OSU Blueberry School
March 16-17, 2015 Corvallis, Oregon

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This two-day blueberry “school” was organized for new and experienced blueberry growers, farm managers, crew leaders, advisors, packers/shippers, and consultants. Experts from Oregon State University, USDA Agricultural Research Service, Washington State University, and the blueberry industry were asked to address key issues of where the blueberry market is going; how you might be more successful in tight labor or volume markets; which cultivars are easiest to grow and are in most demand; how to establish new acreage using cutting-edge methods; projected costs and the resources available to growers for selecting new planting sites; how to best manage existing acreage to maximize returns of high-quality fruit; provide basic information on blueberry plant physiology to help growers minimize environmental stresses and improve yield potential; nutrient management programs for optimal growth and quality; irrigation and fertigation practices for higher quality and better efficiency; use of organic amendments and mulches; planning for and improving machine harvest efficiency; pruning for hand or machine harvest (where can you cut corners….or not), maximizing pollination for good fruit and seed set; overviews of the most important blueberry viruses, diseases, insects, weeds, and vertebrate pests; and tools for good pest management. Information throughout the program addresses the needs of conventional, transitional, and organic growers. Simultaneous interpretation to Spanish has been provided. This proceedings book contains information provided on these topics by each speaker and co-authors. The thumb drive provided in the registration packet for each attendee includes a copy of each presentation. Thank you for attending. It is our sincere wish that this will be a very useful meeting and that you find the accompanying materials a valuable reference! –

Bernadine Strik, Professor and Extension Berry Crops Specialist, OSU and the members of the organizing committee

Organizing Committee

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Blueberry viruses in the Pacific Northwest and suggestions for their management

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The goal of this presentation is to provide a review of the viruses of blueberry that have been reported in the Pacific Northwest (PNW) and highlight those of major concern in the region, Blueberry scorch virus, Blueberry shock virus, Tomato ringspot virus, Blueberry fruit drop associated virus and Blueberry mosaic associated virus are the major viruses that will be discussed. The vectors for each of the viruses will be highlighted, since once the plants are in the ground, management is based on vector control. Virus management strategies will be presented that cover blueberry growing from site selection and preparation to having fields in full production. A short description of viruses not present in the PNW will also be presented to highlight efforts that should be taken to protect the industry in the PNW from these viruses. The most effective management for viruses not already present in the PNW is to keep them out of the production region.

The use of certified virus-tested planting stock is the most important component of a virus management program since there are no field treatments to cure a virus infected plant.

Scorch

Blueberry scorch disease was first reported in 1980 in a field near Puyallup, Washington, and Blueberry scorch virus (BlScV) initially was characterized from two fields in Washington in 1988. The disease has since been detected in three fields in Oregon and several more in Washington. The virus is also the causal agent of Sheep Pen Hill Disease described in New Jersey in 1970. The disease was first reported in British Columbia in 2000 and has since been found to be widespread there, while still limited in its distribution in Oregon and Washington. The disease has also been reported in Connecticut, Massachusetts, Michigan, New York and Pennsylvania as well as in the Netherlands and Italy in Europe. BlScV has also been found in asymptomatic cranberry plants in the Pacific Northwest and in native black huckleberry in the interior of British Columbia.

Symptoms

In cultivars that develop severe symptoms, the flower clusters blight in the spring just as the flowers are about to open. Young vegetative shoots also blight. When shoots blight in the spring, they usually turn grayish-black, but when fully expanded leaves dieback they often turn orange-brown. Blighted tissues, especially flowers, remain on the twig (flag) and in some cultivars they may be present the following year if not pruned out. The cultivars Olympia and Stanley only exhibited a marginal leaf necrosis, Bluecrop develops a general chlorosis and Jersey is the only northern highbush cultivar that remains symptomless. In some cultivars with some strains of the virus an oak-leaf pattern develops in the fall, but this symptom is easily overlooked. Blighted blossoms are brown but bleach to a silver-gray as they weather. Some twigs may die back.
several inches. The margins of leaves on the interior of affected bushes usually are chlorotic. Symptoms first appear on one or a few branches, but the entire bush becomes infected within 1 to 3 years. Once plants become infected and show symptoms, they do not recover and will exhibit blight symptoms year after year. This pattern differs from symptoms caused by Blueberry shock virus (see next section), from which plants usually recover after exhibiting blight symptoms. Fruit production and shoot growth on infected plants is significantly reduced. At harvest, the overall appearance of infected plants is markedly different from that of healthy plants of the same cultivar. The long branches of healthy plants are drooped over under the weight of the ripe berries. In contrast, the short branches on infected plants are upright and bear little fruit.

Transmission

BLScV is aphid transmitted between early May through early August in western Washington and in the Fraser Valley. Aphids are inefficient vectors when looking at transmission by individual or groups of aphids. Using groups of 25 aphids, transmission only occurs 10-15% of the time. However, one must remember if there is one aphid per leaf, a thousand leaves per plant and a thousand plants per acre that would be one million aphids per acre. Transmission is reduced when aphids are controlled. Once infected, there is a 1- to 2-year latent period before symptoms appear. It is not known whether the virus can be transmitted from infected plants during this latent period.

Control

Start with Clean Plants. All cultivars of northern highbush blueberry are susceptible to the virus. Cultivars such as Aurora, Berkeley, Bluetta, Bluegold, Briggitta, Elliott, Liberty, Pemberton, Weymouth, and Dixi are extremely sensitive and exhibit severe annual blighting, with the accompanying yield reductions. A number of cultivars show few if any symptoms and are considered tolerant. Yield on tolerant cultivars is not significantly reduced (Legacy, Liberty).

When the disease is first suspected, have plants tested to confirm the presence of this specific virus since other viruses and pathogens as well as frost damage can cause similar symptoms. Do not wait until the following year to see if symptoms reoccur before testing, delaying control measures will increase the number of plants that will need to be removed. Remove infected plants that exhibit blighting, test adjacent plants to identify infected but symptomless plants. Monitor the field for at least three years for symptoms and remove symptomatic plants, during this time implement aphid control to reduce spread of the virus and increase likelihood of successful eradication of BLScV from the field.

Shock

Blueberry shock disease first observed in Washington state in 1987 and initially confused with blueberry scorch disease caused by BLScV. However, in the case of shock affected plants produced a second flush of leaves after flowering and the plants appeared normal by late summer except for the lack of fruit. In most cultivars, plants flower and fruit normally in subsequent years and do not exhibit symptoms. For many years BLShV was restricted to the Pacific
Northwest (Oregon, Washington and British Columbia) but in 2009, it was identified in Michigan USA, and Nova Scotia, Canada, but has not been detected outside of North America. Michigan is actively trying to eradicate BlShV, as it has only been detected in a single field. They removed all plants from the affected field and with follow up testing it appears they have eradicated BlShV from Michigan. In Nova Scotia, they are not attempting to eradicate the virus, but watching to see if plants recover as they do in the mild Mediterranean climate of the Pacific Northwest. There is a risk that BlShV will transfer to lowbush blueberry if it becomes widespread in Nova Scotia and its impact in this species is unknown.

**Symptoms**

The initial symptoms of shock disease are easily confused with scorch symptoms, however, in most cases plants infected with shock recover completely after exhibiting symptoms for one year, whereas scorch symptoms appear repeatedly and plants do not recover. Blueberry shock virus (BlShV) is pollen-borne. Plant-to-plant spread occurs when insects, especially foraging honeybees, transfer infected pollen to flowers on healthy plants.

Developing flower clusters and young vegetative leaf shoots suddenly die in the spring when the flowers are fully opened. Blighted young leaves are grayish-black, while more developed leaves turn orange. Droplets of clear amber liquid may appear on the blighted tissues. The dead tissues may give off a tea-like aroma. The entire bush may be blighted or, more commonly, only a portion of affected plants will show symptoms. The blighted tissues do not flag, and they usually fall off the plant by early June. These symptoms represent a shock reaction by the plant in response to infection. Infected plants produce a second flush of leaves during the summer and look fairly normal by season’s end. However, they produce little fruit that season, and new vegetative growth may be reduced.

Plants exhibit the shock reaction for 1 to 4 years as the virus moves through the plant, often one or a few canes will show symptoms the first year, and these canes will likely be symptomless the following year, but other parts of the bush will exhibit symptoms. Once the entire bush has developed symptoms and recovered it generally remains symptomless in subsequent years. Recovered plants remain infected and are sources of virus for further spread. When provided with good cultural care, infected plants can produce a full crop of fruit. BlShV can spread very rapidly through some cultivars (Berkeley, Bluetta, Bluegold, Liberty, plus others), while in other cultivars it spreads very slowly (Bluecrop, Blu ray, plus others).

**Control**

Start with Clean Plants. Removing and destroying plants showing symptoms, or those testing positive for the virus, probably will not be successful in eliminating the disease from the planting, since the infected plants do not develop symptoms or test positive for the virus the year of infection. To date, no resistant or tolerant cultivars have been identified. Cultivars where the virus spreads very slowly can provide years of productivity before the virus becomes widespread. Development of cultivars with very slow spread is a strategy to reduce the impact of BlShV on production.
**Tomato ringspot and Tobacco ringspot (Necrotic ringspot disease)**

Tomato ringspot virus has been reported in blueberry in New York, Oregon, Pennsylvania and Washington in the U.S. and in New Brunswick, Canada. This virus disease in blueberry is not known to occur in other areas, even where these viruses are common on other. It is generally a minor disease, but one that should be considered before establishing new plantings. Tobacco ringspot virus causes very similar symptoms and is vectored by the same nematode. Tobacco ringspot virus has been reported in the Pacific Northwest but is very rare, with no reports in the since 1990.

**Symptoms**

Symptoms include; roughly circular, yellow leaf spots about 2 to 5 mm in diameter appear. In some instances, the leaves are malformed. Small, circular, brown necrotic spots may develop on the stems of the newer wood. The strapping and mottling of young leaves also has been associated with infected plants. The virus is transmitted by the American dagger nematode, *Xiphinema americanum*. Blueberry plants can become infected when healthy plants are established in soil infested with virus-carrying nematodes or weeds infected with the virus. The nematodes pick up the virus by feeding on the roots of infected blueberry plants or weed hosts in the field. Infected planting stock is another possible source of the virus.

**Control**

Start with clean plants. For new plantings, control should begin long before plants go in the ground. Test the soil for the presence of the nematode vector. This step is especially important if blueberries are to follow other susceptible crops, such as caneberries or strawberries. Do not assume that a site is free from the nematode (or the virus) because it has been cleared recently or has been in pasture, since this virus infects many weed crops and has been detected in pastures. Deep-fumigate the soil before planting if the nematode is present or the previous crop was infected with this virus. In fields left to fallow with no weeds or crop, the nematodes eventually die out. Plant only certified virus tested plants. The cultivar Bluecrop has been reported as resistant to Tomato ringspot virus, but not to Tobacco ringspot virus. If the disease is observed and the virus is confirmed to be Tomato ringspot, then planting Bluecrop is a good strategy to avoid damage from this virus.

In established plantings, suspected plants should be assayed to determine whether they are infected with Tomato or Tobacco ringspot virus. In addition, soil samples collected from the transition zone between affected and healthy-looking plants should be tested for the nematode vector. Remove and destroy infected plants. Dig out as much of the root system as possible. Remove several symptomless plants surrounding diseased plants, as they may be infected but not yet show symptoms. To halt the spread of the disease, fumigate the soil with high rates of nematicide one year after the plants are removed. Replant with certified virus tested plants.

**Mosaic**

This disease has been observed in cultivars Bluecrop, Briggitta, Blue Jay, Cabot, Concord, Earliblue, Hardiblue, Pioneer, Rubel, Jersey, Stanley and Toro as well as in selections in...
breeding plots. While present in plantings in this region, the incidence of the disease is low and spread is extremely slow. A virus, Blueberry mosaic associated virus, has been detected consistently in symptomatic plants in all areas of highbush blueberry production in the U.S. and Canada and has been observed in Europe and Asia. Symptoms of mosaic have also been observed New Zealand and South America.

**Symptoms**

Leaf variegation is the most characteristic symptom. Leaf colors include a mild to brilliant yellow, pink, white, and a green mottling or mosaic pattern. Usually only a portion of the plant exhibits symptoms, possibly just one branch or a portion of a branch. The appearance of symptoms may not be consistent from year to year. Plants with symptoms one year may be symptomless the next year, with symptoms reappearing the following year. The disease spreads very slowly in the field in the Pacific Northwest, while significant spread has been observed along the east coast from New Jersey to Georgia. The means of spread are unknown, but based on the virus sequence, the best guess is that there is a fungal vector for this virus. Infected plants may produce less fruit than healthy plants, but this difference is limited to the symptomatic portion of the bush. Therefore, for most cultivars impact on yield is minimal. In Brigitta, the entire bush develops symptoms and impact on yield is significant.

**Control**

Start with clean plants. Removal and destruction of visibly infected plants may be worthwhile, but in the PNW most growers do not remove affected plants since the incidence is usually very low, impact on yield is minimal and the virus spreads very slowly. Replant with virus tested planting stock.

**Fruit Drop**

Fruit drop disease was first reported in British Columbia in the early 1990s in the cultivar Bluecrop and has been observed in the same cultivar in northern Washington. The disease appears to spread slowly in the field. The most obvious symptoms is the dropping of the fruit when it reaches 4-6 mm (~1/4 inch) in diameter. The fruit drop approaches 100% in infected bushes of Bluecrop. Also, if one looks out over a field just prior to harvest, canes of infected bushes are very upright since they lack any fruit to weigh them down, and thus are easily observed. Symptoms in other cultivars are not known. Recently a virus has been characterized from infected bushes, which allows for the testing of other cultivars for the presence of this virus to determine susceptibility of other cultivars and symptoms.

**Control**

Start with clean plants. Remove infected bushes and replant with virus tested plants, preferably of a cultivar other than Bluecrop. As we get more information on this virus and disease, control strategies may be modified.
Virus diseases of minor importance in the Pacific Northwest, no evidence of spread and only one or two reported cases

Red ringspot

While this virus disease has been reported in the Pacific Northwest, it is of little economic importance. It is a serious disease in New Jersey and the southeastern U.S. where it spreads in the field.

Symptoms

Red ringspots or roughly circular blotches are found on 1-year-old and older stems (Figure 21, Appendix C). In mid- to late summer, reddish-brown, circular spots develop on older leaves. Young leaves generally remain symptomless. Symptoms may be masked on dark or red-stemmed cultivars as the stems mature. Spots usually are 2 to 6 mm in diameter and are visible only on the upper surface of the leaf.

When spots are numerous, they grow together (coalesce). The center of the circular leaf spots often is green and may be confused with the symptom of powdery mildew. With powdery mildew, however, the red ringspots are conspicuous on both sides of the leaf. Berries on infected plants may be small, deformed, and late to ripen. On Rancocas, light mottling may occur on fruit.

The vector of this virus disease is unknown. In New Jersey, where active spread of the disease in the field occurs, a mealybug has been suggested as the vector, but definitive identification is still lacking.

Control

Start with clean plants. Be especially cautious if bringing plants from the eastern U.S. where the virus is present and spreads in the field. Cultivars differ in susceptibility to the red ringspot virus. Blueray, Bluetta, Burlington, Coville, Darrow, Earliblue, and Rubel commonly exhibit symptoms when infected. Jersey is apparently immune, while Bluecrop has shown field resistance. Remove and destroy diseased plants when symptoms appear and the disease is confirmed.

Stunt (This is caused by a Phytoplasma)

This disease is not important in the Pacific Northwest. Originally thought to be caused by a virus, this disease actually is caused by a phytoplasma. It is transmitted by the sharp nosed leafhopper (*Scaphytopius magdalenensis*), which also is called the blueberry leafhopper.

Symptoms

The primary symptom is the dwarfing of infected plants, hence the name stunt. The dwarfing is especially noticed on new growth after plants have been pruned heavily. Internodes on infected plants are short, and leaves are small. The small leaves also tend to pucker and cup downward. Leaves become chlorotic, mainly along the margin and between the veins. Areas directly
adjacent to the midrib and the lateral veins remain green. In late summer or early fall, the chlorotic areas turn a brilliant red. This change happens before healthy leaves naturally turn color.

**Control**

Start with clean plants. The insect vector does not occur in the Pacific Northwest, thus if starting with clean plants this disease should not be a problem. It occurs only in the Midwest and East. Therefore, control can be limited to removing diseased bushes as symptoms appear. The disease may be introduced to the Pacific Northwest in infected planting stock, so be especially careful if bringing plants in from areas where the disease is present. In the Midwest and East, vector control is an important part of overall disease control. Insecticides are used to treat fields and surrounding wooded areas to reduce reinfestation by migrating adult leafhoppers. Rancocas is the only cultivar with a high degree of resistance. Use disease-free planting stock for new plantings and when replacing infected plants. The disease cannot be transmitted from bush to bush by shears during pruning.

**Shoestring**

This disease is most prevalent in New Jersey (where it was first described) and Michigan. It has been detected in only a single field in Washington, but not in Oregon or British Columbia. In Washington, it probably was introduced on infected planting stock.

**Symptoms**

Several symptoms, when taken together, are diagnostic for this virus disease. Affected leaves are straplike. This symptom occurs when both sides of the leaf fail to develop. When only one side does not develop normally, the leaf is curled or crescent shaped. Petals may exhibit red streaking and be misshapen. Last season’s growth may be twisted rather than straight. The most prominent symptom on stems is a reddish streak on current or last season’s growth. Streaking usually is on the side of the stem exposed to the sun. The above symptoms may appear on many, a few, or just a single branch. Immature berries on infected plants develop a premature reddish-purple coloration.

The virus is spread by the blueberry aphid *Illinoia pepperi*. This aphid is not known to occur in the Pacific Northwest. Its absence may explain why the disease did not spread in the one field in Washington where it was detected.

**Control**

Start with clean plants. Infected plants should be removed and destroyed, preferably by burning. Because the vector is not in this area, plant removal should provide satisfactory control of the virus, however, we lack experience with *Ericaphous* spp. as vectors of this virus. Growers purchasing plants from regions where the disease is prevalent should make sure the plants are certified virus-tested. Bluecrop is tolerant to this disease.
Blueberry viruses not reported in the Pacific Northwest

There are a number of viruses that occur in other regions of the U.S. that are not known to be present in the Pacific Northwest. Blueberry necrotic ring blotch virus in the southeastern U.S. has become widespread there after its initial discovery in 2006. Blueberry leaf mottle virus, Peach rosette mosaic virus, and Blueberry virus A (Blueberry bronze leaf curl disease) are present in the Michigan and can be very damaging there. How important these diseases would become in the Pacific Northwest if the viruses and/or vectors were introduced is not known. For these diseases we have the luxury of isolation from production areas where they are known to occur. Therefore care should be taken to plant only certified virus-tested stock from reputable sources to ensure these viruses do not get introduced into the PNW, since they could threaten the thriving blueberry industry here.

REMEMBER

The use of certified virus-tested planting stock is the most important component of a virus management program

START CLEAN