Title: Advances in Organic Blueberry Management

Authors: William Sciarappa

Affiliations: Rutgers University Department of Agriculture and Resource Management Agents – NJAES

Subject Category: Organic Blueberry Management

Abstract:

When wild blueberries were first selected and cultivated in the early 1900’s, farming practices were largely organic in nature. Early farmers established effective cultural practices, initiated mechanical weed management and took advantage of naturally occurring biological controls. To bolster these proven practices for modern production, the Rutgers Blueberry Working Group has investigated several additional methods. Other land grant universities have recently begun similar advances in applied research. Key examples include:

- Weed Management – weed suppression between rows with plantings of fescue cultivars
- Weed Management – weed suppression within rows with landscape fabric and mulch
- Soil Biology – organic compost from various sources within the planting trench
- Water Management – trickle irrigation to minimize leaf wetness, diseases and insects
- Disease Resistance – cultivar comparisons of disease susceptibility
- Organic fungicides – OMRI approved materials for botrytis and other pathogens
- Organic insecticides – Entrust-spinosad formulations for blueberry maggot and other pests
- IPM systems - pheromone trapping, monitoring and scouting
Nutritional analysis of blueberry fruit (cultivar Bluecrop)

Results from small plot and grower demonstrations with various organic approaches led to a more science-based system focused on pest problems, phenological factors and soil health. Commercial acreage increases on the east coast, west coast, Canada, South America, Europe and Africa demonstrated adoption of these practices as organic blueberry production steadily increases to meet market demand.

**Index Words:** Organic blueberries, organic pesticides, sustainable systems, organic pest management, organic markets, ORAC

**Introduction:**

The organic market segment in the United States accounts for over 3% of food sales and reached over a total of $35 billion dollars in 2013, primarily in the fruit and vegetable categories (see Fig. 1). Human health concerns and benefits are driving this market growth. The consumer demand for organic blueberry continues to exceed supply and will do so for the next decade. This will likely lead to higher price premiums and higher potential profitability then conventional systems. Organic farming is defined by the USDA as a “production system that is managed by integrating cultural, biological and mechanical practices…..” The main requirements are to use only US government approved materials for fertilizer and pesticides when necessary. The Organic Materials Resource Inventory (OMRI) is an independent review agency that disallows most synthetic compounds (www.OMRI.org/). The number of organic farms in the United States is approaching 10,000 certified operations. Within these certification parameters, an organic blueberry farm has been shown to be quite profitable at the 10 to 20 acre size in the Pacific Northwest (Julian et al., 2011)
Since the native blueberry is one of only two solely native American fruits, the Northern high bush species (*Vaccinium corymbosum*) has evolved good natural resistance to local diseases and insects. The crop has an inherent vigor because it has been domesticated for only a hundred years. As a result, this long-lived, perennial is a natural fit with these new organic standards. When wild blueberries were first selected and cultivated in the early 1900’s, farming practices were essentially organic in nature. Early farmers established effective cultural practices, initiated mechanical weed control and took advantage of naturally occurring biological controls. This manuscript overview selects some of these old useful practices and integrates modern advances in production techniques to create a functional system for today’s organic blueberry operations.

**Objectives**

As applied research and extension project, the main objectives were directed at solving several limiting agricultural production problems, inform growers and expand extension capabilities. Specific objectives were:
1. Incorporate effective cultural recommendations encompassing soil health, fertility, sanitation, ventilation and water usage as preventative measures in organic blueberry production.

2. Investigate weed management approaches with cover crops and mulches.

3. Determine an appropriate IPM program using NOP (National Organic Program) approved insecticides as spinosad, pyrethrum and neem against blueberry maggot (*Rhagoletis mendax* Curran).


5. Assess alternative management materials for disease suppression.

6. Integrate organic production practices into sustainable regional and national programs.

7. Transfer outreach results to growers and extension personnel.

**Materials and Methods**

Our Rutgers blueberry research group, grower partners and grant supporters, such as the Northeast SARE, allowed us to develop key components of a model farm system to demonstrate to interested growers considering organic transition on both small farm and large farms. Effective cultural, sanitation and fertility baselines were established throughout the study sites. To increase the quantity and quality of organically produced highbush blueberry, quasi-commercial trials were implemented to control: (1) blueberry maggot with airblast sprayers, (2) oriental beetle with pheromone traps, and (3) botrytis, mummy berry and anthracnose diseases with CO2 backpack sprayers at 75 PSI.
A newly certified 50-acre organic farm site, called Emery's Berry Patch, in New Egypt, NJ served for IPM trials, mulching studies and soil testing. This study site also offered applied research opportunities in weed control, trickle irrigation, perimeter spray strategies, and new crop establishment within large, commercial, highbush blueberry blocks. Our Blueberry Research Working Group worked with commercial grower-driven equipment that included a mechanical cultivator, a 60 HP tractor, spray equipment and a Korvan harvester.

Experimental and demonstrational research for production problems were also researched on another twenty-acre certified farm called Blueberry Acres in Wall Township, NJ. The general farm layout at Blueberry Acres was conducive to combining both a commercial u-pick blueberry business on one half of the farm and allowing the sister half to be used for trial work – both comparative halves are equally divided by a macadam farm road for customer traffic only, and both have the same aged varieties, soil, climate and pest pressures. Also, there is a remote 40 acre block a quarter mile away separated from both these ten-acre halves by tree-lines, meadows and streams. This field situation afforded additional research opportunities related to this specific project as well as extension studies in pruning, brush-hogging and restoration of heirloom varieties. With the help of cooperating growers, commercial work crews and over 20 volunteers, we were able to conduct the following trials:

A. **Weed Management.** Walkways and within-row methods. Mowing practices and fescue seeded walkways were compared within the crop row. Treatments were replicated three times with 8 mulch types assessed within crop rows of 12 ft. in length.
B. **Blueberry Maggot Field Spray Trial.** Four organic insecticides were evaluated: GF-120 NF Naturalyte Fruit Fly Bait (20 fl oz/ac), PyGanic (32 fl oz/ac), AgroNeem (64 oz/ac; Agro Logistic Systems, DiamondBar, CA) and Entrust (2 oz/ac), in a field spray trial to assess blueberry maggot control. This study was conducted at a recently abandoned blueberry field - Blueberry Acres, located in Tinton Falls, NJ. Blueberry bushes were approximately 2 m in height and spaced 1.2 m within and 2.7 m between rows. Treatment plots were 30.5 m by 91.4 m, approximately 0.28 ha. Treatments were replicated three times. Each insecticide, except GF-120, was mixed with 25 gal of water/acre and sprayed using a commercial (air blast) mist blower to both sides of bushes. GF-120 was mixed at a ratio of 1:5 with water for 120 oz of mix/acre, and applied to one side of every row using an ATV Olive Fruit Fly Sprayer (PBM Supply Mfg, Chico, CA). This ATV sprayer had a 25 gal tank, a non-adjustable 100 psi pump, and two nozzles from airblast sprayers consisting of discs (D-3 orifice) without the core.

Insecticides were applied on 7, 15, 22, and 29 Jul 2003. Adult blueberry maggot fly presence was assessed twice a week for six weeks using four Pherocon AM traps baited with ammonium acetate (Great Lakes IPM, Vestaburg, MI) per plot. Larval presence was determined on three dates (24 and 31 Jul, and12 Aug) by randomly selecting 1,000 berries in center rows from each plot and boiling fruit (Pickett and Spicer 1931) or microwaving. Maggots extracted from these samples were counted and commercial demonstrations continued from 2004 – 2011.

C. **Oriental Beetle Mating Disruption, 2003-05.** Three trials were conducted in 0.8 ha plots of highbush blueberry, located in Hammonton, New Egypt, and Tinton Falls, NJ. Plots contained either plastic dispensers or red rubber septa loaded with 1 and 0.1 g of the oriental beetle sex pheromone, respectively. Plastic dispensers and red rubber septa were placed in plots on 2 July and deployed at a rate of 50/ha. Populations of oriental beetles were assessed using four Japanese
beetle traps per plot, baited with the oriental beetle sex pheromone to capture males. Traps were hung on 29 June, and after an initial 4 day pre-treatment check, were inspected at weekly intervals until 14 August. Pheromone lures in traps were replaced after three to four weeks. Four replicates were completed. Studies continued throughout south Jersey by the RU Blueberry Working Group from the Philip Marucci Cranberry and Blueberry Research Center in Chatsworth, NJ.

D. Botrytis control. Efficacy evaluations were made on the number of infested flowers at bloom and percent infection of the flower blossoms and fruit clusters. Two studies were conducted at Blueberry Acres and two studies were conducted at Emery's Berry Patch. The treatments compared were a well-water check, compost tea foliar spray, compost tea soil drench, oxidate (hydrogen dioxide) 1 percent solution, sulphur, Bordeaux mixture, sodium bicarbonate, neem and Serenade. The foliar sprays were applied at 25 gpa with labeled rates of active ingredient.

E. Anthracnose control trials. Disease levels were visually assessed by placing clamshell pints of freshly picked blueberries in the lab and checking disease development on a daily basis. There were pre-harvest sprays of hydrogen dioxide or other OMRI labeled fungicides on replicated strips. Twenty-five pints per replicate were examined for disease symptoms in mid-season varieties and laboratory trials were used for late season harvests.

F. Crop Resistant Studies. USDA researchers Polashock et al. (2005) compared 40 blueberry cultivars in their susceptibility to anthracnose and other diseases.
G. Laboratory work with antioxidants. This analysis was done at USDA labs in Beltsville, Maryland comparing six organic blueberry farms with six conventional blueberry farms with similar varieties, weather and soils.

H. Soil test work. Soil was analyzed with Solvita test kits that measured changes in microbial respiration with gel colorimeters as an indicator of soil health.

I. IPM Program. Integrated Pest Management monitoring, scouting and recommendations for the southern NJ blueberry crop was managed by the Rutgers Blueberry Working Group led by Dean Polk.

J. OPM Program. Organic Pest Management systems research and demonstration led by Rutgers extension agent Bill Sciarappa.

Results and Discussion

A variety of cultural and biological strategies and studies were tested, demonstrated and/or employed over the course of twelve seasons. Results were incorporated into evolving agricultural guidelines for organic blueberry production. In general, tours of commercial enterprises and grower impressions confirmed the utility of these practices. For example, several classic cultural approaches were implemented and found effective in these commercial block studies – raised mounds, rotary hoe for mechanical cultivation, mowing walkways and ventilation-pruning. The installation of trickle irrigation allowed rapid growth of new plantings via consistent use of liquid nutrients and liquid sulphur. Beneficial changes in lowering soil pH were measured.

Results of the testing for biological practices are summarized with the following letters:
A. **Weed Management** with walkway cover crops and in-row mulch.

B/C. **Insect Management** with blueberry maggot and oriental beetle applying organic insecticides and species specific semiochemicals.

D/E. **Disease Management** with cultivar resistance and organic fungicides.

F. **Fruit Analysis** of sugars, acids and anti-oxidants (ORAC).

G. **Growth** with conventional plantings as observed by phenological stages, bush size and crop maturity.

H. **Soil Health** using the Solvita test for microbial assessment.

I. **Integrated Pest Management** measuring pesticide load and calculating risk reduction.

J. **Organic Pest Management** initial program publication and evolving protocols.

K. **Continuing Advances**

A. **Weed Management Results** - In initiating a regular mowing regime on walkways of established plantings, native grasses and orchard grass were shown to dominate broadleaf weeds and serve well for foot and machine traffic. In restoring abandoned blueberry blocks into organically approved programs through bush-hogging old plants, re-growth has been very vigorous and relatively free of scale, aphids and diseases.

In new crop and cover crop plantings, two species of fine fescue show good growth and suppression of crabgrass and foxtail weeds in walkways over two seasons. The following graph shows how the bare ground of a new planting was initially colonized by three weeds which were then out-competed by the newly seeded fescue grasses as measured by % ground cover over time (Fig. 2).
A three year study comparing various mulches showed good initial and long-term results in controlling foxtails, crabgrass and broadleaves. These mulches included pine chips, hardwood chips, coffee grinds, cocoa grinds, tea-leaf compost, municipal-leaf compost - with and without landscape fabric. All mulches maintained acceptably good weed control and retained good soil moisture. The un-mulched treatments were abandoned due to poor growth after the first year (Fig. 3).
B. Blueberry Fruitfly Management Results—Significant results utilizing spinosad biological insecticide (Dow Chemical Corporation) were shown in preventing adult egg deposition into blueberry fruit. Organic blueberries were essentially maggot free (Fig. 4).
Three application methods have shown effectiveness. These methods are as follows: When spinosad is utilized as:

- a 4x spray, seasonal program with spinosad alone
- as a new bait formulation that reduces both rate and spray coverage needs
- within a resistance management program with rotational sprays of pyrethrum (Pyganic) and azadirachtin (Agrineem).

C. Oriental Beetle Management Results - Impressive results were found in collapsing a historically heavy adult population with the use of a mating mass disruption technique (Fig. 5). The strategy used standard pheromone traps to detect the rise of first-flight adult emergence and then the use of numerous point-source dispersal units to confuse male beetles and prevent them from finding mates. With documented prevention of mating, egg laying in the soil was very low and damage to blueberry roots from the larval beetle grubs was avoided.

![Fig. 5](image)

Semiochemical Control for Oriental Beetle
D. Disease Management Results - Eight organic fungicide materials were applied in new, restored and established blocks of organic blueberries with differing results among treatments. With a wet spring, botrytis was a major problem in all fields throughout the state and the mummy berry disease incidence was unexpectedly low. Compost tea sprays and drenches were ineffective. Bordeaux and Oxidate applications provided fair suppression infield screening trials, while Serenade biological fungicide was rated as good. At harvest, initial screening assays of post-harvest fruit show suppression of anthracnose with Armi-carb and Serenade (Fig. 6).

Fig. 6

Comparison of Organic Fungicides
E. Cultivar Resistance - In selecting cultivars for organic blueberry production, crop resistance is especially important. Knowing which cultivars are more or less susceptible to various diseases in one’s area is especially important. USDA researchers Polashock et al., (2005), stationed at the Rutgers Cranberry and Blueberry Center, found significant differences among 40 cultivars to several diseases (Fig. 7).

Fig. 7
Anthracnose Susceptibility among 40 Blueberry Cultivars

F. Comparison of fruit samples from 8 organic farms to 8 conventional farms showed organic fruit to be significantly higher than conventional produce in terms of total phenolics, total anthocyanins and ORAC/antioxidant content. Organic fruit also had higher sugar levels but similar acid levels with the same varieties of the same age grown in the same area in the same season (Fig. 8a & 8b).
**G. Growth** - new plantings of organic blueberries in commercial blocks with Bluecrop, Duke and other cultivars generally showed typical growth and little noticeable differences in flowering times, bush size and maturity compared to nearby conventional blocks.

**Testing soil health** via the Solvita CO2 measurement system is an accurate and inexpensive advance in determining biological soil qualities. The following chart analysis (Fig. 9) shows an
increasing microbial activity and respiration in 2013 after compost application in the fall of 2012.

**Fig. 9**

Soil Health Assessment – Comparison of Microbial Respiration

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**I. IPM Results** - The Rutgers Working Group initiated an Integrated Pest Management program in 2003 that had reduced pesticide load and costs through scouting and economic injury levels while increasing reduced risk pesticide use from 2003 to 2007 (Fig.10) to 2012.
J. Organic Pest Management System for Blueberry - An initial organic management system based on OMRI approved materials and crop phenological stages was developed by Sciarappa for grower use in the northeast and beyond (Childers & Lyrene) (Fig. 11). A 2014 publication by Pritts of Cornell University updates this OPM approach for New York.

<table>
<thead>
<tr>
<th>Crop Stage</th>
<th>Pest Problem</th>
<th>Organic Management Methods</th>
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<tbody>
<tr>
<td>Dormant</td>
<td>Scale, phomapis</td>
<td>lime sulfur</td>
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<tr>
<td></td>
<td>Botrytis, anthracnose</td>
<td>Prune old canes &amp; twiggy wood</td>
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<tr>
<td></td>
<td>Scarab beetles</td>
<td>Milky spot, predaceous nematodes</td>
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<tr>
<td>Bud Break</td>
<td>Curculio, weevil, fruit worm, fruitfly</td>
<td>Rotary hoe or rake middles and cultivate alleyways</td>
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<td></td>
<td>Blueberry thrips</td>
<td>Entrust</td>
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<td></td>
<td>Mummyberry</td>
<td>Disc, rake, sweep, hoe &amp; mulch</td>
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<tr>
<td></td>
<td>Weevils, curculio</td>
<td>Disc, rake, sweep, hoe &amp; mulch</td>
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<td>Pre-bloom</td>
<td>Leaflovers, caterpillars</td>
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<td>Post-bloom</td>
<td>Various diseases</td>
<td>Arnicarb, Bordeaux, Serenade : rotation</td>
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<td>Flowering</td>
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<td></td>
<td>Blueberry maggot</td>
<td>Entrust, Agriomee, PyGanic : rotation</td>
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<td></td>
<td>Leaflovers &amp; caterpillars</td>
<td>Bacterial insecticides</td>
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<td>Leafhoppers &amp; spoids</td>
<td>Styell oil</td>
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<td>Scarab beetles</td>
<td>Pheromone disruption &amp; attractant traps</td>
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<td></td>
<td>Birds &amp; mammals</td>
<td>Hunting, auditing &amp; visual pre-harvesting done</td>
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K. Other Advances - Growers attending a Rutgers/US-AID seminar for 20+ countries in Africa began to see organic blueberry production as an advance in economic development for their struggling countries. A group of these growers began a 400 acre organic blueberry farm in South Africa utilizing a compost bag growing system, weed mats and mulch under shade-cloth protection that reduced sunscald, disease pressure and insect populations – Photos 1 & 2.

Photos 1 & 2

Organic Blueberry Production in South Africa – Plant Media Bags & Shade-cloth Protection

Discussion – Impact and Outcomes

The implementation and promotion of this organic blueberry program has had an important impact in several ways:
1. Hands-on experience with various management methods greatly increased the overall applied knowledge base for extension agents, specialists, field crews, volunteers and farmers – locally, regionally and nationally.

2. Over 250 Northeastern participants attended a blueberry school and two sustainable blueberry field days demonstrating these techniques. These extension programs included conventional and organic growers, extension advisors, organizations like NOFA, Rodale, and organic industry representatives. Survey reports indicated a large increase in learning and expected implementation.

3. Blueberry Production - survey results from both conventional and organic growers indicated a high level of meeting satisfaction and the desire for more sustainable sessions. 110 responses from two meetings had an average rating for overall usefulness, topics covered and speaker effectiveness of 4.6, 4.7 and 4.5 on a 1 to-five scale, respectively. Helpful comments included future program topics and their intentions to use at least one or two of the sustainable practices demonstrated like mulching, composting, rotary cultivating, or trickle irrigation.

4. As a result of this wide-ranging program, organic highbush blueberry acreage has increased from approximately 1 to 70 in 2005, from 70 to 150 in 2008 acres in New Jersey alone and over 225 by 2011. NJ farms growing organic blueberries increased from 1 to 14 within 10 year’s time, including diverse farms and CSA’s (Community Supported Agriculture) where early organic produce increased agri-tourism and customer traffic.

5. Out-of-state contacts for the Northeast region increased considerably through word-of-mouth,
Newspaper-newsletter articles and extension presentations. As a result, northeastern and southeastern states rapidly began to join in this effort. An increase of three new farms or more in each of the following northeastern states - Delaware, Pennsylvania, New York, Massachusetts, Maryland, Maine and Virginia. Similarly, farm increases were noted for the North Carolina to Florida coastal region.


7. A fledgling yet functional system has been created for organic highbush blueberry production that has minimized some major risks of the past that has utility in many other parts of the world. The preliminary groundwork for expansion of this program throughout the Northeast is done, organic growth is now expanding regionally and internationally; especially in South Africa, South America and Europe.

Final Comment

Any IPM system is dynamic and subject to change whether operating conventionally or organically. An example of expected change/disruption in pest management programs is seen when a new invasive organism as Spotted Wing Drosophila (*Drosophila suzukii*) attacks at an economically important level. There are efficacious compounds in the organic tool box such as Bt (*Bacillus thuringiensis*), Entrust (spinosad) or Pyganic (pyrethrum). Unfortunately, over-application of these organic materials or similar synthetic or GMO versions in the conventional farm community may be resulting in more resistant pests. The impact on organic growers is greater as there is a limited number of organic registrations and modes of action. This problematic situation will drive research into breeding new resistant cultivars, growing biological agents on farm and seeking additional organic materials.
Perhaps the most encouraging impact of this applied organic research is how a holistic program plan has ratcheted up interest in adoption shown by both conventional and new farmers. I would estimate that of the 700 east coast farmers contacted, there are 50 that are seriously considering several aspects of this organic system as a viable option within their conventional farm plan. Furthermore, there are probably 100+ growers that will utilize one or two parts of this sustainable system because it sustainably serves economic and environmental goals.

References:


http://www.rcre.rutgers.edu/pubs/publication.asp?pid=FS750

http://www.rcre.rutgers.edu/pubs/publication.asp?pid=FS419

http://www.rcre.rutgers.edu/pubs/publication.asp?pid=FS106

http://www.rcre.rutgers.edu/pubs/publication.asp?pid=FS553

Sciarappa, W. 2004. Ratcheting up commercial organic high-bush blueberry production systems. SARE Grant.
