Raspberries and Blackberries in Ohio

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OHIO
AGRICULTURAL EXPERIMENT STATION
Wooster, Ohio
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RASPBERRIES AND BLACKBERRIES IN OHIO

INTRODUCTION

Raspberries and blackberries are important market crops in Ohio, particularly in sections within easy trucking distance of the larger cities. Probably more than three fourths of the raspberries grown in the State at the present time are black varieties; the remainder are divided between reds and purples, with the reds apparently increasing in popularity.

Interest in raspberries and blackberries has greatly increased in recent years thru market demand for fruit and plants, more information on diseases and insect pests and their control, production of healthier stock for planting, introduction and use of new varieties, and advances in methods of culture.

The purpose of this bulletin by the Departments of Horticulture, Botany and Plant Pathology, and Entomology is to present a rather complete treatise on raspberries and blackberries in Ohio, with emphasis on culture and on the nature and control of diseases and insect pests.

PART I. CULTURE

J. S. SHOEMAKER

LIFE OF PLANTATION

A healthy plantation of black or purple raspberries produces six to eight, or more, profitable crops. The average of many plantations, unfortunately, is not more than three or four crops. Teske and Gardner (15) found the average bearing period of the commercial black raspberry in some Michigan raspberry districts to be about 6 years. Blackberries and red raspberries may produce good crops to an age of 20 years or more; 10 to 12 years of good fruiting is a reasonable duration for plantations of these kinds.

Each succeeding profitable crop reduces production costs and emphasizes the importance of healthy plants for setting, isolation of plantation from disease sources, suitable soil, adequate fertility, good drainage, and proper culture.
YIELD

Many factors influence yield. In general, blackberries and purple raspberries are the most productive, followed in order by black raspberries and by red raspberries.

Black raspberries commonly produce 5 to 15 bushels per acre, sometimes 15 to 20 or more bushels per acre the first fruiting year. Pickings of red raspberries and blackberries are usually negligible until after the plants have grown at least a year in a permanent plantation; altho large red raspberry plants, lightly to moderately headed at planting, may fruit in sufficient quantity in the first growing season to pay the cost of the plants.

Yields of 100 bushels of black raspberries and 75 bushels of red raspberries per acre from mature plants are sometimes claimed, but such production, on a measured acre basis, is exceptional. Acre averages of fairly good fields in the state probably are within ranges of 1700 to 2300 quarts for blackberries and purple raspberries, 1000 to 1700 quarts for black raspberries, and 500 to 1200 quarts for red raspberries. Yields from small patches calculated to an acre basis usually are higher than from plantations of an acre or more, a fact that accounts in large part for high yields sometimes claimed. The varieties differ widely in yield; with some red raspberry varieties a yield of 1000 quarts per acre is exceptional, but with others it is readily exceeded. Yields of 50 bushels or more per acre for black raspberries are not as frequent as desired. However, when growers in Ohio who use suitable varieties, healthy stock, adequate isolation from disease sources, well-drained soil, and proper methods of culture obtain this production annually there is encouragement for the industry.

LOCATION AND SITE

The location is usually determined largely by the farm already in the grower's possession. It should be favorable with respect to market, availability of pickers, and other factors. Any one factor concerned with location is frequently more or less offset by another. For example, a certain district may be ideally located from a market standpoint. Another may be relatively distant from a fresh fruit market, but have compensating advantages in low priced land and cheap labor.

Soil.—Raspberries are grown successfully on a diversity of soil types. Avoid decidedly heavy and extremely light soils. Soils that are hard to work, that bake readily, and absorb water slowly
are undesirable. Light soils are easily worked, may be prepared for planting early in the spring, produce early berries, and are most suitable for the propagation of plants. Clay soils are usually somewhat high in humus content, moisture retentivity, and natural fertility but often are poorly drained. Varieties differ in soil preferences. For example, Cuthbert often does better on light soils than on heavy soils; whereas the reverse seems to be true of Latham. Crown gall may be more serious in plants on sandy soils than on clay soils. Probably the ideal soil is a fertile sandy or gravelly loam, retentive of moisture, well drained, and easily tilled.

Fig. 1.—Cumberland black raspberry plantation exceptionally free from virus diseases and in good condition except for some poorly drained spots.

**Water drainage.**—Good drainage is essential in a raspberry or blackberry plantation. Much damage that growers confuse with disease troubles is due to poor drainage. The site should slope sufficiently and be free of pockets or basins so that surface drainage takes care of surplus water, particularly during late winter or early spring when snow is melting and at other times when tile drainage does not function adequately.

Tile poorly drained land and, if the soil is still wet, provide surface drainage by ridging the rows.
Hoffman and Schnubatis (3) found that height of water level varied greatly from place to place in a 2½ acre raspberry field in Michigan. Marked variations often were found between points 25 to 50 feet apart. These variations were correlated with soil type. Equally marked variations in extent of root development of raspberry plants were found in different parts of this area. The roots varied in depth of penetration from a minimum of 10 or 11 inches, with most of the roots at 5 to 7 inches from the surface, to a maximum penetration of from 30 to 35 inches, with the roots more or less completely filling the soil to a depth of from 16 to 19 inches. Root development and depth of penetration were closely correlated with height of water level. Locations with rather prolonged high water level had poor root development and shallow penetration; locations with low water level had extensive root development. Roots penetrated and branched freely in sandy well aerated subsoil layers not waterlogged. Top growth, yields of fruit, and longevity of plants were directly proportional to root development and correlated with height of water level.

Fertilizers or good cultural practices fail to give desired results in fields where drainage is the limiting factor until the drainage is improved.

Air drainage.—Injury from late spring frosts is avoided to a certain extent by choosing a site free from pockets and with sufficient slope or elevation for good air drainage. During the fruiting season a northern or northeastern exposure affords some protection against hot drying winds of summer. Exposure to strong winds may result in breakage of canes, loss of fruit from whipping, and, by blowing away of snow, lessening protection in winter. The black raspberry is characteristically weak at the crown, and both new shoot growth and fruiting canes are easily broken by high winds. A windbreak tends to reduce wind damage, but plants too close to it sometimes are in a frost pocket. Steep slopes are likely to wash and cannot be worked as advantageously as more level land.

Previous crops.—It is a good plan to turn under a green manure crop previous to planting cane fruits. Land on which corn or other frequently cultivated crops grew a year or more just previous to planting is usually suitable for raspberries or blackberries. Avoid old bramble patches, particularly those in which crown gall was prevalent, as this disease may remain in the soil for a number of years. Old grass sod plowed and immediately planted to cane fruits is not very satisfactory; such soil is usually lacking in proper texture and fertility, is rough and difficult to plant and work properly, and is hard to keep free of grass. Fields infested with quack grass and the like are difficult to keep clean of weeds.
Verticillium wilt sometimes is prevalent when raspberries, particularly stock of weakened vitality, follow such crops as tomatoes, potatoes, muskmelons, or egg plants. Where the grower has a choice of several good sites it is best to avoid such previous crop sites, altho damage from this cause may be overestimated.

Isolation from disease sources.—Isolation of healthy raspberries from disease sources is important, and is discussed later in this bulletin and in Ohio Agricultural Experiment Station Bimonthly Bulletin, Jan.-Feb., 1930 (16). In brief, as a general recommendation for practical purposes, do not set healthy black raspberries within 20 rods of red or purple raspberries, wild brambles, or diseased cultivated plants.

Brambles as inter-crops.—Raspberries or blackberries sometimes can be used to advantage in a young orchard and made to furnish a source of income while the orchard is being established. Disadvantages of inter-planting, however, may exceed advantages.

Do not plant raspberries or blackberries within 10 or 15 feet of newly-set trees. As the trees grow older, keep the berry plants three feet or more from the spread of the branches. Set cane fruits only between every other tree row so as to allow for passage of spray machines. When apple trees are spaced 40 feet apart as many as three rows eight feet apart of raspberries or blackberries can be planted between them. With peaches or other trees only 20 feet apart do not plant more than one row of raspberries or blackberries between the tree rows. For the most part, black or purple raspberries reach the end of their life by the time apple trees come into profitable bearing, but they may be still productive when peaches begin to give good yields. Red raspberries and blackberries, longer lived than blackcaps or purples, overlap more in production with tree fruits. Raspberries and blackberries may be damaged by spray material used on fruit trees relatively late in the season.

Cane fruits may be set between the trees in the rows. This does not give so much acreage of cane fruits as can be obtained from setting between the tree rows, but the results sometimes may be worth while.

The cane fruits draw rather heavily on the soil for moisture and food material and return very little in plant residue; so increased attention to humus content and fertilizers is usually necessary when cane fruits are grown in an orchard.

Cane fruits are taller growing than such crops as strawberries or vegetables, and the habits of growth and the spiny condition of
the branches make them somewhat difficult to handle in an orchard. Raspberries and blackberries, well spaced, can be cultivated in one direction throughout their lifetime, but when planted as a companion crop in an orchard cross-cultivation of the orchard is seldom practical.

**PREPARATION OF SOIL FOR PLANTING**

A well pulverized, mellow soil is conducive to a good stand of plants, for they not only survive planting but become established quickly.

Begin treatment of the soil for raspberries or blackberries at least the year previous to planting, preferably earlier. It is important to build up humus in soil that is to be planted to cane fruits. The practice of plowing in the fall, and working the soil down early in the spring to make it friable, smooth, and ready for early planting is encouraged. If plowing is not done in the fall it should be done as soon as the soil is dry enough in the spring.

**PLANTING**

**TIME OF PLANTING**

*Spring planting.*—The best time to set tip plants of black or purple raspberries in Ohio is in early spring, just as soon as the soil can be well prepared. It is usually better to set the plants early, even if the soil is not well dried out, than to plant late. Plants set early in April at Wooster nearly always do much better than plants set a month or so later.

Stage of growth of plants is important in relation to time of spring planting. The growing points that give rise to new canes are easily injured. Plants growing in a region with a relatively early spring are more advanced at a given time than those propagated in a region with a somewhat later season. This should be borne in mind when ordering plants. With black raspberry plants set after having been heeled-in, stored, or shipped late, instead of a strong new cane developing from each terminal growing point a number of rather spindly ones may result. Some growers, not able to prepare their soil in time for setting practically dormant stock, sometimes wait until the new leaves are visible above ground; this method is of some value where the plants are not shipped. It is hazardous, however, to set plants shipped at this stage of growth; also, anthracnose infection may have started.

Red raspberries and blackberries, like black and purple raspberries, are set successfully in early spring. As a general rule, early spring planting is more advisable than fall planting.
Fall planting.—Fall planting, especially with an experienced grower, is successful with red raspberries, blackberries, and transplants of black and purple raspberries. In fact, with these kinds fall planting sometimes results in better success than spring planting, particularly when adverse weather or other factors prevent early spring planting. Planting in the fall saves time and work in the spring when other matters are demanding attention. Another factor of importance is that the plants often may be transferred from the nursery in the fall to better advantage than in the spring. There is less danger of the roots drying out in transit and handling, because drying winds and warm days are less common than in the spring, particularly late spring. Soil preparation often can be done more thoroly in the fall.

Ordinarily, late is better than early fall planting. Late October or early November is a good time at Wooster. Optimum time for fall planting, however, depends on weather conditions. With too early planting, drouth and relatively warm days may reduce the stand of plants. The relative advantages of early and late fall planting also depend on the variety. Latham, for example, is more hardy and apparently better adapted to somewhat earlier planting in the fall than Cuthbert.

Plants set in the fall are afforded protection by plowing a furrow, with the soil turned toward the plants, on each side of the row or by mulching. Altho ordinarily 12 to 18 inches of the red raspberry cane is left in planting, according to the size of the plants, some growers prefer to trim the canes back to 6 to 12 inches and others to two buds or so above ground. The length of cane to leave at planting time is discussed further on Page 12.

Heeling-in.—Heeling-in is a valuable practice for holding plants a reasonable length of time, but it is at best only a makeshift substitute for planting directly. Heel-in plants where water does not collect, yet where they can be watered when necessary. Partial shade is desirable. A fairly light soil is better than a heavy soil for heeling-in raspberry plants.

Closely arrange the plants in a single row in such manner that the roots of each plant are in direct contact with the soil. Bunched or loosely heeled-in plants are likely to heat or dry out and die or be weakened.

Distance of planting.—Optimum distances between plants and rows depend on a number of factors, such as system of culture, kind and vigor of variety, and area available.
The more plants per acre and the closer the planting the higher, as a rule, the yield; but, if rows are too close such an operation as discing in the spring may be impractical. Adequate spacing for discing and other operations is desirable.

The number of plants required per acre is obtained by multiplying the distance apart in the row by the distance between the rows, in feet, and dividing the product into 48,560. Thus planting 3 x 8 feet requires 1,815 plants. Some extra plants, however, are usually needed for good selection of plants and for replanting.

Straight rows give the plantation a neat appearance and are convenient for cultivation and other operations. Restrict black and purple raspberries to the original plants or crowns. Good distances for planting black raspberries are 3 or 3½ by 7 to 9 feet, and for purple raspberries 3½ or 4 by 7 to 9 feet. It is sometimes a good plan to set some surplus plants in the row of regular plants, then if needed for replanting, they can be dug with earth attached. This method should not be over-done, but it seems better than using heeled-in plants for replanting or waiting until the spaces can be filled by tipped plants.

Red raspberries are usually grown under a system in which suckers are allowed to develop between the plants in the row and so form a solid or hedge row. A distance of 3 to 4 feet in the row and 7 to 9 feet between rows is suitable. Setting the plants closer in the row may be desirable if plants are cheap, as a hedge row forms more quickly than with wider spacing; but the fact that the red raspberry is a prolific plant maker and naturally fills the row quickly demands consideration.

A good distance for blackberries is 3½ or 4 by 8 to 10 feet. Blackberries develop a continuous row somewhat more slowly than red raspberries, but produce fruit from laterals much like black raspberries.

Red raspberries or blackberries grown in hills are planted 5 by 5 feet, or more, apart.

**Procedure in planting.**—To prevent drying out at planting time, take the plants to the field wrapped or covered with wet burlap or other moist material, or dip the roots in muddy water. Do not drop more than a few plants ahead of the planters; this is especially important under dry weather conditions.

One hundred per cent stand of plants is the exception rather than the rule. The average is probably not more than 75 per cent of a stand, especially with plants shipped from a distance; the loss is chiefly due to carelessness.
Set the plants firmly at approximately the same depth, or slightly deeper, than they grew previously. If set too shallow or if the soil is not adequately firmed, many of the plants may dry out.

Fig. 2.—Cumberland tip plants: (above) abundant and (below) scanty root development. Setting the latter type means that practically a year is lost and not more than 25 per cent stand can be expected, unless the plants are dug and set immediately.

Such factors as poor root development, heaving out, weak plants, injury from drouth, and blowing over of the canes may also be encountered. If set too deep the growing points may not push thru the soil; this is a common cause of a poor stand especially on heavy
soil. Occasionally, it is advisable to set two plants together; particularly with red raspberries, small root cuttings of blackberries, and plants of other types, where there is poor root development or where the roots are partially dried out or weakened.

Red raspberries and blackberries are usually set in the soil with a spade. The spade is also commonly used for black and purple raspberries but, as the root system of tip plants is more extensive than that of sucker plants or root cuttings, it is necessary to make a larger hole, usually about a foot square and 6 to 8 inches deep. A post digger is a useful implement for making the holes for black or purple raspberries on soils rather heavy and wet at planting time. The furrow method is used by many growers as the most expedient. A furrow is run for each row, the plants are placed in it, and the roots covered with soil. With this method it is sometimes best at first to cover the plants with only a little soil, and to throw more soil in the furrows when cultivating, after the shoots have started.

After placing tip plants in the holes it is often advisable to pack soil around the roots and sprouts by hand before filling in with the spade; thus enabling the soil to be firmed with a minimum of damage to the tender growth. This takes time but may be energy well spent.

The “handle”, “tail”, or woody cane of a tip plant is of some convenience in planting and in locating the plants. However, the handle of the black raspberry may be a source of anthracnose infection and in planting should be cut off or buried, leaving none of it above ground. The plant suffers no ill effect from this treatment provided it be done early. If, however, removal of the handle be delayed until after growth is well started not only may infection of new shoots have taken place but the plant may be appreciably weakened by loss of reserve food materials. Furthermore, bear in mind that plants may be weakened before planting thru partial drying out, heating, and various other causes. If the plants are thus weakened a higher percentage stand and better initial establishment may result if the handles are not pruned off. In brief, if tip plants are in thrifty condition and are planted early there are decided advantages in cutting off or burying the handles immediately after setting. But, if the plants are weakened in some way, or are set very late in the spring, it may be advisable to make the best of an undesirable situation, leave the handles on the plants, and control anthracnose by spraying.
It is usually best with some red raspberries, as the Latham, to leave a fair amount of cane above ground at planting, as enough fruit sometimes can be picked during the first summer to pay the cost of the plants. Strong canes may be headed back to about 18 inches and less vigorous ones more severely. With some other red varieties, as the Cuthbert, it may be best to prune slightly more at planting than with Latham. Measures for anthracnose control at planting time as suggested for black raspberries are usually unnecessary with reds in Ohio. Pruning at planting need not be as severe with the latter type as with the former, altho in some sections it is practiced with nursery plants to reduce mildew and other troubles. Poor stands of red raspberries are likely to result when the canes of young plants are pruned back to ground level at planting time. This is especially the case with plants set late in the spring, when pruning causes appreciable loss of reserve food materials.

TILLAGE

Plowing the "middles" or discing, preferably the latter, is usually needed early in the spring. Frequent cultivation during spring and early summer is desirable. Cultivation, especially near the plants, should be shallow. Cultivation is sometimes practiced after each picking to loosen the soil packed down by the pickers. Disadvantages of this are that many berries may be knocked off in cultivating and berries on the bushes may be covered with dust. Several hand hoeings are usually needed each year.
In most plantations it is probably best to cease tillage by early August to permit the plants to ripen their wood and to afford opportunity for development of cover crops.

Where the soil is rather heavy and drainage is not good, many growers practice ridging black and purple raspberry rows. Rows of red raspberries should not be excessively mounded up during August or September and left that way over winter, because the buds that form new shoots may be produced so high above ground that the plants are weakened the next year.

FERTILITY

Green manure or cover crops turned under aid in providing the humus necessary for good texture, physical condition, and water-holding capacity of the soil. The choice of crop depends considerably on conditions. Soybeans or oats, for example, thrive well in some places and then either one make a reasonably suitable cover crop, but they are not always satisfactory. In southern Ohio, rye may be a good choice, planted at the rate of one and one-half bushels per acre about September 1. Seed the rye so that it is not too close to the row or there may be trouble in turning it under in the spring. Furthermore, turn under the rye before it becomes too tall. In northern Ohio, millet about 40 pounds per acre sown about August 1 may compare favorably with other cover crops. Under some conditions it may be better to use a crop that winter-kills, under other conditions one that does not, and under still other conditions to use both, either combined or by turning under the crop that winter-kills before the over-wintering one is sown.

When manure can be secured conveniently, or at reasonable cost, apply 10 to 30 tons per acre, and thoroly incorporate it in the soil.

Raspberries and blackberries are not particularly sensitive to soil reactions, altho they seem to prefer a slightly acid soil. Liming is seldom necessary for raspberries or blackberries. Light applications of lime are not likely to be injurious and under some conditions, as thru their effect on the cover crop and physical condition of the soil, are beneficial.

Experiments show that size of cane and vigor of plant are correlated to a marked extent with yield. Some evidence to this effect is shown in Table 1, from work conducted at Wooster, 1927.

In most plantations of the state the canes are not so vigorous as desired. Since there is, in general, a relation between vegetative vigor and productivity, practices leading to development of canes of
large diameter are advised. Judicious employment of fertilizers in most cases increases vigor and yield. The more vigorous the plants the more fruiting wood they can support to advantage.

**TABLE 1.—Diameter of Cane in Relation to Number of Berries Produced**

<table>
<thead>
<tr>
<th>Diameter six inches above ground</th>
<th>Berries per cane</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cumberland</td>
</tr>
<tr>
<td>2/15-4/15</td>
<td>115</td>
</tr>
<tr>
<td>2/15-4/16</td>
<td>359</td>
</tr>
<tr>
<td>7/16-8/16</td>
<td>376</td>
</tr>
<tr>
<td>9/16-10/16</td>
<td>472</td>
</tr>
</tbody>
</table>

Johnston (6), in Michigan, found that yield of canes and of laterals, and likewise size of berry were closely associated with diameter of cane. The largest and most vigorous canes produced the best crop. He believed that cultural methods should be directed toward promoting a vigorous growth. Yields of individual fruiting shoots and likewise the average size of their berries were closely correlated with the amount of foliage. This indicated the importance of methods of culture that promote development of good foliage and that protect it from injury.

In a demonstration on the farm of Mr. Kim Crawford, near Rogers, Columbiana County, by Holland (4, 5), commercial nitrogen fertilizer on black raspberries was applied at the rate of 100, 200, 300, and 500 pounds per acre. Unfertilized plots were left as checks. It was found that the fertilized plots outyielded the check plots, and that there was about one third more fruit produced from the sections that received 300 pounds of fertilizer than from those that received 100 pounds. The full measure of value of the fertilizer could not be taken until at least the following year, because the canes are grown one year and the berries produced the next year. Mr. Crawford checked on one row and reported that 90 cents for the extra fertilizer returned $12 worth of berries. The following year, the 300 pound plot was ahead of all the others in fruit and vigor. Five hundred pounds of nitrate of soda per acre gave more vigorous canes, but did not show a great increase in fruit over 300 pounds per acre.

An annual application of 250 to 300 pounds per acre of a nitrogen fertilizer, such as nitrate soda or a corresponding amount of sulfate of ammonia, early in the spring is recommended in general for fruiting raspberries and blackberries. During the first year of the plantation the nitrogen fertilizer can be applied a month or so after planting, in a circle six inches from each plant, at the rate of about 200 pounds of nitrate of soda. In later years it may be applied near the plants both between and in the rows by hand or be drilled in. If applied directly on the crowns of the plants it is likely to cause injury.
There may be justification for claims that application of quickly available nitrogen fertilizer makes the fruit softer, particularly red raspberries. However, black raspberries receiving the suggested rate of nitrogen fertilizer have been trucked a good distance to market and have arrived in excellent condition. It certainly seems true that many raspberry growers could beneficially use more nitrogen fertilizer than has been their custom.

Lott (11), in Missouri, found that a late-summer cover crop of oats with an early fall application of nitrate of soda resulted in the highest degree of hardiness produced by any treatment. An early fall application of nitrate of soda without a cover crop did not increase hardiness. A late summer crop of oats alone induced a degree of hardiness less than that of the plot with cover crop and nitrate. The only advantage of a fall application of sodium nitrate in relation to hardiness was secured thru the greater growth of the cover crop; that increased hardiness thru a greater drying out of the fruit plant. A late summer cover crop of oats was very effective in increasing hardiness in raspberries.

The need of application to cane fruits of phosphorus, potassium, or lime does not seem to be as imperative as that for nitrogen. These substances, however, can be used to advantage when cover
crops are grown. To obtain proper growth of cover crops, it may be advisable to apply about 200 pounds per acre of a 0-14-6 fertilizer broadcast between the rows just before the last cultivation.

PRUNING

Raspberry and blackberry pruning is grouped here under three headings: summer pinching, removal of old canes, and heading back canes and laterals while dormant. Pruning at planting is discussed in the section on Procedure in Planting. Destruction of undesirable plants between the rows is distinct from the other operations, but, altho of some importance, is not discussed further. Thinning of plants in the row is considered in the general pruning treatment.

Summer pinching.— Summer pinching of the terminal canes is advised when black raspberries are 18 to 24 inches high and purple raspberries 18 to 30 inches high. This checks the terminal, encourages strong branching, and results in a low, stocky plant. The plantation should be gone over several times in order to pinch the canes at a desired height, and so that late-grown shoots in bearing plantations do not interfere with harvesting. It is not necessary and, in fact, may be somewhat harmful to pinch off only the extreme tips. When only the extreme tip is removed, the top lateral may extend more or less as a terminal with a narrow-angled, weak crotch, unduly subject to breaking. A better plan is to pinch or cut the terminal cane 3 or 4 inches from the tip; this induces a wider angled and consequently a stronger union or crotch. The canes pinched at 18 to
24 inches increase somewhat in height; taller canes increase less in height after more severe pruning. The pinching height may be a little higher in established plantations than in young ones. If the canes become higher than 3 feet severe pinching may tend to produce growth from only rather weak buds. It seems better to pinch the tall canes severely rather than leave them tall. In 1930, summer pinching was begun at Wooster about the middle of May in a vigorous planting bearing its second crop.

Summer pinching of the terminal of the blackberry, when practiced, is usually done when the plants are 24 to 30 inches high. Heading back vigorous branches of the current season’s growth is of value to facilitate picking, and for other purposes, but its effect on future yield and growth is uncertain.

Avoid summer pinching of the red raspberry; some tests have seemed to indicate slight benefit, but others have shown appreciable damage.

Removal of old canes.—After raspberry and blackberry canes have fruited in the summer they should be removed; whether soon after fruit is picked or at time of early spring pruning is a debatable question.

On the one hand, it is claimed that the old canes are of no further value in the plantation, that their early removal permits the young canes to grow without obstruction, that the plantation assumes a pleasing appearance, that cutting out and burning them soon after the picking season destroys diseases and insects present, that the canes are less tough and easier removed at this time, and that in large propagation fields where the brush is carried out by wagon removing the old canes soon after harvest avoids tramping
on the tip layered plants. On the other hand, it may be said that the old canes serve as a protection and support for the new canes against breakage by storms, that the amount of disease controlled by destruction of the old canes after harvest is negligible, and that the old canes do not appreciably obstruct the growth of new canes.

Removing the old canes soon after picking is probably the most prevalent practice. Many plantations, however, suffer from wind breakage of canes and the support afforded by leaving the old canes until just before pruning the laterals may outrank all other factors.

Work conducted by Locklin (10) seemed to indicate that in a normal winter, at least, the season of removal of the old canes of the Cuthbert red raspberry had no influence of commercial importance on the amount of tip injury to the young canes. Since there was a slight difference in favor of winter pruning and against late summer pruning, it was possible that in a severe winter there would be a greater difference in favor of late winter pruning.

**Heading back dormant canes and laterals.**—The regular dormant pruning of raspberries and blackberries is best done in late winter or very early spring. It may be delayed until the amount of winter injury can be ascertained but should be completed before growth starts or spray material is applied. Avoid pruning when the soil is soft and muddy. March is probably the most satisfactory time. If too early pruning is practiced the canes are likely to be brittle and to break easily, and when cut back to the proper lengths, subsequent winter killing of the end portions may unduly reduce the amount of fruiting wood left. The various types of

![Fig. 7.—Pruning Cumberland black raspberry after a season's growth. Before pruning (left) and after pruning (right), the laterals being trimmed back to 4 to 7 inches in length](image-url)
raspberries are pruned in different ways for best results and are not pruned the same as blackberries. The amount of pruning necessary varies with the type, variety, vigor, and other growth conditions.

**Dormant pruning of black raspberries.**—Pruning of black raspberries is concerned mostly with laterals, as nearly all terminals are, or should be, eliminated by summer pinching. Practically all terminals encountered in the dormant pruning of black raspberries are weak and should be cut off just above a strong branch.

**Table 2.**—Cumberland. Effect of Heading Back Laterals to Different Lengths

<table>
<thead>
<tr>
<th>Treatment of laterals</th>
<th>Shoots fruiting</th>
<th>Length fruiting shoot</th>
<th>Berries per cane</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pruned to 8 buds</td>
<td>75</td>
<td>64</td>
<td>18.4</td>
</tr>
<tr>
<td>Pruned to 12 buds</td>
<td>72</td>
<td>91</td>
<td>15.3</td>
</tr>
<tr>
<td>Pruned to 18 buds</td>
<td>71</td>
<td>57</td>
<td>14.2</td>
</tr>
<tr>
<td>Pruned to 24 buds</td>
<td>69</td>
<td>55</td>
<td>12.9</td>
</tr>
<tr>
<td>Full length</td>
<td>62</td>
<td>45</td>
<td>12.1</td>
</tr>
</tbody>
</table>

Table 2 shows that the more severe the pruning of Cumberland black raspberry the greater the percentage of fruit-bearing shoots on the main cane and laterals. Average length of these fruiting shoots increased with the greater amount of pruning. Severe pruning decreased the number of berries produced. Laterals pruned to 8 buds, or more severely, tended to bear fruit of larger size, better quality, and appearance than those pruned more lightly, or not pruned. There seemed to be little difference between the grade of fruit on 8- and 12-bud lengths, altho possibly the fruit on the 8-bud lengths was slightly superior. Fruit borne on 18-bud lengths or longer was often dirty and usually inferior in size and quality.

In general, pruning tends to decrease the number of berries and to increase their size. In fact, at times, with the black raspberry, increase in size of berry counteracts the decrease in numbers and results in little difference in yield, particularly in dry seasons or on soil of inadequate fertility.

Pruning the laterals to 4 to 7 inches the first year and to 8 to 12 inches in mature plantations is suggested as the amount that gives the best correlation between size and number of berries when the plants are reasonably vigorous and healthy. This is only a general suggestion and condition of the canes may justify more
severe or more lenient pruning. The more vigorous and healthy the cane the more fruiting wood it can usually support to advantage; take this into account when increased growth is obtained from application of nitrogen fertilizer.

Fig. 8.—Pruning mature Cumberland plants. Heading back the laterals to 8 to 12 inches is suggested for best balance between size and number of berries on vigorous canes

Weak, slender canes may well be removed, but thinning the black raspberry to fewer than 4 to 5 strong canes in the hill is likely to decrease yield.

Teske and Gardner (15), in Michigan, found that yields of the black raspberry were fairly closely correlated with planting distance, stand of plants, and number of canes to the hill. Heavy yields were practically impossible with less than 3000 fruiting canes to the acre and maximum production was possible only when there were from 5000 to 8000. Individual canes in thickly stocked fields might be less productive than those in thinly stocked plantations, but acreage production was greater. Close planting reduced injury from wind. Profits or losses in the plantation depended primarily on yield per acre.

Dormant pruning of red raspberries.—The red raspberry should not be summer pinched; therefore, pruning is concerned primarily with terminals, altho some naturally induced branches occur. Dormant pruning studies were made in 1927 at Wooster with the King red raspberry. Diameter measurements, six inches above ground, were taken. More than 50 canes were cut back one fourth, and an approximately equal number were left unpruned.
Data in Table 3 show a direct correlation between diameter of cane and fruit production. There was some indication that normally branched canes bore more fruit than single canes and that unpruned canes produced more berries than those cut back one fourth.

TABLE 3.—King. Diameter of Cane in Relation to Number Berries Produced

<table>
<thead>
<tr>
<th>Diameter</th>
<th>Berries produced</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Single cases</td>
<td>Branches canes</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cut back %</td>
<td>Not pruned</td>
<td>Cut back %</td>
</tr>
<tr>
<td>1/16-4/16</td>
<td>$N_0$</td>
<td>$N_0$</td>
<td>$N_0$</td>
<td>$N_0$</td>
</tr>
<tr>
<td>2/16-3/16</td>
<td>47</td>
<td>51</td>
<td>64</td>
<td>72</td>
</tr>
<tr>
<td>3/16-4/16</td>
<td>108</td>
<td>137</td>
<td>160</td>
<td>171</td>
</tr>
</tbody>
</table>

The taller the canes the greater the number of berries, number of shoots, and inches of shoot growth, Table 4. The height of pruned canes refers to the amount left after cutting back.

TABLE 4.—King. Height of Unbranched Cane in Relation to Number Berries Produced and Shoot Growth

<table>
<thead>
<tr>
<th>Height</th>
<th>Berries cut back one fourth</th>
<th>Berries not pruned</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cut back %</td>
<td>Not pruned</td>
<td>Cut back %</td>
</tr>
<tr>
<td></td>
<td>$N_0$</td>
<td>$N_0$</td>
<td>$N_0$</td>
</tr>
<tr>
<td>15-19</td>
<td>10</td>
<td>8</td>
<td>14</td>
</tr>
<tr>
<td>20-24</td>
<td>33</td>
<td>12</td>
<td>20</td>
</tr>
<tr>
<td>25-29</td>
<td>54</td>
<td>13</td>
<td>83</td>
</tr>
<tr>
<td>30-34</td>
<td>67</td>
<td>14</td>
<td>101</td>
</tr>
<tr>
<td>35-40</td>
<td>65</td>
<td>18</td>
<td>133</td>
</tr>
<tr>
<td>41-44</td>
<td>156</td>
<td>56</td>
<td>145</td>
</tr>
<tr>
<td>45-48</td>
<td>129</td>
<td>24</td>
<td>152</td>
</tr>
<tr>
<td>49-52</td>
<td>133</td>
<td>29</td>
<td>157</td>
</tr>
</tbody>
</table>

The unpruned single canes produced more berries than canes cut back one fourth, Table 5. The same was true for branched canes, indicating that the greater the amount of pruning of a given cane of the King and the more fruiting wood removed, the less the number of berries produced. Average number of berries, number of shoots, and total shoot growth increased with greater diameter and height of cane. There did not seem to be any appreciable difference in size of fruit from the pruned and unpruned canes. In dry seasons heading back might result in larger berries.
Johnston and Loree (7) studied the Cuthbert variety, three to five years old, on soils ranging from a sandy loam to a clay loam in Michigan. Average canes receiving different pruning treatments were selected for detailed study with reference to bud development. About 62 per cent of the buds on a red raspberry cane produced shoots that matured their fruit; 10 per cent remained dormant; 12 per cent grew into vegetative shoots that produced no fruit; 10 per cent of the buds were winter killed, this condition being more prevalent at the tips of the canes; a few buds developed into shoots that were mechanically injured by the wind or in cultivation; and a few buds produced weak shoots that later dried up. Numbering from the base of the cane, the first five buds were moderately productive, the fifth to tenth buds were the most productive and the tenth to fifteenth buds were second in production. From the fifteenth bud to the tip of the cane, the average yield of the laterals progressively decreased. The size of the berries decreased gradually from the base to the tip of the cane. Markedly higher yields were obtained from large canes as compared with those of small diameter. Therefore, such cultural methods as promote the growth of large canes were advised. Naturally-branched red raspberry canes were larger, more vigorous, and more productive than unbranched canes. The branches produced satisfactory yields of large berries. The first five buds on the branches gave rise to a number of vegetative or barren shoots; the tenth to fifteenth buds produced the best yielding laterals. Beyond the fifteenth bud, the yield and size of fruit decreased rapidly. Pinching the tips of the new raspberry canes resulted in branches being formed that were very susceptible to winter injury. This injury was so severe as to result in a marked reduction in yield. In general, thinning of canes greatly reduced the yield without any material increase in size of berry. However, data were presented to show that probably not more than ten canes to 4 feet of hedge-row should be left for fruiting. Where the plants were grown in hills, eight canes per plant gave the best results. Materially higher yields were expected when the plants grew in hedgerows than when they grew in hills. Light heading back of the canes resulted in an increased total yield over no pruning; while severe heading back greatly reduced the total yield. There was no marked increase in size of fruit due to heading back of the canes, except during a dry season. Canes receiving a light heading back were the easiest to harvest. The dense foliage of the new shoots and the fruiting canes made it more difficult to harvest the fruit from the severely pruned canes. Unpruned canes were likely to be top heavy and bend over into the cultivators. The advice was that the main portion of the cane should receive a light heading back, while the branches should be pruned to approximately 15 buds, or about 10 inches. Somewhat heavier heading was warranted where the moisture supply was a limiting factor.
Pruning studies with the Latham variety were conducted by Brierley (1) in Minnesota. Treatments compared were pruning to heights of 15, 36, and 60 inches. The canes pruned to a height of 15 inches yielded less than one half as much as the higher canes. Yields for the plots pruned to 36 and 60 inches ran very nearly the same throughout the season, and the total crops showed very little difference. There was a slight early advantage in yield of the 60-inch plots, due apparently to the earlier ripening of the berries on the short weak laterals toward the tips of the canes. This advantage was largely offset by the small size of these berries. With the drying up of the upper laterals on the tall canes toward the end of July, yields for the 60- and 36-inch plots became practically equal. There was little gain in yield for the season and variety from the additional two feet of cane height in the plots pruned to 60 inches. This upper portion of the canes generally produced feeble fruiting laterals with berries of small size. This growth habit and the almost identical yields seemed to support the contentions that pruning greatly reduced the yield and did not extend the picking season; in fact, the season was slightly delayed. This delay was not as serious as the loss of crop volume, but might be a factor of considerable importance with an earlier variety such as King when higher prices are considered. Throughout the season the berries from the 60-inch plots averaged smaller in size than those of the 36- and 15-inch plots. This smaller size was likely due to the fact that the upper portion of the 60-inch canes tended to produce fruiting laterals that lacked vigor and produced berries of small size. While these weak laterals tended to be the first to dry up, enough continued to fruit throughout the season to affect the average weight and size from these plots.

![Fig. 9.—Young Latham red raspberry plantation](image)

The red raspberries do not respond alike under all conditions. Pruning treatments must be varied to a certain extent for best results. As a rule it is most profitable to head back the canes as lightly as is compatible with suitable training, freedom from
damage in cultivation, ease of harvesting, and other factors. Sometimes, as indicated by the previous reference, the best practice is to head back more heavily.

Some thinning out of small, slender canes in the hedgerow is frequently desirable. Fruiting canes 6 to 8 inches apart, on an average, is usually good spacing. Removal of too many robust canes materially reduces yield. Higher yields per acre are likely to be obtained from hedgerows than from hills, but when the latter method is used, it is suggested that seven to nine of the most vigorous canes be left per hill. Keep hedgerows relatively narrow. The optimum width of row, however, varies with the distance between rows and various other factors. The wider the row the more berries that will probably be produced, but when the rows become too wide proper picking, tillage, and other factors are interfered with.

**Dormant pruning of purple raspberries.**—The amount to shorten laterals of purple raspberries depends somewhat on the vigor of the canes. Vigorous, healthy canes can support more fruited wood than weak ones.

According to Swartwout (13), Cardinal as grown on the Station grounds at Columbia, Missouri, produced fewer buds near the base of the laterals than black raspberries. Averages of a number of counts showed six and one-tenth buds on the basal 8 inches of Cardinal laterals as compared with nine and two-tenths buds on black raspberries. Moreover, many of the buds near the bases of vigorous Cardinal laterals were poorly developed and either failed to grow or produced little or no fruit. Thus, the basal portion of vigorous Cardinal laterals was relatively unproductive and, to insure a heavy crop, the laterals had to be left fairly long. On small laterals, especially secondary laterals, however, the buds were close together and well-developed, the number found on the basal portion of such laterals being practically identical with the number found on black raspberry laterals. Tho no hard and fast rules could be laid down as to how long the laterals should be left, he stated that in general purple raspberries, like Cardinal, should be left 18 to 24 inches.

The previous reference furnishes an idea of the fruited habit of the purple raspberry, and of this type as compared with black-caps. For Columbian, the principal purple raspberry in Ohio, heading back the laterals to 6 to 10 inches the first year and 10 to 14 inches in succeeding years is generally suggested.

**Dormant pruning of blackberries.**—Blackberry varieties seem to vary more than black or purple raspberries in fruited habits.

Colby (2), in Illinois, grouped blackberry varieties as follows: (a) Those that carry their cluster-buds well in toward the base of the laterals and well down on the canes, for example, the Lawton and Ward. In varieties of this group fruited clusters were rare on the first five buds counting back from the
tip. The number of buds to a lateral varied from eight to twelve. Cutting back moderately, that is, removing up to one half of each lateral, had little effect in reducing the yield. The row where laterals were cut back approximately one half produced as many fruiting clusters as those where no pruning was done. Moderate pruning was recommended, however, to facilitate cultivation and harvesting. (b) Those that carry their buds out nearer the tips of the laterals and canes, such as Early King, Taylor, and Wachusetts. Close pruning of these varieties reduced the crop materially. As a general rule, the first three to five buds next to the main cane on each lateral did not produce fruit. With an average of 16 buds to a lateral enough were left for maximum production if five or six buds, or one third of the lateral, were cut away. Any unbranched canes remaining were cut back to 5 feet in height. (c) Those whose buds are scattered fairly well along the production wood, as Ancient Briton, Wilson, Ohmer, Eldorado, and Mersereau. Our most vigorous and productive varieties were included in this group. Severe pruning was more necessary in this group than either of the two others. Many of the laterals carried up to 18 buds each. These buds usually blossomed and attempted to bear fruit. As a result, too many berries were produced to ripen properly and the fruit was small, seedy, and poor in quality. It was found the best practice to cut back the laterals one half, reducing the number of buds to seven to nine. With this degree of severity, the remaining buds produced the maximum amount of good quality fruit. Unbranched canes were cut back to 4½ feet in height.

Swartwout (13) studied the fruiting habits of blackberry varieties in relation to pruning. The length to shorten the laterals depended on the fruiting habit of the variety. On the basal eight buds of Early Harvest laterals an average of six to eight buds was found and almost as large a number on laterals of the Robinson. On the other hand, on Snyder, Eldorado, Taylor, and Rathburn there were four and five-tenths, four and four-tenths, three and nine-tenths, and five and four-tenths, respectively, or only about one half the number of buds in the same region on Early Harvest and Robinson. The number of buds increased slightly farther out on the laterals, but approximately the same ratio was maintained between the two groups of varieties. With varieties of the second group, it was therefore necessary to leave longer laterals or a greater number, since these varieties produced comparatively few laterals. When possible, however, it was advisable to cut the laterals comparatively short and leave a greater number, since very long laterals with a heavy crop near the tip were likely to split off from the main canes. In general, Early Harvest and Robinson laterals were shortened to 10 to 15 inches; while those of Snyder, Eldorado, Taylor, and similar varieties were left 18 to 24 inches long.

Modify blackberry pruning according to the fruiting habit, vigor, and other conditions; the more vigorous the canes, the longer the laterals. Shortening the laterals of blackberries in the dormant season does not seem to force the buds into fruit as much as it does those of black raspberries. As a rule, shorten laterals of Early Harvest more than those of Eldorado, and laterals of
Eldorado more than those of Blowers. For laterals of Eldorado a length of 1½ feet and of Blowers around 2 feet or slightly more is generally suggested for mature plantations. Undesirable laterals arising close to the ground may be cut off at the main cane.

COMPANION CROPS

Ordinarily, it is probably best to avoid companion crops in a raspberry or blackberry plantation, but the immediate financial return is often important, particularly during the first year when the rows are narrow. Garden crops that are small in size, and require cultivation until August may sometimes be used to advantage. Strawberry plants for propagation sometimes may be grown profitably between rows of cane fruits. Companion crops should not be grown so near cane fruits as to compete with them for moisture or food. Tomatoes, potatoes, egg plants, and muskmelons, as mentioned elsewhere in the bulletin, are to be avoided.

SUPPORTS

Altho trellises and supports possess a number of advantages, wires or stakes are not ordinarily necessary with properly pruned canes. Many experienced growers in the State who formerly used supports have abandoned the practice, largely because of the cost. In home gardens many different means of support are used. These often are not at all suitable for field culture, and, since they are so variable and adapted mostly for a particular condition, they are not specifically described here.

When red raspberries are planted in hills, remove weak, slender canes and tie strong ones, preferably 7 to 9, to a stake in the center of the hill.

Fig. 10.—Red raspberry canes cut back about one-half. A lighter heading back is usually favored
A good way of supporting red raspberries grown under the hedge or solid row system is to use a series of posts, with cross-pieces. Posts are placed in the center of the row and a wire is strung along each side of the row attached to the cross-piece. It seems to be a better plan under some conditions to support very tall red raspberry canes by a wire trellis than to prune back severely.

A fairly satisfactory support for black and purple raspberries is one in which wires are stretched over the ends of X-braces, or on 2- by 4-inch cross-arms 18 to 20 inches in length set on stakes or posts 24 to 36 inches high, spaced 15 to 30 feet apart in the row. The wires can be fastened, with bent nails, in such manner that they may be removed, laid on the ground, and later placed back again after removal of the old canes.

Another fairly good means of supporting black and purple raspberry canes is to tie or loop them to a single wire attached to stakes or posts 24 to 36 inches high in the center of the row.

It is often too slow and costly an operation to tie each cane separately. Various methods of looping the canes to the wires with binder twine or other material are sometimes followed. The following procedure is found in Bulletin 201 of the Indiana Experiment Station: "It is best to wind the twine into small balls before taking to the field. One end of the twine is fastened at the end of the row and is then carried around the first cane, under the wire and around the next cane, and so on down the row. A second person follows closely behind keeping the slack pulled up and draws the twine taut under the wire on top of each post. A man and a boy can tie up a mile of row in a day by this method."

Trailing blackberries, or dewberries, when grown with support in Ohio are usually trained to stakes. The canes are gathered together, and tied at several places to stakes 5 feet or so in height, and any ends protruding above the tops of the stakes are cut off. Training varieties with this type of growth to one wire, or to two wires placed above one another, is occasionally practiced.

**MULCHING**

Cultivation is the usual method of field culture. Where cultivation is impractical there is a place for mulching. The labor in application and the difficulty and cost of obtaining straw or other suitable material usually makes mulching impractical in commercial plantations. Nitrogen fertilizer is particularly necessary in mulched plantations. Where plants are propagated by tip layering a mulch is likely to be a serious drawback.

Mulching heavily with manure is not very satisfactory. It is better to work the manure into the soil.
In the home berry patch mulching with straw, or a loose covering of leaves or other material, is often of advantage and is a practice of some value in conserving moisture, maintaining a relatively cool soil, keeping down weeds, and hindering the development of excessive new plants.

**POLLINATION**

The varieties of raspberries and blackberries commonly grown in the State are self-fruitful. They produce good crops in fields planted to only one variety. Johnston (8), however, found some evidence, Table 6, that benefits derived from suitable provision for pollen transfer, both in increased production and to some extent in perfection of fruit, are such that bees should be placed near the raspberry plantation during the blossoming season.

**TABLE 6.—Influence of Pollination by Insects on Fruit Setting in Raspberries. From Johnston (8)**

<table>
<thead>
<tr>
<th>Variety</th>
<th>Fructing shoots</th>
<th>Blossoms</th>
<th>Blossoms falling to set fruit</th>
<th>Berries</th>
<th>Imperfect berries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cuthbert red raspberry</td>
<td>25</td>
<td>487</td>
<td>354</td>
<td>72.6</td>
<td>133</td>
</tr>
<tr>
<td>Insects excluded by a cage</td>
<td>25</td>
<td>431</td>
<td>147</td>
<td>34.1</td>
<td>204</td>
</tr>
<tr>
<td>Insects not excluded......</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cumberland black raspberry</td>
<td>22</td>
<td>188</td>
<td>13</td>
<td>9.8</td>
<td>164</td>
</tr>
<tr>
<td>Insects excluded by a cage</td>
<td>22</td>
<td>176</td>
<td>.....</td>
<td></td>
<td>176</td>
</tr>
<tr>
<td>Insects not excluded.....</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**IRRIGATION**

Raspberries and blackberries are easily affected adversely by drouths. It seems reasonable to expect that irrigation would be beneficial and that a few timely applications of water might prevent loss that otherwise would occur. Altho irrigation may be a means of saving or increasing the yield of fruit and production of plants, most growers seem able to get along without it, and there are few raspberry or blackberry plantations in the State under artificial irrigation.

One of the chief objections to overhead irrigation is the cost of installation. Such factors as aphis, anthracnose, and mildew may be more prevalent if irrigation is practiced frequently. Consideration of one field disclosed the fact that overhead irrigation had been of appreciable benefit in only one year out of four. With some growers, however, irrigation might be a profitable practice.
HARVESTING

Equipment.—The commercial grower will give attention to harvesting equipment some time before the fruit ripens. Crates and boxes may be ordered as soon as a reasonable estimate of the crop can be made. Some idea of the number necessary may be obtained from the section on Yield, Page 4, but records of local crops may serve as a better guide. Crates holding 16, 24, or 32 quarts, respectively, are used for the various types of berries. Red raspberries are best marketed in 24-pint crates, altho the trade demand varies in different districts. Carriers or trays, with handles, for the pickers hold 4, 6, or 8 boxes. Demand and price for berries are affected when offered for sale in damaged or unattractive packages.

Pickers and picking.—Availability of pickers is important. Women accustomed to outdoor work are often the most efficient berry pickers. Under competent supervision boys and girls over 12 years of age are satisfactory.

The number of pickers required depends on many conditions. At certain periods more are required than at others, as at the height of the season, following rains, or delays resulting in long intervals between pickings, and at other rush times.

Careful handling is necessary. Berries crush and crumble easily and then are not attractive as market fruit. Pickers are instructed to place the berries, not drop them, in the container; to discard all muddy, decaying, injured, and over-ripe fruit; and to put the containers in the shade when they are full. Blackberries exposed to the sun after picking develop a bitter taste and a reddish color. Use the thumb and two fingers instead of the thumb and one finger in picking because less pressure is then required to remove the fruit. Hold only a few berries in the hand at a time. Practice clean picking with regard to stage of ripeness. Remove over-ripe and unsound berries from the bushes, even tho worthless, to avoid them in later pickings. Fruit that is over-ripe, picked when wet, or that has become soft or bruised in picking or handling is soon attacked by molds and quickly decays. Place berries not marketed directly from the field, without delay, in cold storage, a cool cellar, or other suitable place, in order to retard deterioration.

Boxes are usually filled quickest with blackberries, followed in turn by black, purple, and red raspberries. Some varieties are more tedious to pick than others, for example, St. Regis than Latham. As a rule, the picking season of red raspberries extends longer than that of the other types, tending to make harvesting
more expensive; the higher price usually obtained, however, serves
to balance the higher harvesting cost and lower yield. Because
blackberries are the last to ripen and have spiny or thorny plants, it may be worth while at times to give a bonus to blackberry pickers
who remain from the strawberry and raspberry seasons.

**Stage of ripeness.**—Raspberries are ready to be picked when
they separate readily from the receptacle. Blackberries color
before ripe; for home use wait until they just start to become soft
before picking. For shipping begin picking blackberries when the
fruit separates fairly easily from the stem. Often blackberries
are placed on the market in too immature a condition. Frequent
picking is desirable, particularly for red raspberries, as they
deteriorate faster than black raspberries or blackberries.

**Paying the pickers.**—Pickers are usually paid by the hour or
by piece-work. When pickers work by piece-work they are wont to
pick where the berries are thickest, to leave the scattering fruit,
and to fill the boxes as fast as they can, sometimes without due
regard to careful handling. On the other hand, when pickers are
paid by the hour they may not work at the desired speed. In large
raspberry or blackberry plantations it is usually necessary to use
some systematic method of keeping account of the work done by
the pickers. The punch card system is probably the most com-
monly used, but it, like other systems such as the book, check, or
cash, has disadvantages as well as advantages. Sometimes the
berries are picked on shares.

**Shelter shed.**—Picked berries should not remain long exposed
to sun, wind, rain, or dust. A shelter shed may be used to
advantage. It need not be an elaborate structure but should be so
located as to save steps in bringing in the fruit and be reached con-
veniently in hauling it away. For raspberries or blackberries,
because of the difficulty of crossing the rows, it may be necessary
to place the shelter shed at the end of the rows, unless there are
cross-alleys in the plantation.

**PROPAGATION**

The condition of propagation fields with respect to virus dis-
eases is important when securing plants for setting. Virus dis-
eases, for which spraying is ineffective, may increase rapidly from
one season to the next. It has been the experience of many
growers who set diseased plants to harvest a first or partial crop,
one reasonably full crop, and then find that the plantation runs
down badly. On the other hand, if healthy plants are set serious
trouble from virus diseases is minimized. Plants as free as possible from infection are in demand for starting new plantations, and rightly so, because this is most important to success.\textsuperscript{1} Our standard raspberry varieties are not immune to virus diseases and the important factor of isolation from disease sources must not be overlooked. State nursery inspection certificates are required when a practice is made of selling plants.

An experiment showing the great importance of starting the raspberry plantation with clean nursery stock was reported by Johnston (9). In the spring of 1925, a Cumberland black raspberry plantation was started at the South Haven Experiment Station. One half of the plantation, 572 plants, was set with tips laid down the previous August from plants that were examined carefully and which were vigorous and apparently free from disease. The other half of the plantation was set with tips purchased from the trade. They had been laid down in the usual way in an average plantation. They appeared as vigorous as the other lot, tho no special attention had been taken in the selection of individual plants. One half of this new plantation is designated as Section A, and the other half as Section B.

During the first summer, nearly 100 plants, or one fifth of those in Section B, showed symptoms of mosaic or wilt and, therefore, were dug out and destroyed. Only one mosaic infected plant appeared in Section A. The following year 75 diseased plants were rogued out of Section B, while only six plants were taken out of Section A. That year was the first fruiting season, and Section A yielded 26 cases and B yielded only 5 cases. In June, 1927, such a large proportion of the plants in Section B showed mosaic and wilt symptoms that it was considered necessary to destroy the entire section because there was danger of infecting other plantings on the Experiment Station grounds. Section A continued to produced satisfactorily, yielding 36 cases in 1927 and 50.5 cases in 1928. Furthermore, this part of the plantation would have done somewhat better if it had not become infected repeatedly with wilt from Section B.

The importance of a fairly light, well drained, fertile soil for the propagation of raspberries and blackberries cannot be over-emphasized. In certain plantations loss of black raspberry tip plants has been heavy and root development has not been all that could be desired. An experiment involving more than 50,000 plants showed a loss of more than one half of tips on heavy, rather wet soil in contrast to a small loss on sandy or gravelly loam; the loss occurred especially with tips that did not become well established because of dry soil and with those tipped late.

**Tip layering.**—Black and purple raspberries are propagated in Ohio by tip layering in the fall. Occasionally, the long canes bend to the ground, become covered with soil, largely by rain splashing,

and take root. This perhaps is somewhat more common in weedy than in clean-cultivated plantations. In cultivated plantations, wind usually whips the canes around so that many tip portions are injured. The mat formed by a late-summer cover crop, such as oats, may partially prevent injury to the tips from whipping by the wind. However, use of a cover crop for this purpose is still in an experimental stage, altho advantages in other respects are recognized. Tips that root of their own accord seldom make first grade plants. For good multiplication and good plants tips should be put down properly by hand at the right time.

One-year-old fields are sometimes preferred by growers to older fields as a source of tip layered plants. There has been some justification for this preference as one-year-old fields have frequently shown less disease than older fields. Thoro inspections and good cultural care by the nurserymen tend to equalize possible differences and make tips from mature plants as desirable as those from one-year-old plants.

![Image](image_url)

**Fig. 11.—Cumberland, after a season's growth.**

With good care an average of 10 new black raspberry plants may be obtained from each vigorous parent plant after a season's growth. About 10,000 plants per acre is a reasonable production for a one-year-old plantation. This is considerably lower than a ratio of 10 to 1, due to missing plants and other factors. In later years, more than 20 tipped plants may be dug, and it is not uncommon to root 40 or 50 new plants from each parent plant. Probably 15,000 plants per acre is a fair estimate, altho more can be obtained, especially if the plants are kept low and the stand is good. There were 4908 unbranched laterals available for tipping from 830 plants (Fig. 11); an average of 6 per hill after one season's
growth; 21,406 laterals were available the next year, an average of 26 per hill. Each lateral may produce more than one tip plant as the laterals tend to branch just before rooting. With such a condition more plants are obtained, tho they are usually smaller and do not possess the well-developed root systems of tipped unbranched laterals. Large root systems are desirable as a rule, but when plants are shipped, both the nurseryman and the grower may secure best satisfaction from plants with root systems that are well developed but not too large.

With purple raspberries a lower percentage of layered tips take root than with black raspberries. Columbian purple raspberry, because of greater vigor, reproduces at the rate of about 15 to 1, as compared with 10 to 1 for Cumberland black raspberry.

To induce canes of black and purple raspberries to branch freely practice summer pinching somewhat lower than where fruit production is the chief consideration. Tip portions of laterals of unchecked canes often are so spindly that sturdy plants are not obtained.

The best time for layering is when the tip portions lengthen in “snaky” or “rat-tail” fashion, with small, curled leaves. Tips put down too early are likely to push out of the ground. They can again be tipped, but do not make the best plants. Relatively early tipping is preferable to late tipping. Late tipping may result
in several small plants from sub-laterals instead of one new plant with a well developed root system from each lateral and in much loss from heaving out. Do not wait for the tips to become purple, as sometimes suggested, as they may fail to do so. The tip-layering season usually begin about mid-August in the southern half of the state and in late August or early September in the northern part. Since all tips are unlikely to be ready at one time, it is a good plan to go over the plantation several times.

![Image of plant](image)

**Fig. 13.—Cumberland. Tip layered too early. The tip portion grew out of the soil but could again be rooted; plants thus formed are usually not of first grade. This is also likely to occur from shallow or horizontal tip layering.**

There are several methods of layering the tips. Better plants seem to be obtained by the use of a narrow spade, heavy trowel, or dibble than by plowing a furrow, altho, on a large scale, plowing finds some favor. Three or four inches of soil make a satisfactory covering, the most suitable depth varying with the type and condition of soil. Shallow tipping may result in considerable loss from whipping out, heaving out, and other causes, as well as in poor root
development. Too deep tipping may result in breakage of many of the tender growing points in digging. A vertical rather than a horizontal method of tip layering is much preferred.

The number of tips put down in a 10-hour day with a narrow spade averaged between 2,000 and 3,000 in a large plantation. When conditions were just right more tipping was done. Tipping 1,000 plants is a good day's work in some cases.

The tips, under favorable conditions, become well rooted by the end of the growing season, and are left attached to the parent plant over winter. Some time previous to digging, sever the parent cane 4 to 8 inches above ground.

Tip plants are sometimes transplanted and grown a year in nursery rows. Such plants are capable of producing some fruit the year they are set. Transplants usually sell at a higher price than tip plants, but their value in comparison with tip plants is questionable for general purposes.

Suckers.—Red raspberries are propagated by suckers that grow from the underground stems. These suckers appear in the spring after growth starts and at the time of spring digging are only a few inches high. Altho suckers thrive well when set, they are not ordinarily bought for setting in permanent plantations, principally because of their small size. Suckers are the forerunners of red raspberry nursery plants.

Red raspberry plants for setting may be obtained directly from rows of plants either by digging entire propagation rows or by digging near fruiting plants. They may also be obtained from suckers grown a season in nursery rows. Red raspberry plants with well developed so-called T-roots are desirable.

Types propagated by tips, such as black raspberries, produce a quantity of plants after one growing season; whereas with types propagated by suckers, such as red raspberries, an additional year or two years are required before there are many plants for sale. After the plantation is established for propagation purposes many more plants are expected per acre from red raspberries than from tip layered types; ten times as many new plants per acre from reds than from blacks is not uncommon. There is less work involved in the propagation of red than of black raspberries in that tipping in the fall is not necessary.

Blackberries, like red raspberries, can be propagated by suckers, but nurserymen prefer to propagate blackberries by root cuttings.
Deep tillage cuts the underground stems or roots and induces the formation of plants. Accordingly, growers sometimes disc deeply or plow along the edges of the rows either in fall or in early spring for propagation.

**Root cuttings.**—Good blackberry cuttings are made about 3 or 4 inches long and about the thickness of a lead pencil. While success is obtained by making the cuttings in spring and planting directly in nursery rows, the work is usually done in the fall. When cuttings are made in the fall they are stratified in moist sand, or other suitable material, or are buried outdoors over winter in a well drained location. When set in the nursery row, the cuttings are placed horizontally in a trench and covered with several inches of soil. If the cuttings are small and spindly, it may be advisable to place them end to end in a nursery row, or even in double rows; but, if they are of good length and thickness, spacing 3 to 6 inches apart in a furrow is suitable. Greater growth the first season can be secured by setting the cuttings in a frame with slight bottom heat supplied by manure. A surprising number of cuttings can be made from a blackberry plant with strong root development. After a year in a nursery row the young plants should have developed sufficiently to be dug and set in a permanent plantation.

**HANDLING PLANTS FOR SHIPMENT**

It is advisable to obtain plants from a healthy plantation near where they are to be grown. This reduces the time between digging and planting and keeps down transportation charges. Every day that berry plants are out of the ground may lower their vitality. Many successful growers wisely insist on going to a nursery to obtain their plants and on setting the plants directly in their fields the same day as dug, if possible. The majority of plants raised, however, have to be prepared for shipment.

Young plants of raspberries and blackberries are perishable. Do not expose plants to wind or sun more than is necessary as they dry out quickly. After the plants are dug they are immediately covered and taken without delay to the packing shed or storage room, or they are heeled-in if shipment is not to be made at once.

Dig and ship plants as near the dormant condition as soil and weather permit. Prospective growers should order plants at an early date.

Before digging tipped plants, shorten the laterals to which they are attached and leave 4 to 6 inches of the cane on the new rooted plant as a “handle”, or prune so that this length can be left after the plants are bunched and trimmed.
A stout four-pronged fork is a good implement for digging tip plants. Large nurseries sometimes use special digging machines for red raspberries and blackberries when the rows are dug clean. It is important that the young plants actually be dug, not pulled; otherwise only a straight stub with few roots poorly equipped for growth may be left.

Fig. 14.—Cumberland. A.—This whorled type of tip development results in an increase in the number of plants produced, but better root systems are obtained when only the terminal is properly tipped.
B.—One tip from each lateral results in the best plants. This tip was uncovered after being in the soil a short time; note enlargement of tip portion.

Keep the packing shed cool and free from draughts when handling the plants. Have conveniently at hand a quantity of sphagnum moss or other suitable material as well as containers and other packing equipment.

When plants are handled in large quantity, it is often necessary to hold them some time after they are dug until disposed of. Drying out, heating, and growth are probably the three most important factors to guard against. Storage rooms in which the plants can
be kept cool and moist usually are necessary when plants are handled in large quantities. Heeling-in is a fairly efficient method of keeping nursery plants for a limited time.

In packing, surround the plants with sphagnum moss, excelsior, or other material that has been well soaked and squeezed free of surplus water. The proper amount of moisture to leave in the packing depends on such factors as distance the plants are to be shipped, type of container, number of plants in the container, temperature, and stage of growth. Too much moisture in the moss may result in heating, but most complaints seem to be that the moss was too dry rather than too wet in bushel baskets or smaller packages. Pack and ship only plants with good thrifty root systems. Discard all plants affected with crown gall. If there is crown gall in a propagation plantation, washing the roots before shipping may lead to spread of the disease among the plants.

Raspberry and blackberry plants are sucessfully shipped in many kinds of containers. Small orders, two dozen plants, filled when the plants are dormant or nearly so can be done up in specially prepared pliable wrapping material available in commercial forms. Oiled and heavy wrapping paper are sometimes used. Substantial carton boxes are fairly good containers for a 50-plant order, altho oiled and heavy wrapping paper are commonly used. Orders of 100 plants may be shipped satisfactorily in firm containers of approximately half-bushel size. Bushel baskets or strong boxes of similar capacity are reasonably suitable for an order of 200 to 300 tip plants, depending on the size of the plants. Not more than 250 tip plants with large root systems should be placed in a bushel size container. In fact, even with orders of 1000 tip plants, better results may be obtained by using several bushel-size containers instead of one large container. Large shipments are sometimes packed in hardware boxes, barrels, or other containers, but, when packed in bulk, heating may occur. If a hardware or other thin wood box is used for a 1000-plant order, brace and wire it against rough handling. A certain amount of ventilation in the container is necessary, particularly with late dug plants. In filling bushel baskets, or other containers, place a layer of moss on the bottom, then a layer or two of plants with roots to the sides and tops to the center, then moss, and so on. Place moss also between the plants and the insides of the container. After a few layers of moss and plants have been placed in the container, the contents can be pressed firmly.
VARIETIES

BLACK RASPBERRIES

Cumberland.—Fruit large, attractive, conical, reasonably firm, sweet, rich, and of excellent quality. Chief midseason variety in most localities; most of the best fields in the state are of this variety.

Plum Farmer.—Fruit medium size, broadly rounded, firm, not as good in quality as Cumberland. Season rather short; major part of crop comes at first two or three pickings. Earlier than Cumberland.

New Logan.—A relatively new variety, grown near Clyde, and attracting interest in other districts. Ripens about a week before Cumberland. Berry possibly slightly smaller and blacker than Cumberland. Plants somewhat lower growing than Cumberland. More extensive testing is needed to show its proper status. At present it seems to be a very promising variety, particularly for earliness and freedom from virus diseases.

Gregg.—Once popular as a late berry but now found in relatively few plantations in Ohio because of its short life.

Kansas.—Sometimes grown to precede Cumberland. As a rule not a first class berry.

Quillen.—May be worthy of some consideration because of its resistance to anthracnose.

Hoosier.—Usually short lived.

Honeysweet.—Disappointing in limited observations.

Black Pearl.—Only a fair, early variety.

Madison.—A new variety that in at least one good sized plantation has compared favorably with Cumberland. From limited observation at Wooster it has not seemed as desirable as Cumberland.

RED RASPBERRIES

Cuthbert (Victory).—Fruit large, roundish conical, only moderately firm, not as uniform in color as desired, ripens midseason. Plants only moderately hardy; canes tall, often sprawling. When well grown, superior to other varieties in dessert and canning qualities.

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While Cumberland is susceptible to disease it can be maintained in exceptionally healthy condition. See Ohio Agricultural Experiment Station Bi-monthly Bull., Jan.-Feb., 1930 (16).
Latham (Minnesota No. 4, Redpath).—Fruit large, broad, roundish, not as dark nor as sweet as Cuthbert, but less musky and firmer. Ripens midseason and later than Cuthbert. Plants exceptionally hardy, highly productive, and strong plant producers; canes, medium to tall, and reddish; leaves thick and leathery. More widely adaptable than, and usually outyielding, Cuthbert.

King.—Fruit medium size, roundish, light red, quality only fair. Probably the chief early variety but not a first class berry.

Minnesota No. 223.—Promising to replace King.

St. Regis (Ranere).—Fruit small, roundish, soft, poor quality. Bears in summer on year-old canes and in fall on canes of current season. Has some value for fall bearing, but, on the whole, not a very satisfactory variety.

Ohta (Flaming Giant).—In Ohio this variety ranks below Cuthbert and Latham in yield and quality of fruit.

Marlboro.—Used to be extensively grown with Cuthbert which it preceded in season. Now replaced by other varieties.

June.—Fruit rather small and of poor quality. Not very productive. Ripens earlier than King. Outside of the possible value of its earliness it possesses few merits for growing in Ohio.

Herbert.—Ranks fairly good in yield, size, appearance, and quality.

Newman (Newman No. 23).—One of the firmest of red raspberries. Ranks fairly good in yield, size, appearance, and quality.

Viking.—Fruit slightly lighter but more uniform in color than Cuthbert. Some experience seems to indicate that the fruit is softer than Cuthbert, crumbles more easily, and does not can as well. Productive. An outstanding feature is the remarkable vigor and strength of cane.

La France (Erskine Park).—Bears in fall as well as in summer. Fruit so inferior that it possesses little value in Ohio.

Van Fleet.—Apparently a promising variety for southern states, but of doubtful value for Ohio. Possesses undesirable characteristics in color, shape, size, and quality, that more than outweigh its vigor and yield. Blooms and ripens late.

**YELLOW RASPBERRIES**

Golden Queen.—A yellow fruited variety, otherwise much like Cuthbert. Color unsatisfactory for commercial planting.
PURPLE RASPBERRIES

Columbian.—Fruit large, broad, roundish, dark, juicy, rather soft, good quality but somewhat acid. Ripens midseason to late. By far the best purple variety in Ohio.

BLACKBERRIES

Eldorado.—The principal variety.

Blowers.—A good variety when free from orange rust to which it is very susceptible. Later than Eldorado.

Erie.—Well liked by some growers in the Cleveland district. Ripens midseason to late.

Early Harvest.—Not commercially satisfactory in the State. Fruit small. Ripens early.

Snyder.—A standard commercial variety for many years, but its popularity has declined.

Mersereau.—Only a fairly good variety.
PART II. DISEASES OF RASPBERRIES AND BLACKBERRIES

C. W. BENNETT

DISEASES WHICH AFFECT THE ENTIRE PLANT AND USUALLY RESULT IN DEATH

Dead and dying plants are common in black raspberry producing sections of Ohio during some seasons. Entire fields may be destroyed or the trouble may be restricted to localized areas in the plantings. Such injury may be caused by wet soil, wilt, or winter freezing.

INJURY FROM WET SOIL

Few factors are more important in the growing of raspberries than the selection of a well-drained site. Black raspberries in particular will not thrive on soil which is wet for even a short period at any time during the year. Red raspberries, blackberries, and dewberries are somewhat more tolerant, but even these do best on well-drained soil.

Most soils in which raspberries are likely to be planted are dry enough thru the spring and summer to permit satisfactory growth. Except under very unfavorable conditions, injury is not produced until the second year or later. A high water table during the fall, winter, or spring kills many of the small feeding roots of black raspberry plants, and may severely injure the entire root system. Plants injured during the dormant season may fail to start growth in the spring, or they may produce normal development until, with the production of foliage, the demand for water increases to a point at which the crippled root system is no longer able to supply the needs. The leaves turn yellow, the young canes take on a bluish cast, and the plants wilt and die.

Heavy spring rains and cloudy weather followed by a few hot days sometimes cause browning of the oldest leaves on fruiting canes. This is noticeable, usually, soon after the plants come into blossom; it is more common on thrifty plants with dense foliage than on plants making a slower growth but usually leads to no permanent injury.

Moreover, winter injury is often combined with injury due to wet soil, sometimes being confused with it. Low winter temperatures frequently injure the living tissues of the canes, the black
raspberry being especially susceptible. Canes are rendered more subject to freezing injury if they grow late in the fall and do not properly ripen or harden. The winter-injured canes, if not completely killed, produce weak fruiting shoots in the spring and usually dry up before, or soon after, blossoming. In some cases the entire crop is lost. The new canes on such plants usually make a normal growth and may produce a satisfactory yield the following year.

Cover crops sown in August or early September tend to check growth and prevent winter injury.

WILT

Wilt, when thoroly established, is one of the most serious diseases of black raspberries. Fortunately, most fields are free from this disease. It also attacks red and purple raspberries but causes less injury.

Fig. 15.—A three year old Cumberland black raspberry plant killed by wilt

Symptoms.—Wilt symptoms may be seen in first year plantings but more often wilted plants are not observed until the second or third year or later. Signs of disease begin to appear in July or August: affected plants grow slowly, and leaves become faded or yellow. Plants may remain in this condition during the warm part of the summer, and resume growth in the fall, and appear to
recover, partially or completely. The following summer such plants are usually more severely affected. Canes grow slowly and the leaves are closely spaced at the tip, the lower leaves turn yellow, droop and die, and the canes turn blue. This blueing of the canes usually progresses from the base upward but the reverse may be true. Red raspberry plants sometimes have only one or two affected canes and such plants may recover. Affected black raspberry plants, however, usually die in the course of two or three years.

Cause.—Wilt is caused by a fungus, \textit{Verticillium ovatum}, which is capable of living for a considerable period in the decayed organic matter of the soil. It will also live over winter in canes killed the previous summer. Infection apparently takes place from the soil thru the underground parts and perhaps also thru injured parts of the canes. The fungus grows in the water tubes and ramifies to all parts of the plant. This would indicate that the organism may penetrate far enough to infect the tips or young plants and be disseminated in this way.

![Fig. 16.—A three year old field of Cumberland black raspberry plants badly affected by wilt. Plants have been removed from the area in the foreground because of the large number killed by wilt; the “skips” in the part of the planting remaining are also due to wilt.](image)

Control.—No very satisfactory control measures for wilt are known. The removal of diseased plants from infested fields seems to have no influence on the further spread of the trouble. For new plantings, select vigorous disease-free stock and plant on soil which has not recently grown crops of tomatoes, potatoes, or egg plant affected by wilt.
DISEASES WHICH AFFECT THE ENTIRE PLANT AND CAUSE VARYING DEGREES OF STUNTING

Several diseases of brambles affect all, or nearly all, parts of the plant, but require a more or less extended period for the production of severe injury or death. The virus diseases, curl, mosaics, and streak, and the fungous disease known as orange rust are included in this group. Some of these, such as the milder forms of mosaics, do not seriously interfere with the growth of the more resistant varieties. As a rule, however, these diseases are very destructive in their effects, and, in many plantings, profitable production depends on their control.

CURL

Varieties quite susceptible to curl are Cuthbert, Viking, Latham, and Marlboro of the red raspberries; Cumberland, Gregg, and Hoosier of the blacks; and Haymaker of the purples. King and St. Regis red raspberries, Plum Farmer black raspberry, and Cardinal purple raspberry are resistant. Blackberries and dewberries are occasionally attacked, but spread is not rapid enough to cause appreciable loss.

Symptoms.—Affected plants have curled leaves, the margins of the leaflets being rolled downward and inward. Leaves are a darker green than normal and tend to become bronzed early in the fall; the stems and leaves are dry and brittle, and the plants stunted. Diseased black and purple plants do not tip readily. Plants become smaller and weaker each season until they finally die from effects of the disease or are winter-killed. The fruit is of poor quality, small, and clings to the receptacle.

Cause.—Curl is caused by a virus similar to that which causes mosaics of other crop plants. The exact nature of viruses is not well understood, altho certain properties and reactions of some have been studied extensively. So far as determined, they reproduce only in the living plant. In many cases they are transmitted from plant to plant by means of insects, and this is the only known method of transmission of the raspberry virus diseases. There are two types of curl virus, one which attacks red varieties but not blacks, and one which attacks both reds and blacks. The effects on the plants of these viruses are very similar.

Dissemination.—The virus of curl is spread by means of a small plant aphid, *Aphis rubiphila*. This insect is not sufficiently abundant in raspberry plantings to cause injury directly from its
feeding punctures; but after it has fed on a diseased plant, it becomes a carrier of the virus and transmits curl to healthy plants on which it feeds. Winged forms are produced at certain times of the year when the aphids become crowded. Winged aphids may carry infections as much as a half mile from a diseased plant. Curl is not spread by pruning or other cultural practices.

Control.—Roguing out and destroying all diseased plants in the patch and all diseased wild plants in the vicinity of the planting have proven the only successful method for control of curl on susceptible varieties. The disease can be controlled in black and purple raspberry plantings of any age, but in red raspberries, the average grower is not successful in plantings more than one year old. First year plantings should be inspected several times during the summer and all curled plants pulled and destroyed. If this practice is followed, curl is rarely a serious factor. Older plantings should be rogued early in the season, before the aphids multiply and become disseminated. Curl symptoms are evident by the time the first leaves are full grown. Careful early roguing will, in many cases, practically eliminate the disease in black and purple patches. In red raspberry plantings it is difficult to destroy all of the root systems of diseased plants and those roots remaining in the soil send up infected suckers.

In roguing, the diseased plants may be pulled or dug, carried from the patch, and burned. The plants should not be dug and allowed to wilt in the patch, because, as soon as the plants wilt, the aphids present crawl off and find their way to other plants, thus disseminating the virus of disease. A more effective method is to burn the plants in place by means of a torch, such as shown in Figure 17. These torches are too expensive for use except in plantings grown for nursery stock.

The small grower should depend for control on obtaining disease-free stock and on very thorough roguing of the young plantings the first year, followed by systematic roguing each season as early as the first appearance of curl symptoms permits.

MOSAICS

The mosaics are closely related to curl. They differ from curl in the type of symptoms produced and in the range of varieties affected. All known varieties of raspberries, blackberries, and dewberries are susceptible in some degree to at least one type of mosaic. However, these diseases on blackberries and dewberries are not common enough to require rigid control measures. Red
raspberries, however, are very susceptible to infection but very resistant to the effects of the disease. Fields of red raspberries may produce good yields for an indefinite period even after all of the plants have become infected. Black raspberries are among the most sensitive of all bramble fruits to the viruses which cause mosaics. On black raspberries most forms of mosaic cause more or less dwarfing and for this reason the plants must be kept free from mosaics to insure the best results in vigor and yield.

![Image of a person spraying plants](image)

Fig. 17.—Destroying virus-affected raspberry plants by means of a kerosene burner. This burner kills the aphids and prevents further spread.

**Symptoms.**—The most typical symptom of mosaics is the mottling produced on the leaves of affected plants. Splotches of shades of yellow and green, varying in size and contour, are the
usual symptoms by which these diseases are detected. The entire leaf may be yellow except for a few green blisters, or yellow with little or no mottling, or, as is the case more often, the ground color of the leaf may be a normal green with small splotches of yellow along the veins or scattered throughout.

Fig. 18.—Cuthbert red raspberry plant affected by mosaic (left) and curl (right). The plant in the center is healthy

A mild form of mosaic occurs on red, purple, and black raspberries. Symptoms are rarely evident on red varieties. Mottling is very mild on black varieties, and very little stunting is caused by the disease in this variety.

A medium type of mosaic, considerably more severe than the mild, seems to have a more general distribution. Much of the King and Latham stock is infected with this virus. Symptoms on red raspberries occur only on the first leaves formed in the spring, these symptoms consisting chiefly of yellow or faded spots. Little noticeable injury is produced on red varieties. Black raspberries are injured to a greater extent. Leaves produced at low temperatures are distinctly mottled and the plants are considerably dwarfed. Later in the season, after the older leaves yellow and die, leaf symptoms are difficult to find. Cool spells during the summer, however, may result in the production of rings of mottled leaves on the new canes. The current season’s infection usually can be detected regardless of the summer temperatures. Growth stops in the tips of infected canes, and dark spots appear in the
stem tissue near the cane tip and in the leaf petioles. The young leaves are yellow and mottled, the leaf petioles are necrotic, and the tips of the canes curve and become very brittle, Figure 20. The tips may die and lateral buds may start growth, or the tips may grow into apparently healthy canes which are considerably stunted the following season.

Fig. 19.—A type of mosaic mottling common on black raspberries

A type of mosaic more severe in its effects on the plant than either of those described is found on a number of varieties of raspberries. At low temperatures it produces distinct mottling of red raspberries, but symptoms seem to be masked by high temperatures. On black raspberries symptoms are much more severe. Young canes of affected plants are more than 18 inches high, the leaves are rosetted, and the cane tips and leaf petioles are brittle and necrotic. Soon after infection the growing tips are killed. Leaf mottling is either coarse and splotchy or lacking, and the green of the leaves is deeper than normal. Diseased black raspberry plants live for only a short time.

The mosaics described previously seem to be of the same general type and are probably closely related. They are similar in
that they all produce a certain amount of necrosis on susceptible varieties, have symptoms partially or wholly masked at high temperatures, and are more severe on black than on red varieties of raspberries. They differ in severity of effect on the plant.

Fig. 20.—A tip of Cumberland black raspberry cane recently infected by a medium severe type of mosaic from red raspberry. Note the curved and necrotic condition.

A fourth type of mosaic differs from those described in many of its characteristics and is caused by an apparently quite distinct virus. This disease is usually called yellow mosaic because of a more or less characteristic uniform yellowing of the foliage of affected plants. It attacks all common varieties of raspberries and occurs also on blackberries and dewberries. It causes considerable stunting in all varieties. Black raspberries are killed in two or three years; red and purple varieties are distinctly stunted after one or two years, and the plants gradually decline in productiveness until they are finally discarded. Symptoms of yellow mosaic on red raspberries are late in appearing in the spring, and affected plants usually cannot be detected until many of the leaves are of full size. After symptoms appear they are usually visible throughout the remainder of the season and are not so masked by summer temperatures as are some of the other mosaics.
On the King and Latham varieties, yellow mosaic is usually found in combination with one or more of the other types. Plants thus affected show the typical yellow color, but the leaves are more mottled. These combinations may be and often are transmitted to black varieties.

![Stunted Cumberland black raspberry plant caused by yellow mosaic. A healthy plant is shown at the right](image)

**Fig. 21.**—Stunted Cumberland black raspberry plant caused by yellow mosaic. A healthy plant is shown at the right

**Cause.**—The mosaics are virus diseases but the number of viruses involved has not been determined. Because of the overlapping and intergrading of symptoms it is difficult to determine whether mosaics are caused by a large number of distinct and stable viruses, or by a smaller number producing a considerable range of symptoms, which vary with the environmental influences on the plant and with the nature of the viruses themselves.

**Dissemination.**—The chief agent of dissemination of mosaics in Ohio is a rather large, long-legged aphid, *Amphorophora rubi*. This aphid manifests a decided preference for King and Latham over such varieties as Cuthbert and Plum Farmer. It does not readily feed and multiply on the common varieties of blackberries and dewberries. Thus, these latter types of brambles are practically free from mosaics; occasionally they are infected and then the individual plants are injured severely.

If plants are growing rapidly and aphids are abundant, there is likely to be a rapid spread noticeable in fields where badly-infested red raspberries grow near black varieties. There are
instances known where a half or more of black raspberry plantings became infected from adjacent, diseased red raspberries in a single season.

Fig. 22.—A ring of dwarfed and mottled leaves on a mosaic-affected cane of a black raspberry plant produced following a cool period in the summer.

Control.—Mosaics are best controlled by obtaining the very best stock available for new plantings and roguing out all diseased plants as they appear. As with curl, the first year roguing is the most effective, especially for black raspberries. Diseased plants should be pulled, carried from the patch, and scorched enough to kill the aphids. Black raspberries should not be planted within 20 rods of cultivated or wild red raspberries. Plantings handled in this way will give good results for from 5 to 10 years, before mosaic becomes a serious factor.

Red raspberries should be rogued the first season for yellow mosaic and other forms that cause dwarfing. With most red varieties it is unprofitable and unnecessary in commercial plantings to attempt to eliminate all forms of mosaic.
Fields from which plants are to be taken should be rogued three or four times each season as long as used for the purpose of propagation.

**STREAK**

Streak is a serious disease on black raspberries. It is not known to cause severe injury to other types of bramble fruits. Blue stem and rosette are other names for this disease. It is serious in many fields in northern Ohio where some plantings have been completely devastated and others severely injured.

**Symptoms.**—Typical symptoms of streak do not make their appearance until the latter part of June or later. That diseased plants produce normal growth at low temperatures and that streak symptoms appear only after the temperature has reached a relatively high average have been shown by greenhouse tests. This helps to account for the clearly defined symptoms in July and August and for the difficulty in detecting diseased plants early in the season.

Affected plants are stunted, the degree of dwarfing depending on the length of time plants have been diseased. Leaflets are slightly or distinctly rolled, and this condition may be accompanied by a coarse splotching or obscure mottling. The faded areas are large, often obscure, or sometimes lacking. The leaflets at the tips of the canes are twisted or distorted by turns in the midrib.

Reddish or purple stripes, averaging about one sixteenth of an inch in width, are produced on the canes. They are often confluent, and in some cases the whole cane has a more or less solid red or purplish color. These discolorations seem to be governed by the temperature. Striped and normal zones have been produced at will in the greenhouse by subjecting diseased plants alternately to low and high temperatures.
Cause.—Streak is probably caused by a virus of the same general type as those which cause curl and mosaic.

Dissemination.—The distribution, time, and rate of spread under field conditions suggest insect transmission, altho no insect has been definitely shown to be an agent of dissemination. *Aphis rubaphila* and *Amphorophora rubi*, the chief agents involved in transmission of curl and mosaic, have been extensively tested to determine whether they are capable of transmitting streak. During February and March of 1929, each of 50 Cumberland plants was inoculated with more than 50 individuals of *Aphis rubaphila* taken from diseased plants. A similar experiment was made on 30 plants using *Amphorophora rubi*. All of these plants remained healthy during the spring of 1929. Other experiments have yielded parallel results.

![Fig. 24.—Orange rust on Mersereau blackberry plant. Rusted plants produce large numbers of spineless new canes early in the season as shown by the plants at the left](image)

It seems likely that neither of these insects is responsible for transmission of this disease. Other sucking insects, especially leaf hoppers, should be studied in this connection.

Control.—Use healthy stock for new plantings. Inspect fields several times during the season, beginning about the first of July or earlier if symptoms are evident, and destroy all affected plants.

**Orange Rust**

Orange rust is one of the few systemic fungous diseases of plants. It is a serious disease in blackberries and black raspberries. It also attacks dewberries and purple raspberries, altho
the Lucretia dewberry and the purple raspberries are very resistant. The disease has never been found on any variety of red raspberry. Rusted wild blackberries and dewberries are abundant along roadsides and in abandoned fields in some sections of Ohio. Of the cultivated blackberries, the Eldorado is resistant. The Snyder, Mersereau, Blower, and Kittattinny are susceptible.

**Symptoms.**—Affected plants may be detected in the spring as soon as the first leaves are produced and symptoms are quite distinct until about the first of July. Plants are stunted and produce a large number of new canes devoid of spines, and these canes produce laterals which rarely blossom. In some cases healthy and diseased canes appear in the same hill or on the same crown.

Leaves are small and distorted as they begin to unfold. Before they are full grown numerous, orange-colored, glistening bodies appear. This is followed in about two weeks by orange-colored blisters on the lower side of the leaf. In this stage the entire plant usually has a very characteristic orange cast. The blisters soon break open and liberate enormous numbers of orange-colored spores, which may be blown to all parts of the planting and cause further spread of rust. Soon after the spores are liberated the affected leaves die and drop. Leaves produced later in the season do not show signs of rust and diseased plants in this stage are more difficult to detect. The recovery is only apparent, however, for all diseased plants will have rust the following season.

**Cause.**—Orange rust is caused by two species of true rust fungi, one so-called short cycle rust, *Kunkelia nitens*, and the other a long cycle form, *Gymnoconia interstitialis*. These two fungi cause almost identical effects on the plants. They attack the young succulent parts at times favorable for infection, and become established in the canes, crown, or roots as slender branching threads. They obtain their nourishment from the plants but do not kill the invaded tissues. Each season, as the new shoots grow out from the canes, crown, or roots, the fungus grows into the shoots, keeping pace with the growing tips. As the leaves are produced the fungus grows into them where it produces a crop of spores for further spread. These spores, depending on the species of rust involved, are directly or indirectly responsible for spread to other plants.

**Spread.**—Weather undoubtedly has an important influence on the spread of rust. During some years there is practically no increase of the disease in infected plantings; in other seasons 20 per cent or more of the plants may become infected. For example,
1927 was an unusually favorable year for rust infection in southwestern Michigan. Plantings of blackberries and black raspberries in which there was very little rust in 1927 had large numbers of infected plants in 1928. One field of 400 Mersereau blackberry plants, in which there were only 12 rusted plants in 1927, had 194 plants affected in 1928. In this field there were 200 Eldorado plants of which only 4 had become infected. Similar severe spreads were noted in black raspberries.

**Control.**—Destroy all rusted plants in the patch and surrounding territory before the spores are shed. Plants may be dug and allowed to wilt in the field. It is not necessary to burn them. Remove as much of the affected root systems of blackberry plants as possible. Wild plants in the fence rows and waste land may be destroyed by placing a large handful of common salt around the crown of each plant.

**DISEASES WHICH PRIMARILY AFFECT THE CANES**

**ANTHRACNOSE**

Most varieties of black raspberries and dewberries may be severely injured by anthracnose. Blackberries and red raspberries are more resistant and, unless conditions are unusually favorable for the development of the disease, are not seriously affected. The Quillen is the most resistant variety of black raspberry.

**Symptoms.**—Light-colored sunken spots surrounded by a red ring are the most characteristic symptoms of anthracnose. The spots appear on the young canes, fruiting shoots, fruit pedicels, leaf petioles, and veins. On the canes they are a quarter of an inch or less in diameter, smaller and more elongated on the fruit pedicels, leaf petioles, and veins, and smaller on dewberry than on raspberry. These spots persist as long as the parts remain alive. They may be seen on fruiting canes a year or more after they have been formed, and, if numerous, produce a rough condition, sometimes attended by splitting of the canes. Leaf spotting is produced, if there is considerable rainfall and cloudy weather when the leaves are unfolding.

The berries may be attacked and become bleached and dry before two thirds grown, or they may be dried or dwarfed on one side. In the average year, however, the chief damage is done by the spots on the canes and on the fruit pedicels. These interfere with the movement of water and food materials and cause dwarfing. A severe attack on the fruit pedicels causes many of the berries to shrivel and dry about picking time.
Cause.—The cause of this disease is a fungus, *Plectodiscella veneta*, which lives over winter in the spots on the canes. In the spring it produces two kinds of spores. One form is produced in sacs in spherical fruiting bodies located in the bark at the edges of the spots. These spores are discharged during rains and are probably responsible for the spread of anthracnose to uninfected plants. Spores of the other type are produced on little cushions in the bark. They break thru the bark and during rains are spattered to young growing parts. As a rule these spores do not spatter more than a few inches. These are the summer spores and are formed in all of the new spots produced and a supply is available at all times when weather conditions permit of dissemination.

Control.—Most of the anthracnose infection in a first-year black raspberry or dewberry planting originates from spots on the old canes or "handles" attached to the young plant. If planting is done early and the handles removed at planting time, very little anthracnose will be found the first year. If, at the time the tips are dug, the new shoots are already thru the soil, infection may have already taken place, and removal of the "handles" may not markedly decrease the amount of anthracnose.

The disease may be held in check or controlled in most seasons by spraying. The following sprays have given best results.

1. Liquid lime-sulphur, one gallon of the commercial product to 20 gallons of water, applied as a delayed dormant spray about the time the buds show green tips.
2. Bordeaux mixture applied when the blossom clusters can first be seen. Liquid lime-sulphur, 1-50, or the summer strength of dry lime-sulphur may be used instead of bordeaux mixture. The second application may produce a certain amount of burning of the foliage during some seasons. Do not spray raspberries and dewberries after blossoming as considerable foliage injury may result.

CROWN GALL

Crown gall, root gall, or root knot, as this disease is variously called, attacks all bramble fruits as well as many others such as apple, peach, and grape. In the order of their susceptibility the cane fruits probably rank as follows: red raspberry, purple raspberry, blackberry, black raspberry, and dewberry. Very little difference in varietal susceptibility within the group has been noted.
Symptoms.—Galls varying in size are abundant on the roots of red raspberries in many plantings and may be numerous enough to weaken and stunt the whole plant. This is especially true of young plants that have become infected before, or at the time of, planting. Galls are rare on the roots of black raspberries, but are more common around the crowns and on the canes as rough warty overgrowths. Sometimes galls are so abundant around the crowns of black and purple raspberry plants that all the space from which new canes normally arise is completely occupied by gall tissue preventing the formation of new canes. In such cases the plants die after fruiting. Galls occur on the roots, crown, and stems of blackberries, causing a cracking of the canes and general stunting of the plants, Figure 27.

Cause.—Crown gall is caused by a bacterium, *Bacterium tunefaciens*, which finds its way into wounds from infested soil and trash, or from diseased plants. The germs once established in succulent tissues stimulate the plant cells to rapid growth, resulting in a slight swelling which enlarges into a soft white gall. This later becomes dark in color and woody in texture, and liberates germs which cause further spread of the disease. The crown gall bacteria can live in decayed gall tissue for several months.

Control.—There is no satisfactory control for gall once it is thoroughly established in a planting. Good cultural methods and application of suitable fertilizers do much to enable the plants to resist the effects of the disease. New plantings should be started with plants as free as possible from gall.

Most red raspberry nursery stock has a certain amount of gall in spite of the care taken in handling the plants. The operations
necessary in digging, bundling, packing, and shipping are conducive to gall infection. Plants received in good condition and with no signs of gall formation may be so thoroughly infected that a high percentage will have galls a few weeks after planting. The disease can be avoided to a large extent, by growers who produce their own plants, by selecting stock from young plantings. Sucker plants taken the spring following the planting of the patch are quite free from gall and should be utilized where available.

Blackberries may be freed from gall in the same manner, or by making cuttings from gall-free plants and planting in uninfested soil. Gall is less common in carefully grown nursery stock of black raspberries and dewberries.

CANE BLIGHT

All varieties of raspberries seem to be somewhat susceptible to cane blight, and the disease is sometimes found on blackberries. In Ohio the disease is more often found on black raspberry than on any other bramble.

Symptoms.—True cane blight symptoms appear sometime before the fruit ripens. Fruiting branches, tips of fruiting canes, or entire fruiting canes wilt and dry. A single cane may be affected or the disease may be present on several canes. A close examination of the blighted canes reveals a cankered area, sometimes several inches long, in which the wood and bark are dead. Cankers may be seen before the cane begins to show marked wilt symptoms. They have a smoky color, often with lighter-colored spots and many small elevations over the surface, Figure 29.

Fruiting canes injured by winter freezing seem to be very susceptible to the invasion of the cane-blight fungus. During the winter of 1928-29 many patches in central and southern Ohio were winter-injured. The following spring the fruiting canes were
invaded by a fungous growth, bringing about a condition that resembled a severe attack of cane blight. Nearly all of the canes in some plantings died soon after the fruit set.

**Cause.**—Cane blight is a fungous disease. The causal organism, *Leptosphaeria coniothyrium*, enters the canes thru wounds caused by the snowy tree-cricket and other agencies. Infection takes place during the summer and the fungus remains in the cane until the following spring. Renewed activity in the spring kills the wood and bark in the invaded region, and this limits the water supply of the tops; the canes soon begin to wilt and die. The fungus produces fruiting bodies in the bark of affected canes, which appear as small, dark-colored elevations. During rains spores are pushed out of these fruiting bodies and spatter to other canes. A second type of fruiting body has sacs in which spores are formed. When ripe these spores are discharged into the air and are disseminated by the wind.

**Control.**—No satisfactory control measures for cane blight are known. Cutting out and burning the affected canes are usually recommended. Fortunately, this disease is not often serious enough in Ohio plantings to demand the use of control measures.

**WIND INJURY**

It will not be necessary to discuss obvious types of wind injuries such as breaking of fruiting shoots, blowing over plants, and the “whipping” of the tips of black raspberry canes. There is one type of injury, however, usually not recognized as such, which, at times, may be rather common and severe.

In fields of black raspberries, when the new canes are 18 inches to 2 feet high, many of the young canes may begin to wilt and droop at the tip. This is usually followed by death. The canes seem loose on the crown and are easily swayed back and forth. When they are pulled from the crown it is found that they are attached only by a small amount of wood. The surface of the remainder of the woody portion is smooth, the pith has shrunken, and there is a distinct ring of callus around the outer edge. Some of the canes have the appearance of having been gnawed by insects.
Young canes at first have a weak connection with the main crown. A strong wind causes them to sway back and forth, breaking the bark in a ring around the base of the cane. No more wood can be formed and that which has already been produced dries, the cane beginning to wilt. This wilting may not take place until several days after the breaking caused by the wind. Injury of this type may also be produced by striking the canes with cultivator or other implements.

Black raspberry plantings in the second year are more subject to this kind of injury than are older plantings, since there are no fruiting canes large enough to support or protect the new canes.

**GLOEOSPORIUM BLIGHT**

A type of blighting of cane tips, formerly confused with other raspberry troubles, is found to a limited extent throughout the State. The economic importance of this trouble is not definitely known, but no cases of severe injury have been noted. It seems to be more common in black raspberries than in other brambles.

**Symptoms.**—Tips of the canes wilt and die and the stems turn blue. The disease may progress downward in the stem and cause a considerable portion to die.

**Cause.**—The cause of this disease is a fungus morphologically indistinguishable from the apple bitter-rot fungus, *Glomerilla cingulata* or *Gloeosporium cingulatum*. It apparently produces infection thru anthracnose spots and perhaps thru other types of injury. Fruiting bodies and spores are formed in the anthracnose spots, and in wet weather spores may be abundant enough to give the spots a pinkish color.

**Control.**—No measures have been developed for control of this disease. Control of anthracnose may decrease the amount of Gloeosporium infection.
SPUR BLIGHT

Red raspberries are sometimes injured by a disease known as Spur Blight. Solid row plantings and dense stands of canes offer favorable conditions for the disease.

**Symptoms.**—Dark reddish discolorations appear in the bark surrounding the base of the leaf petioles; death of leaf and axillary buds may follow. As a result the affected canes produce few fruiting shoots. Buds on the upper part of the cane are less subject to injury than those on the lower. During the fall and winter following infection the spots become bleached. The fruiting bodies of the causal organism appear as numerous black dots just below the surface of the bark which are clearly visible when the cane is wet.

**Cause.**—Spur blight is caused by a fungus, *Mycosphaerella rubina*. Initial infection takes place during the early part of the summer from spores produced in fruiting bodies on the old canes. After the first spur blight spots are formed on the new canes, summer spores are produced which may continue the spread of disease.

**Control.**—No effective remedy for combatting this disease is known. It is only in rare cases that the disease is severe enough to justify the use of control measures. In such cases thinning out the canes enough to permit free circulation of air reduces the amount of disease.

DISEASES WHICH PRIMARILY AFFECT THE LEAVES

POWDERY MILDEW

The Latham red raspberry is the only variety of bramble fruit seriously injured by powdery mildew. The King is susceptible to a certain extent and the black varieties of raspberries are sometimes slightly infected, especially if grown in the vicinity of a Latham patch, altho the loss even in these cases is negligible.

**Symptoms.**—A superficial growth of a mealy-white fungus appears especially on the lower side of leaves. The leaflets are spotted or deformed, and in some cases mottled. Small leaves, long slender stem tips, and almost leafless canes or “rat-tails” result from severe attacks. Canes are severely stunted and the fruit may be small and of poor quality.

**Cause.**—Mildew is caused by a fungus, *Sphaerotheca humuli*, one of a group of powdery mildews found on many different kinds of crops. It grows abundantly over the surface of the leaves, penetrating the leaf tissue by means of sucker-like processes which
obtain from the leaf cells the food material for growth and multiplication. Spores are produced in great numbers and are disseminated by wind and rain. The fungus apparently overwinters in the buds.

**Control.**—Effective control measures are badly needed for Latham. Ordinary measures, such as spraying, have failed to give satisfactory results.

In plantings grown for nursery stock only, mildew can be controlled by cutting off and burning all the parts above ground in the fall or early spring. New canes are relatively free from mildew the first season. Such canes used as nursery stock the following spring make much more satisfactory growth than do canes thoroly infested with mildew.

**LEAF SPOT**

Leaf spot is not severe on any commercial variety of raspberry. King, a red variety, is one of the most susceptible. The disease is sometimes found on black varieties. It is at times very abundant on dewberries and is often confused with anthracnose.

**Symptoms.**—Small round spots, varying in size from a sixteenth to an eighth of an inch in diameter are found on the leaves. At first the spots are red or dark-colored; later they may be composed of a light-colored center surrounded by a reddish ring of tissue. If the spots are numerous, yellowing and defoliation may result. On dewberries the spots, in addition to occurring abundantly on the leaves, develop on the canes.

**Cause.**—This trouble is caused by a fungus, *Mycosphaerella rubi*, that, in life history and general symptoms produced, resembles a great many other leaf-spotting fungi.

**Control.**—On raspberries and blackberries this disease is not serious enough to justify the use of control measures. On dewberry the sprays recommended for anthracnose control also decrease the amount of leaf spot.

**FROST MARKINGS**

In springs of late frosts, odd types of markings are found on leaves of nearly all varieties of raspberries. These usually take the form of white markings or dots along the edges of the main veins. In more severe cases the leaflets may be distorted, the tissue thrown into ridges, or the leaflets may be long and narrow.
This type of injury does little direct damage. It appears only on leaves which were small at the time of frost. The markings are sometimes mistaken for mosaic altho they do not usually closely resemble the symptoms caused by the mosaic diseases.

Fig. 31.—Frost markings along the veins of a black raspberry leaf
PART III. INSECT PESTS OF BRAMBLES

     J S HOUSER

With a very few notable exceptions, insects do not directly cause serious losses to the Ohio growers of bramble fruits altho, if taken in the aggregate, the damage from this source probably is considerably greater than is generally recognized. However, the indirect losses caused by certain of these insects as carriers of disease virus place the group in a position of decided ill favor in the estimation of the growers.

In the present discussion no attempt will be made to consider in detail all of the various species likely to be encountered, but rather to deal only with the more important ones. The several species will be divided into two general groups: (a) those affecting fruit and foliage, and (b) those affecting stems and roots.

FRUIT AND FOLIAGE FEEDERS

The discussion of this group of pests will be confined to six species: the raspberry byturus, the raspberry sawfly, the blackberry leaf miner, the red spider, and two species of aphids.

THE RASPBERRY BYTURUS, Byturus unicolor Say

In 1907 and 1908, the growers of red raspberries, particularly in northern Ohio, suffered serious losses from the depredations of this insect, and a comprehensive study of the problem was made at that time.

The adult beetle is about one seventh of an inch in length, reddish brown in color, and when viewed under a hand lens is observed to be covered with tawny hairs. It is generally considered that the insect passes the winter in the soil as a pupa. The beetles appear in northern Ohio in early May and begin feeding on both foliage and buds. At that time the leaves may be quite badly skeletonized, Figure 32, and in instances of great abundance the injury to the buds may seriously decrease the crop.

The young larvae, hatching from eggs deposited probably upon the berries, in late May or early June, bore thru the berry cap and feed upon the crown of the cap and the interior of the fruit. Berries so affected when picked show the effects of the injury so clearly that they are practically unsalable. Even in instances of

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\(^{3}\)For a more detailed discussion see Ohio Agr Exp Sta Bull 202
slight infestation the presence of occasional wormy berries decreases profits to a marked degree because of the cost of the careful inspection required to produce a first class pack.

Fig. 32.—Early season foliage injury to raspberry by raspberry byturus beetles—Photo by Goodwin

Fortunately this pest occurs at rather infrequent intervals; hence it is not necessary to make an annual practice of control measures. Furthermore, the control developed is quite effective and fairly simple. Since the presence of the pest in a planting is indicated early in the season by the damage to the developing foliage, abundant opportunity is afforded growers to prepare for its control.

Control.—The principal control measure consists in spraying with arsenate of lead just before or at the time the first beetles appear. The formula recommended is arsenate of lead powder, 2 pounds; water, 50 gallons. Since spraying materials adhere with difficulty to raspberry foliage, adding two or three pounds of fish oil soap to each 50 gallon lot of the poison mixture will add materially to the efficiency of the treatment.

The spraying should be done with all possible thoroness, and if rains follow the application or the attack of the insect is exceptionally severe, a second spraying within a week is advisable. Shallow
cultivation in the fall is a good supplementary or preventive measure to follow, since this practice doubtless destroys many of the insects in their earthen hibernating cells.

**THE RASPBERRY SAWFLY**, *Monophadnoides rubi* (Harris)

Because of the protective coloration of the feeding larvae it is very easy to overlook this insect, particularly in the early part of the season when the insects are young. The adult, a four-winged, fly-like creature, is but rarely observed.

The larvae, after hibernating in the soil, change to pupae in the spring, and the adults appear in late May or early June. Eggs are laid in the foliage and the larvae upon hatching feed by eating holes thru the leaves. When full grown the larvae are about three fourths of an inch long, greenish in color and clothed with spines.

**Control.—**Since this insect is abroad about the same time as the raspberry byturus and since the manner of feeding is much the same, spraying with arsenate of lead will control both species. However, since the sawfly larvae are more likely to be found injuring the lower leaves of the plants, particular care should be taken that this portion of the plant be thoroly covered by the spray.

**BLACKBERRY LEAF MINER,**

*Metallus rubi* Forbes

While this insect is most commonly considered a pest of blackberries and dewberries, it occasionally occurs in considerable numbers, particularly on the lower leaves of some varieties of raspberries. Its work is characterized by large brown blisters or mines with a flattened, active larva, rarely becoming more than one third of an inch in length, feeding within, Figure 33.

The winter is passed in the larval or pupal condition in the soil, the adults appearing in late May or early June. Two broods occur annually, one in June and a second in August.
Control.—Since this insect is a miner between the upper and lower leaf surfaces, applications of arsenate of lead are ineffective in its control. No thoroly successful remedy for this insect has been developed, altho it has been suggested by other workers that spraying with a mixture of nicotine sulphate 1 pint, soap 2 to 3 pounds, and water 50 gallons would probably afford satisfactory relief.

**RED SPIDER, Tetranychus telarius L.**

Aside from the two species of plant lice to be mentioned later, this pest is more generally abundant than any other species. Because of its small size and of the unobtrusive nature of attack its presence is rarely noted until it is well established.

Injury is caused by the young and mature mites feeding for the most part on the under side of the foliage. The combined rasping and sucking manner of attack not only mechanically disturbs the leaf tissues but results in sap losses which at first cause the foliage to appear covered with minute yellow spots, Figure 34. Later the leaf surface presents a grayish, lustreless aspect and still later if the injury is severe the entire leaf may become brown and dead. Hot, dry weather favors the pest.

![Fig. 34.—Mottling of raspberry leaves by red spider. Normal leaf, left, injured, right](image-url)

The winter is passed in the adult or second nymphal stage at the base of brambles or weeds. Since many species of plants, both cultivated and uncultivated, serve as hosts, it is entirely possible that weeds may be important sources of initial infestation. As many as ten generations may be developed within a single season.
Control.—Sulfur sprays are recognized as effective controls for red spider; but, since the raspberry plant is particularly susceptible to injury from these materials, their use is prohibitive.

In California flour paste has been used with satisfactory results. The formula for its preparation and use is as follows: “Mix a cheap grade of wheat flour with cold water, making a thin batter without lumps; or wash the flour thru a wire screen with a stream of cold water. Dilute until there is one pound of flour to each gallon of mixture. Cook until a paste is formed, stirring constantly to prevent caking or burning. Add sufficient water to make up for evaporation. For use add 8 gallons of this stock solution to 100 gallons of water. When mixed in the spray tank, flour paste has a tendency to settle and in order to do satisfactory work agitation is necessary.” (18)

THE PALE GREEN RASPBERRY APHID, Aphis rubiphila Patch

This plant louse, described from Maine on wild red raspberry in 1914 by Dr. Edith M. Patch, has been discussed in an earlier section of this bulletin as a vector of the virus of leaf curl.

The wingless females are small and pale green in color; while the winged forms have a pale green abdomen with shiny black head and dusky antennae. As stated previously, rarely does this insect occur in numbers sufficiently large to demand treatment with insecticides.

AN APHID Amphorophora rubi Haltenbach

This species, to which the growers commonly refer as the “large, long-legged aphid” is easily differentiated from the preceding, since both winged and wingless forms are decidedly larger, more slender, and longer-legged. The insect is well distributed in both Europe and America, and so far as is known infests both cultivated and wild species of the genus Rubus only. Rarely, if ever, does it occur in sufficient numbers to cause primary injury to the host.

Control of aphids.—Since neither the small green aphid nor the large, long-legged aphid occur at any one time in large numbers, the concensus of opinion of growers seems to be that spraying with insecticides is not feasible. Moreover, control by spraying would necessitate frequent applications because of the continued migration from outside sources. The most practicable control measure to be employed with respect to both species seems to be, in addition to roguing plants affected with curl or mosaic, the destruction of
both wild hosts and neglected plantings within the vicinity of the planting proper. It is particularly desirable that attention be given such areas located on that side of the planting from which the prevailing summer winds blow.

It is so obvious as scarcely to merit mention that curl- and mosaic-infected plants, which at the same time are infested with aphid colonies, should not be removed before the insects are destroyed, lest during the process the aphids are dislodged and thus serve to infect healthy plants. The commonly practiced method of accomplishing this is by scorching the plants with a blast torch before removal.

INSECTS AFFECTING STEMS AND ROOTS

Undoubtedly the pruning practices normally followed in bramble culture exert a highly beneficial influence in the control of insects affecting the stems and roots of the plants. In the first place, without any particular effort on the part of the grower, a high percentage of the infested canes are removed in the spring before insect activity begins, and secondly, a little care and watchfulness when pruning is being done will enable the workmen to detect infested canes, the removal of which will reduce still farther possible injury from this source.

THE BLACK-HORNED TREE CRICKET, 
Oceanthus nigricornis Walk

The pithy stems of raspberry and blackberry are favored positions in which the adult tree crickets deposit their eggs, altho other cultivated plants, as well as wild plants and weeds, may serve for this purpose, Figure 35.

The injury caused by the black-horned tree cricket is confined almost wholly to the weakening of the canes by the egg punctures, which occasionally is so pronounced that breaking occurs. In late summer or early fall the curved light-orange
colored eggs are deposited in closely spaced single rows about two inches in length and extending lengthwise of the stem of the host. So distinctive is the work of this insect that it cannot be mistaken.

The winter is passed in the egg stage, the young tree crickets hatching in the spring after vegetation is well started. For the most part the young insects make their way to the soil when they begin feeding upon succulent weeds and other vegetation, gradually increasing in size and finally reaching maturity in late summer or early fall.

**Control.**—If even moderate care is observed during the time of pruning practically all of the hibernating egg masses may be destroyed, and, if this is done, much will be accomplished by way of protecting the planting for the following year. However, the adult tree hoppers are winged insects and some degree of reinestation may be expected even tho every egg mass is removed. Hence, neglected nearby areas supporting vegetation suitable for harboring the pest should be cleaned up either in the spring or fall of the year. The maintenance of clean cultivation within the planting, particularly during the early part of the season, destroys the favored food of the young insects and is, therefore, a commendable practice.

**THE MEADOW GRASSHOPPER,**  
*Orchelimum vulgare* Harris

Recently (19) this insect has been reported as doing notable damage to raspberries in Illinois and, since the species has been recorded from Ohio, a brief discussion is presented at this time. The chief damage is caused by the weakening of the canes by reason of the egg-laying punctures illustrated by the accompanying photograph, Figure 36. However, since egg laying does not occur until late September, the damage becomes serious in those instances only when enough canes do not remain uninjured to provide an adequate stand for the following season after the damaged ones are removed.
Control.—As intimated previously, removal of damaged canes at the time of pruning should be practiced. Another measure followed by some of the Illinois growers is that of hand-picking the conspicuous green grasshoppers in the early morning during late September, when they are sluggish. A combination of these two practices has aided materially in reducing damage the following season.

Since the developing nymphs feed during the summer on succulent vegetation, preferably of a leguminous nature, rank growths of this character in or near the berry planting should be avoided.

THE RASPBERRY CANE BORER, Oboea bimaculata Oliv

Since the native host of this insect is the wild raspberry, cultivated plantings in the vicinity of neglected areas may on occasion suffer marked damage. The adult form, a dark slender beetle, appears in early June and the female makes two rows of punctures encircling the stem about six inches below the growing tip. The two rings are located about an inch apart and it is in this short section that the egg is laid. The tip above the punctures wilts and droops; this condition, together with the distinctive manner of stem girdling, renders the identification of the work of this insect very easy.

The young larva upon hatching in July bores downward thru the cane thruout the remainder of the summer and the second season as well. In the second season the infested cane is likely to die.

Control.—Cutting and destroying the wilted tips of the canes below the lower row of punctures prevents further damage, but if some escape observation and become infested with the larvae, these should be cut near the surface of the soil.

THE RASPBERRY CANE MAGGOT, Phorbia rubivora Coq

Since the work of this insect so closely resembles that of the cane borer the discussion of this pest is included at this point. As with the cane borer, the first evidence of injury by the cane maggot is the wilting of the terminals.

The adult form of this insect is a fly which deposits its eggs in late April in the crotches formed by the terminal leaves when the shoots are a few inches in length. The maggot upon hatching enters the shoot a few inches lower down, burrows in and, after feeding for a short distance, girdles the shoot just beneath the bark. This causes the shoot to wilt and droop, but the larva
continues to burrow downward, in early summer reaching a point near the crown of the plant. Here pupation occurs and the fly does not emerge until the following spring.

**Control.**—Cutting off the tips of the infested canes as soon as tip wilting occurs, and removing tunneled canes during the early spring or late fall pruning period is the recommended procedure.

**RED NECKED CANE BORER, *Agrilus rubicollis* Fab**

The injury characteristic of this insect is swellings in the canes, as shown by the accompanying illustration, Figure 37. The cane so affected in extreme cases may die, but usually the damage is expressed in failure to fruit.

**Control.**—Removal of the spent bearing canes during pruning effectively controls this insect to such a degree that losses from its activities are insignificant.

**THE BLACKBERRY ROOT BORER, *Bemecia marginata* Harris**

Since the larva of this insect attacks the lower part of the canes and the roots, a general appearance of un thriftiness of the plant affected is the principal way in which its presence may be detected. Raspberries as well as blackberries may be affected.

The full grown larva is nearly an inch in length and the adult form is a beautiful, clear-winged moth, which is abroad in August and early September. Eggs are laid in September on the leaves and the larvae bore into the bark of the stem just beneath the surface of the soil. Two years are required to complete larval growth.

**Control.**—Since the root borer is an underground feeding insect its control is not so simple as in the case of the borers previously discussed. Plants showing evidence of weakness should be inspected for the presence of this pest and, if found, the larvae may be removed. On some occasions the infestation becomes so
widespread that the destruction of the entire planting is advisable. This is most easily accomplished by plowing, which should be done in October.

**THE ROSE SCALE, *Aulacaspis rosae* Bouche**

Conspicuous white circular objects about one eighth of an inch in diameter, occurring at the base and extending well up on the stems of raspberry and blackberry, indicate infestation by this pest, Figure 38. When the attack is severe the scales may overlap and completely obscure the bark of the host. Permitting grass to grow in the rows, or other debris to collect therein seems to favor infestation by this species.

![Image](image-url)

Fig. 38.—The rose scale affecting raspberry. Female scales (left) male scales (right)

Injury is caused by the sapping of the plants by the feeding insects, but rarely is the infestation sufficiently severe to cause significant damage. However, finding the insect present in plantings in which a particular effort is being made to produce clean stock is disturbing.
Control.—The rose scale is quite easily controlled by an application of full dormant strength lime-sulfur, or of miscible oil. The concentrated liquid lime-sulfur should be diluted at the rate of 6½ gallons, or the powdered lime sulfur at the rate of 15 pounds, to 50 gallons of water. If one of the oils is employed the strength used should be that recommended by the manufacturer.

Young Cumberland black raspberry plantation at Ohio Experiment Station
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