

## Recent Accomplishments and Research in Progress, Berry Crop Production/Physiology

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More detail on the information presented here (in many cases, published papers) is available by contacting Bernadine.

### **Blackberries:**

#### **'Marion' blackberry:**

##### Plant growth and physiology

- Primocanes emerge in two flushes (early and late) in every-year (EY) systems, resulting in canes of different length at season's end. There is only one flush in alternate year (AY) systems (off year)
- A little over half of primocane growth occurs after fruiting
- Flower bud formation was first observed by microscope in buds of 'Marion' and 'Boysen' in October with development continuing through the winter
- In trailing blackberry, flower bud development occurs all along the cane at once rather than from tip to base as in red raspberry
- Without cold damage, percent bud break in 'Marion' is typically about 50%; it is only higher in shorter canes (due to late suppression or high-density planting)
- Percent drupelet set (how many ovules become drupelets) in 'Marion' ranged from 62% to 74% for early-season fruit and 52 to 60% for late-season fruit

##### Primocane suppression in 'Marion'

- Removing the first flush of primocanes (by cutting) in April or May increased yield 20% the next year compared to no suppression
- Suppression results in more canes/plant, with each cane having less diameter, less total length, shorter internodes and a higher percent bud break

- Primocane suppression had no impact on current season yield (in contrast to what has been reported in raspberry)

### Training/pruning

- August training increased yield 45% compared to February training in EY plants
- In a no-prune system (no removal of dead floricanes) yield was increased by 10 to 100% (double) compared to EY/February training depending on the year. Canes appear to be more cold hardy in the no-prune system due perhaps to less training damage in the no-prune system. However, no-prune systems may need to be hand harvested to minimize debris contaminants.
- Topping primocanes at 1' high in the off year of an AY system did not increase yield the following year compared to no topping

### Cold hardiness

- 'Marion' has a low chilling requirement, estimated at 300 hours (32 to 45 °F) making plants very sensitive to cold winter temperatures as chilling/dormancy is satisfied early
- Late primocane suppression (June) increased subsequent cold hardiness compared to early or no suppression. However, this results in short primocanes (would need higher density planting)
- Primocanes that grew in the off year of an AY system were 3 to 8 °F more cold hardy than primocanes that grew in the presence of floricanes (EY system)
- 'Marion' and 'Kotata' were able to compensate fully for as much as 100% loss of primary buds through secondary laterals emerging. Thus, a cold event that causes damage to buds and not canes can be compensated for by growth of secondary laterals

### Alternative production systems

- In a preliminary study, a 2' AY-topped treatment had a significantly higher machine-harvested yield (7.3 tons/acre) than the 5'AY (4.8 tons/acre). In addition, 2' AY plants had considerably greater cold than 5' EY, February-trained plants.
- Continuing research in 'Marion' has shown that AY systems are more cold hardy and have more consistent yields. However, a 2' AY system with primocane suppression in the off year in late May has not had consistently higher yields than a 5' AY with suppression in April, mainly due to smaller berry size at the higher planting density.

### Machine harvesting

- In our studies, loss to machine harvest without practicing primocane suppression has averaged 16% of total yield in 'Marion'
- We have shown that using a rotary machine harvester or one equipped with brushes to clean fields of debris in winter (before bud break) reduced potential thorny petiole contaminants by 66% -- this practice is now widely used in the industry.

### Nitrogen fertilization

- Fertilizer nitrogen is needed for primocane growth in the spring. Fertilizer N is needed in both the on- and off-year, because very little stored nitrogen is used for primocane growth. No fertilizer N was needed or taken up until the primocanes started to emerge in early April.

In an EY system, delaying removal of the dying floricanes as long as possible conserves N and perhaps carbohydrates.

#### Raspberry Bushy Dwarf Virus (RBDV)

- RBDV has no effect on growth of Marion, but reduced yield 40 to 50%, fruit weight (23 to 40%), and drupelet number per fruit (36 to 39%). RBDV has been found in commercial fields and rate of spread is being monitored – seems to be very slow.

#### **Primocane-fruiting blackberry:**

- The flowering morphology of the erect, thorny, primocane-fruiting blackberry cultivars Prime-Jan™ and Prime-Jim™ was studied. Soft-tipped primocanes developed 2-3 fold more branches and almost twice the number of flowers as un-tipped canes. Days from open flower to black fruit for soft-tipped and un-tipped primocanes averaged 45 to 51.
- Various primocane management treatments were studied in the field on ‘Prime-Jan’ and ‘Prime-Jim’. Fruit harvest began on 16 Aug. but had to stop in mid-Oct. due to bad weather – there was lots of fruiting potential left. Use of rowcovers, advanced bloom 14 days.
- Soft-tipped primocanes had almost a three fold higher yield than un-tipped canes. It is clear that primocane-fruiting blackberries need to be summer-tipped to increase production on primocane branches in the current season
- Fruit harvest began on 12 Sept. in the open field and tunnel, but lasted about 3 weeks longer in the tunnel, ending on 16 Nov. As a result, cumulative yield was 47% less in the open field than in the tunnel.
- Primocanes that were double-tipped (once for main cane and then once for each branch) had nearly twice the flowers and fruit than canes that were soft-tipped only once. Primocanes that were double-tipped produced 33% heavier fruit than other pruning treatments
- Plants growing under the tunnel tended to produce heavier fruit (32%, on average) than those grown in the open field
- Fruit pH and total anthocyanins (TACY) were highest in the early season and total soluble solids (TSS) was lowest in late season fruit. Although fruit under the tunnel was protected from rain, TSS, pH, TACY, and total phenolics began to decline in late October in both tunnel and field likely due to cool night temperatures and low light conditions
- Primocane-fruiting blackberries offer great potential for off-season production through manipulation of cane growth (advancing with rowcovers and delaying by cutting to ground) and use of tunnels to protect fruit from the elements

#### **Other:**

- A survey of worldwide blackberry production was conducted in 2005. There were an estimated 49,505 acres of blackberries planted and commercially cultivated worldwide. ‘Thornfree’, ‘Loch Ness’, and ‘Chester Thornless’ were the most important semi-erect types and ‘Brazos’ and ‘Marion’ the most common erect and trailing types, respectively. Based on this survey, there may be 66,800 acres of commercial blackberries planted worldwide in 2015, not including production from harvested wild plants.
- Work with D. Bryla, indicates that ‘Marion’ primocanes and floricanes may compete for soil water under conditions of dry soil.

- Meadowfoam Seed Meal was not a very effective weed management tool and led to phytotoxicity (plant injury) when top-dressed or incorporated at planting at too high a rate.

Work in progress:

- The impact of in-row spacing and primocane suppression date on the yield, fruit size, and cold hardiness of ‘Marion’
- Determining the chilling requirement of the crown & roots of primocane-fruiting blackberry.
- Leaf nutrient content of primocane-fruiting blackberry throughout the growing season.
- The effect of production system (in-row spacing and AY or EY production) on the growth, cold hardiness, yield, and yield components of fresh and processed trailing blackberry cultivars.

**Cultivars released, ARS/USDA-OSU Cooperative program (Chad Finn, breeder):**

- ‘Siskiyou’, ‘Black Butte’, ‘Obsidian’, ‘Black Pearl’, ‘Metolius’, ‘Nightfall’, ‘Black Diamond’, ‘Wild Treasure’. We continue to evaluate advanced selections and cultivars at the NWREC.

**Red and Black Raspberries:**

Nitrogen fertilization:

- We studied the uptake of fertilizer N in a mature ‘Meeker’ planting at the NWREC. The treatments were: 1) no added nitrogen; 2) 80 lb N/a in mid-March; 3) 40 lb N/a in mid-March; and 4) 40 lb N/a mid-March + 40 lb N/a in mid-May. Nitrogen rate or timing had no effect on plant growth (dry weight) or total plant nitrogen content over the two-year study. There was a trend for the unfertilized plants to have the lowest yield and for the split, 40+40, plants to have the highest yield. Primocanes were longer in the fertilized plants than in the unfertilized plants.
- When fertilizer was applied in mid-March, more of the fertilizer initially went to the fruiting laterals and fruit. Later in the season, fertilizer that was taken up went primarily to primocanes.
- If pruning or removal of dead fruiting canes is done in mid-September, on average, 13 lb N/a are lost (assuming prunings are taken out of field). However, if pruning is done in mid-August, on average 25 lb N/a are lost in the prunings.
- The practice of flailing red raspberry cane prunings in late summer does return N to the plant system within 1.5 years. In fact, the organic form of N in the clippings was taken up as efficiently as a granular, inorganic form of N applied at the same time.

Pruning and training:

- Yield increased with cane number per hill in ‘Meeker’ (from 5 to 15 canes/hill) in a 3-year study. Looped (arc-cane training) produced up to 25% greater yield than topping at 6’, but had 5 to 10% smaller average fruit size, depending on the year. Training had no effect on machine harvest efficiency.
- Machine harvest losses averaged 16% of total yield (with a 2 day harvest interval).

#### Blackcap: pruning and training:

- Various mechanically hedged row widths (12, 24, 36, and 48”) were compared to hand-pruned treatments in a mature blackcap field over two years. There was no treatment effect on yield. Plants with branches pruned short had a greater percent bud break (more laterals) and more fruit per lateral. In one year, berries on shorter branches were larger (1.58 g compared to 1.23 g).
- Hand and machine picking were done to evaluate efficiency. Loss by machine harvest ranged from 30 to 47% of total yield and was not affected by hedgerow width.

#### **Cultivars released, ARS/USDA-OSU Cooperative program (Chad Finn, breeder):**

- ‘Lewis’, ‘Chinook’, ‘Coho’. We continue to evaluate advanced selections and cultivars at the NWREC.
- Various black raspberry cultivars have been tested and identified as potential cultivars for Oregon.

#### Other projects and work in progress:

- Work is in progress on partitioning of macro and micro nutrients in summer-bearing red raspberry throughout the season.
- The effect of rate and method of irrigation on summer- and primocane-fruiting red raspberry is being studied (cooperator with Dave Bryla, USDA/ARS).

#### **Blueberries:**

##### High density planting:

- We compared 'Bluecrop' spaced at 1.5, 3, 4, or 5 ft in the row (10 ft between rows) from fall 1993 through 2001. The high-density planting at 1.5 ft produced 72% greater cumulative yield over 6 years of production (1996-01) compared to the traditional 4 ft in-row spacing. Plants at 3 ft produced 30% greater yield than at 4 ft and those at 5 ft produced 5% less yield. In-row spacing had no dramatic effects on berry size. Percent fruit bud set ranged from 42 to 48% and was not affected by in-row spacing. High-density plantings (1.5 ft) took from 37% to 97% longer to prune than the industry standard (at the time) 4 ft spacing, depending on year. Since our research, the industry standard has become 30 in to 3 ft in the row.

##### Machine harvest efficiency:

- We compared trellised and un-trellised 'Bluecrop' spaced at 1.5, 3, 4, or 5 ft in the row (10 ft between rows) from fall 1993 through 2001. In- row spacing had no effect on percent of total yield lost on the ground during machine harvest in any year.
- Losses to machine harvest ranged from 12% to 24% and averaged 21 % of total yield in un-trellised plots. Trellising had no effect on machine harvest efficiency in 1997 (averaged 21%). However, from 1998-01, as the plants became mature, trellising improved machine harvest efficiency from 3 to 8% of total yield.

### Pruning:

- The effect of early cropping (EC; no blossom removal the first two years) and in-row spacing at 1.5 ft and 4 ft were studied from fall 1999 through 2003 in 'Duke', 'Bluecrop' and 'Elliott' grown on raised beds. Plant growth by year 3 was reduced by EC. EC reduced the dry weight of the root system by 42%. 'Elliott' was the cultivar most adversely affected by early cropping with a 44% reduction in yield in year 3 compared to control plants, whereas yield of 'Duke' and 'Bluecrop' was reduced by 24% and 19%, respectively, by EC. Yield of 'Elliott' in year 4 was still affected by EC. 'Elliott' plants seemed less suited to high density planting due to their large root system.
- A 5-year pruning study in mature 'Bluecrop' and 'Berkeley' showed that un-pruned plants had the greatest yield, but berries were 19 to 27% smaller, harvest was delayed, and harvest efficiency was reduced as much as 51 % compared to conventional pruning. Un-pruned plants could not be machine harvested.

### Mulching:

- In a 3-year study on alternatives to sawdust mulch in blueberries (cooperator: Ross Penhallegon, OSU Extension), nine different mulches (filbert chips, yard debris, crumb tire, crumb plastic, mint straw, grass seed straw at 2 depths, leaf compost, sawdust) were compared to each other and a non-mulched control. Mulches did not differ in their effect on blueberry growth, development, or yield. The un-mulched plots in our study performed as well as mulched plots.
- In a new Elliott planting, mulched plants produced more whip growth than those that were not mulched with sawdust.

### Effect of sawdust incorporation before planting and mulch on planting establishment

- After 2 growing seasons, total plant dry weight of Elliott was greatest in plots where no sawdust was incorporated before planting and in mulched plots.
- Incorporating sawdust before planting in this raised bed system increased irrigation requirement by 5-6 fold.
- Overall, plant growth, yield, and soil moisture were adversely affected by the pre-plant incorporation of sawdust in a good Willamette silt loam soil.

### Nitrogen fertilizer uptake in young and mature plants:

- Young 'Bluecrop' and 'Elliott', in the planting year, do not need much nitrogen (growth was best at 40 lb N/a or less). Young plants are sensitive to under or over fertilization with N. Plants took up little fertilizer early (end of April). Fertilization of individual plants is recommended.
- In mature plants very little fertilizer was taken up by plants before bloom or vegetative growth started. Plants fertilized with high rates of N had a higher concentration of N in harvested fruit and in senescing leaves in the fall. Higher rates of N are not recommended for high-density plantings. Split applications are recommended.

### Effect of photoperiod on growth:

- A controlled environment study was conducted using container-grown 'Duke', 'Bluecrop' and 'Elliott'. Plants were grown under short days (SD = 8 hour photoperiod) or long days (LD = 16 hour photoperiod) at constant temperature (22 °C) for up to eight weeks. Plants grown under LD had three to six flushes of shoot growth and did not initiate flower buds or enter endodormancy. Bud break occurred after 5 to 15 days in the greenhouse. Plants grown under SD had two flushes of shoot growth, developed flower buds after two weeks, and were dormant after four weeks of SD. The number of flower buds per plant and the degree of dormancy increased with time of exposure to SD.

### Irrigation requirements (with Dr. Dave Bryla)

- Plants spaced 1.5 ft apart required only slightly more irrigation water than those spaced 4 ft apart. Higher density plantings did, however, require more frequent irrigations, probably due to their smaller root systems
- Water use increased during fruit filling and then rapidly decreased after harvest. 'Duke' used the most water among cultivars, using 0.20-0.39 inches/day from mid-May to mid-August, while 'Elliott' used the least, using 0.12-0.20 inches/day. Lower water use in 'Elliott' may have been related to lower plant water status due to its larger canopy size and lower penetration of water into the root zone during overhead irrigation.

### Use of grow tubes in planting establishment in the Willamette Valley

- Opaque and transparent plastic and cardboard grow tubes did improve top growth of blueberries during the establishment year. However, use of tubes reduced the number of whips, crown size, and root size. In addition, shoots produced in tubes were thinner and more "brushy" increasing likelihood of these being removed when pruning the following winter.
- Use of grow tubes was a disadvantage for total plant growth in the Willamette Valley of Oregon

### Organic Production Systems

- We began a study in Oct. 2006 to evaluate the effect of raised beds, weed management method, and rate and type of fertilizer in Duke and Liberty blueberries grown in a certified organic production system
- After the second growing season, plants grown on raised beds were larger than those on flat ground; raised beds require more irrigation than flat ground systems; use of weed mat as a mulch increased plant top growth and yield, but increased irrigation requirement compared to sawdust mulch; weeds were lowest on weed mat mulch and highest in the sawdust plus compost mulch; a 25 lb N/a rate of fish emulsion produced the best growth (compared to 50 lb N/a fish and 25 or 50 lb N/a of feather meal); fertilizer seems to affect fruit quality
- We are collected economic data
- Work is on-going

### Work in progress:

- A comparison of drip, micro-sprinkler, and over-head irrigation at 50%, 100%, and 150% of ET in 'Duke' and 'Elliott' (cooperator with Dave Bryla, ARS-USDA).
- Partitioning of macro and micro nutrients in young and mature blueberries.
- The impact of edible coatings on blueberry shelf-life (cooperator with Yanyun Zhao, Dept. Food Sci. and Tech., OSU).
- Evaluation of blueberry cultivars and advanced selections (with Chad Finn, USDA/ARS).

## **Strawberries:**

### Nitrogen fertilization:

- We studied 'Totem' planted at the NWREC from the first through the third fruiting season. Some of our treatments included the following granular (broadcast band) applications: 1) no added fertilizer N; 2) 25 lb N/a in April + 50 lb N/a at renovation; 3) 50 lb N/a at renovation; and 50 lb N/a at renovation plus foliar applied N at bloom, green fruit or after renovation. There was no effect of nitrogen rate or method of application on plant growth, total plant N, yield, or fruit quality (rot, firmness, sugar concentration) from the first through the third fruiting season. There was a trend for increased fruit rot in the high spring N treatment.
- Strawberry plants did take up a large quantity of the 25 lb N/a applied as a granular in the spring, 63% of the fertilizer applied. Very little of the spring fertilizer N went to the roots or the crown, but rather was taken up and moved into the leaves and fruit. When plants were renovated, all of the spring applied N was lost.
- About 42% of the 50 lb N/a applied at renovation was taken up by the strawberry plants. This fertilizer initially went into the leaves, but then accumulated in the crown and roots. About half of the N taken up was lost as leaves senesced going into dormancy.
- Plants that were not fertilized at all had the same total amount of N in the plant as those that received 50 lb N/a at renovation. The needed N in these plants likely came from mineralization in the soil in late summer.

### Other projects:

- Deblossoming 'Totem' in the planting year had no significant effect on yield, berry weight, or plant yield and vegetative components in the first and second fruiting seasons. Late planting of 'Totem' (on flat ground) decreased yield in the first fruiting season, but not the second fruiting season. Berry weight was greater with later planting dates in both fruiting seasons. Production system had no effect on yield.
- Late planting in annual systems (keep for one fruiting season) increased populations of the two-spotted mite the following spring. Populations then dropped due to suppression by the predatory mites. Late planting of 'Totem' on raised beds did not reduce yield the following season.
- Renovation, mowing off leaves post-harvest, increased yield 20-40% in Redcrest and Totem strawberry compared to un-renovated plants. We've found that the best time to renovate is from 2 to 4 weeks after harvest. Later than this, you risk reducing plant growth enough to impact flower bud initiation.

### Work in progress:

- Evaluating the effect of planting date and cultivar in open field and tunnel production systems for fresh market

### **Cultivars released, ARS/USDA-OSU Cooperative program (Chad Finn, breeder):**

- ‘Redcrest’, ‘Tillamook’, ‘Pinnacle’, ‘Valley Red’ (since I’ve been berry crop research leader at NWREC). We continue to evaluate advanced selections and cultivars at the NWREC.

### **Kiwifruit:**

- Iodine staining of starch in ‘Ananasnaya’ hardy kiwifruit is not useful as an indicator of harvest maturity.
- Harvest Brix of ‘Ananasnaya’ significantly affected fruit quality – consumers did not prefer fruit harvested at low Brix (6 Brix). Aroma and flavor were rated higher on fruit that were refrigerated after harvest than on those that were not.
- ‘Ananasnaya’ flowers were thinned [0% (control), 15%, 30%, and 50% flower bud removal (2-5 June)]. The average yield of vines thinned 50% was significantly less than that of control vines. However, marketable yield from vines thinned 15%, 30% and 50% was not significantly different from control vines. Thinning, regardless of severity, increased average fruit volume and king fruit volume by 18% and 27%, respectively, compared to control vines. King fruit were more affected by thinning than the two adjacent lateral fruit in the cluster. Thinning before bloom had no effect on percent soluble solids, seed number or total seed weight per fruit. At the present time thinning does not seem practical.
- Pruning studies have shown that pruning hardy kiwifruit vines, relatively severely, increases fruit size and uniformity of ripening.
- Edible coatings may be used to reduce desiccation of harvested ‘Ananasnaya’
- Overhead shading (~ 50%) of ‘Ananasnaya’ vines for 2 months prior to fruit harvest, led to the greatest reduction in flower number the following season confirming that the period before fruit harvest is an important time for flower bud development (for next year’s crop) in this species.
- In ‘Ananasnaya’, the origination of one-year-old fruiting wood had no effect on percent fruitful shoots. One-year-old canes produced fruitful shoots along their entire length, but were most productive from nodes 6 to 26. There was no relationship between yield per vine and return bloom the following year. Fruit set was 74%.

### Work in progress:

- Determining the chilling requirement of various species and cultivars/selections of kiwifruit
- Leaf nutrient content of ‘Ananasnaya’ and *A. arguta* male throughout the growing season

## Cranberry

- We have studied factors that affect yield components (berry number, fruit set, berry size, fruiting upright number, and density), including biennial bearing and fruit development and the effects of pruning and sanding on production and quality. Alternate-year pruning is now recommended for cranberry as it increases yield 70% compared to annual pruning. Light pruning was found to increase yield 25% over moderate and 82% over heavy pruning. A light application of sand 0.5 inches was shown to increase yield 20% at an older bed, but was not recommended for younger sites. On average, sanding programs are estimated to increase yield by 5%.

### Work in progress:

- The effect of fruit age/development on fruit quality attributes
- The impact of N fertilization rate, harvest, and storage on fruit quality of 'Stevens'

## Aronia

- Evaluated *Aronia melanocarpa* ( 'Albigowa', 'Darbrowice', 'Egerta', 'Kutno', 'Nero', and 'Nowa Wies'). Yield was 4.4 to 12.4 kg/plant with 'Nero' having highest yield. Berries were 2.0 to 2.8 g.

## Haskap

### Work in progress:

- We are evaluating 12 genotypes of *Lonicera* at the NWREC (yield and fruit quality; in collaboration with Maxine Thompson and Linda White)

## Extension Publications:

Strik, B.C. and C.E. Finn. Blueberry Cultivars for Oregon. EC 1308, (major revision) March, 2008, 12 pp.

Finn, C.E. and B.C. Strik. Raspberry Cultivars for Oregon. EC 1310, (major revision) March, 2008, 8 pp.

Finn, C.E. and B.C. Strik. Blackberry Cultivars for Oregon. EC 1617, Mar., 2008, 12 pp.

Finn, C.E. and B.C. Strik. Strawberry Cultivars for Oregon. EC 1618, March, 2008, 8 pp.

Strik, B.C. Growing Blackberries in Your Home Garden. EC 1303, (major revision) March, 2008, 8 pp.

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