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BERRY INFORMATION PACKET
VOLUME 1
RASPBERRIES AND BLACKBERRIES

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BLACKBERRIES AND RASPBERRIES

1. Domestic Production and Imports

Domestic brambleberry (raspberry and blackberry) production is confined primarily to Washington, Oregon, California, and Michigan. Reliable production figures are not collected by the U.S.D.A. The season in California extends from the second week of May through the second week of December. Washington and Oregon are normally shipping from the third week of June through the third week of September.

Imports from Chile can be found on the market from the second week of December through the third week of April. New Zealand imports follow a similar schedule from the second week of December through the third week of March, while Canadian imports are typically available from the last week of June through the third week of September.

Table 1. The major countries which currently export raspberries to the U.S.

Imports Into the U.S. 1986

Country	Metric Tons	1000 Dollars
Canada	7,217	14,668
New Zealand	178	1,336
Chile	323	1,070
Germany	12	133
Australia	4	30
Costa Rica	6	17
Brazil	3	11
Portugal	2	11
Argentina	1	8

Total raspberry imports for 1986 were valued at $17,311,000 and totaled 7,761 metric tons.

2. Market Prices

Typical wholesale prices for 1/2 pint containers of fresh red raspberries are in the $1.25 range during the peak season from June through September. Prices may increase to the $4.00 to $6.00 range in the off-season. The price per 12-pint is typically in $12.00 to $20.00 range.

Fresh market retail prices have a wide range. A typical 1/2 pint will probably sell for around $2.50. The retail price for canned products are in the $1.89 to $1.99/15oz. $2.02 to

$2.12/lb. range. I.Q.F. frozen packages are in the range of $2.59/12 oz. or $3.45/lb. Frozen blackberries are selling in the $1.89/12 oz. or $2.52.lb. range.

Wholesale bulk 30 lb. containers of red raspberries are currently selling at $.61-.63/lb. F.O.B. the Pacific Northwest. Blackberries are priced at $.68/lb. and black raspberries at $.75/ lb. F.O.B. The cost of shipment to the eastern U.S. is approximately $.06/lb.

3. Production

A primary consideration for the production of standard summer fruiting blackberries and red raspberries is the requirement of a dormant period and chilling requirement.

The factor of a chilling requirement is critical for proper flowering. All non-tropical blackberry cultivars require at least 200 hours of air temperature below 7 degrees Celsius (45 degrees F) to meet this physiological requirement, while red raspberries require 800 hours. Temperature below 10 degrees Celsius (50 degrees F) may be of benefit in meeting this need. Temperatures above 15 degrees Celsius (59 degrees F) may reverse the chilling process. Adequate chilling will probably only be obtained at elevations above 2000 meters (6500 feet) in Central America. Other potential experimental treatments to chemically break dormancy include cyanamide (4%), thiourea (1%), oil + DNOC (5%), KNO3 (5%) -see article attached to bramble report.

All other soil factors such as ph, drainage , and fertility should be quite compatible with the native conditions found in Central America.

Supplemental irrigation will be necessary for commercial scale production in most all situations. Brambles require a minimum of 2.5 cm of water per week for proper growth and fruit development.

4. Cultivar Recommendations

Very little information currently exists on bramble cultivars and their performance in Central America. I would suggest a trial planting of the following cultivars at several representative climatic sites.

Blackberry	Red Raspberry
(Erect Types)	(Summer Fruiting)
Cherokee	Meeker
Cheyenne	Titan
Roseborough	
(Trailing Types)	(Primocane Fruiting)
Thornless Evergreen	Heritage
Olallie	New York 114
Floridagrand	Fallred
	Amity
	Summit

The problem of inadequate chilling can be overcome by the use of fall-fruiting (primeocane-fruiting) red raspberry cultivars. In this case the fruiting canes (florocanes) are not biennial as they are in standard summer fruiting cultivars. With these plants the new shoot growth emerges from the crown and root system in the spring, the shoot grows for several months, sets terminal flower buds at the tip of the shoot, flowers, and fruits. This entire process normally takes about five months under cool temperate conditions. Under warmer conditions this cycle would take approximately 18 weeks to complete. Under these conditions it would be possible to continuously fruit a planting by having primocanes at every state of emergence, growth, flowering, and fruiting within the row. When an individual primocane has flowered it is simply cut off at the base and removed. This type of production would allow for a constant and uniform supply of fruit which is currently unavailable from any source in the world. This should allow for a unique and immediate market niche. Establishment of a consistent market presence has traditionally been a key factor in the success of individual produce items.

Additional studies on plant management and post-harvest treatment is needed. The post-harvest bleeding and breakdown of large soft blackberry fruit will present significant problems in handling, transportation, and storage. Red raspberry fruit should be less prone to bleeding but is still one of the most rapidly perishable of all fresh produce crops. The use of rapid cooling to remove field heat from the fruit, cold storage, refrigerated transport, and modified atmospheres in the package will all be important components of a successful export program.

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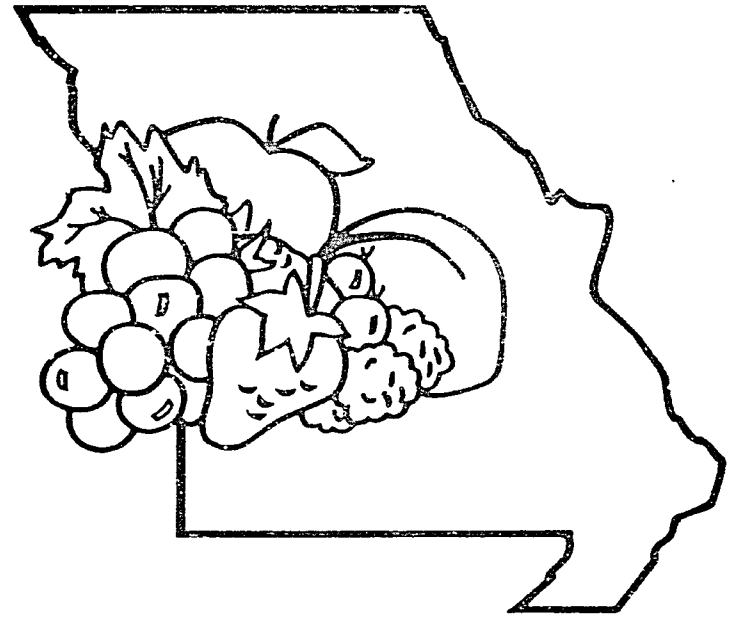
GROWING FALL BEARING RED RASPBERRIES AS A SMALL SCALE COMMERCIAL ENTERPRISE



STATE FRUIT EXPERIMENT STATION
of
SOUTHWEST MISSOURI STATE UNIVERSITY

GROWING FALL BEARING RED RASPBERRIES AS A SMALL SCALE COMMERCIAL ENTERPRISE

One of the major limiting factors in successful raspberry producation has been the large amount of hand labor necessary to produce this crop, especially pruning labor. A recently introduced cultivar "Heritage," has a different growth habit which considerably reduces the pruning time. Raspberries normally fruit on two year old canes. A new shoot emerges from the roots during the spring and grows all summer. The flower buds are formed within the buds during the fall. These flower buds open during the next spring and produce fruit in June. After fruiting, the cane dies. These fruiting canes must be removed by hand pruning from among the newly developing first year canes, which will fruit the following year.

"Heritage" produces fruit on one year old canes. These canes emerge during the spring and begin developing flowerbuds in July. These flowers open and begin producing fruit by the end of August. Fruit develops consecutively down the cane until the first hard freeze of the fall. These canes can then be mowed to the ground during the winter. New canes will develop from the roots the next spring and fruit in that fall. All hand pruning is eliminated as well as the problems of spring frost damage to the flowers and overwintering diseases.

Another labor saving practice is the willingness of customers to "pick-their-own" fresh produce. This eliminates the need for costly harvest labor, storage, and marketing outlets. Many customers will drive a considerable distance to pick fresh fruit in a well tended planting.

Site Selection

Raspberries demand a fertile soil with a high organic matter content and good drainage. Select a well drained site, because the humus content can be improved more cheaply than can the drainage of a wet site. (See Soil Preparation.) Poorly drained bottom land should be avoided. Raspberry plants will grow poorly if their roots are under water for more than a day at a time.

The best location for a site is on the north side of a slope or an area that gets some shade in the afternoon. This keeps the soil slightly cooler and moister. Soils in other sites can be kept cool by increasing the amount of mulch applied.

It is not necessary to plant 'Heritage' raspberries on a hilltop for frost protection. They bloom in July and August and thus avoid spring freezes.

The final aspect of site selection is water. Raspberries must have at least one inch of water per week for good fruit production. This means that irrigation is necessary. The site should be near some water source such as a well, a pond, or a spring. In the absence of rain for a week, each foot of row of raspberry plants will require two gallons of water. This equals 8,100 gallons of water per acre of raspberries per week.

Soil Preparation

There are three main factors in soil preparation: adjusting the fertility and pH, building up the organic matter, and destroying perennial weeds. The system presented here to accomplish these three things is not the only system, but it is one that was used successfully at the State Fruit Experiment Station for a recent 'Heritage' planting.

Most sites are usually in permanent pasture or weeds. The rows should be marked off first. A north-south orientation is preferable if there is no erosion problem. On steep slopes, rows should follow the contour. The row centers should be 10 feet apart, but could be from 8-12 feet, depending on the size of equipment. Glyphosate herbicide (Roundup) should be sprayed 18 inches on either side of the row center. This will leave 3 foot treated strips, with 7 foot grass middles between the row.

Roundup herbicide is expensive, but it will do the most thorough job of weed control if properly applied. It must be sprayed directly on the leaves of actively growing plants to be effective. It moves through the plant and kills the roots as well as the tops. Large weeds such as brambles or multiflora rose will not look dead but they will not grow back the following year.

Roundup is best applied with a small sprayer used exclusively for weed spraying because of the danger of residues applied when not wanted. It is quickly deactivated in the soil so contamination should not occur if it is used correctly. Two weeks after the herbicide treatment, the sprayed strips can be plowed and disked. This should leave three foot plowed strips separated by seven foot strips of grass.

Soil samples should be taken from the plowed strips. Use a small shovel or trowel to dig 10-15 samples of the soil up to 12 inches deep. Thoroughly mix the samples in a bucket and submit 1 cup of soil in a paper bag to the local Cooperative Extension Office for analysis.

The Extension Service will send the grower written recommendations on bringing the soil up to the proper fertility. The pH should be corrected to 5.5-6.5. The P level should be at least 50 lbs/A and the K test at least 300 lbs/A. Materials that are needed should be added only to the plowed strips. Remember that in one acre of land only 30% is plowed. A fertilizer recommendation of 200 pounds per acre would actually be applied to the strips on one acre at 30% x 200 or 60 pounds. Lime can be applied by hand to the strips. A large area is more cheaply limed by truck.

The application of 10-12 tons of cow manure per acre (3 to 3½ tons on the strips) or 5-6 tons of hog or chicken manure per acre (1½-2 tons on the strips) will improve the soil. This will increase the organic matter content of the soil. The amount is equivalent to 150 pounds of cow manure or 75 pounds of hog or chicken manure per 100 feet of row.

Any other rotted plant material can be used in place of manure. Grass clippings, spoiled hay or straw, chopped leaves, sawdust, or bark-chips all make good soil amendments. Old hay, however, often contains many weed seeds.

Sawdust or wood chips are a readily available by-product of the many lumber mills in the area. These are excellent materials for improving the soil. Spread the material on the strips approximately 2-4 inches deep. An equal amount of manure should be added to help this material decompose properly.

Materials that are not fully rotted must be decomposed before the raspberries are planted. Fertilize the strips as the organic matter is spread on the soil by sprinkling ammonium nitrate (33-0-0) at the rate of 50 pounds per ton of material or ½ cup per bushel.

The recommended amounts of lime, phosphorus, and potassium can also be added now. These are then plowed or tilled into the strips. Be sure that this material is thoroughly mixed. The strip should settle for the rest of the summer. Shallow cultivation should be used to keep weeds under control.

Wet areas can be improved by raising the beds where the raspberries are to be planted. The addition of organic matter will help to raise these areas. A blade on a tractor can be used to scrape soil from the row middles on to the row centers. This will produce wide, slightly raised beds and drainage areas between beds. These drainage areas should be cleared at the low end of the field to allow standing water to escape (Figure 1).

Plant Selection

It is important to obtain plants from a reliable nursery. Raspberries can be infected with a number of virus diseases which will cause a planting to lose vigor and yield. Nurseries that sell disease free and virus free certified stock are inspected by the state Department of Agriculture and certified to be free of these problems. It may be cheaper in the short run to dig up extra plants at a neighbor's field, but the likelihood of those plants being infected and not producing well is high.

South of the Missouri River, 'Heritage' raspberries should be planted in the fall. This means the order must be placed by mid-summer or no later than the end of August. Plants for spring planting should be ordered in the early fall, at least by October, to be sure enough will be available. More plants than are needed should be ordered to insure replacements for ones that do not grow.

Planting and Early Care

The plants should be inspected immediately upon arrival. The roots should be moist and brown. Black, soggy, or moldy roots indicate poor plants. The nursery should be notified immediately.

Plants that are not to be set soon should be stored in a cool (35°-45°F.), dark storage room. Any bundles that have dried should be moistened by soaking the roots in water for 6 hours. A root cellar is fine, but make sure the plants stay moist, not wet. The plants can also be lined out in a trench. A furrow or trench is dug about 8 inches deep. The bundles of plants are placed in the trench with the roots down and the tops above the soil line.

The trench is filled with soil and the tops of the plants are mulched. The soil should be soaked with water as soon as possible.

Raspberries can be planted from 2-3 feet apart. It will be more expensive to plant them 2 feet apart, but they will yield more the second year. By the third year, each row should be a solid hedge regardless of initial spacing. The easiest method of planting raspberries is to plow a furrow down the center of each row. A stick marked at the correct interval can be used to space the plants. It will help the young roots to soak them in a thin slurry of mud and water for several hours before being planted in the furrow. This coating keeps the roots from drying out.

Number of Plants per Acre

	space between plants		
Space between rows	*24 inches*	*30 inches*	*36 inches*
8 feet	*2719*	*2175*	*1812*
10 feet	*2175*	*1740*	*1450*
12 feet	*1812*	*1450*	*1208*

Fig. 1. Prepared bed. Notice the slope into the ditch on one side.

A two or three person planting team can operate very efficiently. One person can hold the measuring stick and lay the plants in the furrow and spread the roots (Figure 2). One or two people following should cover the plant roots immediately with soil and tamp it down firmly to remove any possible air pockets around the roots.

The plants should be set at the same depth as they were in the nursery. The piece of cane, known as a handle, should be above ground. The roots should be evenly spread at the same depth as in the nursery before being covered with soil. Each plant should be watered with at least one quart of water after planting.

Newly planted raspberries should be mulched. Sawdust or woodbark chips make an excellent mulch because they are free of weed seeds and produce a thick mat on the soil surface. Any available organic material, such as straw, hay, grass clippings, or chopped leaves may be used. This mulch will protect the tender roots of the plants through the winter as well as keep the soil moist (Figure 3).

Black plastic mulch can not be used on raspberries. Raspberries renew their fruiting canes each year. New canes emerge from the roots. A film of plastic mulch will prevent canes from emerging.

Fig. 2. Planting the plants in a furrow. The canes are spaced 2 feet apart by means of a premeasured stick. The canes are in the bucket filled with water. The trench is filled and lightly tamped after the canes are placed in it.

Fertilization

'Heritage' raspberries require more nutrients than other raspberries or blackberries, because all canes must be renewed each year.

Manure and/or mulch applied will usually supply all the nutrients needed except nitrogen. Ammonium nitrate can be used to supply the nitrogen when manure and/or mulch are used as sources of the other nutrients. The mulch will bind some of the nitrogen for the first 2-3 years. After that period, the breakdown of the mulch should release adequate nutrients to the plants. Additional mulch should be added each year to replace the amount converted to soil organic matter and used by the plants.

Approximately 100 pounds of actual nitrogen should be spread on the 3-foot strips of each acre the first year. This is equal to 330 pounds of ammonium nitrate (33-0-0) per acre or six pounds per 100 feet or row. Where mulch is not used, apply ½ the above rate.

Manure is an excellent source of plant nutrients for raspberries. It can be applied anytime from late fall to early spring when the plants are dormant. It should be applied at the rate of 2-3 tons per acre or 100 pounds per 100 feet of row for cow manure. Poultry manure should be applied at about one half the above rate.

Fertilizer applications in the later years should be based on the appearance of the plants. Nitrogen is usually the element lacking. Small canes will yellowish green leaves indicate a lack of nitrogen. The canes should reach 5-7 feet in height with healthy green leaves before flowering.

Generally 50 to 100 pounds of actual nitrogen either as fertilizer or manure should be applied before growth occurs in the spring in subsequent years. A second "booster" application of 30-50 pounds actual nitrogen should be applied when the flower buds begin forming during July. The fertilizer should be evenly spread over the whole row and not banded down one side.

Irrigation

Red raspberries are a shallow rooted crop and are susceptible to lack of water for even a short period of time. A soil that is high in organic matter and is mulched heavily will provide enough moisture for sustained growth in some years. The typical soils of the Ozarks do not have enough moisture holding capacity for the good growth of red raspberries. Some type of irrigation system to supplement the rainfall will usually pay for itself with increased yields in a few years and will be necessary for plant survival in hot, dry years.

The method of watering raspberries can be as simple as a garden hose and sprinkler or as complex as an electronic timer controlled trickle irrigation system. A small planting can usually be watered by a soaker hose, trickle, drip or sprinkler. Large plantings should install a permanent watering system before planting.

The soaker or trickle system of irrigation applies water through emitters which are plugged into a black plastic line laid down the row. The advantage of drip or trickle irrigation is that it waters only raspberries, not the grass between rows. A sprinkler system which covers the whole field must apply 27,000 gallons to one acre in order to equal one inch of rain. A trickle irrigation system would only use 8,000 gallons. Sprinklers, on the other hand, can be useful during very hot weather to reduce the field temperature.

Detailed specifications and design information on irrigation systems are available from the Fruit Experiment Station and area Cooperative Extension Agriculture Engineering Specialists.

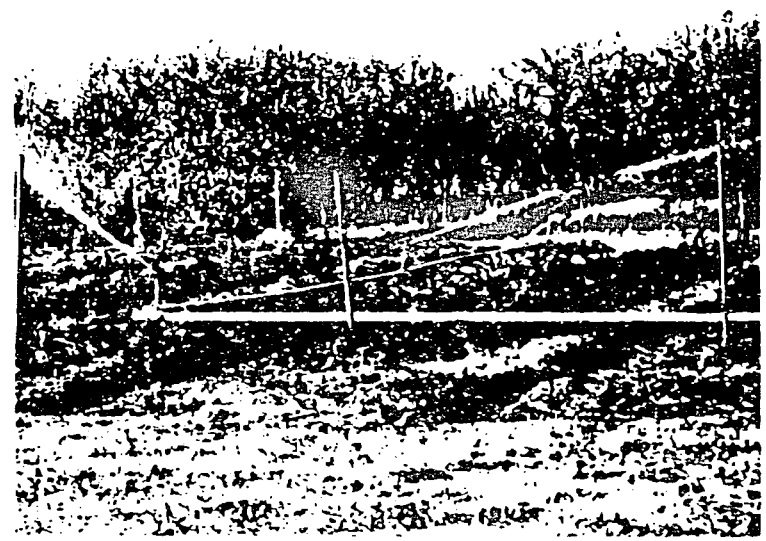


Fig. 3. The completed planting is irrigated. The beds have been mulched with wood chips. The drainage ditches have been left open

Weed Control and Soil Management

Currently there are no herbicides registered for use in newly established 'Heritage' plantings. The most feasible method for weed control the first season is to mulch in the row and mow the aisle frequently.

Research has shown that mulched plantings consistently produce the highest yields and largest berries. Mulch not only suppresses weeds, but it also keeps soil temperatures from fluctuating, thus allowing better root growth. Mulch inhibits evaporation of moisture from the soil. It also breaks down slowly, supplying nutrients to the roots and building the organic matter content of the soil.

Mulched plantings require hand pulling or hoeing every few weeks to remove the few weeds that become established. Plantings that are not mulched should be hoed more often and cultivated mechanically only 1 or 2 inches deep.

A pre-emergent herbicide can be applied in the first fall after planting. Enide 50W or Simazine may be applied to 'Heritage' raspberries at the rates listed on the container. It should be remembered that one acre of land with rows spaced 10 feet apart has only 30% of the area actually under raspberries. Directions on the container may recommend 10 pounds per acre. Each acre of raspberry field would only receive 3 pounds applied on the rows.

Good weed control using herbicides is possible if:

1) All equipment is maintained and calibrated.
2) The recommended rate is applied.
3) The material is applied at the right time and during the right weather conditions.
4) The herbicide used is known to be effective against the weeds found in the field.

Pruning

'Heritage' red raspberries are mowed to the ground after the leaves are killed by a hard frost. Using a brush hog, lawn mower, or hand shears, the canes should be cut as close to the ground as possible.

Marketing

Red raspberries are a highly perishable crop. Their quality deteriorates within 24 hours after picking, even with refrigeration. The plants must be picked at least three times per week during warm weather and twice per week during cool weather in order to achieve the maximum harvest of ripe fruit.

These berries are best marketed through a U-pick type operation. It takes approximately 300 customers to pick one acre of 'Heritage' red raspberries per season. A convenient location and good advertising are the keys to attracting enough customers. Pickers also appreciate adequate parking, an organized operation, and a mud and weed-free field.

Red raspberries bring an excellent price at a road-side stand or a farmer's market. To avoid spoilage of fruit, pick only as much as can be sold in about 5 hours. It takes approximately six full-time pickers to pick an acre. Picking can be accelerated with the use of a picking belt that will hold 2 pint containers. Filled containers must be stored in the shade or in a cooler.

Good management is the key to a successful operation. More money will be made on a well-managed small field than on a poorly managed larger one. A record of all expenses and income should be kept. The appended form may be used to plan the budget. The State Fruit Experiment Station at Mountain Grove and the Department of Agricultural Economics, University of Missouri, Columbia, can assist in preparing budgets and in management techniques.

'Heritage' Raspberry Planning Calendar

Before Planting

January	1) Discuss plans with Fruit Experiment Station or Cooperative Extension Service.
February	2) Site Selection 3) Write for information on irrigation.
March	1) Lay out planting. 2) Begin collecting organic matter.
April	3) Plow 3 foot strips. 4) Soil tests.
May	1) Apply Roundup to actively growing weeds in 3 foot strips. 2) Spread organic matter 2-4 inches deep on the strips.
June	3) Add lime, potassium, phosphorus as indicated on soil test. 4) Mix fertilizer and organic matter in the soil.
July	1) Shallow cultivation of the strips every few weeks to remove weeds. 2) Mow row middles as needed.
August	3) Plan irrigation system. 4) Order plants.
September	1) Make sure plants will be available.
October	2) Stock pile mulch to spread over plants.
November	1) Inspect newly arrived plants. 2) Plow a shallow furrow down the row center for planting the plants. 3) Plant the plants and mulch them. 4) Remove above ground portions of planted canes. 5) Apply at least 2 inches of water to dry soil, 1 inch to moist soil. 6) Store extra plants in cool moist place.

After Planting - 1st season

January	1) Finalize irrigation plans and obtain the material.
	2) Prepare to install irrigation when weather permits.
	3) Order fertilizer or obtain manure and spread it on the planting.
March	4) Attend meetings and seminars.
April	1) Install irrigation system and test it.
	2) Watch for growth of plants.
May	1) Replace dead plants.
	2) Pull or hoe weeds as needed to keep planting clean.
June	3) Use irrigation whenever less than 1 inch of rain has fallen per week. Do not over water after large rains.
July	4) Mow grass in the spaces between the rows as needed.
August	1) Pick a few ripe fruit for the family.
September	2) Add mulch to make up for that which has decayed.
October	3) Continue weeding and watering as needed.
November	1) Apply pre-emergent herbicide, if desired, to ground under raspberry plants - use ½ rate in fall and ½ in spring.
	2) Drain irrigation lines and prepare the irrigation system for winter.
December	1) Cut canes to ground.
	2) Order fertilizer or obtain and spread manure.
January	3) Plan marketing techniques: Call farmer's markets, attend meetings, or contact super markets.
	4) Plan marketing strategy: Make signs; cards; handouts; prepare parking site; obtain containers, etc.
February	5) Attend meetings and seminars.
	6) Repair equipment.

Second and Following Seasons

March	1) Apply chemical fertilizer and ½ rate pre-emergent herbicide, if desired.
	2) Test irrigation system.
April	1) Pull or hoe weeds as needed.
May	2) Water as needed.
June	3) Mow aisles frequently, especially at the edges of the beds to keep canes in a 3 foot wide row. (Use an edging machine.)
July	1) Apply supplemental fertilizer when flower buds appear.
	2) Prepare advertising and marketing arrangements.
	3) Continue weeding, watering, and mowing.
August	1) Begin picking and selling fruit.
	2) Keep planting clean.
	3) Water as needed.
September	1) Continue harvesting.
October	2) Continue watering and weeding as needed.
November	1) Continue harvesting.
	2) Mulch and water as needed.
	3) Apply pre-emergent herbicides at ½ rate, as desired.
	4) Cut canes to ground.

BUDGET FOR U-PICK 'HERITAGE' RED RASPBERRIES

W. W. Thomas, Direct Marketing Specialist
University of Missouri - Columbia

	Establishment Period	2nd Year	My Budget
1. Yield (pounds per acre)[1]	-	4,000	_____
2. Price per pound[2]	-	$ .80	_____
3. Gross income per acre	-	$3,200	_____
VARIABLE COSTS PER ACRE			
4. Plants[3]	$ 545	$ -	_____
5. Fertilizer, lime, etc.[4]	125	40	_____
6. Machinery costs[5]	125	125	_____
7. Irrigation costs[5]	125	125	_____
8. Production labor[6]	125	125	_____
9. Pesticides	30	40	_____
10. Harvesting supplies	-	100	_____
11. TOTAL VARIABLE COSTS PER ACRE	$1,075	$ 480	_____

12. INCOME OVER VAR. COSTS[7]	$	$2,720

1 6-quart tray weighs 8-10 pounds; 3-quart tray weighs 4 pounds; quart tray weighs 1¼-1½ pounds; pint weighs ¾ pound.

2 Price may vary due to location and demand.

3 Plants are spaced 2 feet apart in rows 10 feet apart.

4 Go by soil test and recommendations.

5 Machinery and irrigation costs are listed at custom rates.

6 Labor is computed at $5 per hour. No hand pruning required if plants are mowed down with brush hog or lawn mower after harvest in the fall or winter.

7 Income to pay costs of land, buildings, management, harvesting, hauling, sales tax, sales tax bond, advertising, interest, special liability insurance, commission, utilities, etc.

SOURCES OF PLANTS, SUPPLIES, AND EQUIPMENT

Inclusion or exclusion of companies on this list does not constitute a recommendation.

Source of Plants

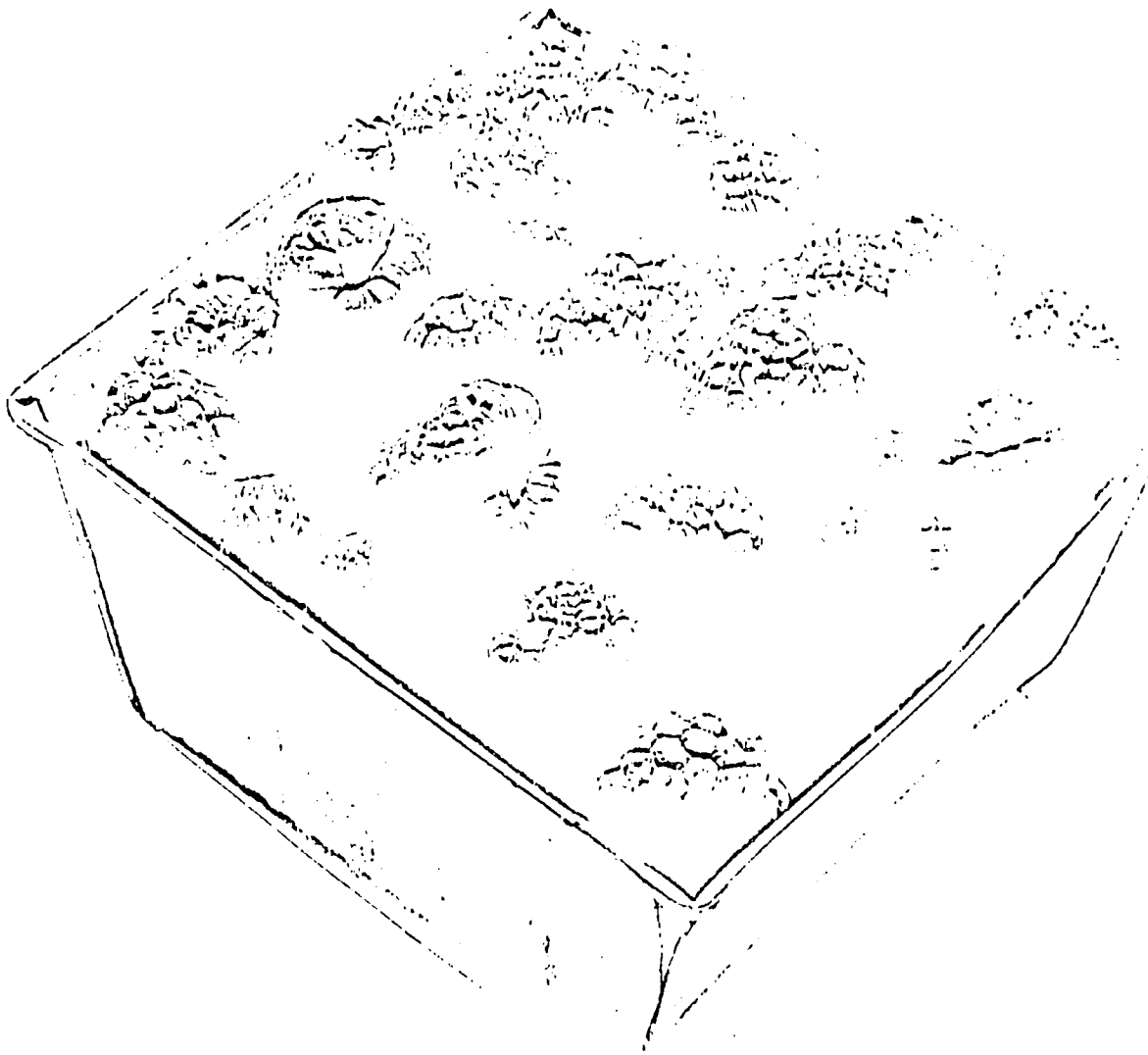
Ahrens Nursery, Route 1, Huntingburg, IN 47542
Bountiful Ridge Nurseries, Princess Anne, MD 21853
Congdon and Weller Nurseries, Mile Block Road, North Collins, NY 14111
Makelski Berry Farm, 7130 Platt Road, Ypsilanti, MI 48197
Rayner Brothers, Salisbury, MD 21801
Stegmaier Nursery, Route 4, Cumberland, MD 21502

Supplies

Anderson Box Co., 663 North 20th Street, East St. Louis, IL 62205
Packaging Corp. of America, 1603 Orrington Avenue, Evanston, IL 60204

Irrigation

The Berry Patch, Route 2, Box 247-B, Cleveland, MO 64734
S & H Equipment Co., Lockwood, MO 65682
Submatic Irrigation Systems, P.O. Box 246, Lubbock, TX 79408



COMMERCIAL RED RASPBERRY PRODUCTION

COMMERCIAL RED RASPBERRY PRODUCTION

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This publication combines all available information related to red raspberry production in the Pacific Northwest. Specific pesticide recommendations are not included because of frequent changes in materials and rates. Annually updated pest control guides are available from Cooperative Extension offices in the individual states.

Edited by William P. A. Scheer, Washington State University, and Ralph Garren, Oregon State University. Contributors: Arthur L. Antonelli, Bruce H. Barritt, Ralph S. Byther, Richard W. Carkner, Perry C. Crandall (ret.), John C. Dodge (ret.), William A. Haglund, Robert A. Norton, Dwight V. Peabody, Nolan B. Servoss (ret.), Carl H. Shanks, Paul A. Wesseler (ret.), all from Washington State University, and Dennis M. Burgett, Joseph Capizzi, Glenn C. Fisher, Roland H. Groder (ret.), Harold J. Jensen, and Lloyd W. Martin, all of Oregon State University.

INTRODUCTION

HISTORY

Cultivated raspberries of North America originate from two groups: 1) red raspberries, *Rubus idaeus*, native to Europe; and 2) *Rubus strigosus*, native to North America.

The red raspberry in Europe did not attract enough attention to be called a cultivated fruit until the 16th century. No doubt it crept into fields and was more or less cultivated from the very beginnings of agriculture in the regions where it grows wild.

The first mention of the American red raspberry as a garden fruit came in 1771 when three raspberry varieties were offered for sale by a person in New York. An 1832 pomological manual lists 18 red raspberry varieties. A list issued in 1867 lists 41 varieties known in American gardens. Much breeding has been done since then to improve varieties for local conditions. Many of the leading varieties now being grown in Washington and Oregon were developed from the Lloyd George variety. Although this variety is not well adapted for production in North America, it is the parent of such improved varieties as Willamette, Canby, and Washington. The Puyallup and Sumner varieties are progeny of the Washington variety. Willamette is the leading commercial variety.

Nearly all the red raspberries produced in Washington and Oregon are sold to processors for freezing. Red raspberries are excellent for fresh consumption but are difficult to ship long distances. Fresh market sales, therefore, are concentrated in the urban areas near the producing fields.

BOTANY

The red raspberry is in the Rosaceae (Rose) family and the genus Rubus. Plants are perennial with roots living for many years. The cane or stem lives only two years. Cane growth occurs the first year. Flowers and fruit are produced the second year and the cane then dies. New canes are produced each year from underground roots or basal cane buds. Some varieties produce fruit on the upper portion of current season canes in late summer or fall and fruit on the lower portion the following summer.

Canes are upright or semi-erect and may reach a height of 8 feet or more. Stems may have sharp, strong thorns or spines, have scattered, weak prickles, or be essentially thornless. Leaves are mostly trifoliate, ovate, and deciduous in the Northwest.

The fruit is an aggregate composed of 75 to 125 drupelets held together by their geometrical symmetry and a network of fine, nearly microscopic, interlacing hairs. The fruit differs from blackberry and other dewberries in the same genus in that it separates from the receptacle, producing a hollow fruit with no core.

NUTRITIVE VALUE

One cup of fresh red raspberries (123 grams) provides 50% of the recommended daily allowance of vitamin C, one-tenth of the iron, and useful amounts of other vitamins and minerals, but only 70 calories. Raspberries are low in sodium and therefore suitable for a low-sodium diet.

Composition of 100 grams (3½ ounces) of fresh red raspberries includes water, 84.2 grams; protein, 1.2 grams; fat, 0.5 grams; carbohydrate, 13.6 grams; fiber, 3 grams; ash, 0.5 grams; calcium, 22 milligrams; phosphorus, 22 milligrams; iron, 0.9 milligrams; sodium, 1 milligram; potassium, 168 milligrams; magnesium, 20 milligrams; vitamin A, 130 international units; thiamine, 0.03 milligrams; riboflavin, 0.09 milligrams; niacin, 0.9 milligrams and vitamin C, 25 milligrams.

MARKETING

Red raspberry growers in the Pacific Northwest have several available market outlets. To maximize returns, growers should consider the various alternatives and decide which is best from a personal standpoint.

Growers wanting to sell red raspberries to processors should obtain advice, counsel, and a contract agreement prior to planting. The contract should stipulate variety, acreage to plant, and whether the berries will be harvested by hand or mechanical means. The grower should also determine ahead of time whether the contract should be negotiated personally with the processor or whether he should depend on group action with an association of growers negotiating the terms.

Recently fresh marketing has gained in importance due to new varieties, new technology in handling, shipping, and packaging, and the desire of many consumers to buy produce direct from the farm. Red raspberries from the Pacific Northwest, if properly handled, can be placed on the market in prime condition in New York, Paris, or Tokyo.

For fresh market, varieties are very important. Each grower should have varieties that permit shipping throughout the season, or be prepared, through a cooperative arrangement, to achieve this goal. High quality, stability, and reliability are essential.

Growers involved in a shipping deal must have adequate packing and cooling facilities and be prepared to ser-

vice the market at the appropriate time, with adequate volume, and at the market price. It is all right to take orders a day or two in advance on the local level, but prices should be negotiated prior to committing a volume of berries for delivery. Local markets include retail store buyers, wholesalers, nursing homes, schools, hospitals, hotels, restaurants, and other institutional users. In most metropolitan areas, consumer buying clubs, store fronts, and cooperatives offer good market outlets for fresh raspberries.

Selling directly to consumers through roadside stands and markets, U-pick operations, or rent-a-farm operations may also be a successful market outlet for many tons of red raspberries. Many communities in the Northwest have retail farmer markets. This alternative should also be considered as a marketing outlet.

Each market outlet requires its own production technique, technology, and business acumen to be successful. It is of the utmost importance that the plan precede the planting. Only carefully planned ventures and full commitments are likely to be successful.

PRODUCTION AND PRICE STATISTICS

Item and Area	Unit	1976	1977	1978	1979r	1980p
Acreage Harvested						
Oregon	acres	2,000	1,900	1,900	2,000	2,100
Washington	"	2,900	2,800	2,600	2,600	2,800
Two-state total	"	4,900	4,700	4,500	4,600	4,900
Yield Per Acre						
Oregon	lbs	4,500	5,530	5,050	5,000	5,050
Washington	"	5,080	5,230	5,100	4,900	4,500
Two-state avg. yield	"	4,843	5,350	5,080	4,943	4,735
Total Production						
Oregon	thou lbs	9,000	10,500	9,600	10,000	10,600
Washington	"	15,012	14,980	13,260	12,740	12,600
Two-state total	"	24,012	25,480	22,860	22,740	23,200
Utilization of Sales						
Oregon						
fresh	thou lbs	800	700	400	700	600
processed	"	8,200	9,800	9,200	9,300	10,000
Washington						
fresh	"	1,312	1,615	1,017	1,790	2,240
processed	"	13,420	13,029	12,243	10,950	10,360
Farm Price						
Oregon						
all	¢/lb	31.8	51.0	74.6	68.2	28.1
processed	"	30.8	50.4	74.8	68.8	26.7
Washington						
all	"	29.6	44.6	70.4	69.5	37.2
processed	"	28.3	44.1	70.7	68.5	30.2

r-Revised. p-Preliminary.

RELATED PUBLICATIONS

The following references are available from county Extension offices.

Washington State University

Insect, Disease, and Weed Control Guide, Commercially Grown Raspberries, EB 0847.
Scheduling the Irrigation of Red Raspberries from Evaporation Pan Data, XC 497
Fertilizer Guide: Red Raspberries, FG 22
A Hooded Spray Boom for Caneberries, Bush, or Vine Fruit, EB 638
Costs of Owning and Operating Farm Machinery in Washington, EM 4035
Red Raspberry Production Costs and Returns, EM 4522

Oregon State University

Spray Program for Cane Fruits in Oregon, EC 852
Improving Bee Pollination of Commercial Caneberries, EC 953
Fertilizer Guide Red Raspberries (Western Oregon—West of Cascades), FG 49
Growing Red Raspberries in Oregon, EC 764
The Raspberry Crown Borer and Its Control, CI 615
Commodity Data Sheet: Red Raspberries.

United States Department of Agriculture

Controlling Diseases of Raspberries and Blackberries, F 2208
Growing Raspberries, F 2165

ESTABLISHMENT

SITE SELECTION

Climate. The most favorable climate for red raspberry production is one providing a relatively cool summer, a rain-free harvest season, and a mild winter just sufficiently cold to satisfy the chilling requirement of approximately 800+ hours below 33°F. Hot, dry, windy weather during early summer will retard cane growth and contribute to softness and seediness of berries. Excess heat during fruit ripening may cause softness, color loss, and scalding of fruit. Rain during harvest creates soft fruit and contributes to fruit rot caused by fungal infections. The raspberry is one of the hardiest of the brambles; roots will tolerate temperatures down to −2°F without damage. Damage to basal tissue, tips, and buds may occur as a result of winter cold, especially if accompanied by drying wind. The amount of winter injury is dependent on the degree and duration of cold and the preconditioning and carbohydrate level of the plant. The moderate climates of western Oregon and Washington are nearly ideal. Areas east of the Cascades are often risky because of extremes in winter and summer temperatures, and the frequency of drying winds. Local climate may be modified by topography. Sloping land may provide good air drainage and avoid frost and freeze damage that occurs in low areas where cold air is easily trapped. Exposed, windswept sites are more likely to promote damage than protected or sheltered sites.

Soil requirement. Desirable soil for raspberries should have depth, high water-holding capacity, good drainage, adequate fertility, and freedom from erosion problems. A loam or sandy-loam soil 2 to 4 feet deep is best suited. Under ideal soil conditions and good cultural maintenance, a planting may remain productive for 10 years or more. Heavy, poorly drained soils are wet and cold. Plants respond with poor growth and yield and the life of the planting is markedly reduced. Some root diseases are enhanced in heavy wet soils. Raspberries should not be planted in soil of this type. Sandy and gravelly soils are to be avoided unless irrigation is available because of their inability to hold moisture and nutrients.

SOIL PREPARATION

A soil improvement program prior to planting is recommended unless the area to be planted has been in sod, hay, or other soil-improving crops. A green manure crop plowed under before planting will help establish organic matter and improve soil tilth. Cereal rye does well for this purpose. It should be planted in early September and worked into the soil in the spring prior to planting. The cover crop should not be allowed to develop beyond the heading stage. The breakdown of heavy straw requires large quantities of nitrogen. When large quantities of straw are mixed with soil, additional nitrogen must be provided or the available nitrogen may become tied up by the straw and not be available for plant growth. If the material is left on or near the surface, there should be no need for extra nitrogen.

Barnyard and poultry manure are good sources of organic matter and plant nutrients. If available, apply annually during early spring 8 to 12 tons of barnyard manure, or 5 to 6 tons of poultry manure, per acre. Since manures are low in phosphorus, applications of commercial fertilizers will likely be needed. A soil test is required to identify specific needs. Refer to discussion on fertilizers for more information.

Eliminate noxious weeds, such as Canada thistle and quackgrass, before planting. Areas that have been in sod should be cultivated or cropped for at least one year to kill the grass. Strawberries, tomatoes, or even other raspberries are hosts for Verticillium wilt and may contaminate the soil. Determine if this is a problem before establishing a new planting. A nematode test to determine the number and kinds of nematodes is essential. Fumigation may be advisable if nematodes are present. See discussion on soil fumigation for additional information.

VARIETIES

Red raspberry varieties can be divided into two types. Summer-bearing varieties produce canes that are biennial in habit, growing one year and producing fruit the next. Fall-bearing varieties produce canes which bear fruit on the upper portions of the cane in the same growing season. These canes, if left for the biennial year, will bear fruit on the portions that did not fruit in the previous season. This type can fruit in both early and late summer. The root systems of both types are perennial and the plants are capable of living for many years.

Most commercial varieties in the northwest are of the type that produce one crop per year. There is growing interest in the varieties that produce in both early and late summer to supply fruit for fresh markets. Such varieties may also be used to avoid damage from winter freeze and late frosts in the early part of the year. This can be useful in the areas with more severe climates.

Willamette (1942 release, Oregon-USDA). Industry standard, comprising the major portion of Oregon-Washington acreage. Fruit large, dark red, fairly firm and suitable for processing. Ripens early and may overlap with late strawberry harvest. Shakes off mechanically when fully ripe.

Plants very vigorous and productive in good, well-drained soils. Canes medium size, tall, and sprawling. Laterals medium length and strong. More susceptible to freeze injury than Sumner. Susceptible to root rot.

Meeker (1967 release, Washington). Second leading variety in the Pacific Northwest and increasing in acreage. Fruit large, bright red, and firm. Excellent for processing and fresh market. Low susceptibility to *Botrytis* fruit rot. Harvest season 4 to 7 days later than Willamette. Can be harvested mechanically as the fruit shakes off readily. Provides a more desirable mechanically harvested product than Willamette because of lighter color, but its long laterals can be damaged by harvest machines.

Plants are very vigorous and have been very productive on well-drained soils. Canes large in diameter, very tall, and tend to flop over. Fruiting laterals long and fairly strong. More susceptible to freeze injury than Sumner. Susceptible to root rot.

Sumner (1956 release, Washington). Fruit medium size, smaller than Willamette and Meeker, bright red, fairly firm, good for processing and fresh market. Harvest season 4 to 7 days later than Willamette. Not suitable for mechanical harvesting as fruit does not shake off easily.

Plants moderately vigorous. Canes medium size and straight. Fruiting laterals medium in length and strong. Tends to grow slowly the first year and does not produce the significant baby crop usually produced by Willamette. Hardiest of varieties adapted to western Washington. Most tolerant variety for heavy, poorly drained soils and for soils with root rot.

Puyallup (1953 release, Washington). Fruit very large, medium red, fairly firm with large drupelets. Suitable for fresh market and processing. Harvest season 4 to 7 days later than Willamette. Fruit shakes off mechanically when ripe.

Plants vigorous and productive on well-drained soils. Strong, straight canes with medium-length, strong, fruiting laterals. Not quite as hardy as Sumner. Susceptible to root rot and powdery mildew. Not widely grown.

Canby (1953 release, Oregon-USDA). Berries medium to large, light red, lack firmness for processing. Harvest season early with Willamette. Berries shake off readily for mechanical harvesting, but tend to crumble.

Plants vigorous and moderately productive on very well drained soils. Canes large, tall, straight, and smooth. Aphid immune. As winter hardy as Sumner. Plants very susceptible to root rot. Not widely grown.

Fairview (1961 release, Oregon-USDA). Berries medium to large, bright medium red, fairly firm, suitable for fresh market and processing. Season starts with Willamette but lasts longer, which makes it suitable for U-pick or home garden use, but not for mechanical harvesting.

Plants very vigorous and productive on good soils. Canes tall, fairly straight. Fruiting laterals very long, tending to break easily. Somewhat tolerant of heavy, poorly drained soils and has some tolerance to root rot. Not widely grown.

Haida (1972 release, British Columbia). Presently under commercial test. Medium small, bright-red fruit, fairly firm, suitable for processing and fresh market. Ripens 3 to 5 days after Willamette.

Plants moderately vigorous and productive. Canes medium sized, straight, and very upright. Laterals medium length and strong. Aphid immune. Susceptible to root rot. Susceptibility to freeze injury has not been well determined.

Chilcotin (1978 release, British Columbia). Recommended for commercial trial. Large, light bright red, fairly firm fruit. Long extended harvest season starts with Willamette. Suitable for fresh market and processing.

Plants are vigorous and productive. Fruiting laterals are medium length and strong. Susceptible to root rot.

Skeena (1978 release, British Columbia). Recommended for commercial trial. Large bright red, fairly firm fruit, harvest season slightly later than Willamette. Suitable for fresh market, processing, and mechanical harvest. Plants are vigorous and productive. Susceptible to root rot.

Nootka (1978 release, British Columbia). Recommended for commercial trial. Medium-size, dark-red, fairly firm fruit. Harvest season slightly later than Willamette. Suitable for processing, shakes off very easily for mechanical harvest.

Plants are vigorous, fruiting laterals medium length. Aphid immune. Susceptible to root rot.

Fall-bearing varieties. Very little in-

formation is available on commercial plantings of these varieties. Two varieties, Heritage (1969 release, New York) and Fallred (1964 release, New Hampshire) are grown to a limited extent for fresh market sales. Heritage usually does not ripen before September 1 in western Washington. Fruits are medium in size, bright red, and quite firm.

PLANTING STOCK

Use certified planting stock. This will prevent the introduction of nematodes, viruses, root rot organisms, and other pests into new fields. Using planting stock from your own fields or from neighbors is not advised because of the risk of such contamination. It is unwise to select planting stock from a first-year planting based solely on plant vigor because this does not indicate freedom from nematodes, viruses, and root rot. These disorders are more easily detected in older plantings.

Dormant plants from the previous season's growth are more easily transplanted than soft (green) planting stock. Select strong canes 1/4 to 3/8 inch in diameter with well-formed root systems. Be sure the hair roots (feeder roots) are not pulled off in digging. Pulling the plant strips away the small hair roots and delays plant growth. The sooner the plants are set after digging, the better. Do not let the roots become dry. Covering with moist burlap or dipping roots in a heavy, muddy suspension will be helpful.

Dormant root cuttings from certified nurserymen may also be used to establish new raspberry fields. The use of root cuttings increases the amount of planting material available from certified growers. Growth and plant stand from the use of root cuttings are comparable to that of common planting stock. Root cuttings are generally 1/16 to 3/16 inches in diameter and of random lengths. Small white buds which give rise to the new shoots are usually visible on the roots. Considerable care must be taken to prevent the roots from drying out prior to planting.

Soft raspberry plants that have come up in the spring are sometimes planted. They must be given special care to prevent wilting or drying out. Transfer them directly, at the time they are dug, to where they are to be planted and set them in the ground at once. Care is needed not to break the succulent new stems. Plenty of water should be given immediately after planting and for several weeks after.

SPACING

Raspberries are usually grown in hills 2-1/2 to 3 feet apart in rows that are 8 to 10 feet apart. For most commonly used machinery, at least 9 feet between rows is necessary. A 10-foot row spacing and 25-30 feet headland for turning is desirable for mechanical harvesting.

The number of plants per acre can be determined at any spacing by dividing 43,560 by the number of square feet per plant. Allow space for roadways, packing or loading platforms, ditches, and room to turn at the ends of the rows. The numbers of raspberry plants required per acre for some of the common spacings are:

2-1/2 feet x 8 feet—2178 plants
2-1/2 feet x 9 feet—1936 plants
2-1/2 feet x 10 feet—1742 plants
3 feet x 8 feet—1815 plants
3 feet x 9 feet—1613 plants
3 feet x 10 feet—1452 plants

When establishing a new planting from root cuttings the same spacing of hills should be used as for dormant plants.

PLANTING

Time of planting and condition of planting stock affect plant stand and growth. Early spring planting of fully dormant plants is ideal. With cold storage (29-31 °F.) of certified plants or root cuttings, dormancy can be maintained in storage and planting can be done when weather and soil conditions allow. When conditions are favorable, early planting will usually result in good first year's growth and a greater second year's crop yield. Dormant plants can be heeled in satisfactorily for a short period of time to prevent them from drying out while waiting for suitable planting conditions. Late planting of actively growing plants is risky and often results in poor plant stands. Cool weather and moisture will lessen the risk.

The soil must be thoroughly prepared if the plants are to survive and grow well. It should be well worked, firm, and moist when the plants are set. The field can be marked off with a hand or tractor-drawn marker, or the plants can be set along a wire stretched over the row. Cross marking of rows permits cultivating both ways until trellis wires are put up. North/south rows are generally preferred, but this is not critical.

Plants may be set: 1) by mechanical transplanter; 2) in a plowed furrow; 3) in holes dug with a shovel; or 4) in holes made by pushing a shovel to make a wedge-shaped hole. This last method is quick and easy but will not make holes big enough for large plants with strong root systems.

The plants should be set so that when the soil is leveled, they will be about an inch deeper than before they

were dug. The roots should be spread as much as possible and the soil firmed well around them. Irrigating the field or watering individual plants after planting is recommended if good moisture isn't present at planting time.

If dormant root cuttings are used, they should be planted at a rate of approximately 2 ounces of random length root material per hill (180 pounds per acre at 3 foot hill spacing and 10 foot row spacing). If a hedgerow is desired, the 2 ounces of root material may be spaced uniformly over each 3 feet of row. At least 2 inches of soil should cover the roots and with very sandy soil at least 3 inches of soil cover are needed. Roots should be planted immediately after being taken from the poly liner of the shipping box to prevent drying. The best time to plant root cuttings is in February and March.

After plants are well established, sidedress approximately half the amount of fertilizer recommended for bearing fields. (See details under Fertilizers section.)

CULTURAL REQUIREMENTS

TRAINING AND PRUNING TECHNIQUES

Cut tops of dormant transplants back to 3 or 4 inches at the time plants are set in the field. The first growing season should produce 3 to 5 strong canes per plant. These will produce berries the following year.

During the second growing season, shoots will come up between the plants and between rows. Keeping the plants in hills makes weed control by tillage and hoeing easier. Cut out all of the new shoots except those in the hills. Use hoes or cultivating equipment. Special sprayers can be built to chemically control young canes or shoots and weeds between hills.

For mechanical harvesting, many growers will want to keep their plants in a hedgerow. This requires good chemical weed control and restriction of new shoot growth. Plant rows must be kept about 12 inches wide by mowing, spraying, or cultivating out excess shoots. The aim should be to develop 3 or 4 fruiting canes per lineal foot of row.

Training. Trellis can be installed during the fall of the first year or before training in the spring of the following year. The trellis wire support consists of two, three, or four No. 10 or 12 galvanized wires stretched along wooden posts 25 to 30 feet apart in the row. The end posts are anchored or braced since they get most of the pull. Sometimes it may be more economical to use steel posts at 20 foot intervals.

The three-wire trellis has a single top wire about 4 1/2 feet from the ground. It is fastened directly to the side of the post. As the pruning is done, the fruiting canes are tied to the top wire. The bottom pair of wires in the three-wire trellis may be fastened to the sides of the posts or to a crossarm nailed to the post. Hooks or bent nails are used so the bottom wire can be lifted off and swung out over the new canes to pull them into the row. They should be about 30 inches above the ground. Their purpose is to hold the new canes in the row to facilitate picking and to protect them from breakage.

The four-wire trellis has two top wires rather than one. Top wires are fastened to a crossarm to provide better separation of fruiting canes and to protect primocanes. Lower wires may be held to the crossarms by notches cut near the ends of the arms but are more often fastened to the posts by strong nails bent into the shape of a hook. If the wire is fastened to the post by notches or hooks, it can be temporarily unhooked and swung out over the new canes to pull them into the row. Because of the crossarms, this system is not suited for mechanical harvesting.

The cane weaving system with the four-wire trellis may be used on productive soils where plants produce vigorous canes 8 feet tall or higher. Some tonnage may be gained by weaving longer canes. Berry size will be reduced slightly. Excess length and winter damaged tips should be cut back in the spring.

The tips may be bent down and tied to the top trellis wire; however, it is faster to bring the canes over the wire and back under, wedging the tips into the upright portion of adjacent canes. Canes should be divided between two trellis wires.

Pruning. The ability of canes to produce berries is largely a matter of cane diameter and distance between buds (internodes). Best yields come from large diameter canes with short internodes. Late season growth often results in long internodes and weak tip growth which is vulnerable to winter damage. Proper nutrient and moisture levels will assure canes of good quality.

After the first season's growth, tie to the first wire those canes and branches that are long enough. Shorter branches are pruned back to spurs of 2 inches. In the following seasons, canes that have produced fruit should be cut out any time from the end of harvest through late winter. Cutting them soon after harvest will help in the hardening off process and reduce insects and diseases. It also simplifies weed control and makes establishing winter cover crops easier. Remove new canes that are weak or have small diameter or long internodes.

Canes should be cut off as close to the soil as possible. The number of canes each plant or hill can support is determined by soil fertility, moisture, and planting distance. Leave all good, strong canes each plant will produce. This may mean 8, 10, or with exceptionally good growing conditions, as many as 12 canes per hill.

Tie the canes to the top trellis wire. Postpone cutting canes back or tipping them until late winter or early spring after the danger of hard freezes has passed. Canes are usually cut back to 4 1/2 to 5 1/2 feet. In fields where plants produce long laterals and school children pick berries, leaving canes 5 1/2 feet long makes the berries too high for some youngsters to reach.

Mechanical pruning. Old canes can be removed mechanically by using a special training system and a specially designed, hydraulically operated, cane-cutting machine attached to a tractor.

The canes in each hill are divided in-

to four parts and tied to the two outside wires in a "teepee" fashion. During the spring when the new shoots are about 1 foot high, the wires are spread out by pivoting the 24-inch crossarm, allowing the new canes to grow inside the wires.

This training system makes it possible to remove the old canes mechanically soon after harvest. It reduces labor costs and allows the new canes to go into dormancy sooner as a result of better light conditions. The cutting machine is of simple design and not expensive to build. Details of the machine design are described in the 1974 Proceedings of Western Washington Horticultural Association.

Topping can be mechanized by using a hedger if enough acreage justifies the investment.

Treating posts. Treating the posts with a 4% solution of pentachlorophenol will extend their life materially. To make the 4% solution, mix a gallon of penta (40% by weight) with 10 gallons of kerosene, stove oil, diesel oil (#400), or other light oil. Stand the posts upright in a 50-gallon drum with enough of this solution to cover 3 or 4 inches above the part of the posts that will be in the ground. Since fir and cedar posts take up this solution slowly, soak them as long as seven days. Use only well-seasoned posts. Fumes of pentachlorophenol can cause serious damage to vegetation. Do not store newly treated posts near plantings and do not install freshly treated posts during the growing season.

ALTERNATE YEAR CROPPING

In alternate year cropping, all canes are cut out during the dormant season, every other year, thereby creating a non-cropping and a cropping year. Mowing off canes mechanically will save much labor as compared to normal pruning and training. In addition, during the non-cropping year, the plants require minimal care with added savings of labor and materials. During the cropping year, cane-burning may be increased allowing higher yield, easier handpicking, reduction in fruit rot, and assistance in mechanical harvest. Even though this practice will result in reduction of size and number of primocanes, plants will recover satisfactorily during the non-cropping season.

Large blocks of fruiting and non-fruiting plants should be used rather than alternate rows. This allows for concentration on either growing canes in the non-cropping blocks or producing as much fruit as possible in the cropping blocks.

The Meeker and Willamette varieties have been biennially cropped for 5 years (3 alternate-year cycles) at Washington State University's Southwest Washington Research Unit in Vancouver. The total yield of the alternate-year plots was 60% of that for the every-year plots. Each year the annual and biennial plots were caneburned to obtain maximum sustained yield. The biennial plots were given one additional caneburning spray.

The reduction in yield, because of cropping only every other year, makes the practice uneconomical during years of high berry prices. If berry prices are low, biennial cropping combined with caneburning may well be a practice progressive growers will want to investigate.

BASAL CANE BURNING

Burning back new shoots or primocanes one or more times with dinoseb can, under certain conditions, increase yield, make picking easier, decrease fruit rot, and reduce labor of pruning and training. These benefits come from improved cane quality and reduced competition between primocane growth and developing flowers and fruits.

Cane burning has two main effects on raspberries. It increases yields during the year of application and it reduces cane size for the next year's crop. The number of cane-burning sprays is based on the size of canes as observed during the dormant season prior to spraying.

Cane Height		
Irrigated	Not Irrigated	Number of Sprays
6 ft.	7 ft.	1
8 ft.	9 ft.	2
Over 9 ft.		3

Cane burning reduces cane number of the variety Meeker more than other varieties. Therefore only one spray is recommended for Meeker. Weak fields or weak hills within a field do not benefit from cane burning and will be harmed. Hand spraying to avoid spraying weak hills may well be justified.

Timing. Apply the first spray in early spring when the tallest of the new shoots are 6-8 inches tall. Start soon enough so that the entire acreage can be covered before the shoots get over 8 inches tall. Second and third sprays should be applied when shoots have regrown to this same height. Timing according to stage of growth is very important for best results.

Materials. Use Dinoseb (Sinox or Dow General) at 2 quarts plus 4 quarts Superior summer spray oil per 100 gallons of water. A spreader (adjuvant or surfactant) may be used in

place of the Superior spray oil at the rate of 1-2 cups (8-16 ounces) per 100 gallons of water.

Rate. It requires about 100 gallons of spray material per acre to get good coverage. The foliage must be thoroughly wetted. Poor coverage will result in incomplete killing and cause weak, malformed canes.

Equipment. Use a weed type sprayer at 40 to 50 psi with a fan-type nozzle (single or double). Higher pressure or too small nozzles cause fogging and may result in damage to fruiting laterals. Confine the spray to the lower 12 inches of the canes. Spray rows from both sides to get good coverage.

Weather conditions. If possible, spray on a sunny day with temperatures between 50 and 70°F. Do not spray during the evening or during windy or rainy weather. Dinoseb codistills with water so moist soil and high temperatures may cause a vaporization that will damage foliage.

FERTILIZATION

Raspberries produce best on large diameter canes with short internodes. For most varieties, the best cane height for optimum yields is about 8 feet, with 9 to 12 canes per hill.

The nitrogen (N) fertilization program should be managed to give this type of growth. Although other fertilizer elements do not generally affect vigor, they are necessary and should be applied according to soil and/or foliar test recommendations. See WSU Fertilizer Guide 22 or OSU Fertilizer Guide 49. See also table for foliar standards.

Raspberry varieties differ in vigor. Meeker and Willamette require less N than Haida, Sumner, or Puyallup. Reduce annual applications of N when there is too much growth. Use more N when cane growth is inadequate.

Make soil tests prior to establishing a planting. Ask for pH, potassium (K), phosphorus (P), calcium (Ca), magnesium (Mg), boron (B), cation exchange capacity (C.E.C.) and base saturation. Soil nitrogen (N) analysis is not usually reliable and therefore not tested.

Soil and foliar testing services are provided by various commercial companies and the state universities. Shipping cartons and instruction sheets may be obtained by contacting commercial laboratories or the local Cooperative Extension office.

Fertilizing during the establishment year. After the new plants start to grow, apply N, P, and K at about half the recommended annual rate. Place the fertilizer in one or two bands 6 inches to the side and 2-3 inches deep.

Annual fertilization. Apply fertilizers annually according to soil or foliar test results as suggested in the fertilizer guides. Nutrients are more likely to be low in coarse, sandy soils than in soils high in clay or organic matter. For such soils, testing is especially important. Apply N, P, and K fertilizers in March or early April when growth starts. They can be banded 12-18 inches from the center of the row and 2-4 inches deep.

If manure is used, apply it in the late fall or early winter. Reduce the rate of N fertilizer. Heavy rates of manure may cause raspberries to continue to grow later in the season and make them more susceptible to winter injury.

Western Washington and Oregon. Most fields in western Washington and Oregon should be given 40-80 pounds N per acre. Apply it to the soil surface beside the plant rows or band with the phosphorus (P) and potas-

RED RASPBERRY FOLIAR TISSUE ANALYSIS STANDARDS*

Percent Dry Weight or Parts Per Million (ppm)

Element		Below Normal	Normal	Above Normal	Toxic
N	Nitrogen	2.5%	2.75%	4.0%	4.75%
K	Potassium	1.0	1.5	3.0	4.0
P	Phosphorus	0.2	0.3	0.6	0.65
Ca	Calcium	0.5	0.6-2.5	2.5+	
Mg	Magnesium	0.25	0.4	1.0	2.0
Mn	Manganese	20 ppm	80 ppm	300 ppm	1000 ppm
Fe	Iron	30	50	150	250
Cu	Copper	1	2	50	100
Zn	Zinc	13	34	80	300
B	Boron	30	46	80	100

*Foliar analysis standards are for leaf samples taken July 21 through August 10. Remove the most recent, fully extended leaf plus stem from current season primocanes (usually within 18 inches of the tip). Select at random five of these trifoliate leaves plus leaf stems (petioles) from exposed areas around the edge of the plant. Sample 10 representative plants within the planting for a total of 50 trifoliate leaves.

sium (K).

East of the Cascade mountains. Apply 80-100 pounds of N during March or early April. Specific information for fertilizing raspberries in this area is not available but in general the recommendations in the fertilizer guide are satisfactory. Both boron and zinc are frequently deficient. Where zinc deficiency is determined before planting, incorporate 20-30 pounds zinc sulfate per acre. Zinc deficiency that occurs after planting may be corrected with one to three foliar sprays during the spring growth period using 1 pound zinc sulfate per 100 gallons of water. Apply boron either to the soil or as a foliar spray during spring growth.

Barnyard manure is not recommended for raspberries in this region. There is too much danger of excess N release late in the season which causes late growth and suceptibility to winter injury.

Foliar fertilizers. Leaf feeding is not generally recommended for raspberries. Soil applications made according to soil and/or tissue analysis results usually supply all the nutrients needed for maximum production.

Unexpected deficiencies sometimes occur, especially in boron, manganese, iron, and zinc. When these occur, foliar sprays may ' . valuable. They are quickly available to the plants and, if the diagnosis is correct and the proper nutrient used, the plants will recover rapidly. Because of the small amount needed per acre, the materials can often be mixed with pesticides in a spray solution.

Most minor nutrients can be picked up by raspberry roots from the soil. Soil applications are thus more economical and longer lasting, once the initial deficiency is overcome with foliar sprays.

MICRONUTRIENT DEFICIENCY SYMPTOMS AND FOLIAR SPRAYS FOR CORRECTION

		Control		
Nutrient	*Visual Symptoms*	*Material**	*Rate/100 gal.*	*Timing*
Boron	Bud break in the spring is delayed, many buds die, leaves from damaged buds may produce elongated, slender leaves giving a "fern-like" appearance. Severe deficiency may cause new shoots to die back.	Borospray or Solubor	1.5 lbs. commercial product	Any time leaves are present. Best in the spring
Iron	Young, terminal leaves turn yellow or white followed by browning of leaf margins and interveinal areas. Basal leaves remain green. Seldom a problem west of the Cascade mountains.	Iron chelate	Follow label instructions	Apply to leaves when symptoms appear.
Manganese	Older leaves turn yellow between the veins. Veins and young terminal leaves remain green.	Manganese sulfate	2 lbs. commercial product	As soon as leaves are well developed.
		or		
		Manganese chelate	Follow label instructions	
Zinc	*No information on raspberries.* Typical symptoms on other crops are: light green, yellow, white, or dead tissue between the veins of older leaves. Short internodes resulting in a bushy or tasseled appearance.	Zinc sulfate 36%	12 lbs. commercial product	Apply to canes during dormant period just as buds start to swell.
			or	
			1 lb. commercial product	1-3 times during growing season.

*An adjuvant or spreader should be added to the spray for better coverage if not already present in the formulation of the material.

IRRIGATION

It pays to irrigate raspberries on most soils and during most years. Yield increases result from larger berry size and from more numerous, larger-diameter canes. The amount of increase depends largely on soil type and available water.

No general rule can be made for determining irrigation needs. Soils vary in their water-holding capacity. Light, sandy soils may hold less than an inch of usable water per foot of soil depth. A medium-textured soil may hold about 2 inches of usable water per foot of depth. Heavy soil may hold up to 3 inches per foot of depth. This means light, shallow soils must be irrigated with small amounts of water, and more often, because the water is depleted more quickly. Highest yields are produced if moisture in the 4-foot root zone is not allowed to become less than about half of what the soil will hold.

The critical time for irrigation is during bloom and as the berries are sizing prior to first picking. Plantings on medium heavy soils should be irrigated heavily just before the first picking. Additional irrigation may not be necessary until after harvest. Lighter soils may require an extra irrigation ahead of harvest and one or two during harvest.

Sprinkler irrigation applied during harvest under good drying conditions has very little effect on fruit rot. If applied during cloudy, damp weather, the results can be disastrous.

Using evaporation pan measurements. The timing and amount of water to apply can be determined by use of an evaporation pan. (See WSU circulars 497 and 527 for more complete details.) This method has been used successfully and is a good means for deciding when and how much water to apply.

It is not necessary that each grower maintain an evaporation pan. Usually one pan in the county can serve the whole area. It is, however, necessary for the grower to keep track of rainfall for his local conditions so he can correct evaporation data accordingly. Evaporation data are presently recorded at Bellingham, Puyallup, and Vancouver in western Washington and at a number of locations east of the Cascades. In Oregon, data are recorded at Aurora and Corvallis. Check with your Extension agent or the weather bureau.

In areas where moisture is available from an underground water table, determine when to start irrigating through use of tensiometers or moisture blocks placed 2-3 feet deep. Once the moisture level at this depth drops below 40-50% it is time to begin irrigating.

Soils vary in the amount of water they have available for plant use. Silt loam has about 9.6 inches available in the 4-foot effective rooting area while sandy loam has about 8.1 inches. Once this information is known for a particular soil, it is possible to use measured evaporation to schedule irrigation by the first method listed below. This information is not essential for the last two methods.

1. Example of calculations to schedule irrigation of raspberries growing in sandy loam soil:

Water Use Between Irrigation

Effective root depth	4 feet
Avail. water/ft. of soil depth	2.0 in.
Total available (4 × 2.0)	8.0 in.
Use 65% before irrigation (.65 × 8.0)	5.2 in.
Evaporation equivalent (5.2 × 1.0)	5.2 in.

Irrigation

Sprinkler application rate	.33 in./hr.
Sprinkler efficiency	75%
Length of irrigation needed $\frac{5.2}{.33 \times .75}$	21 hr. duration

This soil has a moisture holding capacity of 2.0 acre inches per foot of depth, amounting to a total of 8 inches for the 4 feet of rooting depth. Allow approximately 65% removal of this available moisture before irrigation. This is equal to 5.2 inches. Raspberries use 1 inch of water for each inch lost from the evaporation pan. Therefore, 5.2 inches of irrigation water must be applied to bring the soil moisture back to field capacity. An irrigation scheduling chart (ask your extension agent for WSU Extension Circular 341) can be used to record use, rainfall, and irrigation.

The distribution pattern of sprinkler irrigation systems is not uniform. A safe value to use in calculating sprinkler efficiency is 75%. Applying this efficiency factor to an irrigation system rated at .33 inch per hour, 21 hours will be required to fill this sandy loam soil reservoir back to field capacity.

2. Some growers have their irrigation systems set up on a regular time schedule. Evaporation pan data can be used to tell how long to irrigate at each set.

Time between irrigations	10 days
Evaporation measured during the 10-day period	2.56 in.

Inches of irrigation needed (2.56 × 1.0)	2.56 in.
Length of irrigation needed $\frac{2.56}{.33 \times .75}$	10.3 hrs.

3. Other growers run their irrigation systems fixed number of hours each time they irrigate. Example:

Desired length of set	12 hrs.
Application rate	.33 in./hr.
Application in 12 hours	4 in.
Usable application at 75% efficiency (4 × 0.75)	3 in.
Amount to use between irrigations	3 in.

Hence, irrigate when evaporation indicates about 3 inches of water has been removed from the soil moisture reservoir and apply a 12-hour set.

Scheduling irrigation by use of the evaporation pan is simple and practical. It will result in better crops and less damage from over-watering or under-watering.

Drip irrigation. Drip irrigation may have a place in raspberry production. Actual experience with it for this purpose is very limited. The principal advantages are: 1) low labor requirement; 2) low water usage; 3) more uniform moisture level; 4) little effect on fruit rot. Disadvantages include: 1) cost of installation; 2) need for periodic replacement; 3) damage to system from routine cultural practices; 4) increased danger of root rot due to excess water around crowns; 5) susceptible to rodent damage and vandalism; 6) does not provide option of protection from heat or frost.

Two general types of drip irrigation are available: *Emitter type.* This system consists of 1/2-inch lateral lines along the plant row in which are inserted at intervals some kind of fixed or adjustable flow outlet calibrated to deliver 1/2-1 gallon per hour. These emitters range from small diameter plastic tubing inserted into the lateral line (the rate of flow being regulated by inside diameter and length of tubing) to adjustable flow, self-cleaning, plastic emitters. *Soak type.* The 1/2-inch lateral is replaced by a soaker which is either laid or buried along the row. These soakers range from 1/2-inch plastic pipe, with holes punched at intervals, to double-walled laterals with openings at fixed distances, or laterals that ooze water their entire length. Various types of these systems have been laid on the soil surface, buried in the soil, or suspended from the upper trellis wire.

All systems require a good water filter regardless of the water source, and a pressure regulator. Pressures used vary from 3 to 20 psi. Preliminary experience indicates the need to apply water at 1/2 gallon per hour between every other plant (6 foot intervals). The length of time needed to apply the water varies with plant development and weather conditions. Continuous application is not desirable for raspberries.

PERMANENT COVERCROPS

Raspberries are usually rototilled between the rows and herbicides are applied in the row for weed control. As more mechanical harvesters are used, soil compaction and poor traction along with the need for energy conservation have caused growers to look for a better way. A permanent covercrop planted between the rows will reduce soil compaction, improve traction and provide cleaner, more pleasant conditions for hand labor.

Research at one location has shown that yield and berry size of raspberries can be maintained with a covercrop if irrigation is available and if about 10% more nitrogen fertilizer is applied. For anyone who is interested in trying this practice, we recommend the following:

1. Use a long-lived perennial grass such as lawn-type ryegrass ('Manhattan' ryegrass). For the present we do not suggest fescue grasses or legumes. Certain fescues have been shown to stunt the growth of other woody-type plants. Word from New Zealand is that the flowering of clover increases the danger of pesticide poisoning of bees. Additional work is under way to test other grass and legume species.
2. Use a cover crop strip sufficiently wide to provide for the wheels of the harvester and other heavy equipment.
3. Band your fertilizer. Increase nitrogen levels about 10%. Do not apply nitrogen fertilizer to the covercrop.
4. Be especially careful to keep soil moisture levels high during May and June while berries are sizing.
5. Keep the covercrop mowed short during the preharvest season.
6. It may be possible to use a permanent covercrop without irrigation on heavier soils or where ground water levels are high enough to supply water to the raspberries during the growing season.
7. Seed covercrops in the spring after the first growing season or during later years.
8. When a covercrop is planted in an already well-established field, allow at least two years for the root systems of the competing crops to adjust before evaluating yield and growth results.

POLLINATION

In pollination, the pollen grains, are transferred from the stamen (male

part) to the pistil (female part) of flowers. The central part of the raspberry flower consists of 100 to 125 pistils. These are surrounded by numerous stamens. Each pistil is able to produce a seed and a drupelet. Usually 75 to 85 drupelets develop.

Placement of honey bee colonies is important in order to ensure adequate pollination. At least two hives per acre are recommended. Research shows that bees are responsible for 90 to 95% of raspberry pollination. Honey bees are responsible for most of this, although bumble bees and other wild bees may serve more effectively during windy or cold weather. Hives should be placed so that bee flight patterns are not against prevailing winds.

Many of the insecticides recommended for the prebloom or postharvest periods are highly toxic to bees and should not be used during bloom. The insecticides methoxychlor and malathion may be used during bloom if they are applied in early morning or evening when bees are not present.

None of the recommended fungicides for plant disease control are toxic to bees.

CRUMBLY BERRY

Raspberries with fewer than the normal number of drupelets tend to crumble when they are picked. This condition is the result of abnormal development of the fruit.

Normal flowers have from 100 to 125 pistils. Each is able to produce a drupelet with a seed. In normal berries, from 75 to 85 drupelets usually develop. If appreciably fewer than this number develop, the berry does not hold together and crumbles as it is pulled from the plant.

Crumbly berry may be caused by one or more of the following conditions:

Lack of bee activity. Since bees are responsible for most of the pollination activity, a reduction in the number of bees or bee activity can seriously affect pollination and fruit development. Improper use of pesticides may cause this problem.

Lack of nutrients. Drought, low overall fertility, boron deficiency, or damage to roots or crowns from nematodes, root rot, crown gall, crown borers, poor drainage, or deep cultivation may seriously interfere with plant nutrition and affect fruit set.

Varieties. Some varieties tend to crumble more than others. Some clones of the Sumner variety have been known to produce crumbly fruit, but this is generally not true of the Sumner variety. Occasionally plants mutate to a condition that causes crumbly berry.

Diseases. Viruses may interfere with the normal function of flowers or may prevent seeds from developing normally. The raspberry mosaic virus complex and the tomato ringspot virus have been associated with crumble. In certain instances bacterial and fungus diseases such as *Pseudomonas* (bacterial blight), *Cladosporium* and *Botrytis* (gray mold) may contribute to crumble.

Other causes. Frost, winter freeze, insect feeding, and pesticides applied on the bloom can damage the anthers, pistils, or pollen and cause crumble.

Prevention and control. Plants should be selected from vigorous, healthy fields, free from crumbly berry condition. They should be kept growing vigorously through adequate fertilization, adequate watering, and a good insect and disease control program. Plants that produce crumbly berries should not be used for propagation.

COLD INJURY

Cold injury may result from several different temperature conditions:

1. Low temperatures in early winter before the plants are hardened off.
2. Low midwinter temperatures accompanied by drying winds.
3. Sudden cold during late winter after an extended warm period.
4. Frosts after growth has started in the spring.

Damage from early freezes before canes are mature and sudden freezes following a warm period are the most common type of cold injury. Cultural practices which speed up hardening-off by stopping cane growth will help reduce cold injury during the dormant period.

The most frequent freeze injury during mid-winter is to the vascular tissue in the lower part of the bud where it is attached to the cane. Florets in the upper part of the bud will often be in good condition but the vascular tissue will be moderately to severely injured. If the injury prevents movement of nutrients to the bud, the lateral will be weak or even die when stress of fruit and vegetative growth gets heavy. Generally, buds on the lower part of the cane and those on immature wood at the tip tend to be most susceptible.

Irrigation. Put on the last irrigation soon after harvest ends. In eastern Washington and Oregon an additional irrigation during late September, just before the water is shut off, will help prevent dehydration during mid-

winter.

Nitrogen. Vigorous plants are slow to go dormant. Reduce the rate of N fertilizer on fields making more than 8-9 feet of growth. Do not make N applications later than the bloom period. Excessive applications of manure may cause plants to continue growth late into the fall. However, plants deficient in nitrogen are less hardy and more susceptible to winter injury. In general, this applies to deficiencies of any nutrient.

Cultivation. Do not cultivate after mid-August. The natural growth of weeds or an overwintering nonleguminous cover crop such as rye will slow growth and hasten the hardening-off process by taking up excess water and N. Spring oats or barley, planted in late July or early August, are used for this purpose in eastern Washington. If weeds or the cover crop need to be controlled, keep them down by mowing.

Planting sites. Natural windbreaks will help prevent damage from cold winter winds. When possible, raspberries should be planted where they will not be exposed to cold winds.

Frost injury to blossoms is also best controlled by proper selection of planting sites. Various methods of frost protection, such as heating or sprinkling, can be of some help but are expensive. Spray materials reputed to give frost protection have proved to be of limited or no value.

Carbohydrate levels. Freeze injury is greater when carbohydrate levels in the plant are low. Low carbohydrate reduces the capacity of tissues to hold "bound water," which freezes at a much lower temperature than free water, thus affording protection from cold. Any condition that helps lead to carbohydrate deficiency should be avoided. Deficiency may be caused by lack of certain soil nutrients, complications brought on by plant diseases or insects, moisture deficits, late weak growth, and heavy or late applications of nitrogen. A high level of parasitic nematodes will result in high freeze injury. Mites, insects, or diseases that cause premature defoliation will reduce carbohydrate storage and increase susceptibility to freeze injury.

HARVEST

HARVEST PRACTICES

Proper planning and preparations are important to insure a smooth-running harvest. The picking season for red raspberries covers a period of four to six weeks, beginning in late June. The number of hand-pickers needed will vary with the crop load, weather, and skill of the workers. A crew of five or six per acre will suffice for the first and last pickings, but the main crop will require twice that number, and the peak (during warm weather) may require 15 to 20 good workers. Naturally, there is a wide range of picking ability. A beginning 12-year-old may harvest only 40 pounds, while a teenager or adult can average more than 60 pounds, and skillful pickers may exceed 100 pounds in a six-hour day.

The picking interval varies with stage of harvest, variety, and weather conditions. Five or six days may elapse between the first and second pickings; however, a three-day schedule is common during warm weather. A shorter interval may be advisable for fresh-market sales.

The Fourth of July holiday may be a hazard in raspberry harvest operations, so special provisions are advisable to avoid a crisis. Two simple options are: recruit extra help to insure cleanup before the long weekend, or allow a bonus payment for those workers who sacrifice the holiday to stay on schedule.

Quality of fruit must be safeguarded all the way from field to market. Reject all moldy or insect-damaged berries in the field and ship only sound, mature fruit. Pickers should be instructed to remove berries with a light grasp of the thumb and two fingers, using a turning motion rather than a pull or jerk. Avoid squeezing berries by holding too many in the hand before transferring them to the packing container. Pick with hands together, palms up to catch falling berries, working from the outside in. Pawing or digging into the vines will damage fruit spurs and reduce both yield and grade.

Small carriers or buckets attached to a waist belt are recommended for minimum handling and easy transfer of fruit to hallocks or bulk trays. Avoid overfilling containers as this will crush and thereby degrade the fruit. Shipping flats should never be set on the ground because clinging soil will contaminate the fruit below when stacked. Field containers should be kept as clean and sanitary as possible at all times.

Raspberries are firm in the cool morning hours and most easy to pick and handle. Harvesting should be shut down early on hot days because of picking and handling problems. Prompt delivery to the processing plant is desirable. Filled flats for shipping should be shaded from the sun at all times. Leave air space between stacks to allow release of field heat.

Checkstations should be located in the field so pickers do not have to carry filled trays long distances. It is advisable to spend one day acquainting new pickers with harvest procedures. Adequate rest facilities, including drinking water, clean toilets, hand washing, and lunch shelter are a necessity.

Growers who use mechanical picking equipment must observe the same precautions to protect fruit from bruising, contamination with mold, insects and dirt, and from field heat. Prompt delivery to the processing plant is probably more critical for machine-harvested berries. Fresh raspberries are not usually stored commercially, but firm fruit may be held for a day or two at 31° to 32°F and a high humidity of 90 to 95%.

MECHANICAL HARVESTING

Machine harvest of red raspberries is increasing in the Pacific Northwest. Most are large machines that straddle the row and detach the berries by shaking or vibrating the plants. The detached berries fall on inclined catching plates below the plants and then roll onto a conveyor belt. The berries move past a fan to remove debris and are then elevated to short inspection belts before being dropped into flats or other containers for transporting to market.

These machines, with proper operation, will do a good job with minimum damage to fruit and plants.

Training and pruning. Row width must be controlled and the fruiting canes trained so that the catching plates can be positioned under the area of berry production. The wider the row at the base, the lower the fruit-retrieval rate of the machine. Stakes and trellis must allow the passage of the harvest mechanism without damage to the machine, the trellis system, or the plants.

Insect and disease control. Insects that are present may be shaken from the plants along with the fruit. This can be a major problem with mechanically harvested fruit and needs close attention. (See discussion under Insects and Mites.) Better insect control is necessary with mechanically harvested fruit than for hand-harvested fruit. Fruit rot may be more easily spread into the harvested product, since all the rotted berries will readily drop with the other fruit. Rot control is very important.

Machine operator. A properly trained and conscientious operator is a must. Poor operation will damage canes, immature fruit, and equipment

and result in the harvest of immature berries.

Harvest timing. Fields should be harvested more often by machine than by hand because properly operated and adjusted equipment will remove only mature berries that separate readily. There are many raspberry fruits on each lateral ripening at different times, often only one or two days apart. Delays in harvest produce overmature fruit with poor holding quality and excessive fruit rot.

Irrigation. Water application should be timed so that field conditions will allow the operation of heavy equipment. Drip irrigation may be one method of minimizing problems.

Handling fruit. A properly machine harvested berry is at optimum maturity. To maintain this high quality, the harvested fruit must be transported to market and/or cooled as soon as possible.

Mechanization has not solved all raspberry harvesting problems, but it has reduced the total labor needed for harvest and it has brought other production practices into sharper focus. The proper cultural practices—a good machine operator plus the right variety harvested at the proper time—can produce a machine-harvested red raspberry that will compete with hand-picked fruit.

COST COMPARISON, HAND VERSUS MACHINE HARVEST

ADDED COSTS		PER YEAR
Harvester ownership costs*		
depreciation		$ _____
interest		$ _____
taxes		$ _____
housing		$ _____
insurance		$ _____
Harvester operating costs		
harvester operating labor		$ _____
harvester fuel and lubrication		$ _____
harvester repairs and maintenance		$ _____
additional insect control		$ _____
REDUCED RETURNS		
Yield losses in lbs. _____ × expected price/lb _____	=	$ _____
Quality losses if any, grade reduction @ lb. _____ lbs. of production _____	=	$ _____
Reduced yield from lower density planting and increased space for turn rows		$ _____
A. *TOTAL ADDITIONAL COSTS AND REDUCED RETURNS*		$ _____
ADDED RETURNS		
Custom harvest for others, acres _____ × $/acre _____	=	$ _____
REDUCED COSTS		
Picking costs @ $/lb $_____ × total harvest lbs _____	=	$ _____
Field boss labor hrs _____ × $/hr _____	=	$ _____
Transportation for pickers		
fuel and lubrication		$ _____
repairs		$ _____
driver's wage		$ _____
Chemical toilets		$ _____
Miscellaneous (advertising, administration, etc.)		$ _____
B. *TOTAL ADDED RETURN AND REDUCED COSTS*		$ _____
CHANGE IN NET FARM INCOME (Subtract A from B)		$ _____

*Before estimating interest and depreciation, reduce the initial investment by the salvage value of buses and other equipment, if any, that could be sold.

COST COMPARISON, HAND VERSUS MACHINE HARVEST

Increased uncertainty over labor cost and availability may make machine harvesting a viable alternative. The following are basic questions to be addressed:

1. Are your varieties suited to mechanical harvesting?
2. Will you row spacing allow use of a mechanical harvester?
3. Do you have sufficient end row spacing to turn a harvester?
4. Will a mechanical harvester increase or decrease your net farm income?

The answer to the last question, will it pay, requires a comparison of hand picking and mechanical harvesting. It is only necessary to evaluate those

things that will change if a decision is made to mechanically harvest. For example, land costs including taxes, trucking costs for harvested fruit, office supplies, and other overhead costs will likely be the same for both systems and can be omitted.

The analysis is divided into five steps:

1. Identify which costs will increase and how much (ADDED COSTS). Included are the ownership and operating costs for the harvest equipment, less salvage value of buses or other equipment that could be sold.

2. Will gross returns be reduced? If so, by how much? (REDUCED RETURNS) Are there yield or quality reductions from mechanically harvested fruit?

3. Will mechanical harvesting provide new income? (ADDED RETURNS) Will it be possible to custom harvest for others?

4. What costs will be reduced or eliminated? (REDUCED COSTS) Costs for pickers, field bosses, bus drivers will no longer be incurred. Costs for maintenance and operation of buses and perhaps the number of chemical toilets can be reduced.

5. Add the added costs to reduced returns and subtract them from the sum of reduced costs and added returns. The difference is the expected change in net farm income.

PEST MANAGEMENT

WEED CONTROL

Weed problems in crop land, including red raspberries, can be classified by the growth habits of the weeds themselves, that is, perennial or annual.

Annuals live one year and reproduce only by seed. They can be classified on the basis of germination and maturity; *summer annuals* germinate in the spring, grow to maturity in the summer, and die by winter (smartweed, lambsquarters, red-root pigweed, etc.); *winter annuals* (chickweed, groundsel, shepherd's purse) germinate in the fall, overwinter without setting seed, and then mature and die by late spring.

Annual weeds can be controlled by preventing seeding, and if such preventative measures are carried out conscientiously over a period of years and further introduction of new seed is prevented, the annual weed population will decline. Thus, the key to annual weed control is killing the young plants before or during their flowering period before they set seed.

Perennial weeds live for three years or more and reproduce by seed as well as by vegetative progagation. Therefore, to control perennial weeds, seed formation must be prevented and the vegetative reproductive portions (crowns, roots, rhizomes, tubers, etc.) must also be destroyed.

Herbicide application. Herbicides (liquid or granular) must be applied accurately, at the right time of the year, and at the right stage of weed growth for maximum effect. Proper equipment must be used and adjusted correctly to make timely and thorough applications. The spray pattern must be even and uniform. Make sure granular materials are uniformly and evenly spread by a well-adjusted machine. Do not concentrate in "strips" or "clumps." Granules should be uniformly sized.

Liquid applicators include hand-sprayers as well as large power sprayers. Chemicals which dissolve readily may be adequately mixed by using the hydraulic agitation of pump bypass. However, oil-water emulsions and wettable powders usually require constant vigorous mechanical agitation. Keep hose lines and nozzles well screened to prevent plugging or back pressures. Replace worn nozzles (wettable powders are especially hard on brass nozzles).

Equipment care. Always put clean or well-screened water into the spray tank. Salty or hard water may cause gumminess or may precipitate causing nozzles to plug up. Test a small amount of water with the chemical before mixing in the tank. The main line and nozzles should be adequately screened. Mainline screens should include a relatively coarse screen at the intake but must be fine enough to prevent entrance of lumpy materials. Secondary screens in the hose line ensure further straining. For completely soluble materials, use 100 or finer mesh screen, depending upon nozzle size. For wettable powders, a 50-mesh screen size is required; a 100 mesh screen is too fine. Partially plugged screens produce back pressure which reduces spray output at the nozzle. During operation, frequently check screens and watch for plugged nozzles. After each use, drain and clean the tank, lines, screens, and nozzles by flushing into a proper disposal area.

Pre-plant practices. Many chemicals that kill perennial weeds may also damage red raspberry plants. Therefore, weeds such as quackgrass, sheep sorrel, field horsetail, Canada thistle, and others that grow from roots and stems must be controlled prior to planting by tillage and/or registered herbicides. Since perennial weeds can be controlled by tillage alone, advantages and costs of chemical applications must be weighed against costs and time spent in a clean cultivation program.

Cultivation. By the time the raspberry plants are three years old, the roots will have grown out until they meet and intermingle between the rows. Raspberry plants have many shallow roots. Avoid deep cultivation. Do not go below 3 inches; 2 inches is much better. Rotary-type cultivators properly operated provide such tillage very well. Limit cultivation to controlling weeds and keeping down raspberry shoot growth between rows. Fall cultivation may delay cane dormancy. Some hand hoeing is usually needed to keep down shoots and weeds between hills in the row. Two, three, or even more hoeings may be necessary where chemical control is used.

No-tillage. Some growers may prefer to use a no-till system after field establishment. This can consist of a permanent grass cover between rows or complete chemical control of vegetation. Weeds can be controlled adequately with flail or rotary mowers and/or herbicides.

INSECT AND MITE PESTS

The purpose of this discussion is to help growers know when to be on the lookout for various pests—not to recommend routine sprays for all problems listed. Some problems of raspberries occur almost every year and require routine preventive treat-

ments. The best example is leaf rollers. However, other problems, e.g., twospotted spider mite, are sporadic and should be treated only as the need arises. This requires constant vigilance by the grower, so that a problem, if it does occur, will not advance beyond remedy. The reward is a lower bill for pesticides as well as protection of natural control agents. See Washington or Oregon pest control guides for specific current recommendations.

Pesticide application. Application of liquid pesticides to raspberry canes or foliage requires enough water for good coverage and sufficient pressure to cover the interior foliage. The amount of water and pressure needed will vary from 100 gallons per acre at 100 psi to 300 gallons at 250 psi and with the amount of foliage. Washington State University Extension Bulletin 638, "A Hooded Spray Boom for Cane Berries, Bush or Vine Fruit," suggests an effective boom for this work. Whether liquid or dust forms of the appropriate chemical are used, timeliness of application and thorough coverage of upper and lower leaf surfaces and all surface areas of canes and other plant parts are keys to successful control.

Bee poisoning. Honey bees are necessary for complete pollination of raspberry flowers. Poor pollination results in lower yields and small, crumbly berries.

Many of the insecticides recommended for the pre-bloom or preharvest periods are highly toxic to bees and should not be used at times when bees are present. Applications made in late evening and early morning may avoid bees.

Root weevil. Several species of weevils attack raspberries. The adults are beetles which usually cause only negligible damage by chewing notches in the margins of leaves. However, certain species of root weevils have been known to cause serious economic damage in late winter or early spring by chewing of primary buds. Most serious damage is done by white, legless larvae which eat the roots of the plants. Adult obscure root weevils occasionally are contaminants of ripe berries and are controlled by foliage or soil application of insecticides before or after harvest. The primary means of control of the strawberry root weevil and black vine weevil is application of insecticides to the soil prior to planting. If considerable notching of leaves is noted during the summer, determine the species of weevil present and treat accordingly before bloom the following year. Adult weevils are night feeders and are easiest to locate on the foliage by use of a flashlight after dark.

Twospotted spider mite. This mite is favored by warm, dry weather, and thus, seldom requires control before the postharvest period. It prefers mature leaves and feeds on the underside of the leaves. Its presence can be detected by tiny white spots appearing on the leaf surface, and severe infestations will kill the leaves. Plants can tolerate low populations of spider mites, and treatment should not be made unless most of the leaves have a large amount of spotting. Some insecticides kill the predaceous insects and mites which give natural control of spider mites, permitting mite buildup. Therefore, sprays should be applied only when needed.

Dryberry mite. These microscopic mites overwinter near the buds of the previous summer's new growth. In spring they lay eggs in the expanding bud, and the new generation of mites attacks the fruit soon after petal-fall and causes the drupelets to become dry. Sprays are usually timed to kill the overwintering mites just before they enter the swelling bud.

Orange tortrix. Larvae of this moth feed on tender leaves and buds, but do negligible damage. They are a pest mainly as a contaminant of harvested berries. They have a habit of wiggling vigorously when disturbed and dropping out of their shelters. When pickers or machines shake the canes, the disturbed larvae can drop into the containers and cause the harvested berries to be rejected by processors. Spray for this pest only if it is known to be present in the field. This requires frequent inspection for leaves webbed together at the tips of the canes.

Western raspberry fruitworm. The adult beetles feed on unfolding leaves, flower buds, and flowers. The damage to buds and flowers can cause distorted fruit. The beetles lay their eggs on the buds or flowers, and the larvae work into the center of the fruit. Larvae may remain in the harvested fruit and contaminate the product. Sprays are timed to kill the adults before they lay eggs.

Raspberry crown borer. Larvae of this moth tunnel in the lower parts of the canes and crown and can cause serious economic damage. Eggs are laid in late summer and early fall on the underside of leaves. After two weeks the egg hatches and the small caterpillar makes its way to the base of the cane where it forms an overwintering cell, just under the bark. The following spring the larva tunnels into the center of the cane. Larvae require two years to complete their development into moths, so sprays must

be applied to the base of the canes for at least two consecutive years in order to rid a field of this pest.

Raspberry cane maggot. The adult insect is a fly which lays eggs near the tops of young canes. The maggot burrows into the pith and tunnels downward. Later it girdles the cane just under the bark near the tip and then continues tunneling downward in the pith. The girdling causes the cane above the injury to wilt. The degree of infestation is usually low enough to be of no economic concern. Chemical controls are not needed. Wilted canes can be cut off near the ground and burned to destroy the maggot.

Mechanically harvested raspberries. A great number of insects reside or rest on the foliage of raspberry plants. They include aphids, leafhoppers, many kinds of beetles, caterpillars (such as orange tortrix and other leafrollers), small gnats, plant bugs, and many others. In addition, spiders are usually numerous. Most of the insects and spiders are either innocuous or are beneficial by eating other insects. However, when any of these are shaken off with the raspberries during mechanical harvesting, they become contaminants of the harvested product and must be removed before the berries can be sold.

Insects and spiders may be kept out of the finished pack by hand removal on the sorting belt in the processing plant. However, hand removal is very inefficient and costly. In experimental mechanical harvesting, an air blast was found to remove most insects and spiders as well as leaves and other trash. Just after being shaken off the canes, the berries rolled down over an air blast grill mounted at approximately 45°. The air velocity was adjusted to just below the point at which the air began blowing berries away.

An insecticide spray before picking is a good supplement to this procedure. The current Oregon or Washington State University insect control recommendations should be consulted for the correct insecticides and rates of usage. The spray should be applied a few days before harvest begins. Use sufficient water and pressure to thoroughly cover all foliage. This will require 100-300 gal. of water and pressures of 150-400 psi. Less water and pressure will be needed if the spray is applied with a hooded boom, which can be made in many farm workshops. Application by airplane or helicopter may be less effective because there is no pressure to force the spray into the dense foliage.

DISEASES

The most effective control measures for raspberry diseases are those taken before the disease becomes serious. Use only certified planting stock. If available, plant varieties resistant to the major diseases. Test for nematodes and if necessary treat before planting. Also, before planting examine the cropping history of the field to determine potential for soil-borne diseases and possible need for fumigation. Cultural practices that promote vigorous growth are also important in maintaining a healthy planting.

Anthracnose. This fungus disease causes severe damage on black and purple raspberries but seldom occurs on red raspberries. Infected canes first show light grayish spots about 1/8 inch in diameter. As the disease progresses, the spots enlarge and develop purple borders and ash-gray centers. Badly infected canes may be girdled or cracked resulting in poor fruit development the following season. Infected canes are also prone to winter injury.

Anthracnose sometimes attacks the leaves of raspberries, but it rarely defoliates the plant. Spots about 1/16 inch in diameter appear on infected leaves. The spots have light gray centers and purple margins. Leaf tissue that is infected with anthracnose may drop out causing holes in the leaves. Berries on canes infected with anthracnose ripen abnormally, and fruit stems are frequently girdled.

Control: This disease can be controlled by proper cultural practices, good field sanitation, and properly timed fungicide applications.

Choose a planting site that has good air drainage. Use anthracnose-free planting stock. If the disease becomes a problem, make two or three applications of fungicides as outlined in the spray schedule. Try to make fungicide applications before anticipated periods of rainy weather, and thoroughly cover the plants with the spray liquid.

After harvest remove and burn fruiting canes and new canes that are badly infected. Thin out healthy canes to allow good air drainage, and keep rows free from weeds. Remove wild raspberries and blackberries from fence rows and uncultivated land next to cultivated raspberries.

Cane blight. This fungus disease enters raspberry canes only through wounds in the canes and thus is usually of minor importance. Pruning wounds are frequently attacked by cane blight. Wounds caused by mechanical harvesters can contribute to increased blight.

Dark brown cankers appear on wounds and extend down the cane or encircle it. Lateral shoots of infected canes wilt and die in warm weather.

Infected canes turn grayish in summer. At this stage the disease can be confused with winter injury or anthracnose.

Control: Remove and burn infected canes and keep rows free of weeds. If possible, prune during dry weather to allow the canes time to heal (three days). A dormant spray may be required if the disease becomes serious.

Spur blight. This fungus disease can severely damage red raspberries in the Pacific Northwest. The variety Willamette is very susceptible. Brown or purple spots appear at buds along infected canes. Tissue around the buds darkens and the buds shrivel. These buds either die or fail to produce a spur the following season. Buds near ground level are affected more than buds that develop higher on the canes. Brown wedge-shaped lesions appear on diseased leaflets. These leaf blades then fall off, leaving canes with the remaining petioles attached. The canes dry out and may crack.

In recent years spur blight has been of little significance in the Pacific Northwest.

Control: Controls recommended for anthracnose will also be effective for spur blight. Follow the spray program for the application of fungicides as outlined in the spray schedule. Remove and burn infected canes soon after harvest.

Fruit rot. Several fungi are responsible for rots. Gray mold is probably the most common, and this discussion will deal mainly with it.

Infected berries develop a soft rot and become overgrown with a gray dust which is actually the spores of the fungus. Overripe and bruised berries are highly susceptible to attack and warm, wet weather favors disease development. Rot may develop while the berries are still on the plant or after they are in storage.

Control: Only sound, firm berries should be picked and berries should be handled in a way that avoids bruising. Early morning picking when temperatures are cool is advised.

Fungicide sprays aid in reducing fruit rot and are recommended in machine-picked fields. The problem may be lessened in hand-picked fields by frequent and thorough picking. Machine-picked berries are exposed to conditions which favor fruit rot. All control measures possible should be taken to minimize losses. This fungus likes to grow on dead plant material. Removal of old canes and other plant debris from the field will minimize this source of infection but may not be practical.

Verticillium wilt. This soil-borne fungus disease is widespread in the northern half of the United States and along the Pacific Coast where it occurs on many crops. It is particularly damaging to black raspberries. Red raspberries can be infected but are usually less severely damaged.

Leaves on infected fruiting canes turn yellow, gradually wither, and fall. These symptoms begin on the lower leaves and continue up the canes until the canes turn blue and gradually die. Red raspberries can survive for many years. Sometimes only part of a plant will be infected and show symptoms while the remaining canes appear healthy. The vascular tissues of infected canes generally have a red discoloration. Other root rots, insect damage, wind damage, and high soil water content may produce symptoms similar to verticillium wilt and thus make positive identification difficult.

Control: Plant only certified raspberry plants in clean soil. Do not plant raspberries in soil that has previously grown potatoes, tomatoes, peppers, eggplants, or other caneberries or strawberries affected with verticillium. Remove and burn diseased plants. Foliage applications of fungicides are ineffective for control of verticillium wilt. Soil fumigation has proved to be effective in some areas.

Powdery mildew. Powdery mildew is a fungus disease which covers the leaves with a white powder. This white powder is actually the fungus and spores. The mildew can appear on either the upper or lower surfaces of a leaf. The leaves are usually cupped downward or distorted in shape. The infection may attack the shoot tips resulting in distorted and stunted growth.

Control: Plant resistant varieties. Most varieties of red raspberries show resistance to powdery mildew. If the disease was prevalent during the growing season, removing the fallen leaves will reduce the number of spores in the spring. A dormant spray during the winter will also be helpful in reducing the amount of fungus surviving to infect the next year's crop.

Crown gall. Crown gall is a bacterial disease which not only attacks cane berries but many other woody plants. Galls (rough, spongy, or hard wart-like growths) can occur on roots, crowns, and canes and may vary from the size of a pinhead to several inches in diameter. Galls are more common in blackberries than red raspberries. The disease generally reduces the vigor of plants, and if galls are formed in the crown area also reduces production of new canes.

The bacteria can enter the plant only through wounds. If bacteria are present in the soil, they can invade

roots and crowns through natural growth cracks or through wounds from winter injury, insect damage, or pruning and cultivation. Planting stock can become infected in wounds if it comes into contact with the bacteria when being dug, stored, or planted.

Control: Use only planting stock certified to be free from crown gall. Fields to be planted should be free from the bacteria. If the planting site has a history of crown gall or has previously been in cane berries, grapes, or tree fruits, it should be planted to a crop not affected by crown gall (vegetable or grain) for two or three years before replanting with cane berries. If a few plants are found to be infected in a field, they should be removed and burned to avoid spread to other plants in the field.

Close cultivation which causes root wounding should be avoided. Pruning shears should be frequently sterilized by dipping them in formaldehyde or alcohol when used in fields where crown gall is suspected.

Supplying enough water and fertilizer to promote good growth can partially compensate for losses caused by the disease. In fields where there is widespread disease and removing diseased plants is not practical, adequate production may be possible for several years by providing ideal growing conditions.

Virus diseases. Numerous virus diseases can attack cane berries. Some can cause considerable losses while others seem to have little effect on plant vigor. Once a plant becomes infected it cannot be cured and all the vegetative parts will become infected. Thus, plants started from virus-infected plants will also be diseased. Some viruses are also spread by aphids which first feed on the infected plants and then spread the infection when they feed on healthy plants. Other viruses are spread by soil nematodes or infected pollen. Viruses of raspberries have not been shown to be spread by pruning. Descriptions of several specific virus problems are included below.

Control: Several general control measures will help keep virus problems under control: 1) Use virus-free planting stock; 2) remove and destroy diseased plants when found; 3) remove wild blackberries and raspberries from the vicinity of cultivated plantings, 4) control aphids; and 5) plant resistant varieties.

Mosaic. Raspberry mosaic virus may reduce yields of red raspberries by more than 50%. Leaves on mosaic-infected canes show large green blisters. Leaf tissue around the blisters turns yellowish. The leaves are abnormally small and sometimes deformed. Leaves that develop in hot weather show only faint symptoms or none at all. Late spring frosts, powdery mildew, red spider, aphids, and boron deficiency may all produce symptoms which mimic mosaic.

Mosaic also causes progressive stunting of canes. New growth is shorter than growth of preceding seasons. Berries on badly infected canes are dry, seedy or crumbly, and often worthless.

Control: Plant certified raspberry plants that have been found to be free of the mosaic virus, if available. Do not plant healthy raspberries near diseased plants, and do not plant red raspberries near black raspberries even when both varieties are disease free.

Remove and burn diseased plants. Raspberries that leaf out late in spring may be virus infected. The cause of late leaf break should be determined before removing. Leaf-feeding aphids spread mosaic rapidly. Remove wild raspberries and blackberries from the vicinity of cultivated raspberries.

Tomato ringspot. Ringspot is a widespread virus disease that occurs in the major red raspberry areas of the Pacific Coast. In the spring, a few leaves on infected plants show pale green rings that disappear in midsummer. Infected plants grow at a slower rate than normal and become weak. Infected canes die back in the most susceptible varieties or may produce crumbly berries in other varieties. Certain varieties show no noticeable damage and are classed as tolerant.

Ringspot in red raspberry is caused by a virus first identified in tomato and thus called tomato ringspot virus. However, tomato ringspot virus readily infects many hosts, including weeds. It is spread by soil-borne dagger nematodes infesting plant roots.

Control: Plant stock certified to be free from tomato ringspot virus on land which is free from the dagger nematode. See section on control of nematodes.

Calico. Calico is a virus-like disorder resulting in gradual decline of the affected plants. Leaves show a conspicuous bright yellowing along the veins, forming a network pattern. Although the exact cause is not known, evidence shows the disease can spread in a field. Roguing affected plants is suggested.

Raspberry decline. Many growers use the name raspberry decline to describe a condition affecting many red raspberry plantings. Symptoms usu-

ally include leaf wilting and drying of leaf margins on fruiting canes and on developing young canes. Often the condition is scattered in the field with only occasional plants showing the symptoms. Later, it spreads down the rows and often to adjacent rows. Second-year symptoms are usually more severe and the fruiting laterals are stunted and collapse before the fruit ripens. Death of canes occurs the second or third year. The roots of some affected plants are rotted either in the center or throughout. In others, little root rot is noted. Occasionally yellow ring spots are noted on young leaves during May and June. The final results in many fields are poor yield and death of enough plants to make continued production of questionable economic value.

Raspberry decline has been described under several names including wet soil root rot, raspberry root rot, blight, and running out. Root rots, nematodes, and one or more virus diseases may be involved in any given field. Positive diagnosis of the exact cause is difficult. To most effectively combat this situation a grower must carefully identify the one or more causes involved.

Raspberry decline occurs mostly in poorly drained areas or in heavy soils with high moisture-holding capacity. The problem, however, is not limited to such conditions. While a number of fungi have been reported as possible causes of raspberry decline, *Phytophthora* species are most frequently associated with the problem. These species are capable of causing severe root rot. There are differences among raspberry cultivars in their susceptibility to wet soil root rot: Canby and Washington are most susceptible, Willamette and Puyallup are intermediate in reaction, and Sumner and Newburg are most resistant. From limited observations, Fairview and Meeker appear to have about the same level of resistance as Willamette and Puyallup.

Control: Control of raspberry decline in established plantings is usually not possible. The following suggestions are directed toward preventing this situation. No planting should be made on soil that is heavy and has a tight clay subsoil, or on any soil that is poorly drained. In marginal situations select the more resistant varieties. At this time, soil fumigation for the control of raspberry decline is *not* recommended. Additional work is needed. Soil fumigation is recommended, however, for the control of nematode infestations. In some cases this may help in the control of raspberry decline.

NEMATODES

Nematodes are microscopic worm-like organisms which range from 1/50 to 1/125th of an inch in length. They infest soil and water and infect plants. Raspberries are subject to attack by a number of nematode species. The most damaging are root lesion and dagger nematodes. Nematode attack on plant roots often increases the severity of soil-borne plant diseases, especially root rots and verticillium wilt.

Symptoms of nematode injury are most obvious on bearing canes. They include weak lateral growth, small leaves, a reduction in fruit size, and a tendency of the fruit to crumble when picked. Severely infected plants gradually decline in vigor. The root system may be stunted and somewhat matted, rotted, or occasionally knotted (galled). The foliage may turn yellow and leaves may drop early, especially during dry weather. Nematode-infected plants may be more susceptible to winter injury.

Control. Nematodes will become progressively more damaging the longer raspberries are cultivated. Periodic rotations with a wide variety of crops will help to reduce nematode populations. After the canes have been destroyed, leave the soil untilled or grow small grains for three or four years. Avoid crops that are highly susceptible to nematodes such as most vegetables or forage legumes. Use only planting stock that is nematode free. Have the problem identified by soil test for nematodes. If a serious nematode problem exists, fumigate the soil before planting.

The use of nematicides is particularly important in nurseries. Chemical treatments for the control of nematodes are usually applied into the soil by injection equipment. On fields intended for fruit production, use registered nematicides for *preplanting* treatments. Do not use these in or around the soil of established plants.

Sampling for nematode pests. Why sample? Sampling and examination can provide information as to presence or absence, concentration, and identification of the types of nematodes present in the field.

When to sample: Always sample before establishing a planting so that results can be determined early enough to permit an effective treatment before planting. In established plantings, sample when symptoms and observations indicate a likelihood of nematode problems. Sample during the warmer seasons when adequate moisture is available since nematodes are most abundant at this time.

How to sample: Although there are nearly as many ways to sample as there are collectors, the reliability of results depends upon a sample that represents the locality. Thus, the overall sample of approximately one quart should contain at least 20 sub-

samples of the first foot of soil from twenty different locations within the field. Samples are usually obtained with a small shovel or trowel or with a 12 to 18 inch soil tube that is 7/8 inches in diameter. In the absence of an established crop, samples may be taken at random or in a grid-like pattern; however, low spots, entrances to fields, and irrigation and drainage ditches should be included. When crops are present, samples should be taken from root zones of seemingly healthy plants adjacent to those showing symptoms or plants in the transition zone between healthy and severely affected plants. Roots from injured plants along with surrounding soil should be included.

Packaging: Strong polyethylene bags make desirable containers because they prevent moisture loss. Nematodes become inactive and die if soil becomes too dry.

Package poly bags in a strong container that will keep the bag from breaking open. Label both inside and outside containers and attach the data sheet to the sample. Address and ship the sample to the laboratory promptly. Do not delay more than four days. Do not allow the samples to overheat from sitting in the sun or in the trunk of a car.

Information required: Indicate grower's name and address, date of sampling, location of area (by description or map), name and variety of crop last grown in the soil, and name and variety of crop to be planted.

Your Extension agent can provide assistance in obtaining nematode testing data sheets and information on sampling procedures. He can also provide you with addresses of nematode testing laboratories. Contact the laboratory of your choice for cost, containers, etc.

Guide for pre-plant soil fumigation. Soil sampling for nematodes is not an exact science and populations of nematodes recovered from the soil will vary with time of year, environmental conditions, and method of sampling. Soil fumigation prior to planting raspberries is a treatment to prevent a nematode population from developing until the planting is well established.

Soil samples are analyzed by several commercial laboratories and the number and type of nematodes recovered will vary to some degree. Also, the volume of soil on which the nematode counts are based will vary. It is therefore important to read the results and convert all data reported to a standard volume of soil. The guide below is based on the number of nematodes recovered from one pint of soil (approximately 500 cc).

Soil fumigation. Soil fumigation is a practice that should be carefully and seriously considered before establishing a raspberry planting. It is not necessarily warranted in all cases, but in many fields it will help ensure long-term production.

Soil fumigation is used to control nematodes. Nematodes cause varying

GUIDE FOR PRE-PLANT SOIL FUMIGATION

Type of Nematode	*Number per Pint*	*Guidelines for Treatment*
Root lesion	0-100	At this level, usually no major problem and soil fumigation may be of questionable value.
	100-500	Soil fumigation should be considered. At this level nematodes will usually build up and be a problem in the early life of the planting especially on light or sandy soils.
	500-2500	Soil fumigation is usually necessary to establish a normal planting. This population of root lesion nematodes will cause severe damage to raspberries.
	2500 +	Soil fumigation necessary. Should consider resampling after soil fumigation to determine the level of control. May also consider a split application of the soil fumigant.
Virus vectors: Xiphinema (dagger) Longidorus Trichodorus	1 +	These nematodes are a known virus vector and should be considered a potential problem. Low populations may cause considerable damage to raspberries due to virus transmission. These nematodes may be extremely important in locations where raspberries are replanted.
Other parasitic nematodes:		Other known plant parasitic nematodes may be associated with raspberries, however their importance has not been studied. To determine if fumigation is necessary, contact your Extension agent.

degrees of damage to raspberries, depending on the species and the population. One or more species transmit tomato ringspot virus. Soil fumigation is of special importance if certified plants are used. There is little sense in planting certified plants in nematode-infested soil. A nematode analysis should be run and a decision should be made based on the results and recommendations of the testing service. (See nematode sampling.)

It is advisable to fumigate the summer before the spring in which the planting is to be made. Often wet soil conditions and low soil temperatures prevent fumigation before planting in the spring.

Proper techniques of fumigation are of great importance in obtaining good results. Fumigants volatilize upon injection or placement into the soil and the gas permeates the surrounding soil, killing many microorganisms. The degree to which toxic vapors affect soil microorganisms is related to the concentration of the vapor and the exposure time. Vapors in the soil eventually diffuse upward and leave the soil or are broken down by surviving microorganisms that are not affected by the toxic gas. The best conditions for fumigant action are those which permit complete volatilization of the fumigant, allow the vapors to move through the soil readily, and prevent the rapid escape of vapors from the soil, lengthening exposure time.

To do a proper job of fumigating, a number of factors should be considered:

Soil temperature: Most fumigants work best at temperatures between 60-70°F. at the 6-inch depth. When temperatures are lower, it often takes a longer time for the material to change to the gaseous form, and it may not leave the soil fast enough. The organism, on the other hand, may be in a resistant stage at the lower temperature and not be affected by the gas. If the temperatures are too high (above 70°F.) the gas may leave the soil too rapidly and not reach a concentration high enough to destroy the organism. Some organisms may be in a resistant stage at the higher temperature just as they are at the lower temperature.

Soil moisture: Too much water in the soil will slow down the movement of the gas, resulting in a poor job of disinfestation. If there is too little water, the gas will leave the soil too rapidly. Also, the organism may be in a dormant stage or resistant stage and not be affected by the gas. In general, the soil should be in a good seedbed moisture condition, holding about 50-80% of water capacity. A handful of soil squeezed into a ball should break apart when touched with the finger. If it will not ball, then it is too dry. If it will not break apart when touched with the finger, or water can be squeezed out, then it is too wet.

Soil texture: The soil should be well pulverized. Large clods will allow the gas to leave the soil too quickly to do an effective job of disinfestation. Also, fungi and nematodes in clods are especially difficult to kill.

Organic matter: Be sure all the organic matter is well decomposed. Most fumigants will not penetrate plant material that is not well decomposed. Also, soils high in organic matter require larger doses of the fumigant because of the absorbing effect of the organic matter. Muck soils generally require twice the amount of fumigant that would be used on mineral soils.

Seals: Fumigants should be sealed into the soil to be most effective. This will vary with the chemical. Some ways of sealing the fumigant are using a water seal, plastic covers, or by packing the soil with rollers, drags and such. Various combinations of these methods can be used.

Soil type: Check soil types carefully in relation to the amount of fumigant that is to be used. Heavy clay soils require more fumigant than a light sandy soil.

Depth of application: Apply the fumigant at least 8-10 inches deep. Be sure it is applied uniformly, or if injected, that the bands are close enough so the fumigant will do a proper job of fumigating the soil. Spacing of bands may vary depending on type of control desired, but commonly used widths are 10-12 inches.

Time of application: Late summer and early fall are good times to apply fumigants. At this time the soil temperature is relatively high and the soil moisture is relatively low. Application in the spring often must be delayed until soil temperature is above 55°F. and soil moisture is in the 50-80% range. It may then be too late in the season to plant the crop after the required waiting period. An early fall application after crop removal allows the fumes to dissipate over the winter. The crop can be planted at the normal planting time the following spring.

PESTICIDES

PESTICIDE SAFETY

Several questions should be considered before chemical pesticides are used. What are the pests? Does the economic loss to the crop justify the treatment? Are there acceptable, perhaps preferable, alternates to chemical control?

If the decision is to use pesticides, what is the best choice for the particular problem? What are the potential non-target effects? Is timing important? Is there a hazard to humans, bees, pets, livestock, or wildlife?

The preharvest interval restriction needs to be considered. So does the toxicity of the chemical and any special application techniques. Often the broad-spectrum, least-expensive treatment will be most expensive in the long run because of undesirable side effects.

Determine the need before pesticide use. Consider the alternatives. The most important decision may be whether control is necessary. If the choice is a chemical pesticide, choose and use it wisely.

Protect pollinators. Insect pollination of berry crops is extremely important. Killing pollinators, especially honeybees, along with pests is counterproductive.

If you own or rent bees, protect them by using pesticides and timing that is compatible with safety for the bees.

If you rent bees, discuss pesticide use with the beekeeper so that losses can be avoided or minimized. Spraying when bloom is present is hazardous with any insecticide. Anticipate problems and treat in the pre-bloom or post-bloom (any bloom) if at all possible.

Pesticides are toxic. Read and follow pesticide label directions each time you use a pesticide. Only a few pesticides have effective antidotes and even these are dependent upon quick diagnosis and treatment. An attitude that is defensive, that prevents accidents from happening, is one to develop.

Pesticides do not clearly discriminate between living organisms. While fungicides and herbicides are, in general, less toxic than insecticides, do not assume that they will not harm non-target plants or animals. Make it a practice to avoid skin contact, oral contact, or inhalation of any pesticide.

Poison statistics indicate that the most frequent entry route to humans it through the skin. Especially avoid skin contact with concentrated pesticides during the hazardous activity of measuring and loading.

Wear protective clothing, chemical-proof apron or jacket, gloves, and boots at least while handling concentrates. Accidents do happen. Be prepared.

If a spill occurs, remove any contaminated clothing and wash the exposed skin with lots of flowing water and detergent, if available. Many pesticides are readily absorbed from the skin into the bloodstream. Any delay in decontamination will increase the possibility of poisoning.

Signal words. Every pesticide label includes a signal word that indicates the toxicity of the pesticide. The most toxic pesticides have the signal word *Danger* and the word *Poison* and the skull and cross bones on the label. Moderately toxic pesticides include the word *Warning* on the label and pesticides of low toxicity use the word *Caution*. Note that there is no category for non-toxic or safe. Every label includes the words, *Keep out of reach of children*.

Responsibility. In a legal sense *you* must protect yourself and others when using pesticides. You, the user, are responsible for any harmful effects. The label is your guide—but common sense and good judgment is important, too.

Any violation of the label is illegal—even failure to wear a respirator is illegal if the label tells you to do so.

Protective clothing. Chemical-proof clothing, hat, gloves, and boots are required when using the most toxic pesticides. None of this equipment is comfortable to wear. Choose as lightweight, light-colored clothing and gloves as practical.

Minimum protection is given by closely woven long-sleeved shirt and long-legged trousers. Avoid clothing that permits exposure of arms and legs. Don't wear leather or canvas shoes, boots, or gloves for they are easily contaminated and nearly impossible to clean.

Wear trouser legs and shirt sleeves outside boots and gloves to prevent chemicals from running inside.

Use an approved respirator, keep it clean, and change the chemical cartridge frequently. Since the effective life of cartridges is determined by the exposure, a few hours to a few weeks may be a safe margin. Change if you are concerned. Do not depend upon the detection of an odor in the respirator to signal a need for cartridge change. Odors can be deceiving and the nose can be quickly desensitized to odor.

Symptoms of pesticide poisoning. Knowledge of symptoms will alert you and minimize injury. Symptoms are feelings that the person who is poisoned notices, such as nausea or headache.

Each pesticide within the same

class will cause the same kind of sickness. Mild symptoms may well appear identical to common illnesses such as flu or stomach ache. If you are working with pesticides and have unexplainable patterns of illness, get medical advice.

Poisoning symptoms usually occur in a matter of minutes or hours following exposure. If illness strikes days after exposure, pesticides are an unlikely cause.

Organophosphates

Mild poisoning symptoms: Fatigue, headache, dizziness, blurred vision, unusual sweating and salivation, nausea, and vomiting.

Moderate poisoning symptoms: Inability to walk, weakness, chest tightness, twitching, constriction of pupil of eye, intensification of early symptoms.

Severe poisoning symptoms: Unconsciousness, severe constriction of pupil of eye, muscle twitching, secretions from mouth and nose, breathing difficulty, death.

Carbamate poisoning is similar to organophosphate poisoning, but more effectively treated.

Organochlorine poisoning symptoms include many of the above, but also convulsion, excitability, and irritability.

Nitrophenols and pentachlorophenol poisoning symptoms include redness, burning and blistered skin, fever, fast heart beat and breathing, flushed skin, collapse, and coma.

Fumigants and *solvent poisoning* symptoms make the victim appear drunk, with poor coordination, slurred words, confusion, and sleepiness. A fatal dose of fumigant such as methyl bromide can be absorbed before any symptoms appear.

Your physician and your safety. Medical doctors are rarely knowledgeable or experienced to handle pesticide poisoning. Help out your physician by alerting him to the possibility of your exposure. Furnish him with literature on diagnosis and treatment of pesticide poisoning. An excellent reference is *Recognition and Management of Pesticide Poisonings*, by Donald P. Morgan, MD, PhD, EPA-540/9-011. Write to the Environmental Protection Agency, Office of Pesticide Programs, Washington D.C., 20460, for a copy.

Basic information on first aid is on the labels of highly toxic pesticides, as is the antidote, if a specific one has been identified. Check to see if your physician has the telephone numbers of the poison control centers in your state where he can call day or night for consultation.

Immediate action for pesticide poisoning. If poisoning is suspected, take these steps:

1. In severe cases, breathing may stop. Artificial respiration is the most important action to take.

2. Inhalation or swallowing or skin exposure requires the same quick action. Get the patient out of the poison and the poison out of, or off of, the patient.

Remove contaminated clothing. Induce vomiting for swallowed pesticide (except petroleum products which may cause even more harm if they are vomited up and aspirated into the lungs). Follow label directions.

Wash exposed skin with lots of running water and detergent. Get the patient to a doctor.

3. Don't give an unconscious patient anything by mouth. Keep the patient warm.

Transporation of pesticides. Move pesticides from the suppliers or to the field in the back of a truck, securely fastened down and covered for protection against the weather and the unsuspecting public. Never carry chemicals in the cab where an accident could cause a severe problem.

If an accident should occur on the road, treat the injured or contaminated, contain the spill making special effort to see that streams or other water is not reached, and seek help to close the area to protect others.

Storage of pesticides. Store pesticides in dry, well-ventilated and fire-resistant buildings. Keep pesticides from extremes of temperature. Never store herbicides in the same room with fungicides and insecticides so that cross-contamination can be avoided.

Always keep pesticides in their original containers. Keep the storage area locked and posted as to the nature of the chemicals inside.

Disposal of pesticides and containers. In general, empty pesticide containers should be triple-rinsed and the rinse water used in the spray operation. Triple-rinsed containers can be disposed of in most areas in specially designated landfills.

In some areas, triple-rinsed containers may be crushed and buried if burial will not contaminate ground water.

Paper and fiber containers, carefully emptied, may be burned in small quantities where local regulations permit. Herbicide containers should not be burned because of the possible damage through volatilization. Bury these. Keep out of the smoke of burning containers.

Unwanted or unusable pesticides are considered environmentally hazardous wastes. Consult county health departments for disposal sites that will handle these chemicals.

FORMULATIONS AND CONCENTRATIONS

Common pesticide formulations are wettable powders, emulsifiable concentrates, dusts, solutions, aerosols, baits, granules, and flowables.

Wettable powders (WP) are dry forms of pesticides that can be readily mixed with water because a wetting agent has been added. These form a suspension-type spray which must be kept agitated in a sprayer tank.

Emulsifiable concentrates (EC) contain a pesticide and an emulsifying agent in a suitable solvent. These are diluted with water to form an emulsion and applied as sprays.

Dusts (D) are usually made by diluting the toxicant with finely ground, dried plant materials or minerals. These include wheat, soybeans, walnut shells, talc, clay, or sulfur. They are applied in the dried form.

Solutions are liquid forms of pesticides which are dissolved in suitable solvents such as petroleum distillates or liquid gas. Oil-base cattle sprays, household sprays, and gas-propelled aerosols are examples of pesticide solutions.

Aerosols are air suspensions of solid or liquid particles of ultramicroscopic size which remain suspended for long periods.

Baits consist of a poison or poisons plus some substances which will attract the pest.

Granules (G) are formed by impregnating the pesticide upon an inert carrier of 30 to 60 mesh particle size.

Soluble powder (SP) is a powder formulation that dissolves in water.

Flowable (F) is a liquid or viscous concentrate of suspendible pesticide in water.

Fumigant is a substance or mixture of substances which produce gas, vapor, fume, or smoke intended to destroy insects, bacteria, rodents, or other organisms.

SPRAYER CALIBRATION

Every sprayer must be calibrated to uniformly apply the proper quantity of material. Because of wear, recalibrate sprayers at least once a year. First, choose the nozzle designed to deliver the proper spray pattern at the operating speed and pressure used. Refer to manufacturer's tables for the specific nozzle. Adjust height of boom to cover weeds or soil in an even spray pattern.

A suggested procedure is this:

1. Check machine to see that all parts are working properly.
2. Thoroughly clean pump, screens, lines, and nozzles.
3. Note tractor gear and throttle setting for speed desired.
4. Run sprayer with water. Adjust pressure-regulator and check for leaks.
5. Pull sprayer at actual operating speed, to double check.
6. Measure off a test strip by putting two stakes 218 feet apart.
7. Place sprayer on a level spot. Fill sprayer with water. Mark level.
8. Spray test area from stake to

DILUTION TABLE FOR PESTICIDES

	Amount of Formulation Needed Per Acre to Obtain the Following Amounts of Active Chemical Per Acre						
Pesticide Formulation	***1/8 lb.***	***1/4 lb.***	***1/2 lb.***	***3/4 lb.***	***1 lb.***	***2 lbs.***	***3 lbs.***
1% dust	12 1/2 lbs	25 lbs	50 lbs	75 lbs	100 lbs	200 lbs	300 lbs
5% dust	2 1/2 lbs	5 lbs	10 lbs	15 lbs	20 lbs	40 lbs	60 lbs
10% dust	1 1/4 lbs	2 1/2 lbs	5 lbs	7 1/2 lbs	10 lbs	20 lbs	30 lbs
18 1/2 % wettable powder	2/4 lbs	1 1/3 lbs	2 2/3 lbs	4 lbs	5 1/3 lbs	10 2/3 lbs	16 lbs
25% wettable powder	1/2 lb	1 lb	2 lbs	3 lbs	4 lbs	8 lbs	12 lbs
50% wettable powder	1/4 lb	1/2 lb	1 lb	1 1/2 lbs	2 lbs	4 lbs	6 lbs
75% wettable powder	1/6 lb	1/3 lb	2/3 lb	1 lb	1 1/3 lbs	2 2/3 lbs	4 lbs
EC 1 lb. active ingredient/gal.	1 pt	1 qt	2 qts	3 qts	1 gal	2 gals	3 gals
EC 2 lbs. active ingredient/gal.	1/2 pt	1 pt	1 qt	3 pts	2 qts	1 gal	1 1/2 gals
EC 4 lbs. active ingredient/gal.	1/4 pt	1/2 pt	1 pt	1 1/2 pts	1 qt	2 qts	3 qts
EC 8 lbs. active ingredient/gal.	1/8 pt	1/4 pt	1/2 pt	3/4 pt	1 pt	1 qt	1 1/2 qts

stake.

9. Return sprayer to the level spot in 7. Refill the tank to the marked full level, measuring carefully the amount required.

10. Calculate the application rate in gallons per acre (g.p.a.), using the formula

$$\text{g.p.a.} = \frac{\text{gallons water added} \times 200^{*}}{\text{boom length or spray swath in feet}}$$

Sample calculation (over-all spray): If spray boom is 25 feet in length and 10 gallons are required to refill tank, then spray rate

$$\text{g.p.a.} = \frac{10 \times 200}{25} = 80 \text{ gal. per acre}$$

Band spray: If sprayer has four spaced nozzles each delivering a spray pattern of 1 1/2 feet, total width sprayed (4 x 1 1/2) is 6 feet. If 1 1/2 gallons are required to refill tank, then spray rate

$$\text{g.p.a.} = \frac{1.5 \times 200}{6} = 50 \text{ gal. per acre}$$

Remember, in band spraying the area actually covered is less than the crop acreage. For example, a 3-foot band sprayed over rows 9 feet apart requires only one-third the gallonage per acre.

For band application, reduce the per acre recommendation of the chemical to that part of an acre covered. For example, if the recommendation states 3 pounds per acre and the band application covers one-third of the surface acre, then the treatment per acre should be reduced to one-third of 3 pounds, or 1 pound per acre.

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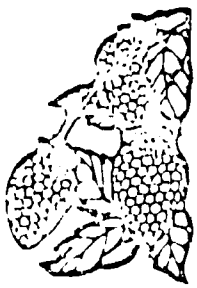
*Factor of 200 is obtained by dividing area per acre (43,560 sq. ft.) by length of test strip in feet (218).



COMMERCIAL RED RASPBERRY PRODUCTION

YEARLY CALENDAR

January. Do repair and maintenance of equipment including irrigation equipment. Check sprayer nozzle disks for wear. Prune out weak canes and old fruiting wood if not already done. Do not top canes yet. Tie canes to trellis. Apply manure when practical. Confirm new plant orders. Apply dormant season sprays for disease and weed control.

February. Continue with January activities. Start topping during late February. Spray for crown borers if needed and not already done. Prepare and plant new fields, weather permitting. Take soil samples for nematodes from fields to be planted next year.

March. Apply fertilizer. Apply herbicides. Spray for crown borers if needed. Plant new fields, weather permitting. All pruning and training should be complete by April 1.

April. Apply delayed dormant spray (lime sulfur + spreader sticker) when buds begin to show green for control of cane blights, anthracnose, mildew, yellow rust. Hoe or spray out extra shoots and weeds around and between hills. Begin shallow cultivation to control weeds. Apply dinitro spray for cane control when new shoots are 6-10 inches high (vigorous fields only). Fertilize newly planted fields.

May. Apply second dinitro cane control spray when shoot growth reaches 6-10 inches, if needed (do not apply after start of bloom). Hoe out extra shoots between hills if dinitro is not used. Apply worm spray 2 weeks prior to bloom (examine in early May to determine need, observe cautions concerning bees). Begin fruit rot and mildew control sprays.

June. Sign up and arrange for picking crews and/or machines. Apply fruit rot control sprays. Place new shoots inside holding wires. Irrigate when necessary. Water to field capacity before picking. Apply sprays for fruit rot, fruit worm, adult root weevil, and orange tortrix if needed. Avoid use of insecticides harmful to bees. Cultivate before harvest if needed. Arrange for harvest boxes. Carry on early harvest as required.

July. Harvest time. Apply fruit rot sprays as needed. Irrigate only if needed. Take foliar samples for analysis.

August. Continue harvest as required. Irrigate after harvest. Remove old fruiting wood (optional). Cultivate once in early August. Plant cover crop. Fumigate land for new plantings to control nematodes if needed. Spray for mites if needed.

September. Mow weeds and/or cover crop. Still time to fumigate for spring planting if needed. Irrigate in late September, *eastern Washington only*. Order plants for spring planting.

October. Start removal of weak shoots and old fruiting wood. Apply fall herbicides. Spray for crown borer if borers are present. Collect soil samples for soil tests. Order fertilizers, spray materials, other supplies and equipment needed for next season. Clean and winterize all equipment. Drain sprayers completely.

November. Continue pruning (do not top canes). Repair trellises and replace rotted posts. Install trellises in new plantings. Apply lime if needed. Apply herbicide for quackgrass control.

December. Apply manure. Continue pruning and trellis repairs as weather permits. Make plans for new season.

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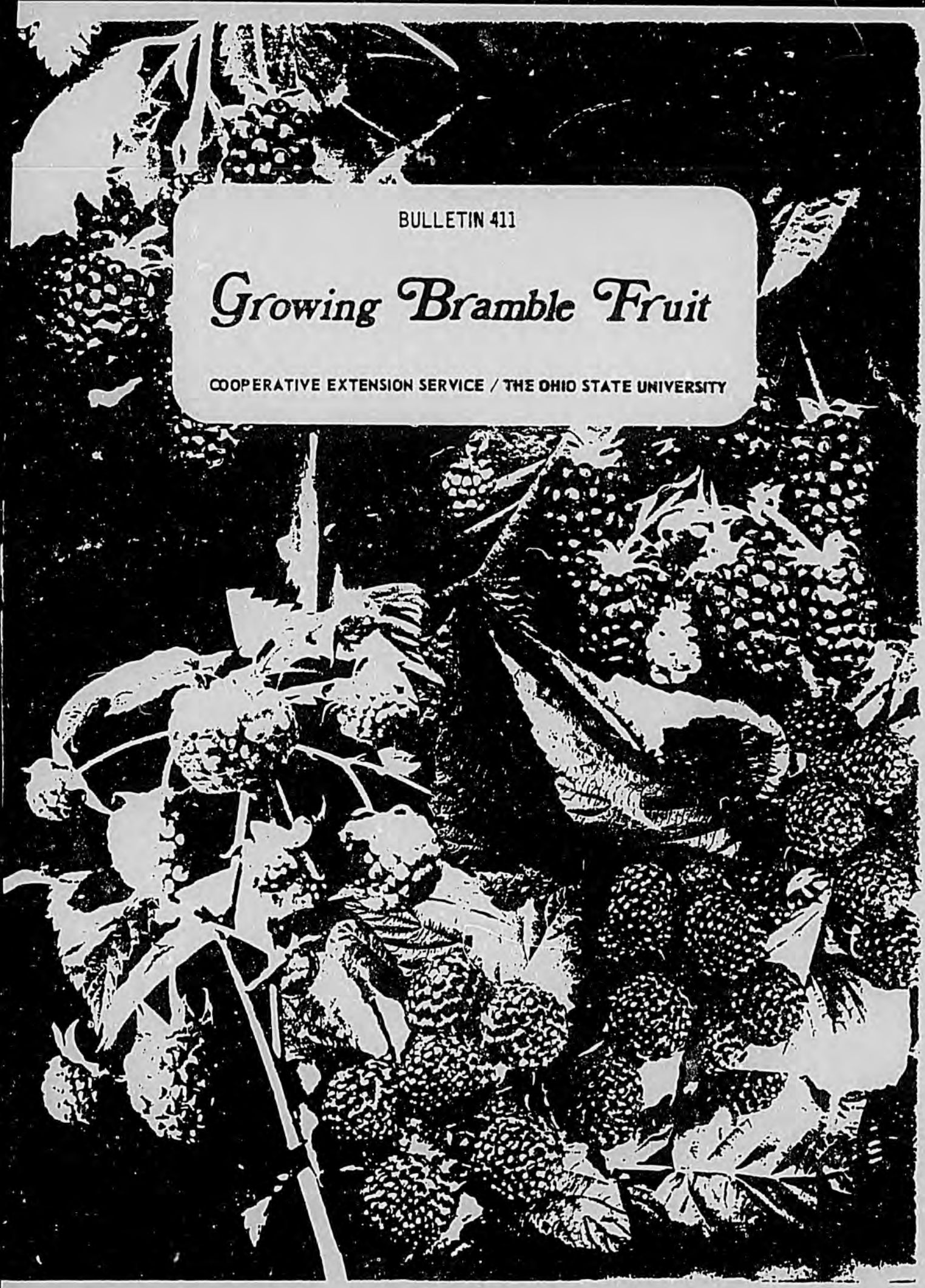

BULLETIN 411

Growing Bramble Fruit

COOPERATIVE EXTENSION SERVICE / THE OHIO STATE UNIVERSITY

-51-

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Growing Bramble Fruit

Bramble fruits, raspberries and blackberries, have long been considered among the choice fruit crops that can be grown successfully in Ohio. With proper care, plantings of these fruits may be expected to produce good crops of high quality berries for a number of years.

Bramble fruit plants are characterized by the biennial habit of their above-ground parts. Each spring the plants produce new shoots from below ground. These shoots overwinter, bear fruit the following season, and die. With everbearing types, the new shoots bear a crop during late summer and a second crop the next year during the regular season. Due to the variations in growth habit, however, each bramble crop requires special cultural practices.

Well grown blackberry plants may yield 1½-2 quarts per plant. Vigorous raspberry plants may yield 1-1½ quarts or more per plant.

A grower's success with brambles, as with any horticultural crop, depends on careful attention to cultural details. With these crops, special attention must be given to avoiding and controlling diseases which, more than any other factor, are apt to limit the profitable life of most plantings.

Raspberries and blackberries ripen shortly after the strawberry. They are highly nutritious and make an attractive dessert. For example, an average serving of black raspberries will supply more than the average daily minimum requirements of vitamin C. These berries are prized for pies, jams, jellies, and also for freezing.

Selecting the Site

The bramble fruit grower can avoid many of the difficulties often associated with the production of these crops through careful site selection. It is generally recommended that new plantings be separated, if possible, by at least 300 feet from other bramble plants, either wild or cultivated. Unless this isolation can be afforded, virus diseases are likely to become serious problems. If only clean, "virus-free" planting stock is used, the different sorts may be planted close together. Such plantings should, however, be isolated from any bramble plants which may carry virus disease. For limited, family size plantings where isolation is not available, mixed plantings may be maintained.

Bramble fruits should not be planted on sites where tomatoes, potatoes, or eggplants have been grown previously. Such sites are frequently found to be heavily infected with verticillium wilt, a disease which may remain in the soil for many years. Brambles, particularly black raspberries, are very susceptible to this disease. At present, there is no practical control for it. Sites likely to be carrying heavy herbicide residues from previous crops should be avoided, too.

Brambles grow and produce satisfactorily on a wide range of soil types from sandy to heavy clay loams. They are not particularly sensitive to variation in soil acidity. The most suitable soil is a deep sandy loam with a good organic matter content, moisture holding capacity, and a pH of 5.8 to 6.5. In general, any good garden soil will be satisfactory.

The site must also afford good drainage—both soil and air. Plantings on poorly drained soils are generally short lived and unproductive. Where air drainage is limited, the crop may be lost due to late spring frosts which can kill the flowers. Ideally, the site should be selected the year before it is to be planted. Early site selection allows proper preparation of the soil, including weed control, fertility adjustments, and elimination of other potential problems. Selection of a suitable site is the first step toward success with bramble fruits.

Bristol—perhaps the most widely planted black raspberry in Ohio. These clusters of fruit are ready for harvest.

Selection of Cultivars*

Many cultivars of each bramble fruit are available, but only a limited number have been proved satisfactory under Ohio growing conditions. All recommended cultivars are self-fruitful and will produce good crops without cross-pollination. Many growers plant several cultivars in order to extend the harvest season.

Raspberries

Black, red, and purple raspberries can be grown successfully both commercially and in home gardens in Ohio. The most popular raspberry in Ohio is the black. The red is the second most popular, while the purple is less widely grown. The latter, a hybrid between the red and black, is very productive, and its fruits are suitable for dessert and culinary purposes.

Usually the black cultivars ripen first, followed by the red and the purple types. There is considerable overlapping in ripening seasons. In Ohio, raspberries are in season in July and early August. Everbearing type, red raspberries are in season in July and again in September and October. In general the purple is the largest fruited and the most productive of the group. The red is the least productive. There are also yellow-fruited kinds, but these are only grown as a novelty and are not of commercial importance.

* **CULTIVAR** is the term now used in place of "variety" which was common in horticultural literature for many years. Cultivar, to be used to designate horticultural varieties throughout the world, was adopted by the International Code of Nomenclature for Cultivated Plants in 1961. The term is being widely used in Europe and is now beginning to be used generally in the United States. Throughout this bulletin the term, cultivar, replaces the former term, variety.

Red Raspberries

Taylor matures in the same season or slightly before Latham. Berries are large, bright, attractive, firm, and of good quality. Plants are vigorous, hardy, and productive.

Latham is the most widely planted red raspberry in Ohio. The berries are an attractive light red which tends to darken as they become over-mature. They are roundish in shape, medium in size, and reasonably firm, but may crumble in some seasons. The fruit is of only fair quality. The plants are winter hardy. Although they are subject to mosaic, they produce well in spite of the disease. The fruit is easy to pick, and the season is fairly long.

Milton is recommended for extending the red raspberry season, ripening its fruit near the end of the Latham harvest. It produces good crops of attractive, large, long conic berries of good quality. Fruits are non-crumbling with a mild sub-acid flavor. The plants are vigorous, erect, productive, and reported to be more resistant to mosaic than Latham or Taylor.

The cultivar, **Hilton**, has recently become available. This cultivar may have promise, but as yet not enough is known about its performance under Ohio conditions to warrant its planting except on a trial basis.

Black Raspberries

Logan (New Logan) is a popular black cultivar in Ohio. The berries are of good quality, medium to large, firm, and attractive. The plants are productive and vigorous.

Bristol, in recent years, has become the most popular and most widely planted black raspberry in Ohio. The berries are medium-large, glossy, attractive, and firm with good quality. They are sometimes difficult to pick unless fully mature. The plants are tall, vigorous, hardy, and productive.

Cumberland, an old, established late season cultivar, produces berries of good quality. The plants are very susceptible to anthracnose as well as to the different virus diseases; produce good, but not exceptional, yields.

Morrison can be planted for extending the picking season. The fruit is somewhat above average in size, firmness, and dessert quality. The plants are vigorous, but not as productive as Bristol and Logan.

Allen has performed well in tests at the Ohio Agricultural Research and Development Center. It is very productive. The berries, which ripen with or slightly before Bristol, are large, attractive, and of good quality. Plants are vigorous. Recommended for trial plantings.

Black Hawk is the latest desirable black raspberry available. Plants are vigorous. The berries are of good size and quality, but it is not as productive as the recommended main season cultivars.

The cultivars, **Huron** and **Lowden** have more recently become available. As yet they have not been grown long enough to determine their value here in Ohio. Until the worth of a new cultivar is established it should be used only on a limited basis.

Purple Raspberries

Purple raspberry fruits resemble the red more closely than the black raspberry in physical characteristics. The berries are grayish-purple color and have a unique flavor. In some areas their fresh market value is limited

because of the unusual color and distinctive flavor of the fruit. Where the berries are known, they are prized for fresh fruit, freezing, and culinary purposes.

Sodus produces very large, attractive purple berries that are firm and of good quality, but quite tart. The plants are very vigorous, upright, very productive, and hardy.

Marion produces berries that are somewhat larger and later ripening than those of Sodus. They ripen 7 to 10 days after Latham. The moderately firm, slight conic, tart fruit holds its size well throughout the picking season. The plants are vigorous, hardy, and productive.

Clyde is a more recently introduced purple cultivar which appears to offer promise, although as yet not enough is known of its performance to warrant its general recommendation. It is reported to be vigorous and productive. It ripens with Marion.

Brandywine (N.Y. 905) is not a true purple raspberry, but more closely resembles purple than red or black raspberries. It is promising as a cultivar to extend the ripening season and is suggested for test planting on a limited basis. Fruit is very large, reddish purple, firm, tart but of good quality.

Everbearing Raspberries

Everbearing raspberries produce one crop during the normal season on one-year-old canes and a second, partial crop on the current season's growth during late summer or early fall. The fall crop is often terminated by frost.

This type of raspberry is quite popular with home gardeners who grow them for the novelty of the fall crop. Commercial production is strictly limited to a few growers who supply special markets with fall berries. Specialized pruning by mowing off canes to the ground line in spring is used in some commercial pick-your-own operations to reduce labor requirements and increase production in the fall crop. Otherwise, cultural requirements are basically the same as those of ordinary types.

Everbearing types of black raspberries have been introduced from time to time, and there is some interest in everbearing purple raspberries. As yet, however, the only reliable everbearing kinds are red raspberries. A brief description of the most desirable cultivars follows:

Durham ripens its fall crop earlier than any other everbearing raspberry. The fruit is large and attractive, but of only fair quality. The plants are vigorous and erect.

September matures its fall crop shortly after Durham and about four weeks earlier than Indian Summer. The berries are large, attractive, well colored, and of good quality.

Heritage, one of the newer everbearing cultivars, produces excellent fall crops of medium sized, firm, attractive and excellent quality berries. Plants are vigorous, upright, and may not need supports. Heritage shows promises as a commercial cultivar for Ohio.

Blackberries

The trailing types of blackberries, such as the Boysenberry, Loganberry, Youngberry, and dewberry, are not adapted to Ohio conditions. The canes, unless given special winter protection, are not hardy enough to withstand severe winter temperatures, and hence are not reliably productive. In addition, the plants, because of their habit of growth, require trellising which is difficult as well as laborious because of their thorny nature. Therefore, trailing blackberries should not be considered even by the home gardener, unless he is willing to give particular care to their culture.

The erect types of blackberry are more winter hardy and can be grown successfully in Ohio in both commercial and home plantings. The plants are vigorous and productive. In recent years, the standard cultivars have been troubled with a disorder commonly referred to as "sterility." This difficulty has been associated with a number of factors, but no real solution to the problem has yet been found. Plants so affected generally make good growth. They bloom profusely but produce few berries, and these are usually malformed.

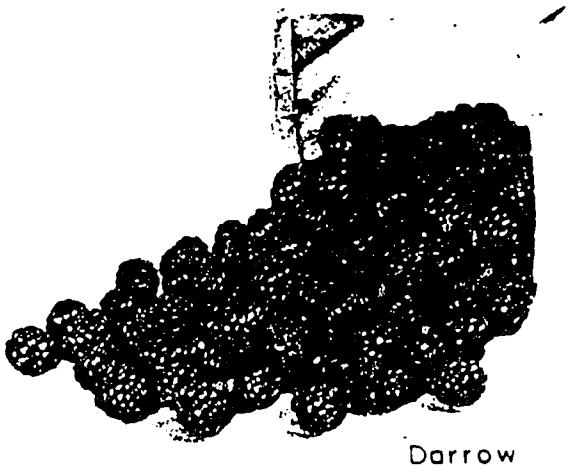
The sterility problem has limited the number of commercial plantings in the state. Growers can best avoid the problem by setting only plants obtained from known healthy fruiting stock. Plants troubled by sterility should be destroyed.

Hedrick is one of the newer erect thorny type cultivars. The plants are hardy, vigorous, and productive. The berries, which ripen in early July, are large, firm, and of good quality.

Bailey, another new erect thorny type which shows promise, produces large, firm, and mild berries which ripen shortly after Hedrick. The plants are hardy and vigorous, but not as productive as Hedrick.

Darrow, also a new erect cultivar, is similar to Bailey, but is reported to be hardier. Plants are very vigorous and uniformly productive. Berries are of good quality. It has produced very well under Ohio conditions.

Sterility has limited blackberry production in Ohio. Fruiting shoot at right is normal, while the one at left shows typical symptoms. Avoid it by the use of good planting stock and destruction of diseased plants.



Darrow is a hardy, vigorous, and uniformly productive blackberry cultivar under Ohio conditions.

Smoothstem is an erect thornless cultivar. Plants are vigorous and very productive. Berries mature over an extended season. Berries are medium to large and of good quality, but lack firmness. Smoothstem is very productive. Smoothstem may not be hardy enough to be profitable in northern Ohio.

Two recently introduced erect thornless cultivars, **Dirksen Thornless** and **Black Satin**, may offer promise, but they have not been grown sufficiently long in Ohio to determine their true worth here. Until their performance under our growing conditions can be more precisely determined, they should be grown on a limited basis only.

Selection and Care of Plants

The selection of planting stock is of major importance. Good quality planting stock is the key to success in the bramble fruit enterprise. The disadvantages of poor stock can never be overcome. Many serious production problems are often directly associated with the plants used in establishing the planting.

It is necessary to secure stock from a reputable source to be sure of getting disease-free plants, true-to-name. To secure plants of the desired cultivar, place orders as early as possible. When placing the order, indicate the desired delivery date. One-year-old plants are best.

The state certificate of nursery inspection is the grower's assurance that the plants are as free of disease and insect pests as possible. It is unwise to use plants that do not carry this certificate. Generally, the better the planting stock, the longer lived and more profitable the planting.

Recently, bramble plants "certified" as having been grown from plants known to be free of virus by indexing and under special conditions to limit virus infestation have become available through a number of nurseries. The superior growth and productivity of such plants has been well established. Every effort should be made, particularly by commercial growers, to obtain this kind of stock for establishing new plantings. It must be remembered that this superior grade of planting stock is only free of virus and not immune to it. Therefore, the grower must use every precaution to avoid the possibility of the reintroduction of viruses once the new plantings are established.

Dormant plants are best for planting. Plants dug and held dormant in storage, if properly handled, are as good as freshly dug ones. In some cases, they may be superior to freshly dug ones. It is important to keep plants from drying out.

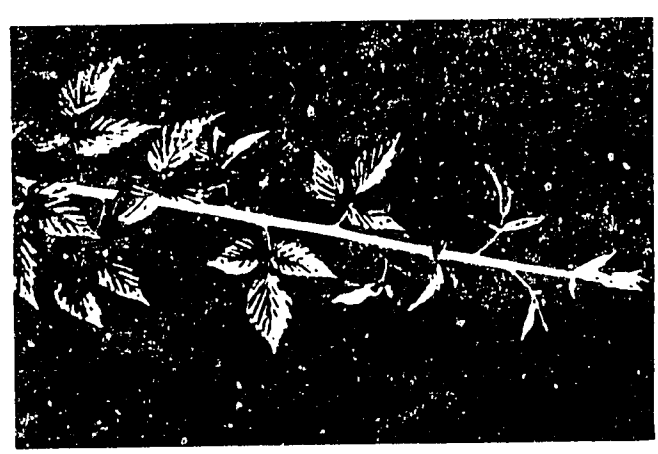
As soon as the plants arrive, open the packages and, if necessary, moisten the roots. Unless planting can be done within a few days, place the plants in storage at about 35° F., or heel them in until they can be planted. To do this, dig a shallow trench, deep enough to accommodate the root systems, in a sheltered area where the soil is well drained. Open the bundles and place a single layer of plants against one side of the trench so that the root systems are completely below the soil surface. Cover the roots with soil, and firm carefully. Plants so treated can be held safely for a reasonable length of time, if they are not allowed to dry out. Do not delay setting plants any longer than absolutely necessary.

Although bramble fruits can be propagated rather easily, most growers find it wiser, unless they are keen observers of disease problems, to purchase nursery stock rather than use their own or their neighbor's plants.

Propagation

Growers are not encouraged to produce their own planting stock. Some growers, however, find the production of plants an interesting sideline, and, occasionally, plant production can be profitably combined with fruit production. The production of plants of the different bramble fruits is not complicated. Plants, however, cannot be sold unless the grower secures the proper certificate from the State Department of Agriculture, Division of Plant Industry at Reynoldsburg, Ohio.

Sucker plants or shoots which arise naturally within the planting from underground stems are used for the propagation of red raspberries. In late winter or early spring, before growth starts, these plants may be dug. After digging, the canes are shortened to 12 to 18 inches. Only large, strong plants should be saved. Limited numbers of some purple raspberry and blackberry cultivars which produce suckers can be obtained in the same way.



The black raspberry is ready for tip layering when new shoots elongate as shown here.

Black raspberries, most purple raspberries, and the new thornless blackberry cultivars are propagated by tip-layering. When the tip portions of the new shoots are elongated and light in color, with small curled leaves—normally in August—they are ready for layering. These tips are inserted vertically into the soil to a depth of 3 to 4 inches. The simplest way to layer is to force a small pointed shovel into the soil, move it back and forth to make a V-shaped opening, insert the tip and press the opening closed with the foot.

The new plant will be ready for transplanting in late fall or the next spring. When the plants are dug, the cane from the parent plant is cut so that 6 to 8 inches of the old cane remains with the new plant. This portion of the old cane is referred to as "the handle."

Frequently, with black raspberries and other brambles having a similar growth habit, the tips that contact the soil will root naturally. These plants are not considered to be desirable for establishing new plantings. Such plants should be destroyed during the pruning operation.

Root cuttings are normally used when large numbers of blackberry plants are to be propagated. This method is more complicated than those previously described. In the fall, plants are dug and the roots about one-fourth inch in diameter are saved. These roots are cut into pieces 3 to 4 inches long. The cuttings are then buried outside for the winter, below the frost line, in moist sand in a well-drained location. In spring, the cuttings are planted 3 to 6 inches apart in furrows 2 or 3 inches deep. They are laid horizontally at the bottom of the furrow. The plants will be large enough to transplant at the end of the first growing season. This method is not recommended for thornless cultivars. This type of plant can be propagated either by tip-layering or by stem cuttings.

Site Preparation

The proposed site should, ideally, be used to grow a fertilized cultivated crop the season prior to planting, or be maintained under a cover crop of soybeans. Chemical means of controlling chronic weed problems, such as thistle, quackgrass, and dock, may be done safely the season prior to planting. Contact your local Extension office for currently recommended herbicides. Avoid sites infested with such troublesome weeds until the weeds have been eradicated. If a sodded area must be used, it is best to plow it the season before spring planting.

To help hold the soil, the area should be planted to ordinary rye the September prior to planting. Usually 2 or 3 pounds of seed per 1000 square feet or 2 or 3 bushels per acre will give the desired results. If animal manures are available, apply them in the fall. A suitable application is 50 to 75 pounds of horse or cow manure per 100 square feet or 10 to 12 tons per acre.

Prepare the site for planting as early as possible, usually during late March or early April. As the soil is prepared, a complete fertilizer may be disked-in. The amount of fertilizer applied should be adjusted on the basis of the history and previous knowledge of the site or by the results of soil tests. On most sites, 8 to 10 pounds per 1000 square feet or 350 pounds per acre of 8-16-16 or similar analysis fertilizer will be beneficial. Work the soil to near "seed bed" condition.

If the soil reaction is known to be below pH 5.5, incorporate limestone or hydrated lime at the time the site is prepared. Use lime only when the need is indicated. If the soil reaction is unknown, local county Extension agents can assist in determining it and will recommend the quantity of lime, if any is needed.

Even though early spring preparation is encouraged, it should not be done until the soil is dry enough to work. The advantages of early preparation will be lost if "wet soil" is worked. It may become "puddled." The effect of puddled soil may be noticeable for the life of the planting, particularly on heavy soils.

Establishing the Planting

Early spring planting is best. Normally, plants can be set in late March or early April. It is better to delay planting than to attempt to work wet soil.

Fall planting may be done if the expected press of spring work will make spring planting difficult. Planting can be done in late October or early November after the plants have become dormant but before the soil freezes. A light mulch applied within the row area will reduce the loss of such plants from heaving caused by freezing and thawing of the soil.

The distance between bramble plants in the row and between rows depends on the training system followed and the vigor of the particular type of bramble. Brambles are generally grown either in "hedge rows" or in the "hill system." Hedge rows are solid rows of plants which limit movement in the planting to one direction. The hill system is established on the basis of individual plants set 6 to 8 feet apart in both directions. It allows movement through the planting in all directions. Most growers, however, prefer the hedge row because it simplifies cultural practices and generally produces higher yields of fruit than does the hill system.

Where the hedge row is followed, red raspberries should be set 2 feet apart in rows 6 to 8 feet apart. Black and purple raspberries, which are more spreading, should be set 2½ feet apart in rows 8 to 10 feet apart, while the erect blackberry should be spaced at least 3½ feet apart in rows 10 to 12 feet apart. Adjust the actual distance between rows to the type of implements to be used in the maintenance of the planting. Most growers prefer the convenience afforded by the wider spacing between rows.

Set the plants at about the same depth as they grew previously. The crown of the plant (the point where the roots and stem join) should be no more than 1 to 2 inches below the soil surface. Plants may be set by hand in a furrow or in individual holes. In planting, spread out the roots and firm the soil carefully about them. To prevent drying of roots, carry the plants wrapped in wet burlap or in a bucket of muddy water during the planting operation. Ordinary mechanical transplanters can be adapted for use in setting bramble plants and may be used to advantage when large plantings are established.

The "handles" (the above ground portion) of black raspberries should be cut away and destroyed at planting time as a safeguard against early infections of anthracnose, a fungus disease.

Soil Management

It is important to keep bramble crops weed free by cultivation and hand hoeing during the first growing season. It is best to plant a cover crop of rye between the rows in mid-September. Usually, 2 to 3 pounds of

seed per 1000 square feet or 2 to 3 bushels per acre will be needed. Some growers prefer annual ryegrass. In growing these cover crops, it is wise to keep the seed out of the row area. The cover, when disked down in early spring, will help maintain the soil organic matter content.

Once the planting has become established, there are several soil management practices that can be followed. Brambles are commonly cultivated between the rows during the growing season, followed with a cover of rye seeded in the fall. In such plantings, weed control in the row area is essential for good production. This may be accomplished by either physical means, hand hoeing, or through the use of herbicides.

Benefits in both growth and yield may be expected where a mulch system of soil management is adapted. Highest yields of the largest berries can be obtained when mulch is used. Although straw is the most commonly used mulch material, other organic materials such as sawdust can be used. Where ample mulch is available, it can be applied to the entire area of the planting, row and aisle areas alike. It is best applied initially during the fall of the second season. Sufficient material must be used to suppress weed growth. Normally, 6 to 8 inches of loose straw is needed. Additional material will be required each succeeding fall to maintain sufficient mulch.

Mulch should be considered as a soil management practice in any planting. Because of the difficulty of obtaining mulch materials, however, it is more applicable to plantings of limited size.

If mulching material is limited, some benefits can be obtained by mulching the row area only. Where this is done, it is better to keep the area between the rows under cultivation with a winter cover of rye. Some growers allow sod to develop between the rows of mulched plants. Where this is done, mow the grass several times during the growing season and allow clippings to remain where they fall.

Some plantings are maintained with between row areas under frequently mowed sod and the row area weed free with herbicides. The system offers many advantages and is worthy of consideration.

Where plantings are used to produce plants as well as fruit, cultivation is generally followed, and no winter cover is seeded. Winter weed growth is depended on to hold the soil. In such plantings the incorporation of animal manures or other organic matter is most desirable.

Chemical Weed Control

Annual weed growth within bramble fruit plantings can be safely and effectively controlled through the use of recommended herbicides. Such techniques, in addition to solving the weed problem, remove the hazard of physical injury to the plants and their roots inherent with mechanical control methods. The use of such techniques should be considered for any large scale planting; however, use of such techniques in small family plantings is questionable.

Chemical weed control in established plantings is of primary value in reducing the weed problem in the row area itself, and is primarily recommended for this purpose. Since weed growth between the rows can be handled most easily with regular mowing or cultivating equipment, and since total elimination of weed growth in this area may create other cultural problems, such use does not appear warranted.

Black raspberry planting on July 12 where no chemical weed control has been followed. Heavy weed growth in the row competes with berry plants for soil moisture and plant nutrients. It is also costly to hoe out such an established weed growth.

Growers should be continually alert to the development of perennial weeds such as quackgrass, thistle and dock within bramble plantings. These type of weeds are best controlled prior to the time the planting is made, but should they appear after the planting is made they can be controlled. Both manual and chemical means should be followed. Widely scattered individual plants that appear might best be controlled manually before they spread. Where sizeable areas become infested, the use of a herbicide is indicated. Many growers, for economic reasons find it practical to "spot treat" only the infested areas rather than their entire plantings.

Before any herbicide is applied within a bramble fruit planting, the grower must be sure that such use is recommended on the label and is in current Extension Ser-

Black raspberry planting that was sprayed on May 11 with a recommended commercial herbicide. The photo was taken two months later. Note complete prevention of weed growth in the berry row. Some herbicides will give season-long control of annual weeds and grasses.

vice recommendations. Further, the herbicide should be used only within the limitations stated on the label. Use of other than such recommended or approved herbicides may result in injury to the plants and undesirable residues in the fruit.

Successful chemical weed control depends on the application of the correct herbicide in the correct amount and at the proper stage of growth of both the weed and bramble. Improper use of even recommended herbicides can result in damage to the crop or lack of weed control.

Since many variables can effect the results obtained, growers are advised to learn to use chemical weed control measures in a portion of their plantings before making extensive applications.

The herbicides recommended for use in bramble plantings are most effective as a means of preventing rather than overcoming weed problems. Most are best applied at low pressures, 40 to 50 pounds per square inch in 50 to 100 gallons of water per acre of sprayed area. A special tractor-mounted herbicide sprayer, which provides agitation within the tank and is nozzled so as to allow directed spray within the row area, is preferred for making applications. Care must be used to assure continued calibration of the sprayer and to avoid contact with crop plants.

Where available, granular formulations of approved herbicides can also prove beneficial. Both hand and tractor mounted granular application equipment is available. Equal care must be exercised with both granular and spray applications. Granular applications may prove more useful in small plantings than the more conventional sprayer technique.

Herbicides available and approved for use in bramble plantings may change from year to year. Growers should consult and follow the latest Ohio Cooperative Extension Service recommendations before making any herbicide applications to bramble plantings.

Fertilization

Brambles, like other plants, require ample quantities of all the essential plant nutrient elements if they are to grow and yield well. Under Ohio growing conditions, the soil generally supplies enough of all the nutrients except nitrogen. Hence, in general, the fertilizer recommendations for these fruits call for annual applications of nitrogen-carrying fertilizers.

The first fertilizer application is normally made when the site is prepared for planting, see page 7. Usually, this is enough fertilizer for the first year of planting. If the plants fail to "grow-off" well, it is advisable, however, to apply additional nitrogen in late May or early June. For this purpose, apply 1 or 2 ounces of a 33 percent nitrogen carrier (ammonium nitrate) or the equivalent per plant. Later applications should be avoided because plants so treated are more likely to suffer winter injury.

The general recommendation for the second and each succeeding season is to apply 50 to 150 pounds of actual nitrogen per acre. This would require 150 to 450 pounds of ammonium nitrate per acre. This material should be broadcast into the row area in early spring before growth starts. In smaller plantings this would mean about 3½ to 10 pounds ammonium nitrate per 100 feet of row, or the equivalent of another carrier.

The appearance of the plants during the growing season provides a suitable guide to the amount of nitrogen to apply the following spring. Small, yellowish-green leaves usually indicate a lack of sufficient nitrogen. Plants showing such leaves will benefit from the higher rate of application. Plants with very dark green leaves and making excessive shoot growth may be over fertilized. The rate of fertilization to such plants should be reduced.

A more exact guide to the nutritional status of the various bramble fruits can be determined by means of foliar analysis. A foliar analysis service is available to Ohio growers through each county Cooperative Extension Service office on a nominal fee basis. The service supplies the grower with precise analytical results and specific fertilizer recommendations based on those results.

Mulched plantings will require more than the normal amount of nitrogen fertilizer until the mulch is well established, perhaps 2 or 3 years. Generally, twice the normal amount of nitrogen during these years will be needed. After that period, the mulched plants will require only about half as much nitrogen as those grown without mulch. As the mulch decays, it releases nitrogen and other nutrients.

If animal manures are available they may be used to fertilize bramble plantings. A general recommendation for most soils is 6 to 8 tons of cow or horse manure (275 to 365 pounds per 1000 square feet) or 2 to 3 tons (90 to 135 pounds per 1000 square feet) of poultry manure per acre. Manures are best applied in late fall or winter months while plants are dormant.

Irrigation

Lack of water can seriously reduce crops of bramble fruits, particularly when it occurs just prior to or during the harvest season. Under such conditions, brambles will respond favorably to irrigation. Lack of available water at this time can not only affect the current season's crop but also limit the production of desirable fruiting canes, thus affecting the following year's crop.

During the growing season, brambles require about one inch of water per week. When rainfall does not supply this amount, supplemental irrigation may be used to advantage. Portable sprinkler type irrigation is most popular and also offers the potential of frost control during bloom, as with strawberries and some vegetable crops. To obtain this protection, it is necessary to maintain free water on the flower parts during the frost period. Trickle irrigation systems also offer a good potential for brambles, but do not offer frost control.

Detailed specifications for both portable sprinkle and trickle type irrigation systems, including water requirements, are available from agricultural engineering specialists. Further information is available through County Agricultural Extension Agents.

Supporting the Canes

Supports for bramble fruit canes are not essential, except in the case of trailing type blackberries. They can be used to advantage, however, particularly with red raspberries, to minimize loss of crop due to wind damage, and to facilitate harvest and other cultural practices. Where supports are not used, more severe pruning is required. Because of the costs involved, supports are more widely used in home garden plantings than large commercial plantings in Ohio.

Where the hill system of culture is followed, support can be given by a single stake driven in the center of the hill. The stake should extend above the soil 4 to 5 feet and be stout enough to last a number of seasons. The fruiting canes are tied securely to the stake each spring following dormant pruning.

A wire trellising system is most practical where the hedge row type of culture is used. The crossarm, two-wire system is common. Posts are set about every 20 feet with 3½ to 5 feet remaining above the ground. Near the top of each post is nailed a cross-piece about 18 inches long. A wire is attached to the ends of the cross-piece and run along each side of the row. The canes are trained between the wires or tied to them. Wire clips, used between the posts, will keep the wires from spreading.

A two-wire, one above the other, trellis may also be used. It is most useful with red raspberries and trailing blackberries. Posts are set in the same manner as for the crossarm trellis, but no cross-pieces are used. One, two, or three single wires are strung between the posts. The individual canes are tied to these wires following dormant pruning.

Pruning

Pruning Black and Purple Raspberries

Summer Topping: An essential step in the production of these brambles is summer topping. Topping consists of removing, by snapping off with the fingers or cutting with a pair of shears, the top 3 or 4 inches of the new shoots as they develop.

Topping should be done with black raspberries when the shoots are about 24 inches high and with purple ones when they reach 30 inches, if they are grown without supports. When plants are grown with supports, the shoots may be allowed to grow 6 to 8 inches more. Plantings need to be topped a number of times as new canes arise over a period of several weeks. In most seasons this operation will, in part, coincide with harvest.

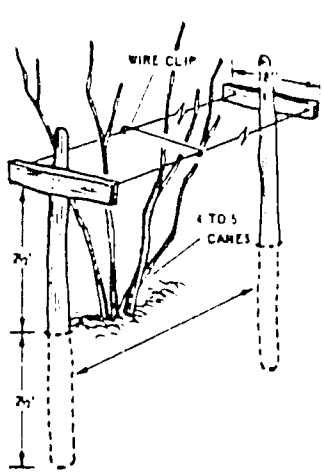
Summer topping encourages the development of strong fruitful laterals. It also produces stronger, stockier plants better able to support their crops and to resist wind damage. Simply pinching out the tips or removing large segments of shoots has not proved to be as beneficial.

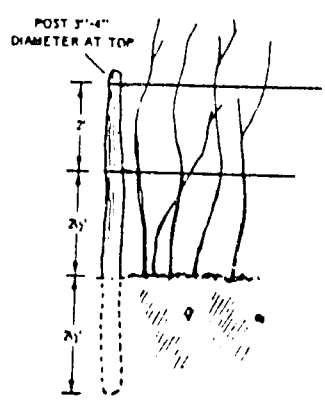
Removal of Fruited Canes: Characteristically, the canes of bramble fruits die shortly after they have produced a crop. These canes can be removed, therefore, anytime after the harvest season. They should be cut off close to the soil surface, removed, and destroyed. Many growers remove these canes immediately after harvest; others wait to remove them until the following season and cut them out as part of the spring pruning. Either practice is satisfactory.

Spring Pruning: Spring pruning is best done after the danger of severe freeze is past and before the buds begin to swell. In Ohio, March is the most suitable month. To improve accessibility to the plants and reduce pruning labor costs, many commercial bramble growers now use some type of mechanical hedging equipment to trim the top and sides of hedgerow plantings. Commercial hedgers for this purpose are generally not available. Growers have, however, adapted power driven hedgers used for ornamental planting care or have developed custom built hedgers specifically for this purpose. More precise control of length of laterals with mechanical pruning is obtained by summer topping plants the previous season at a uniform height.

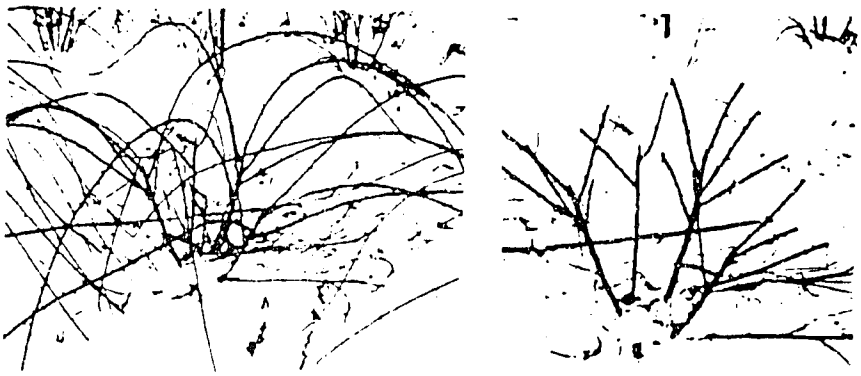
Additional pruning consists of removing all dead, severely damaged, or weak canes, and the shortening of some laterals. With the black raspberry, best yields can be expected when 8 to 12 buds per lateral or 6 to 10 inches of growth are left. Experimental results show that shortening the laterals as indicated will not affect the total yield and will assure production of larger berries. If laterals are left too long, berries will be smaller. The stronger laterals may be allowed to carry more buds than those of smaller diameter. Very small spindly laterals, as well as any laterals close to the soil surface, should be removed entirely. Usually there is no need to thin out or reduce the number of canes per plant. Each plant needs at least 4 or 5 large canes for good yields.

Purple cultivars are handled similarly to the blacks. Because of their superior vigor, they may be allowed to carry 3 or 4 more buds per lateral.





Two-wire, one above the other, and crossarm trellises used with bramble fruits. The two-wire, one above the other, type is most useful with red raspberries and trailing blackberries, while the crossarm system can be used with any of the brambles. The height of the trellis should be adjusted to the vigor of the plants.



Early spring pruning of the black raspberry consists of removing dead, injured, and very weak wood and shortening the laterals. Best results may be expected where only 8 or 10 buds per lateral are left.

Pruning Red Raspberries

No Summer Topping: New shoots of the red raspberry should not be summer pruned or topped. Such pruning usually reduces yields.

Removal of Fruited Canes: The canes of red raspberries are biennial in nature like other brambles. Therefore, they may be removed anytime after harvest. They should be cut off close to the soil surface. Removal may take place immediately after harvest or may be delayed until the time of spring pruning. Either practice is satisfactory. The canes of everbearing cultivars are handled the same way as ordinary cultivars, following the summer harvest. The shoots that bear the fall crop should not be removed after harvest as they will be[illegible]in the following summer.

Where everbearing red raspberries are grown for the "fall crop" only, because of economic advantages, remove all overwintering canes in early spring just prior to the beginning of growth. This can be done manually or mechanically with a mower. This pruning-production technique has proven most profitable with Heritage.

Spring Pruning: Spring pruning is best done in very early spring after the danger of severe cold is past and before the buds begin to swell, usually in March. It consists of removing all dead, weak, or severely damaged canes, adjusting cane stand and reducing cane height. If lateral branches are present, they should be pruned to about 10 inches in length. Fruit normally ripens several days later on the laterals than on the main canes.

In larger plantings, mechanical hedging of tops of hedgerow plantings and mowing to narrow rows reduce hand labor requirements significantly.

Where the red raspberry is grown in hedgerow, best yields will be obtained when the rows are not allowed to exceed 18 inches in width. Thus, in the spring, all canes growing outside this row should be removed. Further, the number of canes within the hedgerow should be thinned so those remaining are 6 to 10 inches apart. In thinning these canes, save only the largest canes as indicated by diameter and length as they are the most fruitful. Where the hill system of culture is followed, only the best 7 to 8 canes should be saved per hill. The size of cane should be the guide in selecting the canes to be saved.

Most canes should be shortened or headed back. The height at which they should be headed depends on the vigor of the planting and whether or not supplemental supports are to be used. Light-to-moderate heading will not reduce yields. Plants so headed produce somewhat larger berries and are more resistant to wind damage than where no heading is done. Severe heading back will result in yield reduction. Normally, the canes should be reduced by a third or quarter of their total length. Where no support is offered, more severe heading is usually required. In most cases, regardless of original cane height, such unsupported canes should be cut to about 3 feet.

Pruning Blackberries

Summer Pruning: Summer topping of the new shoots of erect-growing types serve the same purpose as the topping of black and purple raspberries. The same method is used. Since these plants are more vigorous, top so as to leave the new shoots 30 to 36 inches above the ground. Do not top trailing types.

For best yields and to prevent the planting from becoming a thicket, remove excess sucker plants in the summer. This can be done by pulling or cutting them away soon after they appear. Where the plants are maintained as individuals within the row area or in hills, allow not more than 4 or 5 new shoots to develop within the plant area. Where a hedgerow type of culture is followed, it is best to leave only 3 or 4 shoots per running foot of row. All other shoots should be pulled or cut off as they develop. With trailing types, as many as 12 to 16 new shoots may be allowed to develop per plant.

Removal of Fruited Canes: Canes that have fruited may be removed anytime after the harvest season. They should be cut near the ground surface and removed from the planting. This can be done in the summer or as part of the spring operation.

Summer topping is an important step in the culture of black and purple raspberries as well as erect-growing blackberries. When the new shoots reach the desired height, cut or snap off 3 or 4 inches of the shoot.

Spring Pruning: Spring pruning of erect blackberries is much the same as that of black raspberries. Because of the greater vigor of this type of bramble, the laterals may be left 12 to 18 inches long.

Thin trailing-type blackberries to the best 7 or 8 canes per plant. Cut these canes to about five feet in length and tie them to either a stake or trellis. As with other brambles, remove all dead or weak canes before growth starts.

Winter Protection

The canes of recommended cultivars of red, black, and purple raspberries as well as blackberries, when well grown, are hardy in Ohio and require no special winter protection. Occasional winter injury to red raspberry canes occurs because of severe cold conditions in late winter after the rest period is broken. Attempting to protect canes from such injury is impractical.

Trailing-type blackberries, during most winters, demand special protection if the fruiting wood is to escape injury. They can be protected if, in the fall after the new growth becomes dormant, the new canes are placed on the ground and covered lightly with soil or straw. In the spring when danger of severe cold has passed, the canes are uncovered and placed on the trellis or tied to a stake.

Disease Problems

Brambles are particularly troubled by disease problems. The grower's failure to avoid or control disease is more apt to limit the productive life of a planting than any other factor. For these reasons, special attention should be given to the selection of site and planting stock.

The most serious problems are created by a group of systemic virus diseases. These diseases, which spread rapidly, seriously reduce the quantity and quality of berries produced. There is no program that can be followed to entirely prevent these problems. They can best be avoided by use of certified planting stock, isolated planting sites, and close observation of the planting. Infected plants must be destroyed as soon as observed to prevent spread of disease. Plants suspected of being diseased should be "burned" in place to destroy insect vectors and then removed from the field. Frequent inspection for the presence of these diseases is recommended.

The virus diseases are more severe on black and purple raspberries than on red. Their presence is generally indicated by foliage abnormalities, stunted growth, and poor quality berries. There are three common ones—**Mosaic, Leaf Curl,** and **Mild Streak. Mosaic** causes a reduction of leaf size and a green or yellow mottling of the foliage. **Leaf Curl** severely stunts the plants. Infected plants have small closely spaced leaves which curl downward and inward. **Mild Streak** infected plants are also dwarfed. Light purplish streaks may be visible near the base of new shoots. Berries that mature on infected plants are small, dry, and seedy.

Another troublesome disease of black raspberries and blackberries which cannot be controlled by spraying is **Orange Rust.** Plants infected with it are of little value. In late spring, such plants exhibit small distorted leaves with orange-colored spore bodies on the under side. The new shoots of such plants are willowy and free of thorns. Infected plants must be destroyed when the first symptoms appear to prevent spread of the disorder.

Anthracnose, or **Cane Spot,** is most often associated with black raspberries but also attacks the red and purple types as well as blackberries. The characteristic symptoms are oval grayish spots on the canes with reddish or purple borders. Spots may also occur on leaves and fruit stems. In severe cases, wilting may result. It can be controlled by a regular spray program which begins with a delayed dormant application as the first blossoms open and two weeks later. It requires from 200 to 300 gallons of dilute spray per acre to adequately cover a mature planting.

Crown, or **Cane Gall,** is often found in bramble plantings. It causes cauliflower-like growths on the affected part. Spraying will not control it. Such plants should be destroyed. Infected planting stock and infected sites should be avoided.

Virus diseases can create serious problems in black raspberry plantings. Compare shoot affected with leaf curl on left to healthy one on right. Grower's solution is to avoid planting diseased stock and to destroy infected plants.

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Black raspberry plant showing symptoms of mosaic, a virus disease.

Verticillium Wilt, sometimes called **Blue-Stem** or just **Wilt**, occasionally causes heavy losses in raspberry plantings. No cultivar or species of raspberry has shown resistance to wilt, although black raspberries seem to show severe effects more frequently. Symptoms first appear in midsummer. Affected plants cease growth, the leaves droop, turn yellow, and those at the base of new shoots drop. In severe cases, a broad blue stripe extends from the base upward on each shoot. Plants mildly affected may partially recover in the fall, but the canes usually do not survive the winter. As mentioned under the section, "Selecting the Site," there is no known control of this disease. Do not make plantings on land where tomatoes, peppers, eggplants, or potatoes have been grown recently.

Controlling Pests

To assist growers in controlling pests in fruit crops, including the bramble planting, the Ohio Cooperative Extension Service publishes current control recommendation each year.

Recommendations are given for the control of such pests as weeds, insects, diseases, mites, and rodents.

Obtain and use the following publications for assistance in controlling these pests:

Bulletin 506: "Commercial Fruit Spray Recommendations for Ohio"

Leaflet 1: "Backyard Fruit Sprays for Insects and Diseases"

Anthracnose is a common disease affecting the canes of brambles, especially black raspberries. It can cause marked yield reduction. Growers are advised to follow a regular spray program for its control.

Insect and Mite Pests

Although bramble fruits and plants may be attacked by a number of insects, only a few are so consistently destructive as to warrant a regular annual control program.

One of the most common insects attacking brambles is the **raspberry cane borer.*** The adult insect is a dark, slender beetle which appears in early July. At this time of the year the female makes two rows of punctures which encircle the cane approximately six inches below the tip. The tip above the puncture wilts and droops. This damage, together with the distinctive manner of stem girdling, makes the identification of this pest very easy. This insect is controlled by cutting off the wilted tips a few inches below the girdle during pruning operations.

Another pest of raspberries in Ohio (particularly red raspberries) is the **eastern raspberry fruitworm.**** This insect causes injury of two types: (1) the adult beetles skeletonize young leaves and eat holes in expanding blossom buds; and (2) the small larvae feed within the flower buds and developing fruit.

* *Oberta bimaculata* Oliver.
** *Byturus rubi* Barber.

Raspberry cane borer damage to raspberry. Note the two rows of punctures in the lower center of the photo.

Small plantings are more subject to insects and mites than are larger commercial plantings in which regular pest control programs are followed. Fruitworms, sap beetles and mites are most commonly found in home plantings.

Spider mites can be among the most troublesome pest of raspberries. The **two-spotted spider mite** occurs in practically all raspberry-growing areas. Injury first appears as fine whitish or yellowish speckles on the foliage. The mites suck out the juices and the foliage looks pale and unhealthy. Later the leaves may turn brown and drop. The undersides of the leaves are covered with fine silken webs, and if examined carefully, the mites may also be seen. Injury is usually most severe in hot, dry weather.

Sap beetles, often called **picnic beetles**, are small insects that feed on damaged or over-ripe fruits and vegetables. The adults of these beetles are attracted to fermenting fluids of over-ripe or decaying fruits and vegetables. The removal of ripe fruit at regular close intervals and the removal of any over-ripe, rotten or damaged fruit should help eliminate some of the problem. Since they fly in from surrounding areas in great numbers, chemical control will only be of minimal value. The best aid in controlling sap beetles will be to pick fruit regularly and avoid leaving damaged or over-ripe fruit in the area.

Other insect and disease problems may be encountered occasionally. Should such problems occur, current pesticide recommendations should be consulted.

Up-to-date spray recommendations are published each year for the control of the various pest problems. These are available on request from the local county Extension office. Only current recommendations should be followed. In following these recommendations, it is essential not only to apply the right materials at the right time but also the proper gallonage. Most growers will find it helpful to maintain a supply of pesticides and miticides so they can handle anticipated spray applications and emergency mite sprays.

Harvesting

A partial crop may be expected the second summer after a bramble planting is established. Full production should be reached by the third harvest season. Plantings may be expected to be profitably productive for 8 to 10 years. Carefully cared for plantings on good sites may produce longer, while those on marginal sites and those that receive poor care may become worthless in a few years.

Bramble fruits must be harvested and handled properly if the best yields of the highest quality berries are to reach the table. The best gauges of maturity are those of fruit color and ease of separation. Full color often develops before the berries separate easily. If the berries are picked too soon, berry size and flavor will be sacrificed.

When possible, avoid picking the berries when they are wet. Harvest as often as possible, normally every second or third day. Pick berries by gently lifting the berries with the thumb and fingers. Raspberries separate, leaving the receptacle, the center part of the fruit, on the bush. Blackberries, when harvested, separate so that the receptacle remains with the fruit. Care should be taken to prevent crushing of the harvested berries. As soon as the berries are harvested, they should be protected from the sun, and, if possible, cooled so as to extend their shelf life.

Brambles are normally harvested directly into the container in which they are to be sold. The quart cup is the most widely used container. Some growers, particularly of red raspberries, prefer the pint container in order to minimize crushing. Harvesting can be facilitated by the use of either waist carriers or picking stands which leave both hands free. Waist carriers are the more popular.

Pick-Your-Own

Bramble fruits are well adapted to the pick-your-own or public picking method of marketing and can be successfully harvested and sold this way in Ohio.

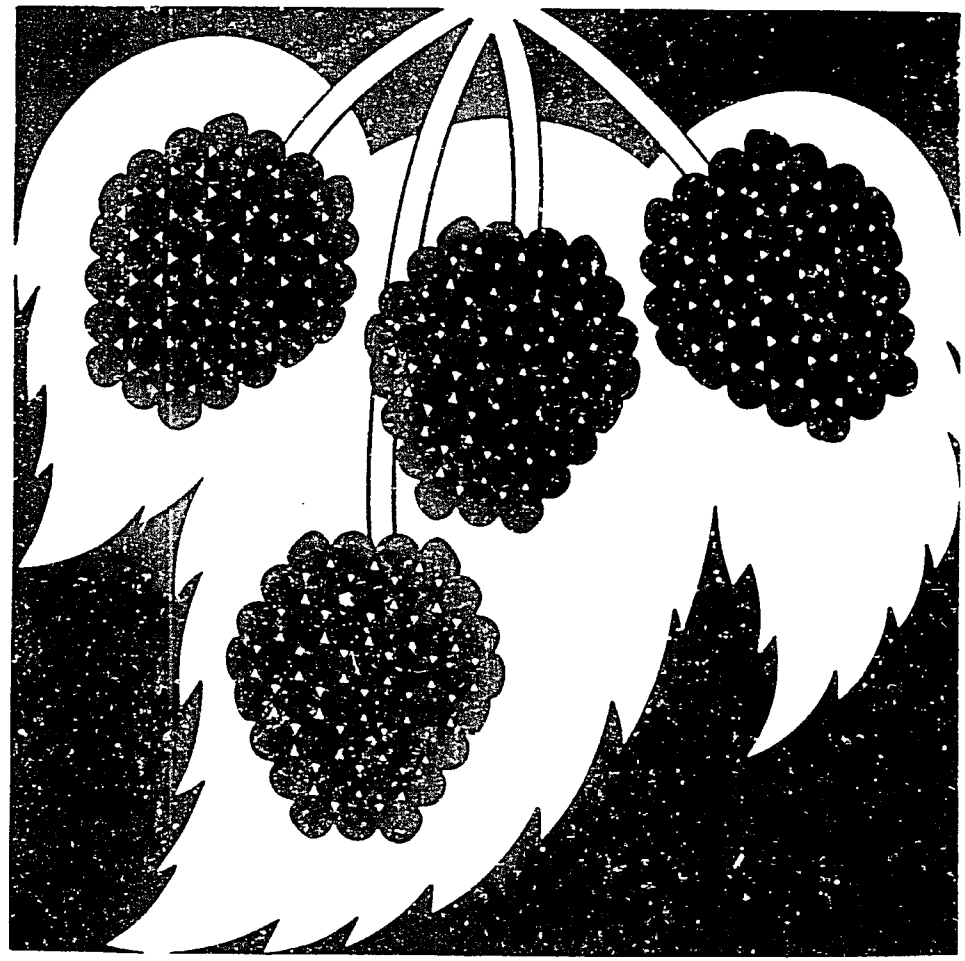
Once this system is developed, much of the cost and the problems of securing and transporting pickers, marketing, and containers is avoided. The system, however, requires careful management and special attention to its development.

One of the prime requirements of this type of operation is the development of a well grown, weed free, productive planting. The planting must be so located that it is readily accessible to the customer and ample parking and supervision must be afforded.

The grower needs to acquaint the pick-your-own customer with the "rules of the planting" and techniques of picking in order to minimize damage to the planting and assure the customer satisfaction. Signs and easily identifiable personable "supervisors" in the planting can do a great deal to help. Further, it is important to limit the number of picker-customers to the volume of mature fruit available. Some operators find it advantageous to allow picking by appointment only, so as to avoid disappointing their customers.

Generally, the grower furnishes the pickers with containers for their fruit, although some growers allow the customers to use their own. Regardless of what container is used, most growers will find it more convenient to sell the fruit by weight rather than volume.

Growing Raspberries



UNITED STATES DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN NUMBER 2165

PREPARED BY SCIENCE AND EDUCATION ADMINISTRATION

A raspberry plantation that is properly managed should yield at least 4,000 pounds (4485 kg/ha) of berries per acre by the second year. To get greatest yield and longest productive life from the plantation—

- Choose types and varieties that are adapted to your area.
- Prepare the soil thoroughly.
- Plant only the highest quality stock.
- Maintain a high level of soil moisture by cultivating frequently and irrigating when necessary.
- Apply fertilizer to the plantation every year.
- Cut out all weak canes and suckers.
- Protect plants from insects, diseases, and winter injury.

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GROWING RASPBERRIES

By FRANCIS J. LAWRENCE, *SEA research horticulturist*[1]

Raspberries grow best in cool climates. They are not well adapted south of Virginia, Tennessee, or Missouri. Nor are they well adapted to areas in the Plains States or Mountain States where summers are hot and dry and winters are severe.

TYPES OF RASPBERRIES

Three main types of raspberries—red, black, and purple—are grown in the United States. They differ in several ways other than the color of their fruit.

Red raspberries have erect canes. They usually are propagated by suckers, which grow from the roots of the parent plant. Red raspberries are grown most extensively in the Northwest.

Black raspberries (blackcaps) have arched canes that root at the tips. They are propagated by the plants that grow at the tips of the canes. Blackcaps are grown mostly in the eastern half of the country and in Oregon.

Purple raspberries are hybrids of red raspberries and blackcaps. They have the same growth characteristics as black caps and are propagated in the same way. They are grown extensively only in western New York, though the area where they are adapted is about the same as the area where blackcaps are grown.

Some raspberries have yellow fruit. Yellow raspberries are variations of red raspberries and, except for fruit color, have all the characteristics of red raspberries. They are grown chiefly in home gardens.

For descriptions of raspberry varieties, see page 12.

PLANTING SITE

A wide range of soil types, from sandy loam to clay loam, is satisfactory for growing raspberries. The character of the subsoil is more important than the type of surface soil. The subsoil should be deep and well drained.

If the subsoil is underlaid by a shallow hardpan or water table, the root system of the raspberry plant will be restricted in its development. Plants with restricted root systems may be damaged

[1] USDA/SEA, Horticultural Crops Research, Oregon State University, Cordley Hall, Corvallis, Oreg. 97331.

during a drought because raspberries need an abundant supply of moisture at all times during the growing season. Raspberries also suffer from root rots in poorly drained soils.

The slope and exposure of the planting site may be important. In areas where winters are severe, raspberries planted on hillsides are in less danger of winter injury than raspberries planted in valleys. In the southern part of the raspberry-growing area, sites with a northern or northeastern exposure retain humus and moisture longer and are better suited to raspberries than sites with a southern exposure.

PLANTING

In the East, plant raspberries in the spring. On the Pacific coast, plant them in the spring or during the rainy season.

Plant only the highest quality stock from a nursery that is certified disease free. If you propagate your own stock, plant only the most vigorous tip plants or suckers.

Preparing the Soil

For best results, prepare the soil for raspberries as follows:

- Plow, in early spring, to a depth of at least 6 inches (15 cm).
- Disk and harrow the soil just before setting the plants.

Prepare the soil for raspberries as thoroughly as you would for corn.

A good plan is to seed and plow under one or two green-manure crops of oats or barley with vetch before you establish a raspberry plantation. This thorough working gets the soil in good condition for planting, and the added organic matter and nitrogen help the plantation to produce an early fruit crop.

Most land that has been in cultivated crops is in good condition for growing raspberries.

Raspberries should not follow potatoes, tomatoes, or eggplant; wilt diseases that affect these crops also affect raspberries. The fungus causing wilt may remain in the soil and damage the raspberry plants.

Immediately before setting the plants, disk and harrow the soil.

Spacing the Plants

Spacing for raspberry plants depends on the system of training you plan to use and on the type of cultivating equipment you own.

Raspberry plants can be set in hills and cultivated on all four sides or set in rows and cultivated on two sides.

For planting in hills, space the plants far enough apart each way so you can cultivate between them. Aline the plants in each direction.

For planting in rows, space the rows far enough apart to cultivate with the equipment you have. Set red raspberry plants 2 to 3 feet (0.5 to 1.0 m) apart in the rows and black raspberry plants 4 to 5 feet (1.2 to 1.5 m) apart.

If you plan to cultivate with a garden tractor or wheel hoe, 5 feet (1.5 m) is enough distance between hills or rows.

If you plan to use a farm tractor, leave 7 to 10 feet (2.0 to 3.0 m) between rows.

Setting the Plants

Do not let planting stock dry out. If you cannot plant the stock as soon as you recei. it, protect the roots from drying by heeling in the plants.

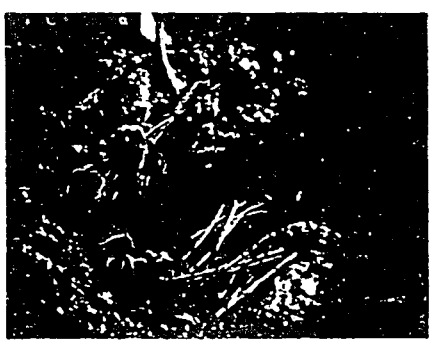
To heel in, dig a trench deep enough to contain the roots. Spread the plants along the trench, roots down, and cover the roots with moist soil.

If the plants are dry when you receive them, soak the roots in water for several hours before you plant them or heel them in.

When you are ready to set the plants out in the field, keep them moist by covering the bundles or lots of plants with wet burlap or canvas, or with plastic film until they are planted.

Before setting the plants, cut the tops back so they are about 6 inches (15 cm) long. The 6-inch (15 cm) top is useful as a handle when setting the plants and will serve to show the location of the plants and aid in alining them.

To make a planting hole, cut a slit in the soil with a mattock



N35736
Heeling in red raspberry plants.

N35716
Setting a tip plant of black raspberry.

N35717
Firming the soil around the roots of a newly set plant.

N35718
Cutting off the protruding cane of a newly set black raspberry plant as a disease-control measure.

blade or shovel. Press the handle of the tool forward to open the slit.

Put the root of the raspberry plant into this opening. Set red raspberry plants so they are 2 to 3 inches (5.0 - 7.5 cm) deeper than they were in the nursery. Set black or purple raspberries the same depth as they were in the nursery or no more than 1 inch (2.5 cm) deeper.

Withdraw the blade of the mattock or shovel from the soil and firm the soil around the roots of the plant with your foot.

After the planting has been set, go over the planting again and cut off all protruding canes to help control diseases.

TRAINING AND PRUNING

Raspberries are easier to cultivate if they are planted in hills than if they are planted in rows. This is not the best training method, however. The plants are set more profitably in rows and the canes trained to wire trellises. The wires to which the canes are tied are strung between posts set 15 to 30 feet (4.5-9.0 m) apart in the rows. Two wires are spaced about 2½ and 5 feet (75 cm and 1.5 m) above the ground.

If stakes are available, drive a stake into the ground 1 foot (30 cm) from the plant the following year after planting. Tie the canes to the stakes at a point halfway between the ground and the tips of the canes and again near the ends of the canes.

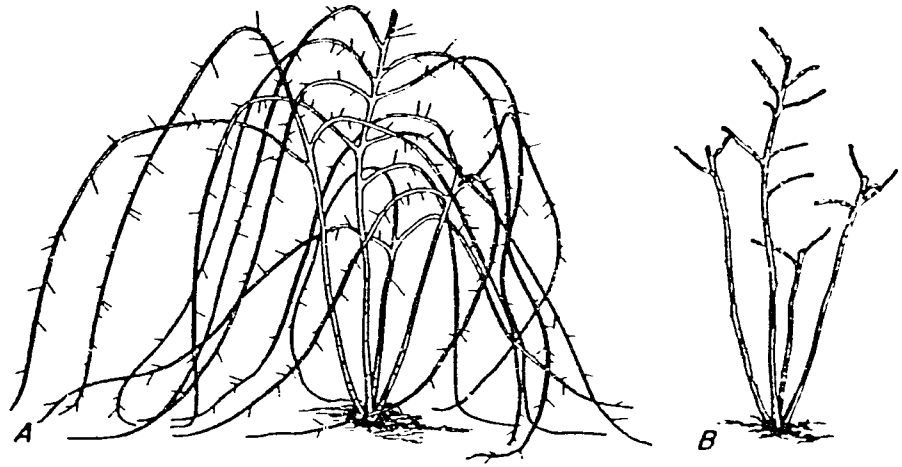
Black and purple raspberries need not be tied; just top them to keep them from growing too tall. Top black raspberries at a height of 18 to 24 inches (45-60 cm). Top purple raspberries at a height of 30 to 36 inches (75-1.0 m).

This topping is done by cutting off the ends of the canes as they reach the proper height.

Toward the end of the first season, the canes send out laterals (side branches). The next season small branches grow from buds on the laterals. Fruit is borne on these small branches.

The laterals should be pruned back in the spring, before growth starts. Fruit from pruned laterals is larger and of better market quality than fruit from unpruned laterals.

Cut the laterals back so that two buds per lateral are left on slim canes, up to six buds per lateral on stout canes.



BN-36906
Left: Black raspberry plant before pruning. Right: The same plant after pruning.

THINNING

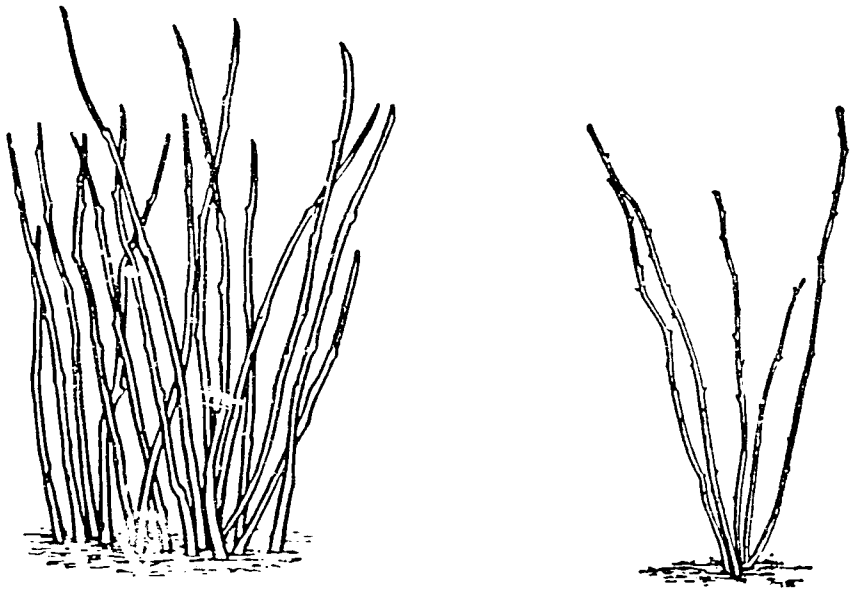
June- and July-cropping raspberry canes are biennial; they grow the first year, fruit the second, then die. Only the crown and the roots are perennial. Old canes should be removed as soon as their fruit is harvested.

Fall-bearing or fall-cropping red raspberries bear fruit on the new canes, flowering first at the tips and then from side branches. These usually start ripening during late August in the East and September in the West and continue until frost. These canes may be cut off at the ground level for producing next year's crop in the fall or a lower portion of the cane saved to fruit next June or July.

New canes grow from buds on the base of the old canes. Two to three new shoots usually come up each year from the base of each fruiting cane. In addition, suckers grow directly from the roots of red raspberries. The new canes and suckers should be thinned immediately after harvest.

Remove weak new shoots and most of the suckers from red raspberries. In the West leave about 7 to 12 strong canes per hill and space on the wires. Do not bunch canes together.

To thin black or purple raspberries, remove canes that are under ½ inch (1.2 cm) in diameter. Most black raspberry plants have four or five canes that are over ½ inch (1.2 cm), but if all the canes are smaller than this, cut out all but the two largest canes.



BN-35910

Left: Red raspberry plant before thinning and pruning. Right. The same plant after thinning and pruning.

FERTILIZING

To get maximum yields from your raspberry plantation, take a soil test and apply fertilizer before planting. Apply fertilizer every year in spring just as new growth begins.

Stable manure, if available, is best for fertilizing. It supplies organic matter as well as nutrients. Apply 10 tons per acre (20 MT/ha).

If stable manure is unavailable, use commercial 5-10-5 fertilizer. Apply it as a topdressing at a rate of 500 to 600 pounds per acre (560-670 kg/ha) or spread ¼ pound (100-125 g) in a wide band no closer than about 6 inches (15 cm) from the crown around each hill.

CULTIVATING

Raspberry plantations should be cultivated thoroughly and frequently enough to prevent grass and weeds from getting started.

Begin cultivating in early spring and cultivate as often as necessary to keep weeds down. Continue cultivating until harvesttime, resume cultivating after harvest, and continue it until late summer.

Do not cultivate in the fall; this tends to stimulate new growth, which is susceptible to winter injury.

To avoid harming shallow roots of the plants, cultivate only 2 or 3 inches (5.0 or 7.5 cm) deep near the rows. For best results and greatest safety, cultivate by shallow disking.

Where suitable land is unavailable or intensive culture is practiced, other crops may be grown between the raspberry rows the first year. Follow the fertilizer and water requirements of the intercrop so that the raspberries do not suffer.

Good crops for this purpose are cabbage, cauliflower, beans, peas, and summer squash. Do not grow potatoes, tomatoes, or eggplant with raspberry varieties.

Do not grow grain crops; they are not cultivated and take too much of the moisture and nutrients needed by the raspberry plants.

Do not grow intercrops after the first year; raspberry plants of bearing size need all the soil nutrients and moisture for satisfactory production.

Mulches are valuable in raspberry production. They help control moisture and weeds and add organic matter. Sawdust, straw, and bark may be used, but extra nitrogen fertilizer will be necessary to help break down the mulch.

USING HERBICIDES

Herbicides can be used as weed-control aids in raspberry plantings. The use of herbicides supplements cultivation and does not replace it.

Herbicides are most useful in controlling weeds within rows or hills, where hand hoeing otherwise would be necessary. The middles between rows and hills should be cultivated regularly even though herbicides are used near the raspberry plants.

For established plantings, spray the rows with a herbicide before the weeds and new canes emerge in early spring.

Herbicide recommendations vary depending on geographical location, soil type, and crop. The recommended chemicals for your area are available from local county agents and State Agricultural Extension Offices. Some chemicals require application by a licensed operator.

IRRIGATING

Raspberries need a large amount of water. Irrigation is essential in dry regions and often is profitable even in humid regions.

Irrigated plants are more vigorous and yield fruit over a longer season than unirrigated plants.

In semiarid and arid regions, begin irrigating at the same time you begin irrigating other garden crops.

Apply 1 to 2 inches (2.5-5.0 cm) of water once a week during the fruiting season and once every 2 or 3 weeks during the rest of the dry season. Light sandy soil needs more frequent irrigation than heavier soils.

In humid regions, irrigation pays only if soil moisture is de-

ficient during the time the fruit is growing and ripening. If a drought occurs from blossoming time until the end of harvest, apply 1 to 1½ inches (2.5 to 3.75 cm) of water once a week.

Drip irrigation using plastic tubes has been useful in raspberry production. The advantages are conserving water, operating under low pressure, and applying water during harvest. The major disadvantages are initial cost and the need for a good filter system.

HARVESTING

Berries that are firm, ripe, and sound bring the highest market price. To get maximum income from your raspberry plantation—

- Pick at least twice a week.
- Handle berries as carefully as possible.
- Discard all decaying, injured, or overripe berries.

The plantation should be picked over frequently to harvest the berries when they are at their best. During hot or wet weather, picking every other day may be necessary. Six to eight pickers per acre are needed for harvesting.

Handle the berries as carefully as possible. Use the thumb, index finger, and middle finger to pick the berries. Do not hold berries in the hand after picking. Place them gently in the cup or basket; do not drop them. After berries are placed in the basket, do not rehandle them.

Discard overripe, injured, or decaying berries. Separate firm fruit and very ripe fruit at time of picking. If two baskets are fitted in a waist carrier, one basket can be used for firm fruit suitable for shipping and the other for fully ripened fruit for canning or freezing.

After filling the baskets in the waist carrier, transfer them to a hand carrier, which always should be kept in the shade or cooled by refrigeration. Cooling is essential for shipping fruit.

PREVENTING WINTER INJURY

In parts of Colorado and in the West North Central States, raspberry canes need protection from cold, drying winter winds. Windbreaks are valuable and may be artificial (such as fences) or living (such as trees and high shrubs). Living windbreaks should not compete with the raspberries for nutrients and water. Usually, the canes can be protected sufficiently by bending all of them over in the same direction and holding them close to the ground with clods of earth. These clods are removed in the spring.

Danger of winter injury to raspberries can be reduced by locating the plantation on an elevated site. Cold air settles to low areas. Winter temperatures are colder, and spring frosts occur later in valleys and hollows than in surrounding upland areas.

NEMATODES

One of the most harmful pests to raspberry plantings is the nematode. Several types of nematodes attack raspberries, and some transmit virus diseases or increase root rots. A soil sample should be taken for nematode count. Local county agents or State agriculture extension offices can help with this sampling. Many soil fumigants are dangerous to handle and apply, and some require a chemical applicator's license to be used. Follow your extension agent's recommendations. As rates for applying the chemicals vary, depending on soil conditions and method of application, follow the manufacturer's directions for specific recommendations.

DISEASES AND INSECTS

Although insects sometimes are harmful to raspberry plantings, they are not as destructive as diseases. Raspberries are attacked by mosaics and other virus diseases, crown gall, wilt, and anthracnose.

Damage from disease can be minimized if these general suggestions are followed:

- Choose disease-resistant varieties.
- Plant only healthy stock.
- Plant black or purple varieties in fields that have not recently been used for tomatoes, potatoes, or eggplant.
- Remove old canes after harvest.
- Keep the field clean of weeds and fallen leaves.
- Destroy seriously diseased plants. Use pesticides when needed.

For specific information on control of insects and diseases, consult your county agricultural agent or your State agricultural experiment station or see USDA Farmers' Bulletin 2208, "Controlling Diseases of Raspberries and Blackberries."

PROPAGATING

Raspberries are not difficult to propagate. Many growers propagate new stock for themselves and sell propagated stock to nurserymen. Often, the first harvest from a new raspberry plantation is new planting stock, rather than fruit.

Black and purple raspberries are propagated by burying the tips of the canes; they root and form new plants. Red raspberry plants are propagated from suckers and from root cuttings.

To prepare black or purple raspberry plants for propagation, pinch off the tips of the canes when they are 12 to 18 inches (30-45 cm) high. The canes branch freely and form a large number of tips for burying.

In late summer, loosen the soil around each plant and bury the tips of the canes 2 to 4 inches (5-10 cm) deep. Point the tips straight downward in the soil.

The following spring, cut the new tip plants away from the parent plants by severing the old cane. Leave 4 to 8 inches (10-20 cm) of old cane on the new plants. After the old cane is cut, the new plants are ready to be set out in the field.

The simplest way to propagate red raspberry plants is by transplanting suckers in early spring. Usually, large suckers from the previous year are transplanted, but new suckers can be transplanted also. These current-year suckers are small, but they grow rapidly after they are transplanted.

To propagate red raspberry plants from root cuttings, dig pieces of root from around established plants in early spring. Cut the roots into 2- to 3-inch (5.0-7.5 cm) lengths and scatter the cuttings on the surface of a nursery bed. Cover them with 2 inches (5 cm) of soil.

New plants, which come up from root cuttings during the growing season, can be set out in the field the following spring.

Instead of digging roots of red raspberries for propagation, you can remove all the old plants from a section of the field. Pieces of roots are left in the soil; new plants grow from these pieces. The new plants can be set out in the field the next spring. Usually, another stand of plants will grow the second year. This system of propagation yields a large number of new plants.

VARIETIES

Following are descriptions of the major raspberry varieties grown in the United States. These descriptions include:

1. State where the variety originated.
2. Time of ripening.[2]
3. Characteristics.
4. Area of special adaptation.
5. Disease susceptibility.

For variety recommendations, consult your county agricultural agent or your State agricultural experiment station.

Commercial stocks of most raspberry varieties are infected with viruses. Obtain plants certified by your State department of agriculture as having originated from essentially virus-free stocks, whenever possible.

Red Raspberries

August Red

1. New Hampshire.
2. Fall cropping—earliest of commercial varieties.
3. Berries medium size, soft, light bright red. Plants medium vigor, hardy.
4. Northeastern United States.

Canby

1. Oregon.
2. Midseason.
3. Berries large, firm, light bright red. Plants vigorous, hardy, productive. Canes thornless.
4. One of the best varieties in Pacific Northwest for freezing. Not adapted to heavy soils.

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[2] The *date* of ripening cannot be given; it depends on many factors in addition to variety. The ripening time—very early, early, midseason, late, or very late—shows when a variety ripens in relation to other varieties grown on the same site. The time lapse between ripening of very early varieties and very late varieties may be as little as 20 days or as much as 40 days.

Fairview

1. Oregon.
2. Midseason.
3. Berries large, bright red, firm, and very good flavor. Berries make a good frozen pack. Plants are vigorous, productive, have long fruiting laterals.
4. Grown in Oregon and Washington. Can be grown on heavy soils.
5. Resistant to root rot.

Fallred

1. New Hampshire.
2. Late summer crop; also a fall crop.
3. Berries medium size, firm, good flavor. Bushes everbearing, productive, vigorous, hardy.
4. Northeastern United States.
5. Should be grown from mosaic-free stock.

Haida

1. British Columbia, Canada.
2. Midseason.
3. Berries medium size, light bright red, medium firm, hardy, medium vigor.
4. Northwestern United States and British Columbia.

Heritage

1. New York.
2. Fall cropping—September to frost.
3. Berries medium size, bright red, medium firm, lower portion of cane may be saved to fruit next June. Plants hardy and vigorous.
4. Northeastern United States.

Hilton

1. New York.
2. Midseason.
3. Berries very large, firm, hard to pick, medium red, darken quickly. Bushes productive, stiff erect canes.
4. Northeastern United States.

Latham

1. Minnesota.
2. Late.
3. Berries large, medium red, firm but often crumbly, quality not high. Bushes very hardy, unusually vigorous, very productive, nearly thornless. Variety good for canning and freezing.
4. Standard red variety in East, hardy in North Dakota.
5. Should be grown from mosaic-free stock. Susceptible to mildew.

Meeker

1. Washington.
2. Midseason.
3. Berries large size, firm, bright red color, long fruiting laterals, plants vigorous, hardy as Willamette or Puyallup.
4. Northwestern United States.
5. Resistant to mildew.

Newburgh

1. New York.
2. Midseason, slightly earlier than Latham.
3. Berries very large, bright red, firm, of good quality.
4. Grown in Northeastern States and Pacific Northwest.
5. Has some resistance to root rot on the Pacific coast. Should be grown from mosaic-free stock.

Puyallup

1. Washington.
2. Late.
3. Berries large, bright red, somewhat soft. Very good flavor. Good quality when fresh frozen or canned. Plants vigorous, hardy, moderately productive.
4. Grown principally in the Pacific Northwest where it is a major variety. Not adapted to heavy soils.

Sentinel

1. Maryland.
2. Midseason to late.
3. Berries medium to large size, bright red, plants very vigorous, hardy, productive.
4. Mid-Atlantic States.
5. Resists injury from fluctuating winter temperatures.

Scepter

1. Maryland.
2. Fall cropping—late August to frost.

3. Berries large, medium bright red, plants vigorous, hardy.
4. Mid-Atlantic States.
5. Resists injury from fluctuating winter temperatures.

SEPTEMBER

1. New York.
2. Plant bears early summer and fall crops.
3. Berries medium size and bright red. Good tart flavor. Plants vigorous, hardy, and moderately productive.
4. Grown extensively in Eastern United States, especially as a home-garden variety.
5. Generally escapes mosaic.

SOUTHLAND

1. North Carolina.
2. Early.
3. Berries medium size, light red, medium firm. Plants medium vigor.
4. North Carolina to Maryland and west to Illinois, south through Arkansas.
5. Highly resistant to leaf spot, anthracnose, and mildew.

SUMNER

1. Washington.
2. Late.
3. Berries medium size, medium red, firm, with high flavor. Plants vigorous, hardy, productive.
4. Well adapted to heavy soils of Pacific Northwest. Somewhat cold hardy.
5. Resistant to root rot on the Pacific coast. Resistant to yellow rust.

TAYLOR

1. New York.
2. Late.
3. Berries very large, of high quality. Well liked for freezing.
4. A leading variety in New York and New England; well adapted to Northeastern States.
5. Susceptible to mosaic viruses and should be grown from mosaic-free stock.

WILLAMETTE

1. Oregon.
2. Midseason.
3. Berries, very large, nearly round, medium red, very firm, of good quality. Good for freezing and canning. Bushes vigorous, very productive, sucker freely.
4. Grown extensively in the Pacific Northwest.

Purple Raspberries

BRANDYWINE

1. New York.
2. Midseason.
3. Berries large to very large, firm, tart. Plants very hardy, vigorous, and productive. Propagated by tip layers.
4. Northeastern United States.
5. Susceptible to mosaic.

CLYDE

1. New York.
2. Late.
3. Berries large, firm, tart. Bushes hardy, very productive; vigorous, stout canes.
4. Northeastern United States.
5. Moderately anthracnose resistant.

Black Raspberry

ALLEGHENY

1. Maryland.
2. Midseason.
3. Berries medium to large, firm, good flavor. Plants vigorous and productive.
4. Mid-Atlantic States.
5. Some mildew resistance.

ALLEN

1. New York.
2. Midseason.
3. Berries large, firm, many ripe at one time. Bushes vigorous, productive.
4. North Central and Northeastern United States.

BLACK HAWK

1. Iowa.
2. Very late.
3. Berries, large, firm, glossy, have good flavor. Plants vigorous, productive, very hardy.
4. Widely grown in Eastern United States.
5. Somewhat anthracnose resistant but mildew susceptible.

BRISTOL

1. New York.
2. Midseason.
3. Berries large, firm, and high flavored. Hard to pick after rain. Plants vigorous, hardy, and productive.
4. Widely grown in Eastern United States.
5. Very susceptible to anthracnose.

CUMBERLAND

1. Pennsylvania.
2. Midseason.
3. Berries large, firm, have very good flavor. Bushes usually hardy and productive.
4. Widely grown in Eastern United States.
5. Susceptible to anthracnose and mosaic viruses.

DUNDEE

1. New York.
2. Midseason.
3. Berries large, glossy, firm; have good flavor. Plants vigorous, hardy, and productive. Fruit hard to pick after rain.
4. Mildew susceptible.

HURON

1. New York
2. Late midseason.
3. Berries large, glossy, firm, good flavor. Bushes hardy, vigorous, productive.
4. Adapted in Western New York and worthy of trial elsewhere.
5. Somewhat anthracnose resistant.

NEW LOGAN

1. Illinois.
2. Ripens a week earlier than Cumberland.
3. Berries are medium size, of good quality.
4. Liked for earliness in Michigan and Eastern United States.

MUNGER

1. Ohio.
2. Midseason.
3. Berries large, firm, have good flavor.
4. A leading variety in Oregon.
5. Susceptible to mildew.

PLUM FARMER (FARMER)

1. Ohio.
2. Early. Has short season; ripens so quickly that entire crop can be harvested in two or three pickings.
3. Berries large, firm, high quality. Bushes hardier than those of most other blackcaps, drought resistant.
4. An important variety in Oregon.
5. Susceptible to anthracnose and mosaic viruses; immune from curl virus.

very productive, vigorous.
4. Adapted to California, western Oregon, and gulf coast region.

SANTIAM

1. Oregon.
2. Early.
3. Bright, deep red color, excellent flavor, medium vigor.
4. Hardy only in the Northwestern United States, especially Oregon (Willamette Valley).
5. Susceptible to leaf spot.

YOUNG

(*Youngberry, Laxaca*)

1. Louisiana
2. Midseason.
3. Berries very large, wine colored, very sweet. Plants vigorous.
4. Adapted in South and Pacific States.
5. Somewhat resistant to anthracnose and common leaf spot. Susceptible to rosette.

USE OF PESTICIDES

This publication is intended for nationwide distribution. Pesticides are registered by the Environmental Protection Agency (EPA) for countrywide use unless otherwise indicated on the label.

This use of pesticides is governed by the provisions of the Federal Insecticide, Fungicide, and Rodenticide Act, as amended. This act is administered by EPA. According to the provisions of the act, "It shall be unlawful for any person to use any registered pesticide in a manner inconsistent with its labeling." (Section 12(a)(2)(G)).

The optimum use of pesticides, both as to rate and frequency, may vary in different sections of the country. Users of this publication may also wish to consult their Cooperative Extension Service, State agricultural experiment stations, or county extension agents for information applicable to their localities.

The pesticides mentioned in this publication are available in several different formulations that contain varying amounts of active ingredient. Because of these differences, the rates given in this publication refer to the amount of active ingredient, unless otherwise indicated. Users are reminded to convert the rate in the publication to the strength of the pesticide actually being used. For example, 1 pound of active ingredient equals 2 pounds of a 50-percent formulation.

The user is cautioned to read and follow all directions and precautions given on the label of the pesticide formulation being used.

Federal and State regulations require registration numbers. Use only pesticides that carry one of these registration numbers.

USDA publications that contain suggestions for the use of pesticides are normally revised at 2-year intervals. If your copy is more than 2 years old, contact your Cooperative Extension Service to determine the latest pesticide recommendations.

The pesticides mentioned in this publication were federally registered for the use indicated as of the issue of this publication. The user is cautioned to determine the directions on the label or labeling prior to use of the pesticide.

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Growing Blackberries

UNITED STATES DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN NUMBER 2160

PREPARED BY SCIENCE AND EDUCATION ADMINISTRATION

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GROWING BLACKBERRIES

Blackberries grow best in temperate climates. They are not well adapted to areas in the Plains States or Mountain States where summers are hot and dry and winters are severe.

If properly managed, a blackberry plantation should yield at least 6,000 pounds of berries per acre (6700 kg/ha). To get the greatest yield and longest productive life from the plantation—

- Choose types and varieties that are adapted to your area.
- Prepare the soil thoroughly.
- Plant only highest quality stock.
- Cultivate frequently.
- Apply fertilizer every year.
- Thin out all weak canes and suckers.
- Protect plants from insects, diseases, and winter injury.

TYPES OF BLACKBERRIES

The two types of blackberries—erect and trailing—differ primarily in the character of their canes. Erect blackberries have arched self-supporting canes. Trailing blackberries, also called dewberries, ground blackberries, or running blackberries, have canes that are not self-supporting; the canes must be tied to poles or trellises in cultivation.

The two types also differ in fruit characteristics. Fruit clusters of the trailing blackberry are more open than those of the erect blackberry. Trailing blackberries generally ripen earlier and are often larger and sweeter than the erect type.

Some varieties have canes that trail the first year after planting. Canes developed in subsequent years are more erect. These are called semitrailing blackberries, but they are essentially erect varieties.

PLANTING SITES

Availability of soil moisture is the most important factor to consider in choosing a planting site for blackberries. While the fruit is growing and ripening, blackberries need a large supply of moisture. During the winter, however, the plants are harmed by water standing around their roots.

Almost any soil type, except very sandy soils, is suitable for blackberries as long as the drainage is good.

In areas where winters are severe, the slope of the planting site is important. Blackberries planted on hillsides are in less danger of winter injury and damage from late spring frosts than those planted in valleys.

In areas where drying winds occur frequently, the plantation should be

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Typical fruit clusters of blackberries: A, trailing varieties; B, erect varieties.

sheltered by surrounding hills, trees, or shrubs.

PLANTING

Plant blackberries as soon as you can prepare the soil—in early spring in the North, in late winter or early spring in the South.

Preparing the Soil

Prepare the soil for blackberries as thoroughly as you would for a garden. For best results, plow to a depth of 9 inches (20–25 cm) as soon as the soil is in workable condition. Disk and harrow the soil just before setting the plants.

Before establishing a new plantation, it is a good idea to seed and plow under one or two green-manure crops of cowpeas or of rye and vetch. This thorough working gets the soil in good condition for planting, and the added organic matter and nitrogen help the plantation to produce an early fruit crop.

Spacing the Plants

Plant erect varieties of blackberries 5 feet (1.5 m) apart in rows that are 8 feet (2.5 m) apart. Space vigorous varieties of trailing or semitrailing blackberries, such as Thornless Evergreen, 8 to 12 feet (2.5–3.5 m) apart in rows 10 feet (3.0 m) apart. Space other trailing varieties 4 to 6 feet (1.2–1.8 m) apart in rows 8 feet (2.5 m) apart. (For description of varieties, see pp. 17 to 20.)

In the Central States, set erect varieties 2 feet (0.5 m) apart in rows 9 to 10 feet (2.5–3.0 m) apart. Let the plants grow into hedgerows.

Setting the Plants

Do not let planting stock dry out. If you cannot plant the stock as soon as you receive it, protect the roots from drying by heeling in the plants.

To heel in, dig a trench deep enough to contain the roots. Spread the plants along the trench, roots down, and cover the roots with moist soil.

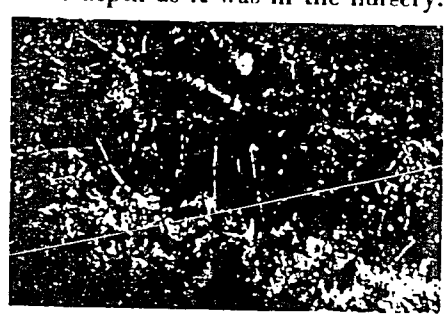
If the plants are dry when you receive them, soak the roots in water for several hours before you plant them or heel them in.

When you are ready to set the plants in the field, dip the roots in a thin mud made with clay and water or keep the plants in polyethylene bags. This coating helps to protect the roots from rapid drying while the plants are being set.

Before setting the plants, cut the tops back so they are about 6 inches (15 cm) long. The 6-inch (15 cm) top is useful as a handle when setting the plants and will serve to show the location of the plants.

To make a planting hole, cut a slit in the soil with the blade of a mattock or shovel. Press the handle of the tool forward to open the slit.

Put the root of the blackberry plant in the hole. Set it so it is about the same depth as it was in the nursery.



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Blackberry plants from the nursery should be heeled in to keep the roots moist until the field is ready to plant.

Withdraw the blade of the mattock or shovel and pack the soil firmly around the root with your heel.

INTERCROPPING

During the first summer after the blackberry plants are set, vegetables can be grown between the rows. Intercropping is not used in the Northwest and is used much less elsewhere now than formerly.

Good crops for intercropping are cabbage, cauliflower, beans, peas, and summer squash. Do not grow grain crops; they are not cultivated and they take too much of the moisture and nutrients needed by the blackberry plants.

Do not grow intercrops after the first year; blackberry plants of bearing size need all the nutrients and moisture for satisfactory production.

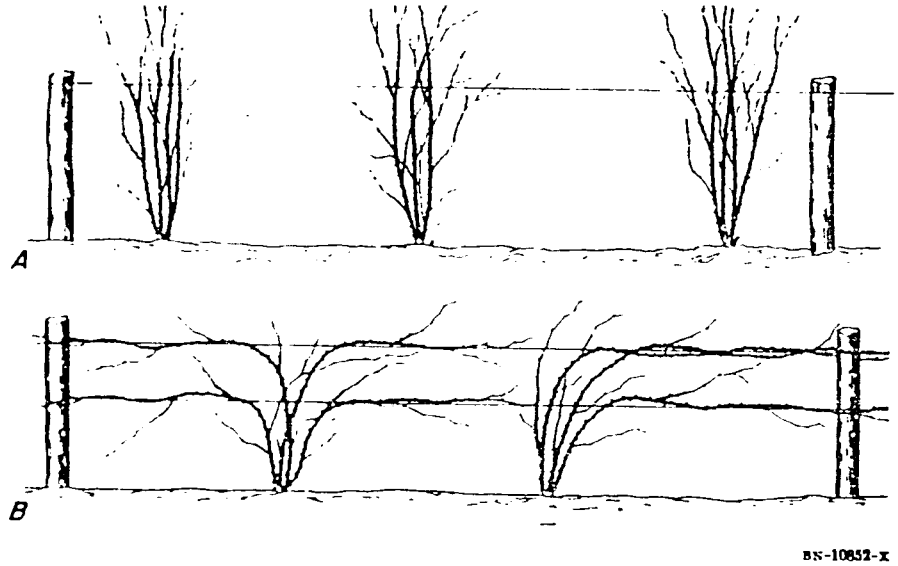
TRAINING

Train blackberry plants to trellises.

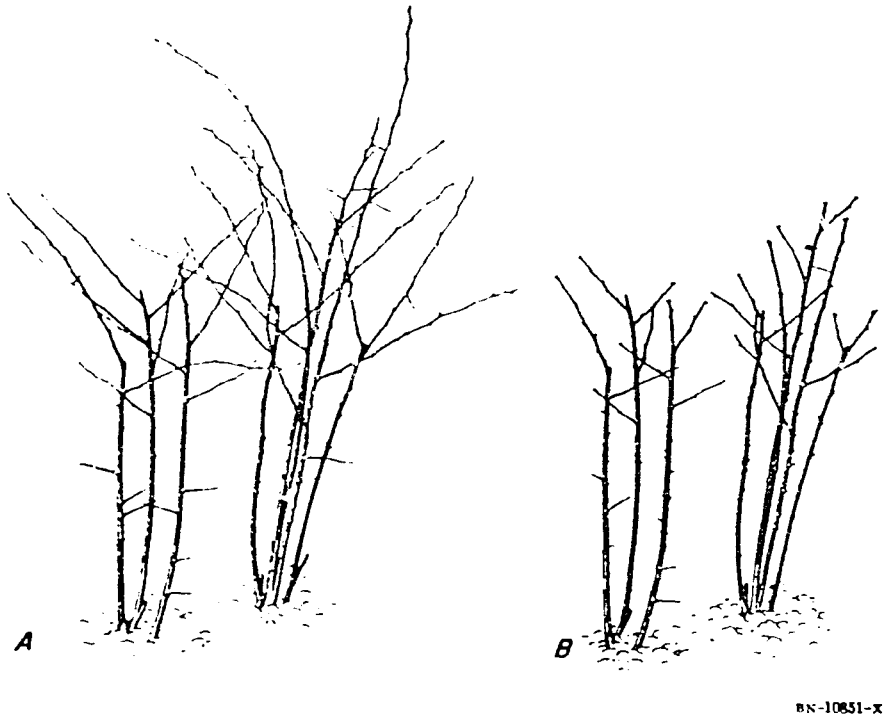
Erect blackberry plants can be grown without support, but many of the canes may be broken during cultivation and picking. Trellises will pay for themselves by reducing this damage.

Many trellis arrangements and methods of training are in use by blackberry growers. The simplest methods of trellis construction and of training are as follows:

- Construct trellises by stretching wire between posts set 15 to 20 feet (4.5 to 6.0 m) apart in the row. For erect blackberries, use a single wire attached to the post about 30 inches (75 cm) from the ground. For semi-



Trellises for blackberries: A, train erect plants to a one-wire trellis; B, train trailing plants to a two-wire trellis.



An erect blackberry plant: A, before pruning; B, after pruning.

trailing and trailing blackberries, use two wires, one about 3 feet (1.0 m) from the ground and the other about 5 feet (1.5 m) from the ground.

- Tie the canes to the wires with soft string. Tie erect varieties where the canes cross the wire. Tie trailing canes horizontally along the wires or fan them out from the ground and tie them where they cross each wire. Avoid tying the canes in bundles.

PRUNING AND THINNING

The crowns of blackberry plants are perennial; new canes arise from them every year. The canes are biennial; they live for only 2 years. During the first year they grow and send out laterals (side branches). The second year, small branches grow from buds on the laterals. Fruit is borne on these buds. After the laterals fruit, the canes die.

The laterals should be pruned back in spring. Fruit from pruned laterals is larger and of better market quality than fruit from unpruned laterals.

Before growth starts, cut the laterals back to a length of about 12 inches (30 cm).

Erect blackberries send up root suckers in addition to the new canes that arise from the crown. If all the root suckers were allowed to grow, they would soon turn the blackberry plantation into a thicket.

During the growing season, remove all suckers that appear between the rows. Pull the suckers out of the ground. Suckers that are pulled do not regrow as quickly as suckers that are cut down.

When canes of erect blackberries reach a height of 30 to 36 inches (75–100 cm), cut off the tips. This makes the canes branch. Tipped canes also grow stout and are better able to support a heavy fruit crop than untipped canes.

In summer, as soon as the last berries have been picked, cut out all the old canes and burn them. Also, thin out the new canes, leaving three or four canes of erect varieties, four to eight canes of semitrailing varieties, and eight to 12 canes of trailing varieties.

In areas of the South where anthracnose and rosette are serious diseases on blackberries, cut out all the canes—both old and new—after fruiting. Then fertilize and cultivate to promote growth of replacement canes for the next year's fruit crop.

If you let suckers form within rows of erect blackberries, thin the suckers to about five or six canes per lineal foot (30 cm) of row.

FERTILIZING

To get maximum yields from your blackberry plantation, apply fertilizer every year at blossoming time. In Southeastern and South Central United States, make a second application after fruiting.

Use commercial 5–10–5 fertilizer for the first application. Apply it as a top-dressing at a rate of 500 to 1,000 pounds per acre (560–1,120 kg/ha) or 5 to 10 pounds per 50-foot row (2.5–4.5 kg/15 m row). Use nitrate of soda or ammonium nitrate after fruiting. Apply nitrate of soda at the rate of 200 to 300 pounds per acre (220–330 kg/ha) and ammonium nitrate at the rate of 80 to 100 pounds per acre (90–110 kg/ha).

CULTIVATING

Blackberry plantations should be cultivated thoroughly and frequently. If grass and weeds get a start, they are difficult to control.

Begin cultivating in the spring as soon as the soil is workable. Cultivate throughout the season as often as necessary to keep weeds down. This may be as often as once a week. Discontinue cultivation at least a month before freezing weather normally begins.

To avoid harming shallow roots of the plants, cultivate only 2 or 3 inches (5.0 7.5 cm) deep near the rows. A tractor-mounted grape hoe or a rotary hoe is useful for cultivating in the rows and under trellises.

HERBICIDES [1]

Weeds in rows and under trellises can be controlled with herbicides.

Herbicides suggested are:

- Simazine [2-chloro-4,6-bis(ethylamino)-*s*-triazine].
- Diuron [3-(3,4-dichlorophenyl)-1,1-dimethylurea].
- Dichlobenil [2,6-dichlorobenzonitrile].
- Chlorpropham [isopropyl *m*-chlorocarbanilate].
- Dinoseb [2-*sec*-butyl-4,6-dinitrophenol].

Simazine and diuron are applied to the soil to control many germinating broadleaf weeds and grasses including pigweed, lambsquarters, crabgrass, and others. They will not control established weeds.

Use simazine after clean cultivation of the soil in early spring or during dormancy after canes have been trained. Use diuron after clean cultivation during dormancy. Rotate use of these herbicides from year to year to avoid excessive buildup of herbicide residues in the soil and prolonged exposure of the crop to one herbicide.

Dichlobenil is most effective when applied during cool weather. Apply it in late fall or early spring. It should be used only on established plantings. If applied during new shoot emergence, it may cause temporary stunting of the new shoots. Dichlobenil, in addition to controlling annual weeds, will also control certain perennial weeds.

Use chlorpropham as a dormant treatment in late fall or early spring. It will control established as well as germinating common chickweed.

Use dinoseb during dormancy of the crop to kill young weeds that are less than 4 inches (10 cm) tall. Weed foliage must be thoroughly wetted by the spray.

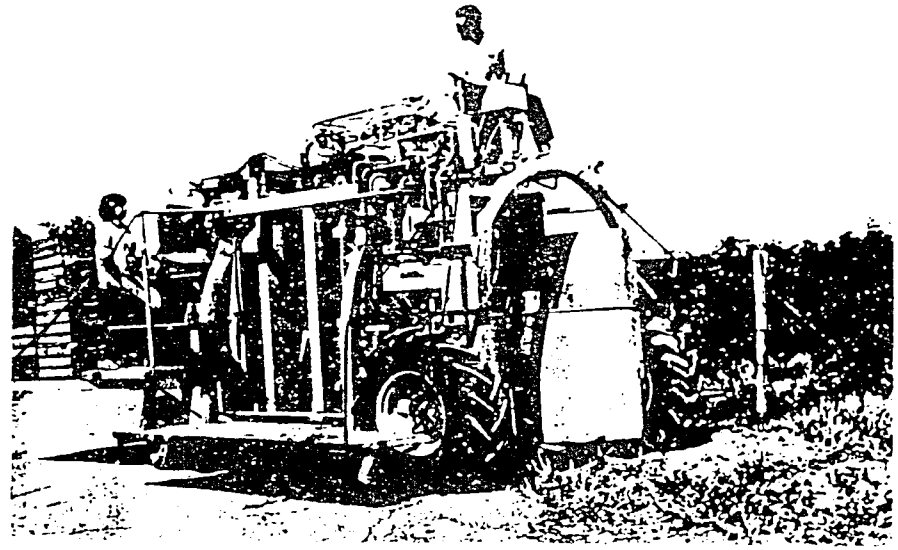
GROWING COVER CROPS

Winter cover crops help prevent soil erosion and they add humus to the soil. They also help protect blackberry canes during the winter by shielding the canes from drying winds.

Sow a cover crop at the last cultivation. Drill cowpeas, spring oats, or rye in the middles, leaving 12 to 15 inches (30–40 cm) next to the plants free of cover crop.

Turn under the cover crop the following spring.

[1] By W. V. Welker, Jr., SEA research horticulturist, Horticultural Crops Research, Rutgers University, New Brunswick, N.J. 08903.



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Harvesting machine that straddles a row of blackberries.

HARVESTING

Firm, ripe blackberries bring the highest market price. Berries that are picked at the proper time, handled carefully, and stored in a cool place will stay in good condition for several days. Berries that are overripe or injured spoil quickly.

Pick the fruit as soon as it becomes sweet. It should be fully ripened but firm.

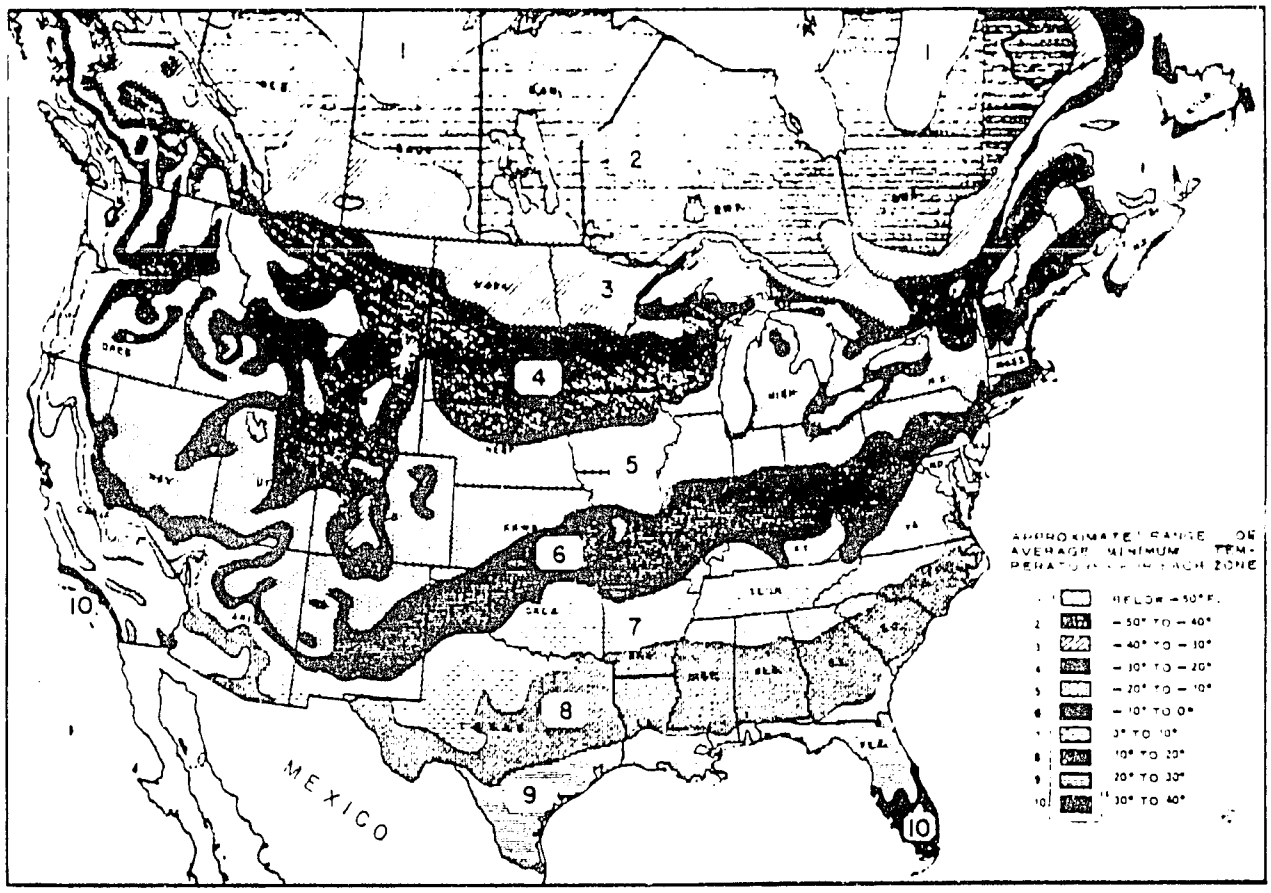
Pick often; for most varieties, pick berries every other day. The fruit of the Evergreen and Thornfree varieties remains firm longer than fruit of other varieties and may be picked less frequently—once a week is often enough.

Pick early in the day. Try to finish picking before the hottest part of the day. Blackberries do not spoil as quickly if they are picked in the morning as they do if they are picked in the afternoon.

Pick carefully for fresh market. Do not crush or bruise the fruit. Place the fruit carefully in the berry baskets. As soon as the baskets are full, place them in the basket carrier, which should always be kept in the shade.

Approximately 40 percent of the blackberries in the Northwest are harvested by machines. These machines are large, in some cases self-propelled, over-the-row types that are economical to operate on units of 20 acres (8 ha) or more planted with long rows. Some machines are owned by growers, and others are leased by growers from a processing company or the manufacturer.

The main varieties harvested in order of ease and fruit quality are Thornless Evergreen, Chelahem, and Marion. Boysenberries and Logans do not harvest well with present mechanical techniques, but future adaptations of the harvesting machine



HARDINESS OF BLACKBERRY VARIETIES BY TEMPERATURE ZONES

Variety	*Zone*	*Variety*	*Zone*
Austin Thornless	7,[a] 8	Flint	7, 8
Black Satin	6, 7, 8	Flordagrand	9
Boysen	7, 8	Georgia Thornless	9
Brainerd	6,[a] 7, 8	Jerseyblack	6, 7
Brazos	8, 9	Logan	7,[a] 8 [c]
Cascade [b]	7,[a] 8 [c]	Lucretia	7, 8 [c]
Chehalem [b]	7,[a] 8 [c]	Marion [b]	8 [c]
Cherokee	6, 7, 8	Mayes	7,[a] 8
Comanche	6, 7, 8	Oklawaha	9
Cory Thornless [b]	7,[a] 8	Olallie [b]	8 [c]
Dallas	6, [a] 7, 8 [c]	Ranger	6,[a] 7
Darrow	5, 6, 7	Raven	6,[a] 7
Dewblack	6,[a] 7, 8 [c]	Smoothstem	7, 8 [c]
Early Harvest	6,[a] 7, 8 [c]	Thornfree	6,[a] 7, 8 [c]
Ebony King	5,[a] 6, 7	Young	6,[a] 7, 8
Eldorado	5, 6, 7		
Evergreen [b]	8 [c]		

[a] Subject to winter injury in some years if not protected.
[b] Not adapted to States east of Arizona.
[c] Adapted to northern part of zone or higher elevations.

may change this. Special training of new canes is usually necessary to enable the berry-catching mechanism of the harvesting machine to be most efficient.

Special efforts must be made to have fields relatively free of diseases (particularly fruit rot) and insects for mechanical harvest. All the mechanically harvested fruit goes into the processing market.

PROPAGATING

Blackberry plants are easy to propagate. Most growers propagate their own planting stock.

Erect blackberry plants can be propagated from root suckers or root cuttings. The latter method yields the greatest number of new plants. Trailing blackberries and some semitrailing varieties are propagated by burying the tips of the canes, which will root and form new plants.

The easiest way to propagate erect blackberry plants is by planting root cuttings in a location where they will fruit. Dig pieces of root from around established plants in early spring. The root pieces should be at least ¼ inch (0.5–0.6 cm) in diameter. Cut the roots into 3-inch (7.5 cm) lengths and bury them in trenches 2 or 3 inches (5.0 or 7.5 cm) deep.

Propagate tip plants from trailing blackberries in late summer. Loosen the soil around each plant, and bury the tips of the canes about 3 inches (7.5 cm) deep, pointing the tips straight down.

Thornless Evergreen and Thornless Logan must be propagated by tipping as the other methods give rise to thorny plants.

PREVENTING WINTER INJURY

Hardy varieties of blackberries can withstand still-air temperatures as low as −20° F. (−29° C.). Throughout most of the areas where they are grown, adapted varieties need no special protection in the winter.

However, in areas where winter temperatures are colder than −20° F. (−29° C.) or cold, drying winds are likely to occur, the plants should be protected during the winter. In the fall, after warm weather has ended but before the ground is frozen, bend the canes over to the ground and cover them with a layer of soil, straw, or coarse manure. Uncover the plants in spring after severe weather has ended.

In western Oregon, where winters are mild and moist, canes of trailing varieties occasionally show a form of winter injury when they are allowed to lie on the ground. There, they are best tied to trellises in late summer and allowed to stay up through the winter. However, if the winter has severe drying winds, considerable injury may occur when canes are on the trellis.

DISEASES[2]

General Disease Control Practices

Damage from disease can be kept at a minimum if these general suggestions are followed:

[2] By R. H. Converse, SEA *research plant pathologist*, Horticultural Crops Research, Oregon State University, Corvallis, Oreg. 97331

- Plant row crops for several years before replanting a field to blackberries.
- Choose disease-resistant varieties.
- Select high-quality planting stock free of nematodes and diseases. Purchase certified stock whenever possible. Examine the planting stock yourself for freedom from diseases whenever you can.
- Remove old canes from the field or thoroughly disk them under.
- Keep the field free of weeds and fallen leaves.
- Destroy plants in which disease appears.
- Remove all wild blackberry and raspberry plants in the vicinity of the field and destroy all plants in abandoned fields.

Root Disease

Verticillium wilt is a soil-borne fungus disease that infects canes of susceptible varieties. Examples of susceptible varieites are Boysenberry, Youngberry, and Lucretia. Susceptible canes turn yellow and die in midsummer. The disease is common wherever blackberries are grown in the United States except in the Southeast. Susceptible blackberries should not be planted in fields that have recently grown solanaceous crops such as potatoes, tomatoes, peppers, and eggplant. Soil fumigation with chloropicrin, a costly procedure, can control verticillium wilt.

Some resistant blackberry varieties are Evergreen, Olallie, and Lawton.

Bacterial Diseases

Crown gall and *cane gall* are caused by bacteria that live in the soil. They infect blackberries through wounds caused by pruning and cultivation. The diseases are widespread throughout the United States. Wartlike growths develop on infected crowns and canes, often weakening plants. Crown gall and cane gall are prevented by planting gall-free nursery stock in soil not recently used for growing caneberries or tree fruits.

Foliage Diseases

Anthracnose is caused by a fungus that produces numerous small purple spots on canes, leaves, and fruit stems. Anthracnose is most severe in Southeastern United States. The disease is controlled by sanitation and by spraying with liquid lime sulfur or polysulfide plus a spreader sticker in late winter while plants are still dormant. Lime sulfur or polysulfide plus a spreader sticker can be applied at the start of bloom. This will also help to control leaf and cane spot.

Leaf and cane spot is a fungus disease common in the Southeastern States and in the Pacific Northwest. Purple spots with white centers develop on leaves and canes, sometimes causing early defoliation and weakening of the canes. Control procedures include cutting out and removing infected canes from the field after harvest. The spray program used for anthracnose control (see above) is also recommended. In the Pacific Northwest, spray Bordeaux mixture (8-8-100) or fixed copper plus a spreader sticker (4 lb+1 qt/100 gal) (1.8 kg +0.95 L/378 L) in late September or early October to help control outbreaks of the disease. Two additional fixed copper sprays (4 lb and then 2 lb+1 qt/100 gal) (1.8 kg and then

GUIDE FOR USE AND SELECTION OF INSECTICIDE [1]

Insect	Insecticide	Minimum days from last application to harvest	Formulation [2]	Where and when to apply
		Number		
Aphids	diazinon [3]	7	D, EC, or WP	On foliage as needed.
	malathion [3]	1	D, EC, or WP	
	parathion [3]	15	D, EC, or WP	
Japanese beetle	carbaryl	7	D or WP	On foliage as needed.
	malathion [3]	1	D, EC, or WP	
	methoxychlor	3	EC or WP	
Orange tortrix	carbaryl	7	WP	On foliage in Northwest when first blossoms appear.
Raspberry crown borer.	diazinon [3]	7	EC	On lower canes & crown; first week in October.
	parathion [3]	15	EC or WP	
Raspberry fruit-worms and raspberry sawfly.	rotenone	1	D, extract or powder.	On foliage when blossom buds appear & just before blossoms open.
Redberry mite	lime sulfur	.....	L	On dormant plants only.
			L	On plants when fruit spurs are 1 ft long.

See footnotes at end of table, p. 15.

GUIDE FOR USE AND SELECTION OF INSECTICIDE [1]—Continued

Insect	Insecticide	Minimum days from last application to harvest	Formulation [2]	Where and when to apply
Red-necked cane borer.	rotenone	1	D, extract or powder.	On foliage just before plants bloom; repeat in about 2 weeks.
Rose chafer	carbaryl	7	D or WP	On foliage as needed.
	methoxy-chlor.	3	D or WP	
Rose leaf hopper.	malathion [3]	1	D, EC, or WP	On foliage as needed.
Rose scale	malathion [3]	1	D, EC, or WP	On foliage as needed.
	summer oil	.....	EC	On dormant plants only.
Spider mites	demeton	(4)	EC	On foliage as needed. Apply demeton after harvest, in late summer or fall.
	dicofol	2	EC or WP	
Stink bugs	carbaryl	7	D or WP	On foliage as needed.
Strawberry weevil.	methoxychlor	3	D or WP	On foliage when insects first appear.

[1] See Use of Pesticides, p. 20.
[2] D=dust, EC=emulsifiable concentrate, WP=wettable powder, L=liquid.
[3] Very toxic to bees; do not spray when there are blossoms, or bees are foraging.
[4] Apply demeton only after last harvest.

0.9 kg + 0.95 L/378 L) should be applied in March for severe outbreaks.

Orange rust is a fungus disease that is common in the eastern half of the United States. The fungus is established internally in the crown of the plant. In the spring, new leaves of infected plants develop orange blister-like pustules of spores. Such plants are weak and barren. Sprays do not control this disease. Control is accomplished by planting nursery stock that is free from orange rust in fields that are free of infected blackberries. Disregard rust pustules that develop late in the season on old leaves—these are caused by relatively harmless leaf rust fungi.

Fruit and Flower Diseases (rosette)

Double blossom (*rosette*) is a fungus disease which may chronically infect blackberry plants in the Southeastern States. It causes flowerbuds to enlarge and produce coarse reddish flowers with twisted petals which make the flowers appear double. These flowers do not produce fruit. Infected plants also develop abnormal broomlike growths of leafy shoots. To control the disease, cut *all* canes close to the ground after harvest and remove them.

Fruit rots caused by several fungi can infect blackberry fruit before or after harvest. Infected fruit is usually overgrown with a gray or black cottony fungus mass. Fruit rot fungi are universally present but develop most readily on damaged and overripe berries. To control the disease, carefully pick sound fruit at frequent intervals and quickly store the fruit under refrigeration at 32° to 40° F. (0°–5° C.). Apply fungicide sprays at the beginning of bloom and at 10-day intervals until harvest if fruit rot is severe, as in rainy weather. Use captan, dichloran, or benomyl. Captan can be applied until harvest (25/ppm tolerance), but dichloran may not be applied within 1 day of harvest and may not be applied more than four times in one season (15 ppm tolerance). Benomyl may not be applied within 3 days of harvest (7 ppm tolerance).

Sterility is a virus disease that causes blackberry plants to produce completely or partially sterile flowers. It is common in the Eastern States. Infected plants grow vigorously without apparent symptoms until fruiting time. To control sterility, plant stocks that are free from this virus and eliminate unfruitful plants whenever they are found.

INSECTS

The blackberry is comparatively free from insect injury; however, the fruit or foliage may become infested with aphids, leafhoppers, mites, sawflies, scales, fruitworms, stinkbugs, leaf rollers, beetles, and weevils. The canes are occasionally attacked by borers, and the roots by white grubs.

Damage from insects can be kept at a minimum if these general suggestions are followed:

- Prune out insect-infested canes and burn them.
- Remove old canes after harvest.

If you need to use pesticides to control insects, purchase only the amount necessary for the current insect problem.

Insects and the insecticides recommended for their control are shown in the table on pages 14 and 15. Follow the directions and heed all precautions on the pesticide label.

POLLINATION

Some self-unfruitful varieties of blackberries require cross-pollination. Other varieties, even though self-fruitful, may benefit from the pollen-distributing visits of insects. The flowers of blackberries are very attractive to honey bees, the primary pollinators, and small acreages are usually pollinated adequately by them.

If a variety of blackberry is known to require cross-pollination, insure a sufficient supply of pollinators in large acreages by placing colonies of honey bees in or near the field.

Use pesticides on the plants that are least toxic to bees; time the pesticide applications to avoid hazard to bees.

VARIETIES

Following are descriptions of the major blackberry varieties grown in the United States. These descriptions include:

1. State where the variety originated.
2. Time of ripening.[3]
3. Characteristics.
4. Area of special adaptation.
5. Disease susceptibility.

For local variety recommendations, consult your county agricultural agent or your State agricultural experiment station.

[3] The date of ripening cannot be given; it depends on many factors in addition to variety. The ripening time—very early, early, midseason, late, or very late—shows when a variety ripens in relation to other varieties grown on the same site. The time lapse between ripening of very early varieties and very late varieties may be as little as 20 days or as much as 40 days.

Erect Varieties

BLACK SATIN

1. Illinois.
2. Late (earlier than Thornfree).
3. Berries large, firm, slightly tart, good flavor. Plants very vigorous, very productive, thornless, semiupright, hardy.
4. Illinois, Ohio, Mid-Atlantic States.
5. Resistant to leaf spot, anthracnose, and mildew.

BRAZOS

1. Texas.
2. Early.
3. Fruit large, attractive, fairly firm. Bushes very vigorous, productive.
4. Texas and gulf coast area.

CHEROKEE

1. Arkansas.
2. Early.
3. Berries medium to large size, firm, good color and flavor. Plants are vigorous and productive.
4. Arkansas and surrounding regions.

COMANCHE

1. Arkansas.
2. Early.
3. Berries large size, firm and good glossy black color. Plants are vigorous and productive.
4. Arkansas and surrounding region.

DALLAS

1. Texas.
2. Early.
3. Berries large, firm. Bushes semitrailing, vigorous, productive. Hardy to −10° F (−23° C.) with wind protection.
4. Grown in Texas and Oklahoma.

DARROW

1. New York.
2. Early; long fruiting season.
3. Berries glossy black, large, firm, mildly subacid. Bushes vigorous, hardy, very productive.

DIRKSEN THORNLESS

1. Illinois.
2. Late (earlier than Black Satin).
3. Berries large, firm, slightly tart, good flavor. Plants very vigorous, productive, thornless, hardy.
4. Illinois, Ohio, Mid-Atlantic States.
5. Resistant to leaf spot, anthracnose, and mildew.

ELDORADO

(Stuart, Louden, Texas)

1. Ohio.
2. Early to midseason; long fruiting season.
3. Berries medium to large, firm, sweet.
4. Bushes hardy, productive, very vigorous.
5. One of the best varieties in adapted area.
6. Not adapted in the extreme South.
7. Most resistant to orange rust of widely grown varieties.

EVERGREEN

(See Thornless Evergreen)

FLINT

1. Georgia.
2. Midseason.
3. Berries large, firm, good flavor. Plants productive, very vigorous, semiupright, prolonged ripening.
4. Adapted in South and Southwest.
5. Resistant to leaf spot and anthracnose.

GEORGIA THORNLESS

1. Georgia.
2. Midseason.
3. Berries large, oblong, firm, good flavor. Plants thornless, semiupright, productive.
4. Adapted in gulf coast region.

JERSEYBLACK

1. New Jersey.
2. Midseason; long fruiting season.
3. Berries medium to large, firm, mildly subacid. Bushes semitrailing, vigorous, productive.

RANGER

1. Maryland.
2. Early, short ripening season.
3. Berries medium size, firm, good subacid flavor. Bushes moderately vigorous, productive in central Atlantic region. Stiff canes.
4. Grown from southern Pennsylvania and southern New Jersey southward.

RAVEN

1. Maryland.
2. Early, short ripening season.
3. Berries medium large, medium firm, very good subacid flavor. Bushes moderately vigorous, productive in South.
4. Grown from southern Pennsylvania and southern New Jersey southward and west to south central United States.

SMOOTHSTEM

1. Maryland.
2. Very late.
3. Berries large, firm, tart, good flavor. Bushes very vigorous, productive. Canes thornless, semiupright.
4. Adpated from southern Maryland to North Carolina along Atlantic coast. Good for home gardens.
5. Resistant to leaf spot.

THORNFREE

1. Maryland.
2. Late.
3. Berries large, firm, tart, very good flavor. Bushes medium vigorous, productive. Canes thornless. Semiupright.
4. Hardy from central New Jersey, southern Pennsylvania, southern Ohio southward to North Carolina and west to Arkansas, and in Pacific Northwest. Not winter hardy in the North. Good for home gardens.
5. Resistant to leaf spot.

THORNLESS EVERGREEN

1. Oregon.
2. Very late.
3. Mutation of Evergreen. Berries large, exceptionally firm, sweet. Seeds large. Bushes vigorous, productive, deep rooted, drought resistant. Hardy to −10° F. (−23° C.) with protection. Canes semitrailing roots at tips.
4. A major variety in Oregon and in Washington. Not generally adapted to States east of the Rocky Mountains. Propagates from tip plants only.
5. Susceptible to rosette in Atlantic Coast States.

Trailing Varieties

BOYSEN

(Boysenberry, Nectar, Rossberry)

1. Origin unknown.
2. Late.
3. Berries very large, tart, high flavor, soft.
4. Widely grown in South and on Pacific coast.

CASCADE

1. Oregon.
2. Early.
3. Berries bright, deep red, have excellent flavor, highest dessert quality. Plants vigorous, very productive. Hardy only in Pacific coast region.
4. Grown in western Oregon and Washington.

CHEHALEM

1. Oregon.
2. Late.
3. Berries small, shiny black, have excellent flavor. Seeds small. Plants vigorous, very productive.
4. Adapted to Pacific coast.

FLORDAGRAND

1. Florida.
2. Very early.
3. Berries large, glossy, soft, aromatic. Bushes vigorous, productive, disease resistant. Require cross-pollination.
4. Best adapted in Florida and along the gulf coast.
5. Resistant to leaf spot and double blossom.

GEM

1. Georgia.
2. Early.
3. Berries large, round, firm, good flavor.
4. Adapted in gulf coast region.
5. Resistant to anthracnose and leaf spot.

LOGAN

(Loganberry)

1. California.
2. Early.
3. Berries large, long, dark red, sweet, high flavored. Plants vigorous, very productive. Thornless form most widely grown.
4. Grown on Pacific coast. Not adapted to East.

LUCRETIA

(Bingleberry)

1. West Virginia.
2. Early.
3. Berries large, long, firm. Plants vigorous, productive.
4. Hardy if protected against severe winter weather.
5. Susceptible to anthracnose and leaf spot.

MARION

1. Oregon.
2. Late.
3. Berries medium to large, bright black, of medium firmness. Plants very vigorous and productive. Canes heavy.
4. Adapted to western Oregon and western Washington.

MAYES

(Austin Mayes)

1. Texas.
2. Early.
3. Berries large, soft. Plants vigorous, productive.
4. Leading variety in Texas.
5. Susceptible to anthracnose and rosette.

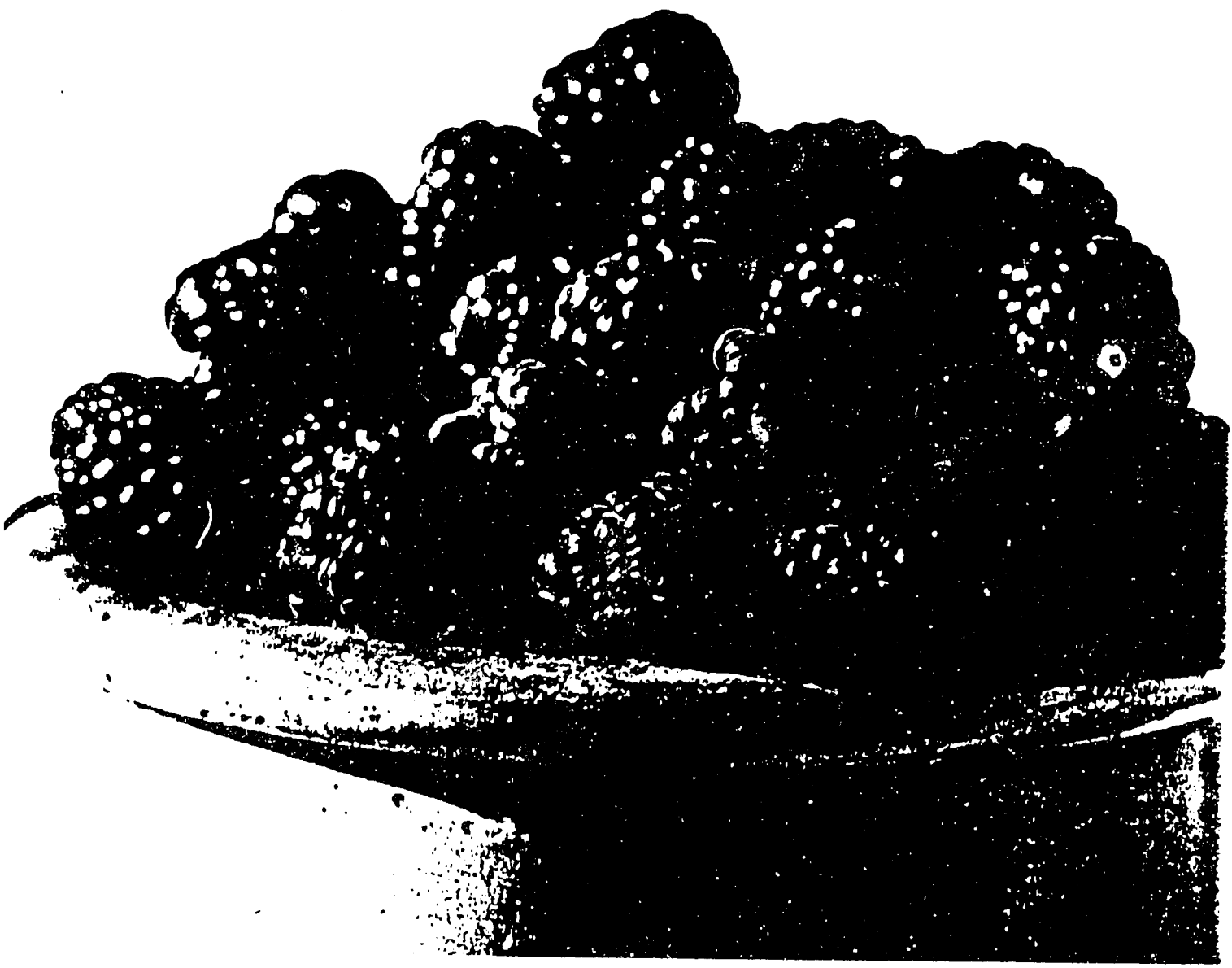
OKLAWAHA

1. Florida.
2. Very early.
3. Berries medium size, good flavor, aromatic fruit, somewhat soft. Serves as pollinator for Flordagrand.
4. Florida and gulf coast region.

OLALLIE

1. Oregon.
2. Midseason.

Growing Boysenberries and Olallie Blackberries



Division of Agricultural Sciences
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LEAFLET
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REVISED JUNE 1979

Growing Boysenberries and Olallie Blackberries

INTRODUCTION

Before planting boysenberries or olallies give careful consideration to the cost of the project. Berries require a great deal of hand labor; this leads to sizable production costs that financing organizations often are reluctant to cover.

It costs initially, at least $1,800 per acre to bring a 5-ton crop into production and pick it. In addition, the minimum equipment needed is a tractor and a disc harrow. A spray rig or duster can be rented if necessary.

The crop is highly perishable, and a great deal of skill and experience are required for top production. Unless you have adequate financial backing, you would do well to start with a small acreage and add to it as your knowledge of the crop increases.

The information in this publication deals mainly with our principal variety of berry, the boysenberry; but applies to other trailing berries, such as olallie blackberries, loganberries, youngberries, and nectarberries. The exceptions are noted.

The series of questions presented, grouped according to subject, are those most frequently asked by boysenberry and olallie growers as well as by prospective growers. See your farm advisor for any other questions.

VARIETIES

The boysenberry was introduced to the public by Walter Knott of Buena Park, California. It is believed to have originated as a chance seedling in the garden of Rudolph Boysen, for whom it is named. It has also been suggested that boysenberries, because of their similarity to youngberries, were originated by Luther Burbank, the originator of the youngberry. It also could have been Burbank's Phenomenal. At maturity, the boysenberry is reddish-black with a noticeable bloom. Its aroma and flavor are suggestive of raspberries.

The olallie berry was created by George F. Waldo of the USDA. It is a cross between black, logan, and young. Originated in Oregon, it is widely grown in California.

The olallie is slightly longer and slenderer than the boysenberry. At maturity it is glossy black. It has the advantage of a shorter winter chilling requirement than the boysen, making it more adaptable to southern California. It has almost complete resistance to Verticillium wilt.

The loganberry, a variety of blackberry, apparently resulted from a cross between the California wild blackberry and the Red Antwerp raspberry. Before 1920, it was the most popular blackberry in California. The acreage declined rapidly between 1920 and 1930. A virus disease (dwarf) was believed responsible for this decline. Only small plantings of this variety now exist. Increased plantings are not recommended.

The youngberry and the nectarberry are quite similar in flavor and appearance to the boysen.

Virus-free selections of most bushberries are now available. Consult your farm advisor.

COSTS

Recent figures show that it costs about $1,200 to $2,100 to establish an acre of boysenberries. No crop is produced the first year. Table 1 shows the general distribution of these costs.

Table 1. Costs of Establishing an Acre of Boysenberries

Plants:	$225 per 1,000 (3' x 8' planting)		$ 408
Lumber:	20 4" x 5" redwood posts 6 feet long @ $5 ea.		100
	363 2" x 2" pressure-treated fir stakes 6 feet long (20 feet apart in the row)	70¢	254
Wire:	Top 2 wires 12-gauge 360 lb; bottom wire 14-gauge 103 lb		153
Survey and layout			25
Planting:	30 man-hours per acre		113
Building trellis			165
Weed control (hand hoeing plus herbicide)			200
Cultivating (machine)			50
Fertilizer and application (200 lb N and manure)			120
Irrigating (6 acre-feet)* water and labor			56
Trellising			450
	Total		$2,094

* Stanislaus County 1978 costs—other areas may be higher.

How Much Does it Cost Per Acre Every Year To Produce Boysenberries on an Established Planting?

An itemized listing of costs involved in producing boysenberries in Stanislaus County in 1978 will be found on page 16.

Does the Grower With the Highest Yield Always Make the Most Profit?

Not necessarily. The careful grower with moderate production may make more profit per acre if the high yield producer has used un-economical methods to achieve high yield.

SOILS

Boysenberries will grow on a wide variety of soils, but do best in deep, sandy loams and loamy sands. Because of the high costs of production, boysenberries should be grown commercially only in soils to which they are best adapted.

What Effect Does Soil Type Have on Production?

Boysenberries yield best on deep, well-drained soils. With good management, yields on these soils have exceeded 10 tons per acre. On

shallow, poorly drained soils, with the best possible management, the top production has been between 7 and 8 tons.

What Effect Does Soil pH Have on Boysenberries?

The term pH is used by soil scientists to express the acidity or alkalinity of a soil. On the pH scale, 7 is neutral; below 7 acid; above 7 basic or alkaline.

Boysenberries do best in slightly acid soils (pH about 6.5), but will do well between 6.0 and 7.5. The pH can be altered somewhat with various soil amendments, such as sulfur and certain fertilizers.

What Effect Will a Previous Crop Have on Boysenberries?

Boysenberries do best following alfalfa. They should not follow tomatoes, potatoes, cotton, strawberries, or other crops which may increase Verticillium fungus in the soil, since this disease remains active in the soil for a long time. Nightshade, a weedy member of the tomato-potato family, also is a carrier of Verticillium. Boysenberries should not be planted in fields infested with nightshade. Do not allow this weed to become established in or near your boysenberry plantings. This is not a problem with olallie or loganberries which are highly resistant to wilt.

WEEDS

It is not necessary to have weed-free soils before establishing boysenberries. However, make every effort to eliminate aggressive perennial weeds, such as johnsongrass or bermudagrass, before planting. Such weeds compete seriously with boysenberry plants for water and nutrients. Where johnsongrass infestation is heavy, pickers become discouraged, because of the difficulty in finding berries. It is important to avoid planting in fields infested with nightshade.

How Can Perennial Weedy Grasses Be Controlled in an Established Planting?

If the problem is not too severe, dig out the grass clumps, carry them from the field, and burn them. Destroy ditchbank weeds that might contaminate irrigation water. Some of the newer chemicals show promise for controlling weeds in boysenberries. Consult your local farm advisor.

PREPLANTING

Most boysenberry fields are leveled to zero grade; a sufficiently large head is used to push the water across the field efficiently. The slope never should exceed 5 percent. Trellis requirements make contouring impossible.

Should Manure Be Applied Before or After Planting?

A 10- to 15-ton manure application is much more effective when applied before planting rather than after. Broadcast the manure and work it into the soil.

Is it Necessary to Rip the Ground Before Planting?

Ripping is recommended if there is any evidence of a plow pan formed from previous cultivations, or if the field has been leveled recently.

PLANTING STOCK

Well-rooted tip plants of medium size start better and produce higher yields than those developed from cane layers or crowns.

For ease in handling, and to see the row when cultivating, a 6-inch portion of the old cane (the handle) should remain attached to the new plant.

Buy plants only from fields which have most consistently shown high production. Try to obtain plants from fields not infected with crown gall. Check the plants carefully for this disease, culling infected plants, to prevent the establishment of crown gall.

How Are Plants Produced?

In late October or early November, cover the tips of the lower canes slightly with soil to encourage root formation (tip layering). Some growers place shallow furrows close to the row with a plow. The tips are placed in the bottom of the furrow and covered with soil. Others plant with a hoe. Making a shallow hole with the corner of the hoe, they place the tip in the hole and cover it with soil.

If the lower canes are not wrapped, they often will voluntarily tip-in without soil being placed on the tips. This is the method most frequently used by growers who want just a few additional plants. The other methods are used by growers who plan to produce a number of plants for sale.

Who Can Sell Plants?

If you are producing plants to sell, check with your County Agricultural Commissioner's Office. A nursery license is required; however, if sales are all local, retail, and under $500, the license is fee-exempt. Inspection must be made by the County Agricultural Commissioner for pests and diseases prior to sale or distribution.

PLANTING

Planting should be done in January or February, since plants are not well rooted before then. In the central valley, plant before March 1. In coastal districts, planting should be completed before April 1. If plantings are made later, irrigation water must be available at planting and at regular intervals thereafter.

Can the Plants Be Kept in Cold Storage Until the Ground is Prepared?

Yes, boysenberry plants have been stored at 28° to 34° F in polyethylene bags for almost 2 months without any apparent weakening.

Caution: Before storing until planting season, make sure that no decay is present. Do not store plants that have started to grow. Before taking the plants down to the lowest storing temperatures, they should be held for a week at 36° F.

How Long Can Plants Be Stored After Delivery?

It is best to set out plants as soon as they are delivered. Keep them in a cool place until you are ready to take them to the field. If inclement weather prevents planting after the plants have been dug, you can hold them at 36° to 38° F for up to 1 month. Do not attempt to store plants unless they are fully dormant. This also applies to plants going into cold storage. If you have to store plants, do not allow them to become dry.

Should Plants be Planted on a Ridge or a Flat?

Planting flat prevents the plants from drying out; raised beds are not recommended.

How Long Should the Rows Be?

Most boysenberry fields are planted in 600-foot rows with alleys at each end so pickers do not have to carry loaded crates farther than 300 feet. In the central coast and north coast areas, the rolling nature of the land makes ease of irrigating and cultivating the most important considerations in row length. Rows there seldom exceed 300 feet.

What Spacing Has Been Found Most Effective?

Plants usually are spaced 3.5 feet apart in the rows. Rows generally are 8 feet apart. In non-

Fig. 1. Establishing new plants. A, the plant is inserted with roots spread in a fan-like shape. B, after planting, the crown bulb is at the soil level.

irrigated plantings, space the plants farther apart in the row. In the coastal areas, plants generally are spaced 6 feet apart.

How Are Rows Kept Straight When Planting?

String a wire between temporary stakes at each end of the field to keep the planting line straight.

In Which Direction Should the Row Run?

Both north-and-south and east-and-west plantings are found throughout boysenberry areas. The direction of the rows does not seem to make much difference, but where the temperature is extremely high during harvest, the fruit on the west side of north-south rows may sunburn. Since this generally is not an important consideration, plant your rows in the direction easiest to irrigate. Where slopes are involved, cross-slope planting is better for irrigation.

How Can Plants Be Spaced Accurately?

The most effective method of keeping plants accurately spaced is to put a bead of solder at each point on the planting wire used to mark the rows. Most growers like to keep their plants accurately spaced in the row so they can cross-cultivate while the plants are very young.

Can Stored Plants That Are Starting To Grow Be Used?

Yes, but take care not to damage the tips of the new growth.

How Deep Should the New Plants Be Set?

Perhaps more growers get off to a poor start by planting too deep than through any other mistake. New plants should be set at the same depth they were growing before transplanting (see figure 1).

Is it Necessary to Water After Planting?

Most growers apply a small quantity of water from a tank immediately after planting. As soon as possible, they irrigate. Don't depend on the light rains occurring at this time of the year.

IRRIGATION

The frequency of irrigations will vary with the soil texture and climate. Most central valley growers irrigate every 7 to 10 days. Just before starting to harvest, they reduce this to light irrigations every 3 or 4 days. In the coastal district, three or four irrigations are used until harvest. An additional irrigation frequently is applied after the first harvest.

Should Flood or Furrow Be Used?

On sandy soil, boysenberries seem to do best under a flood system, using four or five rows to a check. The furrow system is better on heavier soils or in sandy soils where there is side fall or rolling terrain. The furrows give the pickers a dry middle to stand on while picking. The furrow system is in general use in the coastal districts.

Can Sprinklers Be Used for Irrigation?

Sprinkler irrigation may not be advantageous because of the high initial cost, in addition, there is ample land available for surface irrigation. It is difficult to use sprinklers in a trellised planting. Where sprinkler pipe is available, plantings can be sprinkled the first year until trellises are in place.

What Can Be Done About Standing Water?

Although boysenberries require a lot of moisture, the plants can be damaged easily by water standing on the surface of the soil, particularly in the early spring. In some areas temporary drainage may be needed to carry off excess water.

FERTILIZERS

Nitrogen is the only major fertilizer that boysenberries need. It can be applied in any of the commercial forms; cost should be the deciding factor. Figure needs on the cost per unit of actual nitrogen, rather than on the cost per ton of the fertilizer supplying nitrogen. Remember that nitrogen in some fertilizers is more readily available to the plants than in others. Usually, a dry fertilizer is applied at the beginning of the season, and anhydrous or aqua ammonia is used for mid-season applications. If water tends to collect in low spots and at the ends of irrigation runs, it would be well to consider using dry fertilizer throughout the season. There is very little difference in the cost.

How Much Fertilizer Should Be Used?

Plan to use about 200 pounds of actual nitrogen per acre per year, split into five applications. This works out to a 50-pound application before growth starts in the spring, a 15- to 20-pound application about every third irrigation, a 50-pound application after pruning, and perhaps another light application in the early fall.

Where Should Nitrogen Fertilizer Be Applied?

Dry fertilizer is best applied in a band at least 12 inches from the plant row. Do not apply fertilizer on or against plants.

Do Boysenberries Require Phosphate and Potassium?

Test plots in several areas of California indicate that additional phosphate and potassium are not required for bushberries.

What About Manure?

Livestock and poultry manure are beneficial when worked into the soil before planting. Heavy applications of poultry manure to established berry plantings have caused severe zinc deficiency in some soils.

BUILDING A TRELLIS

For the end posts, use 4- by 5-inch or larger timbers. Some growers use railroad ties. In between, at 20-foot intervals, use 2- by 2-inch grape stakes, 6 feet long with 18 inches in the ground. For olallies in coastal areas, use 7-foot stakes, since olallies are more vigorous and there is generally more wind. Most growers prefer a 4½-foot trellis, although higher trellises seem to work equally well. The first wire should be 1½ feet from the ground, the second wire 1 foot above the first, and the other wire at the top of the stake. Only two wires are used for the barrel roll.

Do 4- by 5-Inch End Posts Have To Be Used?

No. Some growers found that 2- by 2-inch posts with a "dead man" or similar brace are satisfactory. This system reduces the initial cost considerably.

Is it Necessary To Treat Posts and Stakes with Wood Preservative?

It is difficult to determine the maximum commercial age of boysenberries, but posts and st[illegible] are in the ground for at least 8 years. [illegible] to treat them with a wood preservative prevents costly replacements. Pressure-treated stakes are superior to farm-treated stakes.

When Should Trellis Be Constructed?

The highest yields from first-year plantings consistently come from plantings where trellising was started as soon as the canes were long enough to reach the middle wire. Early trellising is more expensive, but increased yield more than pay for the additional costs. The trellis should be in place as soon as there are sufficient canes to start the wrapping.

HARVESTING

In the Modesto area, the first berries generally ripen by June 15. Some fields on sandy soils ripen a few days earlier. Picking extends to July 4, although in many fields it is completed 7 to 8 days earlier.

Generally, olallies ripen 10 days to 2 weeks before boysenberries. The Fresno area is a week ahead of the Modesto area (June 7), the Santa Cruz area is a week behind (June 21), and the Sebastopol area about 10 days behind in the start and completion of picking (June 25).

Why Is it Important To Be Close to a Populated Area?

An important consideration in selecting a planting site is the availability of an adequate labor supply at harvest. Farms some distance away from populated areas generally have to pay more to get their berries picked.

Who Furnishes the Crates?

There is no set rule, but most processors furnish them. If you want to own your crates, buy three times the number of crates used on the peak day of harvest. This means, that for a 10-acre field with a 6-ton/A. crop, you would need at least 3,000 crates, and to be safe you should have 4,000. The following formula can be used as a guide in determining the number of crates needed for any given acreage and tonnage:

Number of tons per acre x number of crates needed per acre x 3,

for a 60 ton crop on 10 acres, the number of crates needed would be:

$$6 \times 160 \times 3 = 2880$$

What Is the Greatest Problem During Harvest?

Cap stems sticking to the fruit are the greatest harvesting problem in boysenberries. If there are too many cap stems in the crates, processors usually place a severe dockage penalty on the grower. Cap stems not only affect the berries to which they adhere but may cause as many as five berries to stick together when the fruits are frozen.

What Methods Are Used To Pay the Pickers?

The most common method is to give each picker a card and punch it when he brings a crate to the storage area or truck. At the end of the day the cards are totaled and the pickers paid.

Another method consists in giving a colored card to pickers each time they bring in a crate. At the end of the workday, cards are cashed in.

Other growers pay cash as each crate is delivered. This method is not very satisfactory because, if picking is slow, pickers may walk off before the day is over. When paid at the end of the day, pickers are more likely to stay on the job until the workday is completed. Always insist that pickers complete a row before quitting for the day.

Is it Necessary To Pay Social Security for Pickers?

Yes. Growers must keep a social security record for each picker and pay the required amount for all who make over $150 in wages within 30 consecutive days. To avoid problems, consult your local Social Security Office for more specific information.

What Practices Should One Watch for in Picking?

It is most important to see that pickers are picking uniformly ripe berries free of cap stems. Watch for an excessive number of leaves and bruised fruits.

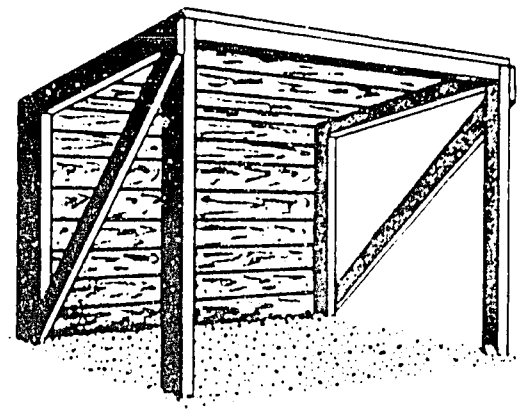

Fig. 2. Storage shed during harvest.

Pickers often put the berries in the center of the crate to make it appear well filled when it isn't. This gives a light crate and increases the number of leakers. Some growers weigh each crate on a scale located at the storage area.

How Can Leakers Be Prevented?

A leaker is a crate in which the fruit has started to break down, causing the juice to leak out at the bottom.

The best prevention is to start picking as early in the morning as possible. Keep the fruit under shade until ready to go to the processor (see figure 2). If necessary, split loads to get the berries to the processor before they start to break down. Avoid heaping berries too high in the center of the crate.

PRUNING AND TRELLISING

What Tools Are Needed for Pruning?

Some growers use curved pruning saws, rice hooks, or rice knives. Rest the tool on the two upper wires and saw through all fruiting wood. It is then fairly easy to remove old canes from the trellis. Then use pruning shears to cut old canes close to the ground.

Few growers using an electric pruner to remove old fruiting wood find it satisfactory.

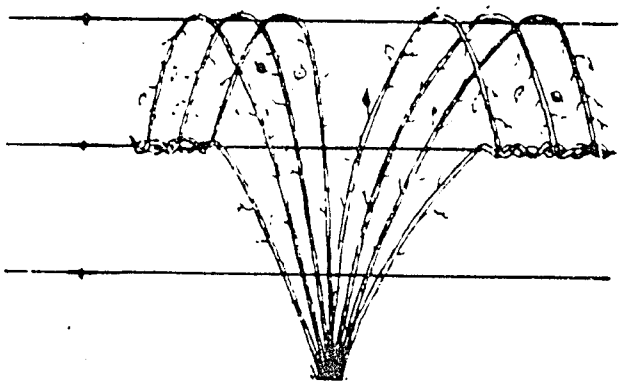

Fig. 3. Fan-like system of trellising. The fruiting wood is well spread over the wires.

What Is an Electric Pruner?

It is an electric hedge clipper. The generator sometimes is mounted directly on a tractor, a small garden tractor, or a horse-drawn car. A boom is attached to the generator to carry the wires over the rows, and permit pruning both sides of two rows at one time.

One grower has installed electric wires over his field crosswise to the rows. He prunes with a long extension cord attached to this wire. This method has advantages for the small grower since the total wiring cost is generally less than the cost of a portable generator. The installation cost is the only cost, there is no up-keep and very little depreciation. This method eliminates the need for having two motors running and an extra person to operate the tractor. The hedge clipper is rested on the wire, then moved forward to cut through old canes instead of using a saw as described previously.

When Should Pruning Be Done?

Prune the vines as soon as the harvest is completed. Remove all wood that has produced the current crop.

When To Trellis?

Trellis immediately after removing the old wood. New wood sunburns very easily when left exposed on the ground – don't allow pruners to get too far ahead of trellisers. In coastal areas, sunburning is not an important factor and trellising can be done in winter.

What Canes Should Be Put on Trellis?

Put up only the larger canes and prune the small ones. Studies indicate that small canes produce small fruits and do not contribute substantially to the yield.

How Many Canes Should Be Used?

Some growers maintain that all large canes should be put up, others put up only a few of the largest. At the 3-foot spacing, a maximum of nine good canes generally returns the best yield with the largest fruit size. More canes can be used if the spacing in the row is more than 3 feet.

What Is the Best Way To Trellis?

The fan-like arrangement is the best way to trellis the vines (figure 3). The fruiting wood is well spread out over the wire. Some growers weave several canes into a rope, but the resulting loss of fruiting wood and the additional winter pruning required make this method more costly.

How Long Should the Canes Be?

The canes should be from 6 to 8 feet long. Put them over the top wire, wrap once around the middle wire, and then remove the tip. In the coastal areas, canes are 10 to 12 feet long. They are taken over and under the top and middle wire three or four times. This is sometimes referred to as a barrel roll (figure 4).

Recent studies indicate that the barrel roll may be mechanically harvested more efficiently than the fan system.

Why Should Canes Be Tipped Back?

Tipping, or removing the end of the canes forces out the laterals on which fruits will be borne the following season. A cane that is not tipped will continue growing. The farther berries are from the crown of the plant, the smaller they will be.

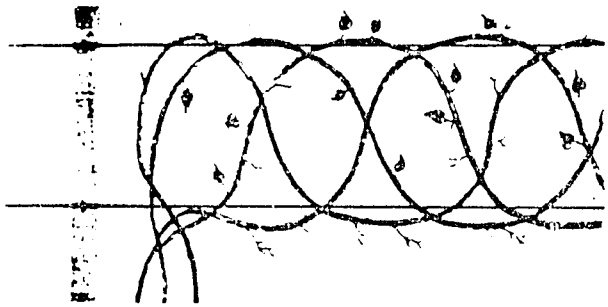

Fig. 4. Barrel roll system of trellising. Canes are taken over and under the top and middle wire three or four times.

When Is Winter Pruning Done and Why?

Winter pruning usually is started around Thanksgiving. Prune to remove all laterals below the lower wire, and head back the long laterals at the top of the trellis to 12 to 15 inches (figure 5).

This promotes larger fruits by removing excess fruiting wood. It also removes all fruiting wood below the lower wire so that fruits are not produced under the cover of new growth where pickers often overlook them.

How Is the Electric Pruner Used for Winter Pruning?

The electric pruner is used just as if you were forming a hedge from the boysenberry plants. Prune the laterals at the top wire to a length of 12 to 15 inches, and progressively shorten the length until you get to the bottom wire. Remove all laterals below the bottom wire. Growers generally try to find a left-handed and a right-handed man to pair up in taking both sides of the same row, since it is a little awkward to handle the electric pruner on the off rows.

How To Dispose of Prunings?

Usually they are disced in; however, a number of growers use brush choppers either entirely or to take care of the pruning wood. The disc has a tendency to form a plow sole and also may cut off many surface feeder roots. When using the disc, set it for shallow cut.

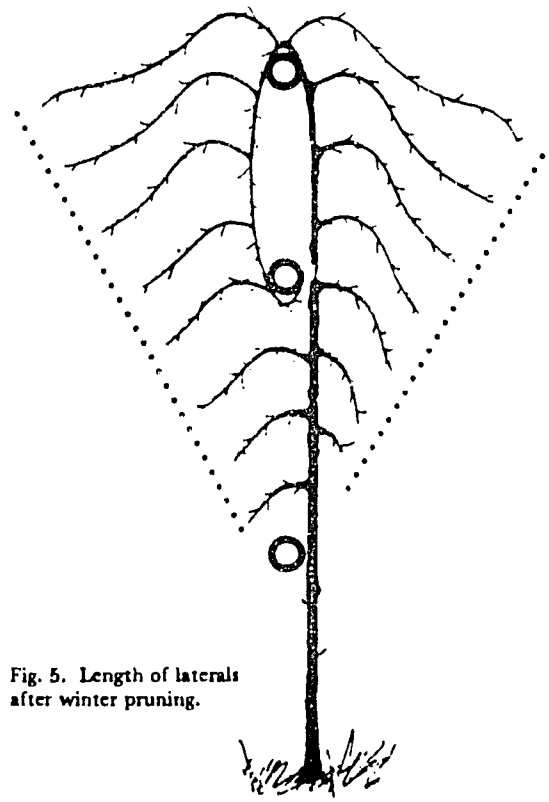

Fig. 5. Length of laterals after winter pruning.

CULTIVATION

Tools other than the disc cultivator can be used for cultivation. Sweeps, duck feet, or a cyclone weeder are recommended, since these usually can be set close to the surface and will not destroy boysenberry roots. A pegtooth or springtooth harrow also can be used to control most weeds, but these tools tend to spread johnsongrass and bermudagrass.

What About the Rototiller?

The rototiller can also be used for cultivation and does a very good job of disposing of brush at the same time. However, it may destroy the tilth in some soils. Since the rototiller must be operated at very low ground speed, it is considered impractical for use on a large scale. Some growers rent a rototiller for brush disposal only, using one of the other cultivating implements for weed control.

What Precautions Should Be Observed in Cultivating?

The most important precaution is to avoid working soil when it is too wet. Set a disc so that it cuts only 3 to 4 inches deep, to avoid destroying surface-feeding roots. Do not drag johnsongrass or bermudagrass, since the moist soil in the berry field encourages the growth of even the smallest sprig.

How Late in the Season Can Cultivating Be Done?

Cultivating should be started before the canes cross from one row to the next. Some growers rig fenders on the front and rear wheels of the tractor to gently lift the canes and push them to one side, so the cultivating equipment will not pull the canes from the vine or cut them up.

Always cultivate each row in the same direction it was cultivated the first time through. Failure to do this will result in tangling of the canes, causing breakage and other difficulties when trellising is done.

PESTS

The redberry mite and thrips are the important insect pests of boysenberries.

What Are the Symptoms of Redberry Mite?

For many years the symptoms of redberry mite were thought to reflect a disease condition. Instead of ripening normally, parts or all of the berry remain red and hard (see figure 6). With severe infestations, many drupelets (individual fleshy units making up the berry) remain green.

How Is the Redberry Mite Controlled?

The control recommended for redberry mite is a spray of 6 gallons of liquid lime sulfur to 100 gallons of water. To obtain thorough coverage, you will need from 100 to 300 gallons of mixture per acre, depending on the amount of vine growth. Apply during spring when the leaf buds are from ½- to 1-inch long.

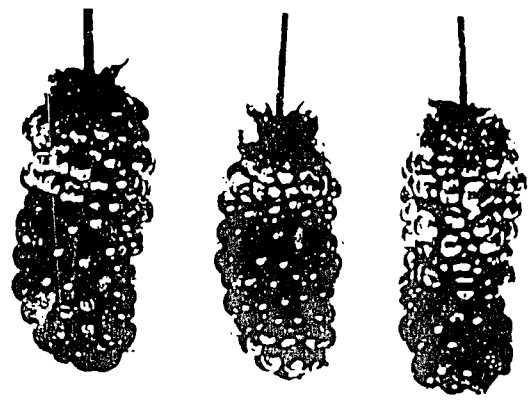

Fig. 6. Boysenberries showing symptoms of redberry mite.

For commercial fields, it is necessary to spray every year, even when the redberry mite has not been seen. Lime sulfur also aids in the control of cane and leaf spot diseases and helps control early infections of powdery mildew.

What Are Thrips?

The western flower thrip is an insect which infests boysenberries and is present throughout the year on many weed flowers. When boysenberries start to flower, thrips move into the field in great numbers, attracted by the bloom and the nectar. They do not cause any damage to the fruit, but remain between the drupelets after harvest, and lower the grade of the fruit. If many are present, the fruit will be rejected.

How Are Thrips Controlled?

Apply suitable chemicals just prior to picking. Control all weeds surrounding the patch early in the season, since these are an important source of infestation. Check your berries frequently if alfalfa is being cut or if grain is ripening on the windward side of the field.

What Other Insects Attack Boysenberries?

The raspberry horntail, certain cutworms, whitefly, aphis, and leafhoppers are minor insects on boysenberries. As the boysenberry acreage increases, some of these pests could become greater problems.

What Are the Symptoms of Raspberry Horntail Damage?

The raspberry horntail lays an egg on the tip of the succulent new cane. The larva hatches, crawls into the cane and moves downward. It bores a tunnel and circles around the cane, cutting off the moisture and food supply to the tip of the cane. The cane then wilts and dies. This causes the cane to push out many laterals, and fruits are borne below the bottom wire where pickers often pass them by. If the raspberry horntail problem becomes serious, it may be necessary to remove the infested canes. For control, see Leaflet 2519, *Raspberry Horntail Control on Boysenberries.*

What Damage Do Cutworms Cause?

There are two types of cutworms. One attacks only olallie berries in the spring. It eats a small portion of the fruiting stem on which buds already are formed, causing the stem to wilt and fall off. Since damage to the olallie has been quite heavy in the past, watch for the first signs of this cutworm and control it.

The other type of cutworm appears around the first of September. It feeds on the growing points and tender young leaves of olallies and boysenberries. Control is not recommended unless the damage is heavy enough to cause excessive lateral growth or empty spots (windows) to be filled in. This recommendation is made because the portion of the vine on which this cutworm feeds generally is removed during winter pruning.

Is Omnivorous Leaf Roller a Problem on Boysenberries?

Yes, just as in other crops the omnivorous leaf roller in recent years has become one of the most serious pests occurring in major bushberry-growing areas in California and Oregon. The larva of the omnivorous leaf roller feeds inside the berry so that its presence is not noted until harvest time when it is too late for control. Insecticides now available will control omnivorous leaf roller when properly applied. Check with a pest control advisor or a farm advisor for these materials and their proper application timing.

DISEASES

Verticillium wilt, the worst disease of boysenberries, is a killer. Other diseases which weaken the plant and cause reduced yield are crown gall, cane and leaf spot, and powdery mildew.

What Are the Symptoms of Verticillium Wilt?

The fruiting canes die just as the fruit starts to mature in June or July. New growth generally is not affected until the following year. The canes often take on a bluish-black cast, especially when seriously infected. A severe infection on newly planted fields will kill the plants the first year.

The only known cure for Verticillium is preplant fumigation—a very expensive treatment—avoid soils hosting this fungus. Breaks resulting from rough handling of the vines during trellising may cause the canes to wilt and die. In some years such breaks do not heal and cause growers concern because of the resemblance to wilt.

What Is Crown Gall?

Crown gall is a bacterial disease caused by an organism present in many soils. It usually enters the plant through a wound. This is another reason to reduce cultivations and to avoid tillage close to the crown of the plant. Often the galls do not protrude through the surface of the soil and can be detected only by digging around the base of plants showing reduced vigor. The disease occasionally kills

plants, but a new plant put into the skip will not become infected with crown gall. Remove and burn as much as possible of the diseased plant before replanting.

What Causes Spots on Leaves and Canes?

Small red-bordered spots on the leaves and canes are caused by Septoria cane and leaf spot disease. In wet winters this disease can greatly reduce the vigor or the vines. To aid in its control, apply copper or zineb sprays in the fall. In the coastal areas, two or more sprays may be needed.

Anthracnose cane and leaf spot, which has similar symptoms, is quite serious in the Northwest; however, it rarely occurs in California.

What is Dieback and Delayed Foliation?

Dieback is a name applied to the wilting and dying back of canes and laterals at the tips early in the spring, as the first leaves are unfolding. It is associated with delayed foliation (delayed leafing out). It is not to be confused with Verticillium wilt, which occurs in June or July. The cause of this disorder has not yet been determined, although it may be associated with seasonal climatic factors. Dieback was quite severe in the early springs of 1948, 1955, 1957, and 1964, each preceded by a long, mild fall; followed by a very cold winter.

Three reasons are offered for the associated delay in leafing out: (1) there may have been freezing injury; (2) winter drought may have weakened the vines; (3) there may have been insufficient chilling.

There is no control for dieback, although some evidence indicates that heavily manured fields are affected less severely. There is also evidence that late fall and winter irrigations can reduce dieback. The benefits derived from the manure may be associated with moisture because the organic matter in the manure increases the moisture retention in the soil.

What Causes Vines To Be Stunted, With Orange-Tinted Leaves?

Anything that adversely affects the growth of the vine will bring about this symptom. It is generally believed to be a sign of nutritional deficiency, and apparently any deficiency will cause it. It also appears in fields where there is poor water penetration and waterlogging on the soil. In some instances, heavy applications of manure help to correct the condition. It is not known whether this correction is the result of improved water penetration generally following heavy applications of manure, or the result of a minor element supplied by the manure, or both.

What Can Be Done About Powdery Mildew?

If a field has a history of powdery mildew, light applications of sulfur dust should help prevent it. Do not apply sulfur after the berries start sizing, since a residue on the fruit may cause a darkening of the tin when canned. Processors strongly object to this. Once powdery mildew gets started, dust generally will not control it. In this case, apply a weak solution of liquid lime sulfur (2 gallons to 100 gallons of water) to infected areas only. The symptoms of powdery mildew are an upward curling of the leaves accompanied by a white, powdery growth on the undersides of the leaves.

SAMPLE COSTS FOR PRODUCING BOYSENBERRIES IN STANISLAUS COUNTY, 1978

Based on a Yield of 10,000 Pounds Per Acre

8 Rows per acre, Avg. 450' per row

All Values Are Rounded to the Nearest Dollar

	Sample Costs	
	Per acre	Per cwt.
Pre-Harvest Cash Costs:		
Prune, put up train, pin back	$ 800.00	
Fertilizer application	20.00	
Fertilizer material	120.00	
Spray application	55.00	
Spray material (can vary quite considerably)	75.00	
Hoe and weed control	60.00	
Cultivate (irrigation prep.)	120.00	
Irrigation labor	40.00	
Irrigation water (Stanislaus Co. Irrig. Dist.)	4.00	
Miscellaneous labor	20.00	
Miscellaneous material	35.00	
County taxes ($350 @ $7.65 per $100) 6%	100.00	
Office, car, int. on operating cap., etc.	208.00	
Repairs	70.00	
Total Pre-Harvest Cash Costs	$1,727.00	$17.27
Harvesting Costs:		
Picking, checking, supervision, etc.	$1,800.00	$18.00
Hauling	100.00	1.00
Harvest overhead	40.00	.40
Total Harvesting	$1,940.00	$19.40
Total Cash Costs (excludes rent)	$3,667.00	$36.67
Depreciation:		
Vines: original cost - $2094 - 6 yr. life	$ 349.00	
Irrigation facilities: $140 cost - 20 yr. life	7.00	
Buildings: $80 cost- 20 yr. life	4.00	
Equipment: $280 cost - 10 yr. life	21.00	
Total Depreciation	$ 381.00	$ 3.81
Interest on Investment @ 8%:		
Vines: on ½ cost ($1047)	$ 84.00	
Irrigation facilities: on ½ cost ($70)	6.00	
Buildings: on ½ cost ($40)	3.00	
Equipment: on ½ cost ($140)	11.00	
Land: @ $4,500	360.00	
Total Interest on Investment	$ 464.00	$ 4.64
Total Cost of Production	**$4,512.00**	

	Costs per Hundredweight at Varying Yields			
Yield, pounds per acre	6,000	8,000	10,000	12,000
Total cost per 100#	$63.00	$52.00	$45.00	$41.00

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SCIENCE AND EDUCATION ADMINISTRATION
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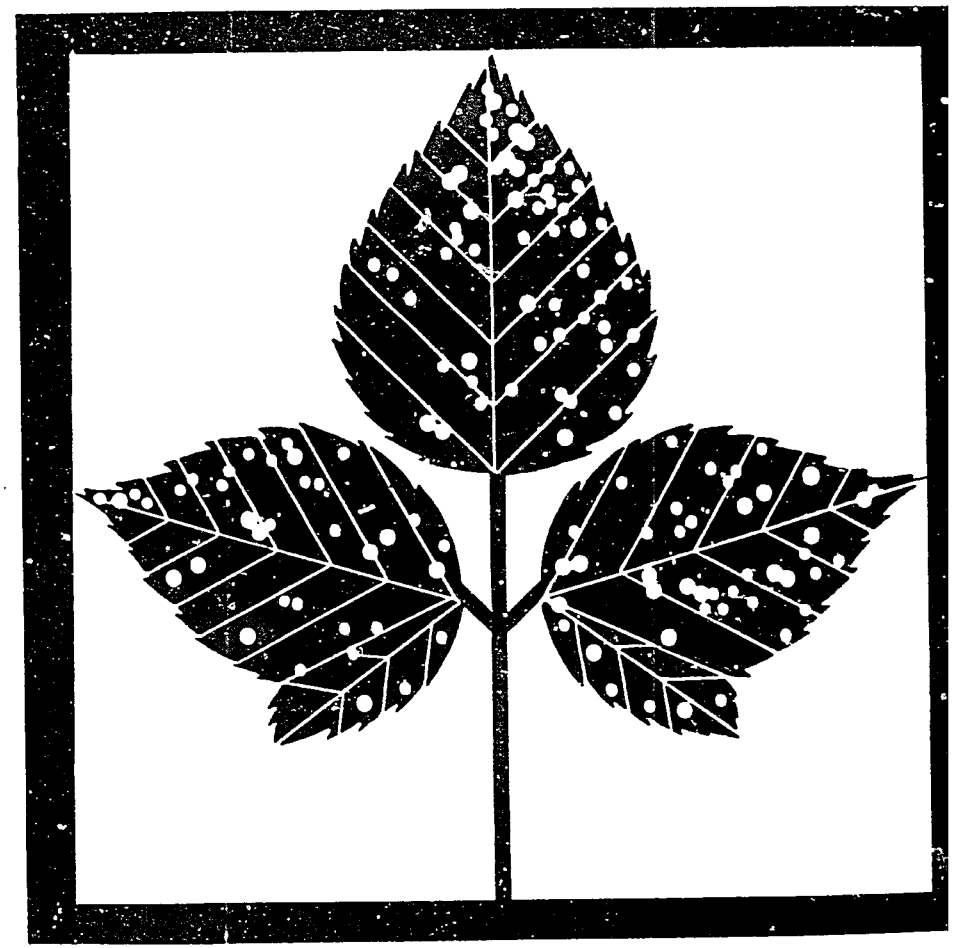
Controlling Diseases of Raspberries and Blackberries



UNITED STATES
DEPARTMENT OF
AGRICULTURE

FARMERS'
BULLETIN
NUMBER 2208

PREPARED BY
SCIENCE AND
EDUCATION
ADMINISTRATION

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On January 24, 1978, four USDA agencies—Agricultural Research Service (ARS), Cooperative State Research Service (CSRS), Extension Service (ES), and the National Agricultural Library (NAL)—merged to become a new organization, the Science and Education Administration (SEA), U.S. Department of Agriculture.

This publication was prepared by the Science and Education Administration's Federal Research staff, which was formerly the Agricultural Research Service.

Washington, D.C.

Revised October 1978

Controlling Diseases of Raspberries and Blackberries

The most effective control measures for raspberry and blackberry diseases are those taken before the diseases become serious. Cultivars adapted to a locality and resistant to the major diseases should be planted, if available. Plants certified as being substantially disease free by a State plant inspection service should be used.

Cultural practices that promote vigorous growth are also important in growing healthy raspberries and blackberries.

RASPBERRY DISEASES

Mosaic

Raspberry mosaic, a virus disease widespread except on the Pacific coast, causes more severe damage on black and purple raspberries than on red raspberries.

Leaves on mosaic-infected canes show large, green blisters (fig. 1). Leaf tissue around the blisters turns yellowish. The leaves are abnormally small and sometimes deformed. Leaves that develop in hot weather show only faint symptoms or none at all.

Mosaic also causes progressive stunting of canes. New growth from mosaic-infected raspberries is shorter than growth of preceding seasons.

On black and purple raspberries, the tips of young canes may bend, turn black, and die.

Berries on badly infected canes are dry, seedy, or crumbly, and often worthless.

BN-22619

Figure 1.—Red raspberry leaves affected with mosaic. Curled leaves have large, green blisters.

Control.—If available, plant State-certified raspberries that have been found to be free from the mosaic viruses. Do not plant healthy raspberries near diseased plants. In areas like the Eastern United States where mosaic is common and spreads rapidly, do not plant red raspberries near black raspberries, even when both are disease free.

Remove and burn diseased raspberries; raspberries that leaf out late in spring are likely to be diseased. Certain leaf-feeding aphids spread mosaic rapidly.

Remove wild raspberries and blackberries from the vicinity of cultivated raspberries.

Parathion, diazinon, or malathion may be used to reduce the number of virus-carrying aphids on raspberries but will not protect plants from infection because insecticides on the plant do not act fast enough to prevent aphids from transmitting mosaic viruses. Follow directions and precautions on the insecticide label. Do not use parathion in the home garden. Parathion is highly toxic and may be fatal if swallowed, inhaled, or absorbed through the skin. This material should be applied only by persons who are familiar with its hazards and who will assume full responsibility for proper use and comply with all the precautions on the labels.

Leaf Curl

Raspberry leaf curl is a virus disease that occurs most frequently in the Mountain States and from Minnesota east into the New England States.

Leaves on canes infected with leaf curl are rounded and curled. Tissue between veins of leaves is arched upward (fig. 2).

New canes are dwarfed and, each year, get shorter. The canes are yellowish at emergence, but they soon darken, become stiff and brittle, and frequently do not branch. As the disease progresses on black raspberries, canes will not bend to root at the tips.

Symptoms often appear on a single cane during a growing season and may not spread to other canes until the following season.

After a cane shows leaf symptoms, its fruit usually is worthless for marketing.

Leaf curl viruses are spread by certain small leaf-feeding aphids.

Control.—Use control measures recommended for raspberry mosaic.

BN-22634

Figure 2. Leaf curl on red raspberry.

CAUTION

If pesticides are handled or applied improperly, or if unused parts are disposed of improperly, they may be injurious to humans, domestic animals, desirable plants, and pollinating insects, fish, or other wildlife, and may contaminate water supplies. Use pesticides only when needed and handle them with care. Follow the directions and heed all precautions on the container label.

Ringspot

Ringspot is a widespread virus disease that occurs in the major red raspberry-producing areas of the Pacific Coast and in the Northeastern United States.

In the spring a few leaves on recently infected red raspberry plants may show pale green rings that disappear as canes mature. Infected plants grow slower than normal, and become weak. Infected canes die back in the most susceptible cultivars or fruit may be crumbly in other cultivars. Certain cultivars show no noticeable damage when infected.

Ringspot in red raspberries is caused by tomato ringspot virus. Tomato ringspot virus occurs in many hosts, including weeds, and is spread through the soil by the dagger nematodes (Certain *Xiphinema* species).

Control.—Plant stock certified to be free from tomato ringspot virus on land that is free from *Xiphinema* species. See section on control of nematodes.

Anthracnose[1]

Anthracnose is a fungus disease that causes severe damage on blackberries and black and purple raspberries throughout the United States. Although common on red raspberries, anthracnose does not seriously affect red raspberries.

Infected canes first show light-grayish spots about 1/8 inch in diameter. As the disease progresses, the spots enlarge and develop purple borders and ash-gray centers (fig. 3). Badly infected canes may be girdled or cracked.

Anthracnose sometimes attacks the leaves of raspberries but it rarely defoliates the plants. Spots about 1/16 inch in diameter appear on infected leaves. The spots have light-gray centers and purple margins. Leaf tissue that is infected with anthracnose may drop out, causing holes in the leaves.

Berries on canes infected with anthracnose ripen abnormally and fruit stems frequently are girdled.

Control.—Choose a planting site that has good air drainage. Plant anthracnose-free raspberries. After planting black raspberries cut off the protruding canes (handles) at ground level.

Make two or three applications of fungicides as follows: For the first application, apply lime sulfur (1 part of active ingredient to 10 parts of water) in early spring when leaf buds begin to open and new leaves are exposed 1/2 to 3/4 inch.

[1]Caused by *Elsinoe veneta*

BN-22645

Figure 3.—Black raspberry cane showing symptoms of anthracnose. Spots have ash-gray centers and purple borders.

Make the second application when flower buds appear and new canes are about 6 inches high. If anthracnose is severe, make a third application after petals fall when new canes are 12 to 15 inches high.

Use captan at 1 pound, or ferbam at 1.5 pounds, of active ingredient per 100 gallons of water for the second and third applications.

Try to make fungicide applications before anticipated periods of rainy weather, and thoroughly cover the raspberries with fungicide.

After harvest, remove and burn fruiting canes and new canes that are badly infected.

Thin out healthy canes to allow good air drainage and keep rows free from weeds.

Remove wild raspberries and blackberries from fence rows and uncultivated land adjoining cultivated raspberries.

Cane Blight[2]

Cane blight is a widespread fungus disease that enters raspberry canes only through wounds in the canes. Pruning wounds are frequently attacked by cane blight.

Dark-brown cankers appear on wounds and extend down the cane or encircle it (fig. 4). Lateral shoots of infected fruiting canes wilt and die in warm weather. Infected canes turn grayish in summer.

Control.—If possible, prune raspberries at least 3 days before an anticipated rain. Remove and burn infected canes, and keep rows free from weeds.

Powdery Mildew[3]

Powdery mildew occurs on susceptible raspberries and blackberries wherever they are grown. Infected leaves may be covered with whitish mealy growth of the powdery mildew fungus causing twisting and dwarfing of the leaves, or the whitish mildew may not be apparent and the leaves may show mottled watersoaked spots. Infected shoot tips may become long and spindly (rattailed) and shoot growth can be dwarfed in

[2]Caused by *Leptosphaeria coniothyrium*.

[3]Caused by *Sphaerotheca humuli*.

BN-22652

Figure 4.—Raspberry cane affected with cane blight. (Courtesy of Michigan Agricultural Experiment Station.)

severe cases. Fruit may occasionally be infected with the whitish powdery mildew growth. Latham and Puyallup red raspberry cultivars are very susceptible (fig. 5).

Control.—Use wide plant spacing to allow good air drainage so that plants can dry out fast after rain. Also avoid susceptible cultivars in fields where powdery mildew is a major problem. Use three to four applications of lime sulfur spray (10 gallons of liquid lime sulfur in 90 gallons of water) when leaves begin to open in spring. Apply benomyl, 3/8 pound of active ingredient per acre, or dinocap, 3 ounces of active ingredient in 100 to 200 gallons of water at the onset of blossoming and at weekly intervals thereafter as needed but not closer than within 3 or 21 days of harvest, respectively. Wettable sulfur sprays (4 to 6 pounds in 100 gallons of water) may also be used to control powdery mildew when it appears, but both sulfur and dinocap sprays may burn the plants in hot weather.

Fruit Rots[4]

Fruit rots are widespread and develop fastest on overripe and bruised raspberries.

Warm, wet weather at harvest favors the development of fruit rots.

Gray mold fruit rot (fig. 6) is caused by *Botrytis cinerea* and is the most common fruit rot of raspberries and blackberries in the field.

Control.—Pick only sound, firm berries and handle them carefully to avoid bruising them. Pick raspberries early in the morning when they are cool.

Store raspberries under refrigeration (32° to 40° F) or, if refrigeration is not available, in a place that is shady and well ventilated. Fungicide sprays aid in reducing fruit rots but are no substitute for frequent, thorough pickings and careful handling. Captan (1 pound of active ingredient per 100 gallons of water) may be used for this purpose during the period of fruit ripening and harvesting.

[4]Caused by *Alternaria* spp., *Penicillium* spp., *Cladosporium* spp., and *Botrytis cinerea*.

BN-26748

Figure 5. Powdery mildew on red raspberry leaves. Note the light discolored areas and the curled margins. (After Fulton, 1960.)

BN-22643

Figure 6. Gray mold fruit rot on red raspberry.

Leaf Spot[5]

Leaf spot is a fungus disease that attacks blackberries and raspberries throughout the United States, but it is most prevalent in the southeastern part of the country.

Tiny greenish-black spots develop on the upper surfaces of infected leaves. As the leaves mature, the spots turn gray. Infected leaf tissue may drop out and cause holes in the leaves. Badly infected leaves fall prematurely.

Control.—Remove and burn fruiting canes after harvest. Thin out healthy canes to allow good air drainage, and keep rows free from weeds.

Apply sprays recommended for anthracnose.

Orange Rust[6]

Orange rust is a fungus disease that attacks blackberries and black and purple raspberries throughout the United States, but it is most common in the northeastern part of the country. Orange rust does not attack red raspberries.

[5]Caused by *Sphaerulina rubi*.

[6]Caused by *Gymnoconia peckiana*.

After entering a plant, this organism spreads throughout the entire plant.

New canes that are infected with orange rust are weak and spindly, and they lack spines.

Infected leaves are abnormally small and yellowish. Blisterlike pustules, which shed reddish-orange spores, develop on the undersides of infected leaves (fig. 7).

Symptoms on upper leaves disappear toward the end of June, but the canes are thoroughly infected and will not blossom the following year.

Control.—Plant rust-free raspberries. Remove and burn raspberries that show symptoms of orange rust in spring. Remove wild black raspberries and blackberries from the vicinity of cultivated raspberries.

Thin out healthy canes to allow good air drainage, and keep rows free from weeds. Fungicide sprays and pruning are ineffective for control of orange rust.

BN-22635

Figure 7. Orange rust on black raspberry. Blisterlike pustules are on undersides of leaves.

Spur Blight[7]

Spur blight is a fungus disease that severely damages red raspberries in the northern part of the United States.

Brown or purple spots appear at buds along infected canes (fig. 8). Tissue around the buds darken and shrivel. Such canes fail to branch and, consequently, do not produce fruit. Buds near ground level are affected more than buds that develop higher on the canes.

Leaves on diseased fruiting canes fall prematurely; the canes dry out and may crack.

Control.—Apply sprays recommended for anthracnose, but delay first application 7 days. Make the second application when canes are 9 or 10 inches high; and 14 days later, make the third application.

In early spring, remove and burn infected canes.

BN-22642

Figure 8.—Red raspberry canes showing spur blight. Infected tissue is brown or purple. (Courtesy of Michigan Agricultural Experiment Station.)

Verticillium Wilt[8]

Verticillium wilt of raspberries is a soil-borne fungus disease that is widespread in the northern half of the United States and along the Pacific coast. It is particularly damaging to black raspberries.

Leaves on infected fruiting canes (fig. 9) turn yellow, gradually wither, and fall. These symptoms begin on the lower leaves and continue up the canes until the canes turn blue and gradually die.

Control.—Plant wilt-free raspberries in clean soil. Rotate raspberries with other crops, but wait at least 3 years before planting raspberries in soils that have grown potatoes, tomatoes, peppers, or eggplants. Remove and burn diseased plants. Foliage applications of fungicides are ineffective for control of Verticillium wilt.

Crown Gall[9]

Crown gall, a bactrial disease of blackberries and raspberries, occurs throughout the United States.

On black and purple raspberries, wartlike growths first appear on canes of infected plants (fig. 10). As the galls enlarge, the diseased canes crack, dry out, and produce berries that are small and seedy. On infected red raspberries, wartlike growths occur just below the soil level on roots and on the crown.

[7]Caused by *Didymella applanata*

[8]Caused by *Verticillium albo-atrum*

[9]Caused by *Agrobacterium tumefaciens*.

BN-22637

Figure 9.—Black raspberry plant affected with Verticillium wilt. (Courtesy of Michigan Agricultural Experiment Station.)

Control.—Plant gall-free raspberries in clean soil. Wait 2 or 3 years before replanting raspberries in locations where gall occurred.

Dig up and burn diseased plants. Do not injure plants when cultivating.

BLACKBERRY DISEASES

Sterility

Sterility is a symptom of a virus disease that occurs in all blackberry-growing areas of the United States. Infected blackberries usually grow more vigorously than healthy blackberries, but they either fail to set fruit or produce misshapen berries (fig. 11).

Control.—Remove and burn blackberries that fail to set fruit; dig up roots to prevent new shoots from appearing. Plant only State-certified blackberries that were propagated from fruitful stock.

Anthracnose[10]

Anthracnose is a fungus disease that attacks both raspberries and blackberries throughout the United States, but on blackberries the disease is most severe in the southeastern part of the country.

Infected canes first show small purplish spots that are about 1/8 inch

[10]Caused by *Elsinoe veneta*

in diameter. As the disease progresses, the spots enlarge and develop light-gray centers and brownish borders. Badly infected canes dry out and crack.

Infected leaves first show tiny purple spots. The spots gradually run together and turn white; the spotted tissue may drop out, causing holes in the leaves.

BN-22641

Figure 10. Purple raspberry canes showing galls on the canes caused by crown gall bacteria.

BN-22638

Figure 11. Blackberries at right are infected with sterility virus, those at left are normal.

Infected berries are abnormally small and scabby.

Control.—Use control measures recommended for anthracnose on raspberries.

Orange Rust[11]

Orange rust, a fungus disease, is common on raspberries and blackberries throughout the United States.

Leaves of infected canes turn yellowish soon after they unfold in spring. As the disease progresses, undersides of the leaves show orange blisterlike pustules, which release spores.

Infected canes are spindly and clustered. Young canes that are diseased may appear to recover in late July or in early August when their upper leaves do not show rust symptoms. The canes are still diseased, however, and will not bear fruit the following year.

Control.—Plant rust-free blackberries; do not propagate cuttings from diseased plants.

Remove wild blackberries and wild black raspberries from the vicinity of cultivated blackberries.

Remove blackberries that show symptoms of orange rust, dig up roots to prevent new shoots from appearing. However, if rust symptoms appear in late August or September, do not remove the plants, because the symptoms are caused by relatively harmless leaf rusts that commonly develop on old blackberry leaves.

[11]Caused by *Gymnoconia peckiana*

Rosette[12]

Rosette, or double blossom, is a fungus disease that attacks blackberries mainly from New Jersey to Illinois and southward. Short, broomlike growths emerge along infected canes (fig. 12). Flower buds are larger, coarser, and redder than usual. Petals are wrinkled and twisted. Blossoms on infected canes fail to form fruit.

[12]Caused by *Cercosporella rubi*.

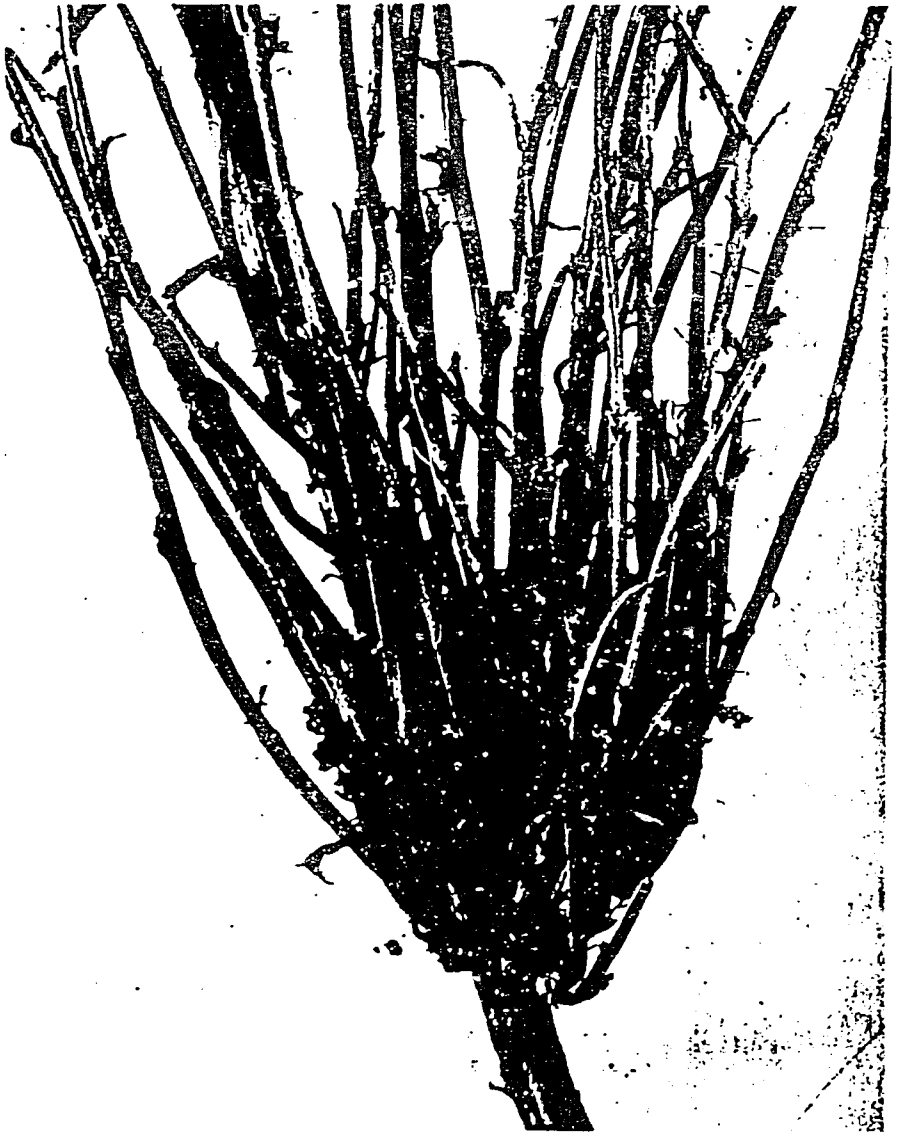


Figure 12 Rosette on blackberry showing broomlike growths. BN-22640

Control.—Remove wild blackberries from the vicinity of cultivated blackberries.

In Delaware and regions southward, cut *all* canes close to the ground after harvest and burn them. In northern regions, cut *fruiting* canes close to the ground after harvest and burn them; handpick and burn infected blossoms in spring or make weekly applications of benomyl, 1/2 pound of active ingredient per 100 gallons of water during the flowering period, starting when the *infected* flowers open.

Leaf and Cane Spot[13]

Leaf and cane spot, a fungus disease of raspberries and blackberries, is common in the Southeastern States and in the Pacific Northwest.

Spots with whitish centers and brown or purple borders show on infected leaves (fig. 13) and canes. If the disease is severe, leaves fall prematurely and canes suffer winter injury.

Control.—Remove and burn infected canes after harvest. In Southern States, apply sprays recommended for anthracnose on raspberries. In the Pacific Northwest, fall spraying for leaf and cane spot with bordeaux mixture (8-8-100) or fixed copper (4 pounds active ingredient plus 1 quart of superior type soil per 100 gallons of water) is recommended.

Crown Gall[14]

Crown gall, a bacterial disease of raspberries and blackberries, is distributed throughout the United States. It is responsible for large losses of salable nursery stock in both crops.

Wartlike growths (galls) appear on the roots and crowns of infected plants (fig. 14). Galls vary in size from that of a pinhead to several inches in diameter.

The above-ground parts of severely infected plants may be stunted. The disease organisms enter the plants only through wounds and growth cracks that are below ground level or slightly above it.

Control.—Plant gall-free raspberries and blackberries in clean soil. Wait 2 or 3 years before planting them in locations where crown gall occurred. Soils that have grown raspberries, blackberries, grapes, and tree fruits are likely to be infested with crown gall.

Dig up and burn diseased plants. Do not injure plants when cultivating.

[13]Caused by *Septoria rubi*.
[14]Caused by *Agrobacterium tumefaciens*.

BN-22633

Figure 13. Blackberry leaves showing leaf and cane spot. Spots have whitish centers and brown or purple borders

BN-22632
Figure 14. Blackberry roots showing crown galls

NEMATODES

Raspberries and blackberries are subject to attack by a number of nematode species. The most damaging types are root-lesion (*Pratylenchus* spp.) and dagger (*Xiphinema* spp.) nematodes. Pin (*Paratylenchus* spp.) nematodes often occur in raspberry and blackberry plantings in high populations but good evaluations of the damage they actually cause are lacking.

Other nematodes found in raspberries and blackberries that may be locally important are root-knot (*Meloidogyne* spp.), spiral (*Helicotylenchus* spp.), and ring (*Cryconemoides* spp.) nematodes. Nematode attacks on plant roots often increase the severity of other soil-borne plant diseases, especially root rots and Verticillium wilt.

Nematode damage is indicated by spindly stands, small canes, and reduced fruit size and yields. The root systems of severely injured plants will often have galls and be rotted, matted, or reduced in quantity, particularly the smaller roots. The foliage may turn yellow and early leaf drop may occur especially during dry weather.

Control.—Clean nursery stock and clean soil are the basic requirements for nematode control in raspberries and blackberries. Resistant cultivars are unavailable and satisfactory rotation programs have not been developed. Chemical control of nematodes infecting established plantings is useful only in certain regions of the country.

Fields to be used fo raspberry or blackberry nursery propagation should be tested for the presence of harmful nematodes before planting. Usually your county agricultural agent can arrange for such tests. The ground should be fumigated if these tests show a sufficient number of harmful nematodes.

Chemical treatments for the control of nematodes are best applied to the soil by injection. You may use dichloropropene, methyl bromide, dichloropropane-dichloropene mixtures, or formulations containing these mixtures and other soil pesticides such as chloropicrin and methyl isothiocyante. Treatments are best made in warm, moist, well-cultivated soil.

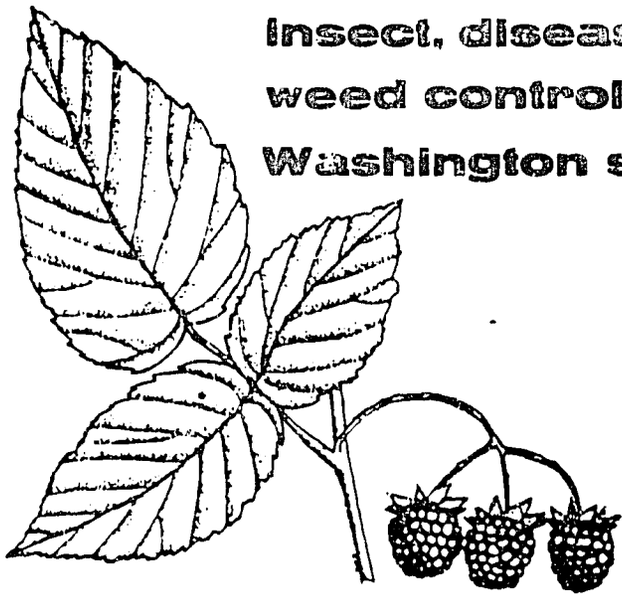
You should allow at least one month to elapse between the time of fumigation and transplanting. Only the highest quality plants known to be free from nematodes, viruses, diseases, and insect pests should be used for nursery plantings.

The rates of application of these chemicals vary depending on types of formulations, uses, and methods of application. For specific materials and dosage recommendations for your area, contact your county agricultural agent and follow manufacturers' label directions.

Extension Bulletin 0847 May 1981

COMMERCIALLY GROWN RASPBERRIES

Insect, disease, and weed control guide for Washington state



COOPERATIVE EXTENSION • COLLEGE OF AGRICULTURE • WASHINGTON STATE UNIVERSITY • PULLMAN

In cooperation with the United States Department of Agriculture

Issued in furtherance of the Acts of May 8 and June 30, 1914, by the Washington State University

Cooperative Extension, J. O. Young, Director

DISEASE AND INSECT CONTROL GUIDE

Disease or Insect and Relative Occurrence	Pesticide (use one)	Amount of Formulation Per Acre*	Minimum Days Between Last Application and Harvest	Remarks
PREPLANT TREATMENT				
Nematodes (occasional)	DD or Telone or Vidden D or Vorex	Follow manufacturer's directions	Preplant only	Have nematode analysis made and base fumigation on results. It is best to fumigate in late summer or early fall before anticipated planting in spring.
Strawberry root weevil Black vine weevil	chlordane** or	50 lb of 20% granular	Preplant only	Work into upper 6 inches of soil. Should give several years protection.
Rough strawberry root weevil (occasional)	heptachlor**	2 gal of 2 EC	Preplant only	Apply to soil in 25-50 gal water per acre for uniform coverage. Incorporate by discing or rotary tillage. Should control weevils for several years.
Woods weevil Obscure root weevil (occasional)	There are no registered materials available that can be applied as a preplant or prebloom treatment.			
ESTABLISHED PLANTINGS				
Prebloom Period				
Dryberry mite△ (rare)	dicofol (Kelthane)△ or	1 1/2 qt of 18 1/2% EC 1 1/2 lb of 35% WP	See remarks	Apply Kelthane in 100 gal water per acre in delayed-dormant period and repeat if needed.
	lime-sulfur	Follow manufacturer's directions for *dormant* or *delayed-dormant* rates.	See remarks	Apply dormant spray in late winter when buds begin to swell. Apply delayed-dormant when blossom buds are out but are still tightly closed.
Powdery mildew (rare) Spur blight (common)□ Cane blight (occasional)□ Anthracnose (occasional)□	lime-sulfur	Follow manufacturer's directions for dormant spray.	See remarks	Apply dormant spray in late winter when buds begin to swell. If anthracnose is severe, apply just before bloom at manufacturer's delayed-dormant rate.

CONTROL GUIDE (continued)

Disease or Insect and Relative Occurrence	Pesticide (use one)	Amount of Formulation Per Acre*	Minimum Days Between Last Application and Harvest	Remarks
Spur blight (common) Anthracnose (occasional)	captan plus spreader-sticker	Follow manufacturer's directions	0	Apply just before bloom. Repeat application in 10 to 14 days if severely diseased.
Strawberry root weevil Black vine weevil Rough strawberry root weevil (occasional)	heptachlor**	1/2 gal of 2 EC	Prebloom only	Concentrate spray in crown area of plants just prior to bloom. Not needed if preplant treatment used within 3 to 4 years, or if no notching of leaves was seen during the previous summer.
Orange tortrix and other leafrollers (common)	azinphos-methyl (Guthion)	1 pt of 2 EC 1/2 lb of 50% WP	14	Apply only if larvae are present. Apply in 200 gal water per acre. Apply Guthion *two times,* once on May 1 and once on May 15. These dates are based on an estimated first-bloom date of May 20, so if bloom begins earlier or later in your area, adjust spray date proportionately. *Highly toxic to bees*—do not apply if blossoms are present.
Western raspberry fruitworm (occasional)	diazinon	1 qt of 4 EC 2 lb of 50% WP	7	Apply in 100 gal water per acre when bloom buds separate and again just before blossoms appear. Apply only if beetles are present. Do not apply to bloom—*highly toxic to bees.* Also controls leafrollers.
Bloom and Harvest Periods				
Leafrollers (common)□	methoxychlor	50% WP	14	Apply 3 1/2 lb per acre in sufficient water to thoroughly cover foliage and fruit, at least 100 gal. Begin applying when small larvae are present and repeat as necessary on 10-14 day schedule. Apply in *late evening* to avoid bee poisoning.

CONTROL GUIDE (continued)

Disease or Insect and Relative Occurrence	Pesticide (use one)	Amount of Formulation Per acre*	Minimum Days Between Last Application and Harvest	Remarks
Fruit rot (occasional—common if moist conditions persist)	captan	Follow manufacturer's directions	0	Apply first spray during the bloom period (10% bloom) and again 7 to 10 days later. Sprays may also be applied 3 to 5 days before harvest, at mid-harvest, and 8 to 10 days after second harvest application if the weather is cool and damp.
	or			
	benomyl (Benlate)	3/4 lb of 50% WP	3	Apply at early bloom and full bloom, then at 14-day intervals as needed.
	or			
	benomyl (Benlate) plus	3/4 lb of 50% WP	3	If benomyl is used, make alternate sprays with captan or use a tank mix of benomyl plus captan to help avoid buildup of benomyl-tolerant strain of fungus.
	captan	Follow manufacturer's directions.		
Western raspberry fruitworm (occasional)	rotenone	2 lb of 5% WP	1	Apply in 100 gal water per acre 7 days after first bloom and repeat twice at 10-day intervals. Do not use if diazinon was used prior to bloom unless beetles (adults of the fruitworm) are still seen in the field.
Spider mites (occasional—common in prolonged hot, dry weather)	dicofol (Kelthane)	1 1/2 qt of 18 1/2% EC 1 1/2 lb of 35% WP	2	Apply in 100 gal water per acre. Apply only if needed, which is rare before the end of harvest.
Obscure root weevil (occasional)	malathion	2 qt of 5 EC		Apply in 300 gal water per acre. Apply to foliage. If blossoms are present, apply in late evening when bees are not foraging. Repeat if necessary.
	or			
	azinphos-methyl (Guthion)	2 lb of 50 WP		Apply only to the soil in the crown area. Do not apply to foliage. *Highly toxic to bees.*
				It is best to apply these chemicals during the last half of June to kill adults before egg deposition begins. Apply only if the species has been identified as a problem in the field.

CONTROL GUIDE (continued)

Disease or Insect and Relative Occurrence	Pesticide (use one)	Amount of Formulation Per Acre*	Minimum Days Between Last Application and Harvest	Remarks
MACHINE-HARVESTED RASPBERRIES				
Aphids, leafhoppers, gnats, and other insect contaminants (common)	malathion	2.4 qt of 5 EC	1	Use as a spray in at least 100 gal of water per acre. Thorough coverage is important. Some insects, particularly large cutworms, will not be adequately controlled by this material.
Slugs (occasional)	metaldehyde (bait formulation only)	Follow manufacturer's instructions		Scatter bait on soil surface around plants. *Do not* contaminate berries or foliage.

Note: Many insects, slugs, and spiders are shaken from plants in machine-picked berries and are potential contaminants of berries going into trays. Correct adjustment of air-blast or vacuum-suction cleaner systems can lessen insect contamination of machine-picked berries. Careful timing of *prebloom, before,* and *during harvest* sprays will help diminish insect contamination. A high percentage of culls may occur from fruit rot. It is not practical to separate rotten berries once they are picked and in the trays. This means an adequate fungicide spray program (during bloom and preharvest) to control rot becomes more important than ever.

Postharvest Period				
Spider mites (common)	(Same as in bloom and harvest period)			Make applications only if needed, which appears to be rarely in western Washington. After September 1, high population will not damage plant enough to affect yield the subsequent year.
Crown borer (common)	diazinon or parathion□	1 qt of 4 EC 2 lb of 50% WP 1 qt of 4 EC 4 lb of 25% WP	See remarks See remarks	Apply in 100 gal water per acre to bottom 3 feet of canes and to crowns between October 1 and March 1. October is the preferred month.
Spur blight (common)	captan plus spreader-sticker	Follow manufacturer's instructions		Apply immediately after harvest.

* EC=emulsifiable concentrate; WP=wettable powder (see page 2).

** Registration of heptachlor and chlordane has been suspended for this use by EPA; however, existing stocks with these uses on the label can be used according to label directions. No substitute is registered for this use.

△ Pest does not appear on product label. See explanation on page 1.

□ A special local needs registration has been granted for this use in Washington under Section 24 (c), FIFRA.

SPRAY COMPATIBILITY (ABILITY TO MIX) CHART FOR FUNGICIDES AND INSECTICIDES

It may be to your advantage to control several problems with one spray by combining several chemicals. *Read the label* and follow the manufacturer's directions when making these mixtures. This compatibility chart is provided to help you in preliminary planning only. Compatibilities can vary from those indicated on this chart because of change in solvents and emulsifying agents, etc. It is a good idea before making a tank mixture to mix the chemicals in a jar of water at approximately the recommended dilution rate and look for any reactions that would cause solids to form and separate out of the solution. Some mixtures may create phytotoxicity problems (plant injury), so unless a label specifies otherwise, either experiment on a few plants or avoid doing it.

	Rotenone	Parathion	Methoxychlor	Malathion	Lime-Sulfur	Kelthane	Heptachlor	Guthion	Ferbam	Diazinon	Chlordane	Captan	Benlate
Benlate	C				X		C				C		
Captan		1	1	1	X	1	1	1			1		
Chlordane												1	C
Diazinon					C								
Ferbam					X								
Guthion					X							1	
Heptachlor												1	C
Kelthane												1	
Lime-Sulfur	X	X	2	X				X	X	C		X	X
Malathion					X							1	
Methoxychlor					2				1			1	
Parathion					X							1	
Rotenone					X								C

Blank=Safe
C=Caution
X=Incompatible
1=Use wettable or soluble powder forms
2=Decomposes after standing when mixed with water

EB 0847

WEED CONTROL GUIDE

Most weeds in raspberry fields can be controlled with herbicides. Information about safe, effective use of the herbicides is on the label. Read it. Failure to follow label directions is illegal besides causing possible crop damage or poor weed control. Among the factors that influence weed control are weed species present, stage of growth, soil moisture and texture, organic matter, and rainfall or irrigation. This weed control guide is intended to help you obtain good weed control with maximum crop safety.

Remember, herbicides are plant killers. The safety of the raspberry plants depends on applying the proper material at the correct time and rate of application. Weak, unhealthy, or cold-injured plants sometimes are damaged. Unusually wet, dry, or hot weather following application also may cause injury. Be careful. Adjust your herbicide program to meet your own particular needs.

Wettable Powder Precautions

Many of the herbicides used for raspberries are wettable powders. They go into suspension, not solution. Therefore, constant agitation is required to keep them in suspension. Mechanical agitation is better than hydraulic agitation. The line and nozzle strainers should be at least 50 mesh. Since wettable powders are abrasive, sprayers should be re-calibrated frequently.

Controlling Weeds Before Planting

The best time to control perennial weeds is before planting. The land can be fallowed with or without herbicides, or it can be planted to a crop that allows the use of herbicides that will control perennial weeds. Examples of this method are corn with glyphosate (Roundup) and cereals with 2,4-D, MCPA, glyphosate, or dicamba (Banvel). Time and money spent to control perennial weeds before planting will prevent using more costly weed control methods during the establishment year.

Controlling Weeds During Establishment

Be sure the raspberry roots are well covered and the soil settled around the plants before applying any herbicide. If weeds have germinated, hoe or cultivate before application. Rainfall or sprinkler irrigation soon after application will greatly improve weed control.

Rates of application are for total acre coverage. For band application, reduce the amount of herbicide applied per acre but keep the rate of application per square foot the same. Follow wettable powder precautions (see page 7).

1. Napropamide (Devrinol) 4 pounds active ingredient (8 pounds of 50 W Devrinol) per acre. Can be applied within a few days of planting.
   Susceptible weeds. Annual bluegrass, barnyardgrass, wild oats, chickweed, common fiddleneck, knotweed, little mallow, purslane, common sowthistle, filaree, groundsel, lambsquarters, pineapple-weed, prickly lettuce, red root pigweed.
   Resistant weeds. Shepherdspurse, species of mustard, henbit, minerslettuce, black nightshade, smartweed, all established perennial weeds.
   Precautions. At least 1 inch of rainfall or irrigation within a week after application is necessary for weed control. Do not use on soils with over 10% organic matter. Do not apply more than once per season.

2. Diphenamid (Enide) 6 pounds active ingredient (6.66 pounds of 90 WP Enide) per acre within a few days after planting.
   Susceptible weeds. Annual grasses including annual bluegrass, ryegrass, barnyardgrass, foxtail, and crabgrass; common chickweed, corn spurry, redroot pigweed, mouseear chickweed, lambsquarters, smartweed, and knotweed.
   Resistant weeds. Mustard spp., wild radish, nightshade, and wild lettuce.
   Precautions. Moisture following application or shallow cultivation is necessary for effective weed control.

3. Simazine (Princep) 1 pound active ingredient (1.25 pounds of 80 W Princep) per acre.
   Susceptible weeds. Annual bluegrass, chickweed, groundsel, lambsquarters, nightshade, redroot pigweed, mustard spp., and smartweed.
   Resistant weeds. All established perennial weeds, groundsel, triazine resistant biotypes of lambsquarters, and redroot pigweed.
   Precautions. Do not apply to loose, gravelly, or very sandy soils. This rate of application is marginal for control of many weed species and it will remain effective for only 1-3 months.

Controlling Weeds in Established Plantings

The higher rates of application may be necessary during the early life of plantings to obtain good weed control. Later, after the weed population is decreased, reduce the rate of application to prevent buildup of the residual herbicides. Alternate the residual herbicides for one year to the next to prevent buildup and to maintain better weed control. Reduce the rate of application in loose, gravelly, or very sandy soils. Late spring applications will often cause crop injury. Heavy stands of quackgrass may require two different herbicides during the same year to obtain complete control. The first gives partial control and makes the stand more susceptible to the second. Such a combination might be simazine at the high rate of application plus paraquat during October followed by pronamide, or pronamide followed by dichlobenil.

Controlling Annual Weeds in Established Plantings

1. Napropamide (Devrinol) 4 pounds active ingredient (8 pounds of 50 W Devrinol) per acre. Spring application to weed-free soil during March through May may be more practical.
   Susceptible weeds. Annual bluegrass, barnyardgrass, wild oats, chickweed, common fiddleneck, knotweed, little mallow, purslane, common sowthistle, filaree, groundsel, lambsquarters, pineappleweed, prickly lettuce, red root pigweed.
   Resistant weeds. Shepnerdspurse, species of mustard, henbit, minerslettuce, black nightshade, smartweed, all established perennial weeds.
   Precautions. At least 1 inch of rainfall or irrigation within a week after application is necessary for weed control. Do not use on soils with over 10% organic matter. Do not apply more than once per season. Do not apply after new shoots have emerged.

2. Simazine (Princep) 4 pounds active ingredient (5 pounds of 80 W Princep) per acre during October or November.
   2 pounds active ingredient (2.5 pounds of 80 W Princep) per acre during October or November and again in March or April.
   2 pounds active ingredient (2.5 pounds of 80 W Princep) per acre during March or April.

Susceptible weeds and *resistant weeds* are the same as listed in "Controlling Weeds During Establishment section."
Precautions. Reduce rate of application in very gravelly, sandy, or loose soils. The usual practice is to use the above rates of application as product rather than as active ingredient.

3. Diuron (Karmex) 1.6 pounds active ingredient (2 pounds of 80 W Karmex) per acre during October or November and again in March or April.
   1.6 pounds active ingredient (2 pounds of 80 W Karmex) per acre during March or April.
   Susceptible weeds. Annual grasses, corn spurry, dogfennel, redroot pigweed, chickweed, fiddleneck, shepherdspurse, wild buckwheat, smartweed, mustard spp., purslane, and lambsquarters.
   Resistant weeds. Most perennial broadleaf weeds.

4. Terbacil (Sinbar) 0.8 to 1.6 pounds active ingredient (1 to 2 pounds of 80W Sinbar) per acre during March through early April or October through November. Use the higher rate on fine soil types and on high organic soils.
   Susceptible weeds. Most annual and perennial weeds.
   Precautions. Do not use on sandy or gravely soils or on soils with less than 1% organic matter. Do not apply around weak plants.

5. Paraquat (Paraquat CL) 1 pound active ingredient (0.5 gallons of 2 EC Paraquat CL) per acre plus 8 ounces non-ionic surfactant per 100 gallons during October through March. May be combined with napropamide, simazine or diuron for residual weed control. Fall application of the simazine-paraquat combination at the high rate to growing quackgrass will give partial control.
   Susceptible weeds. Will kill all top growth back to ground level. Does not kill perennial weeds, but will delay their development.
   Precautions. Do not apply after new shoots emerge in the spring.

6. Dinoseb (Dow General, Premerge, Sinox General) 2.5 pounds active ingredient (0.5 gallon of 5 pounds active ingredient Dow General) plus 2 gallon of Summer Spray oil in 50 or more gallon of water per acre.
   Susceptible weeds. Will kill all top growth back to ground level. Does not kill perennial weeds but will delay their development.
   Precautions. Thorough coverage of weeds is necessary. Use as a directed spray and keep as much off the crop as possible. Do not apply after shoots emerge in the spring.

Controlling Perennial Weeds in Established Plantings

1. Pronamide (Kerb) 2 pounds active ingredient (4 pounds of 50 W Kerb) per acre during November.
   Susceptible weeds. Annual and perennial grasses including quackgrass.
   Resistant weeds. Most broadleaf weed species.
   Precautions. Pronamide is root absorbed so the application must be followed by enough rainfall or irrigation to leach it into the root zone of the grass. Excessive rainfall after application may reduce effectiveness.

2. Dichlobenil (Casoron 4G) 4 pounds active ingredient (100 pounds of Casoron 4G) per acre durin December or January to cold, wet soil.
   Susceptible weeds. Quackgrass, thistle, field horsetail, and most annual weed species.
   Precautions. Use the granular formulation only. The herbicide loses its effectiveness rapidly if exposed to dry, warm conditions. On coarse, loose, or sandy soils reduce the rate to 2 pounds active ingredients (50 pounds of Casoron 4G) per acre. This rate is low for effective quackgrass control but will control field horsetail and most annual weeds.

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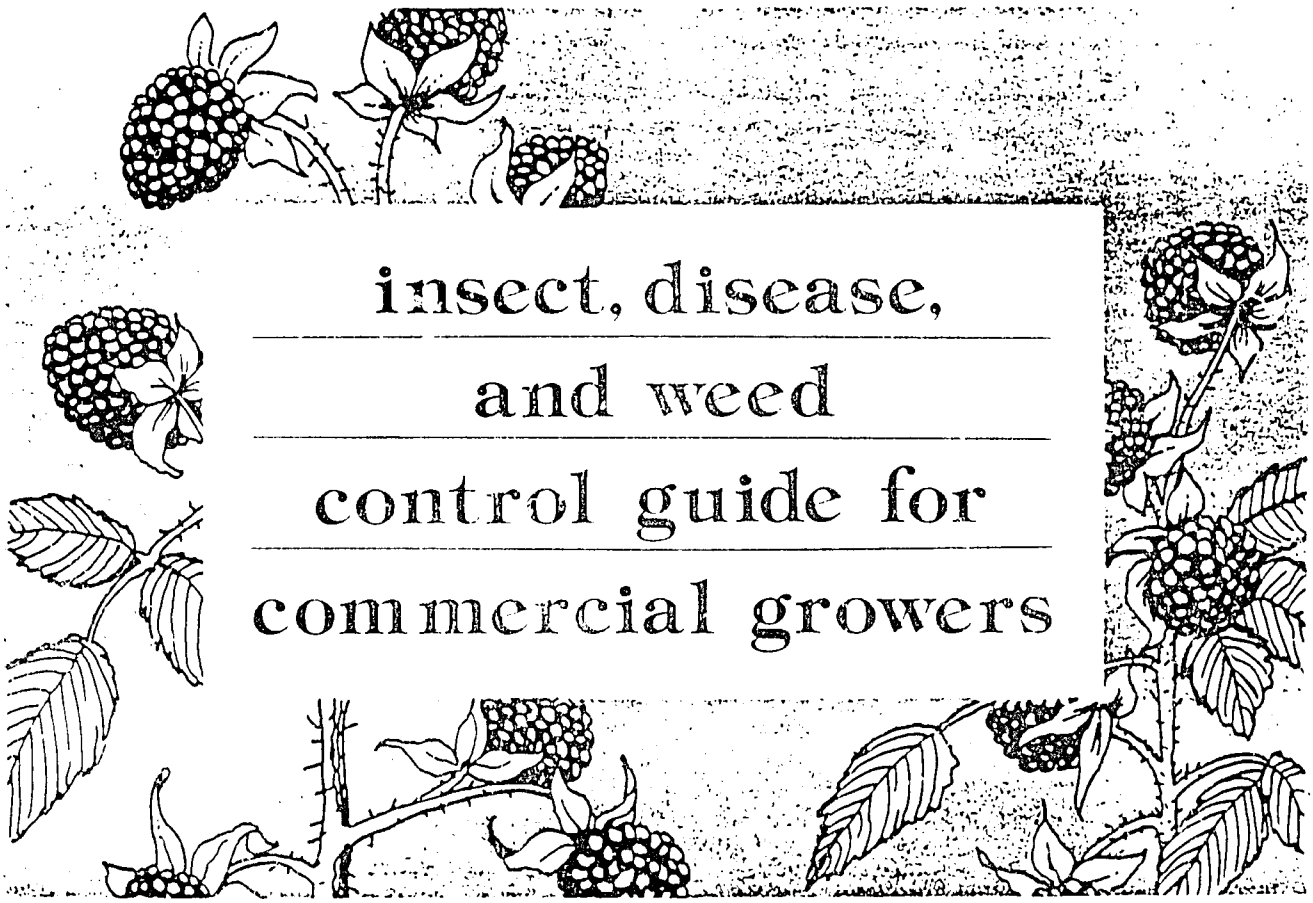
This bulletin is revised from and replaces Washington State University EM 3748.

Cooperative Extension programs and employment are available to all without discrimination. Trade names have been used to simplify information. No endorsement is intended.

raspberries



IMPORTANT NOTICE—PNW 233

EDB (ethylene dibromide) was banned Sept. 30, 1983 by EPA for use as a soil fumigant. It is an ingredient in some of the products suggested for control of nematodes on page 5 of this publication. The specific products affected by the ban are Terr-o-cide 54-45, Terr-o-cide 15, Terr-o-cide 72-27, and Terr-o-cide 30.

The fumigant DD does not contain ethylene dibromide, but the manufacturer has discontinued production of this chemical. Existing supplies of DD may be used in accordance with label directions.

PNW 233

A Pacific Northwest
Cooperative Extension Publication
Washington/Oregon/Idaho

RASPBERRIES

Insect, Disease, and Weed Control Guide for Commerical Growers

Notes

Descriptions and biologies of raspberry pests are outlined in *Commercial Red Raspberry Production*, PNW 176 (75¢), available from County Extension offices.

Lists of chemicals in this publication indicate legally registered materials, and sequence of listing does not indicate better performance of one material over the other.

Diseases and insects are listed according to relative occurrence: rarely encountered, occasionally encountered, or commonly encountered. These terms serve as a guideline in order to prevent or avoid continuous prophylactic or preventive sprays for pests that do not occur regularly.

The materials marked with a ★ are very dangerous to applicators and should be handled with extreme caution.

Pests not on product label

Some suggested uses of pesticides in this publication are for pests not listed on product labels. These are indicated by the symbol △. Such uses comply with the federal law (FIFRA) which says a use is consistent with label directions provided the crop or site is on the label and directions concerning rates and interval before harvest are followed. **Uses marked with a △ cannot be recommended in Idaho.**

Selecting a pesticide

The purpose of this control guide is to help growers know when to be on the lookout for various diseases, insect pests, and weeds—not to recommend routine treatments for all the problems listed. Some diseases and other pests of raspberries occur almost every year and require routine preventive treatments. Examples are fruit rot, certain weevils, and annual weeds. However, other problems, e.g., twospotted spider mite, are sporadic in frequency and location and should be treated only as the need arises. This requires constant vigilance by the grower so a problem, if it does occur, will not advance beyond remedy. However, the reward is a lower bill for pesticides and application, as well as protection of natural control agents which help to further reduce the cost of pesticides.

Bee poisoning

Honey bees are necessary for complete pollination of raspberry flowers. Poor pollination results in lower yields, with small, crumbly berries.

Many of the insecticides recommended for the prebloom or postharvest periods are highly toxic to bees and should not be used during bloom. The chemicals methoxychlor and malathion may be used during bloom if they are applied in the following manner: methoxychlor, during late evening, night, or early morning; malathion EC, only during late evening. None of the recommended fungicides, the miticide Kelthane, or *Bacillus Thuringiensis* bacterial insecticide applied during bloom are toxic to bees. Less is known about the effects of herbicides on bees than for the listed insecticides and fungicides. However, many have been tested, and the results known thus far for the herbicides listed in this publication are as follows:

Dinoseb should *never* be applied to blooming crops or weeds. Simazine should only be applied to blooming crops or weeds during late evening, night, or early morning when bees are not foraging on blooming plants. The effect on bees of the other herbicides listed is unknown, and growers should exercise caution when using them.

CAUTION: The timing of insecticide applications with respect to bee poisoning hazard can be drastically modified by abnormal weather conditions. If temperatures are unusually low following treatment, residues on the crop may remain toxic to bees up to 20 times as long as during reasonably warm weather. Conversely, if abnormally high temperatures occur during late evening or early morning, bees may actively forage on the treated crop during these times.

Growers should read WREP 15, *How to Prevent Bee Poisoning from Pesticides* (50¢), available from county Extension offices.

Contact nearby beekeepers whenever you plan to use a material that is hazardous to bees. This may prevent accidental bee kills and help establish better cooperation between growers and beekeepers.

Explanation of formulations

Many of the materials listed are presented as EC or WP. EC means emulsifiable concentrate, which contains a pesticide and an emulsifying agent in a suitable solvent. The concentrate is diluted with water in the spray tank to form an emulsion. When preceded by a number, such as 2 EC, this means that there are 2 pounds of actual toxicant per gallon of formulation. WP means wettable powders, which are dry forms of pesticides in which the toxicant is carried on powders that can be readily mixed with water because a wetting agent has been added. These form a suspension-type spray which must be kept agitated in a sprayer tank. When preceded by a number, such as 50WP or 50W, this means that there is 50 percent actual toxicant per pound of material.

All recommendations are made as formulations (the way it comes in the package); not to be confused with recommendations as active ingredient (actual pesticide) as may appear in other more technical publications.

Alternate pesticides

It is a good practice to alternate pesticides when multiple applications are used against the same pest. This may slow the development of resistant strains of the pest.

DISEASE AND INSECT CONTROL GUIDE

Disease or Insect and Relative Occurrence	Pesticide (use one)	Amount of Formulation Per Acre*	Minimum Days Between Last Application and Harvest	Remarks
PREPLANT TREATMENT				
Nematodes (occasional)	★ DD or ★ Telone or ★ Terr-o-cide	Follow manufacturer's directions.	Preplant only	Have nematode analysis made and base need to fumigate on results. It is best to fumigate in late summer or early fall before anticipated planting in spring.
Strawberry root weevil Black vine weevil Rough strawberry root weevil (occasional) Woods weevil Obscure root weevil (occasional)	There are no registered materials available that can be applied as a preplant treatment.			Fumigation prior to planting will kill weevils present in the field. It will not protect the planting from weevils that migrate into the field at a later date.
ESTABLISHED PLANTINGS Prebloom Period				
Dryberry mite[1] (rare)	dicofol (Kelthane)[1]	3 pts of 18.5% EC 2 lb of 35% WP	See remarks	Apply Kelthane in 100 gallons of water per acre in delayed-dormant period and repeat if needed.
	or lime-sulfur (Orthorix, Polysul, or Lime Sulfur)	Follow manufacturer's directions for *dormant* or *delayed-dormant* rates.	See remarks	Apply dormant spray in late winter when buds begin to swell. Apply delayed-dormant when blossom buds are out but are still tightly closed.
Powdery mildew (rare) Spur blight (common)[2] Cane blight (occasional)[2] Anthracnose (occasional)[2]	lime-sulfur (Orthorix, Polysul, or Lime-Sulfur)	Follow manufacturer's directions for dormant spray.	See remarks	Apply dormant spray in late winter when buds begin to swell. If anthracnose is severe, apply just before bloom at manufacturer's delayed-dormant rate.

★ This material is very dangerous to the applicator and should be handled with extreme caution.

[1] Pest is not included on product label. See explanation on page 3.

[2] A special local needs registration has been granted for this use in Washington under Section 24(c), FIFRA.

Established Plantings, continued

Disease or Insect and Relative Occurrence	Pesticide (use one)	Amount of Formulation Per Acre*	Minimum Days Between Last Application and Harvest	Remarks
Spur blight (common to occasional)	captan	2.0 lb of 50% WP	0	Apply just before bloom. Repeat application in 10-14 days if severely diseased.
Anthracnose (occasional)	Ferbam (Oregon only)	3.0 lb of 76% WP	40	Cover new growth thoroughly.
Strawberry root weevil; Black vine weevil; Rough strawberry root weevil (occasional)	Malathion or azinphos-methyl (Guthion) Guthion may only be partially effective against black vine weevil.	1.5 pt of 5EC; 2 lb of 50% WP	1	Useful mainly for early emerging individuals. Most weevils have not emerged yet. (See weevil entry in *Bloom* and *Harvest* period.) Apply Malathion in 300 gallons of water per acre. Apply to foliage. If blossoms are present, apply in late evening when bees are not foraging. Repeat if necessary. Apply Guthion only to the soil in the crown area. Do not apply to foliage. *Highly toxic to bees.*
Orange tortrix and other leafrollers (common)	azinphos-methyl (Guthion) or Sevin or Malathion (Oregon only)	1 pt of 2EC; ½ lb of 50% WP; 4 lb of 50% WP; 7 lb of 25% WP	14; 7	Apply only if larvae are present. Apply in 200 gallons water per acre. Apply Guthion and Sevin no later than 2 weeks before anticipated bloom. *Highly toxic* to bees—do not apply if blossoms are present. Sevin causes spider mite increases at times.

Note: Instructions for chemical sprays are based on preventive measures where populations are either unknown or historically heavy. If pheromone traps are used as a survey tool then applications are based on levels of approximately 25 moths/trap/week with application commencing 10 days after peak moth flight. Some years have shown very low leafroller populations in some areas and hence no applications were necessary for this pest. Check with your county agent for instructions on use of this technique.

Western raspberry fruitworm (occasional)	diazinon or rotenone	1 qt of 4EC; 2 lb of 50% WP; 6 lb of 5% WP (2 lb of 5% WP recommended in Washington)	7; 1	Apply in 100 gallons of water per acre when bloom buds separate and again just before blossoms appear. Apply only if beetles are present. Do not apply diazinon to bloom—*highly toxic to bees.* Diazinon also controls leafrollers.

*Pest is not included on product label. See explanation, page 3.

Established Plantings, continued

Disease or Insect and Relative Occurrence	Pesticide (use one)	Amount of Formulation Per Acre*	Minimum Days Between Last Application and Harvest	Remarks
		Bloom and Harvest Periods		
Armyworms and cutworms[1] (occasional)	*Bacillus Thuringiensis* (Dipel and others)	Follow manufacturer's directions	0	Most effective when larvae are small.
Leafrollers (common)	methoxychlor 50% WP State labels in Oregon and Wash. (Not recommended in Idaho)		14	Apply in sufficient water to thoroughly cover foliage and fruit, at least 100 gallons. Begin applying when small larvae are present and repeat as necessary on 10-14 day schedule. Apply methoxychlor in *late evening* to avoid bee poisoning.
	Bacillus Thuringiensis (Dipel and others)	Follow manufacturer's directions	0	
	Note survey technique discussion above in "Prebloom" section.			Sevin XLR or Sevimol plus extra molasses for bee repellency are also registered but *not recommended in Washington during bloom.* Check with bee expert on timing of application of these Sevin formulations.
Fruit rot (occasional—common if moist conditions persist)	captan	2 lb of 50% WP	0	Apply first spray during the bloom period (10% bloom) and again 7-10 days later. Sprays may also be applied 3-5 days before harvest, at mid-harvest, and 8-10 days after second harvest application if the weather is cool and damp.
	or Botran	3 lb of 75% WP	1	
	or benomyl (Benlate)	0.75 lb of 50% WP	3	Apply at early bloom and full bloom, then, up to 3 additional applications at 14-day intervals as needed.
	or benomyl (Benlate)	0.75 lb of 50% WP	3	If benomyl is used, make alternate sprays with captan or Botran or use a tank mix of benomyl plus captan or benomyl plus Botran to help avoid buildup of benomyl-tolerant strain of fungus.
	plus captan	2 lb of 50% WP	0	
Western raspberry fruitworm (occasional)	rotenone	6 lb of 5% WP (2 lb of 5% WP recommended in Washington)	1	Apply in 100 gallons water per acre 7 days after first bloom and repeat twice at 10-day intervals. Do not use if diazinon was used prior to bloom unless beetles (adults of the fruitworm) are still seen in the field.

[1]. Pest is not included on product label. See explanation on page 3.

Established Plantings, continued

Disease or Insect and Relative Occurrence	Pesticide (use one)	Amount of Formulation Per Acre*	Minimum Days Between Last Application and Harvest	Remarks
Spider mites (occasional—common in prolonged hot, dry weather)	dicofol (Kelthane)	3 pts of 18½% EC or 2 lb of 35% WP	2	Apply in 100 gallons water per acre. Apply only if needed, which is rare before the end of harvest.
Obscure root weevil Black vine weevil△ Strawberry root weevils△ (occasional)	Malathion (Not recommended in Idaho)	2 qt of 5EC		Apply Malathion in 300 gallons water per acre. Apply to foliage. If blossoms are present, apply in late evening when bees are not foraging. Repeat if necessary.
	or			
	azinphos-methyl (Guthion) Guthion may only be partially effective against black vine weevil.	1 lb of 50% WP (Obscure root weevil) 2 lb of 50% WP (Black vine weevil and strawberry root weevils)		Apply Guthion only to the soil in the crown area. Do not apply to foliage. *Highly toxic to bees.* *Note:* It is best to apply these chemicals during the first week of June and repeat 10-14 days later to kill adults before egg deposition begins. Apply only if the species has been identified as a problem in the field.
MACHINE-HARVESTED RASPBERRIES				
Aphids, leafhoppers, gnats△, weevils△, and other insect contaminants (common)	Malathion	3 pts of 5EC or 7 lb of 25% WP		Use as a spray in at least 100 gal of water per acre. Thorough coverage is important. Some insects, particularly large cutworms, will not be adequately controlled by this material.
Slugs (occasional)	metaldehyde (bait formulation only)	Follow manufacturer's instructions		Scatter bait on soil surface around plants. *Do not* contaminate berries or foliage.

Note: Many insects, slugs, and spiders are shaken from plants in machine-picked berries and are potential contaminants of berries going into trays. Correct adjustment of air-blast or vacuum-suction cleaner systems can lessen insect contamination of machine-picked berries. Careful timing of *prebloom, before,* and *during harvest* sprays will help diminish insect contamination. A high percentage of culls may occur from fruit rot. It is not practical to separate rotten berries once they are picked and in the trays. This means an adequate fungicide spray program (during bloom and preharvest) to control rot becomes more important than ever.

△ Pest is not included on product label. See explanation on page 3.

Established Plantings, continued

Disease or Insect and Relative Occurrence	Pesticide (use one)	Amount of Formulation Per Acre*	Minimum Days Between Last Application and Harvest	Remarks
		Postharvest Period		
Spider mites (common)	Plictran□ (Not recommended in Idaho)	2 lb of 50% WP	See remarks	Apply Plictran only *once* in 100 gallons water per acre. (*Postharvest* treatment only.) Do not apply later than the end of September following harvest. Make applications only if needed. After September 1, high population will not damage plant enough to affect yield the subsequent year.
	or Kelthane	3 pts of 18.5EC or 2 lb of 35% WP	2	
Raspberry crown borer (common to occasional)	diazinon	2 qt of 4EC 4 lb of 50% WP	See remarks	Apply in 200 gallons water per acre to bottom 3 feet of canes and to crowns between October 1 and March 1. October is the preferred month for Washington, while March is the preferred month for Oregon.
	or ★parathion	1 qt of 4EC 4 lb of 25% WP	See remarks	
	or azinophos-methyl (Guthion)	8 pt 2S or 2L 4 lb 50% WP		
Strawberry crown moth□ (occasional)	As above for raspberry crown borer		See remarks	Apply in 200 gallons of water per acre to bottom 3 feet of canes and to crowns and surrounding soil during October after late summer or fall rains have brought soil moisture near field capacity.
Spur blight (common to occasional)	captan plus spreader-sticker	2 lb of 50% WP		Apply immediately after harvest.
	Ferbam (Oregon only)	3 lbs of 76% WP		

* EC = emulsifiable concentrate; WP = wettable powder (see page 4). S and L mean essentially the same as EC. Pest does not appear on product label. See explanation on page 3.

□ A special local needs registration has been granted for this use in Washington under Section 24(c), FIFRA.

★ This material is very dangerous to the applicator and should be handled with extreme caution.

SPRAY COMPATIBILITY (ABILITY TO MIX) CHART FOR FUNGICIDES AND INSECTICIDES

Combining chemicals

It may be to your advantage to control several problems with one spray by combining several chemicals. *Read the label* and follow the manufacturer's directions when making these mixtures. This compatibility chart is provided to help you in preliminary planning only. Compatibilities can vary from those indicated on this chart because of change in solvents and emulsifying agents, etc. It is a good idea before making a tank mixture to mix the chemicals in a jar of water at approximately the recommended dilution rate and look for any reactions that would cause solids to form and separate out of the solution. Some mixtures may create phytotoxicity problems (plant injury), so unless a label specifies otherwise, either experiment on a few plants or avoid doing it.

	Rotenone	Plictran	Parathion ★	Methoxychlor	Malathion	Lime-Sulfur	Kelthane	Guthion	Ferbam	Diazinon	Captan	Benlate	Botran
Benlate	C					X							
Captan			1	1	1	X	1	1					
Diazinon						C							
Ferbam						X							1
Guthion						X					1		1
Kelthane											1		1
Lime-Sulfur	X	?	X	?	X			X	X	C	X	X	X?
Malathion						X					1		1
Methoxychlor		?				2			1		1		?
Parathion ★						X					1		1
Plictran				?		?							?
Rotenone						X						C	

Note: *Bacillus Thuringiensis* (Dipel, etc.) is not listed. Refer to label for compatibility information.

Blank = Normally compatible; however, newer compatibility charts suggest not to mix unless approved by manufacturer.

C = Caution

X = Incompatible

1 = Use wettable or soluble powder forms

2 = Decomposes after standing when mixed with water

★ This material is very dangerous to the applicator and should be handled with extreme caution.

WEED CONTROL GUIDE

Most weeds in raspberry fields can be controlled with herbicides. Information about safe, effective use of the herbicides is on the label. Read and understand it. Failure to follow label directions is illegal besides causing possible crop damage or poor weed control. Among the factors that influence weed control are weed species present, stage of growth, soil moisture and texture, organic matter, and rainfall or irrigation. This weed control guide is intended to help you obtain good weed control with maximum crop safety.

Remember, herbicides are plant killers. The safety of the raspberry plants depends on applying the proper material at the correct time and rate of application. Weak, unhealthy, or cold-injured plants sometimes are damaged by herbicides. Unusually wet, dry, or hot weather following application also may cause injury. Be careful. Adjust your herbicide program to meet your own particular needs.

WETTABLE POWDER PRECAUTIONS

Many of the herbicides used for raspberries are wettable powders. They go into suspension, not solution. Therefore, constant agitation is required to keep them in suspension. Mechanical agitation is better than hydraulic agitation. The line and nozzle strainers should be at least 50 mesh. Since wettable powders are abrasive, sprayers should be re-calibrated frequently.

CONTROLLING WEEDS BEFORE PLANTING

The best time to control perennial weeds is before planting. The land can be fallowed with or without herbicides, or it can be planted to a crop that allows the use of herbicides that will control perennial weeds. Examples of this method are corn with a preplant application of glyphosate (Roundup) and cereals with 2,4-D, MCPA, or dicamba (Banvel). Time and money spent to control perennial weeds before planting will prevent using more costly weed control methods during the establishment year.

CONTROLLING WEEDS DURING ESTABLISHMENT

Be sure the raspberry roots are well covered and the soil settled around the plants before applying any herbicide. If weeds have germinated, hoe or cultivate before application. Rainfall or sprinkler irrigation soon after application will greatly improve weed control.

Rates of application are for total acre coverage. For band application, reduce the amount of herbicide applied per acre but keep the rate of application per square foot the same. Follow wettable powder precautions.

Napropamide (Devrinol)

Napropamide (Devrinol) 4 pounds active ingredient (8 pounds of 50 W) per acre. Can be applied within a few days after planting.

Susceptible weeds: Annual bluegrass, barnyardgrass, wild oats, chickweed, common fiddleneck, knotweed, little mallow, purslane, common sowthistle, filaree, groundsel, lambsquarter, pineappleweed, prickly lettuce, red root pigweed.

Resistant weeds: Shepherdspurse, species of mustard, henbit, miners-lettuce, black nightshade, smartweed, all established perennial weeds.

Precautions:

1. At least 1 inch of rainfall or irrigation within a week after application is necessary for weed control, otherwise the material is degraded by sunlight.
2. Do not use on soils with over 10% organic matter.
3. Do not apply more than once per season.

IDENTIFYING BRAMBLE PROBLEMS

Special Circular 232

The Pennsylvania State University, College of Agriculture, Extension Service, University Park, Pennsylvania

PREPARED BY:

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The Pennsylvania State University, College of Agriculture.

The College of Agriculture offers educational programs and materials without regard to sex, race, color, or national origin and is also an equal opportunity employer.

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INTRODUCTION

Bramble problems may be caused by:

1) *Pests* (including insects, mites, fungi, bacteria, and viruses);

2) *Abnormal environmental conditions*; and

3) *Harmful cultural practices.*

Diagnosis of these problems requires an ability:

1) to identify visible pests when present (insects, mites, fungus mold, and reproductive structures);

2) to associate symptoms with possible causes; and

3) to associate field pattern of symptom development and spread (when it occurs) with possible causes.

This publication is intended to help bramble growers diagnose the insect and disease problems that are observed most frequently on brambles. Three steps are suggested when using this publication for diagnosis. *First*, note symptoms and period of time when the problem appeared. *Second* use Table 1 to identify "most likely causes." *Finally*, compare symptoms of the bramble problem with symptoms described for problems which are identified as "most likely cause." Recommendations for minimizing bramble problems are listed in current pest control guides available from county Extension offices.

Table 1. Association of Symptoms with Possible Causes of Bramble Problems.

Part of Plant Affected	Symptoms	Possible Causes and Page References
Fruiting canes and/or associated buds, leaves, and fruiting spurs	Generally wilted and/or dying	
	1) associated with insect-bored holes in canes	Red necked cane borer (p. 2), Raspberry cane borer (p. 3), Raspberry crown borer (p. 3)
	2) associated with insect puncture holes in canes	Tree cricket (p. 4)
	3) not associated with insect injury	Freezing temperatures (p.16), Wind (p.16) Poor drainage (p. 16), Verticillium wilt (p. 9), and Leaf curl (p.14).
New canes and/or associated leaves	Generally wilted and/or dying	
	1) *only cane tips affected*	Raspberry cane borer (p. 3), Mosaic on black raspberry (p.11)
	2) starts at base of cane	Verticillium wilt (p. 9)
	3) entire cane affected	Wind (p. 15)
Leaves	Chewing injury	Raspberry fruit worm (p. 4), Raspberry sawfly (p. 4)
	Spotted leaves	Septoria leaf spots (p. 7)
	Superficial mold	Powdery mildew (p. 7), Orange rust (p. 8)
	Mottled	Viruses (p. 11), Mites (p. 5)
Canes	Rows of punctures	Tree cricket (p. 4)
	Localized spots and discolored areas	Anthracnose (p 5), Spur blight (p. 6)
	Swollen areas, callus tissue, and galls	Red necked cane borer (p 2), Raspberry crown borer (p. 3), Crown and cane gall (p. 10), Wind (p 16)
Fruit	Worm in fruit	Raspberry fruit worm (p 4)
	Berries decay or dry up	Raspberry fruit worm (p 4), Anthracnose (p. 5), Fungus fruit rots (p 10), Wind (p 15)
	Crumbly berries	Crumbly berry (p 15)
	Uneven drupelet ripening	Streak virus (p 15)
	Dead drupelets	Anthracnose of black raspberries (p 5)
	Few drupelets formed	Sterility (p 15)

INSECTS

Raspberry Aphids: Aphids are small, soft-bodied, sucking insects. They feed by inserting their needle-like, hollow mouthparts into plants and sucking out the sap. Most bramble viruses are spread to plants by aphids during feeding. Several species of aphids are involved.

Aphids overwinter as eggs which hatch during May. The young aphids mature to be winged or wingless females which give birth to living young during the summer. The winged aphids fly and can spread over great distances, while the wingless aphids remain and develop on brambles where they were born. Males are born only in the fall. The males mate with females which lay overwintering eggs. The development time and reproductive potential of aphids depend on the host.

Aphids are very important in transmitting bramble viruses. All stages except the egg are capable of infecting plants. The minimum feeding time necessary for aphids to pick up a virus from infected plants is about 15 to 30 minutes. Aphids can retain the virus for several hours and are very efficient in transmitting the virus from plant to plant; a single feeding probe by one aphid is enough.

Aphid control is important in reducing the secondary spread of the virus. The virus problem may be reduced in the following ways.

1) Eliminate virus-infected wild and cultivated brambles.

2) Plant brambles that are certified to be as free of viruses as possible.

3) Control aphids with insecticides.

4) Use varieties that are resistant to aphids.

5) Use varieties that are resistant to viruses.

6) Maintain 500 to 1,000 ft between new plantings and virus-infected wild and cultivated brambles.

Red-Necked Cane Borer: The adult red-necked cane borer is recognized by the reddish section (thorax) behind the head; the rest of the body is black. Characteristic injury caused by these borers is cane swelling which may be from 1/4 to 3 inches in length. These

RASPBERRY APHIDS

RASPBERRY APHID CLOSE-UP

RED-NECKED CANE BORER AND LEAF INJURY

RED-NECKED CANE BORER CANE SWELLINGS

swellings may occur at any place on the cane. Usually the cane is weakened or breaks off at the swelling.

The adult beetles are present from late May until early August. On sunny days they can be seen feeding on the leaves. Eggs are laid singly on the bark of new growth.

The young larvae bore into the sapwood, make winding tunnels around the stem, and finally work through the hardwood and into the pith.

Infested canes are weakened and often die. This insect may be controlled by cutting out and removing infested canes from late fall to early spring.

Raspberry Cane Borer: The raspberry cane borer is a slender beetle, about 1/2-inch long, with feelers (antennae) about as long as the beetle. The beetle is black except for a section behind the head which is bright orange with two or three black spots. The beetles appear in raspberry plantings in June, and the female deposits her eggs singly in the pith of the tender new growth about six inches from the tip of the cane. The beetle makes two characteristic rows of punctures which encircle the cane about 3/4 to 1 inch apart; between these, but nearer the lower row, an egg is inserted.

The girdling of the cane causes the tip to wilt. When the eggs hatch the larvae tunnel towards the base of the cane, which they usually reach before fall.

Raspberry Crown Borer: The raspberry crown borer attacks most brambles. Infested canes become spindly, lack vigor, and often break off at ground level.

The "wasp-like" moth is black with yellow bands on the body. The moths live about 10 days. They fly during the day. During August each female lays about 100 eggs on the undersides of the leaves. When the eggs hatch the young borers (larvae) enter the soil near the crown to overwinter. In the spring the borers enter the crown where they cause swellings or galls near the soil line. The borers tunnel in the cane for the entire year, and it is not until the following summer that the 3/4-inch-long borers pupate (become encased in a leathery brown structure)

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RASPBERRY CANE BORER TIP WILT

RASPBERRY CANE BORER ADULT

RASPBERRY CANE BORER EGG IN CANE

Entomology Dept. NYS Agric. Expt. Station Geneva N.Y.

Entomology Dept. The Pennsylvania State University

RASPBERRY CANE BORER LARVAE IN CANE

and then emerge as adults (moths) during late summer. The life cycle requires two years.

Raspberry Fruit Worm: The raspberry fruit worm, also known as the American raspberry fruit worm, is a small (1/8 inch), hairy, light-brown beetle. The beetles appear during May and feed on the buds, which they may kill; on the leaves, which they skeletonize; and on the blossoms. The female deposits eggs on or near the blossom clusters, or on the green berries. When the small worms feed inside the flower bud they may work their way into the berry. This injury is especially significant because the berries frequently dry up or decay and fall off, or worms present in the berries at picking time reduce the value of the crop.

Raspberry Sawfly: The larvae of the raspberry sawfly are small (about 3/4 of an inch long when full-grown), spiny caterpillars that may become a serious pest of red raspberry, but also will attack other brambles. The female sawfly is small (about 1/4 inch long) and black with a yellowish band across the abdomen. The adult sawflies appear in May and the eggs are deposited between the upper and lower surface of the leaf. As the eggs hatch, the young caterpillars feed on the outer edge of the leaves. As they grow older, they feed anywhere on the leaf surface. The full-grown larvae are light green in color and covered with small spines arranged in rows. The larvae feed for about two weeks before entering the soil, where they remain until the following year.

Tree Cricket: Tree crickets are singing insects which commonly occur in all areas. They are greenish, about 3/4 inch long, with feelers longer than the body. Tree crickets injure plants when they puncture the canes to prepare a place to deposit eggs. The punctures are arranged in long rows along the canes. These rows of punctures often are two inches in length, each row containing about 30 eggs. The eggs are laid through the outer layer of wood into the pith. The cavity usually is capped by a plug of chewed wood. The punctures either kill the upper part of

RASPBERRY FRUIT WORM AND BUD INJURY

RASPBERRY FRUIT WORM LARVAE IN FRUIT

RASPBERRY FRUIT WORM ADULTS ON LEAF

RASPBERRY FRUIT WORM ADULT FEEDING INJURY

RASPBERRY SAWFLY

TREE CRICKET ADULTS AND LEAF INJURY

the cane or weaken it so that the fruit will not develop. The eggs are laid in late summer and hatch the following spring. The older crickets are attracted to the flowers and cause some injury to the flowers and fruit.

MITES

Spider Mites: Leaves infested by spider mites have pale, discolored blotches or spots on both surfaces. Infested leaves also will have silken threads spun across the surface. In heavy infestations these threads may form a web. Mites are most prevalent during hot, dry seasons, and injury may occur if soil moisture is low.

The adult female mite is small (1/50 inch long), greenish, with two black spots on its back. The mites feed by sucking plant sap from the leaf. There are several overlapping generations during the summer.

FUNGI

Anthracnose: Anthracnose is one of the most important diseases of black and purple raspberries. Some varieties are affected more severely than others.

Conspicuous cane spots (pit lesions) appear on immature shoots of black and purple raspberries. Initially, these spots are small, purplish, and raised. As the spots enlarge the center becomes grayish and depressed and is surrounded by a reddish margin. Canes may be girdled and severely weakened when spots are numerous. Pit lesions are inconspicuous on immature shoots of red raspberries. However, during the summer superficial infection of the older bark produces an extensive grayish-white area. Pin-point black dots (fungus fruiting structures) later appear in concentric rings on these areas of the canes. Cane spots enlarge during the winter and may cause the bark to crack. Canes weakened by anthracnose are more susceptible to winter injury. Anthracnose spots may develop on leaves and petioles. The spots are elongated, first purplish and later brown. Anthracnose fruit rot can occur on red and purple raspberries but usually is more serious

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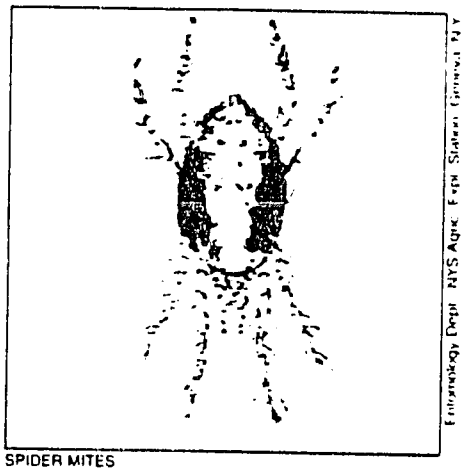
TREE CRICKET EGG LAYING PUNCTURES IN CANES



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SPIDER MITES

A. J. Brann, Plant Pathology Dept. Cornell University

ANTHRACNOSE ON OLD CANES

Plant Pathology Dept. The Pennsylvania State University

ANTHRACNOSE ON YOUNG CANES

on black raspberries. Individual drupelets or larger areas of the fruit may be affected. These areas soon become brown and mummified, resulting in misshapen, off-flavored fruit.

Anthracnose is caused by the fungus *Elsinoe veneta* (*Gloeosporium venetum*). The fungus overwinters on diseased canes and starts producing spores early in the spring. The spores are spread to new growth by running water, splashing rain, and wind.

Spur Blight: Spur blight is more important on red raspberries than on black raspberries. Blackberries appear to be immune. Most red raspberries appear to be susceptible while some black raspberries are tolerant.

Symptoms first appear on new growth in late spring or early summer as discolored purplish to brown areas on the shoot at the nodes. These spots enlarge until the cane may be girdled. In late summer, bark in the discolored areas splits and small black pimple-like reproductive structures of the causal fungus appear. These structures are scattered in contrast to the concentric arrangement of similar anthracnose structures. Affected canes are suceptible to winter injury. Next season, the laterals that arise from buds in the affected areas are weak and the leaves are stunted. These laterals often wither and die, resulting in reduced yield.

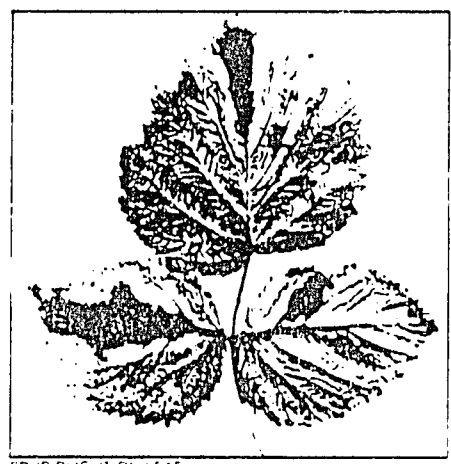
Spur blight is caused by the fungus *Didymella applanata* (*Phoma* sp.). The fungus overwinters on infected canes. Reproductive spores may be discharged into the air or ooze to the stem surface during wet periods from late spring through August. These spores are spread by wind, splashing rain, and running water. New infections occur when moisture is abundant, a condition that frequently exists at the nodes in the axils of leaves.

Cane Blight: The fungus that causes cane blight on brambles also causes a canker of roses and a fruit rot of apples and pears. Cane blight is more prevalent on black raspberries than on red raspberries, purple raspberries, and blackberries.

Although infection may occur earlier, symptoms do not appear on new shoots until late in the season. When

SPUR BLIGHT ON CANES

CANE BLIGHT ON CANES



SPUR BLIGHT ON LEAF

CANE BLIGHT AT TIP-PRUNING INJURY

plants are topped or laterals are cut back, infected areas may appear as brownish purple discoloration developing from the cut ends. These areas enlarge until several inches of the cane are dead. All lateral branches originating in the infected area wilt and die. Weakened canes are subject to winter injury. On fruiting canes the first symptom is sudden wilting of branches when fruit begins to ripen. The wilting is associated with purple areas on the laterals or on the main canes below wilted branches. Often the infected area is centered around an insect injury or other wound.

Cane blight is caused by the fungus *Leptosphaeria coniothyruim* (*Coniothyruim fuckelli*). The fungus overwinters on diseased canes. In the spring, spores are produced and are spread by splashing water, air currents, and insects. The spores can infect plants in moist conditions under a wide range of temperatures. Most infection occurs in late spring or early summer, through cracks in bark, broken fruit stems, and other wounds made by pruning activities and by insects.

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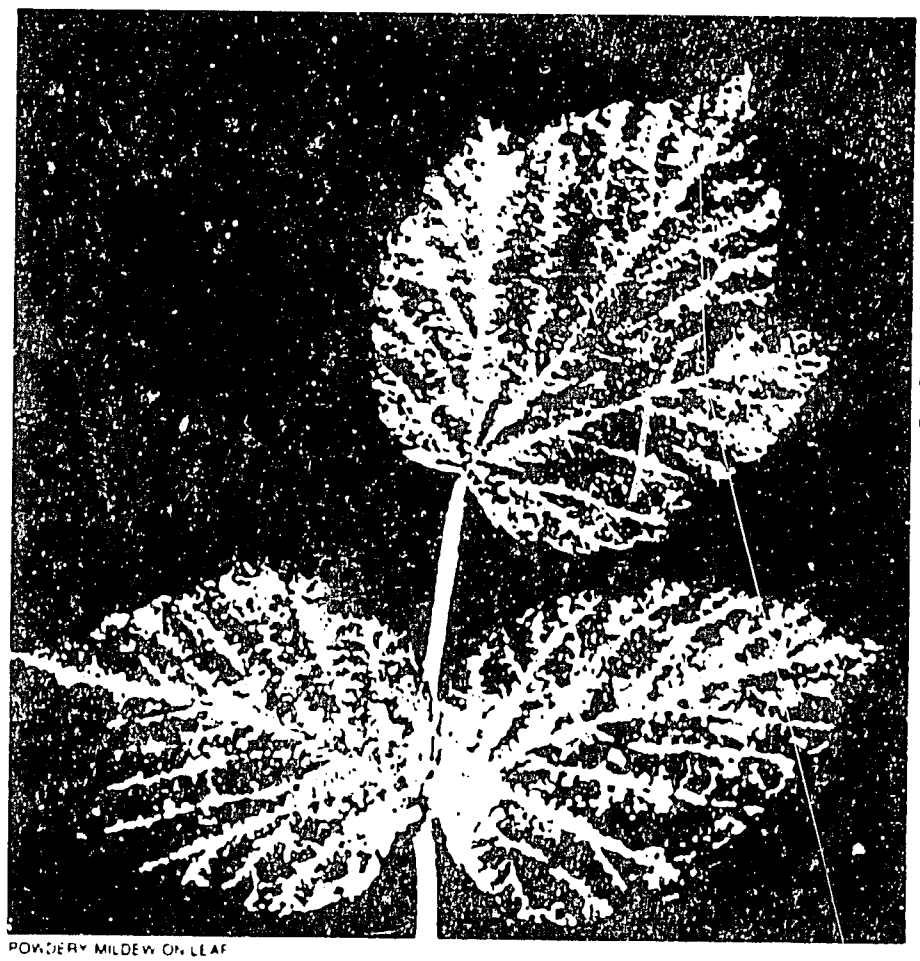
SEPTORIA LEAF SPOT

Septoria and Mycosphaerella Leaf Spots: These leaf spots can affect all brambles. Red raspberry varieties differ in their susceptibility.

The leaf spots are circular; small (about 1/8-inch); white to tan, usually with a purple margin; and may have a few brown specks in the center.

These spots are caused by two fungi, *Mycosphaerella rubi* (*Septoria rubi*) and *Septoria brevisporia*, which overwinter on diseased plant parts. Spore production is promoted by damp weather. The fungus spores are produced in a glue-like material and are spread by splashing rain and running water rather than by wind. Wet conditions are thought to promote new infections.

Powdery Mildew: Mildew may occur on all brambles, but usually is not a severe problem except on certain red raspberry varieties and on certain black raspberry varieties in 1- and 2-year old plantings. The diagnostic sign of this disease is a white powdery fungus growth on leaves and twigs of



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POWDERY MILDEW ON LEAF

young canes, which is more dense on the lower sides of leaves. Affected leaves also may be dwarfed and twisted, and have yellow areas on their upper sides. If the white powdery growth is absent, these mildew symptoms could be mistaken for virus symptoms.

Powdery mildew is caused by the fungus *Sphaerotheca humuli* which overwinters in affected cane tips and dormant buds. Overwintering spores are discharged into the air when spring temperatures reach 50 to 60°F. The white powdery mold contains numerous summer spores which are spread by wind. When mildew spores land on susceptible brambles, new infections are promoted by temperatures of 65 to 90°F and relative humidities of 97 to 99 percent; thus, powdery mildew is favored by warm humid weather without rainfall. It is most prevalent in dry years and in locations where air circulation is poor, in marked contrast to many other fungus diseases such as anthracnose and spur blight, which develop best on wet foliage.

POWDERY MILDEW ON PLANT

Orange Rust: Orange rust is most severe on wild and cultivated blackberries, and sometimes affects black raspberries, but does not affect red and purple raspberries. Blackberry varieties differ in their reaction to rust.

A distinct yellow glandular coating appears on the underside of developing leaflets in early spring. This coating later breaks open and exposes bright orange, dusty spore masses. Affected leaves usually are dwarfed and misshapen. The disease is systemic and infected plants never recover. Diseased plants have an abnormally large number of shoots with a distinctly upright growth habit. Shoots of the most severely affected plants are thornless and never produce blossoms or fruit.

Orange rust is caused by the fungus *Gymnoconia interstitialis* which overwinters in diseased roots and stems. In the spring, fungus growth within the plant keeps pace with new shoot growth. As the leaves form, rust pustules are formed on the undersides. Dusty spores are exposed when pustules break open in June or July. The spores are spread to other plants by wind. After spores land and grow on

ORANGE RUST ON LOWER LEAF SURFACE

leaves, the fungus enters the leaves and grows systemically through the plant into the canes, crown, and roots. Spores are not produced on newly infected plants until the following season. An infected plant remains infected throughout its life and will produce spores every year after it is infected.

Verticillium Wilt: Verticillium wilt has been reported on more than 160 kinds of plants including brambles, strawberries, tomatoes, eggplants, potatoes, peppers, and stone fruits. This disease usually is more severe in black raspberries than in red raspberries. Blackberries, although susceptible, seldom suffer much from wilt.

Wilt symptoms usually begin to appear on black raspberries in June or early July, and on red raspberries about a month later. Leaves on infected plants wilt, turn yellow, and drop, starting at the base of the plant. Eventually the canes may be bare except for a few leaves at the top. Black raspberry canes may exhibit a blue or purple streak from the soil line extending upward to varying heights. This purple streak often is missing or is difficult to detect on red raspberry canes. Final effects of the disease occur on fruiting canes that were infected the year before. In the spring some of these canes may be dead. On others, buds are shriveled or poorly developed. New leaves may be yellow and stunted. Sometimes the canes die before the fruits mature. This results in withered, mummified fruit or small, tasteless fruit.

Losses usually are heavier in black raspberries than in red raspberries because of differences in their growth characteristics. Black raspberry bushes produce new canes from the original crown and do not produce rhizomes and new sucker plants. Therefore, when a black raspberry plant is infected, it dies out almost entirely even though it may survive up to about three years. Red raspberries produce rhizomes and therefore constantly are producing new sucker plants. Production of new sucker plants may be slowed due to reduced vigor, however, production from these new plants may offset production lost by fungus attack.

Verticillium wilt is caused by a soil-

ORANGE RUST AFFECTED (RIGHT) AND HEALTHY (LEFT)

VERTICILLIUM WILT

borne fungus, *Verticillium alboatrum* that persists in the soil for years. The fungus usually is spread with soil but can be spread by wind. The fungus enters the plant roots and moves within the plant in the vascular tissue. Verticillium wilt is a cool-weather disease and is most severe in poorly drained soils and following cold, wet springs. Appearance of symptoms on new canes frequently coincides with water stress caused by hot, dry midsummer weather.

Ripe Fruit Rots: Ripe fruit rots appear in red, purple, and black raspberries. Affected fruit becomes soft, moldy, and sometimes watery when fruit is ripe.

Ripe fruit rots are caused by several fungi including *Botrytis* sp. and *Rhizopus* sp. *Botrytis* causes a dense powdery gray mold growth on ripe berries. *Rhizopus* may produce a coarse mold growth on ripe berries and almost always results in juice running from the berries. These rots develop fastest on overripe and bruised raspberries. Warm, wet weather at harvest favors development of ripe fruit rots.

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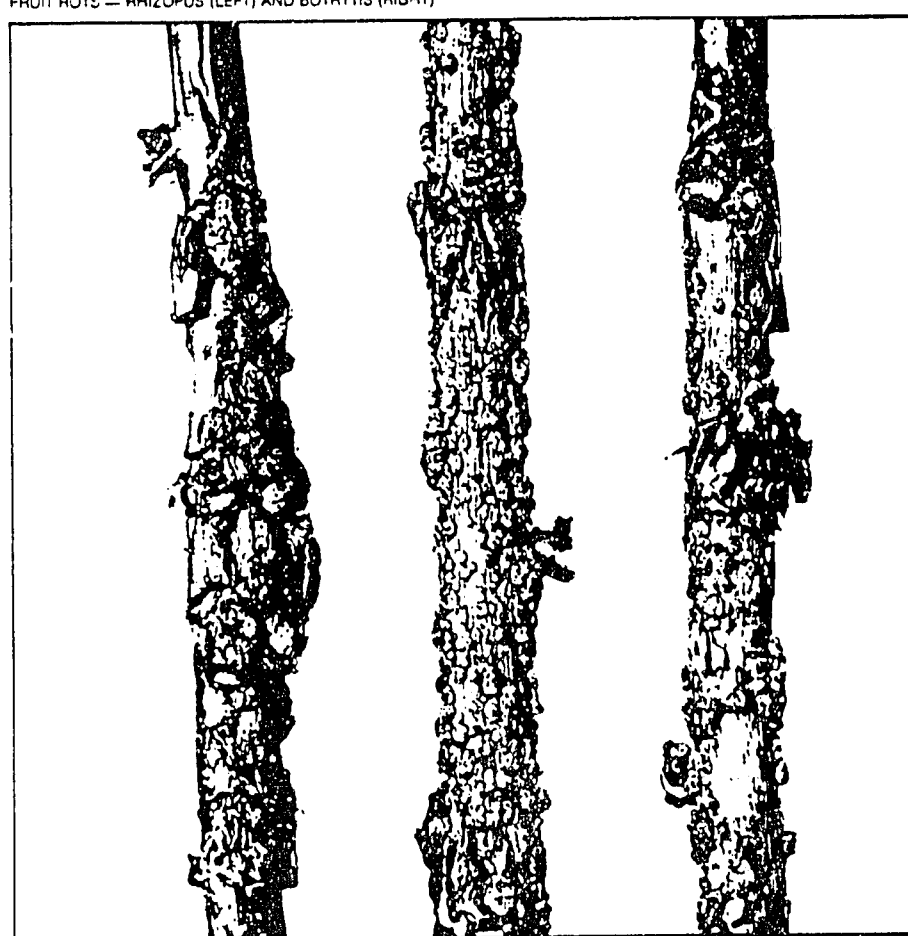
FRUIT ROTS — RHIZOPUS (LEFT) AND BOTRYTIS (RIGHT)



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CANE GALL

BACTERIA

Crown Gall and Cane Gall: Crown gall affects all brambles as well as many other plants including apples, grapes, peaches, and roses. Cane gall affects black and purple raspberries more frequently than red raspberries and blackberries.

Young galls (tumor-like swellings) are spongy, rough, and wart-like. New galls are formed each season. Gall diameter varies from a pinhead to two inches or more. Crown galls develop underground in the spring. Cane galls occur almost exclusively on fruiting canes and appear in mid-June. Both crown and cane galls become brown, woody knots with age. Some disintegrate during the winter whereas others remain hard and woody and last for the life of the plant. Plants with numerous galls may be stunted; produce dry, poorly-developed berries; break easily and fall over; or show various deficiency symptoms due to impaired uptake and transport of nutrients and water.

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CROWN GALL

Both galls are caused by soil-borne bacteria (Crown gall—*Agrobacterium tumefaciens;* Cane gall—*Agrobacterium rubi*). The bacteria overwinter in soil and/or diseased galls. The bacteria are spread by splashing rain, running water, cultivation, and pruning. New infections occur only through wounds. Wounds may be caused by digging and setting plants, cultivation, pruning, and insect feeding. The bacteria may live in the soil for several years.

VIRUSES

Brambles are damaged seriously by virus diseases (Table 2). Once infected, a plant remains infected for life. Generally, all vegetative parts of a plant are infected so that any suckers or tips used for propagation also are diseased. Most bramble viruses are spread from plant to plant by aphids during their feeding activities. Bramble viruses are not known to be spread in the field by activities which wound plants (e.g., pruning, cultivation). Most viruses that affect brambles, and also the aphids that carry the viruses, are largely limited to the bramble family. Specific symptoms of virus-caused bramble diseases which most frequently appear are summarized for black raspberries (Table 3), red raspberries (Table 4), and blackberries (Table 5).

Mosaic: Mosaic affects all raspberries but seldom affects blackberries. Black and purple raspberries are more severely affected than red raspberries.

Symptoms vary with the variety of raspberry, the viruses in the particular mosaic complex, and the season of the year. Some mosaic viruses do not cause distinct symptoms. Specific symptoms are summarized for black raspberries (Table 3), red raspberries (Table 4), and blackberries (Table 5).

Two different groups of viruses can be involved in causing mosaic. One group is heat-sensitive; the other group is heat-stable. Mosaic can be caused by either group alone or in combination.

The mosaic viruses usually are spread by the large raspberry aphid

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MOSAIC OF RED RASPBERRY

Table 2 Expected Effect of Four Virus Diseases on Brambles

Type	Mosaic	Leaf Curl	Tomato Ringspot	Streak
Black and purple raspberries	Severe	Severe	None	Severe
Red raspberries	Moderate	Severe	Severe	None
Blackberries	None	Symptomless	None	None

Table 3. Some Virus Diseases of Black Raspberries

Disease	Initial Symptoms	Permanent Symptoms
Mosaic caused by heat-sensitive viruses	1) Shoot tips and youngest leaves may die. 2) Lower leaflets may become mottled	1) Leaves may be stunted and mottled. 2) Shoots may be dwarfed. 3) New shoots may be rosetted.
Mosaic caused by heat-stable viruses	1) Veins on expanded leaves have spreading yellowish flecks that merge to cause a net-like yellowing of veins. 2) These leaves may become distorted.	1) Plants may be dwarfed, weak, and short lived. 2) Leaves may be distinctly yellow. 3) Leaf margins may curl downward. 4) Fruit is seedy and crumbly. 5) Symptoms persist in hot weather.
Mosaic caused by a combination of heat-sensitive and heat-stable viruses	Unknown	1) Leafing-out is delayed a few days. 2) Shoot tips often die or are brittle. 3) Canes may be short and rosetted, but may appear normal in hot weather. 4) Fruit is small and seedy. 5) Plants generally die in a few years.
Leaf curl	Leaves are arched (curled), firm, small, circular, and develop a dark green, greasy cast.	Young canes are stiff and brittle and frequently do not branch.
Streak	Sometimes faint blue or gray streaks develop on and under the surface bloom of young canes and fruiting canes.	1) The streak symptoms described as initial symptoms sometimes develop one year after infection. 2) The streaks are numerous, narrow, water-soaked lines, less than 1-inch long. 3) Leaves are hooked and twisted. 4) Leaves may be dark green. 5) Sometimes lower leaves have light colored veins and are mottled. 6) Leaf symptoms occur more consistently than cane streaks. 7) Fruit segments may ripen unevenly, giving the fruit a blotched appearance. 8) Such fruit is small, seedy, tasteless, and dull.

TIP DEATH CAUSED BY MOSAIC VIRUS

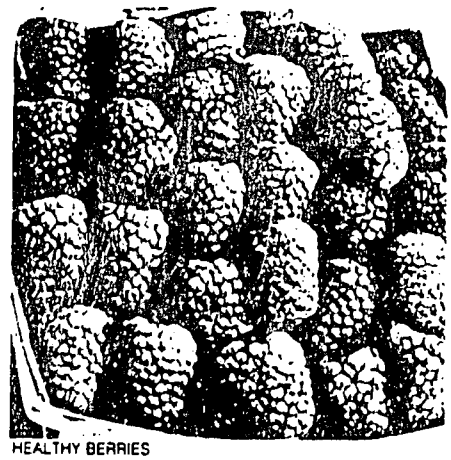
LEAF CURL

STREAK OF BLACK RASPBERRY

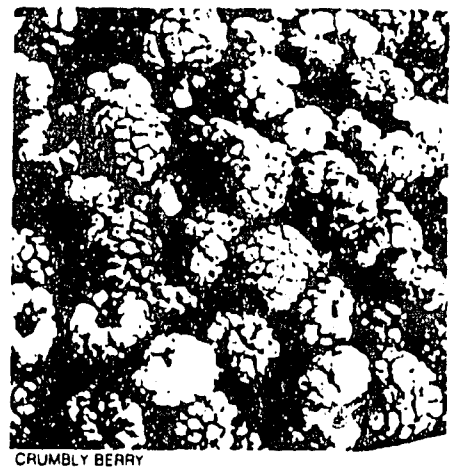
Table 4. Some Virus Diseases of Red Raspberries.

Virus Disease	Symptoms
Mosaic caused by heat-sensitive viruses	1) Secondary veins sometimes have faint yellowish-green spots. 2) New spring growth may be faintly mottled. 3) Number of canes is reduced.
Mosaic caused by heat-stable viruses	1) Leaflets have pale net-like vein yellowing and are cupped downward slightly 2) Growth and yield are not affected.
Mosaic caused by a combination of heat- sensitive and heat-stable viruses	1) Leaves produced in cool weather are mottled, blistered, and distorted; leaves may be symptomless in hot weather. 2) Plant vigor is reduced. 3) Fruit yield and quality are reduced.
Leaf curl	1) Leaves on new and fruiting canes are curled and slightly yellow. 2) Fruiting laterals are shortened. 3) Shoots may grow abnormally, producing a rosette. 4) New canes are stunted, numerous, and branched at the leaf axils. 5) Plants are stunted. 6) Plants may die during the winter. 7) Fruit are small and crumbly.
Crumbly berry (Ringspot)	1) Symptoms vary with varieties. 2) Expanding leaves on new shoots may have yellow ring-spots; these are faint or absent on fruiting canes. 3) Leaves may develop faint yellowish blotches or net-like patterns associated with veins; these symptoms tend to disappear in midsummer. 4) Plants of some varieties may be somewhat stunted. 5) Fruit of most varieties is crumbly.

RINGSPOT



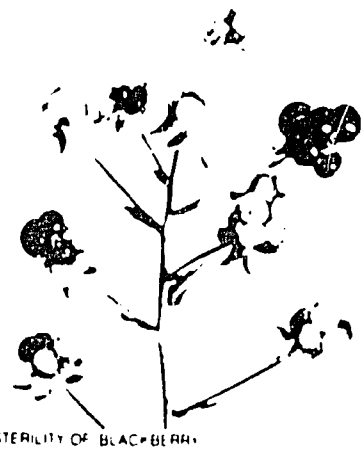
HEALTHY BERRIES



CRUMBLY BERRY

Table 5. Some Virus Diseases of Blackberries

Virus Disease	Symptoms
Mosaic caused by heat-sensitive viruses, heat-stable viruses, or a combination	Blackberries sometimes are infected but usually show no effect
Leaf curl	Most varieties are symptomless even though they may be infected. Some varieties may develop symptoms similar to those on red raspberries.
Sterility	Flowers appear normal. However, only a few of the drupelets develop.



STERILITY OF BLACKBERRY

(*Amphorophora* sp.). When this aphid feeds for a minimum of 15 minutes on an infected plant, its mouth parts become contaminated with the virus. After feeding on a diseased plant, an aphid can remain contaminated for several days and can transmit the mosaic virus to a healthy plant by feeding on it for a few minutes. This aphid is common on the tips of wild red raspberries, many cultivated red raspberries, and some blackberries. The highest population of this aphid occurs in June and July but some are present throughout the growing season.

Mosaic-Like Symptoms: Mosaic may be confused with other problems. Late spring frosts sometimes produce a mottling on fruiting cane leaves. However, leaves on new canes usually appear normal. Powdery mildew on black raspberry may produce leaf symptoms similar to mosaic; however, presence of a white mold on the underside of mildew-affected leaves would not be expected on mosaic-affected leaves. Leaf stippling produced by red spider mite infestation and by certain nutrient deficiencies also may resemble mosaic symptoms. However, injury from mites will begin on older leaves whereas mosaic symptoms usually appear first on the youngest leaves.

Leaf Curl: Raspberries are more severely affected than blackberries. Many blackberry varieties can be infected but remain symptomless.

Specific symptoms are summarized for black raspberries (Table 3), red raspberries (Table 4) and blackberries (Table 5)

Leaf curl likely is caused by two different viruses. One affects only red and purple raspberries, the other affects black raspberries as well. Both viruses are thought to overwinter in wild and cultivated raspberry plants. The common aphid vector is *Aphis rubicola*, although other aphid vectors are likely. The wingless aphids are sluggish and are thought to be of little significance in virus spread. However, the winged aphids that develop in June may be carried considerable distances by air movement

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LEAF CURL OF RED RASPBERRY

STREAK OF BLACK RASPBERRY

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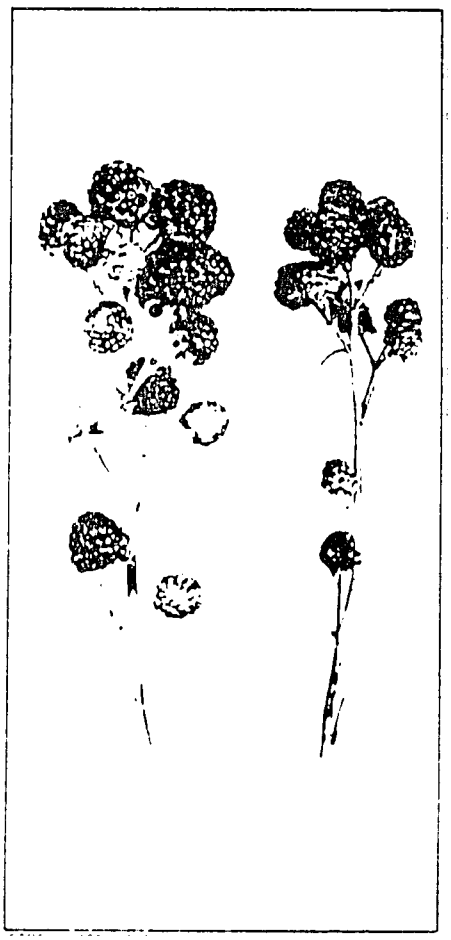
STREAK



Black Raspberry Streak: Streak is known to affect only black raspberry. Streak is thought to be caused by a virus although the method of spread is unknown. Both wild and cultivated black raspberries are overwintering hosts of the agent causing streak. Specific symptoms are presented in Table 3.

CRUMBLY BERRY OF RED RASPBERRY

Crumbly Berry: Crumbly berry is the name given to a red raspberry disease caused by the tomato ringspot virus. Although this virus has not been detected in other brambles it is known to infect strawberries, currants, grapes, stone fruits, apples, roses, elms, tomatoes, gladioli, and many other cultivated and weed plants.

The tomato ringspot virus is spread by the dagger nematode (*Xiphinema americanum*), by pollen, and possibly by natural root grafts. The virus overwinters in infected plants, in infected planting material, in infected nematodes, and in some seed from various infected plants. Ringspot symptoms on red raspberry are summarized in Table 4.

The crumbly berry condition also can be caused by mosaic and streak viruses (Table 3), leaf curl virus (Table 4), a hereditary abnormality of red raspberry resulting in ineffective self-pollination, and mite and insect (thrips, tarnished plant bugs, adult beetle of the raspberry fruit worm) feeding on flower parts.

HEALTHY RED RASPBERRIES

Blackberry Sterility: One cause of blackberry sterility is a virus. Although flowers appear normal, one or only a few of the drupelets develop. The severity of the condition is reported to become progressively greater, although the degree of sterility is thought to vary from year to year.

The method of virus spread within a field is unknown.

Other causes of partial to total sterility in brambles include hereditary abnormalities and insect damage (also see Crumbly Berry).

STERILITY OF BLACKBERRY

United States
Department of
Agriculture

Agricultural
Research
Service

Agriculture
Handbook
Number 66

The Commercial Storage of Fruits, Vegetables, and Florist and Nursery Stocks

By
Robert E. Hardenburg
Alley E. Watada
Chien Yi Wang

remove field debris before storage. A minimum of handling both before and after storage will reduce spoilage. Studies have shown that screening and impact bruising predispose cranberries to physiological breakdown or postharvest softening (*289, 587, 701*).

Cleaned and sorted cranberries can safely be stored in crates or in ventilated consumer units (cartons or film bags) for 2 to 3 weeks at 0°C or 6 weeks at 4° (*414, 762*). Longer storage at 0° may bring on physiological breakdown or chilling injury. Berries in this condition have red-pigmented rubbery-textured flesh rather than the normal crisp, white flesh and have less natural skin luster. Such berries closely resemble those that have been either frozen, smothered, or seriously bruised (*367, 408, 507, 587*). Recent research has shown that warming cranberries stored at 0° to 21° for 1 day each month can help avoid some chilling injury (*408*).

Smothering injury may develop in cranberries stored under poorly ventilated conditions. It is caused by holding berries in tight containers or in overloaded storage spaces where carbon dioxide accumulates and oxygen is depleted. Berries held too long under water may also be smothered. Harvested berries immersed in a flooded bog for 8 to 12 hours or more develop more physiological breakdown in storage (*146*).

Most of the cranberry crop is now processed into sauce or juice. Fruit intended for processing are screened as rapidly as possible and are utilized or frozen shortly after harvest. Such fruit can be frozen at −18°C until needed without quality loss. Freezing berries enhances development of the desired color in the juice. A Wisconsin study (*934*) showed for up to 10 weeks, that refrigerated storage at 4°C is effective in preserving cranberries that are to be processed.

Controlled or modified atmospheres have not been effective in extending the storage life of fresh cranberries beyond that possible with conventional cold storage (*40*) Storage in cartons with sealed polyethylene liners has increased the extent of decay and breakdown at 3°C (*40*).

Further information is available on handling (*241*), precooling (*461*), and market diseases (*367, 762*).

Currants, Gooseberries, and Elderberries

(Temperature, −0.5° to 0°C (31° to 32°F); relative humidity, 90 to 95 percent)

Currants, gooseberries, and elderberries are not stored except briefly or when they must be held for processing. A temperature of −0.5° to 0°C is recommended. Red or white currants and elderberries in good condition can be stored 1 to 2 weeks. Black currants are stored a maximum of 4 weeks (*463*). If necessary, gooseberries can be stored 3 to 4 weeks but with some losses from collapsing berries. Gooseberries stored at the recommended temperature for as long as 3 to 4 weeks should be processed immediately after removal from storage (*861*).

As soon as picked, currants, black currants, and gooseberries should be precooled to a temperature lower than 4°C to reduce damage during transport to market (*463*).

Gooseberries have been damaged by exposure to 12 percent carbon dioxide for 4 weeks at 0° but not by 8 percent carbon dioxide. Storage of hard-green gooseberries for longer periods at 0° in perforated polyethylene bags is possible if some carbon dioxide is allowed to accumulate (*464*).

Raspberries

(Temperature, −0.5° to 0°C (31° to 32°F); relative humidity, 90 to 95 percent)

Fresh raspberries soften and decay rapidly and are not adapted for commercial storage. For maximum life, field heat should be removed immediately after harvest by forced-air precooling to 1°C, and the precooled fruits placed at −0.5° to 0°. This temperature retards ripening and development of gray mold rot, rhizopus rot, and cladosporium rot (*367*) and allows 2 or 3 days of storage prior to marketing (*859, 1048*). Ripening and development of fungal rots are further retarded if raspberries are precooled and transported in an atmosphere containing 20 to 25 percent carbon dioxide through use of dry ice (*859*).

Strawberries

(Temperature, 0°C (32°F); relative humidity, 90 to 95 percent)

Fresh strawberries are highly perishable and cannot be stored except briefly. For maximum life, perhaps of 5 to 7 days, fruit should be precooled immediately after harvest and placed at 0°C. The temperature of harvested strawberries in the field can get up to 30°, and higher when exposed to sun; and when fruits are allowed to remain at this temperature for 4 hours, marketability drops by at least 40 percent (*634*). Precooling of whole pallets by forced air is recommended because the desired temperature (1°) can be obtained within 1 hour, whereas air cooling takes 9 hours (*790*). After a few days in storage, the fruit loses some of its fresh bright color, tends to shrivel, and deteriorates in flavor. Deterioration is arrested by low temperature; but after removal from storage, it proceeds more rapidly than in freshly picked strawberries (*755*). The major diseases causing storage losses in strawberries are gray mold rot, rhizopus rot, and leather rot. Prompt precooling to temperatures of 5° or below and holding at such temperatures in transit, storage, and during marketing will minimize such losses (*367, 600, 634, 755, 894*).

Refrigeration is sometimes supplemented with carbon dioxide gas from dry ice to modify the atmosphere during transit or storage. In air transport, pallets are covered with curtain coated fiberboard or heat-shrink polyethylene to retain the high level of carbon dioxide (*366*). High levels of carbon dioxide (10 to 30 percent) slow the respiration rate of the fruit and reduce the activity of decay-causing organisms, thus extending storage and market life (*178, 352, 364, 983*). Carbon diox-

Table 7
Recommended temperature and relative humidity, approximate storage life, highest freezing point, water content, and specific heat of fresh fruits in commercial storage[1]

Commodity	Temperature °C	Temperature °F	Relative humidity (percent)	Approximate storage life	Highest freezing point[1] °C	Highest freezing point[1] °F	Water content (percent)	Specific heat[3] (Btu/lb · °F)
Apples	−1-4	30-40	90-95	1-12 months	−1.5	29.3	84.1	0.87
Apricots	−0.5-0	31-32	90-95	1-3 weeks	−1.0	30.1	85.4	.88
Avocados	[4]4.4-13	40-55	85-90	2-8 weeks	−.3	31.5	76.0	.81
Bananas, green	13-14	56-58	90-95	([5])	−.7	30.6	75.7	.81
Berries								
Blackberries	−0.5-0	31-32	90-95	2-3 days	−.7	30.5	84.8	.88
Blueberries	−0.5-0	31-32	90-95	2 weeks	−1.2	29.7	83.2	.86
Cranberries	2-4	36-40	90-95	2-4 months	−.8	30.4	87.4	.90
Currants	−0.5-0	31-32	90-95	1-4 weeks	−1.0	30.2	84.7	.88
Dewberries	−0.5-0	31-32	90-95	2-3 days	−1.2	29.7	84.5	.88
Elderberries	−0.5-0	31-32	90-95	1-2 weeks	—	—	79.8	.84
Gooseberries	−0.5-0	31-32	90-95	3-4 weeks	−1.0	30.0	88.9	.91
Loganberries	−0.5-0	31-32	90-95	2-3 days	−1.2	29.7	83.0	.86
Raspberries	−0.5-0	31-32	90-95	2-3 days	−1.0	30.0	82.5	.86
Strawberries	0	32	90-95	5-7 days	−.7	30.6	89.9	.92
Carambola	9-10	48-50	85-90	3-4 weeks	—	—	90.4	.92
Cherries, sour	0	32	90-95	3-7 days	−1.7	29.0	83.7	.87
Cherries, sweet	−1 to −0.5	30-31	90-95	2-3 weeks	−1.8	28.8	80.4	.84
Coconuts	0-1.5	32-35	80-85	1-2 months	−.9	30.4	46.9	.58
Dates	[4]−18 or 0	0 or 32	75	6-12 months[4]	−15.7	3.7	22.5	.38
Figs, fresh	−0.5-0	31-32	85-90	7-10 days	−2.4	27.6	78.0	.82
Grapefruit, Calif. & Ariz.	14-15.5	58-60	85-90	6-8 weeks	—	—	87.5	.90
Grapefruit, Fla. & Texas	10-15	50-60	85-90	6-8 weeks	−1.0	30.0	89.1	.91
Grapes, Vinifera	−1 to −0.5	30-31	90-95	1-6 months[4]	−2.1	28.1	81.6	.85
Grapes, American	−0.5-0	31-32	85	2-8 weeks	−1.2	29.7	81.9	.86
Guavas	5-10	41-50	90	2-3 weeks	—	—	83.0	.86
Kiwifruit	−0.5-0	31-32	90-95	3-5 months	−1.6	29.0	82.0	.86
Lemons	([5])		85-90	1-6 months[5]	−1.4	29.4	87.4	.90
Limes	9-10	48-50	85-90	6-8 weeks	−1.6	29.1	89.3	.91
Loquats	0	32	90	3 weeks	—	—	86.5	.89
Lychees	1.5	35	90-95	3-5 weeks	—	—	81.9	.86
Mangos	[5]13	55	85-90	2-3 weeks	−.9	30.3	81.7	.85
Nectarines	−0.5-0	31-32	90-95	2-4 weeks	−.9	30.4	81.8	.85
Olives, fresh	[4]5-10	41-50	85-90	4-6 weeks[4]	−1.4	29.4	80.0	.84
Oranges, Calif. & Ariz.	3-9	38-48	85-90	3-8 weeks	−1.2	29.7	85.5	.88
Oranges, Fla. & Texas	0-1	32-34	85-90	8-12 weeks	−.7	30.6	86.4	.89
Papayas	7	45	85-90	1-3 weeks	−.9	30.4	88.7	.91
Passion fruit	7-10	45-50	85-90	3-5 weeks	—	—	75.1	.80
Peaches	−0.5-0	31-32	90-95	2-4 weeks	−.9	30.3	89.1	.91
Pears	−1.5 to −0.5	29-31	90-95	2-7 months[4]	−1.5	29.2	83.2	.87
Persimmons, Japanese	−1	30	90	3-4 months	−2.1	28.1	78.2	.83
Pineapples	[5]7-13	45-55	85-90	2-4 weeks[4]	−1.1	30.0	85.3	.88
Plums and prunes	−0.5-0	31-32	90-95	2-5 weeks[4]	−.8	30.5	86.6	.89
Pomegranates	5	41	90-95	2-3 months	−3.0	26.6	82.3	.86
Quinces[1]	−0.5-0	31-32	90	2-3 months	−2.0	28.4	83.8	.87
Tangerines, mandarins, & related citrus fruits	4	40	90-95	2-4 weeks	−1.0	30.1	87.3	.90

[1] Recommended storage temperatures; temperatures for ripening certain fruits given in text.
[2] Data from Whiteman (*1030*).
[3] Specific heat calculated from Siebel's (*830*) formula: S = 0.008 × (percent water in food) + 0.20. In metric units of kJ/kg/°C, S = 0.0335 × (percent water in food) + 0.8374.
[4] See text for maturity and cultivar differences
[5] See text.

Production, Value, and Cost Trends of Selected Pacific Northwest Berry Crops

Lawrence A. Burt M. E. Wirth Linda S. Burt

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The Authors and this Bulletin

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Preface

This report was prepared as a part of the Northwest Agricultural Development Project sponsored by the Pacific Northwest Regional Commission.

The small fruit crops included here are red raspberries, black raspberries, cultivated blackberries, boysenberries, loganberries, and cranberries. For each crop, all available data were collected on acreage, production, and value. Cost data were also obtained.

Neither strawberries nor blueberries were included in this study. Historical trend and cost information are available on strawberries from a separate study done at Oregon State University (1). Blueberry information was not included since little historical data were available and no cost studies have been completed.

Production, Value, and Cost Trends of Selected Pacific Northwest Berry Crops

Laurence A. Burt, M. E. Wirth, and Linda S. Burt

Summary and Conclusions

Commercial berry crops are grown in the Pacific Northwest (PNW) almost exclusively west of the Cascade mountains in the mild marine climates of Oregon and Washington. Most production occurs in the Puget Sound area of Washington and the Willamette Valley of Oregon.

Pacific Northwest small fruit acreage and production have declined substantialy since the mid-sixties. This was especially true in highly urbanized areas such as King, Pierce, and Snohomish counties in Washington and Clackamas, Multnomah, Washington, and Marion counties in Oregon.

The total acreage in berry production that has been transferred to urban uses is not known. However, industry observers have said that the berry production decline is directly related to metropolitan expansion in those counties. An element of this situation concerns rural and suburban land prices. Land prices rose rapidly during the seventies. As a result, both the opportunities and the rewards for selling agricultural land for nonagricultural uses have grown.

Annual changes in acreage for each berry crop in the PNW were examined. With the exception of cranberries, harvested acreage has been declining in both Oregon and Washington for all varieties. In Oregon, the average annual rate of change for the 1950-78 period ranged from −5.4% for black raspberries to −0.7% for cultivated blackberries. Cranberry acreage harvested increased by 2.9% per year over the same time period.

If the past rates of change are valid indicators of what is likely to happen in the future, we would expect less than 6,000 total acres of those berries studied to be harvested in Oregon by the year 2000. The decline in the acreage of berries in this study was even more severe, as measured by the rates of change for the 11-year period ending in 1978. If those average annual rates of change continue, only about 4,600 acres will be harvested in Oregon by the year 2000.

Changes in Washington acreages of berries included in this study revealed the same pattern. For 1950-78, acreage declines ranged from 4.6% annually for cultivated blackberries to 1.4% for red raspberries. Cranberry harvested acreage increased by about 1.6% annually. On the whole, a continuation of these rates would leave only about 3,600 acres harvested by the year 2000. The somewhat more severe rates of decline during the latest 11-year period ending in 1978 would leave less than 3,500 acres by the end of the century if that annual percentage change continued.

Production data followed the same pattern of change as that of acreage. If the 1950-78 annual rates continue to the year 2000, only 75.0 and 58.0 million pounds of berries will be produced that year in Oregon and Washington, respectively. The more severe declines of 1968-78, if continued, imply even lower total production at the end of the century: just 54.2 and 23.2 million pounds.

Available berry cost-returns information was gathered and updated to 1978. Per acre total costs of production ranged from $730.95 for black raspberries to $2,355.32 for marion blackberries. Variable costs, especially preharvest and harvest expenses, were typically the largest part of total costs. Net returns to risk varied greatly, depending on base yields for the 1969-78 period and 1978 prices. The per acre net return ranged from $1,800.58 for red raspberries to $241.80 for black raspberries. With some exceptions, the return to risk appeared to be relative to the risk of financial loss assumed by the operator.

Prospects for long-term berry markets appear good if certain problems can be overcome. Production must be maintained and expanded by use of improved varieties and development of new production acreage. An increased volume of product must be merchandised in a way that increases demand at prices high enough to cover increased production costs, higher transportation charges, and provide competitive returns to growers.

Introduction

The value of Pacific Northwest (PNW) berry production has been high in the past few years, acreage in berry crops and total production has declined steadily for a long time. In 1978, the value at the farm of all berry crops produced in the PNW was $41,140,000. Early projections for the 1979 crop indicated a value of production at just under $40 million. This drop in projected value was due primarily to freeze damage in many berry production areas during the 1978-79 winter.

Commercial berry crops are grown almost exclusively west of the Cascade Mountains in the mild marine climates of the Puget Sound area of Washington and the Willamette Valley of Oregon. The only exception is cranberries, which grow only along the southwestern coast of each state except for some in Clatsop County, Oregon. This area traditionally has been included in southwestern Washington's cranberry zone.

Purpose of the study

For a number of years, the PNW public policy-makers have tried to deal with a wide range of rural community development concerns such as maintaining adequate agricultural productivity, improving environmental quality, and understanding the role of agricultural production in the economy of the PNW states: Oregon, Washington, and Idaho.

The study reported here is part of a broad project to enhance such understanding. It deals with a single commodity sector of PNW agriculture—horticultural production. The horticultural crop information assembled in this report together with that gathered by other researchers on other important crop and livestock sectors should provide a valuable agricultural data base to help policy-makers establish sound recommendations on important PNW rural

development questions. The specific focus of this research was to determine the trends of PNW berry crops, a segment of horticultural production that continues to be important to many growers, processors, and consumers, even nationally.

Study objectives

Specific objectives of this study were to:

1. Develop historical data on selected berry acreage, production and value in the PNW.
2. Project selected berry acreage and production to the year 2000 in the PNW.
3. Identify representative production costs for selected berry crops in the PNW.

Methodology

The small fruit crops included in this research were red raspberries, black raspberries, cultivated blackberries, boysenberries, loganberries, and cranberries. For each crop, all available data on acreage production, and value were collected. Cost data were also obtained.

Neither strawberries nor blackberries were included in this study. Historical trend and cost information is available on strawberries from a separate study done at Oregon State University (1). Blueberry information was not included since little historical data were available and no cost studies have been made.

The data in this report were compiled from published reports of the U.S. Department of Agriculture, the Crop Reporting Services, and the Cooperative Extension Services of Washington, Oregon, and Idaho. Consultations with horticultural specialists and economists provided additional information.

For each berry crop, published information on production was summarized for Washington and Oregon and for the Pacific Northwest (Idaho has no commercial berry production). The assembled data cover a 29-year period, 1950 to 1978.

The information included acreage harvested, annual production, and value of production

Based on the historical record for each crop, acreage and production projections were made for the year 2000. These values were calculated using average growth rates and then evaluated by experienced industry observers.

Estimated production cost-returns budgets were updated to 1978 values from published cost studies. Variable and ownership costs were included. Production values were given by acre and unit. These were included under the following headings:

1. Gross receipts from production
2. Variable costs
3. Income above variable costs
4. Ownership costs
5. Other costs
6. Total of all costs
7. Return to risk

Except for cranberries, production cost budgets were developed for each crop. The budget for cranberries was deleted, since the latest information available was more than 15 years old. Base yields assumed for these budgets were those thought to be typical of well-managed commercial farms. They were not necessarily related to the historical values in the production tables. The data for the cost budgets were derived from many different sources; hence, it was not always possible to keep the components in each of the seven headings listed above consistent. Caution should be exercised in using these budgets, since they are based on cost studies for specific areas.

Berry crop use

An estimated 70.0 million pounds of berries produced in the PNW in 1978 were processed. This amounted to about 95% of all berry production. Berry crops with the largest tonnage processed were red raspberries, cultivated blackberries and cranberries (table 1). These three varieties accounted for almost 64 million pounds in 1978, or about 95% of all berries processed. Similar proportions were processed during 1961-78. Processing data prior to 1961 are not available.

Following the berry production trend, processing steadily decreased during the 1970s by nearly 2.1% annually. Processing of cultivated blackberries, red raspberries, black raspberries, and boysenberries reached their highest levels in the late 1960s. The loganberry record processing volume was 3,540,000 pounds in 1977. This high processing volume was due to expanded markets for loganberries in recent years.

A large portion of the berries picked for processing are frozen whole in both consumer and institution-sized packs. Other processed forms include preserves, juices, wines, syrups, flavors, and fragrances. Lesser quantities of berries are used by ice cream, yogurt, and pie manufacturers.

While the volume of processed berries was declining (as production declined), the value of PNW berries sent to processors was generally increasing for most crops (table 2). Except for black raspberries, the value of each crop sent to processors reached record levels in the 1977-78 period. The 1978 record processing values were $15.5 million for red raspberries and $10.5 million for cultivated blackberries. Boysenberries and loganberries reached record processing values in 1977 of $2.0 and $1.5 million, respectively. The black raspberry record processed value was $2.2 million in 1969 but value was still high, $1.5 million, in 1977-78. The high percentage of PNW berry crops processed may result from processor incentives to producers, including greater financial stability through written contracts, and often, higher prices.

Acreage, Production, and Value Trends

Data on harvested acreage, total production and value of production were assembled for each berry crop by state. Using the historical data as a basis, acreage and production were projected to the year 2000 by calculation of average annual growth rates.

Red raspberries

Acreage of this important berry crop has been declining in both Oregon and Washington (table 3). On a percent-

Table 1. Quantity of PNW Processing Berries, 1961-78

Year	Red Raspberries	Black Raspberries	Cultivated Blackberries	Boysenberries	Loganberries	Cranberries
	1,000 pounds					
1961	23,140	3,507	23,400	4,100	2,400	13,600
1962	26,165	2,605	28,630	2,880	1,750	6,130
1963	31,665	3,771	23,390	3,120	2,100	12,860
1964	28,500	4,854	27,424	3,420	1,640	7,510
1965	30,225	5,685	34,366	4,250	1,370	7,590
1966	35,925	5,184	35,980	5,900	1,969	17,240
1967	30,163	4,970	33,402	5,760	1,880	18,680
1968	25,390	a/	30,200	6,440	2,915	19,310
1969	31,750	6,106	34,020	4,400	2,400	15,130
1970	24,504	3,052	35,934	5,900	2,470	15,400
1971	22,975	2,758	29,549	3,600	2,100	14,480
1972	19,435	2,743	28,455	3,100	1,600	21,860
1973	22,472	1,945	8,474	1,470	980	17,820
1974	22,600	2,195	29,267	2,740	1,801	15,020
1975	24,900	2,417	21,723	3,440	2,750	18,920
1976	21,620	1,793	22,266	1,975	2,450	14,580
1977	22,812	2,386	18,997	3,000	3,540	17,060
1978	21,443	2,034	20,715	1,900	2,450	21,420

a/ Not available.
Source: (11) and Crop Reporting Services for Oregon and Washington.

Table 2. Value of Production of PNW Processing Berries, 1961-1978

Year	Red Raspberries	Black Raspberries	Cultivated Blackberries	Boysenberries	Loganberries	Cranberries
	$1,000					
1961	3,310	874	2,486	566	218	a/
1962	4,220	781	2,583	400	161	a/
1963	5,601	1,140	2,597	437	256	a/
1964	4,392	1,359	4,461	605	279	a/
1965	5,241	1,538	5,931	939	301	a/
1966	6,655	997	3,403	1,003	388	a/
1967	4,809	1,189	3,114	507	180	a/
1968	5,138	a/	3,730	818	350	a/
1969	8,613	2,206	6,390	884	490	a/
1970	5,322	763	5,426	1,056	494	a/
1971	5,435	690	3,519	648	422	a/
1972	6,131	1,232	6,787	1,116	464	a/
1973	9,970	1,657	4,338	728	451	a/
1974	7,902	1,118	6,481	885	724	a/
1975	5,601	1,209	3,113	619	550	a/
1976	6,324	897	6,449	559	500	a/
1977	11,146	1,483	8,602	1,950	1,483	3,224
1978	15,546	1,526	10,482	1,548	1,012	4,648

a/ Not available.
Source: (11) and Crop Reporting Services for Oregon and Washington.

age basis, the decline in Oregon has been somewhat greater over the whole 29-year historical period.

In 1950, Washington had almost 4,000 acres of red raspberries but acreage declined at an average annual rate of about 1.4% through 1978. At that rate there would be only about 1,900 acres in Washington by the year 2000. Based on the most recent 11-year average rate of −1.0% annually, the Washington red raspberry acreage should be 2,000 by the end of the century.

Red raspberry acreage data for Oregon begin with

Table 3. Red raspberry acreage harvested in Washington, Oregon, and Idaho from 1950 to 1978.

Year	Acreage harvested in States of the Pacific Northwest			
	Washington acres	Oregon[a/] acres	Idaho[b/] acres	PNW acres
1950	3,925	NA		3,925
1951	3,250	NA		3,250
1952	2,930	NA		2,930
1953	2,920	NA		2,920
1954	3,100	NA		3,100
1955	3,150	NA		3,150
1956	700	NA		700
1957	3,050	NA		3,050
1958	2,950	NA		2,950
1959	2,900	2,700		5,600
1960	2,600	2,600		5,200
1961	2,400	2,450		4,850
1962	2,350	2,500		4,850
1963	2,550	2,600		5,150
1964	2,900	2,700		5,600
1965	3,100	3,650		6,750
1966	3,100	3,750		6,850
1967	3,100	3,500		6,600
1968	2,900	2,900		5,800
1969	2,900	2,800		5,700
1970	2,900	2,700		5,600
1971	2,700	2,700		5,400
1972	2,600	2,400		5,000
1973	2,700	2,100		4,800
1974	2,300	2,300		4,600
1975	3,100	2,100		5,200
1976	2,900	2,000		4,900
1977	2,800	2,000		4,800
1978	2,600	1,900		4,500

a/ Data from 1950 to 1958 are unavailable.

b/ No significant acreage reported.

Source: (12), (13) and Oregon State University Economic Information Service.

Table 4. Total red raspberry production in Washington, Oregon, and Idaho from 1950 to 1978.

Year	Production in States of the Pacific Northwest (PNW)			
	Washington 1,000 lbs.	Oregon[a/] 1,000 lbs.	Idaho[b/] 1,000 lbs.	PNW 1,000 lbs.
1950	14,600	NA		14,600
1951	13,500	NA		13,500
1952	15,250	NA		15,250
1953	16,730	NA		16,730
1954	14,260	NA		14,260
1955	16,200	NA		16,200
1956	9,800	13,500		14,480
1957	20,200	10,920		31,120
1958	15,340	10,920		26,260
1959	15,080	10 530		25,610
1960	16,640	10,920		27,560
1961	14,400	9,800		24,200
1962	14,810	12,500		27,310
1963	7,954	14,820		22,774
1964	16,666	12,960		29,626
1965	17,662	13,870		31,532
1966	20,000	17,250		37,250
1967	18,248	13,600		31,848
1968	16,240	10,730		26,970
1969	20,010	13,160		33,170
1970	14,500	11,880		26,380
1971	13,500	11,610		25,110
1972	11,960	9,840		21,800
1973	13,550	10,500		24,050
1974	11,300	9,900		21,200
1975	16,500	10,200		26,700
1976	14,732	9,000		23,732
1977	14,644	10,500		25,144
1978	15,030	9,900		24,930

a/ Data from 1950 to 1955 are unavailable.

b/ No significant production reported.

Source: (12), (13) and Oregon State University Economic Information Service.

1959. In that year there were 2,700 acres. The acreage increased in the mid-1960s to about 3,600 acres but gradually declined after that.

The average decline in Oregon red raspberry acreage since 1959 has been 1.74% per year. Acreage in the year 2000 would be about 1,300 acres if that annual rate continued. The average annual decline of 3.7% for the most recent 11-year period was also more severe than the corresponding Washington rate. That larger declining rate implies only about 820 acres of red raspberry production in Oregon by the year 2000.

Given the declines in acreage, the historical and projected changes in production for both states are quite modest (table 4). Washington production was 14.6 million pounds in 1950, and increased only slightly over the 29-year period. At that rate, production in the year 2000 would reach about 15.4 million pounds. The average annual decrease for the last 11 years was 0.7% in Washington. That implies production in the year 2000 of less than 13 million pounds.

Oregon production data were first available in 1956. Production tonnage rose to a peak of 17.2 million pounds in 1966 from 13.5 million pounds in 1956. However, between 1956 and 1978, Oregon production declined an average of 1.3% annually. At that yearly rate, Oregon production of about 7.4 million pounds would be expected by the

Table 5. Value of production for red raspberries in Washington Oregon, and Idaho from 1950 to 1978.

Year	Value of Production in States of the Pacific Northwest			
	Washington $1,000	Oregon[a/] $1,000	Idaho[b/] $1,000	PNW $1,000
1950	2,356	NA		2,365
1951	2,390	NA		2,390
1952	2,776	NA		2,776
1953	3,681	NA		3,681
1954	2,681	NA		2,681
1955	1,928	NA		1,928
1956	230	NA		230
1957	3,394	NA		3,394
1958	1,503	NA		1,503
1959	2,156	1,443		3,599
1960	2,546	1,529		4,075
1961	2,131	1,352		3,483
1962	2,458	1,988		4,446
1963	3,250	2,579		5,829
1964	2,650	1,957		4,607
1965	3,144	2,372		5,516
1966	3,780	3,140		6,920
1967	2,901	2,244		5,145
1968	3,264	2,189		5,453
1969	5,483	3,487		8,970
1970	3,248	2,542		5,790
1971	3,227	2,728		5,955
1972	3,755	3,159		6,914
1973	5,854	4,788		10,642
1974	4,204	3,227		7,431
1975	4,109	2,417		6,526
1976	4,361	2,862		7,223
1977	7,000	5,355		12,355
1978	10,671	7,029		17,700

a/ Data from 1950 to 1958 are unavailable.

b/ No significant revenue reported.

Source: (12), (13) and Oregon State University Economic Information Service.

Table 6. Black raspberry acreage harvested in Washington, Oregon, and Idaho from 1950 to 1978.

Year	Acreage Harvested in States of the Pacific Northwest			
	Washington acres	Oregon[a/] acres	Idaho[b/] acres	PNW acres
1950	250	NA		250
1951	270	NA		270
1952	255	NA		255
1953	250	NA		250
1954	200	NA		200
1955	150	NA		150
1956	50	NA		50
1957	200	NA		200
1958	170	NA		170
1959	190	3,600		3,790
1960	180	3,200		3,380
1961	180	2,850		3,030
1962	160	2,600		2,760
1963	160	2,400		2,560
1964	160	2,700		2,860
1965	160	3,650		3,810
1966	150	3,600		3,750
1967	160	3,500		3,660
1968	150	3,100		3,250
1969	170	2,900		3,070
1970	160	2,900		3,060
1971	140	2,800		2,940
1972	130	2,200		2,330
1973	130	1,800		1,930
1974	140	1,500		1,640
1975	140	1,300		1,440
1976	110	1,200		1,310
1977	110	1,200		1,310
1978	130	1,200		1,330

a/ Data from 1950 to 1958 are unavailable.

b/ No significant acreage reported.

Source: (12),(13) and Oregon State University Economic Information Service.

year 2000. The average annual rate of decline in Oregon production in the last 11 years has been the same as in Washington (0.7%). Production of red raspberries in Oregon at that continued rate would be 8.4 million pounds in the year 2000.

The value of production reached a 29-year peak in 1978 (table 5). The value of Washington's crop in that year was almost $10.7 million. Oregon's crop in the same year was valued at just over $7.0 million.

Black raspberries

In terms of acreage, production and value, the black raspberry crop is much smaller than the red raspberry crop. Historically, acreage, production and value have been higher in Oregon than in Washington. However, Oregon rates for all three items declined faster than Washington's.

Oregon acreage data were first available in 1959, when 3,600 acres of black raspberries were in production (table 6). Since then, the acreage has declined an average of 5.3% each year. A continuation of that rate would leave only about 360 acres in production by the year 2000. The decline in acreage has been even more pronounced in the 11-year period ending in 1978. The rate was −8.3% each year, which would leave only 180 acres of black raspberries in Oregon at the end of the century.

Washington black raspberry acreage was at or above 250 acres in the early 1950s. But the rate of decline on an average annual basis through the 29-year period ending in 1978 was about 2.2%. That decline implies just under 80 acres of black raspberries in Washington by the year 2000. The annual acreage decline rate in the last 11 years has been less severe (1.3%). If that rate continues, Washington will have about 100 acres of black raspberries at the end of the century.

Table 7. Total black raspberry production in Washington, Oregon, and Idaho from 1950 to 1978.

Year	Production in States of the Pacific Northwest (PNW)			
	Washington 1,000 lbs.	Oregon[a] 1,000 lbs.	Idaho[b] 1,000 lbs.	PNW 1,000 lbs.
1950	360	NA		360
1951	424	NA		424
1952	330	NA		330
1953	350	NA		350
1954	220	8,740		8,960
1955	260	9,030		9,290
1956	30	6,120		6,150
1957	450	3,840		4,290
1958	304	3,278		3,582
1959	300	6,120		6,420
1960	260	4,490		4,750
1961	360	3,278		3,638
1962	240	2,470		2,710
1963	274	3,600		3,874
1964	256	4,724		4,980
1965	336	5,474		5,810
1966	284	5,040		5,324
1967	432	4,650		5,082
1968	270	2,170		2,440
1969	442	5,800		6,242
1970	255	2,900		3,156
1971	112	2,800		2,912
1972	104	2,750		2,854
1973	90	1,980		2,070
1974	150	2,160		2,310
1975	170	2,400		2,570
1976	122	1,800		1,922
1977	190	2,300		2,490
1978	177	1,900		2,077

[a] Data from 1950 to 1953 are unavailable.

[b] No significant production reported.

Source: (12), (13) and Oregon State University Economic Information Service.

Table 8. Value of production for black raspberries in Washington, Oregon, and Idaho from 1950 to 1978.

Year	Value of Production in States of the Pacific Northwest			
	Washington $1,000	Oregon[a] $1,000	Idaho[b] $1,000	PNW $1,000
1950	69	NA		69
1951	73	NA		73
1952	49	NA		49
1953	87	NA		87
1954	68	1,154		1,222
1955	52	1,214		1,266
1956	7	864		871
1957	73	1,407		1,480
1958	36	849		885
1959	43	881		924
1960	52	925		977
1961	85	820		905
1962	71	741		812
1963	84	1,084		1,168
1964	72	1,323		1,395
1965	94	1,478		1,572
1966	51	968		1,019
1967	104	1,111		1,215
1968	95	764		859
1969	172	2,071		2,243
1970	64	722		786
1971	28	697		725
1972	44	1,235		1,279
1973	81	1,663		1,744
1974	75	1,099		1,174
1975	85	1,217		1,302
1976	61	889		950
1977	123	1,426		1,549
1978	132	1,425		1,557

[a] Data from 1950 to 1953 are unavailable.

[b] No significant revenue reported.

Source: (12), (13) and Oregon State University Economic Information Service.

With some exceptions, the decline in PNW production parallels that of acreage (table 7). In 1951, Washington produced 424,000 pounds. Production declined an average of 2.4% over the 29-year period ending 1978. A continuation of that rate would cut production to just over 100,000 pounds by the year 2000. The annual rate of decline for the 11 years ending in 1978 was even more, 3.8%. At that rate, production would be only 76,000 pounds by the end of this century.

Oregon production of black raspberries was 8.7 million pounds in 1954, the first year that records were available. The average annual decline in production from that time through the 1978 season was 5.9%. That would result in production of just under 500,000 pounds in the year 2000 if the annual rate continued. In contrast, the rate of decline in production for the latest 11-year period ending in 1978 was only 1.2%. That implies Oregon production of almost 1.5 million pounds of black raspberries in the year 2000.

The value of Oregon and Washington production in 1977 and 1978 was down somewhat from previous highs (table 8). Both states had record black raspberry production values in 1969 of $2,071,000 and $172,000, respectively. Value of production in 1978 for Oregon was only $1,425,000 and for Washington was only $132,000.

Table 9. Cultivated blackberry acreage harvested in Washington, Oregon, and Idaho from 1950 to 1978.

Year	Acreage Harvested in States of the Pacific Northwest			
	Washington acres	Oregon[a] acres	Idaho[b] acres	PNW acres
1950	780	NA		780
1951	1,200	NA		1,200
1952	1,050	NA		1,050
1953	1,080	NA		1,080
1954	1,150	NA		1,150
1955	1,200	NA		1,200
1956	150	NA		150
1957	950	NA		950
1958	850	NA		850
1959	750	3,434		4,184
1960	700	3,860		4,560
1961	670	NA		670
1962	620	NA		620
1963	610	NA		610
1964	660	NA		660
1965	650	NA		650
1966	660	NA		660
1967	630	NA		630
1968	600	NA		600
1969	550	NA		550
1970	460	4,300		4,760
1971	400	4,100		4,500
1972	280	4,000		4,280
1973	160	2,600		2,760
1974	170	4,000		4,170
1975	190	3,000		3,190
1976	210	2,600		2,810
1977	210	2,600		2,810
1978	200	3,000		3,200

a/ Data from 1950 to 1958 and from 1961 to 1969 are unavailable.

b/ No significant acreage reported.

Source: (12), (13) and Oregon State University Economic Information Service

Table 10. Total cultivated blackberry production in Washington, Oregon, and Idaho from 1950 to 1978.

Year	Production in States of the Pacific Northwest (PNW)			
	Washington[a] 1,000 lbs.	Oregon[b] 1,000 lbs.	Idaho[c] 1,000 lbs.	PNW[d] 1,000 lbs.
1950	1,000	NA		1,000
1951	5,062	NA		5,062
1952	NA	NA		NA
1953	5,366	NA		5,366
1954	6,210	NA		6,210
1955	7,965	NA		7,965
1956	506	NA		506
1957	8,014	NA		8,014
1958	7,459	NA		7,459
1959	6,243	17,324		22,874
1960	7,009	22,230		26,460
1961	5,877	18,480		23,704
1962	6,626	23,040		28,930
1963	5,483	18,810		23,684
1964	5,184	23,100		27,708
1965	5,431	29,820		34,648
1966	4,666	32,200		36,348
1967	5,229	29,460		34,108
1968	3,577	27,720		30,900
1969	5,074	30,100		34,610
1970	3,571	33,110		36,284
1971	2,475	27,880		30,080
1972	1,480	27,600		28,916
1973	738	8,060		8,716
1974	1,417	28,000		29,260
1975	1,732	20,500		22,040
1976	1,559	21,300		22,686
1977	1,393	18,200		19,438
1978	1,120	20,100		21,220

a/ No production figure available for 1952.

b/ Data from 1950 to 1958 are unavailable.

c/ No significant production reported.

d/ No production figure available for 1952.

Source: (12), (13) and Oregon State University Economic Information Service.

Cultivated blackberries

Acreage and production of cultivated blackberries have declined since 1950 for both Washington and Oregon. The value of production in Oregon reached record highs in 1978 for the 29-year period 1950-78. In contrast, Washington's value of production in 1978 was only 40% of the record high of 1951.

Washington acreage was as high as 1,200 in the early 1950s (table 9), but declined an average of 4.6% per year over the 29 years ending in 1978. At that rate only about 70 acres of cultivated blackberries would remain in Washington by the year 2000. A much higher annual decline of 9.5% was observed for Washington acreage in the 11-year period ending in 1978. Year 2000 acreage at that rate would be only about 20 acres.

Oregon acreage data were mostly unavailable until 1970. In that year, 4,300 acres were harvested. The 0.7% average annual rate of decline in Oregon acreage since that date has been much less than that observed in Washington. If that rate continues, Oregon will still have about 2,600 acres in the year 2000. The rate of decline in the 11-year period ending in 1978 has been higher: 3.9% per year. But that rate if continued to the year 2000 will still leave more than 1,200 acres in production.

The trend in cultivated blackberry production tonnage was actually up in both states during the 1950s and early 1960s. Declining trends in both states were observed in the latest 11-year period ending in 1978. This was especially true in Washington (table 10).

Washington production was in the 5- to 6-million ton range during a good part of the early 1950s. There was even a very modest growth rate in production of 0.4% per year. That rate projected gives a production in the year 2000 of over 1.2 million pounds. However, the average rate of decline in the 11-year period ending in 1978 exceeded 10.0% annually. At that rate, cultivated blackberry production in Washington will be only about 110,000 pounds in 2000 A.D.

Table 11. Value of production for cultivated blackberries in Washington, Oregon, and Idaho from 1950 to 1978.

Year	Value of Production in States of the Pacific Northwest			
	Washington[a/] $1,000	Oregon[b/] $1,000	Idaho[c/] $1,000	PNW[d/] $1,000
1950	308	NA		308
1951	1,386	NA		1,386
1952	NA	NA		NA
1953	964	NA		964
1954	535	NA		535
1955	779	NA		779
1956	72	NA		72
1957	570	NA		570
1958	378	NA		378
1959	472	1,386		1,858
1960	635	2,223		2,858
1961	559	1,959		2,518
1962	536	2,074		2,610
1963	561	2,088		2,649
1964	742	3,765		4,507
1965	821	5,159		5,980
1966	411	3,027		3,438
1967	469	2,740		3,209
1968	410	3,437		3,847
1969	812	5,689		6,501
1970	451	5,033		5,484
1971	266	3,346		3,612
1972	301	6,596		6,897
1973	310	4,135		4,445
1974	243	6,244		6,487
1975	208	2,973		3,181
1976	395	6,177		6,572
1977	561	8,281		8,842
1978	560	10,251		10,811

a/ No revenue figure available for 1952.

b/ Data from 1950 to 1958 are unavailable.

c/ No significant revenue reported.

d/ No revenue figure available for 1952.

Source: (12), (13) and Oregon State University Economic Information Service.

Table 12. Boysenberry acreage harvested in Washington, Oregon, and Idaho from 1950 to 1978.

Year	Acreage Harvested in States of the Pacific Northwest			
	Washington[a/] acres	Oregon[b/] acres	Idaho[c/] acres	PNW[d/] acres
1950		NA		
1951		NA		
1952		NA		
1953		NA		
1954		NA		
1955		NA		
1956		NA		
1957		NA		
1958		NA		
1959		1,000		
1960		1,500		
1961		1,200		
1962		1,200		
1963		1,100		
1964		1,150		
1965		1,250		
1966		1,450		
1967		1,500		
1968		NA		
1969		NA		
1970		1,450		
1971		1,350		
1972		1,200		
1973		800		
1974		1,200		
1975		950		
1976		600		
1977		700		
1978		750		

a/ No significant acreage reported.

b/ Data from 1950 to 1958 and 1968 to 1969 unavailable.

c/ No significant acreage reported.

d/ No acreage summary necessary.

Source: (12), (13) and Oregon State University Economic Information Service.

The first available Oregon production data are for 1959, when over 17.3 million pounds were produced. The average annual growth rate through 1978 was about 0.8%, somewhat higher than the rate observed for Washington during the same period. If this growth rate continues, 23.7 million pounds will be produced in the year 2000. But Oregon production declined 2.9% per year over the 11 years ending in 1978. If the trend continues, Oregon should produce just over 10.6 million pounds in the year 2000.

The value of Washington's small cultivated blackberry crop has also declined (table 11). The record high value was reached in 1951—almost $1.4 million. The value of production in Washington during 1977 and 1978 was about $560,000. That was sharply up from crop values in the early 1970s but less than half the dollar amounts observed early in that 29-year period. In contrast, Oregon value of production was at a record $10.3 million in 1978. Value of production in Oregon during 1959, the first recorded year, was only $1.4 million.

Boysenberries

Oregon, the only state in the PNW with commercial production of boysenberries, has had significant acreage declines since 1975 (table 12). In the 1960s as many as 1,500 acres of boysenberries were harvested in Oregon. The acreage from 1959 to 1974 averaged 1,239 acres. From 1975-78, the average was 750 acres, 60% below the 1959-74 average. This is an annual rate of decline of about 7.6%. If that rate stayed the same for the remainder of this century, fewer than 200 acres would be harvested by 2000 AD.

Since 1954, Oregon boysenberry production has declined even faster than acreage (table 13). Almost 8.0 mil-

Table 13. Total boysenberry production in Washington, Oregon, and Idaho from 1950 to 1978.

Year	Production in States of the Pacific Northwest			
	Washington[a] 1,000 lbs.	Oregon[b] 1,000 lbs.	Idaho[c] 1,000 lbs.	PNW[d] 1,000 lbs.
1950		NA		
1951		NA		
1952		NA		
1953		NA		
1954		7,800		
1955		8,200		
1956		2,200		
1957		9,100		
1958		6,600		
1959		7,700		
1960		4,650		
1961		4,560		
1962		3,240		
1963		3,520		
1964		3,794		
1965		4,500		
1966		6,234		
1967		6,080		
1968		6,750		
1969		4,750		
1970		6,090		
1971		3,914		
1972		3,360		
1973		1,600		
1974		2,900		
1975		3,600		
1976		2,250		
1977		3,150		
1978		2,000		

a/ No significant production reported.

b/ Data from 1950 to 1953 are unavailable.

c/ No significant production reported.

d/ No production summary necessary

Source: (12), (13) and Oregon State University Economic Information Service.

Table 14. Value of production for boysenberries in Washington, Oregon, and Idaho from 1950 to 1978.

Year	Value of Production in States of the Pacific Northwest			
	Washington[a] $1,000	Oregon[b] $1,000	Idaho[c] $1,000	PNW[d] $1,000
1950		NA		
1951		NA		
1952		NA		
1953		NA		
1954		967		
1955		746		
1956		286		
1957		965		
1958		541		
1959		496		
1960		553		
1961		634		
1962		457		
1963		503		
1964		676		
1965		995		
1966		1,066		
1967		547		
1968		864		
1969		930		
1970		1,090		
1971		709		
1972		1,203		
1973		786		
1974		940		
1975		662		
1976		639		
1977		2,048		
1978		1,628		

a/ No significant revenue reported.

b/ Data from 1950 to 1953 are unavailable.

c/ No significant revenue reported.

d/ No revenue summary necessary.

Source: (12) (13) and Oregon State University Economic Information Service.

lion pounds were produced in 1954, the first year production data were recorded. Production declined an average of 5.3% annually from 1954 through 1978. At that rate, production in the year 2000 would just exceed 600,000 pounds. But if the 1975-78 trend (−17.8% per year) is projected to the year 2000, production then will be less than 50,000 pounds.

Value of production has been variable, but generally up since 1954 (table 14). In 1977, the value of boysenberry production in Oregon reached a record of just over $2.0 million. The value of production in 1978 was just over $1.6 million.

Table 15. Loganberry acreage harvested in Washington, Oregon, and Idaho from 1950 to 1978.

	Acreage Harvested in States of the Pacific Northwest			
Year	Washington[a] acres	Oregon[b] acres	Idaho[c] acres	PNW[d] acres
1950		NA		
1951		NA		
1952		NA		
1953		NA		
1954		NA		
1955		NA		
1956		NA		
1957		NA		
1958		NA		
1959		1,050		
1960		NA		
1961		600		
1962		500		
1963		450		
1964		420		
1965		380		
1966		410		
1967		410		
1968		NA		
1969		NA		
1970		45[illegible]		
1971		40[illegible]		
1972		[illegible]30		
1973		390		
1974		470		
1975		440		
1976		470		
1977		500		
1978		470		

a/ No significant acreage reported.

b/ Data from 1950 to 1958, 1960, 1963 and 1969 are unavailable.

c/ No significant acreage reported.

d/ No acreage summary necessary.

Source: (12), (13) and Oregon State University Economic Information Service.

Table 16. Total loganberry production in Washington, Oregon, and Idaho from 1950 to 1978.

	Production in States of the Pacific Northwest (PNW)			
Year	Washington[a] 1,000 lbs.	Oregon[b] 1,000 lbs.	Idaho[c] 1,000 lbs.	PNW[d] 1,000 lbs.
1950		NA		
1951		NA		
1952		NA		
1953		NA		
1954		1,900		
1955		1,300		
1956		250		
1957		1,300		
1958		850		
1959		1,870		
1960		1,600		
1961		2,460		
1962		1,800		
1963		2,160		
1964		1,680		
1965		1,406		
1966		2,008		
1967		1,920		
1968		2,964		
1969		2,450		
1970		2,520		
[illegible]		2,200		
[illegible].2		1,634		
[illegible]73		1,052		
1974		1,832		
1975		2,800		
1976		2,500		
1977		3,600		
1978		2,500		

a/ No significant production reported.

b/ Data from 1950 to 1953 are unavailable.

c/ No significant production reported.

d/ No production summary necessary.

Source: (12), (13) and Oregon State University Economic Information Service.

Loganberries

Only Oregon raises loganberries commercially in the PNW. Acreage declined in the 1960s but expanded a little during the 12-year period ending in 1978 (table 15). Acreage from 1959, the first recorded year, declined an average 3.9% annually through 1978. That rate if continued to the year 2000 would imply an acreage level just below 200 acres. However, the growth rate averaged 1.1% annually over the last 12 years of the data series. If that rate continues, Oregon should have 600 acres by the year 2000.

The production of loganberries over the 1954-78 period varied (table 16). In 1954, the first year that information was available, 1.9 million pounds were produced. A 1.1% rate of growth continued through 1978, implying production of 3.2 million pounds by the year 2000 if continued. However, production in the latest 11-year period ending 1978 declined annually by an average 0.8%. If that rate continues to the year 2000, production will be about 2.1 million pounds.

Table 17. Value of production for loganberries in Washington, Oregon, and Idaho from 1950 to 1978.

Year	Value of Production in States of the Pacific Northwest			
	Washington[a/] $1,000	Oregon[b/] $1,000	Idaho[c/] $1,000	PNW[d/] $1,000
1950		NA		
1951		NA		
1952		NA		
1953		NA		
1954		NA		
1955		NA		
1956		NA		
1957		NA		
1958		NA		
1959		NA		
1960		NA		
1961		224		
1962		167		
1963		265		
1964		286		
1965		309		
1966		396		
1967		184		
1968		356		
1969		500		
1970		504		
1971		444		
1972		474		
1973		483		
1974		737		
1975		563		
1976		513		
1977		1,512		
1978		1,075		

a/ No significant revenue reported.

b/ Data from 1950 to 1960 are unavailable.

c/ No significant revenue reported.

d/ No revenue summary necessary.

Source: (12), (13) and the Oregon State University Economic Information Service.

Table 18. Cranberry acreage harvested in Washington, Oregon, and Idaho from 1950 to 1978.

Year	Acreage Harvested in States of the Pacific Northwest			
	Washington acres	Oregon acres	Idaho acres[a/]	PNW acres
1950	700	380		1,080
1951	720	440		1,160
1952	750	450		1,200
1953	750	460		1,210
1954	780	470		1,250
1955	729	470		1,199
1956	950	470		1,420
1957	950	450		1,400
1958	900	520		1,420
1959	1,000	540		1,540
1960	1,050	550		1,600
1961	1,100	560		1,660
1962	950	560		1,510
1963	1,000	570		1,570
1964	1,000	570		1,570
1965	1,000	540		1,540
1966	1,000	560		1,560
1967	1,000	620		1,620
1968	1,000	635		1,635
1969	1,000	685		1,685
1970	1,000	745		1,745
1971	1,000	810		1,810
1972	1,000	890		1,890
1973	1,100	900		2,000
1974	1,100	900		2,000
1975	1,100	900		2,000
1976	1,100	880		1,980
1977	1,100	850		1,950
1978	1,100	860		1,960

a/ No significant acreage reported.

Source: (12), (13) and Oregon State University Economic Information Service.

Information on value of loganberry production was available only after 1960 (table 17). Throughout most of the 1960s and 1970s, the value of production was generally increasing, primarily because of higher prices. The 1977 value of production was a record $1.5 million. In 1978 it declined to just over 1.0 million dollars, but was still the second highest gross return since 1961.

Cranberries

Cranberry acreage remained steady to slightly up from 1950 to 1978. During the last half of that period, production was maintained at near record levels. Value of production increased to record and near record levels in the most recent years.

Just over 700 acres were harvested in Washington during the early 1950s (table 18). Acreage increased gradually through 1978 at about 1.6% annually. If this rate continues to the year 2000, about 1,550 acres will be harvested then. The growth rate of 1968-78 was just under 0.9%. That annual rate if continued will result in 1,330 acres harvested by the end of the century.

Oregon's acreage remained somewhat less throughout the 29-year period but grew faster than Washington's. Only 380 acres of cranberries were harvested in Oregon during 1950. Through 1978, this acreage increased by about 2.9% annually. A continuation of this rate to the year 2000 projects 1,600 acres in Oregon and a PNW total of 2,930 acres. The annual growth rate for the last 11 years of the Oregon data series was about the same as that for the entire series.

Table 19. Total cranberry production in Washington, Oregon, and Idaho from 1950 to 1978.

Year	Production in States of the Pacific Northwest (PNW)			
	Washington 1,000 lbs.	Oregon 1,000 lbs.	Idaho[a/] 1,000 lbs.	PNW 1,000 lbs.
1950	3,300	1,426		4,726
1951	5,950	2,080		8,030
1952	3,000	2,150		5,150
1953	5,400	3,230		8,630
1954	6,150	3,000		9,150
1955	5,940	2,730		8,670
1956	6,470	4,000		10,470
1957	8,400	4,100		12,500
1958	5,730	3,230		8,960
1959	10,050	4,930		14,980
1960	4,270	2,800		7,070
1961	13,900	4,540		18,440
1962	5,400	2,950		8,350
1963	11,100	4,075		15,175
1964	6,700	3,450		10,150
1965	6,600	4,180		10,780
1966	13,500	4,860		18,360
1967	13,900	6,530		20,430
1968	16,300	5,180		21,480
1969	10,500	5,710		16,210
1970	14,000	6,060		20,060
1971	14,500	6,880		21,380
1972	15,400	10,400		25,800
1973	11,800	9,730		21,530
1974	9,200	9,200		18,400
1975	13,500	9,710		23,210
1976	10,300	8,930		19,230
1977	13,600	8,020		21,620
1978	13,900	9,450		23,350

a/ No significant production reported.

Source: (12), (13) and Oregon State University Economic Information Service.

Table 20. Value of production for cranberries in Washington, Oregon, and Idaho from 1950 to 1978.

Year	Value of Production in States of the Pacific Northwest			
	Washington $1,000	Oregon $1,000	Idaho[a/] $1,000	PNW $1,000
1950	289	124		41[illegible]
1951	779	268		1,04[illegible]
1952	450	335		78[illegible]
1953	1,021	449		1,47[illegible]
1954	738	360		1,09[illegible]
1955	594	273		86[illegible]
1956	608	380		98[illegible]
1957	1,025	492		1,51[illegible]
1958	705	375		1,08[illegible]
1959	874	439		1,31[illegible]
1960	389	244		63[illegible]
1961	1,168	409		1,57[illegible]
1962	524	286		81[illegible]
1963	1,299	476		1,77[illegible]
1964	978	504		1,48[illegible]
1965	1,023	648		1,671
1966	2,106	739		2,84[illegible]
1967	2,224	[illegible]66		3,19[illegible]
1968	2,722	793		3,51[illegible]
1969	1,722	879		2,601
1970	1,624	642		2,266
1971	1,550	736		2,28[illegible]
1972	1,939	1,310		3,24[illegible]
1973	1,628	1,323		2,951
1974	957	957		1,914
1975	1,796	1,291		3,087
1976	1,401	1,214		2,615
1977	2,448	1,444		3,892
1978	3,016	2,051		5,067

a/ No significant revenue reported.

Source: (12) (13) and Oregon State University Economic Information Service.

Washington produced only 3.3 million pounds of cranberries in 1950 (table 19). The average annual growth rate for the 29 years ending 1978 was 5.1%. This implies production of 41.3 million pounds in the year 2000. However, in the latest 11 years of the historical period, production decreased by an average 1.4% annually. If this decline continues Washington will produce 10.0 million pounds in 2000 AD.

The trend in Oregon production was clearly up. Production was only about 2.0 million pounds per year in the early 1950s. The average annual growth rate through 1978 was just above 6.7%, which projects to almost 40 million pounds in the year 2000 if the rate stays the same. That rate of growth was just slightly less for the 11-year period ending in 1978: 5.6%, which, projected to 2000, gives a production of 31.5 million pounds.

The value of cranberry production set records in 1978 for both states (table 20). In Washington, total value of the cranberry crop to producers was just over $3 million. In Oregon, the value was just over $2 million.

Table 21. Production costs per acre for red raspberries - Wa. - 1978 - Irrigated[a/]

	Unit	Price or Cost/ Unit	1969-1978 Base Yield	Price or Cost/ Acre	Cost/ Production Unit
1. Gross receipts from production	lbs.	0.71	5,216.00	3,703.36	
2. Variable costs					
Preharvest:					
Nitrogen	lbs.	0.25		62.50	0.01
Herbicide, fungicide	acre			178.43	0.03
Preharvest labor	hour			271.11	0.05
Machinery fuel & repairs	acre			73.13	0.01
Interest on Op. Cap. (9%)	dols.			52.66	0.01
Total preharvest	acre			637.83	0.12
Harvest					
Picking labor	lbs.	0.09		484.50	0.09
Other labor	lbs.	0.05		257.24	0.05
Interest on Op. Cap. (9%)	dols.			66.76	0.01
Total harvest				808.50	0.16
Total variable costs				1,446.33	0.28
3. Income above variable costs				2,257.03	0.43
4. Ownership costs (replacement, taxes, insurance, interest)					
Tractors & field equipment	acre			15.34	0.00
Total ownership costs				15.34	0.00
5. Other costs					
Interest on land	acre			103.86	0.02
Taxes on land	acre			17.31	0.00
Amortized establishment	ton				
(7 yrs., 9%, $946)	acre			187.96	0.04
Cash overhead	acre			7.50	0.00
General management (7%)	acre			124.48	0.02
Total of other costs				441.11	0.08
6. Total of all costs				1,902.78	0.36
7. Return to risk				1,800.58	0.35

[a/] Based on 25 acres of red raspberries.

Source: (9)

Production Costs and Returns

Estimates of production costs per acre in 1978 for all berry varieties ranged from $731 for black raspberries to $2,355 for marion blackberries. In relation to total production costs, variable costs were typically the largest proportion. Ownership costs were usually small in relation to variable costs and "other" fixed costs. The "other" fixed cost categories included interest and taxes on land, establishment cost amortization, cash overhead, and a general management charge.

The return to risk ranged from $242 for black raspberries produced in Washington to $1,801 for red raspberries also produced in Washington. Typical production units ranged from 5 acres for loganberries to 40 acres for black raspberries.

Red raspberries

Cost-returns budgets were estimated for both Washington and Oregon (tables 21 and 22). The base yield used for Washington was 5,216 pounds per acre and for Oregon, 4,571 pounds. Total variable costs per acre were estimated at $1,446 and $1,384 for each state, respectively. The major elements of variable costs were herbicide, fungicide, and preharvest and harvest labor expenses. For each state, ownership costs were $15 and "other" costs were $441. Due to a higher base yield and slightly lower total costs, return to risk in Washington for red raspberries was about $1,800 per acre compared to nearly $950 for Oregon.

Table 22. Production costs per acre for red raspberries - Or. - 1978 - Irrigated[a]

	Unit	Price or Cost/ Unit	1969-1978 Base Yield	Price or Cost/ Acre	Cost/ Production Unit
1. Gross receipts from production	lbs.	0.71	4,571.00	3,245.41	
2. Variable costs					
Preharvest:					
Nitrogen	lbs.	0.25		62.50	0.01
Herbicide, fungicide	acre			178.43	0.04
Preharvest labor	hour			271.11	0.06
Machinery fuel & repairs	acre			73.13	0.02
Interest on Op. Cap. (9%)	dols.			52.66	0.01
Total preharvest	acre			575.33	0.13
Harvest					
Picking labor	lbs.	0.09		484.50	0.10
Other labor	lbs.	0.05		257.24	0.06
Interest on Op. Cap. (9%)	dols.			66.76	0.01
Total harvest				808.50	0.17
Total variable costs				1,383.83	0.30
3. Income above variable costs				1,861.58	0.41
4. Ownership costs (replacement, taxes, insurance, interest)					
Tractors & field equipment	acre			15.34	0.00
Total ownership costs				15.34	0.00
5. Other costs					
Interest on land	acre			103.86	0.02
Taxes on land	acre			17.31	0.00
Amortized establishment (7 yrs., 9%, $946)	ton acre			187.96	0.04
Cash overhead	acre			7.50	0.00
General management (7%)	acre			124.48	0.03
Total of other costs				441.11	0.10
6. Total of all costs				2,302.69	0.50
7. Return to risk				942.72	0.21

[a] Based on 25 acres of red raspberries.

Source: (9)

Table 23. Production costs per acre for black raspberries - Wa. - 1978 - Irrigated[a/]

	Unit	Price or Cost/ Unit	1969-1978 Base Yield	Price or Cost/ Acre	Cost/ Production Unit
1. Gross receipts from production	lbs.	0.75	1,297.00	972.75	
2. Variable costs					
Preharvest:					
Nitrogen	lbs.	0.23		35.25	0.03
Herbicide, fungicide	acre			18.86	0.01
Irrigation power	acre			15.00	0.01
Irrigation district charge	acre			7.50	0.01
Preharvest labor	hour			79.63	0.06
Machinery fuel & repair	acre			10.21	0.01
Interest on Op. Cap. (9%)	dols.			14.98	0.01
Total preharvest				181.43	0.14
Harvest					
Picking labor	lbs.	0.11		182.05	0.13
Other labor	lbs.	0.01		17.41	0.01
Interest on Op. Cap. (9%)	dols.			18.03	0.01
Total harvest				217.49	0.17
Total variable costs				398.92	0.31
3. Income above variable costs				573.83	0.44
4. Ownership costs (replacement, taxes, insurance, interest)					
Tractors & field equipment	acre			15.34	0.01
Total ownership costs				15.34	0.01
5. Other costs					
Interest on land	acre			103.86	0.08
Taxes on land	acre			17.31	0.01
Amortized establishment	acre				
(7 yrs., 9%, $842)	acre			167.30	0.13
Overhead cash	acre			7.50	0.01
General management	acre			20.72	0.01
Total of other costs				316.69	0.24
6. Total of all costs				730.95	0.56
7. Return to risk				241.80	0.19

[a/] Based on 40 acres of black raspberries.

Source: (5).

Black raspberries

The cost-returns levels for black raspberries were estimated to be comparable in each state (table 23 and 24). The only difference was a 1,297-pound base yield in Washington compared with a 1,418-pound base yield in Oregon. Total variable costs were $399, which consisted in large part of nitrogen and preharvest and harvest labor expenses. Ownership costs were estimated at $15 and "other" costs at $317. Return to risk for black raspberries was estimated at just over $240 in Washington and about $330 in Oregon.

Table 24. Production costs per acre for black raspberries - Or. - 1978 - Irrigated[a/]

	Unit	Price or Cost/ Unit	1969-1978 Base Yield	Price or Cost/ Acre	Cost/ Production Unit
1. Gross receipts from production	lbs.	0.75	1,418.00	1,036.50	
2. Variable costs					
Preharvest:					
Nitrogen	lbs.	0.23		35.25	0.02
Herbicide, fungicide	acre			18.86	0.01
Irrigation power	acre			15.00	0.01
Irrigation district charge	acre			7.50	0.00
Preharvest labor	hour			79.63	0.06
Machinery fuel & repair	acre			10.21	0.01
Interest on Op. Cap. (9%)	dols.			14.98	0.01
Total preharvest				181.43	0.13
Harvest					
Picking labor	lbs.	0.11		182.05	0.13
Other labor	lbs.	0.01		17.41	0.01
Interest on Op. Cap. (9%)	dols.			18.03	0.01
Total harvest				217.49	0.15
Total variable costs				398.92	0.28
3. Income above variable costs				637.58	0.45
4. Ownership costs (replacement, taxes, insurance, interest)					
Tractors & field equipment	acre			15.34	0.01
Total ownership costs				15.34	0.01
5. Other costs					
Interest on land	acre			103.86	0.07
Taxes on land	acre			17.31	0.01
Amortized establishment	acre				
(7 yrs., 9%, $842)	acre			167.30	0.12
Overhead cash	acre			7.50	0.00
General management	acre			20.72	0.01
Total of other costs				316.69	0.22
6. Total of all costs				730.95	0.52
7. Return to risk				332.55	0.23

[a/] Based on 40 acres of black raspberries.

Source: (5).

Table 25. Production costs per acre for Marion blackberries - Or. - 1978 - Irrigated[a/]

	Unit	Price or Cost/ Unit	1969-1978 Base Yield	Price or Cost/ Acre	Cost/ Production Unit
1. Gross receipts from production	lbs.	0.51	5,780.00	2,947.80	
2. Variable costs					
Preharvest:					
Nitrogen	lbs.	0.23		58.75	0.01
Herbicide, fungicide	acre			55.73	0.01
Irrigation power	acre			7.50	0.00
Irrigation district charge	acre			15.00	0.00
Preharvest labor	hour	3.72		478.02	0.08
Machinery fuel & repair	acre			36.12	0.01
Interest on Op. Cap. (9%)	dols.			61.42	0.01
Total preharvest				721.54	0.12
Harvest					
Picking labor	lbs.	0.10		689.52	0.12
Other labor	lbs.	0.02		192.27	0.03
Interest on Op. Cap. (9%)	dols.			79.36	0.01
Total harvest				961.15	0.17
Total variable costs				1,682.69	0.29
3. Income above variable costs				1,100.62	0.19
4. Ownership costs (replacement, taxes, insurance, interest)					
Tractors & field equipment	acre			54.18	0.00
Total ownership costs				54.18	0.00
5. Other costs					
Interest on land	acre			186.94	0.02
Taxes on land	acre			19.04	0.00
Amortized establishment	acre				
(13 yrs., 9%, $2494)	acre			333.11	0.06
Overhead cash	acre			47.31	0.00
General management	acre			41.05	0.01
Total of other costs				627.45	0.11
6. Total of all costs				2,355.32	0.41
7. Return to risk				592.48	0.10

[a/] Based on 10 acres of Marion blackberries on a 75-acre farm.

Source: (3).

Cultivated blackberries

Cost-returns information on marion blackberries was available only for Oregon (table 25). The average price per pound in 1978 was 51 cents. With base yield estimated at 5,780 pounds, total revenue was just under $3,000 per acre. Total variable costs were estimated at $1,683 and consisted in large part of preharvest and harvest labor. Ownership costs were only $54. "Other" costs totaled $627, of which $187 was attributable to interest on land and $333 was established cost amortization. The return to risk was estimated at nearly $600 per acre.

Table 26. Production costs per acre for Evergreen blackberries - Wa. - 1978 - Irrigated[a]

	Unit	Price or Cost/ Unit	1969-1978 Base Yield	Price or Cost/ Acre	Cost/ Production Unit
1. Gross receipts from production	lbs.	0.50	6,271.00	3,135.50	
2. Variable costs					
Preharvest:					
Nitrogen	lbs.	0.23		58.75	0.01
Herbicide, fungicide	acre			43.62	0.01
Irrigation power	acre			7.50	0.00
Irrigation district charge	acre			15.00	0.00
Preharvest labor	hour	3.22		414.54	0.07
Machinery fuel & repair	acre			36.12	0.01
Interest on Op. Cap. (9%)	dols.			51.79	0.01
Total preharvest				627.32	0.10
Harvest					
Picking labor	lbs.	0.10		551.20	0.09
Other labor	lbs.	0.02		111.30	0.02
Interest on Op. Cap. (9%)	acre			63.30	0.01
Total harvest				725.80	0.12
Total variable costs				1,353.12	0.22
3. Income above variable costs				1,782.38	0.28
4. Ownership costs (replacement, taxes, insurance, interest)					
Tractors & field equipment	acre			54.18	0.01
Total ownership costs				54.18	0.01
5. Other costs					
Interest on land	acre			186.94	0.03
Taxes on land	acre			19.04	0.00
Amortized establishment	acre				
(13 yrs., 9%, $2406)	acre			321.36	0.05
Overhead cash	acre			47.31	0.01
General management	acre			46.22	0.01
Total of other costs				614.87	0.10
6. Total of all costs				2,022.17	0.32
7. Return to risk				1,113.33	0.18

[a] Based on 10 acres of Evergreen blackberries on a 75-acre farm.

Source: (4).

Cost-returns information for evergreen blackberries was available only for Washington (table 26). The base yield of 6,271 pounds per acre was slightly higher than that typical for Oregon. Revenue per acre was estimated at about $3,135. Variable costs totaled $1,353, about $330 lower than variable costs estimated for marion blackberries in Oregon. Ownership costs were the same. However, the total of "other" costs was slightly lower for evergreen than for marion blackberries, primarily due to lower establishment amortization costs. Total return to risk for evergreen blackberries in Washington at 1978 levels was estimated at $1,113, nearly double the return to marion blackberries in Oregon.

Table 27. Production costs per acre for boysenberries - Oregon - 1978 - Irrigated[a/]

	Unit	Price or Cost/ Unit	1969-1978 Base Yield	Price or Cost/ Acre	Cost/ Production Unit
1. Gross receipts from production	lbs.	0.80	3,218.00	2,574.40	
2. Variable costs					
Preharvest:					
Nitrogen	lbs.	0.23		22.33	0.01
Lime sulfur	acre			14.14	0.00
Irrigation power	acre			7.54	0.00
Irrigation district charge	acre			15.00	0.00
Preharvest labor	hour	4.03		519.61	0.16
Machinery fuel & repair	acre			35.08	0.01
Interest on Op. Cap. (9%)	dols.			55.23	0.02
Total preharvest				668.93	0.21
Harvest					
Picking labor	lbs.	0.11		301.33	0.09
Other labor	lbs.			75.44	0.02
Machinery fuel & repair	acre			28.29	0.00
Interest on Op. Cap. (9%)	dols.	0.03		36.45	0.01
Total harvest				441.51	0.14
Total variable costs				1,110.44	0.35
3. Income above variable costs				1,463.96	0.45
4. Ownership costs (replacement, taxes, insurance, interest)					
Tractors & field equipment	acre			59.40	0.01
Total ownership costs				59.40	0.01
5. Other costs					
Interest on land	acre			135.79	0.04
Taxes on land (FUV)	acre			62.70	0.01
Amortized establishment (18 yrs., 9%, $1700)	acre			307.15	0.10
Overhead cash	acre			50.73	0.01
General management (7%)	acre			120.83	0.04
Total of other costs				677.20	0.21
6. Total of all costs				1,847.04	0.57
7. Return to risk				727.36	0.23

[a/] Based on seven acres of boysenberries on a 100-acre farm with 3/4 acre additional headland.

Source: (7).

Boysenberries

A cost-returns budget for boysenberries is presented only for Oregon, the only commercially producing state in the PNW (table 27). The average price in 1978 was 80 cents per pound. Given a base yield of 3,218 pounds per acre, total revenue per acre averaged about $2,600. Total variable costs were estimated to average $1,110 per acre with preharvest and harvest labor accounting for about 80% of this total. Ownership costs amounted to $59 and "other" costs totaled $667. "Other" costs consisted mainly of establishment cost amortization, interest on land and general management expenses. Return to risk for boysenberries was estimated to be almost $730 per acre.

Table 26. Production costs per acre for loganberries - Oregon - 1978 - Irrigated[a/]

	Unit	Price or Cost/ Unit	1969-1978 Base Yield	Price or Cost/ Acre	Cost/ Production Unit
1. Gross receipts from production	lbs.	0.43	5,153.00	2,215.79	
2. Variable costs					
Preharvest:					
Herbicides, insecticides, fungicides,	acre			60.45	0.01
Irrigation power	acre			7.50	0.00
Irrigation district charge	acre			15.00	0.00
Preharvest labor	hour	3.42		96.01	0.02
Machinery fuel & repair	acre			39.11	0.01
Interest on Op. Cap. (9%)	dols.			19.62	0.00
Total preharvest				237.69	0.05
Harvest					
Picking labor	lbs.	0.10		569.15	0.11
Other harvest costs	lbs.	0.02		143.61	0.02
Harvest materials	acre			8.89	0.00
Machinery fuel & repair	acre			35.56	0.00
Interest on Op. Cap. (9%)	dols.			67.99	0.01
Total harvest				825.20	0.16
Total variable costs				1,062.89	0.21
3. Income above variable costs				1,145.90	0.22
4. Ownership costs (replacement, taxes, insurance, interest)					
Tractors & field equipment	acre			58.67	0.01
Total ownership costs				58.67	0.01
5. Other costs					
Interest on land investment	acre			140.81	0.02
Taxes on land	acre			29.33	0.01
Amortized establishment (7 yrs., 9%, $1716.39)	acre			341.03	0.07
Overhead cash	acre			51.47	0.01
General management	acre			117.89	0.02
Total of other costs				680.53	0.13
6. Total of all costs				1,802.09	0.35
7. Return to risk				413.70	0.08

[a/] Based on five acres of loganberries on a 100-acre farm with 1/2 acre additional headland.

Source: (2,9)

Loganberries

As with boysenberries, a cost-returns budget for loganberries was prepared only for Oregon (table 28). The 1978 price per pound averaged 43 cents. The estimated base yield was 5,153 pounds, so total revenue averaged about $2,215 per acre. Total variable costs were estimated at $1,063. Major variable cost outlays included those for herbicides, insecticides and fungicides; preharvest and harvest labor; other harvest costs; and interest on operating capital. Ownership costs were estimated to be $59. "Other" costs, mainly interest on land, establishment cost amortization and general management expenses, were estimated at $681. Total return to risk was estimated to be almost $415 per acre.

Future Alternatives and Constraints

On a positive note, the long-term outlook is for continued strong demand for most berry crops. Prices will likely tend to rise with the general price level. Supporting this observation were cold storage stocks from year-to-year at continued low levels. Per capita consumption on the whole has remained steady to slightly up. Furthermore, possibilities exist for expansion of berry markets in areas east of the Rocky Mountains and in Asia. Consumers are becoming more aware of the nutritional qualities of berries, and should increase consumption (6).

For berry crops in general, genetic improvements are necessary to overcome production problems and to increase yields. Given the pressures of urbanization in PNW areas suitable for berry production, new or improved varieties are looked upon as the only way that production might increase enough for market expansion. With proper merchandising, any resulting increase in berry production might be sold at prices high enough to cover the substantial costs of shipping out of the relatively isolated PNW.

A number of constraints on long-term prospects for the berry industry must be addressed. The pressures of urbanization in the PNW have been one reason for a downward trend in berry acreage and production. Genetic improvements in new varieties of berries that have been developed have helped to counter the decline in production.

The long distances to new or expanded markets and high energy costs will continue to be serious problems. These factors are making PNW fresh and processed berry products less competitive with fruit production from other areas nearer large markets. Transportation is becoming increasingly costly. Energy problems have only aggravated the situation. Part of this problem may be offset by the relatively fast population growth in the western U.S. in recent years. If population continues to grow, the market area in which the PNW has a location (competitive) advantage should expand substantially (8).

The future for berry production appears bright if these problems can be overcome. Development of increased berry production and markets will depend in part on government perception of the need to expand output of horticultural foods in general. Nonagricultural use competition for land and water will be an important influence.

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