

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 floricanne-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 WCROC, Alexandria and Grand Rapids, carefully-timed high pressure water sprays are effective for control early in the season. Biological controls were required for later season control.

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.

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 unpruned, 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.

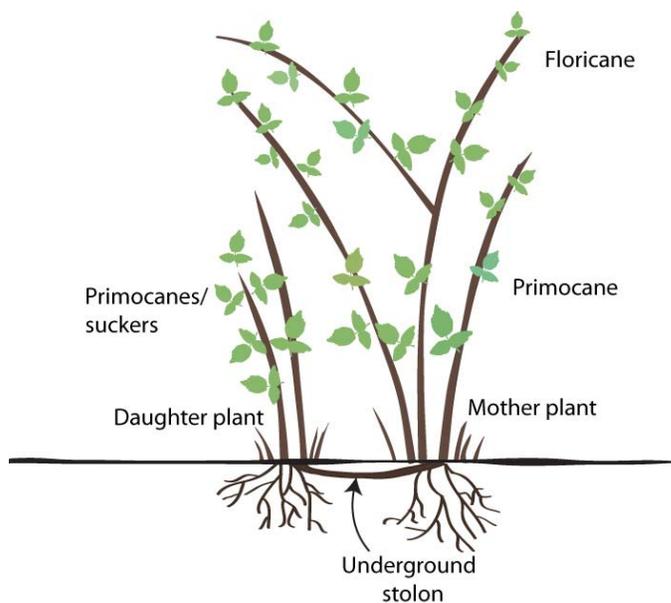


Figure 1. Parts of the raspberry plant (photo by Emily Tepe)

Table 1. Cultivar Selection – based on UM field variety trials

Variety	Harvest Season	Productivity	Fruit Size	Attractiveness	Firmness	Flavor	Freezing Quality	Vigor	Thorniness
Autumn Bliss	mid	G	MED	VG	G	VG	VG		H
Polana	early	EX	MED	EX	F	F	G		M
Autumn Britten	mid	VG	L	EX	VG	EX	VG	M	M
Caroline	late	EX	L	EX	G	VG	VG	H	M
Joan J	mid	VG	L	EX	VG	VG	VG	M	thornless

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

Source: <http://fruit.cfans.umn.edu/raspberry/varieties.htm>

Site Preparation, Layout and Planting

The 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. This will provide sufficient time to construct the tunnel, prepare the soil, and work out any problems that may arise with the new structure.

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. See the sections on Soil Fertility and Organic Soil Management in this manual.

Row orientation

Orienting the rows north/south will optimize light exposure.

Row spacing

Row spacing depends on how vigorous the canes are expected to be. 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. The planting at WCROC has 7-foot row spacing, which has been adequate for Autumn Britten and Caroline.

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 and watering in. 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.

Figure 2 illustrates this type of trellis, which is used in UM trials due to its simplicity, effectiveness, minimal labor requirement and low cost. Many other trellis styles could be effective in high tunnels as well.



Figure 2. Trellis system at WCROC high tunnel

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 or snow to protect them from winter damage. To achieve snow protection, leave side-walls open throughout the winter to allow snow to blow into the tunnel. In WCROC trials, a walk-behind snow blower has been used in years when wind did not blow sufficient amounts of snow into the tunnel.

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 primary purpose of a high tunnel for growing fall-bearing raspberries is to extend theseason later into the year and protect the plants and fruit from frost damage. Therefore the most important time to hold heat in the tunnel is in the fall when outdoor temperatures drop and threaten frost. Tunnel temperatures should be monitored throughout the season, and especially at this time to ensure full production.

Depending on production preferences and weather conditions, it may or may not be beneficial to regulate the sidewalls in the early season. In UM WCROC trials, sidewalls are lowered in the spring once growth is activated, to bring the tunnel temperature to 70°F. It is questionable whether this is beneficial, as advancing growth in the early season leads to early 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. It may be beneficial to leave sidewalls 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. Further research at WCROC will explore the effects of early-season temperature regulation.

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.



Figure 3. Spider mite damage on raspberry (photo by Emily Tepe)

Twice weekly scouting with a 10x hand lens is generally recommended for spider mites. A high-pressure water spray can be effective for eliminating spider mites in the early season. If this does not provide sufficient control, there are numerous predatory insects that have proven successful in combating mites. In UM trials, two releases of 1000 *Phytoseiulus persimilis*, two weeks apart provide control for a single 80' row in a 12' x 90' high tunnel. Numerous other predatory insects are recommended for raspberry.

For control of raspberry sawfly, horticultural oil sprays are effective at eliminating larvae in UM trials.

Find more information in the Insect Pest Management section of this manual.

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 and potential income. The figures in Table 2 are 2009 costs to construct and establish the high tunnel raspberry planting at WCROC and are to be used only as a guide, since many factors are dependent on the particular circumstances of each site.

FarmTek Growers Supply 30' x 48' High Tunnel	\$2700.00
Hired labor to construct	\$1778.00
Thermostatically controlled roll-up sides	\$1600.00
Electrical	\$1200.00
Wood materials with door	\$800.00
Drip irrigation	\$160.00
Cost of Plants (NUMBER OF PLANTS X COST OF PLANTS)	\$137.00
Total Initial Costs	\$8,375.00

Table 3 illustrates the potential income from a 30' x 48' high tunnel after two full production years. Yield is based on highest yields of 'Autumn Britten' (2009) and 'Caroline' (2010) in the UM-WCROC high tunnel raspberry planting in 2009 and 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 4 shows income based on various price points and a range of yields.

Year	2009		2010		Average 2009/2010	
	Caroline	Autumn Britten	Caroline	Autumn Britten	Caroline	Autumn Britten
Yield (lbs)	99	106	179	147	139	127
Number of 6oz containers filled	264	283	477	392	371	339
Price per 6oz container (\$)	\$5.00	\$5.00	\$5.00	\$5.00	\$5.00	\$5.00
Income per variety	\$1,320.00	\$1,415.00	\$2,385.00	\$1,960.00	\$1,855.00	\$1,695.00

Table 4. Potential income of various yields at various price points, calculated for 6oz. containers.

Yield (lbs)	Price per 6 oz. container			
	\$4.50	\$5.00	\$5.50	\$6.00
300	\$3,600.00	\$4,000.00	\$4,400.00	\$4,800.00
400	\$4,801.50	\$5,335.00	\$5,868.50	\$6,402.00
500	\$5,998.50	\$6,665.00	\$7,331.50	\$7,998.00
600	\$7,200.00	\$8,000.00	\$8,800.00	\$9,600.00
700	\$8,401.50	\$9,335.00	\$10,268.50	\$11,202.00
800	\$9,598.50	\$10,665.00	\$11,731.50	\$12,798.00

Yield and Cane Growth

Figure 4. Cumulative yield of two varieties in field and high tunnel (pounds/36 linear feet of row).

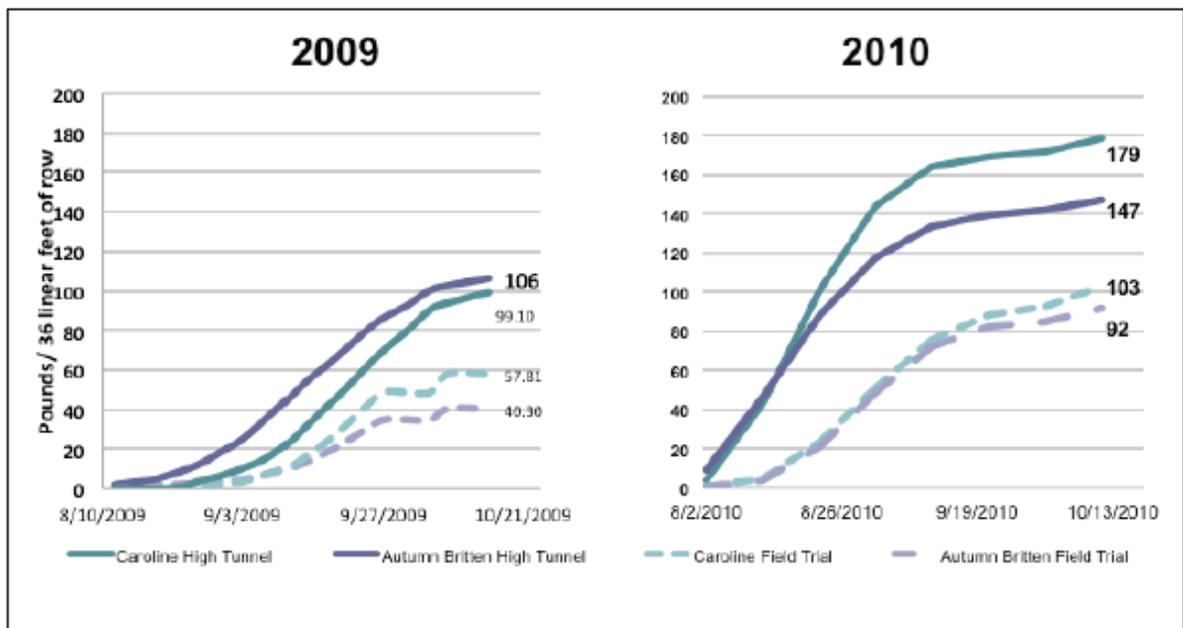


Figure 5. Comparison of cumulative yield of two varieties in field and high tunnel across two years (pounds/36 linear feet of row).

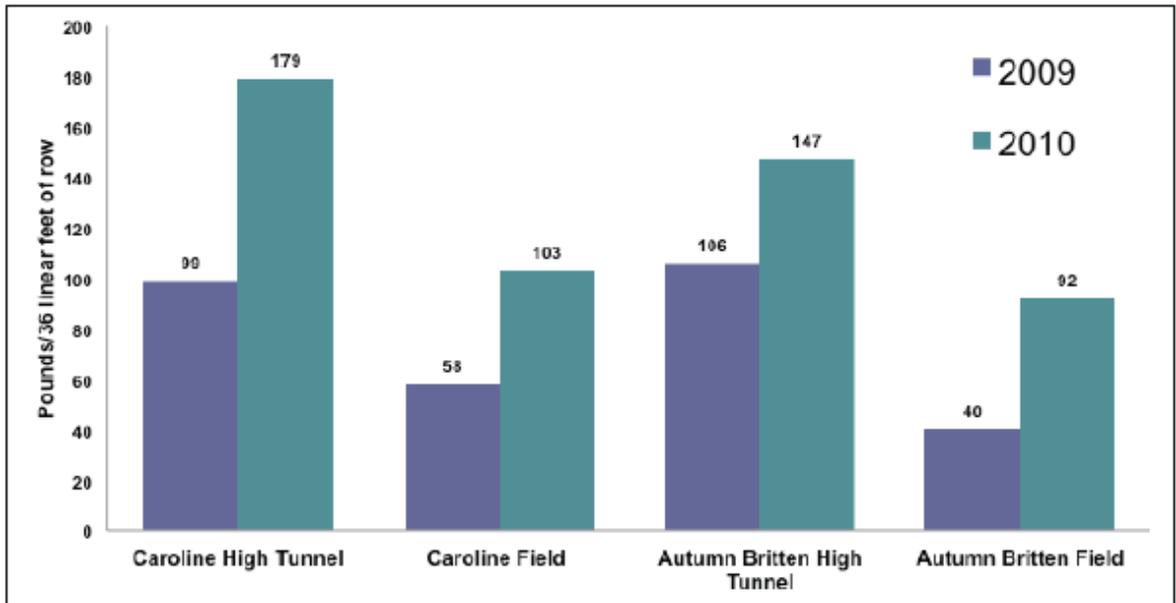


Figure 6. Primocane Heights - two varieties in field and high tunnel (inches).

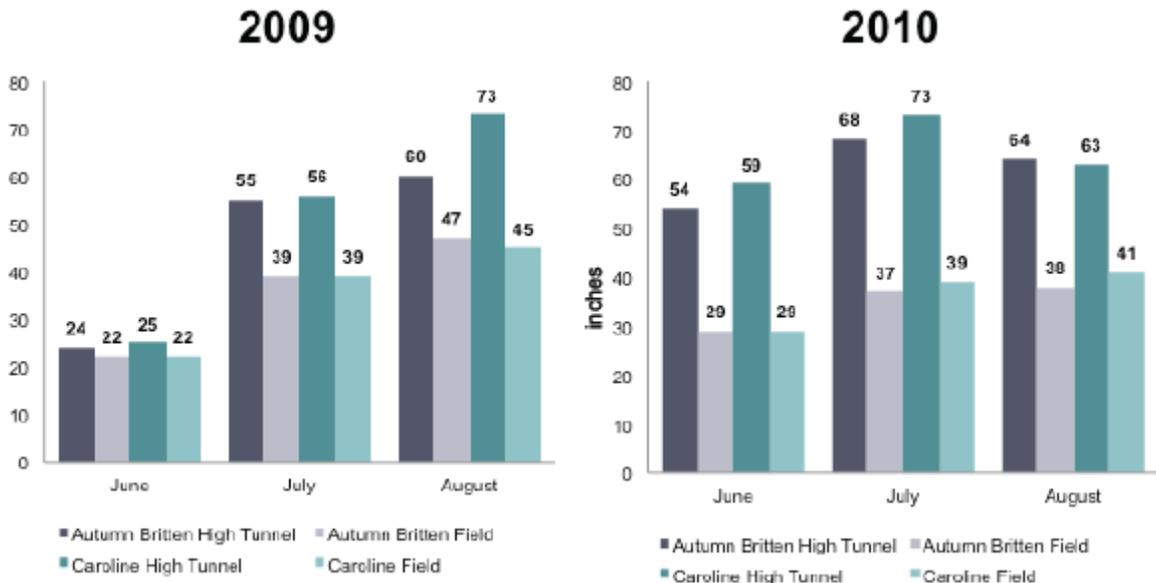


Figure 7. Individual berry weight - two varieties in field and high tunnel (ounces).

