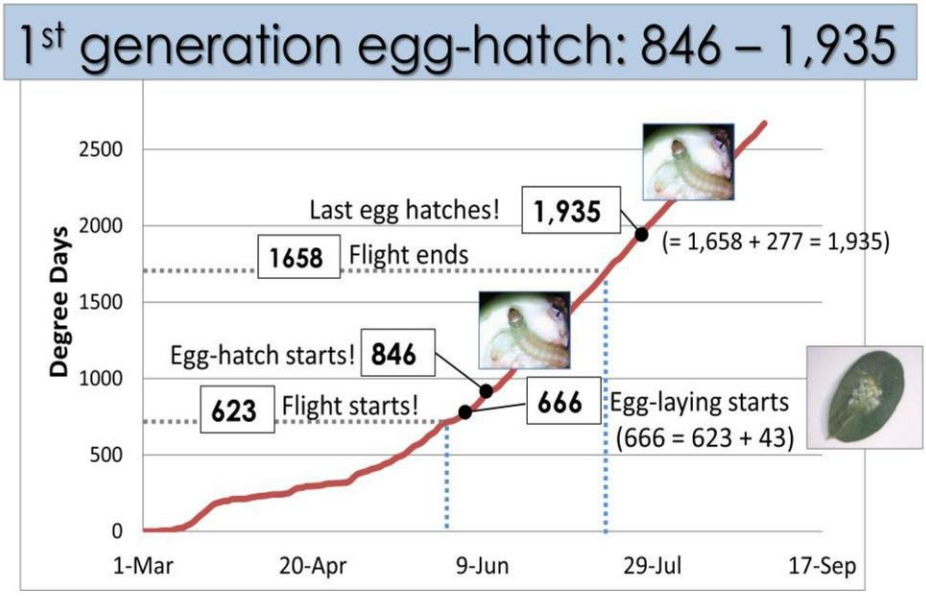
Sparganothis phenology:

Sparganothis fruitworm (SFW) has long been one of the more serious pests of cranberries (Eck, 1990), necessitating preventative pre-bloom sprays and subsequent "clean-up" sprays mid-season. A better understanding of its biology will sharpen our existing IPM toolbox by improving the timing of these sprays. We set out to uncover the development rates and degree-day (DD) accumulations associated with adult flight and egg-hatch.



SFW larval growth rates were measured over a wide range of controlled temperatures (44-101°F). Growth rates were then plotted against temperature, and a model was fit to the dynamic. From this model, we were able to determine the lower (48°F) and upper (85°F) development thresholds of SFW larvae. The thresholds were used to generate degree-day (DD) accumulations that were linked to developmental events, such as flight initiation and length, adult lifespan, pre-ovipositional period, ovipositional period, and egg gestation period. These DD accumulations represent key developmental benchmarks, helping to optimize pest management in the cranberry system.

Using the temperature thresholds from our growth rate trials (48°/85° F) and accumulating DD from March 1st, we found that the first males tended to fly around 623 DD, and the flight ended by 1,658 DD. We also determined that females tend to require 43 DD before they will begin laying eggs, which means that the first eggs will likely be laid by 666 DD (again, counting from March 1st). Given that each egg takes a minimum of 180 DD to hatch, the very earliest larvae can be expected to emerge by 846 DD. Ultimately, the larval emergence period can be estimated to last through 1,935 DD, and peak larval emergence (the 50% mark) should be around 1,390 DD.



The Bug Floods, re-visisted:

During the spring "trash flood," a tremendous volume of plant material floats to the surface as water levels rise. This "trash" is removed from the beds by various means (e.g., by backhoe; Fig. 1) and is generally trucked away to other areas of the marsh. Since the trash floods are often used as a means of insect control, growers have been wondering if insect pests can be controlled by drowning as well as by physically removing the survivors from the bed. To address this question, we took samples of trash material from beds being flooded for insect control.

Figure 1. Removal of bed "trash."

On average, the per-acre volume of plant material removed from any given bed was 0.51 yd^3 (cubic yard). On a 4-acre bed, for example, there were over 2 yd^3 of leaves, stems, berries, and various other "stuff" removed. We took our samples (2-liters/bed) and then sorted through them under miscroscopes to separate the arthropods. All arthropod specimens were curated in ethanol and identified. Based on our counts (per-liter), we could extrapolate how many arthropods were present per cubic yard, and thus how many arthropods per-acre were present in the trash.

Interestingly, the single most abundant organisms we found were not arthropods, but rather aquatic snails (2,892 specimens/acre). Among the arthropods, the most abundant group we found was the Coleoptera (beetles; Figs. 2-3), which were represented by 18 families (!) and totaled over 1,300/acre. Top among the beetles were the Staphylinidae (290/acre), Scarabaeidae (219/acre), Elateridae (141/acre), Carabidae (131/acre), and Curculionidae (51/acre). While the Scarabaeidae (white grubs and June beetles), Curculionidae (weevils), and Elateridae (wireworms/click-beetles) are significant pests and thus good to eliminate, the Staphylinidae and Carabidae are largely predaceous and probably eat many pests.

Figure 2. Adult scarab (June beetle/white grub) crawling on the surface of the trash during the floods.

Figure 3. Clockwise from top-left: Staphylinidae (rove beetles), Elateridae (click-beetles), Anthicidae (ant-like flower beetles), and Curculionidae (weevils).

This brings us to the second most abundant group: the spiders (Fig. 4). Over 121 spiders/acre were removed in the trash floods. Since spiders are absolute carnivores, it is possible that thousands of beneficial arthropods were removed in the trash. Ants, the third most abundant group (115/acre), vary widely in their ecological function, so it is difficult to characterize their role on the marsh. The fourth most commonly found arthropods were the Noctuidae (cutworms, loopers; Fig. 5), suggesting that these large caterpillars were readily floated out of the beds (78 cutworms per-acre).

Figure 4. Lycosidae (wolf spiders)

Figure 5. Noctuidae (cutworms, loopers).

Many other insect families were found, mostly from parasitic wasp families (e.g., Ichneumonidae, Pteromalidae), Hemipteran bugs (Piesmatidae, Miridae, and Pentatomidae) and various fly groups (syrphid flies, crane flies, marsh flies).

In all, there were at least 50 different *families* of insects documented within the Wisconsin marshes we studied. The total number of arthropods removed per-acre from the beds was approximately 2,127 specimens.

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TARGETING RED-HEADED FLEA BEETLE LARVAE

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Introduction

Red-headed flea beetle (RHFB), *Systena frontalis*, feeds on cranberry roots during its larval stage and on tender leaf growth as an adult. Despite its recognition as a pest nearly 100 years ago, details of its life history and options for control remain largely unknown. Indeed, even its status as a pest is debated among growers. For marshes with multi-year infestations located in several beds or throughout the marsh, RHFB is a significant concern because of observations of abnormal vine growth after several years of infestation and the number of insecticide applications that are required for control.

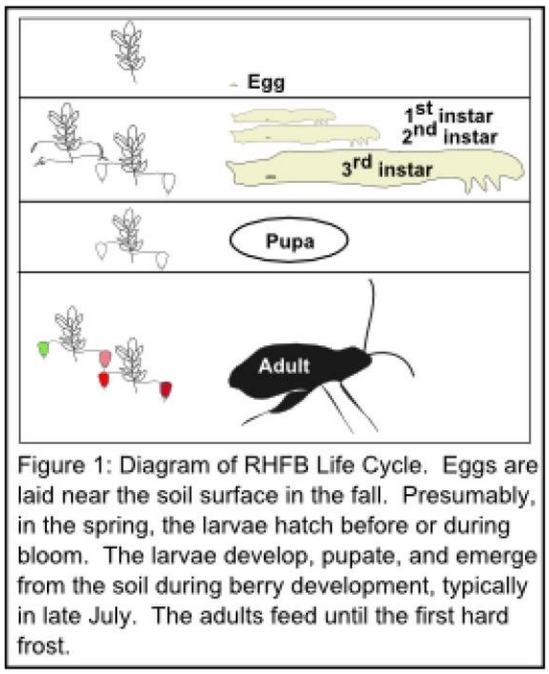

Figure 1: Diagram of RHFB Life Cycle. Eggs are laid near the soil surface in the fall. Presumably, in the spring, the larvae hatch before or during bloom. The larvae develop, pupate, and emerge from the soil during berry development, typically in late July. The adults feed until the first hard frost.

RHFB has a single generation per year with four life stages: egg, larva, pupa, and adult (Fig. 1). In the fall, the eggs are laid near the soil surface, most likely in leaf litter (Scammell 1917). The egg or larval stage overwinters and in the spring, the larvae begin to feed on plant roots. The larval stage consists of three instars that progressively increase in size until reaching a length of 5.1 to 10.0 mm. After the third instar, the larva pupates in the soil and emerges as an adult, usually in mid- to late July. There are many species of flea beetles but the key identifiers for RHFB are a shiny, black body with a reddish-brown head.

Adult RHFB feed on a veritable buffet of plant species spanning many plant families (Clark, LeDoux et al. 2004). For a complete list of RHFB host plants, please see the table included at the end of this article. At least twenty common weeds of cranberry are host plants for RHFB. Very little is known about their feeding preferences and reproductive capacity on different host plants. In a survey of RHFB in corn fields, RHFB were observed feeding on weeds in the fields or at the edges for 35 of 39 Iowa counties versus sightings on corn were limited to only 6 of 39 counties (Jacques 1969). On commercial cranberry marshes, RHFB are typically observed feeding on weeds on the dikes and in the cranberry bed. In addition, for marshes with severe infestations, areas of abnormal vine growth can be observed.

The research objectives for the summer of 2012 were:

1. Determine whether abnormal vine growth areas or hotspots, normal areas of vine growth, or the dikes were infested with RHFB larvae.
2. Locate the overwintering site of RHFB and identify adult feeding patterns.
3. Evaluate an insecticidal soil drench, targeting the larval stage, to reduce RHFB populations.

1. Sampling for larvae

Method:

To sample for RHFB larvae, soil cores were taken from the dikes, cranberry bed, and hotspots located at both sites. The cores were placed in plastic bags, transported in chilled coolers, and stored at 0°C until processing. Each core was washed through a series of sieves. Roots and detritus were transferred to Berlese funnels. Meanwhile, the material in the bottom sieve was transferred to a glass jar to which a concentrated Epsom salt solution was added. The jar was inverted to thoroughly mix the material, after settling, the surface layer was examined for any arthropods. Berlese funnels were inspected after the root material had thoroughly dried.

Results:

After processing 226 out of 656 soil samples, only one larva was recovered from the edge of a probable hotspot. Based on the adult emergence patterns, that are discussed in the next section, the population is highly variable and scattered throughout the bed reducing the effectiveness of this sampling method.

2. Emergence and feeding patterns

Method:

The overwintering study sites were located at two commercial cranberry marshes in Wisconsin. Emergence cages were placed either on the dike or in the cranberry bed after cranberry bloom, on June 22, 2012 and June 25, 2012. The cages were 15 ft. (4.6 m) in length by 3 ft. (0.9 m) in width by ft. (0.5 m) in height. Cages were supported by wire hoops and enclosed with a spun polyester fabric that has 90% light transmission. The fabric was secured at the soil surface using bio-degradable starch staples. Adult RHFB were collected weekly from the cages using a vacuum-based insect collection device. Collected beetles were transferred to a plastic bag and stored over ice until reaching the laboratory and subsequent stored at -20°C. Adult collections began on July 23, 2012 and ended on August 24, 2012.

Three commercial cranberry marshes were study sites for assessing the feeding distribution at the bed level. Ten sets of twenty sweeps were performed on the dikes, at the bed edges, and in the interior of the cranberry bed. The bed edges were defined by the outer fifteen feet (5 m). Sweep paths were in a zig-zag for the edges and interior. After each set of twenty sweeps, the net was visually inspected and the number of adult beetles recorded. Sweeps were performed in the morning at all locations.

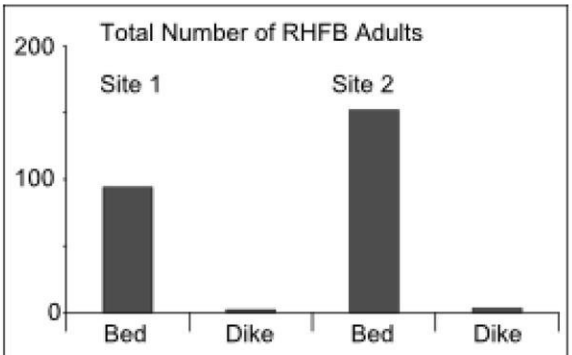

Figure 2: Total number of RHFB Adults recovered from emergence cages. Eight cages were placed in each location, bed or dike, at both sites. Adults were collected each week from July until August.

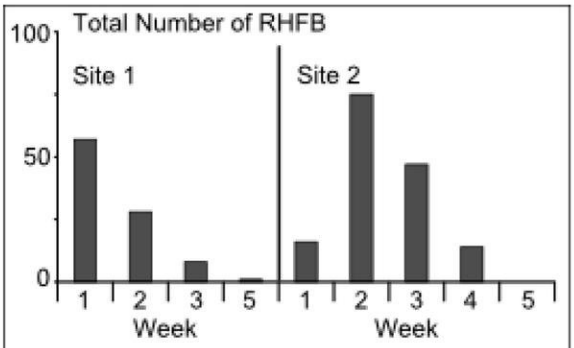

Figure 3: Weekly total of adult RHFB caught in emergence cages. This is another way to represent the data in Figure 2.

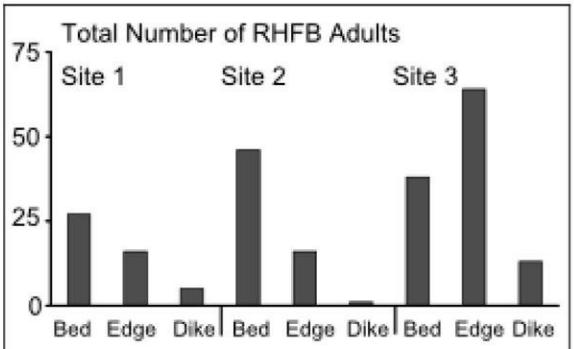

Figure 4: Feeding distribution of RHFB adults at three sites. The values reflect the total number of adults recovered in sweep nets during the 2012 growing season.

Results:

From the emergence cages, most adult RHFB were caught from the bed compared to the dike, 246 individuals versus 5 individuals for the entire season at both marshes (Fig. 2). Most of the adults emerged during the first three weeks at both sites (Fig. 3). However, the highest number of RHFB adults was collected during the first week at Site 1 versus the second week at Site 2.

Sweep net sampling in the interior of the bed, at the edges, and on the dikes at three sites suggests that most of the RHFB adults are feeding in the bed (Fig. 4). However, it is important to note that for all three sites, the dikes were mown regularly. Mowing eliminates most of the leaf tissue from the broad-leaf weeds that could serve as food for the RHFB. The distribution of adults is likely to change depending on the availability of host plant species.

3. Insecticidal soil drench

Method:

Three field sites were selected according to variety, region, and history of RHFB infestation. Insecticides were applied to the canopy and drenched into the soil with irrigation one week prior to bloom and one week following bloom to small plots within the cranberry bed. Each of the following treatments was applied to four plots per treatment: before bloom Altacor, Delegate, Belay, and NematacC, an entomopathogenic nematode product and after bloom, Belay. Control plots that received no insecticidal soil drench were included at each marsh. Emergence cages were installed over treated and control plots to contain any adults. Feeding damage and adult populations were monitored each week. Yield could not be estimated because the plots were caged prior to bloom.

Results:

The number of adults was not statistically different when comparing the soil drench treatments (Fig. 5). However, the post-bloom Belay soil drench had significantly less damaged uprights compared to the control and other pre-bloom applications (Fig. 6).

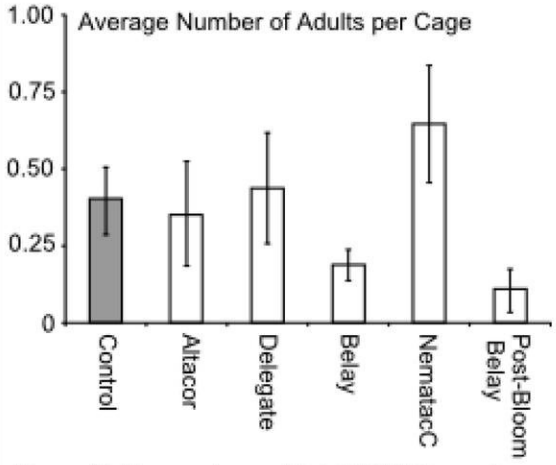

Figure 5: Comparison of Adult RHFB counts between soil drench treatments. Each plot was caged and sampled each week. A short ten second sampling with an insect vacuum was performed three times per cage. Very low numbers of adult RHFB were found with this method and were not statistically different. However, this trend is similar and significant for upright damage.

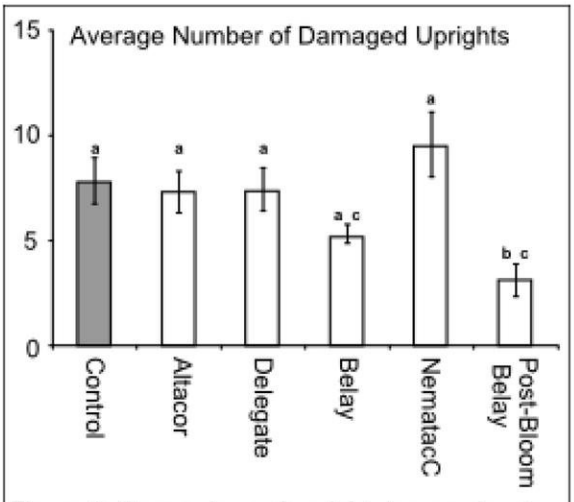

Figure 6: Comparison of upright damage levels between soil drench treatmens. Altacor, Delegate, Belay, and NematacC were applied before bloom. After bloom, Belay was applied. Each treatment was replicated with four small plots at three commercial cranberry marshes. Treatments that share a letter, e. g. "a", are not statistically different. The post-bloom belay application is the only treatment different from the control.

Acknowledgements

I'd like to thank the grower-cooperators who participated in these projects. Their help and flexibility were invaluable. Thank you to everyone from the Steffan Lab who helped with sampling. Also, thank you to Leroy Kummer and Hannah Gaines for their advice.

List of Recorded Food Plants of RHFB Adults

Asterix (*) indicate recognized weed in cranberry production; list was compiled with the following references: (Clark, LeDoux et al. 2004; Colquhoun, Roper et al. 2009), see http://plants.usda.gov/java/ for images and more information.

Common Name	Scientific Name	Plant Family
American water-willow	*Justicia americana*	Acanthaceae
Redroot amaranth	*Amaranthus retroflexus*	Amaranthaceae
Poison oak	*Rhus toxicodendron*	Anacardiaceae
Carrot	*Daucus carota*	Apiaceae
Parsley	*Petroselinum crispum*	Apiaceae
Indian hemp	*Apocynum cannabinum*	Apocynaceae
Common winterberry	*Ilex verticillata*	Aquifoliaceae
*Common milkweed	*Asclepias syriaca*	Asclepiadaceae
*Common ragweed	*Ambrosia artemisiifolia, A. trifida*	Asteraceae
*Common burdock	*Arctium lappa, A. minus*	Asteraceae
*Aster, Bottomland aster	*Aster spp.*	Asteraceae
*Common beggarticks, devil's beggarticks	*Bidens frondosa*	Asteraceae
Nodding plumeless thistle	*Carduus nutans*	Asteraceae
Chrysanthemum	*Chrysanthemum*	Asteraceae
*Canada thistle	*Cirsium arvense*	Asteraceae
Dahlia	*Dahlia*	Asteraceae
*Burnweed	*Erechtites hieraciifolia*	Asteraceae
Joe pye weed	*Eupatorium purpureum*	Asteraceae
*Narrowleaf goldenrod, slenderleaf goldenrod	*Euthamia graminifolia*	Asteraceae
Sunflower	*Helianthus annuus*	Asteraceae
Strawflower	*Helichrysum*	Asteraceae
Canada lettuce	*Lactuca canadensis*	Asteraceae
Oxeye daisy	*Chrysanthemum leucanthemum*	Asteraceae
*Canada goldenrod	*Solidago spp.*	Asteraceae
cocklebur	*Xanthium sp.*	Asteraceae
*Jewelweed	*Impatiens capensis*	Balsaminaceae
Gray alder	*Alnus incana*	Betulaceae
Horseradish	*Armoracia rusticana*	Brassicaceae
Turnip	*Brassica oleracea*	Brassicaceae
Hops	*Humulus lupulus*	Cannabaceae
Bush honeysuckle	*Diervilla*	Caprifoliaceae
Japanese honeysuckle	*Lonicera japonica*	Caprifoliaceae
Weigelia (not in WI)	*Weigelia*	Caprifoliaceae
Beet	*Beta vulgaris*	Chenopodiaceae
*Common lambsquarters, goosefoot	*Chenopodium album*	Chenopodiaceae
*Virginia marsh St. Johnswort	*Hypericum virginicum*	Clusiaceae

Common Name	Scientific Name	Plant Family
Sweet potato	*Ipomoea batatas*	Convolvulaceae
Swamp azalea (not present in Wisconsin)	*Rhododendron viscosum*	Ericaceae
Blueberry, high bush	*Vaccinium corymbosum*	Ericaceae
Cranberry	*Vaccinium macrocarpon*	Ericaceae
Soybean	*Glycine max*	Fabaceae
Alfalfa	*Medicago sativa*	Fabaceae
Lima bean	*Phaseolus lunatus*	Fabaceae
Kidney bean	*Phaseolus vulgaris*	Fabaceae
*Clover, white and red	*Trifolium pratense, T. repens*	Fabaceae
Horse bean (not in WI)	*Vicia faba*	Fabaceae
Black currant	*Ribes nigrum*	Grossulariaceae
Gooseberry	*Ribes sp.*	Grossulariaceae
Carolina redroot (not in WI)	*Lachnanthes tinctoria*	Haemodoraceae
Harlequin blueflag	*Iris versicolor*	Iridaceae
*Wild mint, Germander	*Lycopus rubellus (Mentha, Teucrium)*	Lamiaceae
*Healall, selfheal	*Prunella vulgaris*	Lamiaceae
Flax	*Linum sp.*	Linaceae
Swamp loosestrife	*Decodon verticillatus*	Lythraceae
Crape myrtle (not in WI)	*Lagerstroemia indica*	Lyrthraceae
Okra	*Abelmoschus esculentus*	Malvaceae
Velvetleaf	*Abutilon theophrasti*	Malvaceae
Common marshmallow	*Althaea officinalis*	Malvaceae
Cotton (not in WI)	*Gossypium sp.*	Malvaceae
Rosemallow	*Hibiscus militaris*	Malvaceae
Sweetgale	*Myrica gale*	Myricaceae
Forsythia	*Forsythia*	Oleaceae
Willowherb	*Epilobium adenocaulon*	Onagraceae
*Evening-primrose	*Oenothera biennis*	Onagraceae
Royal fern	*Osmunda regalis*	Osmundaceae
Common plantain	*Plantago major*	Plantaginaceae
Rice	*Oryza sativa*	Poaceae
*Giant foxtail	*Setaria faberi*	Poaceae
Corn	*Zea mays*	Poaceae
Buckwheat	*Fagopyrum*	Polygonaceae
*Water smartweed	*Polygonum amphibium*	Polygonaceae
Black bindweed	*Polygonum convolvulus*	Polygonaceae
Marshpepper knotweed	*Polygonum hydropiper*	Polygonaceae
*Pale smartweed	*P. lapathifolium*	Polygonaceae
*Pennsylvania smartweed	*P. pensylvanicum*	Polygonaceae
*Ladysthumb smartweed	*P. persicaria*	Polygonaceae
*Arrowleaf tearthumb	*P. sagittatum*	Polygonaceae
*Sheep sorrel	*Rumex acetosella*	Polygonaceae
*Swamp candles, swamp loosestrife	*Lysimachia terrestris*	Primulaceae
*Strawberry	*Fragaria spp.*	Rosaceae

Common Name	Scientific Name	Plant Family
Apple	*Malus sylvestris*	Rosaceae
Pear	*Pyrus communis*	Rosaceae
Carolina rose	*Rosa carolina*	Rosaceae
Shining rose (not in WI)	*Rosa nitida*	Rosaceae
*Blackberry, Raspberry, Swamp dewberry	*Rubus spp.*	Rosaceae
*Hardhack, Steeplebush	*Spiraea tomentosa*	Rosaceae
Buttonbush	*Cephalanthus occidentalis*	Rubiaceae
Poorjoe	*Diodia teres*	Rubiaceae
Virginia buttonweed (not in WI)	*Diodia virginiana*	Rubiaceae
Smooth false buttonweed (not in WI)	*Spermacoce glabra*	Rubiaceae
Heartleaf willow	*Salix cordata*	Salicaceae
Bebb willow	*Salix rostrata*	Salicaceae
Roundleaf greenbriar (not in WI)	*Smilax rotundifolia*	Smilaceae
Eggplant	*Solanum melongena*	Solanaceae
Potato	*Solanum tuberosum*	Solanaceae
*Riverbank grape	*Vitis riparia*	Vitaceae

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PHEROMONE-BASED MATING DISRUPTION TO CONTROL THE HISTORICAL TOP THREE INSECT PESTS OF WISCONSIN CRANBERRIES

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Alternative methods of pest control, specifically mating disruption (MD), have been investigated in many agricultural systems. MD has been used extensively in the US apple and pear industries for the last 20 years and is now a major component of orchard pest management in the Pacific Northwest. MD has also been tested in cranberry but there have always been drawbacks due to an inadequate carrier.

The premise of MD is that the air is saturated with the synthetic sex pheromone(s) of the target species, which impairs the male's ability to track the true female pheromone plume. If MD is successful, mating frequency drops significantly and many eggs remain unfertilized, thereby eliminating much of the subsequent generation. MD is most efficient in areas of moderate to low pest density, since in high pest areas there is a greater likelihood that males and females will find each other just by chance. A major consideration for implementing a MD program is that there is a method to release enough pheromone into the air during adult flight to adequately confuse the males. Two factors, the number of pheromone dispensers and the length of time that the pheromone is released, are key to ensure thorough coverage from a single application.

The need for a suitable pheromone carrier that provides high point-source densities, consistent pheromone release rates, and reduced labor costs, may be resolved with the SPLAT® technology. SPLAT® (Specialized Pheromone & Lure Application Technology) was developed by ISCA Technologies (Riverside, CA) and is a viscous, inert, food-grade wax emulsion that can be impregnated with synthetic pheromone(s). SPLAT® also has the potential for mechanical application, and once we have established that it works, we will be partnering with ISCA engineers to retrofit a tubing system that can deposit SPLAT® directly into the marsh using existing pesticide application equipment.

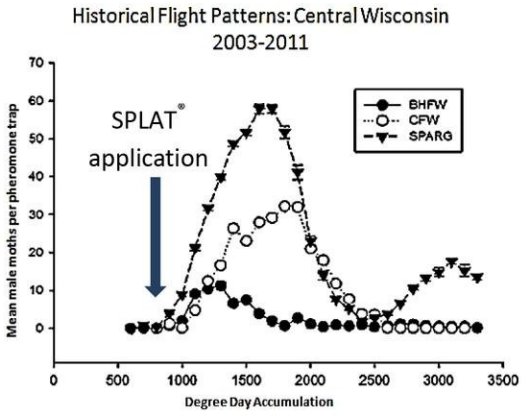


Figure 1. Trap count of CFW, SFW, and BHFW male moths from 2003-2011 across the major growing regions in Wisconsin. Degree days were calculated from a March 1 biofix using 41°F/85°F thresholds. The arrow indicates the correct time for a SPLAT® application.

In our 2012 trial, we tested SPLAT® as a pheromone dispenser in the cranberry system. However, instead of targeting only one insect pest, we were attempting to disrupt the mating of three species: cranberry fruitworm (CFW), *Spargnaothis* fruitworm (SFW), and black-headed fireworm (BHFW). There have been limited MD studies targeting multiple pests at once because it is not feasible in most agricultural systems. Cranberry has the potential because 1) all three of these major perennial pests have the main component(s) of their sex pheromone

commercially available, and 2) the adult flights are tightly correlated (Fig. 1). Thus, one application of SPLAT® right before the first adults emerge would be at the correct time to disrupt mating for all three species (Fig. 1).

METHODS

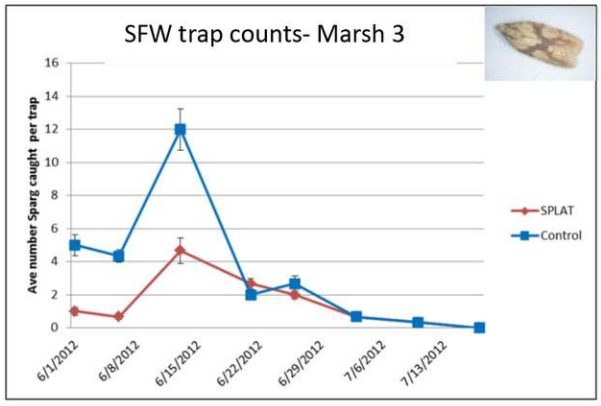
SPLAT® was loaded with the synthetic pheromones at ISCA's facility and shipped in 250 ml caulking tubes. Unfortunately, due to production issues, ISCA could only supply 20 acres worth of the CFW pheromone, so the remaining SPLAT® contained just SFW and BHFW's pheromones. A total of 20 acres at two marshes were treated with the three species blend and a total of 29 acres at two other marshes were treated with the two species blend. There was a total of 59 acres of untreated control. We deposited SPLAT® by caulking gun in 3.2g dollops directly on the runners (Fig. 2). In each bed, SPLAT® was applied in 8 rows with 7-8 feet between dollops, totaling over 300 dollops per acre.

Figure 2. SPLAT® deposition within the canopy.

RESULTS AND DISCUSSION

Our metrics of success were based on the number of male moths caught in pheromone-baited traps, female mating frequency, and larval densities in subsequent generations.

Pheromone-baited traps were set down the center of the inner most three beds of each block. We expected to see fewer male moths in our SPLAT® versus control traps, since adequate pheromone levels would prevent the males from locating the traps. At two of our marshes, we caught very low numbers of BHFW and SFW moths in both our treatment and control blocks, so we were unable to determine the effect of SPLAT® at those locations. At Marsh 3 we caught fewer BHFW and SFW moths in our SPLAT® versus control block (Fig. 3). At Marsh 4, we actually caught more SFW moths in our SPLAT® versus our control block but we discovered that there were inconsistencies in helicopter-applied insecticide from the previous season, resulting in a likely SFW hotspot in the SPLAT® treated beds. We did catch fewer BHFW moths in our SPLAT® versus control block at this marsh, however, SPLAT® efficacy could not be assessed since our control and SPLAT® blocks did not have similar treatment histories. Regarding CFW, in the marshes treated with the three species blend, we caught similar numbers of moths in our control



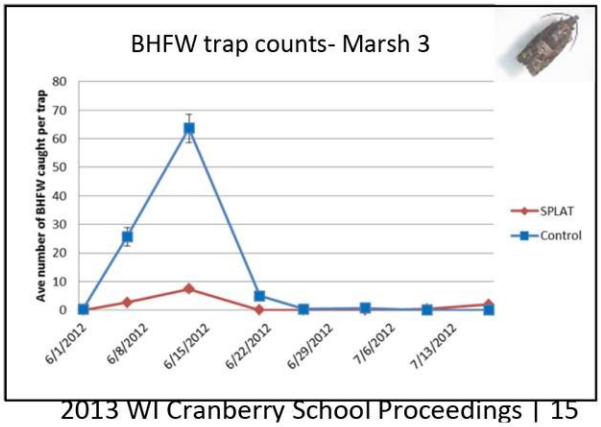


Figure 3. Average number of male moths caught per pheromone-baited trap at Marsh 3.

and SPLAT® treated beds. Previous studies have shown that CFW moths require two pheromone components to elicit any response, but the SPLAT® formulation from 2012 only contained one of the two pheromone components. Next season, ISCA will manufacture SPLAT® with both components of the CFW pheromone. Nevertheless, even with all these difficulties, insecticide applications were reduced by one spray in the SPLAT® beds at all four marshes.

To determine mating frequency, we attempted to collect female moths using a Dvac, a large insect vacuum. In previous seasons it had been successful as a low-impact sampling device, but last season it did not catch the moths that were needed, so we were unable to determine mating frequency. This coming summer we are planning to determine mating frequency using sentinel moths, which are virgin females that are set out in cages. These females can easily be collected and dissected to determine their mating status. Last summer we were also unable to determine any differences in larval densities since we only found CFW larvae, which we were effectively not treating for due to the incomplete CFW pheromone. Next season we will be adding timed visual scans, sweeping, and more berry scoring to increase our chances of finding larvae of all three species. On a positive note, both our collaborating growers and the Ocean Spray receiving station reported that they did not see any SPLAT® dollops coming in with the harvested berries.

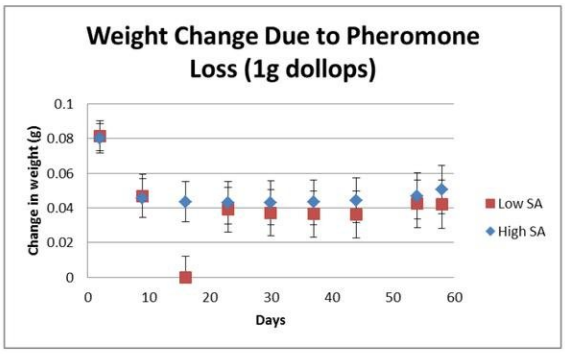


Figure 4. Volatilization pattern of the pheromone components from 1g SPLAT® dollops. Positive values indicate weight loss entirely due to pheromone release.

This first year we also performed a volatilization study to determine the effect of SPLAT® dollop size and shape on the pheromone release rate. Our experiment was set up as a two-way fully crossed factorial comparing size (1g vs. 3.2g) and shape (round, low surface area vs. cylindrical, high surface area). Blank SPLAT® was used as a positive control. We found that shape did not affect the release rate for the 1g dollops, but it did affect the release rate for the 3.2g dollops. This indicates that we can use 1g dollops in the future without worrying about perfect uniformity in shape among the dollops. Regarding the release rate across time, we discovered that, for the 1g dollops, there was a large initial release, but it quickly leveled off and remained low and constant for the rest of our study. This means that SPLAT® contains enough of the pheromones to last the full length of the adults' first flight (Fig. 4).

In conclusion, SPLAT® looks promising for multi-species MD in the cranberry system. In terms of the logistics of the program, we found that SPLAT® deposition within the cranberry canopy was feasible and the pheromone components were released in a low, uniform manner that lasted the full eight weeks of our study. As for the potential of MD using SPLAT®, where we had measurable moth populations and our experimental conditions were maintained, we caught fewer SFW and BHFW moths in our SPLAT® versus control blocks. Additionally, we found that SPLAT® did not contaminate the berries at harvest. And, most importantly, even in this first season, SPLAT® replaced one insecticide application. Next season, as we increase the acreage treated with the three species blend and improve our sampling technique, we

hope to see high levels of MD for all three species, levels which, in the future, may no longer require insecticidal sprays for these pests.

ACKNOWLEDGEMENTS

We would like to thank ISCA technologies for supplying the SPLAT®. We gratefully acknowledge our collaborating growers and the help we had from the Steffan and Zalapa lab personnel. This project was funded by the USDA-ARS, Wisconsin Cranberry Board, and the Cranberry Institute.

Meet our new entomologist

CHRISTELLE GUEDOT

UNIVERSITY OF WISCONSIN-MADISON, DEPARTMENT OF ENTOMOLOGY

Christelle is originally from Southern France where she obtained her B.S. in Cell Biology and Physiology and a Maîtrise in Neurobiology. In 1998, she moved to Logan, UT and in 2004 she obtained her Ph.D. from the Entomology Department at Utah State University. Her dissertation was on the nest location and nest recognition in two solitary cavity-nesting bees, the alfalfa leaf-cutting bee and the blue orchard bee, both important commercial pollinators.

One project addressed the effect of three dimension and color patterns on nest location and reproductive success of the alfalfa leaf-cutting bee, *Megachile rotundata*, in commercial alfalfa pollination. In commercial alfalfa seed production, where high bee densities are released, alfalfa leaf-cutting bee females may enter several nesting holes before locating their nests. Such levels of "wrong hole" visits lead to an increase in the time spent by females locating their own nests, thereby decreasing alfalfa pollination efficiency and possibly healthy brood production. The objectives of this study were to determine the effect of different nesting board configurations in commercial alfalfa leafcutting bee shelters (applying a three-dimensional pattern to the boards, applying a color contrast pattern, or applying a combination of three-dimensional and color contrast patterns) on nest location performance and on the incidence of chalkbrood disease. The three-dimensional pattern and the combined three-dimensional and color contrast pattern improved the ability of females to locate their nests compared with the uniform board (a standard configuration currently used commercially). The percentage of larvae infected with chalkbrood decreased by half in the three-dimensional board design, compared with the uniform board. These results have important implications for pollination efficiency and bee brood production.

Another study looked at the relationship between homing ability and body size in *Osmia*. The maximum homing ability of female bees, that is, their capacity to return to the nest after being displaced a certain distance, is considered to be an estimate of their maximum foraging distance. The homing ability of the blue orchard, *Osmia lignaria*, is 1,200m; beyond that distance females are not able to return to their nest. Homing ability and body weight for *Osmia lignaria* were combined with data for five other congenerics, *O. rufa*, *O. cornuta*, *O. pedicornis*, *O. cornifrons*, and *O. emarginata*. Homing ability is positively and linearly related to body weight: the bigger the bee, the further it can fly and still be able to return to its nest. These results should be of use in selecting *Osmia* species as potential crop pollinators, distributing nesting shelters in orchards, and establishing adequate buffer distances around genetically modified crops.

In 2005, Christelle moved to Yakima, WA to conduct a post-doc at the USDA-ARS. There she worked on the basic biology, behavior, and chemical ecology of pest insects in fruit trees and vegetable crops. One of her many projects there was to identify a sex attractant pheromone for the pear psylla, *Cacopsylla pyricola*. The pear psylla is a major pest of pear, in that the nymphs produce honeydew that drips onto the fruit and get colonized by sooty mold fungus, making the fruit unmarketable for fresh

market. To isolate the pheromone, we washed whole insects, batches of 50 males or females, in a solvent and performed chemical analyses of these solvent washes. The chemical analyses revealed that males and females had very similar profiles but that females produced more of a particular chemical called 13-methylheptacosane (13-MeC27). This chemical was found to be attractive to males but not to females in Y-tube olfactometer choice tests and was also found to be as attractive to males as a solvent wash of females, suggesting that this chemical might be solely responsible for the male attraction to females. This chemical was then tested in field at different doses (0, 10, 100, 1000ug of 13-MeC27) on sticky traps. More males were caught on traps baited with the chemical (10, 100, 1000ug) than on control traps (0ug). Females were not attracted to 13-MeC27. We also tested different trap designs (our mesh trap, a clear mesh trap, a clear solid panel, and a delta trap) and found that the clear mesh trap was more efficient at catching psylla than the other types of traps. This is the first identification of a pheromone in any psyllid.

In October 2012, Christelle started at UW-Madison in the Entomology Department as the fruit crop entomologist and extension specialist. Her first research project at UW will address cranberry resistance to insect pests. She plans to hire a M.S. student in June that will work on this project to determine insect development rates, fecundity, and population densities in the field of blackheaded fireworm, sparganothis fruitworm, and cranberry fruitworm on six cultivars grown in Wisconsin to screen for cranberry resistance to insect-feeding damage.

IRRIGATION AND SOIL MOISTURE MONITORING IN WI CRANBERRY BEDS

REBECCA HARBUT[1], BETH WORKMASTER[1], LESLIE HOLLAND[2], CLAY VANDERLEEST[1], JEAN CARON[3]

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Water is an essential resource for cranberry production as it is used for irrigation, pest management, crop protection and harvest. Irrigation accounts for the largest amount of water consumption in cranberry production. A greater volume of water is used for management practices such as pest prevention, crop protection, and harvest however, unlike irrigation, the water used in pest management, crop protection, and harvest is recycled. Reducing water use in irrigation is critical due to both the consumption of water as well as the cost of fuel used to run the irrigation pumps. There are currently several soil moisture monitoring tools that are available to growers to provide additional information to help improve the efficiency of water use in cranberry production. This study was designed to evaluate the impact on crop productivity under two irrigation regimes based on two different tensiometer set points and evaluate the use of two types of soil moisture probes.

Methods

Setup and Experimental Design

This field study was conducted on a 5 acre cranberry bed of the cultivar 'Stevens' in Tomah, Wisconsin during the 2011 and 2012 growing season. The cranberry bed is divided into 8 blocks, and each block contains a wet and dry treatment area at either end of the bed (Figure 1). Tensiometers were located in blocks 2, 4 and 8 of the cranberry bed and volumetric water content probes were installed in Blocks 4 and 6 to record soil moisture levels daily.

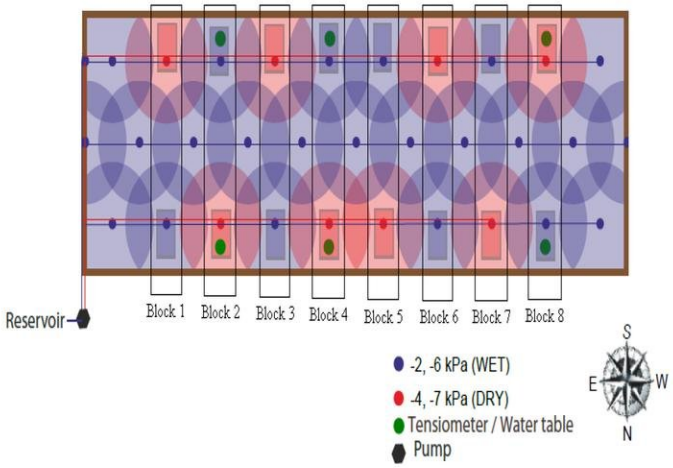

Figure 1. Experimental design in cranberry bed. Each block contains a wet and dry treatment, assigned randomly.

*Treatments***.** Two soil moisture treatments were established through two independent irrigation lines using overhead sprinklers. The matric potentials for the treatments were maintained at -2 to – 6 kPa (wet treatment) and -4 to -7.5 kPa (dry treatment). The wet treatment broadly corresponds to what producers regularly target in their fields (Table 1)

Table 1. Water applications for wet and dry treatments in 2011 and 2012

Year	Data collection Period	Treatment	Rain		Heat Protection		Irrigation		Other[1]		Total
			Inches	%	Inches	%	Inches	%	Inches	%	Inches
2011	6/20-8/31 (72 days)	Wet	7.44	36	0.08	0	12.72	62	0.20	1	20.43
		Dry	7.44	66	0.08	1	3.46	31	0.28	2	11.26
2012	6/1-9/7 (99 days)	Wet	8.87	25	0.0	0	26.09	75	0	0	35.0
		Dry	8.87	42	0.20	1	11.88	57	0	0	20.9

Soil Moisture Measurements. Soil moisture was continuously monitored by Hortau tensiometers and volumetric water content probes (Echo 5, Campbell Scientific, Inc.) throughout the growing season. Tensiometers measure soil water tension, or the force that is required to 'pull' water out of the soil matrix. This type of measurement provides an indication of how difficult it is for plant roots to extract water from the soil matrix. This type of probe can be used in many soil types however, it requires 24-48 hours to equilibrate with the soil matrix before measurements can be made.

Volumetric water content probe. This type of probe measures the % of the soil volume occupied by water. It does this by measuring the travel time of an electromagnetic wave along a waveguide (rods). The speed of the signal changes based on the volume of the soil occupied by water, so the value generated indicates the % volumetric water content. This value is not a direct measurement of soil moisture, but a calculation based on the electromagnetic wave, therefore the instrument must be calibrated to the specific soil type that it is being used in to generate accurate readings. A brief comparison of these two types of probes is listed in Table 2.

Table 2. Comparison of tensiometers and volumetric probes

Tensiometer	Volumetric Probe
Measures tension required to 'pull' the water out of the soil matrix	Measures percent volume of water in the soil matrix
Does not need to be calibrated to specific soil	Must be calibrated to specific soil
Requires 24-48 hours to equilibrate before reading can be taken	Readings can be taken immediately
Must have proper contact with soil for proper readings	Must have proper contact with soil for proper readings
Maintain adequate water levels in the tensiometer and porous tip	Maintain electrical connections

Plant Physiological Parameters

Photosynthetic capacity (A_{max}) and stomatal conductance (g_s) measurements were made on current season's growth. After completing gas exchange measurements the portion of the upright measured inside the chamber was bagged for leaf area analysis so that photosynthetic rates per leaf area could be calculated. Leaf area was measured by scanning the leaves of each upright in reference to a ruler and using ImageJ to calculate the area.

Xylem Potential is a measure of the tension on the water column in the plant. The greater the water stress, the more negative the tension on the water column. Xylem potential was measured on

fruiting and non-fruiting uprights of the current season's growth throughout the growing season. This parameter was measured with a plant water status console or pressure bomb. Uprights were selected from each treatment and a fresh cut was made at the base of the stem prior to being placed in the sealed chamber. In the chamber samples were pressurized with nitrogen gas. The pressure is slowly increased until sap from the fresh cut stem is released.

Chlorophyll fluorescence was measured with a Handy PEA Chlorophyll Fluorometer (Hansatech Instruments Ltd.). These measurements were taken pre-dawn (23:30 HR to 01:00 HR) on healthy, current season's growth. Fv/Fm is a commonly used metric to measure plant stress by exposing dark adapted leaves to a super-saturating pulse of light and measuring the plants ability to utilize the light for photochemistry compared to dissipating the light as heat or fluorescence. Stressed plants have a lower capacity to convert incident light energy to photochemistry.

Growth measurements and Yield Potential. Vegetative and reproductive uprights were collected from the experimental blocks for both treatments and brought back to the lab for length measurements of current season's growth. Fresh weights were taken, and uprights were placed in drying oven for 24 hours prior to taking biomass measurements. Flower counts were conducted in late June while fruit set counts were made in the end of July and yield data was collected at harvest.

Results and Discussion

Soil moisture status was monitored throughout the growing season with two different probes. The irrigation treatments were applied based on the tensiometer set points and soil moisture was maintained within the limits of these set points throughout the season (Figure 2). The volumentric water content of the treatments ranged between approximately 12-15% for the dry treatment and 14-19% for the wet treatment during most of the season (Figure 3). The range of % soil moisture can not be used to inform irrigation set points for another field as the different soil textures will have different % water content in a saturated soil. The tension set points can be used in any soil texture and can therefore be used in different locations. Both probes provided consistent readings during the 2012 growing season. During late August and September, the soil moisture content was similar in both treatments due to increased precipitation events.

Results from photosynthetic capacity (A_{max}) and chlorophyll fluorescence (Fv/Fm) measurements suggest that there was no difference in photosynthetic rates or fluorescence rates. Fv/Fm is a physiological parameter that is often used to measure plant stress. These results suggest that the dry treatment did not reduce the photosynthetic potential of the photosystems and that the plants are not experiencing physiological stress. Photosynthetic data can be a useful indicator of the plants ability to assimilate carbon, however it does not provide information about how the plant is utilizing the assimilated carbon. Therefore, this data provides evidence that the plants potential to assimilate carbon does not appear to be impacted by the reduced irrigation treatments but it is not an indication of how the carbon is allocated in the plant.

Xylem potential results from 2012 show that the dry treatment resulted in more negative xylem potential readings than that of the wet treatment, consistent with the reduced irrigation. As the 2012 season progressed and plants were further exposed to water stress there was a greater difference between the two treatments with less negative xylem potential in the wet treatment. Preliminary

results (2011) also determined that the dry treatment experienced more negative xylem water potentials. Collectively, these results for xylem potential suggest that the reduced irrigation directly affects the water status of the plants. However, the water stress did not seem to be extreme enough to impact physiological mechanisms that are typically affected by water stress as evidenced by the photosynthetic and chlorophyll fluorescence data.

Biomass measurements indicated that there was no difference in growth between the wet and dry treatment There were differences between the vegetative and reproductive uprights however, this is expected as reproductive uprights allocate a significant amount of carbon to the developing fruit rather than to vegetative growth (Table 3).

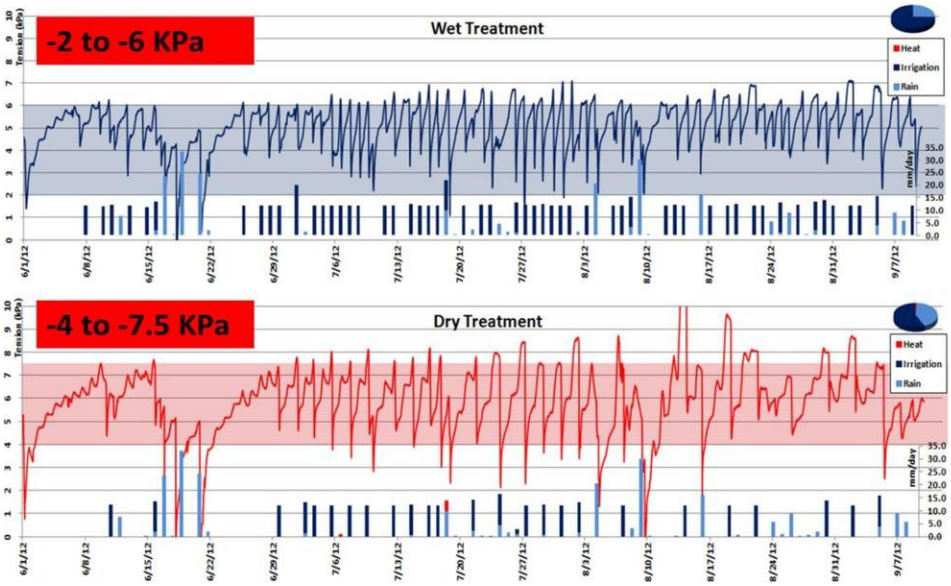

Figure 2: Water tension was monitored throughout the 2012 growing season for both treatments. The dry treatment experienced a higher matric potential than the wet treatment

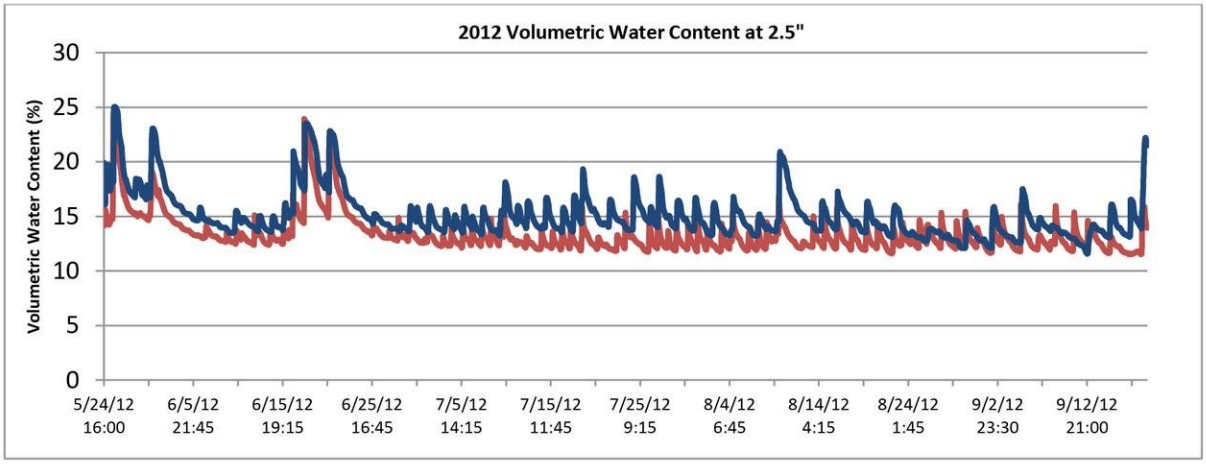

Figure 3. Volumetric water content of the Dry treatment (red line) and Wet treatment (blue line) measured throughout the 2012 growing season.

Table 3: Upright length of reproductive and vegetative uprights during 2012 season. There was not difference between wet and dry treatments in the vegetative or reproductive growth. Values followed by the same letter are not significantly different.

Structure	Upright length (cm)
Vegetative	11.511 a
Reproductive	6.623 b

Table 4: The overall biomass (vegetative and reproductive) for the wet and the dry treatment. Values followed by the same letter are not significantly different.

Treatment	Biomass (g)
Wet	3.304 a
Dry	3.39 a

Flower counts and fruit set results were consistent with general trends, where flower number is higher than fruit number because not all flowers set fruit (Figure 4). Fruit set counts were not statistically different between the wet and the dry treatment indicating there was no impact on yield potential by the dry irrigation treatment. Yield results also indicate that there was no impact on productivity by the reduced irrigation treatment (Table 5).

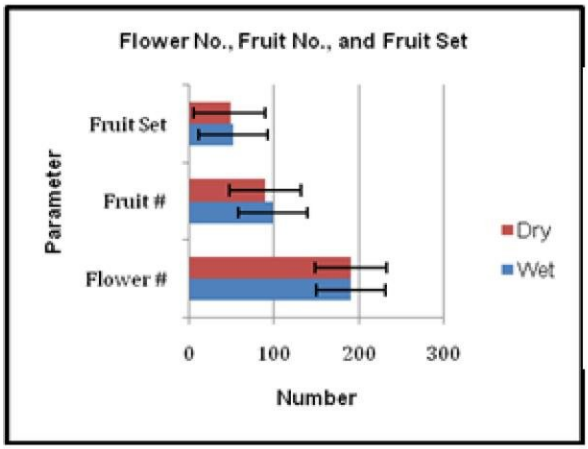

Figure 4: Flower and fruit set averages for the wet and dry treatment the bars indicate the standard error of the data collected. Overlapping bars indicate no significant difference in values.

Table 5. Yield parameters for the wet and dry irrigaiton treatment for 2011 and 2012.

Year	Treatment	Yield (lb/A)	Marketable Berrty #/sqft	Marketable Berry Wt (g)	Unmarketable Berry #/sqft
2011	Wet	33,751	231	1.5	17.2
	Dry	34,382	240	1.5	21.7
2012	Wet	25,853	190	1.44	6.2
	Dry	27,673	200	1.45	6.8

Conclusions

Cranberries are perennial crops and their yield potential is determined 14-15 months prior to harvest. It is currently thought that the fruit set of cranberry plants are limited by carbohydrate status, which is impacted by the plants ability to assimilate carbohydrates. The results of this study suggest that reduced irrigation rates did not adversely affect the photosynthetic capacity of the plants and did not lead to reduced productivity. With this being the second growing season that this study was conducted, it is encouraging that results are recurrent. A limitation of this study is that it is difficult to isolate the treatment effects to the area of data collection as the root system extends beyond the area of data collection. It is also difficult to determine the role of capillary rise of the water. Continued research and monitoring is needed to insure that these results are recurrent and accurately representing the current season's growth.

The results of this study indicate that it is possible to significantly reduce the amount of water applied through irrigation without detrimental crop effects. The use of soil moisture probes will allow growers to more accurately track soil moisture conditions and utilize these tools to manage application of water. Both the tensiometers and the volumetric water content probes provided soil moisture data that could be used to inform irrigation management decisions. However, in order to use these soil moisture monitoring tools, it is essential to understand the principles of how they work and their limitations. Factors that must be considered when developing an irrigation management plan include; uniformity of irrigation system, water dynamics in the beds being irrigated and an understanding of the technology. A moisture probe will only measure the moisture content of the small region immediately surrounding the probe and therefore it is important to have an understanding of the variability in water dynamics in the entire area being irrigated. It is also important to remember that if a bed has been heavily irrigated, the root system of the plant will be very shallow and therefore a transition to a reduced irrigation schedule may need to occur gradually in order to allow plants to develop deeper root systems.

The results of this study suggest that the amount of irrigation applied to a cranberry bed can be reduced without detrimental effects on the productivity of the crop. Soil moisture probes can be a valuable tool by providing information about soil moisture status that can used to make irrigation management decisions.

Acknowledgments

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BERRY SCARRING ASSOCIATED WITH TOBACCO STREAK VIRUS

PATTY MCMANUS
Department of Plant Pathology, University of Wisconsin, Madison

Among the unusual observations in Wisconsin cranberry marshes in 2012 was a unique berry-scarring problem that showed up in early July. The worst affected beds were the Mullica Queen cultivar at three sites near Warrens. The scarring appeared as necrotic blemishes and cracks on berries, while leaves remained green and healthy in appearance (see photo). By September, some affected berries had dried up, while others were greatly distorted (see photo).

Necrotic scarring on fruit of Mullica Queen in July (left) and September (right).

Several factors were suggested as possible causes of the scarring. Toxicity from sprays was suggested, because some pesticides or combinations of products can burn berries, especially in hot weather. However, this idea was quickly dismissed because where the scarring occurred, it affected every berry on an upright while some other nearby uprights showed no symptoms at all. Superficially, the injury resembled damage caused by thrips insects on other fruit and vegetable crops. While populations of thrips were high on some other crops in the state, they are normally not a problem for cranberries, and cranberry scouts were not monitoring them closely in 2012. A third possibility that was suggested was Tobacco Streak Virus (TSV). The scarring on every berry on an upright would be consistent with systemic virus infection, and in fact, TSV has been described previously on cranberry, although until this year, it has never been associated with symptoms.

Three different tests were conducted to determine if TSV was present in plants with necrotic scarring and plants without symptoms. First, samples were sent to Agdia, a commercial laboratory that specializes in virus detection. The scarred berries and leaves from the uprights carrying scarred berries tested positive for TSV based on a test called enzyme-linked immunosorbant assay (ELISA). A diagnostic laboratory at the University of Minnesota found virus particles the size and shape that would be expected for TSV. The UM lab also did reverse-transcriptase polymerase chain reaction, a molecular test, and found further evidence for TSV. Thus, there was no question that we had TSV in cranberry, but the

question remained how widespread it was and whether it was the cause of scarring. As a next step, we tested several additional beds with a variety of symptoms on fruit and/or leaves.

Additional ELISA tests showed that in the affected Mullica Queen beds at three marshes near Warrens, 57 of 63 uprights with necrotic berries tested positive for TSV (see table). Plants with other types of symptoms such as ringspots, pinheads, or blossom blast from those same sites tested positive in 10 of 38 samples. Additional samples of symptomless uprights from the same Mullica Queen beds in which scarred berries tested positive for TSV were mostly negative; just 3 of 45 samples tested positive for TSV. It is not surprising to find TSV in a few uprights without symptoms, because viruses are often latent, or present without causing symptoms, in plants and animals. Samples with a variety of symptoms and healthy uprights from other areas turned up negative for TSV. Additionally, several samples were tested for a range of other common "berry" viruses, and all those results were negative.

Summary of ELISA tests for Tobacco Streak Virus on cranberry in Wisconsin, 2012

Location	Symptom type	Fraction of samples positive for TSV
Warrens (3 marshes, Mullica Queen)	Necrotic scar	57/63
	Pinhead, blossom blast, or ringspot	10/38
	No symptoms but collected from known TSV-positive bed	3/45
Manitowish Waters, Tomah, Mather (Stevens, GH1)	Necrotic scar, tie-dye, misc. ringspots, yellow mottled leaves	0/95
Babcock, Necedah, Tomah, Warrens (various cultivars, including Mullica Queen)	No symptoms	0/60

The data suggest an association between TSV and necrotic scarring in Mullica Queen beds near Warrens. However, to prove that TSV and/or thrips cause symptoms requires reproduction of those symptoms. While we will be attempting to do just that, we might not succeed. The unusual weather and growing conditions of 2012 may have contributed to symptom expression in a way that will be hard to mimic.

What threat does scarring and TSV pose? At the levels observed in 2012, berry scarring had a negligible impact on yield in affected beds. In isolated "hot spots," however, many berries were aborted or so misshapen that they did not enlarge and mature. On a more widespread basis, the scarring would undoubtedly reduce yields. Another concern is that TSV is carried on pollen, and in other crops, thrips vector the virus. In certain viruses related to TSV, it is actually pollinators who spread the virus.

Obviously, you cannot spray an insecticide to kill the insect vector, if the insect is your pollinator! Finally, viruses are unpredictable. It might be the case that cranberries yield fine for years despite infection with TSV, but then under certain environmental conditions or when combined with another virus, problems arise. There is precedent for this in other crops, so we must take TSV seriously, even if it is currently not reducing yields or killing plants. In 2013, we intend to survey cranberry marshes in Wisconsin for TSV and intensively resample sites affected in 2012 to determine which tissues, including pollen grains, harbor the virus. If we can obtain enough diseased tissue, we will do a genetic analysis to determine whether it is similar to TSV that infects other crops in Wisconsin, or if we have a unique strain on cranberry.

2012 Pesticide Screening Project Update -

Jack Perry, Jed Colquhoun, P. McManus and C. Williamson

2012 Weather Review

Winter - open, mild; snow lacking
Spring - "jump start" in March; April – back to normal temps
Summer - May / all summer – warmer than normal with minimal rain
July / August - hot & drought
Summer summary - hot *& dry*

Effects of 2012 Weather on Friends and Foes
Everything – 2-3 weeks earlier than "normal"
Cranberry - early warmth caused early break in dormancy – lots of frost protection required
Weeds - broke dormancy or germinated early
Insects – arrived earlier; surprise 2nd generation when normally one generation
Insects – some 2nd generation Sparganothis found
Diseases – less disease than normal; lack of rain was not favorable for disease development; cranberry diseases don't do well in extreme heat

Projection for Summer of 2013

A quote from a USDA climatologist "Drought conditions have changed very little across the Plains and Midwest this winter and have increased concerns as to what this may mean for the upcoming summer growing season

While not an official forecast for this summer, the historical analogs that similarly match last year's heat and dryness do indicate that *odds are in favor of drier and warmer conditions again this summer."*

FUNGICIDES & DISEASES

Where have all the diseases gone? 2010 was a banner year for fruit rot. 2011 - 2012 not much fruit rot.

2012 Review

2012 Fungicide Trials Objectives

1. evaluate registered fungicides for early rot, fruit rot and cottonball control
2. evaluate 11 candidate products for early rot, fruit rot control and cottonball
3. is there any value in alternating fungicides?

2012 Cranberry Fungicide Trials Materials & Methods

Bravo WeatherStik 6L, Bravo Ultrex 82.5WDG, Evito 4SC
Dithane 75DF, Indar 2F, Abound 2.08SC
11 Experimental Fungicides

Six Locations

3 trials for fruit rot; 3 trials for early rot; 3 trials for cottonball

Treatments

18 products; 20 treatments

Application Schedules

Two applications/disease
Early Rot –two applications at 50% bloom & 10 days later
Fruit Rot – two applications at late bloom /early fruit set & 10 days later
Cottonball – two applications at 10% bloom & 25% bloom

Successes and Failures in the 2012 Disease Trials

3 early rot trials with good disease pressure in newer plantings
3 fruit rot trials – insufficient disease pressure (less than 5% disease)
3 cottonball trials – no disease

What worked for early rot control:

Bravo WatherStik, Bravo Ultrex, Abound, Abound + Indar use rate, Abound + Indar ½ use rates and Dithane and Evito provided 80 - 90% control of early rot; Indar – 60%; exp fungicide – 92%

both Bravo WeatherStik and Bravo Ultrex caused significant fruit scarring but the scarring was probably a factor of exceptionally high July temperatures

Value of mixing & matching fungicides

Bravo followed by (fb) Bravo, Abound fb Abound, Dithane fb Dithane, Bravo fb Abound,
Abound fb Bravo, Bravo fb Dithane and Abound fb Dithane provided 84 – 89% control of earlyrot

2012 Cranberry Fungicide Trials Summary

Good early rot disease pressure, in young plantings
Bravo, Dithane, Abound and Evito worked; Indar not so well
Efficacy of Bravo WS comparable to Bravo Ultrex
One of the eleven candidate fungicides one shows much promise
Is there value in alternating fungicides - from a performance standpoint – no
BUT from an IPM / resistance deterrent standpoint – it makes good sense

What to do in 2013

1) Continue early rot & fruit rot control trials
   a) continue with registered products
   b) more experimental fungicides
   c) hone in on one candidate fungicide

2) Early rot trials in newer plantings – ***need sites***

3) Do cottonball trials - ***need sites***

INSECTICIDES & INSECTS

2012 Objective

Evaluate registered, newly registered and candidate insecticides for control of tipworms, fruitworms, fireworms, spanworms, flea beetles, leafhoppers and white grubs.

Insecticides Tested:
Actara 35WDG, Assail 30SG, Belay 2.1 SC, Delegate 25WG, Diazinon AG600, Imidan 70WP, Intrepid 2F, Confirm 2F, Knack 35WP, Lorsban 4EC, Rimon 0.8EC, Altacor 35WDG and 5 experimental insecticides

Materials & Methods

17 products, 20 treatments; 14 Trials in 2012, 2/pest; 1 or 2 applns/pest

Altacor Introduction:

New chemistry from Dupont; use rate 3 – 4.5 oz/acre = 3 applns/season; 9 oz max; 1 day PHI; broad spectrum of pests; safe on bees; systemic; lots of successful uses in 2012; a bit expensive.

Belay Update: Changes In progress *but not approved yet: 1)* Add rate range of 4-8 oz/appln; 2) Remove "apply post bloom" 3) Add " do not apply when bees are present"

To Make Imidan Work Best Know the pH; Imidan is most efficacious when the spray solution is slightly acidic (pH 6)

New Insecticides Tested in 2012:

5 candidate insecticides evaluated
4 had good activity on several of our insect pests
registrations for 3 of these are in-progress

Flea Beetles
Are we going to have to learn to live with them ? Yes - probably;
Why:-1) milder winter trend and 2) less use of OP insecticides; flea beetles are easily controlled; populations increase later in the season (August);
Effective products – Actara, Assail, Belay, Lorsban, Imidan, Diazinon, Orthene, Sevin

2012 Insecticides Summary

Registered products performed as expected, we have a good arsenal
Several experimental products showed good utility; 2 show great promise
Imidan has potential but must be pH adjusted to be effective
Need to learn to manage flea beetles

HERBICIDES & WEEDS

2012 Objectives

1. Problem weed escapes
2. New post herbicides

Weed escapes include sweet vernal grass, creeping red fescue, cinquefoil, Solomon's plume, maples, willows, popples, oaks, dewberry, St Johnswort, leatherleaf.

New POST Herbicides:

not many candidate products coming out - glyphosate resistant agronomic crops have degraded the market value of developing new herbicides

a lot of new products in the agronomic crops marketplace but most are package mixes of existing herbicides

two products have potentially pending cranberry registrations but both needs more work to find fit in WI

We anticipate a label for a new cranberry herbicide in 2013. This herbicide has demonstrated efficacy on dodder, yellow loosestrife, maples, golden rod and St. Johnswort

Status of Cranberry Pesticides Registrations

2010:

1) Intrepid – improved use – restrictions removed;
2) Belay and Rimon insecticides registered;
3) 3) Evito fungicide registered;

2011- 2012 - Altacor insecticide registered

2013 - new herbicide label anticipated in cranberry

In Registration Processes – 1) 3 new insecticides, 2) expand Belay rate, 3) 2 new herbicides, 4) 2 new fungicides

Causes of Berry Damage in 2012 – 1) disease – early rot, TSV virus, 2) chemical – mostly chlorothalonil, 3) scald – exceptionally hot temperatures in July

REFLECTING ON BUD APPEARANCE AND ITS ROLE IN YIELD PREDICTION

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Introduction

External appearance of buds is a widely used method of yield prediction in cranberry. This qualitative approach considers big and round buds to be reproductive and thus containing flower initials that will contribute to next season's crop. Alternatively, small and narrow buds are considered to be vegetative and, consequently, lack flower initials. Despite its widespread use, the margin of error associated with this approach to yield prediction can be significantly large.

Research in our lab is attempting to create a more accurate and quantitative approach to yield prediction. Yet, creating an improved method of yield prediction necessitates an enhanced understanding of bud development and the role buds impart in determining yield. Studies on cranberry bud development date back to the early-to-mid 1900s. While valuable, these studies utilized small sample sizes, were conducted for only one growing season, and included cultivars that are no longer widely cultivated. Reports of "rebud," which circumvents biennial bearing, is also widespread among recently released cultivars and is not described in previous literature.

These observations have led us to question our current understanding of cranberry bud development and the role of external bud appearance in yield prediction. To address these issues, we undertook the following project with the overall objective of improving our knowledge of cranberry bud development. Specific sub-objectives of the project include:

1) Characterize bud development and flower initiation throughout two or more growing seasons.
2) Compare patterns of bud development and flower initiation across several cultivars, including recently released cultivars.
3) Evaluate the relationship between external appearance of buds and presence/absence of flower initials.

Materials and Methods

Uprights were randomly sampled from a marsh located in Wood County, Wisconsin. Cultivars sampled include Stevens and Searles, as well as the two recently released cultivars of HyRed and Crimson Queen. Approximately 100 uprights of each cultivar were collected at two week intervals from 5 March to 7 Dec. 2011. Based on the 2011 data, sampling was reduced to 70 uprights per cultivar in 2012 and statistical robustness was maintained. Collection of uprights in 2012 was concentrated during the projected floral initiation period and occurred twice per week from 5 July to 30 Aug. Additional uprights were collected on 14 Sept. & 26 Oct. 2012. These final two collection dates permitted assessment of bud fate after harvest and upon entrance into dormancy.

After each collection date, uprights were divided into two categories – vegetative (nonfruiting) and reproductive (fruiting). Length, width, and size ratio (width/length) of buds were recorded before dissection via light and scanning electron microscopy (SEM). Presence/absence of flower initials was noted after each dissection. Growth degree days (GDD) were also determined from a Watchdog 2465 Plant Growth Station (base temperature of 61°F; maximum temperature of 86 °F).

Results

Excluding 'Searles,' flower initials were first observed across all cultivars on 29 July 2011 and 10 July 2012. These dates correspond to 290 and 332 GDD, respectively. Greater amounts of flower initials were observed within buds of vegetative uprights in 'Stevens,' whereas reproductive uprights had a tendency not to form flower initials (Fig. 1). This contrasts with 'HyRed' and 'Crimson Queen,' in which both vegetative and reproductive uprights had the capacity to form flower initials.

For convenience, only bud width data from 2011 are presented below (Fig. 2). However, results are consistent between 2011 and 2012. These data demonstrate that wider buds have a tendency to contain flower initials, regardless of an upright's fruiting status. Also noted was that the recently released cultivars of HyRed and Crimson Queen had a greater average bud width relative to Searles and Stevens. Few samples of 'Searles' could be included in the analyses due to an abundance of terminal bud death. Bud death within 'Searles' occurred during both growing seasons, despite no evidence of tipworm (*Dasineura oxycoccana)*.

Figure 1. Comparison of floral initiation patterns across three cultivars of cranberry and four categories of upright growth. Data were collected on 26 Oct. 2012 and included the dissection of 90 uprights per cultivar.

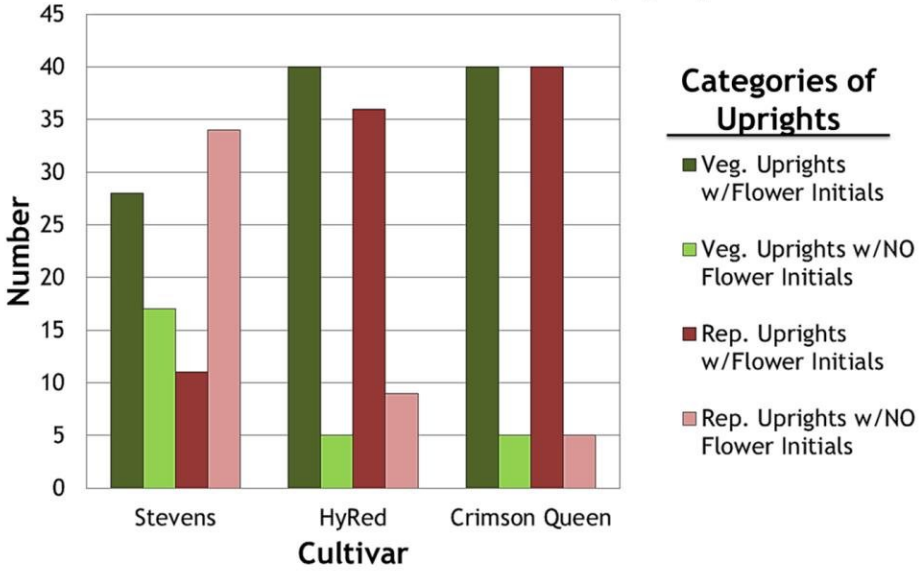
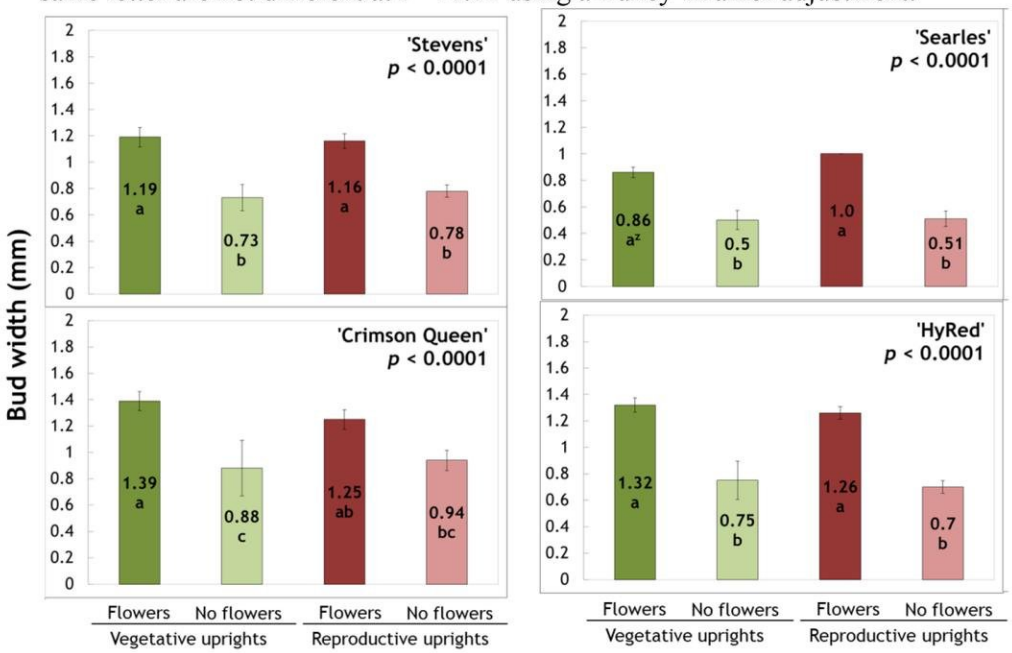


Figure 2. Relationship between bud width and presence/absence of flower initials across four cultivars and their respective categories of upright growth. Average bud widths (in boxes) were determined from 90 uprights per cultivar. Averages with the same letter are not different at $P < 0.05$ using a Tukey-Kramer adjustment.



Conclusions

- Flower initials were first observed in mid-late July during both growing seasons. Initiation appears to be determined primarily by time of year as opposed to accumulation of GDD. This suggests light and/or other physiological factors are involved in flower initiation within cranberry buds.
- The recently released cultivars of HyRed and Crimson Queen have a greater number of reproductive uprights that form reproductive buds. This observation is consistent with reports of these cultivars' ability to rebud and circumvent biennial bearing.
- Reproductive buds are wider relative to vegetative buds. Furthermore, buds of 'HyRed' and 'Crimson Queen' were, on average, wider than 'Searles' and 'Stevens.'
- Biennial bearing in cranberry is not consistent across all cultivars, particularly among the recently released cultivars included within this study.
- Given the variation of bud width across the sampled cultivars and qualitative nature of external bud evaluation, yield prediction models based on bud appearance may be in need of reevaluation.

Acknowledgements

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2013 Cranberry School Grower Survey Results

During the 2013 Cranberry School, a live survey was conducted with the growers present in the room. The survey was carried out using Turning Point 5 (Turning Technologies, LLC) software and clicker hardware. Clickers were made available to attendees to allow for anonymous responses to be collected. Questions were displayed and respondents were allowed to select answers. After all responses were collected, the results of the survey were displayed. Results were not displayed until after the polling was closed and all responses were collected. The Percent column indicates the % of respondents and the count column indicates the number of growers that responded.

1) Did you raise the water level in the ditches after the harvest in 2011?

	Responses	
	Percent	Count
Yes- all beds were irrigated	32%	31
Yes- some beds received water	24%	24
No	44%	43
Totals	**100%**	**98**

2) Was your decision to raise water levels in ditches influenced by concern of having enough water for the winter flood?

	Responses	
	Percent	Count
No – I did not raise water levels because I did not feel it was necessary	39%	33
No - I raised ditch levels but was not concerned about water availability	49%	42
Yes – I did not raise ditch levels due to concern for available water	6%	5
Yes – I raised ditch levels, but not as much as I would have liked to due to water availability	6%	5
Totals	**100%**	**85**

3) What was the primary goal in raising ditch levels?

	Responses	
	Percent	Count
NA- Did no raise ditch levels	44%	45
Provide moisture to root zone	47%	48
late trash flood	3%	3
frost protection	2%	2
wind protection	4%	4
Totals	**100%**	**102**

4) Did you have a secondary goal in raising ditch levels in the fall?

	Responses	
	Percent	Count
NA - Did not raise ditch levels	41%	39
Provide moisture to root zone	5%	5
late trash flood	4%	4
frost protection	2%	2
wind protection	12%	11
no secondary reason only one primary reason	36%	34
Totals	**100%**	**95**

5) Do you feel that the vines were stressed going into the winter of 2011-2012?

	Responses	
	Percent	Count
Yes	21%	13
No	79%	50
Totals	**100%**	**63**

6) Do you feel that the vines were stressed going into the winter of 2011-2012?

	Responses	
	Percent	Count
Yes	18%	18
No	82%	84
Totals	**100%**	**102**

7) Was your timing of the winter flood application…

	Responses	
	Percent	Count
Optimal	62%	65
Too early	3%	3
some beds were optimal, some were too late	14%	15
all beds were flooded too late	21%	22
Totals	**100%**	**105**

8) Did poor ice cover result in any damage to the vines?

	Responses	
	Percent	Count
Yes	31%	33
No	69%	72
Totals	**100%**	**105**

9) Did you flood in April 2012 for frost protection?

	Responses	
	Percent	Count
Yes – all beds	67%	73
Yes – some beds	13%	14
No	20%	22
Totals	**100%**	**109**

10) If you did flood, how long did you hold the April flood?

	Responses	
	Percent	Count
1-2 days	2%	2
3-5 days	29%	28
6-10 days	59%	56
11-15	9%	9
Totals	**100%**	**95**

11) Did you use overhead irrigation for frost protection in April 2012?

	Responses	
	Percent	Count
Yes – all beds	82%	89
Yes – some beds	4%	4
No	14%	15
Totals	**100%**	**108**

12) Did you observe any damage to the vines that you would attribute to irrigating for frost protection?

	Responses	
	Percent	Count
Yes –all irrigated beds showed some damage	3%	3
Yes – some irrigate beds showed damage	25%	26
No	72%	76
Totals	**100%**	**105**

13) Did you observe typical bud break in spring 2012?

	Responses	
	Percent	Count
Yes, typical year	8%	8
No – all beds were delayed in breaking bud	2%	2
No - some beds were delayed in breaking bud	12%	13
Early, normal progress	40%	42
Early and fast	38%	40
Totals	**100%**	**105**