Organic production systems in northern highbush blueberry – After 14 years of research what are the best choices for growers?

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14 years of experience in a certified organic research trial (2007 through 2020)


Overview of presentation

- Introduction to organic blueberry industry
- Soil amendments when establishing plantings
- Mulching in the row: Impacts on weed control and soil properties
- Research study results on best systems: Planting method; mulch; fertilizer source and rate; leaf tissue testing
- Summary of best practices

- Oregon and Washington lead the USA in volume of fruit produced at 160 and 165 million pounds in 2020, respectively
- About 50% of the fruit in Oregon is fresh marketed, compared to 30% in Washington. We are a global leader in high-quality processed fruit
- This region has the highest yields in the USA, with about 35% of the harvested acreage but 62% of the total production in 2020
- We lead the world in organic production; 20% of the 15,000 acres in Oregon and 20,000 acres in Washington, accounting for about 60% of USA organic volume
- Transitional and organic area continues to increase in this region

Fruit Yearbook: https://www.ers.usda.gov/topics/crops/fruit-tree-nuts/
World Blueberry Report, International Blueberry Organization

Advantages to berry production in western USA

- Dry summers reduce incidence of weeds and diseases
- Some major insect pests are not present in this region
- Temperate climate: Relatively low risk of winter cold injury; good weather during bloom (good fruit set)
- Strong industry support and opportunities for grant funding through levied funds
- Industry asked for organic production systems research in mid-2000s


Typical production systems used in early 2000s

- 2% of blueberry area was certified organic
- Flat ground or raised bed plantings
- In-row sawdust mulch
- Over 15 cultivars grown, ranging in fruiting season and other traits
- In conventional systems, ammonium-N fertilizer sources applied in spring to early summer, granular or fertigated
- In organic systems, composts as amendments and added as a mulch; fish solubles fertigated at high rates, most common
- Organic growers tended to use “substitution” method

Common traits of soil good for blueberry

- No issues with prior crops (pests)

- Good drainage (impact on root growth & disease)
- Suitable pH (4.5 to 5.5; or pH can be modified)
- Suitable organic matter content (or can be modified)

Organic matter (OM)

- Soil OM ideally greater than 4%
  - If not then amending soil prior to planting by adding appropriate material is recommended
- Additionally, soil OM may be improved after planting when mulching with organic materials
- Type of organic amendment is important in blueberry

An ideal organic amendment for blueberry:

- Should not injure plants with salts when applied liberally
- Should be of proper pH (acid)
- Should be free of weed seeds, insects, and disease

High pH symptoms

Symptoms of salt injury

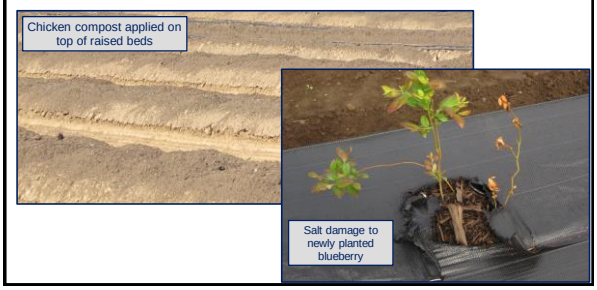
Common organic materials available for amendments

Compost type	pH	EC	Comments
Dairy	7.6	6.1	C:N <12; excess N (2+%)
Horse	7.8	7.8	C:N <12; excess N (2+%)
Yard debris	7.0	4.0	C:N 12-25; 1-2% N
Leaf debris	7.4	2.2	
Peat	4.8	0.7	
Sawdust; wood chips	4.5-5.2	0.4	C:N 200+; deficient N

Adapted from D. Sullivan, OSU; pH and EC by saturated media extract (SME)

All materials with an EC (salt content) above 1.5 dS/m are too "salty" for use as a pre-plant amendment and in high amounts after planting

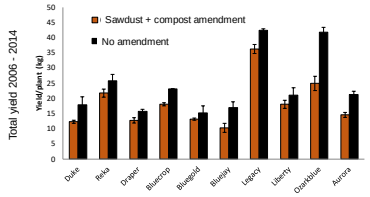
Adding some "composted chicken manure" when planting – grower experience



Avoid using organic materials that are of high pH for amendments

- Compared incorporation with 2-inch-deep sawdust plus ½-1-inch-deep yard-debris compost to no amendment in establishing blueberry (Strik et al., 2017b)

Amendment treatment	Soil pH at planting (Autumn, 2006)	Soil pH (Autumn 2011)	Soil pH (Autumn 2012)
No pre-plant amendment	4.9	5.4	5.1
With amendment: Yard debris compost 1 inch deep topped with 2 inches of sawdust	4.9	6.9	5.9 (after 300 lb S/acre)



This on-farm compost had 213 lb calcium carbonate/dry ton, the equivalent of adding 0.7 to 1.4 ton lime/acre (½ to 1 inch deep)

(adapted from: Strik et al., 2017b)

Symptoms of high soil pH

- Only 'Duke' showed classic symptoms of high pH ("lime induced iron deficiency")
- Other cultivars had no symptoms but also had lower yield
- Thus very important to monitor soil pH and adjust during planting life as needed

Organic materials – suited for blueberry:

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Woody materials are best used as a pre-plant amendment

Douglas fir sawdust applied as an amendment (prior to incorporation)

After incorporation

Organic Materials & Mulching in Blueberries

- Organic amendments – best choices
- Organic mulches can also improve soil organic matter. What are other reasons to mulch blueberries?
- Mulching options – advantages & disadvantages

The presence of weeds in the row reduces yield

Organic mulch layer

- In early 2000s, a sawdust mulch layer was most common
  - Applied to soil (bed) surface soon after planting
  - Few inches deep, replenished every few years, as needed
  - Organic growers were using compost as a slow-release nutrient source & goal of increasing OM as part of the mulching program

Organic Production Systems in Blueberry: I – Impact of Planting Method, Cultivar, Fertilizer, and Mulch on Yield and Fruit Quality from Planting through Maturity (2006 – 2016)

Julian et al., 2012
Larco et al., 2013a, 2013b
Strik et al., 2017a
Strik et al., 2019

Treatments:
- Planting Method (raised or flat beds)
- Cultivar (Duke, Liberty)
- Mulch (sawdust; compost + sawdust; weed mat)
- Fertilizer source (fish solubles, feather meal)
- Fertilizer rate (low and high; 29 or 73 kg/ha N during establishment; 57 and 140 kg/ha N during maturity)

June 26 2013

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Organic mulches were replenished, as needed, and weed mat replaced once during 10-year study

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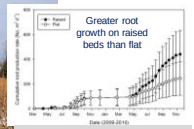
Results – Planting method



Valenzuela-Estrada et al., unpublished

Flat ground

Raised beds
22% greater cumulative yield (2008-16) in 'Liberty' but not in 'Duke'

Strik et al., 2017a

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Yield & Quality – Mulch

- On average, yield 8% to 20% greater with weed mat than other mulches in 5 of 9 years
- In 'Duke': no effect of mulch on cumulative yield
- In 'Liberty': 11% greater yield for weed mat than other mulches
- Fruit quality: No effect of mulch
- Fruiting season: No effect of mulch

Strik et al., 2017b

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Mulch – Weed management costs organic production

Total cost including product (mulch) and installation at establishment and replenishment (3x sawdust; 1 x weed mat) & weed control costs

Cumulative 2006-2014	Compost topped with sawdust mulch	Sawdust mulch	Weed mat with sawdust in "planting hole" area
Total cost per acre	$18,500	$12,950	$6,500

Weed mat reduced costs whereas adding compost increased weed presence & management costs (Julian et al., 2012; Strik & Vance, 2017)

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Erosion of upper sawdust layer exposing compost layer

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One day after application of 20% acetic acid

Spot spraying with 20% acetic acid was effective on young weeds in warm weather
(Larco et al., 2013; Julian et al., 2012)

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One day after application
May 17, 2012 (year 6)

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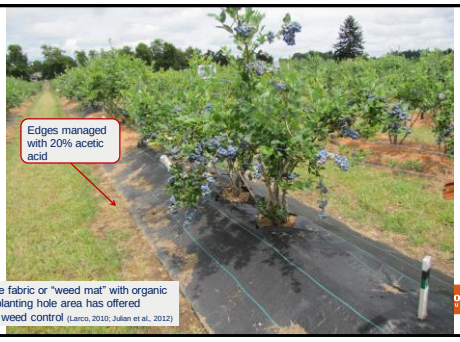

Edges managed with 20% acetic acid

Landscape fabric or "weed mat" with organic mulch in planting hole area has offered nearly full weed control (Larco, 2010; Julian et al., 2012)

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Maintaining cover crop edges with string trimmer in research trial

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Maintaining cover crop edges with string trimmer in commercial field

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Between row cover crop management
Propane burning, transitional farm, Oregon

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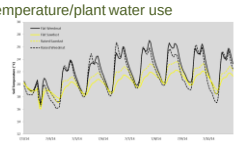
Between-row cover management

Impacts of mulch on other properties in research trial

Soil temperature/plant water use



Soil temperature at 2 inch depth:

- About 9 °F (5 °C) warmer under weed mat than sawdust
- About 7 °F (2 °C) warmer for raised beds than flat ground

Irrigation:
Plots were irrigated to maintain similar soil water content (25 – 30%)

Strik et al., 2017a

Cumulative irrigation applied by bed and mulch type (L/plant):

		2007	2008	2009	2010	2011	2012	2013	2014	2007-2014
Flat	Sawdust, Sawdust + Compost	247	69	242	480	517	561	506	685	3307
	Weedmat	449	190	227	506	616	650	938	802	4379
Raised	Sawdust, Sawdust + Compost	282	170	295	480	517	561	506	733	3544
	Weedmat	651	465	287	556	685	730	952	577	5304

Weed mat 32% more water

Weed mat 50% more water

Presence of voles higher with weed mat

Properties – Mulch

Over the course of the 10-year study, cumulative nutrients applied in mulch:

Mulch component	N (kg/ha)	P (kg/ha)	K (kg/ha)	Ca (kg/ha)
Sawdust	261	28	88	217
Yard-debris compost	2274	400	961	2744

Strik et al., 2019

Douglas fir sawdust Yard-debris compost

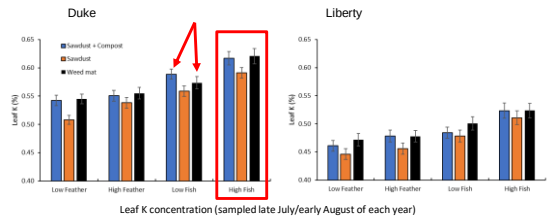
Soil properties & nutrients – Mulch effect

Impacts of mulch type on some soil properties (average of last 5 years, 2012–2016; Strik et al. 2019)

Soil property	Weed mat	Sawdust	Compost + sawdust
pH	5.3 a	5.0 c	5.2 b
Organic matter (%)	2.9 c	3.3 b	4.1 a
K (ppm)	233 b	206 c	373 a

- Soil pH was within desirable range for blueberry (4.5–5.5) during entire 10-year study
- Organic matter was highest with compost + sawdust and lowest with weed mat mulch
- Adding yard-debris compost to mulch increased soil K levels which became a problem in long-term production

Leaf tissue %K (mulch x fertilizer interaction)



Leaf K concentration (sampled late July/early August of each year)

Strik et al., 2019

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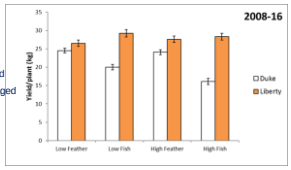
Fertilizer Source, organic

Strik et al., 2017

Fish solubles (4–1–5) - fertigated
Feather meal (12–1–0.5) - granular

Fertilizer N rate:
"Low": 25 to 50 lb/acre N, increased as plants aged
"High": 65 to 125 lb/acre N, increased as plants aged



- No effect of fertilizer source in 'Liberty'
- 'Duke' had 35% lower yield, overall, with fish solubles than with feather meal

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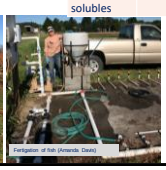
Fertilizer Source, organic

Strik et al., 2019

- Many organic fertilizer sources contain more than just nitrogen
- Fish contains high K and P
- Feather has more Ca

Fertilizer additions in a representative mature year (2013 through 2016) PER YEAR as affected by source and rate:

Fertilizer source	Rate	N (lb/a)	P (lb/a)	K (lb/a)	Ca (lb/a)	Mg (lb/a)
Feather meal	High	120	4	4	11	1
Fish solubles	High	120	24	45	2	6



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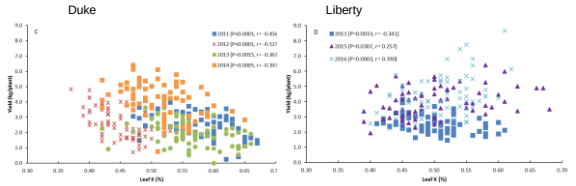
Correlation between leaf %K and yield

Strik et al., 2019



Duke: Negative relationship in 4 of 9 years

Liberty: Negative relationship in 1 of 9 years
Positive relationship in 2 of 9 years

Highest yield within leaf K range of 0.40–0.55%

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Key findings – 10-year organic study

2006-2016

Strik et al., 2017a; Strik et al., 2019

- Weed mat reduced weed control costs & improved yield in 'Liberty'
- N in yard-debris compost as part of mulch did not increase yield
- Yield did not increase with N fertilizer rate
- Yard-debris compost as part of mulch program increased soil P, K, Ca, and Mg, but only leaf N, K, and sometimes P
- Fertilizing with feather meal increased leaf and fruit Ca
- Fertilizing with fish solubles increased soil K and leaf K and P
  - High soil and leaf K were negatively correlated with yield in 'Duke'
  - High soil K reduced leaf Ca and Mg in both cultivars

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Mulch options

- Organic mulches
  - Add soil OM over time
  - Cool the soil and conserve soil moisture
  - Some advantages to weed control compared to bare soil
- Plastic, woven ground covers (weed mat)
  - Provides the best weed control
  - Improves yield in some cultivars compared to sawdust
  - Have some disadvantages (reduced soil OM, voles, may need more irrigation)

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Weed mat – zippered for opening

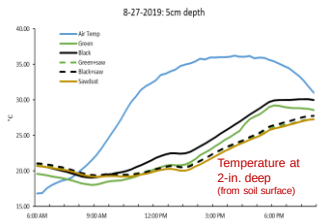
Oregon

Weed mat – open to apply granular fertilizer (and check drip)

Weed mat with organic matter underneath

- Layer of sawdust under weed mat in organic from establishment to maturity was best mulch in 10 cultivars (2006–2014) (Strik et al., 2017b)
- Sawdust + weed mat looked good in establishing 'Duke' (2016– 2020) in conventional production (Strik et al., 2020a; 2020b; Strik and Davis, 2021)

Canopy and soil temperature



Temperature at 2-in. deep (from soil surface)

Strik et al., 2020a

Changing mulch and fertilizer source to reduce weed management costs and mitigate high K issues

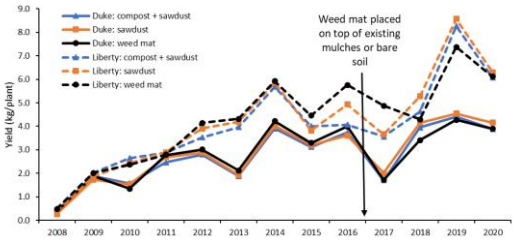
Davis and Strik, 2021

New management 2017 through 2020:

- In late winter, 2017 changed all to weed mat
  - Comparing weed mat alone, weed mat over existing sawdust, and weed mat over any existing compost+sawdust
- Switched to soy-bean based fertilizer (5.5–0–0 or 14–0–0; fertigated)
  - Used moderate rate (94 lb of N/acre)

April 5 2017

'Liberty' harvest July 21 2020



Yield per plant from year 2 (2008) through 14 (2020) with management change prior to 2017. Results for flat ground planting

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'Duke' June 19 2020

Soil organic matter – Mulch

Mulch treatment	Soil organic matter (%) 2016	2017	2018	2019	2020
Weed mat over compost+sawdust	4.8 a	5.2 a	5.0 a	5.8 a	5.0 a
Weed mat over sawdust	3.9 b	4.6 a	4.4 b	4.4 b	4.1 b
Weed mat	3.1 c	3.3 b	3.1 c	3.2 c	2.9 c
Significance	0.0002	0.0002	<0.0001	<0.0001	<0.0001

Prior study

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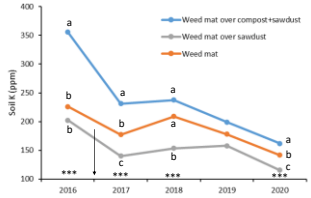
Mulch change – Soil K



Davis and Strik, 2021

Even though not replenished, yard-debris compost under sawdust and weed mat still had significantly higher soil K in 2020. All still had soil K within acceptable levels

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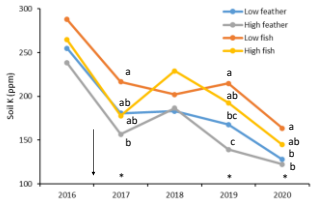
Historic fertilizer use – Soil K



Davis and Strik, 2021

Soil K as affected by fertilizer use from 2008 through 2016 [all fertilized with soy protein from 2017 through 2020 (no K)]. Averaged over cultivar and mulch

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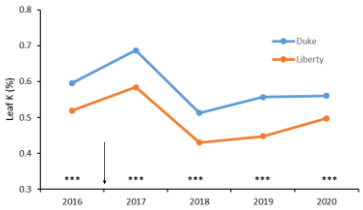
Cultivar – Leaf % K averaged over mulch and historic fertilizer source/rate for raised beds



Davis and Strik, 2021

Leaf %K declined from 2016 to 2018 in both cultivars. 'Duke' still had higher leaf %K than 'Liberty'

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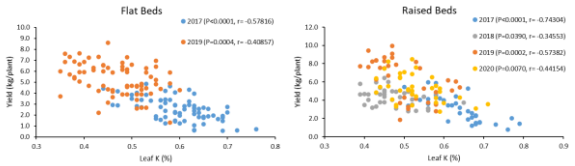
Correlation between leaf %K and yield, 2017-2020



Correlations are for all data (cultivars, fertilizer, mulch) by planting method

Davis and Strik, 2021

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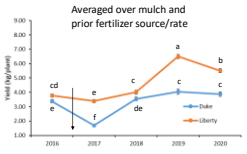
Conclusions - Fertilizer



- Yield increased from year 10 (2016) through 13 (2019)
  - Percent yield increase depended on prior management
- Changing to moderate rate of N (94 lb/acre) increased yield regardless of prior fertilizer rate (thus not limiting)
- Switching to soy protein fertilizer (no K) led to decrease in soil and leaf K for both cultivars. Stopping compost use decreased soil K
  - Soil K was still within recommended levels
  - Leaf %K was still negatively correlated with yield (0.40–0.55% best)

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Leaf tissue sampling to adjust fertilizer programs

- Sample leaves from laterals and compare nutrient levels to published sufficiency standards
- Grower questions:
  - Should new cultivars be sampled at the same time, regardless of fruiting season?
  - Should sufficiency standards differ for organic production?

Cultivar yet to harvest

Cultivar done harvesting

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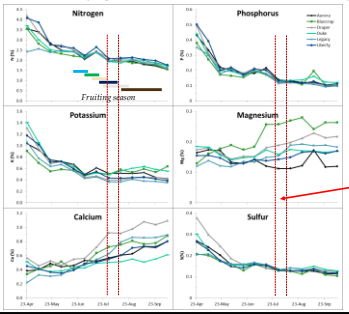
Effect of cultivar and sampling time on leaf tissue macronutrient concentration (conventional)



Adapted from Strik and Vance, 2015

Current recommended leaf sampling time, Oregon

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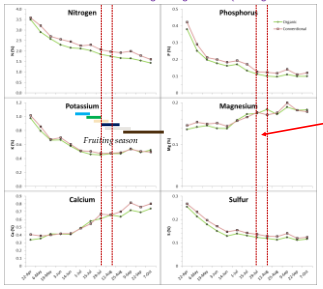
Effect of organic versus conventional production system on leaf tissue micronutrient concentration over growing season (averaged over 6 cultivars)



Adapted from: Strik and Vance, 2015

Current recommended leaf sampling time, Oregon

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Leaf nutrient sufficiency levels, northern highbush blueberry

Region	Western Oregon **Revised**[z]	Western Washington[y]	Eastern Washington[y]	Michigan[x]
Sampling time	Late July to early Aug.	Mid- to late Aug.	Mid- to late Aug.	Mid- July to mid-Aug.
Nitrogen (%N)	1.40 to 2.20	1.50 to 2.00	1.25 to 1.75	1.7 to 2.1
Phosphorus (%P)	0.08 to 0.20	0.10 to 0.20	0.08 to 0.15	0.08 to 0.4
Potassium (%K)	0.40 to 0.55	0.50 to 0.65	0.40 to 0.50	0.4 to 0.65
Calcium (%Ca)	0.40 to 0.80	0.50 to 0.85	0.50 to 0.85	0.3 to 0.8
Magnesium (%Mg)	0.10 to 0.25	0.15 to 0.20	0.11 to 0.17	0.15 to 0.3
Sulfur (%S)	0.10 to 0.16	0.12 to 0.15	0.12 to 0.15	0.12 to 0.2
Manganese (ppm Mn)	100 to 300	100 to 300	100 to 300	50 to 350
Boron (ppm B)	30 to 80	40 to 70	30 to 60	25 to 70
Iron (ppm Fe)	45 to 300	60 to 200	60 to 200	60 to 200
Zinc (ppm Zn)	8 to 20	10 to 25	10 to 15	8 to 30
Copper (ppm Cu)	3 to 10	5 to 10	5 to 10	5 to 20
	Strik & Davis (2021)	Davenport & Devetter (2019)		Hanson and Hancock (1996)

- Sample most recent full-expanded leaves for ALL cultivars at the same time regardless of fruiting season, but keep samples separate
- Tissue levels outside range may indicate nutrient or cultural problem

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Changes to organic production systems informed by research "Best practices"

- In 2020, 20% of blueberry area was certified organic
- Ensure good drainage, soil organic matter, and soil pH
- Plant on raised beds
- Use predominantly sawdust as an amendment
- Use any composts very carefully
- Most use weed mat with drip irrigation (& fertigation) underneath
- Reduced N fertilizer rates, particularly when using fish
- More organically approved fertilizer sources available to growers
- Greater confidence in leaf tissue testing
- Future change in using a combined sawdust topped with weed mat mulch?

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Bernadine Strik & Amanda Davis; 2021
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