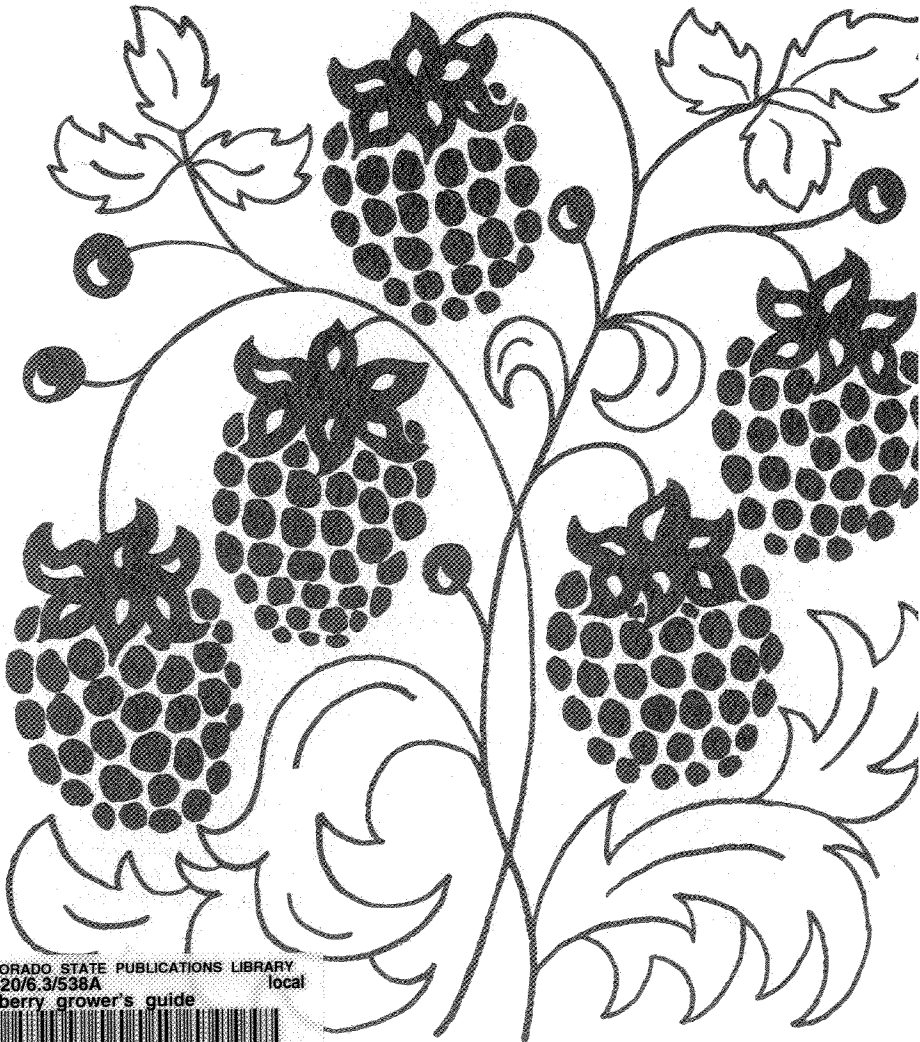


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RASPBERRY GROWERS GUIDE

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RASPBERRY GROWER'S GUIDE
Bulletin 538A

by

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INTRODUCTION

Red raspberries are a popular soft fruit used fresh and prepared in jams and pastries. They are grown in many moderately cold areas of the United States. A one time, hundreds of acres were grown commercially in Colorado, however, virus-infested nursery stock, high production costs and harvest labor costs led to a decline in the 1940's. This was a common phenomenon which occurred in much of the United States.

Interest in raspberry production has returned in the past 20 years with the propagation of virus-free plants and increased consumer interest in fresh fruits. The consumer has more money to spend on healthful, high quality fresh fruit. Harvesting procedures have also changed to include both mechanical harvesters and pick-your-own (PYO) operations.

With the front range population increase and the relatively high disposable income of Colorado residents, PYO operations and even grower-pick operations seem feasible. In order to facilitate this, Colorado State University has evaluated raspberry cultivation procedures appropriate for Colorado conditions.

An understanding of the growth and fruiting characteristics of the red raspberry, *Rubus idaeus*, is basic to production of the fruit. It is a perennial but has a biennial growth and fruiting habit. The roots live for many years, but the canes (or stems) live only two years. The term "primocane" refers to the first year of cane growth and "floricane" to the second year. The berry, an aggregate fruit consisting of drupelets, separates from the receptacle or core which remains on the bush when picked.

Growth Habit. There are two types of raspberries, summerbearing (biennial bearers) and fallbearing (everbearers) that have the same general growth but differ in fruiting habits. New canes arise from basal buds each spring and these primocanes develop vegetatively during the summer. Summerbearing types form flower buds in early fall when the days shorten and temperatures cool and complete development in late fall and early spring. The second year canes, floricanes, will flower and produce berries midsummer. After fruiting, the floricanes die.

In contrast, fallbearing types produce berries late in the first season on the tips of the primocanes. Flower buds develop at the primocane tips when they reach a certain height, usually in July. These flowers open and produce fruit by the end of August. Meanwhile, flower buds develop in the lower part of the cane. The next summer the lower portion of the cane will bear fruit midsummer while the tips remain bare. Therefore, fallbearing varieties produce two crops a year with two-year old canes dying after the midsummer fruiting. Fallbearing varieties can also be used to produce only fall crops by mowing down the dormant canes at their base in late fall. New canes will develop from the roots in the spring and fruit in the fall.

VARIETIES

Both summerbearing and fallbearing types can be grown in Colorado. Summerbearing types can be grown on the western slope. However, they need winter protection to be grown successfully, on the front range. If winter injury is significant, a fallbearing variety is a better choice since it bears fruit on the

current season's canes.

Varieties selected should be suitable for the grower's locality and market. Factors that need to be considered in choosing a variety are winter hardiness, production, time of ripening, fruit quality, ease of harvest, and resistance to diseases, insects or disorders. Winter bud hardiness is important in summerbearing types where fruit buds are present all winter, while early ripening is important among fallbearing varieties where early freezes can cause crop losses. A raspberry variety that allows for easy harvesting is essential for a PYO operation. In addition, raspberries grown for the fresh market should be firm, bright red in color and with good flavor. Some varieties are more susceptible to fruit whitening and leaf scorch, two disorders that can occur in Colorado.

After a variety is selected, spacing needs to be decided and a nursery identified so that certified virus-free (disease-free) plants may be ordered several months in advance.

Fallbearing varieties. Fallbearing raspberries that can be successfully grown in Colorado include **Heritage, Pathfinder, Trailblazer, Fallred** and **Fallgold**.

Heritage. The plant is very vigorous, productive and hardy. The berries are medium red in color, medium size, very firm and of excellent quality. This is the current favorite but it is risky wherever ripening does not begin until September. This variety produces more fruit in the fall than other varieties.

Pathfinder and Trailblazer. These two varieties are hardy, productive and vigorous but low-growing with slender canes. The berries are medium colored to deep red, medium to large in size, medium in firmness and of good quality. The ripen two weeks earlier than Heritage. The leaves may scorch if water stressed. These varieties are not readily available from nurseries.

Fallred. This variety is medium red and ripens two to three days earlier than Heritage. The quality is good but yields are generally much lower than Heritage in the fall.

Fallgold. This variety produces yellow or amber colored berries. They are sweeter to the taste than Heritage with excellent quality but too soft to ship commercially.

Summerbearing varieties. Summerbearing varieties that can be grown in Colorado include **Boyne, Canby** and **Latham**.

Boyne. The plant is very hardy, vigorous and productive. The fruit is produced early to mid-season (July) and the berries are medium to dark red, medium size, moderately firm and somewhat tart, of fair quality but excellent for freezing.

Canby. Plants have few thorns and are hardy, vigorous and productive. They are susceptible to root rots and should be grown on well-drained soils. Fruit produced early to mid-season and berries are light in color, medium to large in size, moderately firm and of good quality.

Latham. The plant is hardy, vigorous, productive and tolerant to mosaic virus. The fruit is produced in mid-season and the berries are medium to large in size, firm and of good quality.

SELECTING A SITE

A red raspberry planting will produce for at least eight to ten years, and generally longer, if the proper site is selected. Climate, air drainage and exposure, type of soil, source of irrigation water, and previous crops grown at the site are all factors to consider.

Climate. Red raspberries grow best in a climate with a relatively cool summer, dry harvest period, and moderate winters that are cold enough to satisfy the chilling requirement of approximately 800 plus hours below 45°F. Red raspberries are the hardiest of the brambles, but severe cold winter temperatures, especially if accompanied by drying winds may damage canes, buds and the crown. In the summer, excess heat and high light intensities during fruit ripening may cause softness and whitening or scalding of the fruit and scorching of the leaves. Rain during harvest causes softening of the fruit and contributes to postharvest soft rots.

The climate in Colorado offers a unique set of conditions for growing raspberries. The chilling requirement is easily satisfied in all areas of the state, but winter can bring extreme cold temperatures and drying winds. Occasional late spring and early fall frosts can injure the plants and cause crop losses. The low natural rainfall makes irrigation necessary; however, the dry climate reduces the incidence of cane and foliar diseases. Preharvest fruit rots are usually not serious. The most favorable weather during harvest in late summer is moderate day temperatures, cool nights and very little rainfall. In midsummer, high light intensities and temperatures may cause scalding or whitening of the fruit and scorching of the leaves. With careful site selection, an appropriate variety and cropping system and proper cultural practices, raspberries can be grown successfully in Colorado.

Air drainage and exposure. Local topography can modify the climate resulting in different microclimates. For example, because cold air drains into low areas, fallbearing raspberries planted on a slope are less likely to be damaged by early frosts than those at the bottom. Sites for summerbearers should have some protection from strong winds to protect canes from breakage and winter desiccation.

Soil. Raspberries grow best on a soil that has depth, good drainage, and adequate fertility. The ideal soil is a deep, sandy loam well supplied with humus. However, brambles will grow on a wide range of soils from coarse sand to medium loams and even clay loams. The soil depth should be 2 or more feet. Good drainage of soil water is essential because raspberry roots are sensitive to poor soil aeration and can be severely injured if submerged for more than 24 hours. The soil should be well drained to a depth of at least 3 feet. For this reason soils with a high clay content should be avoided.

Another important soil characteristic to consider is its water-holding capacity. Adequate continuous soil moisture is one of the most important factors in successful raspberry culture. Sandy soils hold less water than loam soils. Frequent irrigation and fertilization may be needed to compensate for the low

moisture-holding capacity of sandy soils.

A soil test should be done to determine major and trace elements, percent organic matter, total salts, the sodium level and soil pH. Raspberries are not salt tolerant and will not grow well on soils high in salts or sodium. In addition the characteristically poor physical structure of sodic soils make them unsuitable for raspberry production. A soil pH level recommended for growing raspberries is 5.5 to 6.5. At high pH levels, common in Colorado, micronutrient deficiencies can occur but may be corrected with appropriate fertilization.

Irrigation water. Irrigation water should also be tested for total salts and levels of sodium and boron. High levels of salts, sodium or boron can reduce yield or be toxic to raspberries.

Previous crops. Solanaceous crops (such as potatoes, tomatoes, peppers and eggplant), strawberries and other raspberries can be hosts for verticillium wilt. Raspberries should not be planted for three to four years where such crops have been grown. Soil fumigation before planting may be necessary in some areas.

Nematodes. A soil test for nematodes before establishing a planting will determine if they are likely to be a problem. Nematode assessment in June or July a year before planned planting will allow for an effective treatment that fall prior to planting. Consult your local Cooperative Extension County agent for more information about this problem in a specific area.

ESTABLISHMENT

Field preparation. Land on which corn or other cultivated row crops have grown a year or more prior to planting raspberries is suitable and will also aid in weed control. Perennial weeds should be eliminated before planting. If weeds persist, a suitable herbicide may be used in the fall before planting (see Colorado Small Fruits, XCM-49). Addition of organic matter to the soil provides nutrients, improves the tilth and increases its water-holding capacity. A green manure crop such as wheat can be planted in September and plowed under in spring before planting the raspberries. Well rotted animal manure is another good source of organic matter and can be applied to a depth of 1 inch and plowed in early spring before planting.

Time of planting. Planting during early spring before cane growth begins is recommended to give the plants time to become well established the first growing season.

Planting stock. Planting certified stock is recommended. Noncertified stock may introduce nematodes, viruses, or root pathogens into a new planting. Strong canes with a well-developed root system are desirable. Black, soggy or moldy roots indicate poor plants. If plants arrive early, they may be wrapped in moist burlap and held in cool (32-38°F), dark storage until weather and soil conditions are favorable for planting.

Plant spacing. The distance between rows may vary from 8 to 12 feet depending on the type of tractor and equipment owned by the grower. Within the row the raspberry plants can be planted 1/2 to 2 feet apart if a hedgerow system is used or 2-1/2 to 3 feet apart if a hill system is used.

Setting the plants. The soil should be thoroughly prepared, well-worked and moist before planting. A drip irrigation system, where selected, should be installed before setting the plants. Plants may be set in a plowed furrow about 6 inches deep or in holes dug with a shovel. Cloudy days with no wind are best for planting. The plants can be kept moist during the planting operation by covering them with moist burlap or keeping them in a tub of water. The plants are set so that after the soil settles and is leveled, they will be an inch deeper than previously grown. The roots are spread out and covered with soil. Then the soil is firmed around the plant and the cane is cut back to 1 inch above ground level. This prevents the plant from drying out and stimulates shoot production. Irrigation is usually necessary at the time of planting in Colorado. After the plants are established, they should be sidedressed with approximately half the amount of fertilizer recommended for bearing fields.

CULTURAL REQUIREMENTS

Training. The first season three to five canes per plant will grow. The second year more shoots will sprout and begin to fill in the spaces between the rows and between the plants within the row. Some system of training is necessary to allow for proper cultural management.

One common system of training is the hedgerow. In this system the shoots are allowed to fill in the spaces between the plants to form a solid row. Plant rows are kept 12 to 24 inches wide by hoeing, cultivating, and mowing new shoot growth. Canes within the row are thinned to four to six canes per row foot. A vigorous planting may be able to support more canes. Good weed control within the row is necessary. The advantage of this system is that there is a larger number of canes per acre and so higher yields per acre are possible. The hedgerow system is recommended for growing Heritage raspberries to produce a fall crop only.

In the hill system, suckers are not allowed to fill in the spaces between the plants. About eight to twelve canes are kept at each hill or planting point. This system makes weed control within the row easier. The hill system is useful for summerbearing raspberries where the canes must be laid down on the ground in one direction and covered for winter.

Most varieties of red raspberries have stout canes and do not require support. No support system is needed with the fallbearing varieties in the fall-crop-only system. However, some varieties can benefit from a support system that helps prevent cane breakage from winds and makes harvesting easier. The material and labor costs of a training system may be offset by its benefits, especially easier picking, in a small planting or a PYO operation.

A trellis system can be made with two or four galvanized wires and wooden or steel posts at 25 feet and 20 feet respectively. End posts are braced and the top two wires (No. 10 or 12) are fastened to a 24-inch long crossarm about 4-1/2 feet from the ground. The bottom two wires (no. 12 or 14) are fastened to the sides of the post by hooks about 30 inches from the ground. The bottom two wires are used to protect the new canes. The wires are unhooked and pulled out and over the new canes to bring them into the center of the row. The fruiting canes can be separated and tied to the top two wires. Installation of only the top two wires proved a simpler system (see Figure 1).

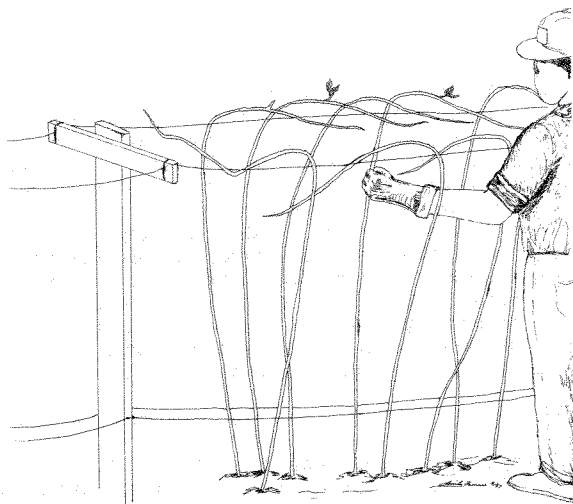


Figure 1. Training dormant red raspberries using a cross-arm trellis.

Pruning. A planting of summerbearing raspberries should be pruned to: 1) remove old floricanes and diseased or weak one-year old canes, 2) thin the remaining canes to achieve proper spacing for best production, and 3) head back canes.

Canes that have fruited are removed soon after harvest by pruning at ground level. Their removal aids in insect and disease control and conserves water. In early spring before the buds begin to swell, the canes are thinned. Weak, diseased, or winter damaged canes are removed. To achieve the desired number of canes per hill, canes less than one-half inch in diameter are removed since better yields are obtained from large diameter canes. Topping or heading back floricanes should be done in the spring. Canes are headed back to remove damage tips, prevent bending over, to bring them down to a convenient height for picking and to increase berry size by decreasing the number of berries produced per cane. A height of 4-1/2 to 5 feet is satisfactory. The canes should not be topped too severely because this reduces yields and will not be compensated for by increased berry size.

Pruning of fallbearing raspberries grown with the fall-crop-only system requires 1) thinning of canes to maintain the hedgerow during the growing season, 2) removal of any diseased canes and 3) removal of all canes after harvest. The hedgerow width is maintained by pulling excess suckers and shallow summer cultivation. Within the row weak, diseased, and small canes less than one-half inch in diameter are removed to achieve the proper spacing. After harvesting the fall crop canes are mowed to the ground following one or two hard frosts.

Irrigation. A continuous supply of soil moisture is essential for a productive crop of raspberries. Adequate early season moisture is necessary to produce numerous and large canes for the fall crop or the crop next year. During the bloom and harvest periods proper irrigation is critical for good quality fruit development.

Drip, furrow or sprinkler irrigation can be used with raspberries. Drip irrigation systems are very efficient; they use less water, require less labor and provide a more uniform moisture level. A filter is necessary to prevent solid particles from clogging the small outlets. A pressure regulator is also needed. The system should be installed and tested before the plants are set. Disadvantages of a drip system include the initial cost and repair or replacement costs.

Raspberries are shallow rooted and obtain most of their moisture from the top two feet of soil. Highest yields are obtained if the complete 4-foot root area is kept at 50 percent of it's moisture holding capacity. Soils vary in their moisture holding capacity. A light sandy soil contains about an inch of usable water per foot of soil depth or about 4 inches of water in the effective rooting area. A loam soil may hold two inches of water per foot of soil depth and 8 inches in the effective rooting area. A sandy soil therefore will need to be irrigated more frequently and with smaller amounts of water.

As a rough guide, raspberries require 1/2 to 1 inch of water per week from either rain or irrigation early in the season and 1 1/2 to 2 1/2 inches of water per week from the bloom period through the end of harvest. Drip irrigation three to seven times per week is ideal, so long as the proper amount is applied. Instruments, such as a tensiometer, which measure soil moisture, are available and may be helpful. A soil test can determine the soil moisture holding capacity.

Check with the county extension agent for information on proper irrigation and scheduling. Proper scheduling is important to prevent overwatering as well as underwatering. Overwatering can result in soft fruit which damage easily, leaching of nutrients, and poor root growth and development. During harvest irrigation should be scheduled so that the soil is not wet when the pickers are in the field. After harvesting of summerbearing varieties is complete, it is important to minimize irrigation to prevent growth and harden off the plants for winter. Finally, additional irrigation should be applied in the fall and in midwinter (if the soil thaws) to prevent winter desiccation.

Good water quality is important. A water quality test should be done before planting. Raspberries are sensitive to high levels of salt in the root zone. A 25 percent yield loss is possible at a soil EC level (salt content) of 2.1 mmhos/cm. Higher values (up to 3.5 mmhos/cm) are tolerable if most of the soil salt is gypsum.

Soil leaching can reduce the average salt content of the soil somewhat. Irrigation practices such as irrigating alternate furrows will prevent the accumulation of salts in the root zone. These methods are effective if the irrigation water is only slightly saline.

Fertilization. A soil test should be done before establishing the planting. The test will determine pH, EC (salt content), SAR (sodium adsorption level), percent organic matter, lime content, NO₃-nitrogen, potassium (K), phosphorus (P), calcium (Ca), magnesium (Mg), boron (B), iron (Fe), zinc (Zn) and copper (Cu). Soil test services are offered by the Colorado State University Soil Testing Lab and private labs. The soil test results include recommendations for fertilizer application.

Raspberries yield best on large diameter canes with short internodes. The fertilizer program should be managed to obtain this type of growth. The nitrogen fertilizer program is especially important for plant vigor. Fallbearing raspberries grown for the fall crop require 1.5 to 2 times the amount of NPK fertilizer recommended for summerbearing varieties. First year planting require only 1/2 the amount of NPK recommended for established plantings. Fertilizer is applied each spring as soon as the plants begin to grow. The fertilizer can be banded on both sides of the row. With drip irrigation small applications of water soluble fertilizer at different times are preferable, up until about one month before the start of harvest.

Well-rotted animal manure can be added to the soil (equivalent of 1 inch depth) prior to planting to increase the organic matter content, improve the texture, and provide nutrients. Application amounts of other nitrogen fertilizers should then be reduced accordingly. Animal manures may contain high amounts of weed seeds and salts.

At high pH levels, greater than 7.0, micronutrients such as zinc, iron, and manganese become unavailable to the plant. Raspberries are especially sensitive to low iron levels in the soil. Any micronutrient deficiency should be corrected before planting. If unexpected deficiency symptoms occur a foliar spray application followed by a soil application may be necessary. Proper diagnosis of a micronutrient deficiency is important and may require foliar analysis. Symptoms such as chlorosis (yellowing) and necrosis (death) of tissue may be caused by a disease, herbicide injury, or other damage. Micronutrients must be applied with care since the difference between deficient and toxic levels are small.

Boron toxicity can occur if high levels of boron are present in the irrigation water or soil. A boron level greater than 0.5 ppm (0.5 mg/l) in the irrigation water requires leaching in order to control boron levels in the soil.

Pollination. In a well-pollinated fruit about 50 to 85 drupelets develop. Raspberries are crumbly if an insufficient number of drupelets are formed. Although raspberries are self-fruitful, insect pollination is essential to ensure maximum yields of high quality fruit.

The honey bee is the most important pollinator. Placement of two honey bee colonies per acre will ensure adequate pollination. The hives should be placed so that prevailing winds are not against bee flight patterns. Many insecticides are highly toxic to bees and care must be taken during the bloom period. Some insecticides are highly toxic and should never be applied while the raspberries are in bloom. Others can be applied only when honey bees are not foraging, such as early morning or late evening. Contact the county Cooperative Extension agent or consult XCM-49 for the relative hazard of different pesticides to honey bees before applying any pesticide during the bloom period.

Crumbly berry. This results in a berry with fewer than the normal number of drupelets that crumbles when picked. The following are some of the causes of crumbly fruit:

- 1) Nutrient deficiency. A nutrient deficiency may be caused by low fertility, drought stress, damage to the roots from disease, nematodes, deep cultivation or poor drainage, and damage to the crown from diseases, insects or

mechanical wounding. Poor plant nutrition can result in poor fruit set.

2) Diseases. Viruses, especially mosaic and ringspot, can interfere with normal flower development and fruit set resulting in a crumbly berry.

3) Varieties. Some varieties other than those recommended for Colorado tend to crumble more than others.

4) Damage to the flower. Frost, winter injury, insects and pesticides applied during bloom can damage the flower and result in poor fruit set and crumbly berry.

Crumbly berry can be prevented through proper fertilization, irrigation, winter protection, insect and disease control, and pesticide application.

Frost injury. Developing leaves, especially those of summerbearing varieties, are susceptible to frost damage. The leaves on summerbearing raspberries should be hardened to avoid severe injury by uncovering canes before the buds begin to swell. By uncovering the leaves will gradually hardened as they leaf out.

Flowers and fruit of fallbearing varieties can be injured by early fall frosts. Although no protection techniques have been developed for Colorado, sprinkler irrigation is a possibility.

Winter injury. Winter injury to raspberries may result from cold temperatures, desiccation and crown heaving. The pith and the vascular tissue in the basal portion of the buds, the pith of the cane and floral primordia are the most susceptible to freeze damage.

Temperature conditions that cause injury include:

- 1) Low temperatures in early winter before the plants are hardened off.
- 2) Extreme low temperatures in midwinter.
- 3) A rapid fluctuation in temperature in a 24-hour or slightly longer period, such as sudden cold temperatures that follow a warm period in late winter or early spring. The canes can be protected from cold temperatures by covering them with soil as described in winter protection.

Winter desiccation due to cold, dry winds and low humidity can also injure or kill the raspberry canes. Canes may dry out beyond recovery even at temperatures above freezing. At cold soil temperatures water uptake by the roots may be slow and inadequate to replace water lost from the plant through evaporation from the canes and buds. If the plant moisture level falls below 50 percent of the moisture content of the mature cane, cell breakdown and death occurs.

The alternate freezing and thawing of soil caused by fluctuating temperatures may cause a heaving of the crown that can damage roots or expose them to dry air and freezing temperatures. This is common in soil with a high clay content.

Hardiness. Short days in the fall induce the raspberry to begin a dormant or rest period. Hardiness or resistance to cold is developed gradually when the canes are frequently exposed to temperatures at or below freezing. Canes become fully hardened after exposure to temperatures around 20°F over several nights.

The variety is the most obvious of many factors that influence winter hardiness. All of the varieties recommended for Colorado have a high resistance to cold.

Cultural practices produce healthy canes and speed up the hardening process by stopping late season cane growth thus reducing winter injury. Late growth is weak and susceptible to freeze injury. It is best to make fertilizer applications early in the growing season and to avoid excessive nitrogen. Summerbearing varieties require only minimal irrigation late in the season. However, full irrigation is needed before the soil freezes in late fall and once again in the winter if the soil thaws. Cultivation after mid-August is not required because growing weeds compete for soil moisture with the raspberries, slowing down their growth and speeding up the hardening process.

Freeze injury is less severe when carbohydrate storage levels in the plant are high. Any condition that induces a carbohydrate deficiency should be avoided. Injury from mites, insects, diseases, and hail can cause premature defoliation or damage to the photosynthetic tissue thus reducing sugar accumulation. Plant nutrient deficiencies, drought stress, and root diseases can also reduce carbohydrate levels.

Winter protection. In Colorado it is necessary to protect raspberries from severe winter cold and drying winds. Proper site selection before planting is important. Overwintering canes must be covered completely with soil or a mixture of soil and straw for winter protection. Straw, cornstalks or other materials alone can be blown away. Canes should be covered between October 15 and November 15. A furrow may be plowed to the side to lay bent over canes as flat as possible without breaking. All the canes in a row are laid down lengthwise in one direction and then covered with 4 to 6 inches of soil. The soil is raked off uncovering the canes in the spring, between March 1st and April 1st, before the buds swell. If the canes are left covered while the leaves begin growth the leaves are more susceptible to frost injury when uncovered.

Fallbearing raspberries grown only for the fall crop avoid freeze injury to canes and buds because the canes are mowed down before winter. Mulching the rows with a straw covered with soil will prevent heaving. Remove the mulch before growth begins in the spring. Mulching is not necessary but is beneficial.

PEST MANAGEMENT

Publication XCM-49 contains information on specific chemical sprays and spray programs to use in treating the following pests:

Weeds. Perennial weeds must be eradicated the season prior to planting because many herbicides that kill perennial weeds can also damage raspberry plants. Methods to remove perennial weeds include a tillage program, growing a green manure crop and using a systemic post emergence herbicide.

Once the planting is established annual weeds are controlled with

herbicides, cultivating and hoeing. Because raspberry plants have many shallow roots, cultivation should only be done between the rows and to a depth of 2 inches. A mulch within the row and around the hills can also help to reduce weeds. Any perennial weeds that are reintroduced should be hand pulled or spot sprayed with round-up.

Insects. Raspberry plantings can be attacked by many different insect pests. Insect damage can weaken plants and reduce yields and fruit quality. Some insects can be vectors of viruses. It is important to be able to recognize insects and signs of their injury and understand their biology for effective control. Both pest and beneficial insect populations should be monitored for effective use of chemical sprays. Care must be taken when applying pesticides during the bloom period. Good cultural practices are also an important part of an integrated pest management program.

Listed below are some common insect pests of raspberries.

Pests attacking leaves

Spider mites. Mites are favored by warm, dry weather. The two-spotted spider mite is common. Tiny white specks appear on the undersides of the leaves where the mites suck the plant sap. Heavy mite infestations turn leaves brown, causes leaf drop and reduce fruit yields. Spider mite infestation are difficult to control so they should be controlled early.

Aphids. Aphids are small yellow-green insects that colonize the bottoms of leaves, the tips of new shoots and suck plant sap. The most serious damage aphids do is transmit virus diseases from one plant to another.

Sawflies and leafrollers. These insects chew on raspberry foliage causing conspicuous holes in the leaves. They are not usually present in high enough numbers to warrant control.

Cane pests

Raspberry cane maggot. This pest is the white larva of a small brownish fly. The larva infests terminal shoots in late spring and early summer. The affected tips wilt and there is a bluish ring present where the larva girdled the stem. The cane should be cut below the affected part as soon as the injury appears.

Red-necked cane borers. A black beetle with a red neck, the adult feeds on foliage and lays its eggs on young canes in late May or June. A swelling occurs where the larvae enter the cane. The larvae tunnel through the canes and can cause death of the entire cane. Any canes that show signs of swelling in late fall or early spring should be removed and burned. The canes can be sprayed during the egg-laying period.

Pests attacking flowers and fruit

Western flower thrips. Thrips are sometimes found in harvested berries. They do not appear to cause any observable injury to the fruit and are not responsible for fruit whitening. To control, do not harm thrip predators such as the minute pirate bug. There has been no success with chemical control.

Pests attacking the crown and roots

Raspberry crown borer. The adult is a moth with clear wings and yellow bands on the body. Eggs are laid on the undersides of leaves in late summer and hatch to produce larvae that are white with a brown head. These crawl down to the base of the canes where they make small cavities and overwinter. In spring and summer the larvae feed within the crown and the roots causing canes and even entire plants to wilt and die. Insecticide drenches are used to control the larvae.

Diseases

Raspberry diseases can seriously reduce plant growth and yields. Some cultural control measures can effectively minimize or avoid serious disease problems. First choose varieties that are adapted to the region and, if possible, resistant to major diseases. Secondly, only certified disease-free raspberries should be planted. Lastly, use of proper cultural practices will promote healthy, vigorous plants that are generally less susceptible to disease.

Virus diseases. Virus diseases are the most damaging diseases of raspberries. There is no control measure to eliminate the virus once the plant is infected. Infected plants are weak and stunted and produce few canes. Yields are reduced and certain viruses can cause the berries to be dry, seedy and crumbly. The three most common viruses that affect red raspberries are raspberry mosaic, leaf curl and tomato ringspot.

The mosaic virus causes large, green leaf blisters surrounded by yellow areas. Canes are progressively stunted with small, deformed leaves and dry and crumbly berries. It is spread rapidly by aphids.

The leaf curl virus causes leaf curling with progressive stunting of the canes. The canes are yellowish at emergence and then become dark and brittle. Aphids spread the leaf curl virus.

Growth of plants infected with tomato ringspot virus is weak. A few leaves may show pale green rings in the spring but the rings disappear in midsummer. The canes of the most susceptible varieties die back while less susceptible varieties merely develop crumbly berries. Some varieties are tolerant of the ringspot virus and show no symptoms when infected. The virus has many hosts including weeds and may be spread by dagger nematodes.

No chemical control is available for virus diseases. Removal of infected plants is the only option. The best approach is that of avoiding virus problems by using only certified virus-free stock and through control of aphids and nematodes that spread virus diseases. Eliminate weeds that may be hosts for viruses.

Verticillium wilt. Verticillium wilt is caused by a soil-borne fungus. The leaves turn yellow, wither and drop. These symptoms appear first on the lower leaves and continue up the cane. Then the cane turns blue and dies. The vascular tissue has a discoloration. Red raspberries are not as seriously damaged as black raspberries.

To control, only certified stock should be planted in clean soil. All

diseased plants should be removed and burned. Foliage applications of fungicides are ineffective. Soil fumigation prior to planting is effective in some areas.

Powdery mildew. Powdery mildew is a relatively minor fungus disease that can infect leaves and shoot tips and sometimes the fruit. Persistent warm, humid weather favors rapid development of the disease. Infected leaves and shoot tips are covered with a white powdery growth. Leaves are cupped downward or distorted in shape and shoot tips are stunted and distorted. Affected fruit is tasteless and unsuitable for consumption. Few varieties are affected severely, but 'Latham' is susceptible.

If possible, plant resistant varieties where powdery mildew is a problem. Fallen leaves should be removed to reduce the number of spores in the spring.

Anthracnose. Canes infected with this fungus develop purple spots that expand and become grey with a purple border. Severely infected canes may be girdled or cracked. Infected leaves show similar spotting. Berries ripen abnormally and fruit stems are girdled.

This disease can cause severe damage if not controlled. Only disease free stock should be planted. The fungus overwinters within infected canes and starts the disease cycle the following year with spore production on these canes in the spring. Thus, removal and burning of all diseased canes is essential for good control. Fungicides can be applied in early spring just before bloom and at petal fall. Improve air movement within the row by controlling weeds and thinning canes.

Cane blight. Cane blight is caused by a fungus that enters raspberry canes only through wounds. Dark brown cankers appear on wounds and extend down the cane or encircle it. Infected canes turn grey in summer and laterals wilt and die.

All infected canes should be removed and burned in the spring. It is important to remove weeds and thin canes properly to allow for air movement within the row. To prevent cane blight, prune only during dry weather. If the disease becomes serious a dormant spray may be applied.

Other potential problems include phytophthora root and crown rot and spur blight. See publication XCM-49 for descriptions and control of the disease.

Fruit rots. Fruit rots are caused by several fungi. Rot may develop while the berries are still on the plant and in storage. Overripe and bruised berries are highly susceptible. Warm, wet weather favors disease development.

Solid, firm berries resist fruit rots best. The fruit should not be wet or bruised when picked. Proper cooling and storage are essential in preventing rots and increasing the shelf life of the berries.

Nematodes. Nematodes are microscopic wormlike organisms found in the soil and water. Nematodes attack plant roots causing direct injury and stunting overall plant growth and fruit productivity. Symptoms include weak lateral growth and small leaves on fruiting canes. Fruit may be crumbly and small. Leaves may turn yellow and drop early and plants may be more susceptible to winter injury. Roots may be stunted, matted, rotted or galled. In addition,

damaged roots are susceptible to soil-borne plant pathogens and some nematodes are vectors of virus diseases.

Soil should be tested before planting to see if a nematode problem is present. If a problem exists a nematicide application may be applied. To avoid a progressive buildup of nematodes it may be necessary to periodically rotate raspberry plantings with crops, such as small grains, that are not susceptible to nematodes.

Physiological disorders

Sunscald or fruit whitening. Sunscald or whitening of individual or groups of fruit drupelets is a common disorder of raspberries in some areas. The cause of fruit whitening is not fully understood. Exposure to excess heat and or high sunlight intensities are suspected of being involved. Observations show that fruit whitening is more severe in midsummer than late summer and early fall. Varieties vary in their susceptibility to fruit whitening. Red fruit varieties are more susceptible than light colored fruit varieties.

Leaf scorch. Sunburn injury to leaves can be a problem when plants are water stressed. Injured leaves show a bronze coloration. Leaf scorch can be prevented through proper irrigation scheduling.

HARVEST AND STORAGE

Red raspberries are highly perishable. The harvesting season should begin with an adequate supply of containers, arrangements for pickers and an established well-defined marketing system.

Picking. The picking season lasts about four to six weeks. Berries for fresh market must be picked every other day. The number of pickers required per acre can vary from six to twelve depending on their ability, the yield and other factors.

For best quality, raspberries should be picked when they are firm but well colored and when they are mature enough to come away readily from the receptacle. The berries should be removed using the thumb and two fingers with a turning motion or a gentle pull. Any diseased or insect damaged fruit must be discarded in the field because grading after harvest is impossible. It is important to avoid bruising berries while handling them and placing them in the container. Half pint boxes are best to prevent bruising and mashing, but pints also work if not overfilled. Filled boxes are then placed in shipping flats which should never be set directly on the ground. Clinging soil can contaminate the fruit.

The best time for picking is early morning when it is cool. The berries are firm and easy to handle. No picking should be done during the hot midday period or when the berries are wet from dew or rain. While picking, filled flats should be shaded from the sun at all times. They can be kept in a field shelter until they can be taken to cold storage. In addition, flats should be stacked in such a way as to leave air spaces that allow for release of field heat.

Storage and shipping. Raspberries should be kept cool from the time of harvest until they are eaten. They deteriorate rapidly at warm temperatures because of fungal rots and metabolic changes. Rapid cooling to 40°F can extend

the shelf life of the berries by one or two days.

The berries can be cooled rapidly by blowing cool air around and through the containers. Merely stacking the berries in a refrigerated room is not sufficient. Fruit entering the cooler contains field heat and gives off heat due to respiration. Berries in the middle of a stack may not be cooled sufficiently. Ideally, the berries should be cooled to the desired temperature in two to six hours.

Raspberries must be kept cool during shipping and at the market outlet. The berries are best stored at 33 to 40°F and at a relative humidity of 85 percent to 90 percent. Under these conditions they will retain good quality for up to three to four days.

Pick your own raspberries (PYO). Another method of marketing raspberries is selling the berries directly to customers who pick the fruit themselves. The advantages of this system for the grower are reduced needs for seasonal labor, packing and storage and receipts are available as the crop is harvested. The customer receives farm fresh produce at a lower price and may also enjoy picking as a form of recreation.

Several factors should be considered to make a PYO operation successful. Ideally the location should be close to a population center and be easily accessible. Advertising is essential to inform people when the crop will be ready, what times the operation will be open for picking and gives directions to find the farm. Newspaper, radio, and postcards to former customers are various ways to advertise. Cultural practices such as irrigation and pest control must be planned around the u-pick access, and provision made for parking, adequate insurance coverage, and personnel to supervise picking. Toilet facilities and drinking water should be available and consideration given to provision for child play area and picnic area. Berries can be sold by the pound or in standard size containers. If they are sold by the pound, the scales must be inspected and registered by the State Department of Agriculture. For information on scale licensing contact the following office: Colorado Department of Agriculture, Weights and Measure Section, 2331 West 31st Avenue, Denver, CO 80211, (303) 839-2845.

Public relations or how you handle your employees and customers is critical in running a smooth operation. Dealing with crowds of customers on a daily basis can be very taxing. Patience is a must to maintain good customer relations. Good planning can avoid uncomfortable situations. You should also become acquainted with your local county and state cooperative extension office. A national growers organization with which one should be familiar is: North American Bramble Growers Association, c/o Dr. Harry Jan Swartz, Department of Horticulture, University of Maryland, College Park, MD 20742.

Knowing your production costs is essential in order to establish a fair price for your crop. Selling your raspberries by weight instead of volume can eliminate many disagreements with your customers concerning price.

Profit is essential for the grower to stay in business. It can be increased by strictly following proven production practices and by maintaining good business relationship with employees and customers alike. Establish a fair price for your crop based on your production costs, whether based on weight or volume.

Bear in mind that many customer disagreements can be avoided by selling your raspberries by weight rather than volume. A reputation for fairness can be invaluable in establishing a viable raspberry business.

Sources

Plants

Ahren's Strawberry Nursery
R.R. 1
Huntingburg, ID 47542

Allen Co.
P.O. Box 1577
Salisbury, MD 21801

Nourse Farms
B485
Deerfield, MA 01373

Lewis Strawberry Nursery
P.O. Box 24
Rocky Point, NC 28457

Makielski Berry Farm and Nursery
7130 Platt Road
Ypsilanti, MI 48197

North Star Nursery
Route 13
Williamstown, NY 13493

Sakuma Bros. Farm
Box 427
Burlington, WA 98233

PYO Supplies

Cordage Packaging
66 Jarney Road
Dayton, OH 45404

Dewey-Carter Co. (sign kits)
Box 822
Doylestown, PA 18901

Fruit Picking Equipment Co.
Lawrence, MI 49064

Fruit & Produce Packaging Co.
Div. Anderson Box Co.
Box 1851
Indianapolis, IN 46206

Ben Meadows Co. (flags)
3589 Broad Street
Atlanta, GA 30366

Metro Equipment Corp. (scales)
187 Agnew Station
Santa Clara, CA 95054

Midland Plastic (pennants)
3001 East 30th Street
Indianapolis, IN 46218

Packaging Corp of America
1422 Packers Avenue
Madison, WI 53704

Promotional Items

American Knitwear
and Fabric Emblem Manufacturers
Plaistow, NH 03865 (shirts and emblems)

Lou Nor
244 Park Avenue, N.W.
New Philadelphia, OH 44663 (strawberry and fruit jewelry items)

Mechanical Supplies

Ahren's (see above)

Friday Tractor Co.
69226 Cr 687
Hartford, MI 49057

Mechanical Transplanter Co.
P.O. Box 10088
1150 South Central Avenue at US 31
Holland, MI 49423

Kennco Mfg. Inc.
P.O. Box 1158
Ruskin, FL 33570