



Growing Day-Neutral Strawberries in Western Washington

WASHINGTON STATE UNIVERSITY EXTENSION FACT SHEET • FS132E

Western Washington has a long history as a strawberry-growing region, historically focused on high-quality fruit from June-bearing cultivars for the processing market. This publication introduces day-neutral strawberry production to commercial growers who are interested in exploiting the long season and fresh market capability of day-neutral cultivars.

Introduction

Day-neutral strawberry cultivars offer growers in most areas of western Washington the opportunity to produce strawberries throughout a period spanning four to five months, and longer, under protected culture. Unlike the more familiar June-bearing cultivars that produce fruit over a concentrated harvest period (typically in June), day-neutral cultivars flower and fruit continually over the growing season while temperatures remain between 40°F and 90°F. In western Washington, production usually begins in June and continues through October (Figure 1), depending on weather conditions and the use of protective structures.

There has been some confusion with the terms “day-neutral” and “everbearing” strawberries, as these are often used interchangeably. Modern day-neutral cultivars have more consistent fruit production patterns than the older everbearing cultivars (such as ‘Ogallala’, ‘Ft. Laramie’,



Figure 1. Day-neutral strawberries fruit through the summer well into the fall season. Photo by Matt Unger.

and ‘Quinault’), which tend to produce fruit in early summer and again in late summer after a significant gap in production. These are not generally suitable for commercial production.

Day-neutral strawberries perform best in a production system tailored to their long fruiting season. They are generally grown on raised beds covered with black plastic mulch to suppress weeds and warm the soil. Drip irrigation is laid on the soil’s surface (covered by the mulch) and provides plants with water and nutrients throughout the season. Plant type and planting time differ for day-neutral and June-bearing strawberries: day-neutrals perform best when planted as plugs in September. Although most plantings of day-neutrals are annual, growers sometimes hold healthy plantings over for a second year of production. Day-neutrals tend to have firmer and larger fruit than common June-bearing strawberries.

These traits, along with their extended fruiting pattern, make day-neutral strawberries well suited to fresh market sales (Figure 2). However, day-neutrals require intensive management, and the higher costs must be considered for a viable production plan.



Figure 2. Day-neutral strawberries in pint containers at a market. Photo by Wendy Hoashi-Erhardt.

Preparing to Plant

Soil preparation. Like other strawberries, day-neutral cultivars grow best on well-drained soil. Unless the soil is to be fumigated, strawberries should not follow rotations of lettuce, spinach, or Solanaceous crops, such as potatoes or tomatoes. This is because damaging levels of *Verticillium*, a soil-borne disease (see Plant Protection below), may build up in these other host plants even when symptoms are not evident. Prior to planting, a soil sample should be sent to an analytical laboratory for basic nutrient analysis. If the soil test indicates that soil pH is too low (below 5.4) or there are deficiencies in macro- or micronutrients, these should be corrected with a pre-plant fertilizer if possible. Strawberry fertility guidelines are available in publications such as *Strawberries (Western Oregon—west of Cascades)* (Hart et al. 2000). A pre-plant application of 60 to 80 lb of nitrogen per acre, along with a similar amount of potassium, helps plant establishment the following spring, and supplies about half of the crop's needs for these nutrients. A good database of analytical laboratories in the Pacific Northwest is available online at the [Washington State Pest Management Resource Service](#).

The ground should be worked to a fine texture, as for a seedbed. Conventional growers may choose to fumigate



Figure 3. Mulch-laying equipment applies plastic to pre-formed beds. Photo by Thomas Walters.



Figure 4. Plastic can be laid by hand after bed formation. Photo by Thomas Walters.

at this time, depending upon field history and known pest pressures. Specialized bed shapers can make the 10- to 12-inch-high beds ideal for strawberries, but a vegetable bed shaper can also produce acceptable beds, which are about 8 inches high. This can also be done by hand or using specialized rototiller attachments. Highly specialized equipment is available to shape beds, lay drip tape, and lay mulch in a single pass, or a dedicated mulch-layer may be used (Figure 3). Mulch may also be laid by hand (Figure 4).

Choosing a cultivar. The day-neutral cultivars available to Washington growers were mainly developed in other strawberry-growing regions, and tend to have firmer and larger fruit than the June-bearing varieties commonly grown in the Northwest. However, these day-neutral varieties can be grown successfully and find acceptance in the fresh market. We have found 'Albion' and 'Seascape' to be productive, flavorful, and attractive. Table 1 summarizes available varieties.

Cultivar choice is especially important for organic farmers planning to harvest their strawberry plantings over more than one season. All available day-neutral varieties were developed and evaluated in conventional systems using synthetic fertilizers and pesticides. Although strong yields can be attained in the second, and even third year of a day-neutral planting grown in conventional production systems, nutrient dynamics and pest pressures in an organic system affect varieties unequally. The cultivar 'Albion' has been gaining in market share since its release in 2006, while plant sales of 'Seascape' have been declining. However, the suitability of 'Albion' to organic management has been inferior to 'Seascape' and 'Aromas', with regards to durability and yield in our trials on organic farms in western Washington. Organic farmers who prefer the flavor of 'Albion' will need to carefully manage plant health to allow the planting to produce into its second year. On the other hand, where *Verticillium* wilt is a problem, 'Seascape' has been more susceptible than 'Albion' (Inglis et al. 2011). Growers are cautioned not to plant 'Seascape' in soil with a known or suspected *Verticillium* problem.

Plant types. In experiments at the WSU Mount Vernon Research and Extension Center, plug plants similar to those used by growers in the southeastern U.S., were found to be the most productive (Table 2 and Figure 5). Although plug plants typically cost more than bare root plants (\$0.25 per plug plant when purchased in volume, vs. \$0.12 per bare root plant in 2013), their added productivity (approximately 1/3 lb per plant of marketable fruit) more than compensates for the additional cost. Plugs produce more fruit early in the season, when prices are often high. Although there are numerous plug plant producers in the eastern U.S. and Canada, there were no commercial producers in western Washington at the time of writing. However, one nursery is currently producing small volumes of plug plants, and they may become more widely available soon. Plug plants should be planted in early September.

Table 1. Summary of Traits of Available Day-Neutral Strawberry Varieties for Washington.

Cultivar ^{1,2}	Vigor	Durability	Yield	Fruit Quality	Comments
Aromas	Excellent	Excellent	High	15–20g size, moderately firm, fair flavor	Recommended if yield and durability are highest priority.
Albion	Fair to good	Fair	Medium	15–20g size, firm, good flavor	Yields 20–40% less than Aromas, 2nd year vigor is fair, recommended for flavor, internal color can be light.
Seascape	Good	Good	Medium to high	10–15g size, moderately firm, good flavor	Good organic yields except on sites with Verticillium wilt; good choice for flavor and yield.
San Andreas	Fair to good	Fair	Medium	20–25g size, very firm, fair to good flavor	Yields 20–40% less than Aromas, 2nd year vigor is fair, too firm for some, internal and external color is light.
Monterey	Fair to good	Fair	Medium	20–25g size, very firm, fair to good flavor	Slightly more susceptible to botrytis than Albion, non-traditional flavor, internal color can be light.
Evie 2	Good	Good	Medium to high	15–20g size, a bit soft, fair to good flavor	A bit soft for fresh market, prone to botrytis, non-traditional flavor.
Tristar	Fair to good	Fair	Low	5–15g size, moderately firm, good flavor	Low yields and small fruit size makes picking time consuming, some specialty farmers grow successfully.

¹Varieties Sarian, Portola, Whitney, and Malling Pearl are omitted because of low suitability for commercial production.

²For information on minor commercial varieties not listed here, see *Strawberry Cultivars for Western Oregon and Washington* (Finn et al. 2014).

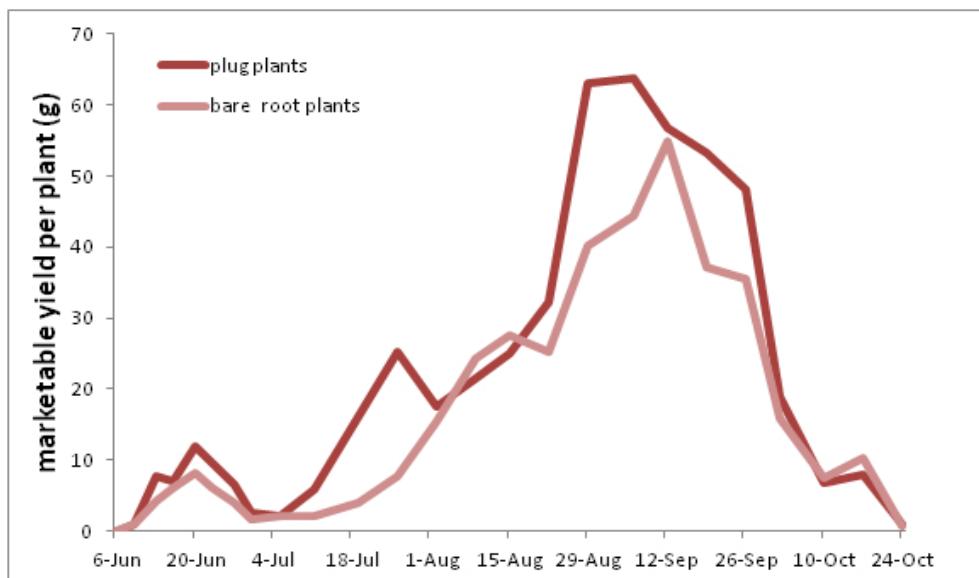


Figure 5. Production curve of plug and bare root 'Albion' plants, Mount Vernon Washington, 2011.

The second most productive plant type for western Washington has been semi-dormant bare root plants from high elevation nurseries in California. These plants are dug from the nursery in late September through mid-October, when they are just entering dormancy. They are dug, trimmed, and shipped to their destination in a matter of a few days, and unlike fully dormant plants, semi-dormant plants cannot be stored. They must be planted immediately upon receipt. Although they are not available in early September (the ideal time for fall-planted strawberries), they can be planted through October to produce a good crop the following year.

Fully dormant bare root plants, similar to those used for June-bearing varieties, are more widely available than plug plants or semi-dormant bare root plants. They can be planted in the early spring, but will not produce as well as the other plant types. The best yields from fully dormant plants will be realized from plantings started early in March rather than later in the spring.

Plant orders must be made well in advance of planting. Plug-plant or semi-dormant bare-root plants to be set in the fall should be ordered by May or June. Bare-root plants to be set in the spring should be ordered by November or December.

Table 2. Effect of Plant Type on 'Albion' Production. Mount Vernon, Washington, 2011.

Plant Type	Marketable Fruit/Plant (g)
<i>Outdoor Production</i>	
plug	476
bare root	340
<i>Inside Tunnel</i>	
plug	489
bare root	325



Figure 6a. Bulb planters (left), hole with plug plant (center), and set plant (right). Photos by Thomas Walters.



Figure 6b. Simple tool and planting technique for planting bare-root strawberries. Photos by Wendy Hoashi-Erhardt.

Establishing Strawberries

Planting. Plug plants with well-developed root systems will better withstand the stresses of transplanting. A few days prior to planting, allow the plants to harden off by moving them from the moist, warm conditions of the greenhouse to an outside area that is somewhat sheltered from extreme temperatures and sunlight. A bulb planter can be used to puncture the plastic and establish a planting hole (Figure 6a). Place the plug in the hole so that the soil slightly covers the plug, and press soil in to set the plug firmly. Alternatively, a simple tool can be made for puncturing the plastic, and driving the roots of a bare-root plant into the soil (Figure 6b). Bare-root plants should be planted just up to the base of the crown, and the roots should extend straight down rather than in a "J" shape. Plants are usually laid out in staggered double rows, with 10 inches between each twin row, and 12 inches between the plants in the row (Figure 7).

Irrigation. Drip irrigation is preferable to overhead irrigation methods, because water remains under the plastic mulch and does not wet the plant canopy. This is an important consideration for preventing extended leaf wetness and fruit rot. Strawberry beds with two rows of plants will generally have a single drip line; more lines

are needed if more rows are planted per bed. Choose drip lines with an emitter spacing of 12 inches or less to insure uniform soil moisture. Plants will need to be irrigated from the time of planting until fall rains begin, and again once growth begins in the spring. The amount of water to apply at each irrigation should not be more than needed to wet the soil in the rooting zone (up to 1 foot below the soil surface). Excessive irrigation will leach nutrients out of the root zone. Strawberries can use up to 0.23 inches of water per day during summer (Hess et al. 1997), and under these conditions, can deplete available water in the root zone in as little as two days. Growers can use evapotranspiration records or soil moisture (preferably both) to decide when to irrigate.

Evapotranspiration-based irrigation scheduling methods use weather data to model daily crop water use; irrigations are scheduled to replace the water lost through evapotranspiration. Growers can find strawberry water use data from weather stations throughout Washington State, along with an irrigation scheduler, at WSU's Ag Weather Net ([www.weather.wsu.edu](http://weather.wsu.edu)).

Alternately, other methods rely on measurements of soil moisture in the root zone; irrigations are scheduled once soil moisture drops below pre-established thresholds. There

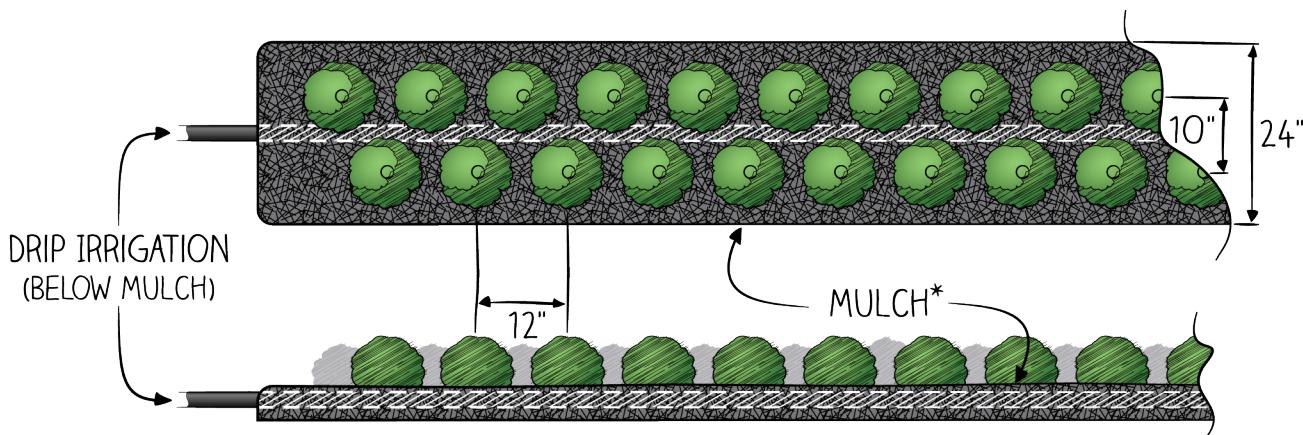


Figure 7. Diagram of plant spacing, bed width, and drip placement. Illustration by Andrew Mack.

are many soil moisture sensors available. Tensiometers are accurate, and do not require any special equipment to read. However, they do require weekly maintenance during the season. At WSU Mount Vernon, researchers found that applying $\frac{1}{4}$ to $\frac{1}{2}$ inch of water to the soil whenever tensiometer readings fell below -30 cb, kept the soil moist and kept productive plantings free from symptoms of water stress.

Some growers prefer electronic sensors, such as Granular Matrix Sensors (e.g. Watermarks). These are not as accurate as tensiometers, and while they require a data-logger or handheld reader, they do not need maintenance during the season. Soil moisture-based and evapotranspiration-based methods are discussed in more detail by Black et al. (2008). Whichever method is chosen, it is important to verify irrigation decisions by using an alternative method, and to develop the habit of observing and feeling the soil under the plastic mulch. It should be moist but not completely saturated.

Fertility. Supplemental nitrogen (N) use in June-bearing strawberries in the traditional matted row system is generally low, about 50 lb of N per acre. In contrast, more productive fields of day-neutral cultivars grown in an annual system can use 120 lb or more N per acre. Pre-plant fertilization meets part of this nutrient demand, but supplemental fertilization is required through the season. When plastic mulch is present, nutrients are best delivered through the drip line (fertigation), using a fertilizer injector, a proportioning device that dilutes a set volume of concentrated liquid fertilizer with irrigation water. At Mount Vernon, researchers have had good results supplementing with 0.5 lb N per acre per day, applied weekly from the onset of vigorous growth in April through mid-September. Strawberry plants use about as much potassium (K) as N, so it is important to supplement with K at a comparable rate. Symptoms of calcium deficiency (leaf puckering, tip-burn, syrupy exudate on leaf and petiole tissues, and dense cover of seeds on unexpanded fruit) are common in rapidly growing strawberry plants, and can be avoided with a weekly calcium supplement. Injectable fertilizers are available to meet most macro- and micronutrient needs. Flush the irrigation system after each fertigation, especially after using organic fertilizers such as fish emulsion. Many fertil-



Figure 8. "Tip-burn" in strawberry is a characteristic of calcium deficiency. Photo by Mark Bolda, University of California Cooperative Extension.

izers can plug emitters directly with particulate matter, but also indirectly, by providing nutrients to algae or bacteria in the lines.

Organic growers will find that providing sufficient nutrition to their day-neutral crop is a challenge. Mineralized nitrogen from previous cover crops can be an important resource for strawberry grown in an organic production system, but additional organic fertilizer will need to be applied regularly throughout the crop season to achieve high yields (Muramoto and Gaskell 2012). If organic fertilizers are injected through the drip lines, special care must be taken to choose an appropriate fertilizer, agitate the injection mixture adequately, and rinse the lines thoroughly, to avoid problems with clogged emitters. Frequent foliar application of a liquid fertilizer is another option, which can be applied by a backpack or tractor-pulled sprayer. Some organic growers choose to lay permeable landscape fabric as mulch instead of plastic, or only cover the sides of a bed and leave a strip of soil exposed, allowing for periodic topdressings with compost or other organic nutrient sources. Drip-tape may be placed as usual, in the middle of the row, above the bare soil. Such an arrangement increases the need to periodically weed the strip and increases the risk of soil contact with fruit.



Figure 9. Protective structures for strawberry production, a) single bed cloche constructed from alternating over-under wire skeleton to hold plastic in place, b) a hoop-house (Photo by Doug Collins), and c) a multi-bed high tunnel. Photos 9a and 9c by Wendy Hoashi-Erhardt.

Harvest. Time of fruit harvest depends a great deal on weather conditions, but generally starts in early June and continues through late September to mid-October. There is a peak of production in June and a broader peak between mid-August through September (Figure 5). Both harvest peaks begin about a week earlier under tunnels, compared with open field production. Commercial growers typically harvest two to three times a week, depending on air temperature and rate of ripening. Fruit that are at least 75% red are ripe enough for harvest, depending on how the fruit are marketed. Fruit should be picked in the early stage of ripeness (75% red) for maximum shelf life, and in later stages (first fully-red) for best flavor. It is critical to bring the fruit's temperature down to 35°F as soon as possible after picking—every hour the fruit remains un-chilled, shortens the shelf life of the fruit by a day. Forced air cooling, or “pre-cooling,” will achieve quicker cooling and better shelf life than merely refrigerating fruit. Picking before the heat of the day reduces the length of time needed to cool fruit to the desired temperature, increasing fruit quality.

Tunnels and Hoop-Houses. Fruiting season, yield, and quality may be extended or increased with the use of protective structures, which range in size and expense. Cloches constructed from 9-gauge wire, or low-tunnels with metal conduit hoops, usually span one bed, and can be covered with clear greenhouse plastic or agricultural fabric (“Remay”) to provide basic protection from frost and rain (Figure 9a). The coverings for these structures can be anchored with clips, ties, outer skeleton hoops, or weights. Hoop-houses are somewhat more permanent and span multiple beds (Figure 9b). High tunnels contain multiple beds and are tall enough to allow tractor work (Figure 9c). All protective structures are used primarily to reduce leaf wetness and increase air temperature, which improves marketability and extends the fruiting season. Diseases such as Botrytis fruit rot and rain damage are greatly reduced in tunnels, compared with field production, leading to better fruit quality, marketable yield, and shelf life. However, powdery mildew and Verticillium wilt can become problems with susceptible varieties in the relatively warm and humid tunnel environment.

Tunnels must be managed carefully on a daily basis to prevent excessive temperatures and humidity inside the structure. Plastic must often be removed in the winter to avoid damage from high winds. The sides of low tunnels must be opened during bloom so bees can pollinate the flowers. For more detail on tunnel production for strawberries, see *2011 Cost Estimates of Producing Strawberries in a High Tunnel in Western Washington* by Galinato and Walters (2012).

Good Agricultural Practices. As for any perishable fresh market crop, the use of Good Agricultural Practices (GAPs) in every stage of production is essential to minimize the risk of contamination by food-borne illnesses. The implications of a human pathogen outbreak are significant for both public safety and farm economics. Irrigation practices, worker hygiene, and animal exclusion are often the most important aspects of strawberry production that influence contamination risk. An excellent [guide to GAPs for berries](#) is available free from North Carolina State University (Mahovic et al. n.d.).

Economics

A comprehensive discussion of strawberry production economics in western Washington, especially using protected structures, can be found in *2011 Cost Estimates of Producing Strawberries in High Tunnel in Western Washington* by Galinato and Walters (2012). Briefly, the total season's production at WSU Mount Vernon has been over 450g per plant for 'Albion' plug plants, and about 300-350g marketable fruit per plant for bare root 'Albion' plants. Strawberry plants are set 12 inches apart in two rows per bed, with 5 feet between beds, resulting in 17,424 plants per acre. Projected marketable yield is thus 7,841kg per acre. Assuming that a quart of strawberries weighs 550g, there will be 14,256 quarts of strawberries per acre. If these sold for \$3.50 each, the gross returns would be just under \$50,000 per acre.

Plant Protection

There are many significant diseases and insects affecting strawberry; the most widespread and severe pests are listed below.



Figure 10. Strawberries affected by *Botrytis* fruit rot. Photo by Wendy Hoashi-Erhardt.



Figure 11. A 'Seascape' plant infected with *Verticillium*. Photo by Thomas Walters.

Diseases

Botrytis Fruit Rot (*Botrytis cinerea* Pers. ex Fr.).

Botrytis causes a common fruit rot of strawberry nearly everywhere strawberries are grown, including Washington State. Blossoms, immature fruit, and mature fruit are susceptible to infection, which is often expressed in the mature fruit as a velvety grey growth (Figure 10). Cool weather and extended periods of flower and leaf wetness favor this disease. Cultural methods, such as maintaining airflow within the plant by avoiding overcrowding or over-fertilization, can help reduce *Botrytis* fruit rot. Choosing a site with good airflow is especially important for organic production. Avoid fields that often experience cool, stagnant air, and consider widening plant spacing to enhance airflow. Good air movement promotes daily warming of the crop, dries foliage after rain, and helps ventilate the canopy to reduce *Botrytis*.

Protective structures, such as high tunnels, greatly reduce leaf wetness and have dramatically reduced losses to *Botrytis* in experiments at Mount Vernon. Growers can consult the [Pacific Northwest Plant Disease Handbook](#) for *Botrytis* management in strawberry. Organic farmers will find the disease section (Broome and Koike 2012) of the Organic Strawberry Production Manual helpful.

Verticillium wilt (*Verticillium dahliae* Kleb.). This widespread disease is caused by a fungus with a wide host range and long persistence in soil. Strains affecting tomato and potato also affect strawberry. Affected plants show browning on their outer (older) leaves, and eventually collapse (Figure 11). Pre-plant soil fumigation with chloropicrin can effectively control *Verticillium*. When fumigation is not practiced and *Verticillium* is known to be present, growers are advised to avoid planting strawberry following susceptible crops like tomato, potato, eggplant, spinach, or lettuce. Crop rotations of 1 to 3 years between strawberry crops can help reduce the presence of *Verticillium* in the soil, especially when broccoli is grown prior to the next strawberry crop. The use of relatively resistant cultivars, such as 'Albion', is highly recommended. Soil solarization, the pre-plant practice of mulching moist soil during the summer months with clear plastic to elevate the



Figure 12. Moist soil is solarized by tarping with clear plastic during the summer months to elevate soil temperature and suppress pests. Photo by Wendy Hoashi-Erhardt.

soil temperature (Figure 12), may suppress *Verticillium* and other soil-borne pathogens, and may become an important pest management tool. A [guide to solarization](#) is available online from the University of California.

Powdery Mildew (*Podosphaera aphanis*). Powdery mildew thrives in humid, but not wet conditions, and can infect any part of the above-ground strawberry plant. Signs of infection include white powdery patches of mycelia on stems, fruit, or the underside of leaves; and leaves curling upward and later developing purplish blotches (Figure 13). Flowers and fruit infected by powdery mildew have a direct impact on marketable yield, as fruit may experience poor fruit set, may not ripen properly, and may have a bitter taste, making it unmarketable (Carisse et al. 2013). Available varieties have varying degrees of resistance to the disease, with 'Seascape' being among the most susceptible of the day-neutrals. Practices that lower the humidity of the canopy, such as improving airflow, avoiding excessive fertilization, and avoiding overhead irrigation, will reduce powdery mildew incidence. Most available fungicides protect against future disease, rather than eradicate existing infections, and for maximum efficacy should be applied when symptoms are first noticed. Organic growers have



Figure 13. Powdery mildew affecting green fruit, leaf, and petiole of a strawberry plant. Photo by Wendy Hoashi-Erhardt.

access to a number of approved protectants, including sulfur, bicarbonates, and certain oil-based products (Broome and Koike 2012).

Slugs. Slug damage on strawberries is often seen as holes in the fruit, which renders the fruit unmarketable and increases the potential for fruit rot in the planting. Slugs are sensitive to low moisture conditions and are a greater threat to strawberry fruit in the cool, humid periods of spring, fall, and after rain events. They find harbor in moist crevices under mulch and among weedy areas in a strawberry field. Widening the distance between the strawberry row and a grassy border or other field debris, will reduce slug access to the strawberry plants. Thorough weed control will also help to control slugs. Conventional and approved organic slug baits are also available.

Lygus bugs (*Lygus hesperus* Knight). Lygus bugs in affected areas can become pests of day-neutral strawberries beginning in late July and lasting through early fall. Lygus bugs feed on developing seeds, preventing uniform fruit

expansion and resulting in misshapen fruit (Figure 14). This damage is often called “monkey-facing” or “cat-facing,” and renders fruit unmarketable.

Lygus bugs migrate to strawberries from more highly-preferred plant hosts. Controlling weeds around plantings is an important practice to limit the movement of Lygus bugs onto strawberry crops. For diversified vegetable operations, brassica crops should be located at a distance from strawberries. Alfalfa may be used as a trap-crop along the borders of a strawberry planting, or with rows intermixed with strawberry rows, to lower lygus bug pressure in both conventional and organic production (Swezey et al. 2007). The alfalfa trap-crop is then regularly treated with an insecticide or a bug-vacuum. Active management of the trap-crop is essential to prevent the trap from becoming a nursery for the lygus pest.

Spotted wing drosophila (SWD, *Drosophila suzukii*)

This vinegar fly is a pest of ripening fruit, and although it appears to prefer other berry crops such as raspberry, blackberry, and blueberry, day-neutral strawberries are at risk of infestation because the mid- to late-summer production season coincides with the building populations of the fruit fly. Female SWD often lay eggs in ripe, undamaged fruit, creating a soft spot that enlarges once the larvae begin feeding, and rendering the fruit unmarketable (Figure 15). Trapping and scouting techniques are described in *Monitoring, Identifying and Fruit Sampling for Spotted Wing Drosophila* (SWD) (Gerdeman et al. 2011).

Basic cultural controls for this pest include the removal and disposal of culls and rotting fruit from the production field, and an eradication of nearby wild fruit crops (such as Himalaya blackberry or abandoned orchards). Harvests should be carefully timed to pick fruit at the earlier stages of ripeness, as risk of infestation increases rapidly with advanced ripeness. There is evidence that immediate and prolonged cold storage of harvested fruit can slow, or even halt, the development of SWD eggs and larvae (Bolda 2010). Chemical controls are available, but diligent,



Figure 14. Lygus bug damage of day-neutral strawberries. Undamaged fruit (from left) to severely damaged fruit (right). Photo by Wendy Hoashi-Erhardt.



a



b

Figure 15. a) Male and female spotted wing drosophila adults. Photo by Bev Gerdeman. b) fruit damage indicative of SWD oviposition and larval feeding in strawberry. Photo by Wendy Hoashi-Erhardt.

frequent spraying (sometimes on a 5 to 7 day schedule) is required for control of SWD adults before eggs are laid in ripening fruit. Organic options are limited—only two active ingredients, spinosad and pyrethrins, are available in organic formulations, and these have been shown to have limited residual activity. Heavy reliance on any insecticide class will promote the development of resistance. More information on management of SWD is in the Pacific Northwest Insect Management Handbook.

References

- Bell, N. and J. DeFrancesco. Strawberry-Spotted Wing Drosophila. In Hollingsworth, C.S. (ed), *Pacific Northwest Insect Management Handbook*. Corvallis, OR: Oregon State University. <http://pnwhandbooks.org/insect/small-fruit/strawberry/strawberry-spotted-wing-drosophila>.
- Black, B.L., R. Hill, and G. Cardon. 2008. Strawberry Irrigation. *Utah State University Cooperative Extension*. http://extension.usu.edu/files/publications/publication/Horticulture_Fruit_2008_05pr.pdf.
- Bolda, M. 2010. Length and Magnitude of Fruit Cooling and Spotted Wing Drosophila Mortality. *Strawberries and Caneberries*. University of California Agriculture and Natural Resources Blogs. <http://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=2474>.
- Broome, J.C. and S.T. Koike. 2012. Disease Management for Organic Strawberries: Foliar and Fruit Problems. In Koike, S., Bull, C.T., Bolda, M., Daugovish, O. (eds.), *Organic Strawberry Production Manual*. Publication 3531. 67–81 University of California Agriculture and Natural Resources.
- Carisse, O., A. Lefebvre, H. Van der Heyden, L. Roberge, and L. Brodeur. 2013. Analysis of Incidence-Severity Relationships for Strawberry Powdery Mildew as Influenced by Cultivar, Cultivar Type, and Production Systems. *Plant Disease* 97(3): 354–362.
- Finn, C.E., B.C. Strik, and P.P. Moore. 2014. Strawberry Cultivars for Western Oregon and Washington. *Oregon State University Extension Service Publication EC 1618*.
- Galinato, S., and T. Walters. 2012. 2011 Cost Estimates of Producing Strawberries in High Tunnel in Western Washington. *Washington State University Extension Publication FS093E*. <http://cru.cahe.wsu.edu/CEPublications/FS093E/FS093E.pdf>.
- Gerdeman, B., L. Tanigoshi, and G.H. Spitler. 2011. Spotted Wing Drosophila (SWD) Monitoring, Identifying, and Fruit Sampling. *Washington State University Extension Publication FS049E*. <http://cru.cahe.wsu.edu/CEPublications/FS049E/FS049E.pdf>.
- Hart, J., T. Righetti, A. Sheets, and L.W. Martin. 2000. *Strawberries (Western Oregon—West of Cascades)*. Oregon State University. <http://ir.library.oregonstate.edu/xmlui/bitstream/handle/1957/20625/fg14-e.pdf>.
- Hess, M., B. Strik, J. Smesrud, and J. Selker. 1997. *Western Oregon Strawberry Irrigation Guide*. Oregon State University. <http://bioe.oregonstate.edu/Documents/IrrigationGuides/STRAWBER.pdf>.
- Inglis, D., B. Gunderson, C. Miles, J. Roozen, R. Wallace, A. Wszelaki, and T.W. Walters. 2011. Evaluation of Gray Mold and Verticillium Wilt on Strawberry Cultivars Grown in High Tunnel vs. Open Field Plots, 2010. *Plant Disease Management Reports*. 5:SMF047. <http://www.plantmanagementnetwork.org/pub/trial/PDMR/reports/2011/SMF047.pdf>.
- Mahovic, M., J.K. Brecht, S.A. Sargent, M.A. Ritenour, K.R. Schneider, A. Simonne, and J. Bartz. 2002. Good Agricultural Practices for the Production and Handling of Strawberry, Raspberry, Blackberry, and Blueberry. *North Carolina Cooperative Extension Service*. <http://www.ces.ncsu.edu/depts/foodsci/ext/programs/producesafety/berries.pdf>.
- Muramoto, J. and M. Gaskell. 2012. Nitrogen Management for Organic Strawberries. In Koike, S., Bull, C.T., Bolda, M., Daugovish, O. (eds.), *Organic Strawberry Production Manual*. 43–53. *University of California, Agriculture and Natural Resources Publication 3531*.

Pscheidt, J.W. and Ocamb, C.M. 2013. Strawberry (*Fragaria* spp.)-Gray Mold {Fruit Rot}. *Pacific Northwest Plant Disease Management Handbook*. Corvallis, OR: Oregon State University. <http://pnwbooks.org/plantdisease/strawberry-fragaria-spp-gray-mold-fruit-rot>.

Swezey, S.L., D.J. Nieto, and J.A. Bryer. 2007. Control of Western Tarnished Plant Bug *Lygus hesperus* Knight (Hemiptera: Miridae) in California Organic Strawberries Using Alfalfa Trap Crops and Tractor-Mounted Vacuums. *Environmental Entomology* 36(6): 1457–1465.

Washington State Pest Management Resource Service. Analytical Laboratories and Consultants Serving Agriculture in the Pacific Northwest. Washington State University. <http://www.puyallup.wsu.edu/analyticallabs/search>.

Resources

Plants

(Note: At the time of writing, there were no suppliers of commercial certified organic plant stock.)

Cloud Mountain farms, 6906 Goodwin Road, Everson, WA 98247; 360-966-5859; cloudmountainfarmcenter.org (call for availability of plug plants).

Indiana Berry & Plant Co., 2811 US 31, Plymouth, IN 46563; 1-800-295-2226; www.indianaberry.com.

Krohne Plant Farm, 65295 CR342 Hartford, MI 49507; 269-424-5423; www.krohneplantfarms.com.

Lassen Canyon Nursery, Redding, CA; 530-223-1075 lassencanyonnursery.com.

Nourse Farms, 41 River Road, South Deerfield, MA 01373; 413-665-2658; www.noursefarms.com.

Sakuma Bros. Farms, Inc., PO Box 427 Burlington, WA, 98233; 360-757-6611 Ext. 150; shop.sakumabros.com.

Raised Bed Supplies and Fertilizer

Dripworks, 1-800-522-3747, www.dripworks.com (irrigation supplies).

Dunning Irrigation 11979 W Highway 12, Touchet, WA 99360-9710. 509-529-6043, (mulch, irrigation supplies).

McConkey's, 1615 Puyallup St., Sumner, WA 98390, 253-863-8111, (plastic mulch, fertilizer, and organic fertilizer).

Robert Marvel Plastic Mulch 2425 Horseshoe Pike (Rt. 322), Annville, PA 17003. 800-478-2214, www.robertmarvel.com (mulch, irrigation supplies, mulch-laying equipment).

Skagit Farm Supply, 20476 Conway Road, Mount Vernon, WA 98273, 360-445-5015, www.skagitfarmers.com (inorganic and organic fertilizers).

Watertec North America, 177A Birch Bay-Lynden Rd, Lynden, Washington 98264, 1-877-591-4790, www.watertecna.com (irrigation supplies, plastic mulch).

Whatcom Farmer Co-op, 2041 Agronomy Way, Lynden, WA 98264, 360-354-2418, www.wfcoop.com (inorganic fertilizers).

Soil Amendments

Seattle Tilth, <http://seattletilth.org/learn/resources-1/compost/compostsources>.



By Wendy Hoashi-Erhardt, Scientific Assistant, Washington State University Puyallup Research and Extension Center, Puyallup, WA; and Thomas Walters, Walters Ag Research, Anacortes, WA.

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Use pesticides with care. Apply them only to plants, animals, or sites as listed on the label. When mixing and applying pesticides, follow all label precautions to protect yourself and others around you. It is a violation of the law to disregard label directions. If pesticides are spilled on skin or clothing, remove clothing and wash skin thoroughly. Store pesticides in their original containers and keep them out of the reach of children, pets, and livestock.

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