Disease Scouting and Management

Diseases

The first step in minimizing disease problems is to start with disease-free plants from certified nursery stock. Tissue culture plants are one option since the plants are grown under sterile conditions. Dug canes are also used for faster fruit production, but the risk of introducing of pest problems increases since insects and diseases may be attached to the canes and/or small soil particles on the roots.

Botrytis Fruit Rot and Cane Blight (Gray Mold): *Botrytis cinerea*

Botrytis is a fungal pathogen that can affect not only the fruit, but also other parts of the plant including the flowers, laterals and the canes themselves. Botrytis can be identified by the appearance of fuzzy, gray mycelial growth on the fruit or other affected parts of the plant. The fungal infection tends to occur under conditions of high humidity and shaded conditions, and any physical damage to the fruit and/or plants will increase the risk of infection. Therefore, care should be taken when harvesting the fruit and moving plants in and out of the greenhouse to minimize physical damage to the canes.

Botrytis is especially damaging to harvested fruit that will be shipped or stored. Harvest fruit before it becomes overripe, store the fruit as soon as possible in a cooler around 2°C (34°F), and sell the fruit as quickly as possible. Fortunately, protected culture dramatically reduces gray mold on fruit, but can enhance

Botrytis cane blight.

Botrytis can be controlled by various management practices such as using wider plant spacings, thinning of excessive primocane growth, cleaning plant debris from the greenhouse, and maintaining an open canopy for good light penetration and air circulation. The use of drip irrigation minimizes the wetting of fruit and plant parts. If hand watering is practiced, water the containerized plants early in the day so the plants will have time to dry off before evening.

Powdery Mildew: *Sphaerotheca macularis*

Powdery mildew is a fungal pathogen that can infect raspberry plant leaves, fruit and shoot tips. Infected leaves have light green mottling or speckles on the upper surface, and white mycelial growth on the underside. Control of this pathogen is most effective with partially resistant cultivars such as Tulameen. Infected shoot tips can be covered by white mycelial growth and the shoots can become elongated, spindly and have smaller than normal leaves. Infected fruit will also be covered by the white mycelial growth. Infection can occur under warm and

dry conditions, so keeping the greenhouse temperatures below 24°C (75°F) and the humidity above 60% will be helpful. Keep the area clean of plant debris and maintain an open canopy for good air circulation. The use of inexpensive box fans on the greenhouse floor can aid in better air circulation. A sodium bicarbonate (baking soda) mixture has been shown to be somewhat effective in the control of small, isolated outbreaks of powdery mildew. An effective, commercially available product based on bicarbonates is Armicarb. Certain greenhouse growers use a sulfur vapor to manage powdery mildew. Elemental sulfur is placed in a small foil pie pan on a heating element over night to release the sulfur into the air as a vapor. When powdery mildew is a problem in greenhouses, a weekly application of sulfur vapor tends to keep the problem to a manageable level.

Phytophthora Root Rot: *Phytophthora fragariae* var. *rubi*
Phytophthora root rot is a disease that is more likely if using dug canes instead of tissue culture plants, as the pathogen may travel from the field into the greenhouse on infected root systems or soil particles. If purchasing dug canes, be sure they are certified. Also, check for the characteristic brick-red color of the cambium near the crown. Symptoms of root rot are sudden shriveling of healthy plants, followed by cane death. If the disease is encountered, discard all infected plants and sterilize all infected containers before reusing.

Crown and **Cane Gall**: *Agrobacterium tumefaciens* and *A. rubi*
Crown and cane galls are caused by a bacterium that causes galling in the crown of the plant's root system just below the soil surface or on the lower canes. This disease will only occur on dug canes where the disease was present in the field from where the plants originated. Severely galled plants are weakened, stunted, and unproductive. The abnormal proliferation of plant tissues that results in gall formation disrupts water and nutrient uptake and transport in the plant. No effective control measure for this disease exists, other than to discard the infected plants. Begin with disease-free tissue cultured plants grown in sterile, soil-less growing media and sterilized growing containers.

Fire Blight: *Erwinia amylovora*

Fire blight on raspberries is rare in the field, but it has been observed in the greenhouse. Fire blight is caused by a bacterium that infects many plants in the *Rosaceae* family, including raspberries. The common symptom of fire blight is a dark, scorched shepherd's crook at shoot tip. Fire blight is unlikely to be a serious threat to greenhouse production of raspberries, but the grower should watch for symptoms and remove infected cane tips. Sterilize pruners with a chlorine or alcohol solution after every cut as it is possible to transmit the disease by infected pruners. Fire blight has the potential to spread rapidly under warm, moist conditions.

Physiological Anomalies

There are certain physiological problems that may be encountered with growing any particular crop, either inside or outside of a greenhouse. Physiological anomalies may occur one year and not the next. It is not fully understood why these anomalies occur, but damage from them if they do occur is usually minimal. A couple of examples are provided.

Solar Damage: Solar damage can cause individual and/or groups of individual drupelets to turn white. Some varieties of raspberries are more susceptible to solar damage than others. This damage tends to occur under bright light and high temperature conditions. White washing the greenhouse, or using shade cloth in summer, significantly reduces injury.

Leaf Chlorosis: Leaf chlorosis is often caused by a nutrient imbalance, but in some cases a few leaves may show symptoms of a unique coloration while the rest of the plant and surrounding plants remain healthy looking. It is not clearly understood what the cause for this problem is, but the damage seems to be isolated and does not cause significant damage to the plant and/or harvest. If the problem spreads to the rest of the plant or surrounding plants, a sample should be immediately sent in for nutrient or disease testing analysis at the nearest diagnostic lab.

Marketing Greenhouse Raspberries

Greenhouse grown raspberries can be extremely large yet flavorful. Consumers and chefs have been willing to pay between $3.00 and $6.00 per half-pint for these superb quality fruits. How a grower intends to market their fruit, where their potential niche market is located, and how it will be advertised and serviced should be taken into account and planned out well in advance. A Cooperative Extension agent may be a good source of helpful marketing strategies.

Some marketing options include:
- Sell directly to supermarkets or co-ops
- Sell directly to chefs
- Sell at farmer's markets
- Sell alongside spring annual/perennial plant materials
- Sell to other farmers who market retail

Sell fruit in 4 to 6 oz. containers in order to preserve quality and obtain the highest possible price.

Budget Assumptions:

The following budget scenario is based on an example of growing raspberries in a 24 X 96 ft (7.32 X 29.25 m) greenhouse. Three hundred tissue culture plants were purchased for $1.20 each and planted one each in a 3 gal (13 L) container with a soilless growing media. The containers were spaced pot-to-pot, 100 containers per row with 6 ft (1.8 m) between rows. The building materials for the trellis support system were purchased at a local hardware supplier, and the irrigation materials were ordered from a greenhouse supply company. A total of 41 hours of labor at $8.00/hr were added to the start-up costs including planting the tissue culture plugs, setting up the containers and assembling the trellis and irrigation systems.

The production costs for the five month growing period in the greenhouse includes the total fertilization costs, the pest management supplies, two bumble bee hives for the pollination, and a greenhouse space charge of $0.10/ft^2 per month for five months. Harvesting costs include paying the picker $0.50 per half-pint piece work, and $0.10 for the cost of each half-pint container.

The yields and profitability are listed for three years (a total of four years including the planting year) realizing no yield in the planting year, 2 half-pints per plant in the first fruiting year, and 16 half-pints per plant the following years. Each half-pint of fruit received a price of $3.00.

Budget for Floricane-type raspberries
Grown from plugs in an unlighted 24 X 96 ft. greenhouse

I. Start-up costs			
Planting			$1,260
	300 plants	($1.20 per plant x 300 = $360)	
	300 pots (3 gallon)	($1.50 per pot x 300 = $450)	
	Pro-Mix	($1.50 per pot x 300 = $450)	
Trellis			$1,200
	Wood, screws, wires, ties		
Irrigation			$850
	Tubes, clamps, connectors		
Labor			$320
	Build trellises, planting (40 hrs)		
TOTAL			**$3,630**

II. Annual production costs (mid December - mid May)	**Year 1**	**Year 2+**
Start-up costs	$3,630	
Fertilizer per pot	$400	$400
Pest management (predators, stylet oil, sticky cards	$1200	$1200
Bee hives (2 @ $125 each)	$250	$250
Greenhouse costs $0.10 per sq. ft. per month, 5 months	$1150	$1150
Labor	$896	$1056
TOTAL	**$7, 526**	**$4,056**

Labor breakdown		**Year 1**	**Year 2**
Set-up outdoors		12 hrs	16 hrs
Move plants into house		8 hrs	8 hrs
Trellising	(8 hrs. twice)	16 hrs	16 hrs
Irrigation set-up	(8 hrs. twice)	16 hrs	16 hrs
Scout/Biocontrol	(2 hrs/wk)	40 hrs	40 hrs
Primocane management		8 hrs	24 hrs
Move plants outside		8 hrs	8 hrs
Remove trellis and irrigation		4 hrs	4 hrs
TOTAL		**112 hrs**	**132 hrs**

III. Harvest costs
$0.50 per half-pint piece work
$0.10 per half-pint for containers

IV. Yields and profitability
(Yields per plant: 2 half-pints {Year 1}, 16 half-pints {Year 2}; Price received: $3.00/half-pint)

			Expenses		
Year	Yield	Income	Harvesting	Production	Total Profit
Planting year	0	0	0	$7, 526	($7,526)
Year 1	600	$1,800	$360	$7,526	($2,616)
Year 2	4,800	$14,400	$2,880	$4,056	$7,464
Year 3	4,800	$14,400	$2,880	$4,056	$7,464
TOTAL	**10,200**	**$30,600**	**$6,120**	**$19,694**	**$4,786**

A few examples of independent growers growing greenhouse raspberries

Visit www.raspberryrich.com

This is what it's all about - smiles and happy customers!

Suggested Readings

- **Bramble Production Guide** NRAES-35
  (Pritts, M. P., Handley, D. 1989. (NRAES) Natural Resource, Agricultural & Engineering Service)
  Available for purchase at: <http://www.nraes.org/publications/nraes35.html>
- **Cornell Fruit Resources** <http://www.fruit.cornell.edu/berry.html>
- **Cornell Greenhouse Horticulture Resources**
  <http://www.hort.cornell.edu/greenhouse/cropcult/culture.html>
- **Compendium of Raspberry and Blackberry Diseases and Insects** (Ellis, M.A., Converse, R.H., Williams, R.N., and Williamson, B. 1991. The American Phytopathological Society)
  Available for purchase at <http://www.apsnet.org/>
- **High Tunnel Plasticulture Resources** from Penn State <http://plasticulture.cas.psu.edu/>
- **Water and Nutrient Management for Greenhouses** NRAES-56
  (Weiler, T. C., Sailus, M. 1996. (NRAES) Natural Resource, Agricultural & Engineering Service)
  Available for purchase at: <http://www.nraes.org/publications/nraes56.html>
- **Greenhouse Operation and Management**
  (Nelson, P. 2002. 6th edition. Prentice Hall College Div.)
  (Provides detailed instructions in layman's terms.) Available for purchase through your local and on-line book sellers.
- **The Ball Redbook**
  (Internet link for print resources for all aspects of greenhouse operations.)
  <http://www.ballpublishing.com/commerce/>
- **Small Fruit Crop Management**
  (G. Galletta and D. Himelrick, 1990) Prentice-Hall, Englewood Cliffs, N.J.

Sources for Biological Controls and Bumble Bees

- **Biotactics Inc**., 20780 Warren Road, Perris, California 92570.
  Phone: (909) 943-2819, FAX: (909) 943-8080, E-mail: sales@benemite.com
  <http://www.benemite.com>
- **Crop King**, 5050 Greenwich Road, Seville, OH 44273-9413
  Phone: (330) 769-2002, Fax: (330) 769-2616
  <http://www.cropking.com>
- **GB Systems**, P.O. Box 19497, Boulder, CO 80308 or P.O. Box 39063,
  N. Avon Belden Rd., North Ridgeville, OH 44039 (216) 353-9437
- **The Green Spot**, 93 Priest Rd., Nottingham, NH 03290 (603) 942-8925
  <http://www.greenmethods.com>
- **Hydrogardens**, P.O. Box 25845, Colorado Springs, CO 80936-5845
  Phone: (888) 693-0578, FAX (800) 694-6362
  <http://www.hydro-gardens.com>
- **IPM Laboratories**, P.O. Box 300, Locke, NY 13092 (315) 497-2063
  <http://www.ipmlabs.com>
- **Koppert Bio Systems**, 28465 Beverly Rd, Romulus, MI 48174 (800) 928-8827
  <http://www.koppert.nl/>

An electronic database of suppliers of beneficial organisms with information on IPM may be accessed through the California Department of Pesticide Regulation homepage at
<http://www.cdpr.ca.gov/docs/ipminov/bensuppl.htm>

Or request a written copy:
California Department of Pesticide Regulation
Environmental Monitoring and Pest Management Branch
1020 N. Street, Room 161
Sacramento, CA 95814-5604
(916) 445-4300

For another comprehensive listing of biocontrol suppliers and information visit this website: <http://www.anbp.org>. This is the site of The Association of Natural Biocontrol Producers (ANBP), a professional association representing the biological pest management industry. ANBP membership includes producers, distributors, and in addition, users of natural enemies and researchers.

Sources for Plant Material

- **Fruit, Berry and Nut Inventory** (2001. 3rd edition. Chelsea Green Publishing.)
- **Cornell's berry and small fruit nursery list**: http://www.hort.cornell.edu/nursery

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Dale, A., *Primocane-fruiting Raspberries Continue to Fruit Without Chilling in Greenhouses*. The All Ontario Berry Grower, Vol. #0.11 - November/2001.

Demchak, K. *High Tunnel Production of Primocane-Bearing Raspberries*. Penn State University. 2003. Electronic access:<http://www.fruit.cornell.edu/Berries/hightunnels.html>.

Pritts, M. P., *Raspberries in Winter: An Alternative Growing System for Northern States*. New York Fruit Quarterly, Vol. 6, No. 4. 2-4, 1999.

Pritts, M. P., *Winter Raspberry Production in a Greenhouse*. Fruit Notes, Vol. 65, 20-21, 2000.

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Pritts, M. P., W. Langhans, T. K. Whitlow, M. J. Kelly and A. Roberts. *Winter Raspberry Production in Greenhouses*. HortTechnology, Vol. 9 No. 1, 13-15, 1999.

Thomas, C. *Bug vs. Bug - Sources for Biological Controls and Bumblebees*. Integrated Pest Management Program Pennsylvania Dept. of Agriculture, 2003.

Glossary

Adventitious bud - A vegetative bud that develops along the root of a bramble plant and that will grow into a primocane.
Aggregate fruit – A type of fruit that develops from a single flower, but which consists of many smaller drupelets that fuse and ripen together.
Annual – A plant that completes its life cycle (vegetative growth, flower, and seed) in only one year.
Anthesis – The time at which a flower is at full bloom and the pollen is shed.
Apical meristem – A group of cells at the growing point of roots and shoots from which all vegetative or reproductive growth originates.
Axillary bud – A bud that develops in the axil of a leaf, the point where the leaf attaches to the shoot.
Biennial – A plant that requires two growing seasons to complete its life cycle; vegetative growth occurs the first year, reproductive growth the second year, and then the plant dies.
Certified plant stock – Plants from a nursery which have been visually inspected by a state representative and found to be free of virus and other disease symptoms.
Chlorosis – A yellow color that develops in a green leaf.
Crown bud – A vegetative bud originating from just below the base of a bramble plant and which will develop into a primocane.
Cultivar – A “cultivated variety”; an entity of commercial importance which is given a name to distinguish it from other genetically different plants.
Cultural control – The use of production practices to improve plant growth and yield to also control pests.
Cuticle – The waxy layer on the surface of a leaf or fruit.
Desiccation – The process of drying or losing water.
Differentiation – The physiological and morphological changes that occur in cells, tissues, or organs during development and maturation.
Drupelet – The small sections of a raspberry or blackberry fruit, each containing a seed.
Entomology – The study of insects.
Epidermis – The outside covering or skin of a leaf or fruit.
Evapotranspiration – The total water lost through evaporation from the soil surface and from transpiration through the plant.
Fall-fruiting – A raspberry which forms fruit on the tops of first-year vegetative canes near the end of the growing season; the same as primocane-fruiting.
Fertigation – The delivery of nutrients using an irrigation system.
Fibrous root – A type of root system characterized by many branches of fine roots.
Floricane – The second-year cane which overwintered and will fruit and die in the current year.
Floricane-fruiting – A raspberry or blackberry which forms fruit only on second-year canes in late spring or summer; the same as summer-fruiting.
Frass – Plant residues or fecal material that remains after insect feeding.
Hardiness – The ability of a plant to withstand cold temperatures.
Inflorescence – A flower cluster.
Instar – A stage in the development of an insect between molts.
Lateral roots – Roots that originate from the primary roots.
Leader bud – Buds at the base of a cane, often underground, which have the capacity to grow into a primocane.
Micronutrient – An essential plant nutrient that is required only in small quantities.
Necrosis – The death of plant cells.
Node – The point of attachment of buds or laterals to the main cane.
Ovary – The enlarged lower part of the pistil, enclosing the ovules or young seeds.
Oviposition – The laying of an egg by an insect.

Pathology – The study of diseases and the organisms which cause them.
Perennial – A plant or plant part which lives for more than one year.
Petiole – The stalk of a leaf.
pH – A measure of the acidity or alkalinity of the soil ranging from 0 to 14; a low pH indicates acid, a pH of 7 is neutral, and a high pH indicates alkaline.
Photosynthesis – The process in a plant of making sugars for growth and respiration from the raw products of water, carbon dioxide, and sunlight.
Phytotoxicity – The ability of a chemical substance to cause harm to a plant, often used to characterize the effect of an herbicide on crops.
Pistil – The female reproductive organ of a flower.
Pollination – The act of placing pollen from the male reproductive organ onto the female reproductive organ of a flower; often is carried out by bees or wind.
Primocane – The first-year cane of a raspberry or blackberry.
Primocane-fruiting – A type of raspberry which forms fruit on the tops of first-year canes near the end of the growing season; the same as fall-fruiting.
Receptacle – The portion of the flower to which the flower parts attach.
Respiration – The process of converting sugars into carbon dioxide, water, and energy. Often, the energy is in the form of heat.
Setae – Bristle-like parts or organs of an insect.
Shoot bud – A bud on the aboveground portion of a plant.
Stamen – The male part of a flower; it produces pollen.
Stigma – The female portion of a flower upon which the pollen germinates.
Stomata – Pores on the bottom of a leaf through which carbon dioxide enters the plant and water vapor exits.
Sucker shoot – A young, vegetative cane originating from an adventitious bud on the root.
Summer-fruiting – A raspberry or blackberry which forms fruit only on second-year canes in late spring or summer; the same as floricane-fruiting.
Threshold – A predetermined level below which no response occurs.
Tipping – The process of removing the tops of primocanes for the purpose of stimulating lateral branching; sometimes called pinching.
Tissue culture – A method of propagation in which whole plants are obtained from meristematic tissue in indoor facilities.
Topping – The removal of the top portion of cane after it has overwintered.
Torus – The center of a fruit to which the drupelets attach, also called the receptacle.
Transpiration – The process of water exiting the plant through the stomata.

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