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RASPBERRY PRODUCTION GUIDE

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HISTORY

Raspberries are bramble fruits belonging to the genus Rubus and family Rosaceae, the rose family. The raspberry is distinguished from the blackberries and dewberries, which belong to the same genus, by bearing fruit that separates from its receptacle, while that of blackberries and dewberries does not.

The cultivated raspberries of North America originate from two groups: 1) red raspberries, Rubus idaeus, native to Europe and 2) Rubus strigosis, native to North America.

If raspberries were cultivated in ancient times, there is no proof of it. 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.

There seems to be no mention of the American red raspberry as a garden fruit until 1771 when, in a list of plants to be sold by a person in the State of New York, 3 raspberry varieties are offered for sale. A Pomological manual in 1832 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 of red raspberries now being grown in Washington were developed from the Lloyd George variety. Although this variety is not adapted for production in North America, it is the parent of such improved varieties as the Willamette, Canby and the 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 are sold to processors for freezing. Red raspberries are excellent for fresh consumption but are difficult to ship long distances because the berries tend to mash. Fresh market sales, therefore, are concentrated in the urban areas near the producing fields. Larger planes, reduced air freight cost, and better handling methods are beginning to change this and more air shipments are probable in the future.

NUTRITIVE VALUE

One cup of fresh red raspberries, 123 grams, provides 50 percent of the recommended daily allowance of Vitamin C, a tenth of the iron and useful amounts of other Vitamins and minerals, but only 70 calories. They are low in sodium and suitable for use in a low-sodium diet.

Composition of fresh red raspberries, 100 grams (3 1/2 ounces) includes water, 84.2 grams; food energy, 57 calories; protein, 1.2 grams; fat, 0.5 grams; carbohydrate, 13.6 grams, including 3 grams fiber; 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.
Red raspberry production is centered in 3 counties: Pierce, Whatcom and Snohomish. These counties accounted for 84 percent of the state production in 1972. Other counties with sizeable production include King, Skagit and Clark.

### Red Raspberries: Acres Harvest, Yield and Production by Counties, Washington, 1971-72

<table>
<thead>
<tr>
<th>County</th>
<th>Acres Harvested</th>
<th>Yield Per Acre</th>
<th>Production 2/</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clark</td>
<td>130</td>
<td>120</td>
<td>3,800</td>
</tr>
<tr>
<td>King</td>
<td>160</td>
<td>140</td>
<td>5,000</td>
</tr>
<tr>
<td>Kitsap</td>
<td>55</td>
<td>50</td>
<td>4,000</td>
</tr>
<tr>
<td>Lewis</td>
<td>20</td>
<td>20</td>
<td>1,400</td>
</tr>
<tr>
<td>Pierce</td>
<td>90</td>
<td>880</td>
<td>5,600</td>
</tr>
<tr>
<td>Skagit</td>
<td>175</td>
<td>155</td>
<td>4,400</td>
</tr>
<tr>
<td>Snohomish</td>
<td>400</td>
<td>380</td>
<td>5,600</td>
</tr>
<tr>
<td>Whatcom</td>
<td>770</td>
<td>770</td>
<td>4,900</td>
</tr>
<tr>
<td>Others 1/</td>
<td>90</td>
<td>85</td>
<td>1,500</td>
</tr>
<tr>
<td>State</td>
<td>2,700</td>
<td>2,600</td>
<td>5,000</td>
</tr>
</tbody>
</table>

1/ Includes Clallam, Cowlitz, Mason, Spokane and Thurston Counties

2/ Excludes unharvested production: 1971, 265,000 lbs.; 1972, 90,000 lbs.

<table>
<thead>
<tr>
<th>Year</th>
<th>Acres Harvested</th>
<th>Yield Per Acre</th>
<th>Total Production</th>
<th>Value of Production</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lbs.</td>
<td>Lbs. 000</td>
<td>Lbs. 000</td>
<td>Dollars</td>
</tr>
<tr>
<td>1959</td>
<td>2,900</td>
<td>5,200</td>
<td>15,080</td>
<td>2,156</td>
</tr>
<tr>
<td>1960</td>
<td>2,600</td>
<td>6,400</td>
<td>16,640</td>
<td>2,546</td>
</tr>
<tr>
<td>1961</td>
<td>2,400</td>
<td>6,000</td>
<td>14,400</td>
<td>2,131</td>
</tr>
<tr>
<td>1962</td>
<td>2,350</td>
<td>6,300</td>
<td>14,805</td>
<td>2,458</td>
</tr>
<tr>
<td>1963</td>
<td>2,550</td>
<td>7,100</td>
<td>18,105</td>
<td>3,250</td>
</tr>
<tr>
<td>1964</td>
<td>2,900</td>
<td>6,000</td>
<td>17,400</td>
<td>2,650</td>
</tr>
<tr>
<td>1965</td>
<td>3,100</td>
<td>5,800</td>
<td>17,980</td>
<td>3,144</td>
</tr>
<tr>
<td>1966</td>
<td>3,100</td>
<td>6,600</td>
<td>20,460</td>
<td>3,780</td>
</tr>
<tr>
<td>1967</td>
<td>3,100</td>
<td>6,400</td>
<td>19,840</td>
<td>2,901</td>
</tr>
<tr>
<td>1968</td>
<td>2,900</td>
<td>5,600</td>
<td>16,260</td>
<td>3,264</td>
</tr>
<tr>
<td>1969</td>
<td>2,900</td>
<td>6,900</td>
<td>20,010</td>
<td>5,483</td>
</tr>
<tr>
<td>1970</td>
<td>2,900</td>
<td>5,000</td>
<td>14,500</td>
<td>3,248</td>
</tr>
<tr>
<td>1971</td>
<td>2,700</td>
<td>5,000</td>
<td>13,500</td>
<td>3,227</td>
</tr>
<tr>
<td>1972</td>
<td>2,600</td>
<td>4,600</td>
<td>11,960</td>
<td>3,755</td>
</tr>
</tbody>
</table>

1/ Includes unharvested production which is excluded in computing value: 1963, 150,000 lbs.; 1964, 733,000 lbs.; 1965, 318,000 lbs.; 1966, 460,000 lbs.; 1967, 1,592,000 lbs.

2/ Excluded unharvest production: 1968, 430,000 lbs.; 1970, 125,000 lbs.; 1971, 265,000 lbs.; 1972, 90,000 lbs.

Red Raspberries: Utilization and Price Received by Growers, Washington, 1959-1972

<table>
<thead>
<tr>
<th>Year</th>
<th>Processed Frozen Sales</th>
<th>Price</th>
<th>Fresh Market Sales</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frozen 000 Lbs. c/Lb.</td>
<td></td>
<td>Fresh Market 000 Lbs. c/Lb.</td>
<td></td>
</tr>
<tr>
<td>1959</td>
<td>14,570</td>
<td>14.3</td>
<td>510</td>
<td>15.0</td>
</tr>
<tr>
<td>1960</td>
<td>16,110</td>
<td>15.3</td>
<td>530</td>
<td>16.5</td>
</tr>
<tr>
<td>1961</td>
<td>13,940</td>
<td>14.7</td>
<td>460</td>
<td>19.0</td>
</tr>
<tr>
<td>1962</td>
<td>14,315</td>
<td>16.0</td>
<td>490</td>
<td>21.5</td>
</tr>
<tr>
<td>1963</td>
<td>17,535</td>
<td>18.0</td>
<td>420</td>
<td>20.9</td>
</tr>
<tr>
<td>1964</td>
<td>16,200</td>
<td>15.8</td>
<td>467</td>
<td>21.1</td>
</tr>
<tr>
<td>1965</td>
<td>17,055</td>
<td>17.6</td>
<td>607</td>
<td>23.7</td>
</tr>
<tr>
<td>1966</td>
<td>19,400</td>
<td>18.8</td>
<td>600</td>
<td>22.1</td>
</tr>
<tr>
<td>1967</td>
<td>17,263</td>
<td>15.6</td>
<td>985</td>
<td>21.7</td>
</tr>
<tr>
<td>1968</td>
<td>15,470</td>
<td>20.0</td>
<td>770</td>
<td>23.1</td>
</tr>
<tr>
<td>1969</td>
<td>19,390</td>
<td>27.4</td>
<td>620</td>
<td>28.0</td>
</tr>
<tr>
<td>1970</td>
<td>13,504</td>
<td>21.9</td>
<td>996</td>
<td>29.8</td>
</tr>
<tr>
<td>1971</td>
<td>12,365</td>
<td>23.7</td>
<td>1,135</td>
<td>26.2</td>
</tr>
<tr>
<td>1972</td>
<td>10,995</td>
<td>31.2</td>
<td>965</td>
<td>33.2</td>
</tr>
</tbody>
</table>

1/ Includes canned and other uses.  2/ Includes home use.
SOIL REQUIREMENTS

Raspberry plantings on deep, well-drained soils are the most productive, last longest, and give the best return from the investment of capital and labor. A loam or sandy-loam soil 2 to 4 feet deep is ideal. With ideal soil conditions and good care, plantings may remain productive for 10 years or more. On poor sites, plantings may become unprofitable in fewer than five years.

Raspberry plants grown in tight clay soil, or where there is a high water table, or where water cannot drain readily from the rooting area, are more subject to root killing and to root rot than those on well-drained soils. Some raspberry varieties, such as Sumner and Newburgh, tolerate poor soil conditions better than others.

A soil improvement program usually pays unless the area to be planted has been in sod, hay, or other soil-improving crops. Heavy applications of barnyard manure will increase organic matter in the soil, as will green manure crops grown during the winter before planting. Abruzzi rye is a good choice.

Barnyard and poultry manure are good sources of organic matter and plant nutrients. If available, apply annually 8 to 12 tons of barnyard manure, or 5 to 6 tons of poultry manure per acre. Since manures are low in phosphorus, 500 pounds of ordinary superphosphate (48 percent) per acre may be needed annually to supplement the manure.

Growing winter cover crops is a good way to keep up soil organic matter. Winter rye should be planted in early September and worked into the soil in the spring by mid-May. If left longer, the cover crop may take so much water that the raspberry plants will suffer. Even where irrigation is available, do not let the rye get beyond the heading stage. Heavy straw requires large quantities of nitrogen to break it down. When large quantities of strawy material are plowed under or mixed with the soil, apply extra nitrogen. If the material is left on or near the surface, there should be no need for extra nitrogen.

Eliminate noxious weeds, such as Canada thistle and quackgrass, before planting. Ground that has been in sod should be cultivated or cropped for one year to break down and completely kill the grass. Land that has grown potatoes or tomatoes in recent years should be avoided because of the possibility of Verticillium wilt infection. A nematode test to determine the number and kinds of nematodes is good insurance. The use of soil insecticides is important for the control of root weevils.

PLANTING STOCK and VARIETIES

Planting Stock. The source of planting stock and choice of variety can affect the number of years a raspberry planting will remain productive more than almost any other factor. The selection of clean planting stock is of utmost importance. Nematodes and the viruses some of them carry, and the organisms causing root rot, can be easily introduced into new fields on planting stock. The best way to protect against the introduction of these pests and diseases is to obtain clean stock by purchasing Certified plants. However, it has been common practice for growers to obtain planting stock from their own fruiting fields, from their
neighbors and friends or from the Oregon Register of Merit program. This can be very risky unless the field to be used for planting stock has been tested for soil nematodes, indexed for viruses and is known to be free of root rot. It is unwise to obtain planting stock from a first year fruiting field because first year vigor is not a good indication of freedom from nematodes, viruses and root rot. These disorders may take several years to become evident.

The time of planting and condition of planting stock affect plant stand and growth. Planting of fully dormant plants in February is ideal. The condition of the plant, i.e. whether it is dormant or whether new shoots have emerged, is more important in insuring a good plant stand than planting time. With cold storage (29-31°F) of Certified plants, dormancy can be maintained in storage and planting can be done when weather and soil conditions allow. The earlier the planting, the greater will be the first year's growth and the greater the baby 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. However, late planting of actively growing heeled-in plants will result in poor plant stands.

VARIETIES

Willamette (1942 release, Oregon-USDA). Industry standard, comprising approximately 2/3 of Washington acreage. Fruit very large, dark red, fairly firm and suitable for processing and fresh market. Ripens early and may interfere with strawberry harvest. Shakes off mechanically when fully ripe.

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

Meeker (1967 release, Washington). 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. Very well suited to mechanical harvesting as fruit shakes off readily.

Plants are very vigorous and have been very productive on well drained soils. Canes large, tall and tending to lop over. Fruiting laterals long and fairly strong. More susceptible to freeze injury than Summer. 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. Hardest of varieties adapted to western Washington. Most tolerant variety of heavy, poorly drained soils and thus has some root rot resistance.
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 so hardy as Sumner. Susceptible to root rot and powdery mildew.


Fairview (1961 release, Oregon-USDA). Berries medium to large, bright medium red, fairly firm, suitable for fresh market and processing. Harvest season starts with Willamette but extends late into the season. Fruit shakes off readily 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 some tolerance to root rot. Not widely grown.


PLANTING ESTABLISHMENT

Buying Certified plants is the best assurance for establishing a disease free planting. If Certified plants are not available, planting stock should be obtained from a young, vigorously growing field that is free of disease and produces well-formed fruit. The field from which plants will be purchased should be inspected. The best time to do this is during the growing and harvest season the year before planting.

Hard plants from the previous season's growth are the best raspberry planting stock. They should have strong canes 1/4 to 3/8 inch in diameter and well-formed root systems. They should be dug in such a way that the hair roots (feeder roots) are not pulled off. Pulling the plants 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.

Plants should be heeled in if they cannot be planted immediately. Spread them out enough in the row so that soil moisture can get to all of the roots. Cover the roots well. Water them if necessary. Plants can be stored for a short period at near freezing temperature if they are protected from drying.
Soft (green) raspberry plants that have come up in the spring are sometimes planted. They must be given special care to prevent wilting or drying out. They should be transferred directly, at the time they are dug, to where they are to be planted and set 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.

Ordinarily early spring, preferably February and early March, is the best time for transplanting. Plants that are set early, are well fertilized and have adequate moisture, should produce 3 to 5 strong canes during the first season.

Fall planting is possible when good plants are available.

Soil nutrient deficiencies and need for organic matter should be corrected before planting.

The soil must be prepared as carefully as for planting any other crop. If a high percentage of the plants is to survive and grow well, the soil must 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 with straight, even rows both ways 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) in a furrow plowed out even with the row, 2) in holes dug with a shovel, or 3) in holes made by pushing a shovel about 8 inches into the ground and pushing the handle back and forth to make a wedge-shaped hole. The 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. The soil must be firmed well around them as the planting hole is filled. The canes should be cut back to 6 or 8 inches. Irrigating the field or watering individual plants will pay dividends almost any time the soil is dry enough to work well during planting.

SPACING. Raspberries are usually grown in hills 2-1/2 to 3 feet apart in rows that are 8 to 10 feet apart. For many of the tractors, cultivators, and sprayers, 9 feet between rows is necessary. A 10-foot distance 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:

<table>
<thead>
<tr>
<th>Spacing</th>
<th>Plants per Acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-1/2 feet x 7 feet</td>
<td>2489 plants</td>
</tr>
<tr>
<td>2-1/2 feet x 8 feet</td>
<td>2178 plants</td>
</tr>
<tr>
<td>2-1/2 feet x 9 feet</td>
<td>1936 plants</td>
</tr>
<tr>
<td>2-1/2 feet x 10 feet</td>
<td>1742 plants</td>
</tr>
<tr>
<td>3 feet x 7 feet</td>
<td>2074 plants</td>
</tr>
<tr>
<td>3 feet x 8 feet</td>
<td>1815 plants</td>
</tr>
<tr>
<td>3 feet x 9 feet</td>
<td>1613 plants</td>
</tr>
<tr>
<td>3 feet x 10 feet</td>
<td>1452 plants</td>
</tr>
</tbody>
</table>
Soil fumigation is a practice that should be carefully and seriously considered prior to establishing a new raspberry planting. It is not necessarily warranted in all cases, but in many fields it is vital to help ensure long-term production from a planting.

Soil fumigation in the Northwest is used frequently and successfully to control nematodes. Nematodes cause varying degrees of damage to raspberries, depending on the species of nematode and the population. One or more species are vectors for Tomato Ringspot Virus. Soil fumigation is of special importance if Certified plants are being planted. There is little sense in planting Certified plants in nematode infested soil.

A nematode analysis should be run and a decision based on the results and recommendations of the testing service. (See nematode sampling). Nematode tests are available through private industry.

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 of spring prevent fumigation immediately prior to planting.

Proper techniques of fumigation are of great importance to obtain good results.

**ACTION OF FUMIGANTS**

Fumigants, upon injection or placement into the soil, volatilize and the resulting gas permeates the surrounding soil, thus killing many soil microorganisms. The degree to which specific toxic fumigant vapors affect soil microorganisms is related to the concentration of the vapor in the soil and the exposure time. The fumigant vapors in the soil eventually diffuse upward and leave the soil, or are broken down by certain 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, but prevent the rapid escape of these vapors from the soil, thus lengthening exposure time.

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

1. **Soil temperature:** Most fumigants work best at temperatures between 60-70°F at the 6" 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 at a particular level to destroy the organism. Some organisms may be in a resistant stage at the higher temperature just as they are at the lower temperature.
2. **Soil moisture:** Too much water in the soil will slow down the movement of the gas and do a poor job of disinfestation. If too dry, 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 about 50-80 percent of the field capacity, whereby 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.

3. **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.

4. **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.

5. **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 the mentioned methods can be used.

6. **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.

7. **Depth of application:** Apply the fumigant at least 8-10" deep when using it in ground beds. Be sure it is applied uniformly, or if injected the bands are close enough so the fumigant will move sideways and do a proper job of fumigating the soil. Depth and spacing of bands may vary depending on type of control desired, but commonly used widths are 10-12".

8. **Time of application:** Late summer and early fall are often the best times to apply fumigants. At this time the soil temperature is relatively high and the soil moisture is relatively low. Applying the fumigant in the spring often must be delayed until soil temperature is above 55°F and the soil moisture is in the 50-80% of field capacity 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 and one can plant at the normal planting time the following spring.

**KINDS OF SOIL FUMIGANTS**

Chemically there are several kinds of soil fumigants that a grower might consider for use in raspberries for pre-plant nematode control. The cost per acre varies greatly according to the kind of chemical used and the rate of application. The dichloropropene-dichloropropane types of compounds are probably used most extensively. Common trade names include DD Soil Fumigant (Shell), Telone (Dow), Terr-o-cide 15D, and 30D (Great Lakes ), and Vorlex (Morton).
While other compounds, such as methyl bromide and chloropicrin, will also work, they are usually much more expensive.

Consult the product label for rates of application.

NEMATODE SAMPLING

When to sample. Soil samples can be collected at any time for nematode analysis.

How to sample. Collect soil from top 12 inches with trowel or soil sampling device. A 7/8 inch by 12 inch soil tube is ideal for this type of sampling. Collect samples from root zone of established plantings and from general area in fallow field. Sample 20 to 30 locations in a field, combine the samples and mix into one uniform sample. Remove 1 pint to 1 quart of soil.

Packaging. Send in containers provided by the lab if possible. If not, place blended sample in strong plastic bag and forward to lab for analysis. The volume of soil required will depend upon the method used for nematode analysis.

Information required.
Name and address.
Description of area or map.
Date of sampling.
Cropping history past 2 years and crop to be planted.

Important.
Do not pack in paper or allow sample to air dry.
Do not store sample for more than 4 days prior to forwarding for analysis.
If stored for short period of time, store at room temperature.
Do not place label in contact with moist soil. Label plastic bag and attach the data sheet to sample bag.
Since only live nematodes can be recovered, samples should be handled with care in order to prevent possible kill as a result of temperature extremes or desiccation.

NEMATODE TESTING LABORATORIES

Cascade Agricultural Service
P. O. Box 693
Mt. Vernon, WA 98273

U.S. Testing
2800 George Washington Way
Richland, WA 99352

Soil & Plant Laboratory, Inc.
P. O. Box 1648
Bellevue, WA 98009

Plant Disease Clinic
Dept. of Plant Pathology
Oregon State University
Corvallis, OR 97331

Contact the company of your choice for cost, containers, etc.
TRAINING AND PRUNING TECHNIQUES

Cut old canes back to 6 or 8 inches at the time plants are set in the field. Do not try to produce fruit the first season. 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 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.

**Training.** The trellis or wire support for red raspberry canes consists of two, three, or four No. 10 or 12 galvanized wires stretched along posts 25 to 30 feet apart in the row. The end posts are anchored or braced. They get most of the pull.

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 cross-arms 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.

The four-wire trellis has two top wires rather than one. Top wires are fastened to the post or a cross-arm. Lower wires may be fastened to the cross-arms 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 by notches or hooks, it can be temporarily unhooked and swung out over the new canes to pull them into the row.

The cane weaving technique may be used on productive soils where the plants produce vigorous canes 8 feet tall or higher. Some tonnage may be gained by leaving longer canes. Berry size will be reduced slightly. If the canes grow to 8 or 9 feet, they can be cut back 18 inches after weaving.

The tips may be bent down and tied to the top trellis wire, but it is faster to bring the canes over the wire and back under. Wedge the next cane or bundle of canes between the tips and the trellis wires. Canes may be woven on a single top trellis wire, but where growth is so vigorous as to favor weaving, two top trellis wires with cross-arms are desirable. It is best if there are not more than three or four canes in each bundle when the canes are bent down and woven.

**Pruning.** Canes that have produced fruit should be cut out any time from the end of harvest through late winter. Cutting them soon after harvest simplifies late-season spraying for insects, diseases, or weed control. It also simplifies growing winter cover crops. While removing old canes, the new weak canes should be pruned out as well. Canes should be cut off as low 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 the good, strong canes each
plant will produce to bear fruit. This may mean 8, 10, or, with exceptionally good growing conditions, as many as 12 red raspberry 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 or 5 1/2 feet. In areas 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.

In principle, the canes in each hill are divided into 4 parts and tied to 2 outside wires in a "tepee" fashion. During the spring when the new canes are about one foot high, the wires are spread out by a pivoting 24-inch section of wood, allowing the new canes to grow inside the wires.

The training system makes it possible to remove the old canes mechanically soon after harvest.

This system reduces labor costs and allows the new canes to go into dormancy more quickly 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 1974 Proceedings of Western Washington Horticulture Association meetings.

Treating the Posts. Treating the posts with a 4 percent solution of pentachlorophenol will extend their life materially. To make the 4 percent solution, mix a gallon of Penta (40 percent 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 desirable plantings.

CANE LENGTH AND DIAMETER

Cane quality, i.e. the ability to produce berries, is largely a matter of cane diameter and distance between buds. In general, the larger the cane diameter, the greater the yield. Since large diameter tends to go with tall canes, yields increase with height. However, if cane height causes a large distance between buds, or if height growth occurs late in the season, the beneficial effects of cane diameter may be offset.

Fertilize and irrigate to obtain a sizeable number of large diameter, short internode canes. Reducing the number of new shoots allowed to develop per hill increases cane quality. During pruning, eliminate small diameter, long internode canes. Try to leave 10-12 good diameter canes per hill to fruit.
BASAL CANE BURNING

Several years' research in Washington and Oregon and considerable commercial experience has indicated that under certain conditions the practice of burning back the new raspberry shoots (primo canes) one or more times with dinoseb (dinitro-ortho-sec. butyl phenol) can be of considerable benefit in terms of yield increase, ease of picking, less fruit rot and ease of training and pruning. This benefit is attributed to a reduction of cane height and increase in the number of buds below 5 1/2 feet.

Cane burning should be practiced only in vigorous, well-managed plantings with cane growth of 8-10 feet or more. Older, or weak fields with canes under 7.5 feet in height should not be subjected to cane burning. Instead efforts should be concentrated on improving fertility, irrigation practices, weed control and general management.

TIMING

Apply in April when new canes are 4-8 inches in height. Canes 8-12 inches high will be defoliated but may not be killed because they are already beginning to harden. Only one application is normally used. If irrigation is used, or the soil has good water retention, a second and third application may be applied at 20-30 day intervals. However, using more than one application involves greater risk to the next season's crop as canes may be shortened more than desired. Each application will reduce final cane height from a few inches to a foot, depending on plant vigor and climatic conditions. If vigor of the planting is marginal, use a hand-held spray gun and avoid spraying new canes in the hill.

MATERIALS

Use Dinoseb (Sinox or Dow General) at 2 quarts plus 4 quarts Superior 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. Kerosene or fuel oil may be used instead of Superior oil, but vigorous agitation is necessary to maintain a uniform spray mix. Paraquat is neither effective nor registered.

RATE

The amount of spray mixture necessary to cover one acre varies with the stage of new growth. Up to 100 gallons or more may be required to cover an acre. The foliage must be thoroughly wetted. Insufficient coverage will result in incomplete killing which subsequently causes weak malformed canes.

EQUIPMENT

Use a weed type sprayer at 40 to 80 psi. with a fan-type nozzle (single or double). High pressure or small nozzles cause fogging which may result in damage to other foliage. Foam type nozzles and special foam adjuvants can be used to reduce spray drift.
WEATHER CONDITIONS

If possible spray on a sunny day with a temperature between 50 and 70 degrees. Do not spray on a hot and/or windy day. Avoid spraying during the evening or during inclement weather.

CAUTION

Casoron (dichlobenil) used for weed control has in some instances inhibited cane growth. Cane burning in addition may cause excessive stunting.

FERTILIZERS

Raspberries produce best on large diameter canes with short internodes. For most varieties, this condition is attained with an average cane height of about 8 feet. Ten to 12 canes of this size per hill appear to give best yields.

The fertilizer program can be adjusted to give this type of growth. Although fertilizer elements other than nitrogen (N) do not generally have a marked effect on vigor, they are necessary and should be applied according to soil test recommendations (see Fertilizer Guide 22). Plant vigor can be adjusted by varying the N rate.

Raspberry varieties vary in vigor. Meeker and Willamette require less N than Sumner or Puyallup. Annual applications of N should be reduced when there is too much growth. If cane growth is inadequate, more N can be used.

Soil testing services are provided by various commercial companies and Washington State University. Shipping cartons and instruction sheets may be obtained by contacting the local Cooperative Extension Service.

Western Washington

Most fields in western Washington should be given 40-80 lb. N per acre in March or early April. It should be applied to the soil surface beside the plant rows or it can be banded with the phosphorus (P) and potassium (K).

Make a soil test periodically and apply P and K according to recommendations in the fertilizer guide for western Washington (FG 22).

Calcium, magnesium and boron may be low in coarse, sandy soils. Their levels can be determined by a soil test. Required amounts should be broadcast and incorporated into the soil.

If manure is applied, use a lower rate of N application. Apply N, P, and K fertilizers in the spring when growth starts. They should be banded 12-18 inches from the center of the row and 2-4 inches deep.

Heavy rates of manure may make the plants more susceptible to winter injury by causing them to continue to grow late in the season.
Eastern Washington

Apply 80-100 lbs. of N during March or early April. Specific information for fertilizing raspberries in eastern Washington is not available but in general the recommendations in FG-22 are satisfactory. Both boron and zinc are frequently deficient. Where zinc deficiency is suspected before planting, incorporate 20-30 lbs. zinc per acre as zinc sulfate. Zinc deficiency that occurs after planting may be corrected with 1-3 foliar sprays during the spring growth period using 1 lb. zinc sulfate per 100 gallons of water. Boron may be applied either to the soil or as a foliar spray.

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

FOLIAR FERTILIZERS

Leaf feeding is not generally recommended for raspberries. Soil applications made according to soil test results usually supply all the nutrients needed for maximum production. Little proof is available that foliar sprays as a routine part of the fertilizer program are any better than a good soil fertility program.

Unexpected deficiencies sometimes occur, especially in boron, manganese, iron and occasionally zinc. When these occur, foliar sprays may be 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 of the 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.

Many growers will want to try foliar feeding. That's O.K. Try it. But please leave a few rows unsprayed to check results. Most of the time it will be just a drain on your pocketbook with no tangible results, provided you are already on a good fertility program.
## Deficiency Symptoms and Foliar Sprays

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Visual Symptoms</th>
<th>Material*</th>
<th>Rate/100 gal.</th>
<th>Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Boron</strong></td>
<td>Bud break in the spring is delayed, many buds die, leaves from damaged buds may produce elongated, slender leaves giving a &quot;fern-like&quot; appearance. Severe deficiency may cause new shoots to die back.</td>
<td>Borospray</td>
<td>2 lbs. commercial product</td>
<td>Anytime leaves are present. Best in the spring.</td>
</tr>
<tr>
<td><strong>Iron</strong></td>
<td>Young, terminal leaves turn yellow or white followed by browning of leaf margins and interveinal areas. Basal leaves remain green. Seldom found in western Washington.</td>
<td>Iron chelate</td>
<td>Follow label instructions</td>
<td>Apply to leaves when symptoms appear</td>
</tr>
<tr>
<td><strong>Manganese</strong></td>
<td>Older leaves turn yellow between the veins. Veins and young terminal leaves remain green.</td>
<td>Manganese sulfate or Manganese chelate</td>
<td>2 lbs. commercial product, as soon as leaves are well developed.</td>
<td></td>
</tr>
<tr>
<td><strong>Zinc</strong></td>
<td>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.</td>
<td>Zinc sulfate</td>
<td>12 lbs.</td>
<td>During dormant period just as buds start to swell. 1 lb.</td>
</tr>
</tbody>
</table>

*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 in western Washington. Yield increases result from larger berry size and from more numerous, larger diameter canes. The amount of increase in berry production depends largely on soil type and rainfall.

No one general rule can be made for determining the irrigation needs of raspberries. 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 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. Many growers on medium heavy soils plan to irrigate heavily just ahead of the first picking and do not put on any more during the season. 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.

The timing and amount of water to apply can be determined by use of an evaporation pan. (See 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 condition 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. There may be others. Check with your Extension Agent or the weather bureau.

In areas of Skagit County where moisture is available from an underground water table, it will probably be necessary to 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. The evaporation pan method of scheduling can be used satisfactorily.

Scheduling Irrigation for Raspberries from Evaporation Measurements

Soils vary in the amount of water they have available for plant use. Felida silt loam has 9.6 inches available in the 4-ft effective rooting zone area while Lauren sandy loam has 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. Following is an example of the calculations necessary to schedule the irrigation of raspberries growing in sandy loam soil:

   **Water Use Between Irrigation**
   
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effective root depth</td>
<td>4 feet</td>
</tr>
<tr>
<td>Avail. water/ft of soil depth</td>
<td>2.0 inches</td>
</tr>
<tr>
<td>Total available (4 x 2.0)</td>
<td>8.0 inches</td>
</tr>
<tr>
<td>Use 65% before irrigation (.65 x 8.0)</td>
<td>5.2 inches</td>
</tr>
<tr>
<td>Evaporation equivalent (5.2 ÷ 1.0)</td>
<td>5.2 inches</td>
</tr>
</tbody>
</table>

   **Irrigation**
   
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sprinkler application rate</td>
<td>.33 in./hr.</td>
</tr>
<tr>
<td>Sprinkler efficiency</td>
<td>75%</td>
</tr>
<tr>
<td>Length of irrigation needed</td>
<td>5.2</td>
</tr>
<tr>
<td></td>
<td>.33 x .75</td>
</tr>
<tr>
<td></td>
<td>21 hr. duration</td>
</tr>
</tbody>
</table>

   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. It has been determined that raspberries use 1 inch of water for each inch lost from the evaporation pan. This means that when 5.2 inches of water are lost from the evaporation pan, 5.2 inches of irrigation water must be applied to bring the soil moisture back to field capacity. An irrigation scheduling board (ask your extension agent for Ext. Cir. 341) can be used to keep the record of 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 Lauren 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. Following is an example of how this can be calculated:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time between irrigations</td>
<td>10 days</td>
</tr>
<tr>
<td>Evaporation measured during</td>
<td>2.56 inches</td>
</tr>
<tr>
<td>the 10 day period</td>
<td></td>
</tr>
<tr>
<td>Inches of irrigation needed</td>
<td>2.56 inches</td>
</tr>
<tr>
<td>(2.56 x 1.0)</td>
<td></td>
</tr>
<tr>
<td>Length of irrigation needed</td>
<td>10.3 hours</td>
</tr>
<tr>
<td></td>
<td>.33 x .75</td>
</tr>
</tbody>
</table>
3. Other growers want to run their irrigation systems a fixed number of hours each time they irrigate. Evaporation measurements can be used to guide this practice as in the following example:

<table>
<thead>
<tr>
<th>Desired length of set</th>
<th>12 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application rate</td>
<td>.33 in/hr</td>
</tr>
<tr>
<td>Application in 12 hours</td>
<td>4 inches</td>
</tr>
</tbody>
</table>

Usable application at 75% efficiency (4 x 0.75) 3 inches
Amount to use between irrigations 3 inches

Hence, irrigate when evaporation indicates about 3 inches of water has been removed from the soil moisture reservoir (when \(3 + 1.0 = 3.0\) inches of evaporation has occurred after the last irrigation) 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 of drip irrigation 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) possibility of vandalism.

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. **Soaker 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, and 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 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 ft. intervals). The length of time needed to apply the water varies with plant development and weather conditions. Continuous application is not desirable for raspberries.
WEED CONTROL

Problem Description

Generally and by over-simplification, weed problems in crop land, including red raspberries, can be classified by the growth habits of the weeds themselves, i.e. 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 preventive 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.

Perennial weeds live for three years or more and reproduce by seed as well as by vegetative propagation. 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 Techniques

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 a 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 especially are hard on brass nozzles).

Screens and Screening

Always put clean or well-screened water into the spray tank. Salty or hard water may cause gumminess or precipitation 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. Main-line 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 a 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, check screens frequently and watch for plugged nozzles.

Pre-Plant Herbicides

Most chemicals that kill perennial weeds 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 killed before raspberries are planted.

Tillage plus cropping is an effective and economic program for reducing large infestations of perennial weeds. The time needed to obtain control by clean cultivation depends on soil type, climate, weed species, etc. It can be shortened by growing competitive crops such as alfalfa, rye, peas, etc., or annual row crops.

In addition, herbicides can be used in combination with tillage, or on certain crops to give better control of many weeds. For instance, EPTC applied to quackgrass infestations the fall before raspberries are planted will materially reduce such infestations. Atrazine in corn and 2,4-D, MCPA or dicamba in cereal grains will also reduce the vigor and extent of certain perennial broadleaved weeds such as Canada thistle, dock and some grassy weeds. Labels of these chemicals should be carefully read to prevent possible damage to new raspberry plantings from herbicide residue. 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, are very good. 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 not used.
Weed Spray Guide

The chemicals (herbicides) listed in this table are registered for use on raspberries and recommended by Washington State University.

The herbicides Diphenamid (Dymid, Enide) and CIPC (chloropropham, Furloe, chloro IPC) are also registered for use on raspberries but not recommended by Washington State University.

Herbicides such as Paraquat and Amitrole-T are not registered on raspberries and therefore illegal to use.

<table>
<thead>
<tr>
<th>Weed Description</th>
<th>Herbicide</th>
<th>Amount</th>
<th>Timing</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual broad-leaved and grassy weeds</td>
<td>Simazine (Principal)</td>
<td>1 lb/A</td>
<td>Apply prior to emergence of weeds after planting.</td>
<td>1. Soil must be settled firmly around the plants before application of the herbicide may be carried into crop root zone.</td>
</tr>
<tr>
<td>in new plantings</td>
<td></td>
<td></td>
<td></td>
<td>2. DO NOT apply to excessively loose soil.</td>
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<td></td>
<td></td>
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<td></td>
<td>3. Maintain constant agitation of spray mixture. Use a strainer of 50 mesh or larger.</td>
</tr>
<tr>
<td>Field horse-tail, quackgrass, and annual weeds in established plantings</td>
<td>Dichlobenil (Casoron)</td>
<td>Apply in December or January to cold, wet soil. Rate per acre assumes full coverage. For band applications, rate per sq.ft. covered is the same but amount needed per A of crop is reduced.</td>
<td>1. Reduce rate to 2 lb/A on light, sandy soils. This rate is too low for quackgrass control but is effective on field horsetail.</td>
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<tr>
<td></td>
<td></td>
<td>4 lb/A granular</td>
<td></td>
<td>2. Use on plantings established at least 6 months.</td>
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<td></td>
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<td></td>
<td>3. DO NOT apply less than 6 months before harvest.</td>
</tr>
<tr>
<td>Weed</td>
<td>Herbicide</td>
<td>Amount</td>
<td>Timing</td>
<td>Remarks</td>
</tr>
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</tr>
<tr>
<td>Annual broad-leaved and grassy</td>
<td>Diuron</td>
<td>(Active ingred-</td>
<td>Apply in the spring</td>
<td>1. Apply only to plantings established 1 yr. or more.</td>
</tr>
<tr>
<td>weeds in established plantings.</td>
<td>(Karmex)</td>
<td>ident) 1.6 lb/A</td>
<td>(March-April) and again in the fall (September-October) if necessary.</td>
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<tr>
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<td></td>
<td>2. Direct the spray across the row at the base of the hills in order to minimize spray damage to the plants.</td>
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<td>3. DO NOT apply to very loose, sandy, or coarse soils.</td>
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<td></td>
<td>4. After several years and weeds are under control, reduce the rate to one application of 1.6 lb/A per year.</td>
</tr>
<tr>
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<td></td>
<td>5. Maintain constant agitation of spray mixture. Use a strainer of 50 mesh or larger.</td>
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<tr>
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<td>6. DO NOT replant to any crop within 2 yrs. after application.</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7. DO NOT apply less than 2 months before harvest.</td>
</tr>
</tbody>
</table>

**Remarks:***
- 1. Apply only to plantings established 1 yr. or more.
- 2. Direct the spray across the row at the base of the hills in order to minimize spray damage to the plants.
- 3. DO NOT apply to very loose, sandy, or coarse soils.
- 4. After several years and weeds are under control, reduce the rate to one application of 1.6 lb/A per year.
- 5. Maintain constant agitation of spray mixture. Use a strainer of 50 mesh or larger.
- 6. DO NOT replant to any crop within 2 yrs. after application.
- 7. DO NOT apply less than 2 months before harvest.
Weed | Herbicide | Amount | Timing | Remarks
---|---|---|---|---
All weeds | Dinoseb (Active in- (Sinox Gen- eral, Dow General) dinoseb in oil) | 2.5 lb | Apply during the winter months. | 1. Thoroughly cover soil and weeds while minimizing contact to plants.

Dinoseb can also be mixed with oil and water if an emulsifier (adjuvant or spreader) is added. A mixture of 25% oil and 75% water is just as effective provided there is good agitation.

SPRAYER CALIBRATION

Every sprayer must be calibrated to apply the proper quantity of material uniformly. 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 as follows:

1. Check machine to see that all parts are working properly.
2. Clean pump, screens, lines, and nozzles thoroughly.
3. Note tractor gear and throttle setting for speed desired.
5. Pull sprayer at actual operating speed to double check.
6. Measure off a test strip by setting 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 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:

\[ g.p.a. = \frac{\text{gallons water added} \times 200}{\text{boom length or spray swath}} \]

in feet

Sample calculations:

Over-all spray - If spray boom is 25 feet in length and 10 gallons are required to refill tank, then spray rate

\[ g.p.a. = \frac{10 \times 200}{25} = 40 \text{ gallons per acre} \]

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

\[ g.p.a. = \frac{1.5 \times 200}{6} = 50 \text{ gallons per acre} \]

*Factor of 200 is obtained by dividing area per acre (43,500 sq. ft.) by length of test strip in feet (218).

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

**YEARLY CALENDAR**

| January | -- Attend Horticultural Association meetings and equipment shows.                |
|        | Repair and maintenance of equipment (don't forget irrigation equipment or to check sprayer nozzle disks for wear). |
|        | Prune out weak canes and old fruiting wood if not already done.                  |
|        | Do not top canes yet. Tie to trellis.                                          |
|        | Apply manure.                                                                   |
| February| -- Continue January activities.                                                 |
|        | Start topping during late February.                                            |
|        | Spray for crown borers if needed and not already done.                         |
|        | Plant new fields, weather permitting.                                          |
| March  | -- Apply fertilizer.                                                            |
|        | Apply herbicides.                                                               |
|        | Plant new fields, weather permitting.                                          |
|        | All pruning and training should be complete by April 1.                         |
April -- Limesulfur clean up spray when buds show breen.
Hoe or spray out extra shoots and weeds around and between hills.
Begin cultivation to control weeds (shallow).
Fertilize newly planted fields.
Apply dinitro spray for cane control when new shoots are 6-10" high (vigorous fields only).
May -- Apply second dinitro cane control spray, if needed.
Hoe out extra shoots between hills if dinitro not used.
Apply worm spray before bloom, if needed.
June -- Line up picking crew.
Apply fruit rot control sprays.
Tuck new shoots inside holding wires.
Irrigate when necessary. Make sure field is at field capacity just before picking.
During bloom, do not spray insecticides that will kill bees.
Apply fruit worm and orange tortrix sprays, if needed.
Cultivate before harvest.
July -- Harvest time.
Apply fruit rot sprays as needed.
Irrigate only if needed.
August -- Irrigate after harvest.
Remove old fruiting wood (optional).
Cultivate once in early August.
Plant cover crop.
Go salmon fishing!
September -- Mow weeds and/or cover crop.
Irrigate in late September -- Eastern Washington only.
Fumigate soils for spring planting.
Order plants for spring planting.
October -- Start removal of weak shoots and old fruiting wood.
Spray for crownborer, if borers are present.
Apply fall herbicides.
Collect soil samples for soil tests.
Order fertilizers, spray materials, other supplies and equipment needed for next season.
Winterize all equipment; drain sprayers completely.
November -- Continue pruning (do not head back).
Repair trellises and replace rotted posts.
Install trellises in new plantings.
Apply lime (if necessary).
December -- Apply Casoron 4 G for quackgrass control.
Apply manure.
Continue pruning and trellis repairs on good days.
Harvest and Post Harvest Practices

Harvest

Careful harvesting and handling of raspberries will bring the grower higher returns for his crop and proper planning and preparation are important for a smooth running operation. The picking season for red raspberries covers a period of 4 to 6 weeks beginning in late June. The number of hand pickers needed will vary with vigor of plants, weather and skill of the workers. A crew of 4 to 5 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 12 to 15 good workers. Naturally, there is a wide range in picking ability. A beginning 10-year old may harvest only 45 pounds while a teenager or adult can average more than 100 pounds and skillful pickers can exceed 150 pounds in a 6-hour day.

The picking interval varies with stage of harvest, variety and weather conditions. Five or 6 days may elapse between the first and second pickings; however, a three day schedule is common during warm weather.

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 to recruit extra help to ensure clean-up 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 plant to market. Reject all moldy or insect-damaged berries 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 transfer to the picking container. Pick with hands together, palms up to catch falling berries, work from the outside in. Pawing or digging into the vines will damage fruit spurs and reduce both yield and grade.

Small belt buckets or carriers are recommended for minimum handling and easy transfer of fruit to the hallocks or bulk trays. Shipping flats should never be set on the ground because adhering soil contaminates fruit below when stacked.

Raspberries are most firm in the cool morning hours and harvesting should be suspended in early afternoon on warm days. Prompt delivery to the processing plant is desirable.

While awaiting shipment, filled flats should be shaded from the sun at all times. Air space between stacks is necessary to facilitate release of field heat.

Another consideration is the location of check stations in the field so that pickers do not have to carry filled trays long distances. It is advisable to spend one day acquainting new pickers with the 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, as well as field heat. Prompt delivery to the processing plant is probably more critical for machine harvested berries. Raspberries are not stored commercially. If held for a day or two, they should be kept at 31 to 32° and a high humidity of 90 to 95 percent.
Post Harvest

Old canes can be removed anytime from the end of harvest through late winter. Follow the guidelines as described under pruning. Fall pruning is desirable since it simplifies late season spraying and other cultural practices. It also improves light conditions allowing new canes to go into dormancy more quickly. Since dormancy is very important in minimizing freeze injury, plantings should not be fertilized or irrigated in late summer or fall. Irrigation should be discontinued after August 15. Fall cultivation, since it stimulates root growth, may also delay dormancy.

Fall mowing will prevent seed formation of annual weeds, aiding the weed control program.

MECHANICAL HARVESTING

Several machines have been used experimentally to harvest red raspberries in Washington, Oregon and British Columbia. These have varied from portable platforms, on which pickers stand and pick fruit as the machine moves down the row, to catching frames which catch berries shaken loose by hand, to complex machines that straddle the row, shake the berries from the plants, and elevate them to the top of the machine where they are run across a short inspection belt and into flats.

These machines have picked from 60 to 80 percent of the ripe fruits without serious damage to immature fruit left on the plants or to the plants themselves. For several years a few growers have successfully used the large machines that straddle the row, but for the most part, growers feel that hand-pickers are still the most satisfactory as long as they are available. Reasons are as follows:

1. Machine-picked fruit is of lower quality and more difficult for processors to handle because berries tend to collapse from the rolling, dropping and jiggling in the machine operation. It is also difficult to eliminate overmature berries.

2. Shaking the canes to remove the berries shakes out insects of many kinds. Some of them enter the berries and are difficult to remove. A good air cleaner with a well-directed strong air blast minimizes, but does not completely eliminate this problem. Special insect control programs are required in advance of machine harvesting.

3. In years when there is an appreciable mold problem, it is practically impossible to separate or sort damaged berries from sound fruit in the machine harvesting operation.

4. The smaller, less expensive machines which pick from one side of the row require special trellising and training of the canes in order to get the fruit out away from the row and over the area where the machine runs, so that the fruit will drop onto the catching frame.

Some varieties are more suitable for mechanical harvesting than others. The variety descriptions indicate which are most suitable.
POLLINATION

Pollination is defined as the transfer of the pollen grains 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. Research has shown that bees are responsible for 90 to 95% of raspberry pollination, resulting in usable berries. Wind has very little, if any, effect on pollination. The transfer of pollen between varieties (cross pollination) does not appear to be an important factor. Honey bees are responsible for most of the pollination activity, although bumble bees and other wild bees may serve more effectively during windy or cold weather.

Introduction of honey bee colonies is important in order to ensure adequate pollination. At least one hive per acre is generally recommended.

Many of the insecticides recommended for the prebloom or post-harvest 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 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 would seriously affect pollination and subsequent fruit development.

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

Varieties. Some varieties tend to crumble more than others. The Tahoma variety had considerable tendency to crumble. Seedlings of the Latham variety often bear crumbly fruit. 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 of most varieties 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, but specific viruses associated with raspberry crumble have not been identified.
In certain instances, bacterial and fungus diseases—Pseudomonas (bacterial blight), Cladosporium, and Botrytis (gray mold)—have been suspected of contributing to crumble.

Other Causes. Chemical damage to flowers from in-bloom applications of insecticides or fungicides could damage the anthers, pistils, or pollen.

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 stock.

Crumbly berry condition can in some cases be controlled after proper diagnosis of the cause(s).

COLD INJURY

Cold injury results from several different temperature conditions including:

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. Frost after growth has started in the spring.

Damage occurring from early freezes before canes are mature is probably the most common type of cold injury. Fortunately, there are some things growers can do to prevent it. These involve cultural practices which speed up the hardening off process by stopping cane growth early.

Irrigation — Western Washington: Put on the last irrigation soon after harvest ends. Eastern Washington: An additional irrigation during late September just before the water is shut off will help prevent dehydration of canes during midwinter.

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.

Cultivation — Do not cultivate after mid-August. An overwinter nonleguminous cover crop or the natural growth of weeds 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 cover crop need to be controlled, keep them down by mowing.

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.

Freeze injury can also be caused by low levels of carbohydrates in the canes. This can be an indirect result of inadequate amounts of certain soil nutrients and/or plant disease organisms. For example, field tests have indicated that
there is a correlation between the levels of parasitic soil nematodes and freeze injury. Premature defoliation as a result of mites, insects or other causes will reduce carbohydrate storage and consequently increase freeze injury susceptibility.

Generally buds on the lower part of the canes with the exception of those at the very tip, tend to be more susceptible to freeze injury. In many cases of exposure to low winter temperatures, the primary (main) bud of a future lateral is killed while the secondary buds develop normally. Buds that have been partially injured may show normal development initially and decline later. Observations have shown that in healthy plantings symptoms of moderate bud injury may be overcome by the plant during later development. New plantings are generally more susceptible to freeze injury than established plantings.

Late winter injury and frosts are best controlled by proper selection of planting sites and varieties. 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 limited or of no value.

INSECT AND DISEASE SPRAY GUIDE

When to Spray

The purpose of this spray schedule is to help growers know when to be on the lookout for various diseases and insect pests -- not to recommend routine sprays for all the problems listed. Some problems of raspberries occur almost every year and require routine preventive treatments. The best example is fruit rot. 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. 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.

Tips on Application

Preplant treatments. Application of insecticides to the soil prior to planting requires only that enough water be used for good coverage, usually 50 to 100 gallons per acre. The chemical should be incorporated as soon as possible by double-disking or rotary tillage. Soil fumigation for nematodes is best accomplished in early fall while soil temperatures are above 45 degrees F.

Foliation treatment. Application of pesticides to raspberry 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 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. Thorough coverage is important, especially in treating for plant disease control.
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 early morning or evening when bees are not present. None of the fungicides recommended are toxic to bees.

Insect Pests

Root weevils. There are several species of weevils that attack raspberries, but their life cycles and damage done are similar. The adults are beetles which cause negligible damage by chewing notches in the margins of the leaves. Most damage is done by white, legless larvae which eat the roots of the plants. Adult obscure root weevils occasionally are contaminants of ripe berries. Since DDT can no longer be used, it is necessary to rely on foliage or soil application of less persistent insecticides. The primary means of control of the strawberry root weevil and black vine weevil is application of insecticides to the soil prior to planting. Heptachlor will remain effective for several years. 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 will kill the predaceous insects and mites which give natural control of spider mites, permitting buildup of mites. Therefore, sprays should be applied only when needed.

Dryberry mite. This microscopic mite overwinters 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. The larvae of this moth feed on the tender leaves and buds, but the damage they do in that respect is negligible. 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 shake the canes, the disturbed larvae can drop into the containers and cause the harvested berries to be rejected by processors. It would be best to 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. They 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. The larvae of this moth tunnel in the lower parts of the canes and in the crown. Eggs are laid in late summer and early fall. Sprays are applied in late fall or in winter to kill the new larvae which spend their first winter in a cell just under the bark. The larvae require 2 years to complete their development so sprays must be applied in at least 2 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 of the cane and then continues tunneling downward in the pith. The girdling causes the part of the cane above the injury to wilt. Chemical controls are not needed. Wilted canes can be cut off near the ground and burned to destroy the maggot.

Plant Diseases

The most effective control measures for raspberry and blackberry diseases are those taken before the diseases become serious. Varieties resistant to the major diseases should be planted, if available.

Cultural practices that promote vigorous growth are also important in growing healthy raspberries and blackberries.

Anthracnose. This is a fungus disease that causes severe damage on black and purple raspberries. Although also common on red raspberries, anthracnose does not seriously affect them.

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.

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 frequently are girdled.

Control -- Choose a planting site that has good air drainage. Plant anthracnose-free planting stock. After planting black raspberries, cut off the protruding canes (handles) at ground level.

Make 2 or 3 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 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. This is a 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. 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.

Spur blight. This is a fungus disease that can severely damage red raspberries in the northern part of the United States. Brown or purple spots appear at buds along infected canes. Tissue around the buds darkens; the buds shrivel, 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.

In recent years, the disease has been of little significance in Washington.

Control -- Apply sprays recommended for anthracnose. Remove and burn infected canes soon after harvest.

Fruit rot. Fruit rots are widespread and develop fastest on overripe and bruised raspberries.

Warm, wet weather at harvest favors the development of fruit rots.

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.

Verticillium wilt. This is a soil-borne fungus disease that is widespread in the northern half of the United States and along the Pacific Coast and occurs on many crops. It is particularly damaging to black raspberries.

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.

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.
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. 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.

Control — Plant certified raspberries that have been found to be free from the mosaic viruses, 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 raspberries; raspberries that leaf out late in spring are likely to be diseased. 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-producing areas of the Pacific Coast. In the spring, a few leaves on infected red raspberry plants 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 varieties, or may be crumbly in other varieties. Certain varieties show no noticeable damage when infected, and are classed as tolerant.

Ringspot in red raspberry is caused by a virus first identified from tomato, and thus designated tomato ringspot virus. However, tomato ringspot virus readily infects many hosts, including weeds, and is spread through the soil by the dagger nematode.

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. Although the exact cause is not known, there is evidence to indicate the disease can spread in a field. Roguing of affected plants is suggested.
RASPBERRY DECLINE

This name is used by many growers to describe a condition affecting many red raspberry plantings. Symptoms usually include wilting and marginal drying of leaves on fruiting canes and on developing young canes. Often the condition is scattered in the field, with only occasional plants at first showing the symptoms. Later it spreads down the rows and often to adjacent rows. The 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 in the past 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 as to the exact cause is difficult. To most effectively combat this disease situation one must more carefully identify the one or more causes involved. The remainder of this discussion will outline the several specific diseases that may be responsible for this generalized condition in red raspberries.

Observations indicate that 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 found to be associated with the declining plants. These species are capable of causing severe root rot. Reports indicate that there are differences among the raspberry cultivars as to their susceptibility to wet soil root rot. The varieties Canby and Washington are most susceptible, with Willamette and Puyallup being intermediate in reaction, while Sumner and Newburgh are the most resistant. From limited observations, Fairview and Meeker appear to have about the same level of resistance as Willamette and Puyallup.

Control of raspberry decline is best achieved as follows:

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 and in some cases may help in the control of raspberry decline.

Nematodes. Raspberries and blackberries are subject to attack by a number of nematode species. The most damaging types in Washington are root knot, root lesion, and dagger nematodes. Nematode attack on plant roots often increases the severity of other soil-borne plant diseases, especially root rots and verticillium wilt.

Symptoms of nematode injury are best expressed on bearing canes. These may 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 early leaf drop may occur, especially during dry weather. Nematode infected plants may be more susceptible to winter injury.

Control — Nematodes will become progressively more damaging the longer raspberries and blackberries are cultivated. Periodic rotations of a wide variety of crops will help to reduce nematode population. After the canes have been destroyed, leave the soil untilled, or grow small grain for 3 or 4 years. Avoid other highly susceptible crops such as most vegetables or forage legumes.

It is necessary to obtain nematode-free planting stock. For field planting, use only planting stock that is nematode-free.

The use of nematicides in nurseries is particularly important. Chemical treatments for the control of nematodes are usually applied into the soil by injection apparatus.

On fields intended for fruit production use DD, Telone, Vidden D or Vorlex, or similar compounds for preplanting treatments. Do not use these in or around the soil of established, growing plants.

The rates of application of these chemicals vary, depending on types of formulations, uses, and methods of application. For specific dosage recommendations, follow the directions on the label.

### TREATMENT GUIDE

<table>
<thead>
<tr>
<th>Disease or Insect</th>
<th>Pesticide (use one)</th>
<th>Amount of formulation per acre</th>
<th>Minimum days between last application and harvest</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nematodes</td>
<td>Telone</td>
<td>Follow manufacturer's only</td>
<td>Preplant</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DD</td>
<td></td>
<td></td>
<td>Have nematode analysis run and base fumigation on results. It is best to fumigate in late summer or early fall before anticipated planting in spring.</td>
</tr>
<tr>
<td></td>
<td>Vidden D</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vorlex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strawberry root weevil</td>
<td>Heptachlor</td>
<td>2 EC 2 gal. only</td>
<td>Preplant</td>
<td>Apply to soil in sufficient water for good coverage. Incorporate by disking or rotary tillage.</td>
</tr>
<tr>
<td>Black vine weevil</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rough strawberry root weevil</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
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### ESTABLISHED PLANTINGS

#### Dormant and Prebloom Period

<table>
<thead>
<tr>
<th>Disease or Insect</th>
<th>Pesticide (use one)</th>
<th>Amount of formulation per acre</th>
<th>Minimum days between last application and harvest</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Berry Mite</td>
<td>Lime Sulfur</td>
<td>4 gal. (1st spray)</td>
<td>2 days</td>
<td>See Remarks</td>
</tr>
<tr>
<td>Powdery Mildew</td>
<td>Lime Sulfur</td>
<td>20 gal./A/ (10 gal. per 100 gal. rate)</td>
<td>2 days</td>
<td>See Remarks</td>
</tr>
<tr>
<td>Spur Blight</td>
<td>Kerthane</td>
<td>18 1/2% EC 1 1/2 qt. 35% WP 1 1/2 lb.</td>
<td>Apply Kelthane in delayed-formant period and repeat if needed.</td>
<td></td>
</tr>
<tr>
<td>Cane Blight</td>
<td>Kelthane</td>
<td>10 gal./100 gal. rate</td>
<td>2 days</td>
<td>Apply 10 gal./100 gal. rate as dormant spray only.</td>
</tr>
<tr>
<td>Anthracnose</td>
<td>Kelthane</td>
<td>8 gal./A/ (4 gal. per 100 gal. rate)</td>
<td>Dormant application at 4 gal. rate followed by a delayed-dormant spray using 2 1/2 gal./100 gal. rate.</td>
<td></td>
</tr>
<tr>
<td>Rust (on Washington and Cuthbert varieties only)</td>
<td>Ferbam 95WP</td>
<td>3 lb./A/ (1 1/2 lb. per 100 gal. rate)</td>
<td>Apply either fungicide just before bloom.</td>
<td></td>
</tr>
<tr>
<td>Anthracnose</td>
<td>Captan 50WP</td>
<td>4 lb./A/ (2 lb. per 100 gal. rate)</td>
<td>0 days</td>
<td></td>
</tr>
</tbody>
</table>

1/ Gallons or pounds of formulation per acre based on 200 gallons of spray mixture being applied per acre.
### Disease or Insect

<table>
<thead>
<tr>
<th>Disease or Insect</th>
<th>Pesticide (use one)</th>
<th>Amount of formulation per acre</th>
<th>Minimum days between last application and harvest</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strawberry root weevil</td>
<td>Heptachlor 2 EC</td>
<td>1/2 gal.</td>
<td>50% WP 3 lb.</td>
<td>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.</td>
</tr>
<tr>
<td>Black vine weevil</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rough strawberry root weevil</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Western raspberry fruitworm</td>
<td>Diazinon 4 EC</td>
<td>1 qt.</td>
<td>1 lb.</td>
<td>Apply when blossom buds separate and again just before blossoms appear. Apply only if beetles are present. Do not apply if blossoms are present because it is highly toxic to bees.</td>
</tr>
<tr>
<td>Orange tortrix</td>
<td>Guthion 2 EC</td>
<td>1 qt.</td>
<td>50% WP 1 lb.</td>
<td>Apply only if larvae are present. Other leafrollers are often seen in lower parts of canes but rarely require treatment. Poisonous to bees -- do not apply if blossoms are present.</td>
</tr>
<tr>
<td>and other leafrollers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fruit rot</td>
<td>Captan 50WP</td>
<td>4 lb. / A/</td>
<td>0</td>
<td>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.</td>
</tr>
</tbody>
</table>

1/ Gallons or pounds of formulation per acre based on 200 gallons of spray mixture being applied per acre.
### Disease or Insect
- Western raspberry fruitworm
- Spider mites
- Obscure root weevil
- Crown borer

### Pesticide (use one)
- Rotenone
- Kelthane
- Guthion
- Malathion
- Diazinon
- Parathion

### Amount of formulation per acre
- 5% WP 2 lb.
- 18 1/2% EC 1 1/2 qt.
- 35% WP 1 1/2 lb.
- 4 EC 1 qt.
- 50% WP 2 lb.
- 4 EC 1 qt.

### Minimum days between last application and harvest
- 1
- 2
- 3
- See Remarks

### Remarks
- Apply 7 days after first bloom and repeat twice at 10-day intervals. Do not use if diazinon was applied prior to bloom unless the beetles are seen in the field.
- Apply only if needed, which is rare before the end of harvest.
- Apply only to the soil in the crown area. Do not apply to foliage. Highly toxic to bees.
- Apply to foliage and repeat in 1-2 weeks. If bloom is present, apply in evening or early morning when bees are not foraging.
- Apply only if the species has been identified as a problem in the field.
- 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.

---

**Postharvest period**

<table>
<thead>
<tr>
<th>Disease or Insect</th>
<th>Pesticide</th>
<th>Amount of formulation per acre</th>
<th>Minimum days between last application and harvest</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spider mites</td>
<td>Kelthane</td>
<td>18 1/2% EC 1 1/2 qt.</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Crown borer</td>
<td>Diazinon</td>
<td>4 EC 1 qt.</td>
<td>See Remarks</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Parathion</td>
<td>4 EC 1 qt.</td>
<td>See Remarks</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>50% WP 2 lb.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>25% WP 4 lb.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

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.
ENVIRONMENTAL HAZARDS

Our environment is shared with hundreds of thousands of organisms such as wild animals, fish, birds, plants, insects, bacteria, fungi, and many more. Most species within this balanced system are harmless to our crops, or even beneficial. Only a few compete with man and become pests to him. Many techniques have been developed to prevent their damage to our crops. Encouraging natural predators, sterilization to prevent their breeding, introduction of pest diseases and resistant varieties of crops are only a few of the methods used to combat these problems.

The use of chemical pesticides is another technique developed for crop protection, and, like other methods, is not always perfect. The poisoning effect of chemicals is not specific to just pest species. In addition, the continued use of some of these chemicals has resulted in resistant strains of pests which then require heavier doses, more frequent applications or other chemicals to be used.

In spite of their imperfections, pesticides still remain one of the most important and effective means of pest control. If used intelligently and with skill, they can provide large economic returns, and adverse side effects on other organisms can be minimized.

Although they are a useful tool in raspberry management, pesticides should be used carefully and only when needed. This often means a difficult weighing of alternatives. How much damage, down-grade or crop loss will a pest cause if not checked or controlled? Is the pest numerous enough to warrant treatment? Does weather look favorable to increasing damage by the insect or disease organism? Are parasites or predators likely to halt the pest before damage is done?

Know your pest

Proper timing of pesticide applications often requires less chemical and will give better results.

Know your pesticide!

Some pesticides are especially harmful to beneficial species. Where possible, avoid these materials. Bee pollination is very important in the production of raspberries and other berry crops. Therefore, utmost care should be taken to avoid insecticide poisoning of domestic or wild bees.

Use pesticides only if needed!

Low populations of some pests can be tolerated without economic loss.

Avoid treating wildlife habitats!

Wild animals have no control over their surroundings or food supplies. Keep pesticides away from these areas. Do not clean spray equipment or dump excess material in or near lakes, streams or ponds.
PRECAUTIONS

1. Read the label each time you use a pesticide -- no matter how often you have used it and no matter how well you think you know the instructions -- and FOLLOW THE LABEL DIRECTIONS EXACTLY.

2. Clothing -- wear protective waterproof clothing and non-absorbent gloves while spraying hazardous materials. Change and launder clothing and bathe daily.

3. Mask -- when loading or mixing wettable powders or when applying dusts, wear a respirator approved for the material in question by the U. S. Department of Agriculture. An approved respirator should be worn whenever the more volatile of the toxic compounds are sprayed. The filter and pad should be changed at regular intervals.

4. Before using organic phosphorus insecticides (Parathion, Diazinon, Guthion), get in touch with your physician. He will be in a better position to deal with a sudden illness if he is told of probably spraying dates and other details. He may wish you to have a supply of 1/100 gr. Atropine tablets for use in an emergency. This drug should never be used before exposure to organic phosphorus insecticides, for it may hide important warning symptoms. Use one or two tablets only after definite symptoms occur. Never take Atropine without calling your physician at once. Any person who is ill enough to receive a single dose of Atropine should remain under medical observation for 24 hours, because of the fact Atropine may produce only temporary relief of symptoms in what may prove to be a serious case of poisoning. Keep Atropine tablets away from children.

5. Never measure or leave mixtures of insecticides in beverage bottles or in labeled cans or boxes which have formerly contained food products. Each year, tragic, preventable poisonings occur when children obtain food containers filled with insecticide.

6. Do not smoke, chew tobacco, or eat while spraying or while your hands are contaminated, especially with concentrate materials.

7. Mix insecticides according to directions and apply at the recommended rate. Rinse containers 3 times, adding the rinse to the spray tank. Use the least toxic compounds that will do the job.

8. Experience shows that poisoning occurs most often in hot weather. Spraying should be done during cooler periods insofar as possible and extra care taken when it is necessary to spray during periods of high temperature.

9. Bury spilled insecticide and wash contaminated area with detergent and lots of water.

10. Keep your pesticide storage shed or room locked. Pesticides should be stored in the original, labeled containers and in a dry, well-ventilated room or building away from human food or animal feed and OUT OF THE REACH OF CHILDREN.
11. Dispose of used pesticide containers and waste pesticides in a way that will not leave a hazard to people -- particularly children -- or to animals. Disposal must be by burial in an approved sanitary landfill. Local health departments, in cooperation with the Departments of Ecology and Social and Health Services, have designated proper disposal sites in many localities of the state. For proper locations of sites, contact your local health department. Combustible containers should be burned only if directions for burning are included on the label and burning is not prohibited by local ordinance. Glass, plastic, or metal containers should be thoroughly rinsed as soon as they are emptied. In this way the rinsings can be poured into the spray tank. Glass jars should be broken and metal or plastic containers crushed or punched with holes to render them useless before disposal.

12. Avoid drift of pesticides to other crops -- do not spray with leaking hose or connections -- avoid working in the drift of spray or dust.

13. Pesticides that persist for long periods of time in the soil may injure susceptible crops planted the following year and/or result in illegal residues. Observe restrictions concerning the intervals and crops which may be grown in treated soils.

14. Some processors may not accept a crop treated with certain pesticides. If crops are going to a processor, be sure to check with their fieldman before applying pesticides.

POISONING

1. In severe cases of organic phosphorus poisoning, breathing may stop. In such a situation, artificial respiration is the most important first aid until breathing has resumed.

2. Get the patient to a hospital or physician as soon as possible. Give artificial respiration on the way if the patient turns blue or stops breathing. Take along a label for the doctor's information.

3. Never try to give anything by mouth to an unconscious patient.

4. Internal -- If the insecticide has been swallowed and vomiting has not resulted, induce vomiting by giving a tablespoonful of salt dissolved in one-half glass or warm water.

5. Skin -- where the insecticide has come into contact with the skin, immediately remove all clothing and bathe the patient with generous amounts of soap and water, rinsing thoroughly.

6. Eyes -- if spray, especially insecticide concentrate, gets into the eyes, wash with flowing water immediately.

7. Make the patient lie down and keep him warm.
<table>
<thead>
<tr>
<th>Date of Application</th>
<th>Crop &amp; Planting Location</th>
<th>Rate of Chemical</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 - 10 - 73</td>
<td>Raspberry Willamette - North 5 acres</td>
<td>500 lbs. 10-20-20/acre</td>
<td>2E in 200 gal. water/acre</td>
</tr>
</tbody>
</table>
### WEIGHTS and MEASURES

**WEIGHTS**

<table>
<thead>
<tr>
<th>Conversion</th>
<th>Metric Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 ton = 2,000 lbs</td>
<td>0.907 metric tons</td>
</tr>
<tr>
<td>1 lb. = 16 oz. = 7,000 grains</td>
<td>0.453 kilograms</td>
</tr>
<tr>
<td>1 oz. = 437.5 grains</td>
<td>28.349 grams</td>
</tr>
<tr>
<td>1 short hundredweight = 100 lbs.</td>
<td>45.359 kilograms</td>
</tr>
<tr>
<td>1 long hundredweight = 112 lbs.</td>
<td>50.802 kilograms</td>
</tr>
<tr>
<td>1 short ton = 2,000 lbs.</td>
<td>0.907 metric tons</td>
</tr>
<tr>
<td>1 long ton = 2,240 lbs.</td>
<td>1.016 metric tons</td>
</tr>
<tr>
<td>1 kilogram = 1,000 grams = 2.2046 lbs.</td>
<td></td>
</tr>
<tr>
<td>1 gram = 1,000 milligrams</td>
<td></td>
</tr>
<tr>
<td>1 metric ton = 1,000 kilograms = 2,204.62 lbs.</td>
<td></td>
</tr>
</tbody>
</table>

**CAPACITY (liquid measure)**

<table>
<thead>
<tr>
<th>Conversion</th>
<th>Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 gal. = 4 qts. = 8 pts. = 16 cups = 128 fluid oz.</td>
<td>3.785 liters</td>
</tr>
<tr>
<td>1 qt. = 2 pts. = 4 cups = 32 fluid oz. = 64 tbsp.</td>
<td>0.946 liters</td>
</tr>
<tr>
<td>1 pt. = 4 gills = 2 cups = 16 fluid oz. = 32 tbsp.</td>
<td>0.473 liters</td>
</tr>
<tr>
<td>1 cup = 8 fluid oz. = 16 tbsp. = 48 tsp.</td>
<td>0.237 liters</td>
</tr>
<tr>
<td>1 tbsp. = 3 tsp.</td>
<td></td>
</tr>
<tr>
<td>1 liter = 1,000 milliliters = 1.05671 qts. = 2.11342 pts.</td>
<td></td>
</tr>
</tbody>
</table>

**LENGTH**

<table>
<thead>
<tr>
<th>Conversion</th>
<th>Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 mile = 5,280 ft. = 1,760 yds. = 320 rods = 80 chains.</td>
<td>1.609 kilometer</td>
</tr>
<tr>
<td>1 chain = 66 ft. = 22 yds. = 4 rods = 100 links.</td>
<td>1.257 meters</td>
</tr>
<tr>
<td>1 yard = 3 ft. = 36 in.</td>
<td>0.914 meters</td>
</tr>
<tr>
<td>1 ft. = 12 in.</td>
<td>30.480 centimeter</td>
</tr>
<tr>
<td>1 mile an hr. = 88 ft. per minute</td>
<td>26.82 meters per min.</td>
</tr>
<tr>
<td>1 kilometer = 1,000 meters = 0.62137 mile</td>
<td></td>
</tr>
<tr>
<td>1 meter = 100 centimeters = 39.37 in. = 3.28 ft.</td>
<td></td>
</tr>
<tr>
<td>1 centimeter = 0.3937 in.</td>
<td></td>
</tr>
</tbody>
</table>

**AREA**

<table>
<thead>
<tr>
<th>Conversion</th>
<th>Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 sq. mile = 640 acres</td>
<td>2.590 sq. kilometers</td>
</tr>
<tr>
<td>1 acre = approx. 209 x 209 ft. = 4840 sq. yds.</td>
<td>0.405 hectares</td>
</tr>
<tr>
<td></td>
<td>0.836 sq. meters</td>
</tr>
<tr>
<td>1 sq. yd. = 9 sq. ft.</td>
<td>0.093 sq. meters</td>
</tr>
<tr>
<td>1 sq. ft. = 144 sq. in.</td>
<td></td>
</tr>
<tr>
<td>1 hectare = 10,000 sq. meters</td>
<td></td>
</tr>
</tbody>
</table>

**SPEED**

<table>
<thead>
<tr>
<th>Conversion</th>
<th>Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
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</table>
WEIGHT AND MEASURES

METRIC SYSTEM

<table>
<thead>
<tr>
<th>Metric</th>
<th>English Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 meter</td>
<td>3.281 feet</td>
</tr>
<tr>
<td>1 kilogram</td>
<td>2.205 pounds</td>
</tr>
<tr>
<td>1 liter</td>
<td>0.264 gallon</td>
</tr>
<tr>
<td>1 gram</td>
<td>0.035 ounce</td>
</tr>
</tbody>
</table>

CAPACITY (Volume)

<table>
<thead>
<tr>
<th>Volume</th>
<th>English Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 liter</td>
<td>1.057 quarts</td>
</tr>
<tr>
<td>1 cubic meter</td>
<td>35.3 cubic feet</td>
</tr>
<tr>
<td>1 cubic centimeter</td>
<td>0.00066 cubic foot</td>
</tr>
</tbody>
</table>

LENGTH

<table>
<thead>
<tr>
<th>Length</th>
<th>English Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 kilometer</td>
<td>0.621 miles</td>
</tr>
<tr>
<td>1 meter</td>
<td>3.281 feet</td>
</tr>
<tr>
<td>1 centimeter</td>
<td>0.394 inch</td>
</tr>
</tbody>
</table>

AREA

<table>
<thead>
<tr>
<th>Area</th>
<th>English Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 square meter</td>
<td>10.76 square feet</td>
</tr>
<tr>
<td>1 square centimeter</td>
<td>0.155 square inch</td>
</tr>
</tbody>
</table>

VOLUME

<table>
<thead>
<tr>
<th>Volume</th>
<th>English Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 cubic meter</td>
<td>35.3 cubic feet</td>
</tr>
<tr>
<td>1 cubic centimeter</td>
<td>0.00066 cubic foot</td>
</tr>
</tbody>
</table>

SPEED

<table>
<thead>
<tr>
<th>Speed</th>
<th>English Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 meter per second</td>
<td>0.621 m/s</td>
</tr>
<tr>
<td>1 kilometer per hour</td>
<td>0.621 mph</td>
</tr>
</tbody>
</table>