Cultivating red raspberries in Eastern Canada

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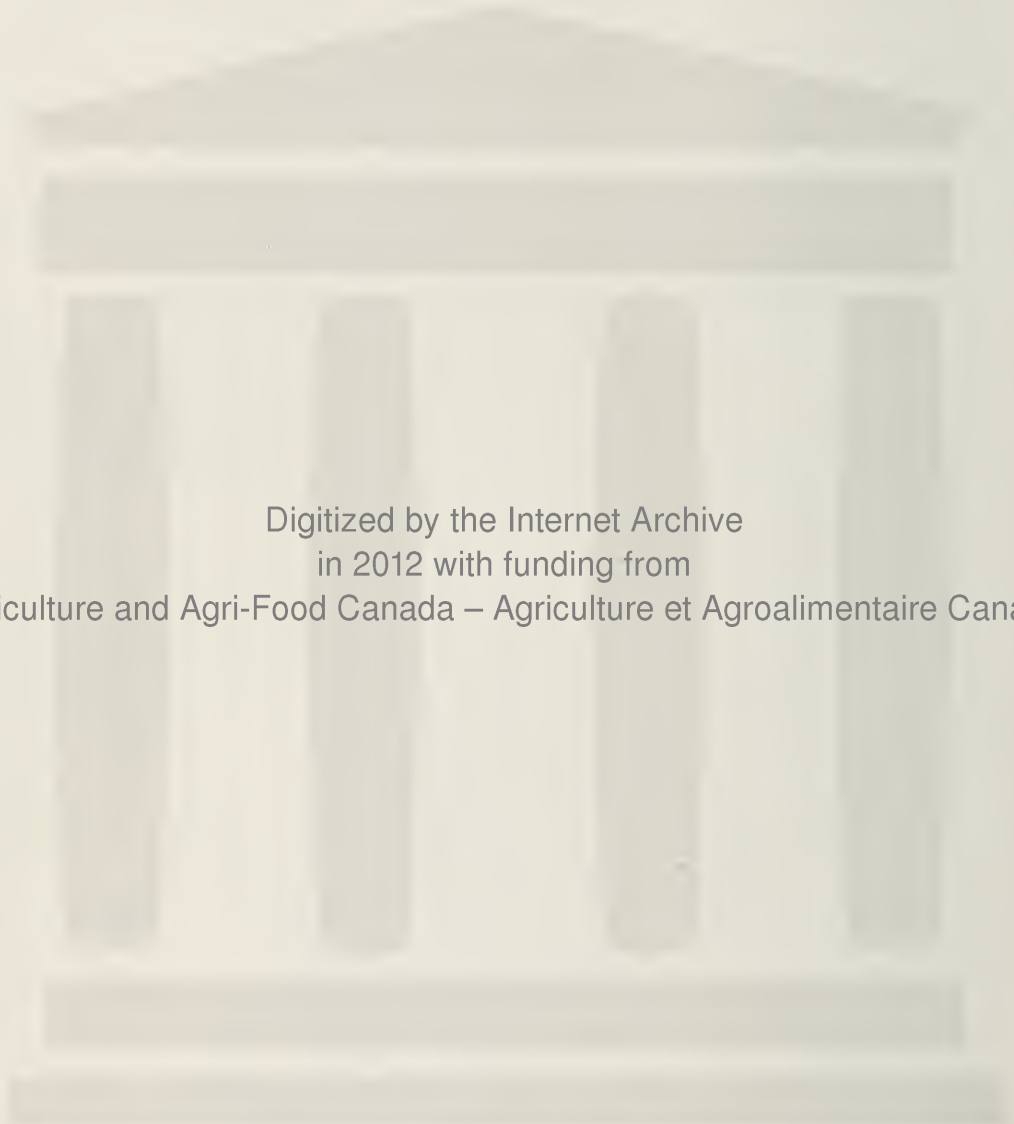

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This publication replaces Agriculture Canada Publications 1196, *Growing red raspberries in Eastern Canada* and 1447, *Red raspberry cultivars for Eastern Canada.*

CONTENTS

CONVERSION FACTORS

Metric units	Approximate conversion factors	Results in:
LINEAR		
millimetre (mm)	x 0.04	inch
centimetre (cm)	x 0.39	inch
metre (m)	x 3.28	feet
kilometre (km)	x 0.62	mile
AREA		
square centimetre (cm^2)	x 0.15	square inch
square metre (m^2)	x 1.2	square yard
square kilometre (km^2)	x 0.39	square mile
hectare (ha)	x 2.5	acres
VOLUME		
cubic centimetre (cm^3)	x 0.06	cubic inch
cubic metre (m^3)	x 35.31	cubic feet
	x 1.31	cubic yard
CAPACITY		
litre (L)	x 0.035	cubic feet
hectolitre (hL)	x 22	gallons
	x 2.5	bushels
WEIGHT		
gram (g)	x 0.04	oz avdp
kilogram (kg)	x 2.2	lb avdp
tonne (t)	x 1.1	short ton
AGRICULTURAL		
litres per hectare (L/ha)	x 0.089	gallons per acre
	x 0.357	quarts per acre
	x 0.71	pints per acre
millilitres per hectare (mL/ha)	x 0.014	fl. oz per acre
tonnes per hectare (t/ha)	x 0.45	tons per acre
kilograms per hectare (kg/ha)	x 0.89	lb per acre
grams per hectare (g/ha)	x 0.014	oz avdp per acre
plants per hectare (plants/ha)	x 0.405	plants per acre

CULTURE

This publication has been prepared to assist commercial growers in Eastern Canada with the production of red raspberries. It is not possible to give detailed cultural instructions that apply to all situations. General practices are given and growers must decide how to adapt this information to their own conditions. When there is doubt about the suitability of the site, some cultural practice, or the value of a variety, it is best to proceed on a small scale and learn by experience.

Specific recommendations are not given for the control of insects, diseases, and weeds, or for fertilizers because this information is continually being updated. For current information, consult your provincial agricultural office.

Selecting the site

When selecting the site for planting keep in mind the soil, surface water drainage, air drainage, moisture supply, exposure, and previous crops.

Soil

A good soil is important. Deep, sandy loam soils well supplied with humus are ideal. They are well drained yet hold moisture, which is essential for high yields. Avoid coarse and gravelly soils because they need more plant food and water to support a raspberry crop. Also avoid soils with a high clay content for they are usually poorly drained and difficult to manage. Good drainage of soil water is essential because raspberry roots will not grow well in a wet soil.

Drainage

For good air and water drainage, choose a site with a slope. A slight slope is preferred, but with contour planting even steep slopes can be used.

Because cold air drains into low areas, raspberries planted on a slope are less likely to be damaged by frost than those at the bottom. Good air drainage also helps to control fungus diseases of the canes and fruit, which flourish in warm humid air.

Raspberry roots may be severely injured if they are submerged in water for more than 24 hours. This is another good reason for choosing a slope. If a slope is not available, improve the interior drainage of the soil by using tiles or ditches. Do not use wet land for red raspberries.

Erosion

Soil erosion can be a serious problem in plantings where the rows run up and down the slope. If the degree of the slope assists erosion, orient the rows across the slope.

Soil moisture supply and water for irrigation

Because new canes develop and the crop ripens in midsummer when moisture is often deficient, take steps to ensure an adequate supply of soil moisture. If the organic matter content of the soil is low, before planting apply large amounts of manure or grow and plow in one or more green-manure crops. Irrigation is generally necessary for maximum yields. Nearness to a good supply of irrigation water is a necessary requirement of a good site.

Exposure

Red raspberry canes must be protected by windbreaks. Plantings in wind-swept areas do not grow well during the summer, and in the winter they suffer because the cold winds dry out the canes and kill them under extreme conditions.

Southern slopes are ideal for early cropping, but plants on them are more likely to be damaged in winter because of repeated thawing and freezing. A northern slope usually provides a better supply of moisture in the summer than a southern one, but fruiting is a few days later.

Previous crops

Do not plant raspberries in soils that grew tomatoes, peppers, eggplants, or potatoes in any of the previous 4 or 5 years. There is the risk that the disease verticillium wilt will become a problem when plantings follow these crops.

Preparing the soil

A raspberry planting in well-prepared soil should produce fruit for 8–10 years. Organic matter plowed into the soil is really its life blood. It provides plant food, improves the physical properties of the soil, promotes the growth of helpful soil organisms, and increases the water-holding capacity of the soil. To prepare the soil before planting raspberries, plant a row crop, followed by a green-manure crop such as rye (125 kg/ha), buckwheat (70–80 kg/ha), oats (95–115 kg/ha), or millet (28 kg/ha). Fertilize the green-manure crop well to obtain maximum growth to increase the soil humus content.

Barnyard manure (35–45 t/ha) is another way to improve the organic matter content of soil. Lesser amounts of poultry manure (10–20 t/ha) can also be used in the fall. Raspberry roots in contact with fresh poultry manure will be severely injured.

If the soil is acid, use agricultural limestone prior to planting to bring the soil up to a pH level of 5.7–6.0.

Growing a hoed crop just before planting raspberries helps to condition the soil and kill weeds. Weeds, particularly quack grass, must be eliminated before planting. Eradicate quack grass by summerfallowing, or by using a suitable chemical along with summerfallow.

Use of fertilizer and response

Poor plant growth does not always indicate lack of soil fertility. Root disease such as crown gall, insufficient moisture, and poor soil drainage can also result in poor growth. Soils should be tested to find out the kinds and amounts of fertilizer required. Different soils require different kinds and amounts of fertilizer for the production of maximum yields.

In most of the world's raspberry production areas it is generally acknowledged that applications of nitrogen bring about the greatest growth response. However, nitrogen must be used with caution because if there is an excess in the soil late in the season it will stimulate late growth, which is subject to winter injury. As a general rule, nitrogen at 70 kg/ha as supplied by 45% urea at 150 kg/ha or ammonium nitrate at 200 kg/ha is all that is required in any given season. Most soils in Eastern Canada that are suitable for red raspberry production should

contain a sufficient supply of the essential elements for growth, but this should be confirmed by a soil test. If the organic matter content of the soil is maintained at a high level with manure and green-manure crops, little commercial fertilizer will be needed.

Planting

Time of planting

Planting in early spring is recommended for most areas in Atlantic Canada. Because growers in Ontario and Quebec have a longer growing season than the more eastern provinces, they favor fall planting. This gives them more time to prepare the soil and they can secure freshly dug plants, which when fall planted are ready to grow as soon as conditions in the spring are favorable. Spring planting must be done early to give the plants the maximum time to become well established during the first growing season.

Planting stock

Plant certified stock. It is a waste of money to use noncertified plants, which may be partially or completely virus infected, or be infected with crown gall or one of the several cane diseases.

Several nursery operators in Eastern Canada specialize in growing certified raspberry plants from virus-indexed stock. They cooperate with the provincial and federal departments of agriculture in the production of healthy stock. There is no guarantee that this stock is completely free from virus or other diseases. It is, however, the best stock available. Regulations controlling the growth of certified raspberry plants in Eastern Canada are as strict as those in any other area in Canada or the United States.

Type of plant

Use strong suckers that have completed one season of growth and are dormant at the time of planting. This type of plant can be shipped long distances and is suitable for either spring or fall planting. Young growing suckers that develop early in the growing season can also be used. Irrigation is necessary for these young succulent plants if the weather becomes warm and dry.

Space between plants

For machine cultivation in a commercial planting, have the rows at least 3 m apart. Space the plants 60 cm apart within the row. At these spacings, you need 5382 plants per hectare.

Setting the plants

Measure the distance between rows and mark with stakes. A tractor-drawn marker may also be used. Use several stakes in the row as guides and plow a furrow 13–15 cm deep. It is not necessary to mark the distance between plants in the row. Set the plants against the side of the furrow and slightly deeper than they were previously grown. Cover the roots with soil, firm it with your feet, and then plow back the rest of the soil. Keep the plants from exposure to the sun and wind to prevent them from becoming dry during the planting operation. When planting is complete, cut the canes back to ground level in order to stimulate maximum shoot

Fig. 1. (*a*) Dormant year-old red raspberry sucker; (*b*) dormant sucker pruned for planting.

Fig. 2. Spread the roots out when planting.

production from the root system. If the plants arrive before the field is ready either hold them in a cold storage or plant them outdoors in a shallow trench and placed in a vertical position with the roots spread out and covered with soil to prevent drying.

Care of the planting

The yield and quality of the crop depend largely on the care, growth, and development made during the growing season. Therefore, it is important to pay special attention to cultural operations such as cultivation, irrigation, pruning, and the control of insects, diseases, and weeds.

Weed control and cultivation

Chemicals are available (see the most recent edition of Publ. 75 *Guide to chemical weed control*; and Agdex 230/605, Conseil des productions végétales du

Québec)* for the control of most weeds and if properly used will greatly reduce the amount of hoeing required within the row. The area between rows can be kept free from weeds and raspberry suckers with chemicals or by shallow cultivation. Avoid deep cultivation near the row, because raspberry roots grow near the soil surface. The upper 25 cm of soil can contain 70% of the root system, which consists of many fibrous and small-diameter roots. Therefore, cultivation depth between rows should not exceed 5 cm; discing or rototilling are the most common methods of cultivation. Commence cultivation early in the spring and discontinue it just after harvest to enable the new canes to mature before the arrival of cold weather.

Cover crops

After the final cultivation, it is best to sow a cover crop such as oats, barley, buckwheat, or Italian rye grass. All these crops except rye grass die before spring. Because it remains alive in winter, rye grass is the most useful cover crop for slopes that have a tendency to erode. Work the rye grass into the soil early in the spring or it will become a weed problem. Also, avoid seeding rye grass directly in the row where it acts as a weed. If properly sown between the rows the management of rye grass is simple.

Mulching

Mulching conserves soil moisture, reduces soil temperature, helps to control weeds, and prevents erosion. However, for most growers the cost of the mulch and the expense of applying it are too great. Weed-free material is difficult to obtain, the mulch becomes a fire hazard, and it may increase the susceptibility of the plants to fungus diseases. It may also stimulate late growth and thus keep the canes from maturing properly. The most satisfactory alternative to a mulch is irrigation equipment, a good supply of water, and a chemical weed control program.

Sawdust, wood chips, and straw are suitable for mulching. Apply a layer about 10–15 cm deep. Nitrogen must be added to the soil to replace that used by the organisms that break down the mulch. Apply ammonium nitrate, or its equivalent, at 25 kg/t of mulch material.

Time to mulch

The time of mulching is important. The new planting should have a season's growth before the mulch is applied, otherwise the new shoots will be unable to establish themselves.

Apply the mulch either in the fall or in the spring, when the soil is wet. If you apply it when the soil is dry, the plants may not benefit from showers; it takes a great amount of moisture to penetrate 15 cm of dry material.

Sod culture

Sod culture can be used between the rows. Sod provides a clean walking area for pick-your-own customers and eliminates the need for cover crops.

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*Publ. 75, *Guide to chemical weed control*, is prepared by members of the Ontario Herbicide Committee and approved by Atlantic Provinces Herbicide Committee. Published by Information Branch, Ontario Ministry of Agriculture & Food, Parliament Buildings, Toronto. Agdex 230/605, Conseil des productions végétales du Québec, is published by Agriculture Québec.

Keep the sod closely mowed until after harvest, then let it grow to help harden the canes for winter. During summer dry periods, additional irrigation is needed because the sod competes with the raspberries for water. To establish the sod, seed creeping red fescue or Kentucky bluegrass at 10 kg/ha.

Irrigation

Irrigation is essential for consistent high production of raspberries. Insufficient soil moisture is one of the main factors limiting high production. There are few years when irrigation would not be beneficial. Purchasing an irrigation system for use only on raspberries would not be a sound investment for growers with small plantings. However, if plantings are sufficiently large, or other crops that would benefit from irrigation are grown, then a system should be considered.

A plentiful supply of water is necessary for the growth of robust shoots early in the growing season and also to maintain good fruit size during the harvest period. Irrigation must be started before plants show wilting. The amount of water required by raspberries varies with the weather, plant stand, and plant vigor. However, the maximum or peak moisture-use rate is considered to be about 0.5 cm/day. This peak moisture-use rate can be of considerable value as an irrigation guide when moisture-storage capacity of the soil is known.

Raspberries obtain practically all their moisture from the top 60 cm of soil. Soils vary in the amount of water that they can hold here. For example, well-drained sandy soils may hold only 5 cm, whereas loams may hold up to 10 cm. It is best to start irrigation when 50% of the available moisture in the soil has been used. It can readily be seen that with peak moisture-use rates, this situation would generally occur in 5–10 days, depending on the soil type.

The feel of the soil when squeezed into a ball in the hand can also be a useful irrigation guide (see Table 1). Take the soil sample from the depth of maximum rooting (15–25 cm). If the soil does not hold together in a firm ball when squeezed, the moisture content has dropped to a level where irrigation should be started. A ball that is sticky when squeezed contains enough moisture. Instruments for measuring soil moisture are also available and an investment in a good instrument is well justified for larger plantings.

In considering how much water to apply, it is generally advisable to use enough to bring the available moisture in the top 60 cm of soil back to 100%. Irrigation equipment is only about 75% efficient, so about 3.38 cm of water would need to be discharged from the sprinklers to supply 2.5 cm of available soil moisture. Water should not be applied at a rate faster than it can be absorbed by the soil.

Excessive irrigation should be avoided because it is wasteful and sometimes harmful. It can result in soft fruit, which does not handle or ship well. It leaches nutrients, especially nitrogen, below the root zone. Also, excessive soil moisture hinders aeration, normal root growth, and development.

As a rough guide, raspberries require 2.5–3.8 cm of water per week, from either rain or irrigation, from bloom time until the end of harvest. Irrigation may be required in August if dry weather occurs, but generally it is not desirable to irrigate in late summer and fall so that canes can harden off for the winter.

The use of fairly tall risers to place the sprinkler heads above the raspberry plants is advisable. This permits more uniform coverage than is obtained from

sprinklers on low risers. Also, with high risers, there is little risk of injury to berries and foliage from water being discharged from the nozzles.

The value of trickle irrigation for applying water to raspberries through a plastic hose is currently under investigation. This system appears to be well adapted to both small and large plantings. One of the obvious advantages is the avoidance of wetting all the foliage and the fruit. Wet foliage and fruit are more susceptible to infection by fungus diseases.

If irrigation is used, cultural practices need revision. For example, more fertilizer may be required and less pruning is necessary, particularly heading back of canes. If irrigation is not accompanied by adequate disease control measures, diseases such as anthracnose, spur blight, and mildew may be more prevalent. If irrigation is to be used, good drainage is essential. Good soil-management practices should not be neglected even though irrigation is available.

Table 1. Guide for estimating moisture content of soil

Percentage of available soil water remaining	Loamy sand, sandy loam	Silty loam, loam	Silty clay loam, clay loam
0–25	Dry, loose, flows through fingers.	Powdery, sometimes crusted but easily broken down into a powdery condition.	Hard, cracked; difficult to break down to powdery condition.
25–50	Appears to be dry, will not form a ball with pressure.	Somewhat crumbly, but holds together with pressure.	Somewhat pliable, forms a ball under pressure.
50–75	Tends to form a ball under pressure, but breaks easily when bounced in hand.	Forms a ball, somewhat plastic, sticks slightly with pressure.	Forms a ball, ribbons out between thumb and forefinger, has a slick feeling.
75–100	Forms a weak ball, usually breaks when bounced in hand, will not slick.	Forms a very pliable ball, slicks readily.	Easily ribbons out between thumb and forefinger, has a slick feeling.
Field capacity 100	Upon squeezing no free water appears on the surface, but wet outline is left on hand.	Same as sandy loam.	Same as sandy loam.
Saturation	Free water appears on soil when squeezed.	Same as sandy loam.	Same as sandy loam.

Training

Systems of training

The most common system of training in Eastern Canada is the hedgerow, in which the plants are set 60 cm apart in rows 3 m apart. The plants form a solid row that is kept to a width of 35–45 cm. Each spring the canes within the row are thinned to about 15 cm apart or about six canes per 30 cm of row.

The hill system is a modification of the hedgerow that allows better control of weeds, diseases, and insects. The planting distances are the same, but the suckers are not allowed to fill the row. Only five to eight suckers are kept at each planting point.

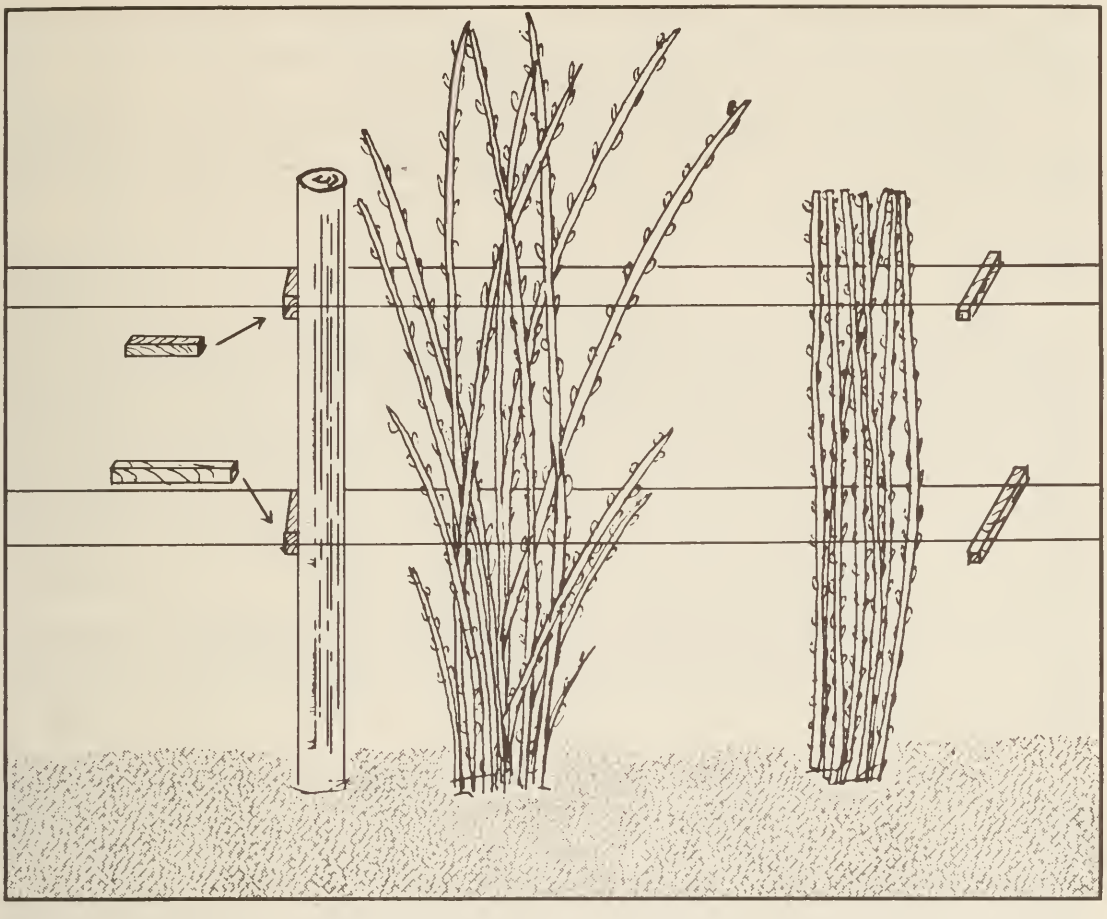

Fig. 3. Pruning and support for the hill system of growing red raspberries.

It is necessary to control suckers because they compete with the fruiting canes for moisture and nutrients. Removing suckers from between hills can increase yields by as much as 20%. It is equally important to keep hedgerows narrow because of sucker–fruiting cane competition.

In developing either the hill or the hedgerow system, select the earliest suckers because they are the ones that produce the largest crop the next year. Remove all other suckers with a hoe or pull them out by hand.

Supports for canes

Most varieties of red raspberries require support to prevent cane breakage and to make harvesting easier. Place posts 9 m apart in the row (400 posts per hectare). There are many training systems using various combinations of galvanized wire. The spread trellis system is one of these. It involves a 5 × 10 cm crossarm securely fastened to the post 1.2 m from ground level. The crossarm is 60 cm long and centered on the post. Two 10-gauge wires are stretched between the tops of the crossarms and fastened at each end of the crossarm by means of a staple. A second set of light wires (14-gauge) is also stretched between the crossarms near to and on either side of the post. Just before fruiting, the light wires are moved out to the ends of the crossarms taking one-half of the fruiting canes to each side. The 14-gauge wire is attached to the 10-gauge wire by means of staples. Moving the fruiting canes to the outside of the row gives the new canes freedom of growth in the center

of the row. Do not move the fruiting canes out before flowering takes place. If the canes are moved early in the growing season the fruiting laterals tend to grow back to the center of the row, making harvesting difficult.

There are approximately 3160 m of row per hectare if rows are 3 m apart. If the two-wire system is used, the required supply of 10- and 14-gauge wire will be 400 kg/ha and 160 kg/ha, respectively.

Pruning

The red raspberry root system is perennial. Each year it sends up new shoots that are biennial. These shoots complete their growth the first season, bear fruit the next summer, and then die. New shoots arise from the base of old canes and from buds on the roots. Some cultivars will bloom and form fruit at the tops of the new canes during the fall. This behavior seems to be partly genetic, but it occurs more frequently when the new canes stop growing early as a result of stress, such as lack of moisture. The true first-year fruiting cultivars start producing flowers during the summer in the buds of actively growing first-year canes.

Pruning consists of removing old fruiting canes, thinning out weak, damaged, or excess 1-year canes, and topping.

Thinning canes

It is good practice to remove the old canes as soon as the last fruit is harvested. They are of no benefit to the new developing canes. Their removal helps to control cane diseases by improving the air circulation and by getting rid of a possible source of infection.

If your plantation is in hedgerows, do not thin out the new fruiting canes until spring. Then before growth commences, remove all weak and diseased canes and those that have been damaged during the winter. If the hill system is used it will also be necessary to tidy up early in the spring while the canes are still dormant. The number of canes to leave in either system of training is dictated by the vigor of the planting and not by a set numerical count. Vigorous plantings can support more canes than plantings having moderate or poor vigor. Thin the canes on the basis of cane quality. Canes that are removed can be left between rows and incorporated in the soil. They will increase the soil organic matter without increasing disease or insect problems.

Heading back shoots and canes

The red raspberry has the capacity to produce fruiting laterals from approximately 70% of the buds on the cane. Laterals developed from the top 30 cm of the cane are shorter and weaker than those in the mid-cane area. Tipping will improve production by stimulating development of the lower, more productive buds. Removal of excess fruiting canes will permit the remaining canes to produce longer and more productive laterals. Because very vigorous canes have fewer nodes in the mid and lower portions of the cane, medium-sized canes with short internodes are preferred.

Pinching off the tops of young red raspberry shoots in the summer to promote growth of side branches is not recommended. No particular advantages result and the laterals produced are more susceptible to winter injury than are unbranched canes.

Heading back of canes should be done in the spring. It is best to delay this until the extent of winter injury can be determined. Ideally, all canes in a row do not require heading back to the same height because vigorous canes can be left longer than weaker ones. However, to reduce labor costs, heading back can be done by mechanical mowing at one height.

Cane height varies with the variety and growing conditions. Canes over 1.5 m should be cut back to bring them down to a convenient height for picking, to prevent excessive bending over of canes with the weight of the crop, and to increase berry size by reducing the number of berries produced per cane.

Because heading back removes part of the potential crop, severe heading back should not be done, for the loss of crop will not be offset by increased berry size. As a guide, a height of 1.4–1.5 m has been satisfactory when irrigation is practiced. A somewhat shorter height may be required when irrigation is not available.

Pollination

Most commercial red raspberry cultivars are self-fruitful but require insects to provide adequate pollination. The failure of a large portion of the ovules to set produces a berry that crumbles when picked.

Harvesting and handling

Picking

It is important that labor be available and engaged before the harvest period. Fifteen to 20 pickers per hectare are required. The exact number will depend on the experience of the pickers and the size of the crop. Berries for the fresh market must be picked every second day. Pick when the berries are firm but well colored and mature enough to come away readily from the receptacle (core). Pick directly into the containers that are to be marketed. Pint boxes are generally used for the fresh market trade. Grading after harvesting is impossible because the berries are susceptible to breaking, bruising, and crushing. Instruct the pickers to pick all the ripe berries. Berries not picked when they are ripe will be too ripe by the next picking.

When harvesting, use a carrier that holds the master container with its pint boxes. This leaves both hands free for harvesting. Pull gently on the ripe berries with the thumb and forefinger; cup a few berries at a time in the hand, and then carefully place them in the container. When the boxes are properly filled, take them promptly to the field shelter where they are prepared for market. The shelter provides shade for the harvested berries until they can be taken to cold storage. The use of shallow trays without boxes is satisfactory for processing berries.

Mechanical harvesting

Over-the-row mechanical harvesters have been developed in recent years and are in use on the Pacific coast for harvesting raspberries for processing. These harvesters are expensive and can only be justified for large-scale plantings. Mechanical harvesting is a rapidly developing field, and growers should keep up-to-date on this and other methods of harvesting through their nearest agricultural office.

Fig. 4. A convenient picking tray for red raspberries.

Precooling, storage, and shipping

Raspberries deteriorate rapidly at warm temperatures because of chemical changes and fungus diseases such as gray mold. Rapid cooling to approximately 4°C is essential for slowing down these changes. Proper cooling can extend the shelf life of the fruit by 1 or 2 days.

Stacking the fruit in a refrigerated room is not satisfactory. Berries entering the cooler contain field heat and produce heat due to respiration. Berries in the center of a stack may take up to 36 hours to lose 5–10°C of temperature. Cool the berries by placing them in a wind tunnel or other means of air circulation. A forced airflow around and through the containers is necessary. The system must be large enough to cool the berries to the desired temperature in 2–6 hours. Raspberries can be kept in storage in good condition for a few days at a temperature of 0–4°C and at a relative humidity between 85% and 90%.

Raspberries must be precooled and kept cool during transit to market and in the retail outlet. In fact, they should be kept cool from the time of harvest to the time of eating.

Pick-your-own operation

Pick-your-own is a special method of selling produce that means farm-fresh, high-quality raspberries at lower prices to the consumer. The raspberries are sold directly to customers who pick their own fruit.

Advantages for the grower:

- The need for seasonal labor is reduced.
- Leisure time is increasing, and pick-your-own takes advantage of the largest labor force available in the area.
- Packing and storing are eliminated.
- Many customers provide their own boxes or they will accept less expensive containers than wholesale shipment requires.
- The money comes in as soon as the crop is harvested, with no risk in price changes and no commission to be paid.
- Impulse buying is at a maximum.

Advantages for the customer:

- It affords an opportunity to buy fully ripened, farm-fresh produce in quantities for canning or freezing and at prices lower than one would expect to pay elsewhere.
- An outing of this type for nonfarming people is so psychologically rewarding that time, distance, inconvenience, and cost seem insignificant.

There are various considerations if a pick-your-own operation is to be successful. A location on a paved road relatively close to a center of population is desirable. However, with advertising and a good crop of high-quality berries, people will drive considerable distances and to somewhat out-of-the-way locations to obtain berries. Advertising is necessary to inform people when the crop is going to be ready, the time when the planting will be open for picking, and how to get to the planting. Various means of advertising are used including signs at the farm, newspaper and radio advertisements, and postcards to former customers. Satisfied customers telling their neighbors is one of the most effective means of advertising. For urban people, picking the berries often becomes a family outing and this recreation aspect is sometimes used in advertising.

Any rules such as times the planting is open, minimum age of pickers, and price of berries should be strictly followed. Other considerations are the necessity for ample parking, good organization in checking people into the planting and collecting payment for the berries, supplying containers of standard size, some supervision of the picking, and adequate insurance coverage. Toilet facilities and drinking water should be provided, and the provision of a shaded area for children and picnics should be considered if the recreation aspect of a pick-your-own operation is emphasized.

Yields and duration of plantings

Yields of raspberries of 10–14 t/ha are obtained in the main production areas in the world. The yields in Eastern Canada are generally much lower than this, but they can be just as high if the general principles outlined in this publication are taken into consideration.

The prevalence of diseases, particularly virus diseases and crown gall, and weeds such as quack grass largely determine the length of the profitable life of a raspberry planting. If the correct steps are taken a red raspberry planting will be productive for at least 8–10 years.

Everbearing raspberries

Varieties listed as everbearers do not produce fruit continuously all summer. They produce a crop at the normal time in the summer, and then produce a fall crop from the top buds on the canes that were produced during the summer. Fall bearing is a better term for this type of raspberry.

Everbearing varieties that are now available have little or no commercial potential. The cool fall weather of Eastern Canada delays ripening so that only a few berries ripen and even they are inferior to the quality of the summer fruit. The present everbearing varieties should only be grown in home gardens where additional attention and protection make them an interesting garden subject.

DISEASES AND PHYSIOLOGICAL DISORDERS

Diseases of diverse origin can develop in raspberry plants even after healthy plants have been selected, a favorable site chosen, and appropriate cultural practices followed. In addition to diseases caused by pests, physiological disorders, which result from unfavorable environmental conditions and acute nutritional problems, can also occur and are sometimes difficult to identify. *For chemical control, refer to the small-fruit protection guide for your area.*

Virus diseases

Mosaic

Mosaic is the most widespread virus disease in Eastern Canada. There are several variations of this disease, depending on the source of the virus, which is spread by aphids. The affected leaves exhibit alternating dark green, light green, and sometimes yellowish green patches. Mottling, which varies in intensity, may be present on the whole foliage but is sometimes confined to the lower leaves. This disease is easier to detect early in the season than in the summer, when it tends to become less pronounced. Some infected red raspberry cultivars are nearly symptomless yet remain a source of infection. Plants infected with mosaic produce stunted canes, have lower yields, and have a shorter life. The fruit is small and tends to be crumbly.

Mosaic is treated by roguing diseased plants as soon as they appear and by controlling aphids. Always use certified virus-free plants when setting out new plantings, and keep them at least 200 m away from old plantings.

Leaf curl

Leaf curl, a disease that is also spread by aphids, is much less common than mosaic but is sometimes found in older plantings. The leaves of an affected plant are darker than normal, are often wrinkled, remain small, and curl down at the edges. More than the usual number of fruiting laterals form but remain short, and

new canes develop but quickly become stunted and often have many branches. The entire plant takes on a stunted appearance, and the fruit is small, crumbly, and lacks flavor.

The treatment for leaf curl is the same as that for mosaic, except that when roguing, all canes in the immediate vicinity of an infected plant should also be removed.

Fungus diseases

Botrytis cane wilt

This disease, caused by the fungus *Botrytis cinerea* Pers., occurs under warm, wet conditions. It usually attacks the fruiting organs, especially the ripening fruit. In cultivars highly susceptible to botrytis cane wilt, more than 30% of the fruit may be destroyed at some stage of the fruit's development. In areas with dense growth, the disease can develop quickly when weather conditions are favorable to it.

Brownish or brown areas appear on the fruit and other fruiting organs. These areas are often covered with a fairly dense gray moldy growth that contains thousands of conidia, or asexual spores, capable of infecting other fruit.

Cultivars vary greatly in their susceptibility to the disease, but none seems totally resistant. Reduce cane density in order that plants have good air circulation and can dry off quickly. Excessive use of nitrogen fertilizer promotes too lush a growth and encourages development of the disease. During periods highly favorable to the disease, especially during harvesting, effective fungicides should be applied.

Anthracnose

This disease, caused by *Elsinoe veneta* (Burkh.) Jenkins, can severely damage a red raspberry planting if adequate control measures are not taken. Moreover, it can quickly destroy a planting. The disease usually attacks the canes. Gray spots with purple borders appear on the young canes. The spots are circular to oval, and sometimes several of them merge and completely girdle the cane. These lesions may also appear on the fruiting laterals and even on the fruit stalks. Often the bark cracks, making the canes susceptible to winter injury and easy breakage. Anthracnose can sometimes cause green fruit to dry up quickly and ripe fruit to turn brown. Purple spots, which later turn brown, appear on the leaves.

No cultivar appears to be resistant to this disease. At the first appearance of diseased canes, you should prune them and burn them as soon as possible. To keep the disease in check, fungicides should be applied from the beginning of the growing season until flowering. Ensuring that the air around the plants is well circulated also delays establishment of the organism.

Spur blight

The causal organism is a fungus, *Leptosphaeria coniothyrium* (Fckl.) Sacc. Most red-fruited cultivars are susceptible to the disease. On affected plants, purple to chocolate brown areas appear on the canes directly below the leaf attachments. When these areas enlarge, they may spread to the buds, leaf stems, and even leaves. The disease weakens the canes and makes them susceptible to winter injury. The following spring, the diseased areas become grayish and exhibit tiny

black specks (fruiting bodies of the fungus). Often buds around these areas begin to open but die suddenly, thus greatly reducing the number of fruiting laterals.

Fungicides should be applied from the beginning of the growing season until flowering. Good air circulation and low cane density (18–20 canes per metre of row) are useful in controlling the disease. Effective control is also ensured by removing fruiting canes immediately after harvest and eliminating weeds, which contribute to high humidity between the canes and hence to the spread of the causal fungus.

Verticillium wilt

Verticillium wilt, also called bluestem, is caused by soil-dwelling fungi. Wilt develops suddenly with the onset of hot summer weather and usually appears in young canes. Successive swelling and wilting of the leaves finally cause them to drop. The bare canes frequently become bluish, remain stunted, and finally dry out.

Soil that is cool because of poor drainage greatly encourages development of verticillium wilt. The causal organisms of the wilt can persist in this kind of soil for a long time.

At the first sign of the disease, the entire plant must be destroyed, including the roots. The fungi, which attack through the roots, can survive on several hosts, including weeds. Do not plant after potatoes, tomatoes, eggplants, peppers, or strawberries. A well-aerated soil that retains plenty of moisture is ideal for raspberry growth and for the control of this root disease.

Powdery mildew

Sphaerotheca macularis (Wallr. ex Fr.) Magn. is the causal fungus of this disease. Persistent warm, humid weather favors the rapid development of powdery mildew. It is characterized by a white powdery growth on the leaves and tips of the young shoots. Severely infected leaves become twisted and shrunken, and sometimes resemble leaves infected with mosaic. In highly susceptible cultivars, cane tips may lose all their leaves. When environmental conditions are particularly favorable the bare cane tips may die back. The fruit can also become affected, causing it to be tasteless and unsuitable for consumption.

Excessive density of canes favors the development of powdery mildew. For adequate protection, apply an effective fungicide as soon as the first symptoms appear, because it is virtually impossible to irradicate the fungus once it has invaded the tissues. Whenever possible, plant cultivars that are resistant to the disease.

Yellow rust

This disease is caused by *Phragmidium rubi-idaei* (DC.) Karst., a fungus not commonly found in plantings. Numerous clumps of orange yellow pustules develop on the undersides of the leaves. The affected leaves turn yellow, develop brownish areas, and fall prematurely. Severely affected plants may die during the winter. Infection takes place late in the season. Under our conditions, yellow rust remains a minor problem.

Unless a highly susceptible cultivar is being grown, it is not necessary to apply fungicides as a control method. Avoid planting cultivars that have either no or little resistance to the disease and destroy infected plants as soon as they appear.

Crown gall

Crown gall is a bacterial disease caused by *Agrobacterium tumefaciens* (E. F. Smith & Town.) Conn. It is characterized by galls, or knots, ranging from the size of a pea to that of an apple, on the roots and crown. The galls turn from cream to brown, and take on a blackish, warty appearance with age. The organism is present in many soils, especially those in which fruits and plants of the Rosaceae family (to which the raspberry belongs) are grown. There is no effective treatment of plants against the disease. Do not set out plants that have galls, do not injure plants during cultivation, and avoid areas where nursery stock, particularly raspberries, have already been grown. If you must use such areas, you should sterilize the soil. Dig up and destroy diseased plants.

Physiological disorders

Winter injury

Winter injury is the most important physiological disorder, and sometimes causes substantial plant mortality. The problem is physiological and occurs when the canes dry out as a result of lengthy exposure to drying winter winds, thus killing the cells that would produce new growth. When the buds start to open, they immediately dry up and die, often leaving the top third of the cane leafless, and occasionally affecting more than half its length.

Choose cold-resistant cultivars. Adopt cultural practices that encourage good air circulation. Apply adequate fertilizer so that the canes mature early. Sites exposed to the wind should have windbreaks. These windbreaks also help to provide snow cover at the onset of winter. Sites exposed to excessive sun are not recommended, because the warmth may stimulate early bud growth, which could become subject to damage from late frosts.

Mineral deficiencies

Many physiological disorders are the result of mineral deficiencies. To alleviate this problem, a fertilization program should be adopted on the basis of a soil analysis. It is stressed here that the normal absorption of nutrients is directly related to the regularity and stability of the soil moisture supply, which in some plantings should be provided by an effective system of irrigation, such as the trickle system.

PESTS

Raspberry plantings are attacked every season by many different pests. Pest infestations, which vary from year to year, weaken plants, reduce yields, and lower fruit quality. To prevent or limit such damage, it is important to know how to recognize the injuries caused by different insects and to have some knowledge of their biological habits and life history. If found necessary, treatments can then be applied, not only to prevent the spread of pests but also to restore full production potential to the plants.

When raspberries lack vigor or are wilting and dying, or when the presence of harmful insects is suspected, the various parts of the plant should be carefully

examined and the appropriate treatments applied where necessary. *For chemical control, refer to the small-fruit protection recommendations for your area.*

Since it is vital to have bees for good pollination, care should be taken to select insecticides that are the least toxic to them. Whenever possible, sprays should be applied early in the morning or late in the day when the bees are not active.

Good cultural practices are also important for insect control in raspberries. Destroy weeds and wild raspberries and brambles growing near plantings, because they may be being used as host plants by harmful insects. As soon as harvest is completed, remove and burn canes that have fruited or are heavily scarred, cracked, or swollen, weak, or otherwise undesirable.

Pests attacking leaves

Leafhopper

The leafhopper is a small, light green or whitish, wedge-shaped insect, less than 5 mm long. It is very active and flies or jumps when disturbed. It first appears in June and sucks the sap from the undersides of leaves. The leaves become speckled with small yellowish dots, especially along the veins, and sometimes take on a mottled or whitish appearance. The weakened plant produces smaller fruit and a reduced yield. Although leafhoppers produce several generations during the summer, plant injury is most noticeable in July.

Aphid

The aphid is a small, generally greenish insect. Like the leafhopper, it colonizes on the undersides of leaves and sucks the sap, causing the leaves to become discolored and distorted. Aphids usually attack the tips of new shoots, but the most serious damage they cause is the spread of virus diseases from one plant to another. Aphids overwinter as eggs on the canes and develop several generations of larvae and adults from spring to fall. Their populations are especially high during periods of rapid plant growth, and the most severe aphid attacks usually occur before harvest and in late August or early September.

Raspberry sawfly

The raspberry sawfly is a blackish, hymenopterous insect that lays eggs in the leaf tissues. The spiny, pale green larvae of the raspberry sawfly may be 15–20 mm long at maturity. These larvae appear on the plants in late May or early June and eat out irregular holes in the foliage, sometimes leaving only the larger veins.

Obliquebanded leafroller

The obliquebanded leafroller is a green, defoliating caterpillar. It folds the leaves of the plant together or webs the tips of growing shoots, and feeds in the shelter thus formed. The most serious injury is caused when the insect attacks the fruit. The young larvae overwinter in silken cocoons under the bark and bud scales. In the spring, they emerge and feed on the leaves, reaching their maturity in June. They pupate within the folded leaves. The adult, a reddish brown moth with oblique dark bands across the wings, hatches in late June or July. The females lay their eggs on the leaves to produce a second generation.

Twospotted spider mite

The twospotted spider mite is a small, greenish yellow mite with two dark spots on its back. It occurs in all regions where raspberries are grown, but plants can tolerate low populations of spider mites. These mites overwinter as adults in or on the ground, under plant refuse, and in the spring crawl to the leaves where they may increase rapidly by a succession of generations. Hot, dry weather is favorable to the mite's rapid spread, and it is usually at this time when the most severe plant injury occurs. The mites cover the undersides of the leaves with a fine silken web, under which they suck the plant's juices. At first, minute whitish or yellowish specks appear on the foliage; later the leaves may even turn brown and drop.

Pests attacking canes

Raspberry cane borer

The adult of the raspberry cane borer is a black beetle, about 15 mm long, with a yellow collar and long antennae. It usually appears around mid-June and often severely attacks small home plantings. The insect cuts two rings, approximately 1 cm apart and about 15 cm below the tip of new canes, and lays an egg between the rings. The tip of the cane later wilts, dries up, and drops off. The whitish larva feeds on the cane pith and overwinters not far below the point of girdling. The next season, the larva bores on down the cane and spends its second winter at ground level. The following spring, it pupates in the cane, and in June emerges as an adult. Because of the peculiar life cycle of the raspberry cane borer, its injury to plants is usually most severe every 2 years.

The best method of controlling this pest is to remove infested plants. Examine the plantings frequently in June and July and, if they are affected, cut below the lower rings of the canes as soon as the rings appear.

Raspberry cane maggot

The adult of the raspberry cane maggot is a brownish humpbacked fly, about half the size of an ordinary housefly. Mature larvae are white, footless, and 7–8 mm long. The injury caused by this insect resembles that caused by the raspberry cane borer, but it occurs earlier in the spring. The young, infested shoots droop and shrivel up, leaving a bluish ring where the larvae girdled the cane just below the bark.

The best way to control this pest is to cut the cane below the affected part as soon as injury appears.

Rednecked cane borer

The adult of the rednecked cane borer is a black beetle, about 1 cm long, with a coppery red neck. It usually appears during June and July, and feeds on the foliage. It lays its eggs on the young canes, and the larvae enter the cane and cut a spiral tunnel. A swelling, 30–80 mm long, occurs at the point of entry, causing the bark there to split lengthwise. Affected canes may break, dry out, or be unable to produce fruit. Although its occurrence is widespread, the rednecked cane borer is not considered a major pest.

In the event of infestation, any canes showing signs of swelling in the fall or early spring should be cut and burned.

Raspberry crown borer

The adult of the raspberry crown borer is a moth with yellow bands on its body and with clear wings. It resembles a wasp in appearance. It is first seen in August and lays its eggs on the undersides of leaves. The larvae are white, have a brown head, and are about 2 cm long. They overwinter at the base of the canes and bore into new plant shoots in April. Then, during the summer, the larvae girdle the canes, causing galls to form at the base. The affected canes become weak and break easily. The raspberry crown borer is usually found in old plantings. The eradication of wild and neglected red raspberry and blackberry plantings is advised.

Cynipid gall wasp

The cynipid gall wasp is small and black. It lays its eggs at the base of the canes, sometimes causing deformed, reddish brown swellings, 30–60 mm long, to occur there in the fall. These hard swellings, or galls, harbor numerous whitish larvae, each one occupying an individual cell.

Affected canes should be cut and destroyed, because this insect can cause fruiting laterals to wither and dry out.

Pests attacking flower buds and fruit

Strawberry weevil

The strawberry weevil is a small, reddish brown or blackish beetle, about 3 mm long, with two light spots on its back and a long snout. The adults overwinter on the soil surface among plant debris and appear on the plants around mid-May, when the first flower buds form. The females lay their eggs in the bud and then cut the stem below the bud so that it withers and drops off or is left hanging by a shred of tissue. The larvae develop in the dried-out buds and emerge as adults around mid-June. The new adults enter their winter quarters a month later.

Tarnished plant bug

The adult tarnished plant bug is brownish, flat, oval-shaped, and about 6 mm long. The larva is white, oval-shaped, and barely more than 8 mm long. It is one of the first insects to appear on raspberry plants in the spring, and attacks the flower buds. It flies away quickly when disturbed. The main injury caused by this insect, however, is to the fruit, which it pierces in order to feed. The berries become misshapen and shriveled and take on a violet shade. The adults spend the winter hidden under fallen leaves or other debris. They emerge with the first warmth of spring to feed and lay their eggs on a wide variety of plants, including several species of weeds.

Eastern raspberry fruitworm

The eastern raspberry fruitworm is a small, yellowish brown beetle, 4 mm long, covered with fine, short hairs. The adults, which overwinter in the soil, emerge when the flower buds appear. They feed on developing leaves and blossoms, enter the fruit buds, and lay eggs at first on the flower clusters and later on the green berries. The larvae enter the blossoms or young fruit and devour the fleshy cores.

Sap beetle

The sap beetle is a small, black insect, 5–7 mm long, with two pairs of yellow spots on its back. At harvest time, the beetles frequently invade plantings, especially those located near cornfields. They are particularly attracted by ripe fruit that has fallen and started to decay. They feed by boring into the berries and contaminating them with their waste.

Because there is no satisfactory chemical control for sap beetles, avoid planting raspberries near cornfields. Also, to help prevent fruit contamination at harvest, do not leave picked raspberries on the ground. Remove them to a shelter as soon as possible after picking. In small plantings, poisoned baits can also be used to reduce attacks by this beetle on the fruit.

Pests attacking roots

Nematode

The nematode is a microscopic, wormlike organism. Its presence in the soil or in the actual plant roots has often been associated with the decline of raspberry plantings. Some endoparasitic species may directly destroy the plant root system and encourage the development of other microorganisms such as fungi and bacteria, which hasten the breakdown of plant tissues. Generally, affected plants remain stunted and do not produce much fruit. Other species of nematodes spread virus diseases, thus greatly contributing to the reduction of plant growth and fruit production.

Common and scientific names of diseases

Anthracnose	*Elsinoe veneta* (Burkh.) Jenkins
Botrytis cane wilt	*Botrytis cinerea* Pers.
Crown gall	*Agrobacterium tumefaciens* (E. F. Smith & Town.) Conn
Leaf curl	Virus
Mosaic	Virus
Powdery mildew	*Sphaerotheca macularis* (Wallr. ex Fr.) Magn.
Spur blight	*Leptosphaeria coniothyrium* (Fckl.) Sacc.
Verticillium wilt	*Verticillium* sp.
Yellow rust	*Phragmidium rubi-idaei* (DC.) Karst.

Common and scientific names of pests

Aphid	Aphidoidea
Cynipid gall wasp	Cynipidae
Eastern raspberry fruitworm	*Byturus rubi* Barber
Leafhopper	Cicadellidae
Nematode	Nematoda
Obliquebanded leafroller	*Choristoneura rosaceana* (Harris)
Raspberry cane borer	*Oberea bimaculata* (Olivier)

Raspberry cane maggot	*Pegomya rubivora* (Coquillett)
Raspberry crown borer	*Pennisetia marginata* (Harris)
Raspberry sawfly	*Monophadnoides geniculatus* (Hartig)
Rednecked cane borer	*Agrilus ruficollis* (Fabricius)
Sap beetle	Nitidulidae
Strawberry weevil	*Anthonomus signatus* Say
Tarnished plant bug	*Lygus lineolaris* (Palisot de Beauvois)
Twospotted spider mite	*Tetranychus urticae* Koch

CULTIVARS

The only way to select the cultivar of red raspberry that is best suited to your location is to test several of the cultivars that are recommended for your area. The ideal cultivar would be productive, hardy, and disease resistant, and would have large, firm, plump, juicy berries. However, no single cultivar has all these characteristics. Before you start your planting, ask your agricultural representative for the latest information on cultivars, because new ones are constantly being developed.

The cultivars recommended in Table 2 for general planting have been thoroughly tested by agricultural scientists and commercial producers. The cultivars listed for limited planting only, although they appear promising, need further testing before they can be recommended for general use.

When you intend to set out a new planting, buy only certified plants.

Table 2. Characteristics of cultivars

Name and origin of cultivar	Season	Canes	Fruit	Suitability	Recommendations for planting	Province
Bonanza (Sunrise × Washington)	midseason	tall, slender, branched, tender in winter (injured some years at Vineland, Ont.), susceptible to spur blight and anthracnose	medium red, bright, attractive, medium large, medium firm, quality fair	fresh fruit and processing	limited* planting	southern Ontario
Boyne (Chief × Indian Summer)	early midseason	medium tall, very strong, spiny, very hardy, vigorous, productive	medium dark red, attractive, medium size, somewhat soft, tart (acid), quality fair	fresh fruit excellent for freezing	general** planting limited planting	Ontario Quebec Nova Scotia New Brunswick

Table 2. Characteristics of cultivars (continued)

Name and origin of cultivar	Season	Canes	Fruit	Suitability	Recommendations for planting	Province
Carnival (Ottawa × Rideau)	mid late season	tall, upright, sturdy, nearly spineless, moderately hardy	bright red, medium size, firm, quality excellent, foliage and fruit susceptible to mildew	fresh fruit market and freezing	limited planting	Quebec New Brunswick Nova Scotia
Comet (Ottawa × Madawaska)	early midseason	tall, sturdy, moderately spiny, moderately hardy, fairly resistant to anthracnose and spur blight, but moderately susceptible to mildew	medium red, bright, attractive, medium large, rather soft, quality good	fresh fruit	general planting	Ontario Quebec
Festival (Muskoka × Trent)	midseason	short, erect, nearly spineless, very hardy, requires good soil, lacks vigor on sandy soils	medium red, bright, very attractive, size medium to large, good quality	fresh-fruit market and pick-your-own	general planting limited planting	Newfoundland Nova Scotia Quebec Ontario
Gatineau (Lloyd George × Newman 23)	very early	short, hardy, very susceptible to anthracnose, very productive	medium dark to dark red, medium large to large, moderately firm, quality fair	fresh fruit	limited planting general planting	Ontario Quebec
Heritage [(Milton × Cuthbert) × Durham]	autumn fruiting in areas having a long growing season; first crop ripens in midsummer, second crop ripens in September or October	vigorous, upright, moderately hardy	medium red, attractive, medium size, firm, good quality	fresh fruit	limited planting for summer crop; fall crop only in long-growing season areas	Ontario

Table 2. Characteristics of cultivars (continued)

Name and origin of cultivar	Season	Canes	Fruit	Suitability	Recommendations for planting	Province
Killarney (Chief × Indian Summer)	midseason	medium tall, sturdy, very hardy, productive	bright red, medium size, attractive, rather soft	fresh fruit	limited planting	Ontario
					general planting	Quebec
Madawaska (Lloyd George × Newman 23)	early	short, very hardy, susceptible to mildew	medium dark to dark red, medium large, moderately firm, tending to crumble, somewhat acid, quality fair	fresh fruit	limited planting	Ontario
Marcy (Lloyd George × Newman)	late midseason	medium tall, strong, hardy, moderately productive susceptible to spur blight and anthracnose	medium red, somewhat dull, fairly good flavor	fresh fruit and processing	limited planting	Ontario
Matsqui (Sumner × Carnival)	late	medium tall, upright, nearly spineless, hardy	bright medium red, medium size, firm, mild flavor	fresh fruit and freezing	limited planting	Prince Edward Island
					general planting	Quebec
Muskoka (Newman 23 × Herbert)	early midseason to midseason	medium tall, very hardy	medium red, bright, attractive, medium size, medium firm, quality good	fresh fruit	general planting	Quebec
					very cold areas	New Brunswick
Newburgh (Newman 23 × Herbert)	midseason	medium tall, rather slight, sometimes branched, spiny, moderately hardy, resistant to the common cane diseases	light red, large, firm, ripening unevenly, hard to pick unless fully ripe, tending to crumble because of poor drupelet adhesion	fresh fruit	limited planting	Ontario

Table 2. Characteristics of cultivars (concluded)

Name and origin of cultivar	Season	Canes	Fruit	Suitability	Recommendations for planting	Province
Rideau (Lloyd George × Newman 23)	early midseason	short, hardy, susceptible to mildew	medium red, rather dull, small, firm, quality fair	fresh fruit and processing	general planting	Quebec
					limited planting	Ontario
Trent (Newman 23 × Lloyd George)	early	medium tall, upright, spiny, hardy, productive, susceptible to mildew, anthracnose, and spur blight	medium red to medium dark red, small, moderately firm, tending to crumble, quality fair to good	fresh fruit	general planting	Quebec
Tweed (Newman 23 × Lloyd George)	early	short, moderately hardy, susceptible to mildew	dark red, small, medium firm, quality fair	fresh fruit	limited planting	New Brunswick

* Limited planting indicates cultivar value but planting limited for various reasons.

** General planting indicates well-known cultivars having predictable performance and established market value.