Organic Raspberry Production in Three-Season High Tunnels

by Eric Hanson[1], Vicki Morrone[2], Rufus Isaacs[3], Michigan State University Extension
[1]MSU Department of Horticulture, [2]MSU Department of Community Sustainability, [3]MSU Department of Entomology
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High tunnels offer several potential advantages for production of raspberries in humid regions such as the Midwest, including:

- Improved plant vigor and yields.
- Extended harvest and marketing season.
- Improved berry quality.
- Reduced damage from several pests and diseases.

For organic producers, these benefits may be particularly valuable since pesticide options are limited. This bulletin integrates knowledge on conventional culture of high tunnel rasperries (see Cornell publication in references) with information collected from a Michigan State University organic high tunnel research project. Initiated in 2009, the project tested cultural methods for organic production of fruits under high tunnels.

The high tunnel research included nine, 26-by-200-foot, multi-bay tunnels from Haygrove Tunnels, Ltd., constructed on a sandy loam soil on the Michigan State University campus in East Lansing, Michigan. Three bays were each planted with raspberries, sweet cherries and mixed raspberry and sweet cherry plantings. This publication provides guidance for growers interested in high tunnel production of organic raspberries, though the information is of value to non-organic growers as well. Here are some suggestions based on this and other's work.

Site selection

Sandy loam or loamy sand soils are best because they provide good drainage. Poor drainage promotes root rot in brambles.

With loam and clay loam soils, modify drainage by using raised beds and installing drain tiles under sidewalls. Flooding and erosion can also occur since during rain storms, large volumes of water run off the tunnel sides. If soil does not drain adequately, subsurface drain tile should be installed along each side of the tunnel to help direct rain water away from the plants. Tiling is especially important if the soil has a high percentage of clay or if the slope is negative from surrounding areas.

Sub-surface tile and pea gravel installed along each tunnel leg-row to remove excess water.

The year before planting, be sure to test the soil and adjust the pH to 6.0 to 6.5 with lime or sulphur additions. Soil preparation should also include planting cover crops for a year prior to planting brambles to reduce weeds and improve soil quality. Short-lived cover crops such as buckwheat and oats work well as they can be grown and incorporated twice in one season to add organic matter and suppress weeds. Sorghum-sudangrass is another good option for smothering weeds and producing large quantities of organic matter. Sites may also benefit from applications of 1 to 2 tons of manure per acre the year prior to planting canes.

Tunnel and plastic types

Raspberries grow well in multi-bay tunnels and stand-alone tunnels. Multiple bay tunnels consist of interconnected bays and are relatively inexpensive per area covered, but they can be damaged by snow and need to be uncovered

during the winter in snow-prone areas. Plastic needs to be installed and removed annually, which can tear the plastic and is a high labor cost. *Plastic should be installed after the threat of snow in the spring and removed before the first autumn snowfall.*

Stand-alone tunnels may be smaller but more costly by square footage.

Stand-alone high tunnels vary in size and design, but are generally smaller and more costly per square foot. Many can withstand snow, stay covered all year and be tightly enclosed so that harvest times can be manipulated more than with multiple-bay tunnels. Stand-alone tunnels can also protect raspberry canes from winter injury.

One acre range of multiple bay tunnels in southwest Michigan.

Plastic coverings vary in light transmittance. We used Luminence THB plastic, which reduces tunnel temperatures by screening infrared light and also diffuses (scatters) light. This or similar films will work well for raspberries since optimum summer temperatures are likely below 80 degrees Fahrenheit (26 degrees Celsius). Standard greenhouse films that do not remove infrared light allow more direct light and thus increase summer temperatures. With any plastic film, tunnels need to be vented during warm weather. Peak temperatures can also be reduced by several degrees by placing 30 percent shade materials over the plastic film.

Tunnel orientation

North-south orientated tunnels provide the most uniform light distribution. However, multiple-bay tunnels are subject to wind damage. Since wind direction during summer storms in Michigan is usually from the west, orienting tunnels east-west may reduce risks since wind can blow through the tunnels. Choice of orientation is site-specific. If the site is protected by hills or trees, wind hazard is less important. Tunnels oriented up a gentle slope will help dissipate heat by acting like a chimney.

Varieties

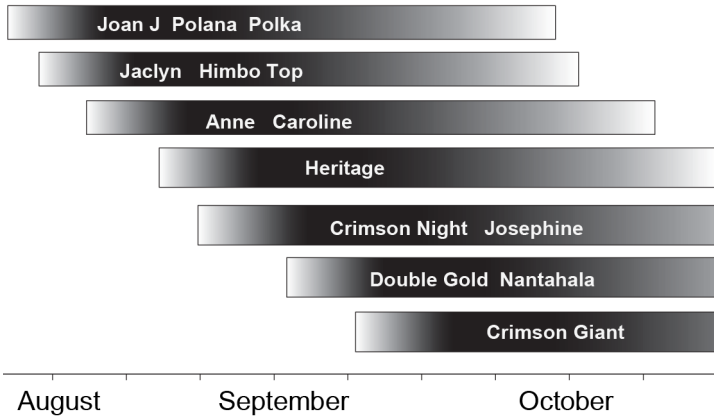
Desired varieties have high yields and fruit quality, some resistance to pests and diseases, and ripen at the desired marketing time. Primocane-fruiting varieties produce fruit on one-year-old canes in the late summer and fall. Floricane-fruiting varieties only fruit on two-year-old canes in June and July. In previous high tunnel studies, we observed that the relative qualities of raspberry varieties in the open field tend to be similar in high tunnels. We tested three newer primocane-fruiting varieties in this study: Joan J, Himbo Top and Polka. Yields from these varieties were similar, ranging from 6,500 to 11,500 pounds per acre.

'Himbo Top' is vigorous and produces large, lighter red berries that are somewhat soft. 'Joan J' produces firmer berries with an excellent flavor, but they are a darker red that some customers perceive as over-ripe. 'Polka' berries also are very tasty and firm with a shiny, bright skin, but 'Polka' is very susceptible to potato leafhopper damage. Cultivars Joan J and Polka are early season primocane-fruiting types. Other varieties (e.g., Caroline, Josephine) have potential as well and new types are regularly being introduced.

High tunnels retain heat and can greatly extend harvest periods so berries can be marketed when field-grown plants are not fruiting. As a rule of thumb, harvest in mul-

Organic raspberry production under multiple bay tunnels in East Lansing, Michigan. Bay on the left is covered with shade fabric to reduce summer temperatures.

tiple bay tunnels will begin one to two weeks earlier and continue one to two weeks later than open field harvest. Stand-alone or single bay tunnels usually retain more heat so harvest periods may be extended even more. Early primocane-fruiting varieties in multiple-bay tunnels in central Michigan begin bearing the first week of August. Consider later varieties to extend the picking season later into fall (see figure below).



Relative harvest season for various primocane fruiting raspberry varieties in tunnels in southern Michigan. Harvest volume increases with bar darkness.

Appearance of the raspberry varieties (L to R) Himbo Top, Joan J and Polka from organic tunnels.

Planting, irrigating, trellising

In the spring, set plants 18-24 inches apart in rows spaced 7-8 feet apart, depending on tunnel dimensions. Install trickle irrigation immediately. Plants must be irrigated once or twice every day during the summer. A tunnel of raspberries will need about 1 inch of water (27,000 gallons per acre) per week in the summer. Initially we installed a single irrigation drip-tube per row with 0.6 gallons per hour emitters spaced at 24 inches. A single tube may be adequate on heavier soils, but on our loamy sand soil, the area between emitters stayed too dry since the water did not easily wick in the soil. We later added a second tube to wet more of the plant root zone. To provide 1 inch of water per week with this dual tube set-up required running the system for about one hour per day. Adjust the timing and application rate depending on soil type, temperature and the amount of rainfall infiltrating from tunnel run-off. Using soil moisture sensors such as tensiometers may help to avoid over or under-irrigating.

Plants grow tall, 5-8 feet, and need a trellis for support. Sturdy end posts of wood or metal are needed. A simple system consists of pairs of metal poles, such as conduit poles, placed 18 inches apart every 20 feet down the row. Run twine or plastic wire the length of the row and secure it to the conduit at desired heights to support the canes.

Pairs of conduit inserted into the ground 1 foot apart provide a suitable support for primocane fruiting raspberries. Plastic wire is secured to the conduit with zip-ties.

A V-shaped trellis is desirable for floricane-fruiting plants. The fruiting floricanes can be tied to the outside wires to make berries more accessible and allow room in the middle for new primocanes to grow. Trellis posts must be untreated wood or unpainted metal in organic systems. Rot-resistant wood is preferred, such as cedar or black locust.

Weed and groundcover management

Start by eliminating perennial weeds such as thistle and quackgrass before planting. This is best achieved by repeated cultivation and use of cover crops. To suppress weeds using cover crops, it is usually best to use a drill for uniform spacing and sow at relatively high rates for a full canopy. For high carbon (biomass) cover crops like sorghum sudangrass, cut and incorporate or incorporate directly in the fall before planting canes to avoid tie-up of nitrogen in the spring. Once raspberries are planted, weeds emerging within the plant rows will need to be removed by hand-weeding and tilling two to three times per year. On sandier soils, the surface between the rows tends to dry out during the summer, so few weeds emerge late in the season.

Growing cover crops between raspberry rows for weed and nutrient management is challenging in high tunnel systems due to limited moisture, harvest traffic and shade from the raspberry canopy. Perennial cover crop species like ryegrass and fescues that are sometimes used in non-tunnel systems have limited persistence in tunnels unless supplemental irrigation is used. Legumes such as Dutch white clover are also problematic since they have high water requirements and may host potential pests including root-lesion nematodes. Weed barrier cloth can also be used between the rows if care is taken to avoid entanglement during tillage operations.

Pest management

Spotted winged Drosophila (SWD) is the most important pest of tunnel and field raspberries. This small vinegar fly infests and contaminates berries. In mid-Michigan, populations are generally low until early August when their activity increases sharply and remains high late into the fall. This coincides with harvest of primocane-fruiting (fall-fruiting) raspberries. Organic pesticide choices are very limited for SWD, so effective control requires investment in cultural controls combined with approved pesticides. For a current list of registered pesticides for use on raspberries, see the Michigan Fruit Management Guide from MSU Extension. Sanitation and timely harvest are critical; harvest all ripe berries every one to three days. Collect soft or damaged berries in separate containers and destroy them. Keep plant rows narrow so berries are easy to see and remove. Harvested fruit should be cooled to 34-38 F immediately to stop deterioration. Recent research shows exclusion netting can also be used to minimize access of SWD to tunnel plants.

Hannah Burrack, North Carolina State University, Bugwood.org

Inside of raspberry showing larvae of spotted wing Drosophila.

Two-spotted spider mites can also be a serious pest of tunnel raspberries because they thrive in hot, dry tunnel conditions. Outbreaks may be severe during hot summers and absent during cooler years. The primary management approach is to adequately vent the tunnel to lower temperatures when they reach 80 F. Predatory mite species are also available for purchase and may help suppress populations if they are introduced before the spider mite populations have become a problem. Mite problems are increased by applying pesticides to control SWD ***since the pesticides also kill beneficial insects,*** including predatory mites that feed on two-spotted mites.

Rufus Isaacs, MSU

Two-spotted spider mite (above) and its damage (right).

Less serious raspberry pests encountered during this project include **raspberry sawflies** (*Monophadnoides geniculatus*), **potato leafhoppers** (*Empoasca fabae*) and **Japanese beetles** (*Popillia japonica*). Raspberries are preferred by Japanese beetles. When populations are high, beetles can be picked from small plantings by hand and disposed of in buckets of soapy water. Potato leafhoppers feed on raspberry leaves and cause deformed growth and stunted canes. In our research, damage was severe on the variety Polka, but only minor on the other two cultivars. Sawflies cause some damage to leaves early in the summer, but likely not enough to cause economic losses.

Leaves yellowing and curling from potato leafhopper damage.

Raspberry sawfly damage.

Rufus Isaacs, MSU

Japanese beetles.

Diseases. Fungal diseases are greatly suppressed by keeping plants dry. Botrytis gray mold, which is a common problem in the field, is scarce in tunnels. Moldy fruit may occur in outer rows of the tunnel when exposed to water dripping from the sides of the tunnels or wind-blown rain. In our trial, no other diseases have been significant. Small amounts of powdery mildew and botrytis cane blight have been seen. Powdery mildew can become serious in tunnels that are poorly vented. East-west orientated tunnels may improve ventilation and suppress mildew.

Pollination

Bees are needed to pollinate raspberries. Honey bees do an adequate job of pollinating in smaller tunnel operations. Although they do not prefer working under plastic, raspberry flowers are very attractive to them. Bumble bees are adapted to working in tunnels, but it is unclear whether the cost of hives is justified for small tunnel raspberry plantings where native bees also help. However, if tunnels are being netted for SWD exclusion, it will be essential to have bumble bee colonies for pollination. Place hives of bumble bees (*Bombus terrestris)* in tunnels before bloom begins. Bumble bees will cost approximately $0.15 per square foot ($75 per hive covering a minimum of 5,000 square feet).

Bumble bee hives placed in tunnels for pollination.

Nutrient management

Raspberries have a high demand for nitrogen (N) and potassium (K). Meeting those needs is complicated in tunnels because rain is excluded, making it difficult for the nutrients to move into the root profile. Solid fertilizers and compost placed on the soil surface tend to dry out except under irrigation lines, so the nutrients in these materials are not available later in the season. Nutrients for annual crops can be incorporated into the soil before planting, but not in perennial crops such as raspberries. Conventional growers have numerous high concentration soluble fertilizers that can be injected through the irrigation system to supply plant needs throughout the year. Injectable organic nutrient sources, such as fish or kelp products, are often expensive, yet effective if applied weekly through the drip irrigation system.

A combination of solid nutrients (organic fertilizer, compost) and liquid products appears to work well for organic tunnel raspberries on sandier soils. Apply the solid materials over the top of the plant rows several weeks before

the plastic is installed in the spring. Some of these nutrients are released and moved into the soil by rain. From June through early September, supplement with injections of liquid nutrient sources such as fish emulsion. Solid materials in the spring may be adequate for plantings on heavier loam soils that retain more nutrients.

Economics

Costs and potential returns have been compiled in a spread sheet. Email Eric Hanson at hansone@msu.edu to request a copy. Capital investments to establish one acre of raspberries under tunnels were paid off in the second year and annual net profit after the first year was estimated to be about $12,000. The primary drawback to organic raspberry production under tunnels at this point is the challenge to manage spotted wing Drosophila with organic-approved practices. We do not have a means of consistently controlling this pest.

References and resources

This bulletin integrates MSU organic research experience with existing knowledge on high tunnel raspberry culture as described in Cornell University's High Tunnel Raspberries and Blackberries publication: www.fruit.cornell.edu/berry/production/pdfs/hightunnelsrasp2012.pdf

Recommendations for conventional raspberry culture in tunnels are available at Cornell University's Fruit website: www.fruit.cornell.edu/berry/production/bramble-production.html

Michigan Fruit Management Guide from MSU Extension is updated annually and includes pesticide recommendations. Bulletin E0154. Order at shop.msu.edu

MSU Spotted Wing Drosophila website. Resources for the North Central U.S. at bit.ly/swdmsu

500 JNL-IPM

Photos by Eric Hanson, MSU, unless noted otherwise

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