Raspberry Production in High Tunnels

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**Introduction**

Raspberry production in the Upper Midwest has a number of challenges. Fruit quality of summer-bearing, or floricane-fruiting cultivars can be low due to hot temperatures during July harvest, and yields may be lowered due to winter injury. Locally-grown fruit harvested in summer competes with abundant and low-priced California berries for market share, and it can be difficult for smaller producers to sell their fruit at a profit.

Fall-bearing, or primocane-fruiting cultivars, which fruit on current-season’s growth offer some benefits. Risk of winter injury is minimal because the canes are pruned to the ground after harvest and do not winter over. Fruit quality is often excellent because fall-bearing cultivars are harvested as the temperatures are cooling in late summer and fall. However, peak production may occur after the first average frost date. For example, in Minnesota in 2007 the first freeze occurred the night of September 17th. Fall-bearing raspberries that had not yet matured were lost to the freeze. Some growers estimated 80% of their crop was not harvested. High tunnels offer protection from frost events, and in University of Minnesota trials, fall-bearing cultivars continued fruiting into early November.

Season extension is not the only benefit high tunnels offer to raspberry production. In field production, yield losses to fungal infection can be high. Typically, growers manage fungal pathogens by pruning and thinning to improve air circulation, and judiciously applying fungicides. Raspberries grown under high tunnels are protected from rain, and have very little fungal growth due to the lack of moisture on the fruit and leaves. Raspberries in high tunnels can be grown with minimal or no application of fungicides.

Weed pressure is reduced in a high tunnel because the between-row paths do not need to be kept in sod, as there is very low risk of erosion under the tunnel. Additionally, through the use of in-row drip irrigation the aisles are never irrigated and weed seeds rarely germinate.

The insect pest complex is somewhat different from field production, more closely resembling that of greenhouse production. Spider mites, whiteflies and aphids are the most common insect pests found in high tunnels. In trials at Morris, Alexandria and Grand Rapids carefully-timed high pressure water sprays and biological controls have been extremely successful in controlling outbreaks.

Research at the University of Minnesota suggests that high tunnel raspberry production can be successful and profitable in Minnesota. In experiments between 2004 and 2009, researchers and farmers examined growing practices, yield potential, and cultivar selection. The recommendations in this section are based on these experiences and on work done in other northern states.

A well-designed, well-maintained raspberry planting can be productive for up to ten years. Typically the initial investment of the high tunnel and the plants is returned after the third year. Subsequent plantings, reusing hardware for a new planting, will be profitable even more quickly.
Before Planting

Primocane-fruiting Raspberries
Summer-bearing, or floricane-fruiting cultivars produce fruit on second-year canes, or floricanes. These cultivars require a year of growth before the canes produce fruit, meaning the canes must be left to winter-over. Raspberry cultivars that produce fruit on first-year growth (primocanes) are known as fall-bearing, ever-bearing or primocane-fruiting. Primocane-fruiting cultivars will produce fruit on their floricanes the next year if left un-pruned, however this will decrease the fall crop potential. Primocane-fruiting raspberry cultivars are used in high tunnel production for multiple reasons:

- No risk of cold-damage to overwintering canes
- Fruit quality is higher thanks to the cooler temperatures during the bulk of harvest in the fall
- Cleaning debris out of the rows is easier after pruning all canes to the ground, reducing disease incidence.
- Pruning is much faster, since all canes are pruned to the ground.
Cultivar Selection

<table>
<thead>
<tr>
<th>Variety</th>
<th>Harvest Season</th>
<th>Productivity</th>
<th>Fruit Size</th>
<th>Attractiveness</th>
<th>Firmness</th>
<th>Flavor</th>
<th>Freezing Quality</th>
<th>Vigor</th>
<th>Thorniness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autumn Bliss</td>
<td>mid</td>
<td>G MED VG</td>
<td>G VG vg VG</td>
<td>G VG VG VG VG H</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polana</td>
<td>early</td>
<td>EX MED EX F</td>
<td>F F G M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Autumn Britten</td>
<td>mid</td>
<td>VG L EX VG EX VG M M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caroline</td>
<td>late</td>
<td>EX L EX G VG VG VG H M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Joan J</td>
<td>mid</td>
<td>VG L EX VG VG VG M M thornless</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

F: fair; G: good; VG: very good; Ex: excellent; M: moderate/medium; H: high; L: large

Site Preparation, Layout and Planting

First rule of thumb if you are building a new high tunnel for a raspberry planting: build the tunnel the year before you intend to plant.

Site preparation is similar to planting field-grown raspberries. The usual recommendations for soil testing, ensuring adequate drainage, weed eradication and soil amendments should be followed.

Row orientation

Orienting the rows north/south will optimize light exposure. Row spacing depends on how vigorous the canes are expected to be.

Row spacing

For vigorous raspberries (black and red) spacing of 8-10 ft. between rows is recommended. For less vigorous red raspberry cultivars spacing between rows of 6-8 ft. is sufficient. Trials at Morris and Grand Rapids had a spacing of 8 feet, which was adequate for all varieties listed above.

Plant spacing

We have determined 18” to be ideal spacing for newly planted raspberries. Spacing is only significant in the first and second years, since canes will fill in the row in subsequent years and make original spacing irrelevant. In an Alexandria trial of Joan J at three spacings, 18” appeared to be the best choice for economy of initial planting and yields in the first and second years.

Total cumulative yield of plants spaced at 12” was virtually the same as plants spaced at 18”. The yield per plant however, was significantly less. In addition, the expense of the extra plants needed to achieve a 12” spacing would increase the initial cost of establishing the planting.

Plants spaced at 24” had a lower total yield than those at 18”. However, a calculation of yield per plant indicated virtually no difference. This means that the first and second year yields may be a bit lower due to fewer plants; however the savings in plant material to
establish the planting may be a good economic choice. In UM trials, 18” provided the perfect compromise between establishment costs and yield potential.

**Plants and Planting**
Tissue cultured, bare-root plants are the ideal choice for the high tunnel. Tissue culture ensures virus-free, more uniform plants. Sources for bare-root and tissue cultured plants can be found in the Resources section.

Raspberry plants should be transplanted as soon as the soil can be worked. In Minnesota this should be no later than early to mid-May. Follow standard guidelines for planting depth, watering in, etc.

Disturb the soil as little as possible to avoid turning up weed seeds. In the alleys between the plant rows, landscaping fabric provides a good barrier to weeds, and should be rolled out and pinned down right after planting. Within the rows, expect to hand-weed throughout the season.

**Drip Irrigation**
In the UM trials, drip irrigation was installed following the guidelines in the Irrigation section. Two drip lines were run down each row, straddling the plants.

**Maintenance**

**Trellis**
Construction of a trellis should begin before the plants are tall enough to need it. In UM high tunnel raspberry trials, we have used a fairly simple system of steel fencing stakes as uprights, half-lengths of fencing stakes as cross-pieces, and baling wire or twine to support the canes.

In the high tunnel, raspberry primocanes can grow in excess of 6 feet tall. Trellis stakes should be approximately 5 feet tall after being pounded into the ground. The top cross-piece should be at that level, and additional cross-pieces should be attached at 4’, 3’, and 2’. Attach baling twine to these cross-pieces to ensure canes will be supported evenly along their length. This reduces the pressure of the canes on the twine, and thus reduces incidence of twine cutting into the canes. The more rows of twine, the less likely canes will be damaged by it. As the canes grow, they may need a little training to stay within the trellis. Simply tuck the canes behind the highest twine they reach to prevent unruly rows and breakage.

This type of trellis was used in trials due to its simplicity, effectiveness, minimal labor requirement and low cost. Many other trellis styles could be effective in high tunnels as well.
Row Maintenance – Pruning & Thinning

Pruning at the end of the season is quite simple. All canes should be pruned to the ground and covered with a layer of straw to protect them from winter damage. High tunnel raspberry rows should be maintained at a width of 12”, and no more than 18”. This will promote taller canes, greater light penetration, higher yields and easier harvesting. As canes begin to emerge in spring, cut back any shoots that are growing outside the 12”-18” row.

Similarly, the rows require thinning to increase air circulation and light penetration, reduce disease incidence, and increase yields. The first canes to emerge will usually be the largest, and other smaller canes will fill in between those. Leave the largest canes and prune out the smaller canes, maintaining 6-8 canes per linear foot of row. Remember, the larger the cane diameter, the larger the fruit it will yield.

Temperature & Ventilation

Proper tunnel ventilation and temperature monitoring are necessary to ensure greatest plant growth and highest yield. This can be achieved with roll-up (or roll-down) sidewalls, end walls that can be opened, upper level vents, or a combination of the three. Thermostatically-controlled, automated sidewalls can be very helpful in maintaining proper tunnel temperature, reducing the time and labor required to manually raise and lower the sidewalls.
However, if an automated system is employed, it remains important to monitor tunnel temperature. A malfunction in the automated system could result in severely damaged plants. The temperature inside a closed high tunnel on a warm day can easily reach temperatures in the hundreds, which can severely damage plants and limit production. A single incidence of extremely high temperature in our 2008 trial caused severe dieback, stunted growth for the remainder of the season, and significantly reduced yield. The optimal temperature for raspberry plant growth is between 59 and 68°F.

The main purpose of a high tunnel for growing fall-bearing raspberries is to extend the season later into the year. Therefore the most important time to hold heat in the tunnel is in the fall when outdoor temperatures drop and threaten frost damage. For these reasons, it is unlikely to be beneficial to close the sidewalls in the spring as growth is just beginning, unless extreme cold and frost is forecast. If the tunnel is closed in the spring, the temperature inside the tunnel will, of course, increase which in turn will speed up growth. This may seem like a good idea, however if growth is advanced in the spring, the result is likely to be earlier fruit production (mid-August). This is undesirable considering the high heat inside a tunnel in August. Fruit held at high temperature has significantly reduced quality and shelf-life. If earlier growth and fruiting is desired, daily harvesting will likely be necessary to prevent heat-damaged fruit.

In Morris, MN trials, sidewalls are left open throughout the spring (day and night) unless extremely low temperature or frost is forecast. This practice allows for a normal rate of primocane growth throughout the early season. Start monitoring tunnel temperature around May 1 or when new growth is visible.

Pest Control

The environment inside the high tunnel is very different from the field, and more closely resembles that of a greenhouse. Consequently, the pest complex and pest control practices also differ.

**High Tunnel Raspberry Diseases**

A significant benefit of high tunnels for raspberry production is the elimination of most of the common raspberry diseases. Protecting the foliage and fruit from water goes a long way to preventing many diseases. Protection from wind and other environmental factors reduces stress on the plants, making them less prone to attack.

Powdery mildew is one disease that tends to be more common inside high tunnels than in the field, due to the increased humidity and reduced airflow. Infection is most likely to occur when the side walls are down. The lack of air flow and transpiration saturating the air can result in condensation forming on the foliage optimizing the likelihood of infection. Risk of infection is greater if plant density is high, as overlapping plant tissues can result in localized high humidity. The following practices will help prevent an outbreak of powdery mildew in high tunnel raspberries.

**Prevention**

- Proper tunnel ventilation
- Good air circulation within the row (achieved by proper pruning and thinning)
- Drip irrigation to keep water off the foliage
- Scouting for disease occurrence throughout the season
Control
- Prune and thin the row
- Remove any dead plant material or debris from the tunnel

In UM high tunnel raspberry trials, no other diseases have been encountered. However, other common raspberry diseases can potentially occur in high tunnels.

High Tunnel Raspberry Insect Pests

Four insect pests were encountered in University of Minnesota trials at Morris, Alexandria and Grand Rapids. Spider mites, whiteflies, raspberry sawfly and aphids caused minimal to moderate damage and were rather easily controlled. The most common insect pest throughout two growing seasons was the spider mite.

Weekly scouting with a 10x hand lens revealed spider mites. If high pressure water spray does not eliminate spider mites, there are numerous predatory insects that have proven successful in combating mites. In the Alexandria trial, two releases of 1000 Phytoseiulus persimilis, two weeks apart provided control for a single 80’ row in a 12’ x 90’ high tunnel.

A few details on *Phytoseiulus persimilis*
- Eats 5-20 mites or eggs per day.
- Must have mite prey or will disperse/starve
- Require high humidity to be effective (above 70%; best between 80-99%)
- Plants should be in contact for greatest effectiveness
- Best used where little or no spider mite damage can be tolerated.

Numerous other predatory insects are recommended for raspberry. Find information and sources in Resources.

General Insect Pest Prevention for High Tunnel Raspberries
- Keep area free of weeds
- Do not over-fertilize
- Keep plants well watered and vigorous
- Prune heavily infested plant material if possible before attempting control.
Economics

The following tables illustrate the estimated costs of establishing raspberries in one 30’ x 48’ high tunnel, potential income and return on investment. The figures in Table 1 are 2009 costs to construct and establish the high tunnel raspberry planting at the West Central Research and Outreach Center in Morris, MN and are to be used only as a guide, since many factors are dependent on the particular circumstances of each site. For example, choosing to manually raise and lower the sidewalls would contribute savings. Similarly, different styles of high tunnels will carry varying costs.

**Table 1.** Cost of construction and planting in a 30’ x 48’ high tunnel. Dollar amounts are from 2009.

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>FarmTek Growers Supply 30’ x 48’ High Tunnel</td>
<td>$2700.00</td>
</tr>
<tr>
<td>Hired labor to construct</td>
<td>$1778.00</td>
</tr>
<tr>
<td>Thermostatically controlled roll-up sides</td>
<td>$1600.00</td>
</tr>
<tr>
<td>Electrical</td>
<td>$1200.00</td>
</tr>
<tr>
<td>Wood materials with door</td>
<td>$800.00</td>
</tr>
<tr>
<td>Drip irrigation</td>
<td>$160.00</td>
</tr>
<tr>
<td>Cost of Plants (NUMBER OF PLANTS X COST OF PLANTS)</td>
<td>XXXXXX</td>
</tr>
<tr>
<td>Total Initial Costs</td>
<td>$8238.00</td>
</tr>
</tbody>
</table>

Table 2 illustrates the potential income from a 30’ x 48’ high tunnel in its first full production year, or year 2 of the planting. Yield is based on highest yields of ‘Autumn Britten’ in the WCROC high tunnel raspberry planting in 2010. Number of containers filled is calculated by weight, and the price per container is an average price asked at local MN farmer’s markets. The matrix in table 3 shows income based on various price points and a range of yields.

**Table 2.** Potential income from a 30’ x 48’ high tunnel raspberry planting in the second year (first full harvest year).

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>106.32 pounds/36 feet of linear row x 3 rows per 30’ x 48’ high tunnel</td>
<td>318.96</td>
</tr>
<tr>
<td>Number of 6oz. containers filled</td>
<td>850</td>
</tr>
<tr>
<td>Price per 6 oz. container</td>
<td>$4.50</td>
</tr>
<tr>
<td>Total per 30’ x 48’ high tunnel in the second year (first full harvest year)</td>
<td>$3825.00</td>
</tr>
</tbody>
</table>

**Table 3.** Potential return on investment from a 30’ x 48’ high tunnel raspberry planting.

<table>
<thead>
<tr>
<th>Year</th>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planting Year</td>
<td>1/3 of full harvest potential</td>
<td>$1275.00</td>
</tr>
<tr>
<td>Second Year</td>
<td>Full harvest</td>
<td>$3825.00</td>
</tr>
<tr>
<td>Third Year</td>
<td>Full harvest</td>
<td>$3825.00</td>
</tr>
<tr>
<td>Total income after third year</td>
<td></td>
<td>$8925.00</td>
</tr>
</tbody>
</table>
Yield and Cane Growth
Effect of spacing on ‘Joan J’ plant growth, yield and berry size. Trial at Berry Ridge Farm, Alexandria, MN.

**Primocane Height**
Joan J at three spacings
(inches)

**Cumulative Yield**
Joan J at three spacings
(pounds/36 feet of row)
Yield and Cane Growth
Trial of two cultivars, ‘Autumn Britten’ and ‘Caroline’ in a high tunnel and in the field. Morris, MN

Primocane Height
Two Varieties in Field and High Tunnel (inches)
Cumulative Yield
Two Varieties in Field and High Tunnel
(Pounds/36 linear feet of row)

Cumulative Yield
Two Varieties in Field and High Tunnel
(Pounds/36 linear feet of row)
In 2012, U of M researchers and Extension personnel began working in cooperation with growers in the Crookston, MN area to further study high tunnel fruit production. Three tunnels on grower-cooperator farms were planted with tree fruits including apple, cherry and plum. One tunnel was planted with a variety of small fruits: blueberry, honeyberry, strawberry, raspberry and blackberry. An additional tunnel has been built for planting in 2013 of high-risk tree fruits including peach, apricot and pear.

As of publication no data has been collected on these plantings; therefore no conclusions have been made on the success of these fruits in high tunnels. Information will be posted on our website, [http://hightunnels.cfans.umn.edu/](http://hightunnels.cfans.umn.edu/), when it becomes available.