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BERRY INFORMATION PACKET
VOLUME 2
BLUEBERRIES

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A. Introduction and Overview (By David Himelrick)

1. Production Costs

The costs of blueberry production have been estimated for Washington state in 1981. Variable pre-harvest costs totaled $1293, harvest costs, and fixed costs $1764. The total costs per acre were calculated at $4929.00. With a total production of 8000 pounds of fruit per acre the break even price was $.62 per pound. The enterprise budget assumed a return to the grower of $.61 per pound. These costs assume a mature fully productive blueberry planting which is not achieved until eight years after planting. No fruit is normally harvested until the third year after planting. The cumulative balance of costs versus returns does not become positive for 5 to 8 years after planting. This can present a serious cash flow problem for many producers. Production cost estimates from Washington state are included in Appendix 1.

2. Market Prices

Market prices in 1986 ranged from $10.00 to $13.00 per 12-pint flat at the wholesale market. This translates into $1.11 to $1.44 per pound which includes the cost of master boxes, pint tills and shipping and handling costs incurred up to the terminal market. U.S. producers received $.75 to $.90 per pound for fruit in 1986. The early season market begins with Florida and Georgia around the first week of May. The domestic market sales begin in force with North Carolina which comes into production the last week of May. This production concentration continues northward and finishes with Maine around the second week of October. The only major off-season imports come from New Zealand during January and February. The most concentrated domestic supply is found on the market during July, August and September. Off-season air freighted blueberries will occasionally command prices of $25.00 to $50.00 a flat.

Retail prices for canned blueberries are in the $1.69/15 oz. or $1.180/lb. range. I.Q.F. frozen packages are in the $2.39/16 oz. or @.39/lb. range. Other frozen packages of blueberries are selling in the $1.49/12 oz. pr $1.99/lb. Bulk 30 lb. containers of frozen product are currently selling for $.85/lb. F.O.B. New Jersey or Michigan.

3. Production

Domestic blueberry production extends from early season production of the rabbiteye types in the southern U.S. up the eastern coast to North Carolina, New Jersey and Michigan with the highbush varieties. The season finishes in Maine with the lowbush types. Additional production can also be found in Washington and Oregon.

Table 1. 1986 North American blueberry crop production statistics.

CULTIVATED:	(000 lbs)
North Carolina	5.5
Michigan	57.0
New Jersey	40.0
Oregon	4.8
Washington	2.8
British Columbia	7.0
AR,LA,MS,TN	9
Georgia	2.3
Florida	8
Total cultivated	121.1
WILD:	
Maine	41.0
Nova Scotia	16.2
Quebec	1.0
New Brunswick	6.0
Newfoundland	1.7
P.E.I.	6
Total Wild	66.5
1986 Total North American Blueberry Production	187.6

Table 2. The major countries which currently export blueberries to the U.S. 1986.

Country	Metric Tons	1000 Dollars
Canada	4,288	3,709
New Zealand	530	1,901
Australia	11	25
Chile	2	5
Mexico	6	2

Total blueberry imports for 1986 were valued at $5,642,000 and totaled 4,837 metric tons.

4. Variety Recommendations

Since little or no data on the performance of blueberry cultivars (varieties) in Central America currently exists, I would recommend that trial planting of both rabbiteye and highbush types be established. The rabbiteye types should perform better under most climatic conditions encountered in Central America. The rabbiteye types are generally more heat and drought tolerant. The following summarizes the current southern cultivars:

In addition to the rabbiteye types a trial planting of southern highbush blueberries should be considered. The following is a list of southern highbush blueberry cultivars with some information on what is currently known about them. The cultivars are place in probable ripening order for a climate like that of south Georgia.

a. Highbush Cultivars

'Sharpblue'- Approximate ripening date in lower South Georgia: early May, low to moderate vigor, semi-upright, moderately productive, fruit medium in size, light blue, fairly firm but with a wet scar, and good flavor. Resistant to stem canker but leaf diseases can be a problem. Recommended for trial in zone 9A only (Gulf Coast area)). 300 chilling hours. 1976 release by Drs. Sharpe and Sherman.

'O'Neal'(NC1688)- Approximate ripening date in South Georgia: early May; southeast North Carolina; June 1, vigorous, semi-upright, productive,fruit very large, medium blue, excellent firmness, picking scar and flavor. Blooms over an extended period in southeastern North Carolina. Tolerant to some races of stem canker. Recommended for trial in the coastal plain and piedmont in the southeast. 400 chilling hours. 1987 release by Drs. Ballington and Draper.

'Avonblue'- Approximate ripening date in low South Georgia: early to mid May, low vigor, semi-upright, moderately productive, fruit medium large in size, light blue, good firmness, dry stem scar and good flavor. Recommended for trial in zone 9A (Gulf Coast Area). 400 chilling hours. 1977 release by Drs. Sherman and Sharpe.

'Georgiagem' (T285)- approximate ripening date in South Georgia; mid May; North Georgia and southeast North Carolina: early June, vigorous,upright, medium productivity, fruit medium in size with a good color, firmness, picking scar and flavor. Probably susceptible to stem blight and canker. Recommended for well-drained sites in the coastal plain and also in the piedmont if frost protection can be provided. 350 chilling hours. 1986 release by Drs. Austin and Draper.

'Gulf Coast' (MS90) - Approximate ripening date in South Georgia: mid May, vigorous, semi-upright, medium productivity, fruit medium in size, firm, small stem scar and good flavor. 400-500 chilling hours. 1987 release by Drs. Gupton and Draper.

'Cooper' (MS78) - Approximate ripening date in South Georgia: mid May, vigorous, semi-upright, medium productivity, fruit medium large in size, firm, small stem scar and good flavor. 400-500 chilling hours. 1987 release by Drs. Gupton and Draper.

'Cape Fear' (NC1525) - Approximate ripening date in South Georgia: mid May; southeast North Carolina: June 7, vigorous, semi-upright, very productive and precocious, fruit large to very large, light blue, excellent firmness and picking scar, good flavor, susceptible to stem canker and tolerant to stem blight. Recommemded for trial in the coastal plain, piedmont and lower mountains in the southeast. It will be important to start with stem-canker-free nursery plants. 500-600 chilling hours. 1987 release by Drs. Ballington and Draper.

'Floridablue' - Approximate ripening date in lower South Georgia: mid to late May, difficult to propagate and grow. 300 chilling hours. 1976 release by Drs. Sharpe and Sherman.

'Blue Ridge' (NC1440) - Approximate ripening date in South Georgia: mid to late May; southeast North Carolina: June 12, vigorous, upright, productive, fruit large to very large, very light blue, excellent firmness and high acid flavor, wet picking scar, similar to 'Blueray'. Susceptible to stem canker but tolerant to stem blight. Recommended for trial in the coastal plain, piedmont and lower mountains in the southeast, but only for pick-your-own plantings because of the fair picking scar.

It will be important to start with stem-canker-free nursery plants. 500-600 chilling hours. 1987 release by Drs. Ballington and Draper.

b. **Rabbiteye Cultivars**

'Tifblue' - Leading rabbiteye cultivar. Very vigorous and widely adapted. Mid-to-late season, fruit large, round light blue, sweet, very firm with a small dry scar. Berries appear to be ripe several days before full flavor develops. Berries remain on plant several days after fully ripe. Georgia 1955.

'Woodard' - Early, 7-10 days before 'Tifblue'. Bush size is the shortest and most spreading of Georgia varieties. Produces many suckers. Berries are light blue, firm, large, with excellent quality when full ripe but very tart until ripe. Georgia 1960.

'Climax' - upright, open plants. Berries are medium in size, medium dark blue in color, have a small scar and good flavor. Early season, ripening 3 to 5 days before 'Woodard'. Concentrated ripening, excellent for machine-harvest. Georgia 1976.

'Briteblue' - Moderately vigorous, grows upright and open. Mid-season, generally before 'Tiftblue'. Berry firmness, heavy bloom, and small dry scar combine to make this a good shipper. Fruit with good flavor when fully ripe. Georgia 1969.

'Bluebelle'- Good pick-your-own cultivar. Berries large, round, light blue with excellent flavor that size well throughout the season. Mid-season. Plants moderately vigorous with upright growth. Scar tends to tear, not recommended for shipping. Georgia 1976.

'Delite'-Upright bush, moderately vigorous. Season slightly later than 'Tifblue'. Berries are light blue, often with reddish undercoat; large, firm with excellent flavor. Berries are not tart before reaching maturity. Georgia 1969.

'Southland'- Moderately vigorous, dense upright plant. Berries are light blue, medium large with good flavor. Tend to lose size as season

progresses. Same season as 'Tifblue'. Scar is small and dry. Georgia 1969.

'Brightwell'- Early, same as 'Woodard'. Berries are medium in size and in blue color, with small dry scars and good flavor. Plant growth is vigorous, upright and produces enough new canes to renew the plant. Georgia 1981.

'Premier'- Earlier (2-3 weeks) than 'Tifblue'. Large fruit with good flavor. Vigorous, disease resistant, productive. North Carolina 1978.

'Powderblue'- Vigorous, disease resistent, productive. Same season as 'Tifblue' with better fruit color and more foliage disease resistance. North Carolina 1978.

'Centurion'- Later than 'Tifblue'. Adds one or more weeks to the rabbiteye ripening season in North Carolina. Good flavor, not as firm and darker than 'Tifblue'. North Carolina 1978.

'Beckyblue'-Early ripening. Low chilling requirement (less than 400 hours). Extends the cultural range of rabbiteye blueberries into South-Central Florida. Should be interplanted with 'Aliceblue'. Not recommended north of North Florida. Florida 1978.

'Aliceblue'- Early ripening with low chilling requirement, Similar to and should be interplanted with 'Beckyblue'. Florida 1978.

'Baldwin'- Productive, late-ripening cultivar with good flavor and firm, dark-blue fruit. Has lengthy ripening period; adapted to pick-your-own and backyard plantings. Georgia 1985.

The following cultivars are low-chilling tetraploid (Southern highbush) plants and are included since their climatic adaptability is within the range of rabbiteye blueberries:

'Avonblue'- Adapted to North Central Florida. Ripens after 'Sharpeblue' but before any rabbiteye cultivars. Fruit quality high. Florida 1976.

'Floridablue' and 'Sharpblue'- adapted to Central and South-Central Florida, considerably south of the best range for present rabbiteye cultivars. Suitable for pick-your-own and local

markets. Interplant both cultivars for cross-pollination. Florida 1976.

'Blue Ridge'- Early-mid-season cultivar with medium-large, firm, high acid flavored fruit. recommended for local sales and pick-your-own in piedmont and lower mountains of Southeastern U.S. Chilling requirement - 500-600 hours. North Carolina 1987.

'Cape Fear' - Mid-early cultivar similar in season to Croatan in North Carolina. Productive with very large fruit of good color, scar, and firmness and average quality. Recommended for hand harvest and commercial shipment or PYO plantings. 500-600 hours chilling requirement. North Carolina, 1987.

'O'Neal'- Very early ripening cultivar with large very high quality fruit. Adapted for PYO or hand harvest for commercial shipment. Chilling requirement -400 hours. North Carolina, 1987.

Cooper' and 'Gulfcoast' - Moderately vigorous, upright, productive cultivars with high quality medium size fruit. Fruit size of 'Cooper' is larger and 'Gulfcoast'is more productive. Flower later than 'Climax' and ripen 2-3 weeks earlier than 'Climax' or 'Premier'. Mississippi 1987.

'Georgiagem'- Moderately vigorous, upright, productive with medium size fruit that has good color, small scar, and is firm. Blooms later than 'Climax' but earlier than 'Sharpblue' and 'Avonblue' and ripens 2 weeks before 'Climax'. Georgia, 1987.

5. Site Selection

The first critical factor in site selection for blueberries is soil ph. Blueberries require an acid soil below a ph of 5.2. This crop also responds very favorably to high levels of organic matter in the soil. Well decomposed organic matter should be added to the planting hole and the plant should be mulched annually with sawdust or other materials. Much soils in Central America are much to alkaline for good blueberry growth and will undoubtedly produce an iron chlorosis (deficiency) in the plant. Soil ph can be reduced through the addition of sulfur. The practical limitations of this procedure is limited by the

natural ph of the soil and its tendency (buffering capacity) of return to this native ph.

In this case of acid-loving crops such as blueberries the soil ph may need to be lowered. In this situation the use of agricultural grade sulfur is recommended as a soil amendment. One year is required for bacteria to oxidize sulfur and lower the soil ph. No more than 400 pounds of sulfur should be used on established blueberry plantings in one year. Table 3 give the approximate quantities required to change the soil ph of various soil types and initial acidity levels.

Table 3. Pre-plant sulfur recommendations to lower soil ph to 4.5. Pounds of sulfur needed are per acre. Aluminum sulfate can be substituted at six times the suggested rates.

	Soil type		
Current ph	Sand	Loam	Clay
4.5	0	0	0
5.0	175	530	800
5.5	350	1050	1600
6.0	530	1540	2310
6.5	660	2020	3030
7.0	840	2555	3830
7.5	1000	3040	4560

The second critical factor is a chilling requirement for proper flowering. All rabbiteye and southern highbush cultivars require at least 250 hours of air temperatures below 7 degrees Celsius (45 degrees F.) to meet this physiological requirement. Temperatures below 10 degrees Celsius (50 degrees F) may be of benefit in meeting this need. Temperatures above 15 degrees Celsius (59 degrees F) may reverse the chilling process. Adequate chilling will probably only be obtained at elevations above 2000 meters (6500 feet) in Central America. Other potential experimental treatments to chemically break dormancy include cyanamide (4%)m thiourea (1%), oil + DNOC (5%), KNO3 (5%) -see article attached to bramble report.

The third critical factor will be the water requirement of the plants. Blueberries have a fibrous and limited root system which is inefficient in foraging for water. The plants will need at least

2.5 cm (1 inch) per week of water during the fruiting season. This will demand the use of supplemental irrigation for successful fruit production and plant growth. In most areas irrigation will be required from November through April. In other areas irrigation will be necessary every month of the year.

6. Trial Plantings

Since no information exists on the growth, flowering and fruiting of blueberries under Central American conditions we can not be certain of their performance. In this situation I would recommend the establishment of trial plantings at various locations which are representative of the typical climatic conditions in the proposed production areas. Due to the following cultivars for evaluation:

Highbush Types	Rabbiteye Types
Sharpblue	Beckyblue
Floradablue	Aliceblue
Avonblue	Briteblue
	Woodard

Due to the long term nature of a blueberry planting no reliable data on cultivar performance will be available for 3 to 5 years from planting. Trial plantings should be started as soon as possible.

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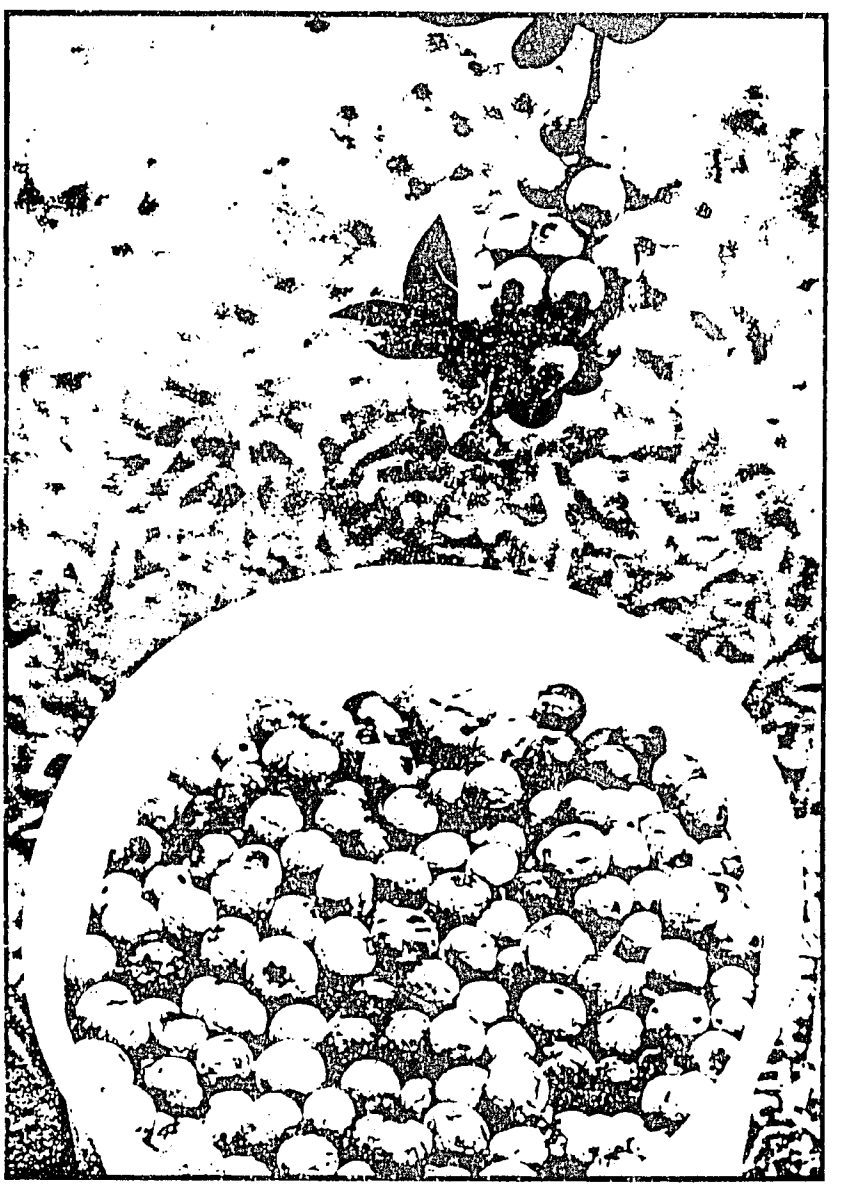
Florida Blueberry Handbook

P.M. Lyrene and T.E. Crocker



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FLORIDA BLUEBERRY HANDBOOK

P.M. Lyrene and T.E. Crocker

Since 1920, blueberry culture in the United States has increased from almost nothing to a major agricultural industry. This growth has been largely due to the release of improved cultivars, the first of which were adapted to the northern United States. These cultivars formed the basis of a new fruit industry which has grown as better varieties were developed and more growers became familiar with blueberry culture. Today, about 30,000 acres of cultivated blueberries are grown in the United States, primarily in New Jersey, Michigan, and North Carolina.

The success of blueberry cultivation in the northern states has stimulated blueberry trials in other parts of the country. In Florida, Georgia, and other southeastern states, rabbiteye blueberries have shown much promise. The rabbiteye is a southern blueberry, and differs in several ways from the highbush blueberries grown farther north. The berries themselves, however, closely resemble those of the highbush, and the two are essentially indistinguishable in the marketplace. The high plant vigor and high yields of rabbiteye blueberries have encouraged widespread plantings in Florida, and it appears that a sizable blueberry industry is developing in the state.

This handbook summarizes for growers and potential growers what is currently known about growing blueberries in Florida. As with most new enterprises, much is unknown, but the oldest plantings of improved blueberries in Florida are now 25 years old, and much valuable information has been obtained by the pioneering growers who established them. In addition, improved cultivars and cultural information have come from research on blueberries which began at the University of Florida in 1950. Additional information is available from university research and grower experience in North Carolina, Georgia, Arkansas, Michigan, and New Jersey, and from U.S. Department of Agriculture blueberry research. Information from all of these sources is used in this report. The best procedures for growing blueberries in Florida are still being worked out and serious growers should keep informed on the latest developments through the Florida Blueberry Growers Association and through their county agents.

The Outlook for Florida Blueberries

Blueberry plantings can range in size from a few plants in the dooryard to a large commercial plantation covering many acres. The needs of the plants are the same in both cases. Although this handbook was prepared with commercial plantations in mind, much of the information is also relevant to dooryard plantings.

The profitability of blueberry plantations in Florida depends on site selection, cultivar selection, cultural procedures, and method of marketing. Well-planned and well-managed blueberry farms can be quite profitable in Florida. Production costs per pound of berries here compare favorably with those in other areas of the country where good growers have made good profits. The cost of good blueberry land in north Florida compares favorably with that in the major blueberry states of Michigan and New Jersey, and Florida plantations reach peak production sooner because of longer growing seasons. In Arkansas, a profitable blueberry industry has been established during the past two decades on soils that are inherently less suitable for blueberry culture than many soils in Florida. Well-managed blueberry farms established in Florida during the last 20 years are doing well, further demonstrating the profitability of Florida blueberries.

Marketing Florida Blueberries

The method of marketing should be the first consideration in planning a Florida blueberry farm. Of the approximately 500 acres of blueberries currently in Florida, most are sold on the farm with the customer picking the fruit (you-pick farm). To

Rabbiteye blueberries may be harvested by hand or by use of various harvesting machines.

be successful with a blueberry you-pick farm, a grower must enjoy working with people and must be located in an area where potential customers are available and where the market for you-pick blueberries is not likely to be oversupplied within the near future. In many parts of Florida where blueberries can be grown, the you-pick market is still almost untapped. Information is available from the Extension service on how to establish and run a you-pick farm. Diversified you-pick farms, on which several different crops are produced, are often the most successful.

Only recently have blueberry farms been established in Florida for markets other than you-pick. These are not yet in full production, and the most profitable way to market the fruit has not yet been determined. One alternative used by the 8000-acre New Jersey industry is hand picking into pint containers for the fresh market. This requires large amounts of reliable labor.

Mechanical harvest of blueberries is also possible. A large machine can pick about 5 acres per day. Mechanically-harvested blueberries can be sold on the fresh market after cleaning and sorting, but this requires a well-adjusted machine, a skillful operator, proper timing of harvest, and suitable cultivars. Not all the blueberies on a plant can be picked on a single date because not all ripen together. Growers may choose to hand harvest the earliest ripening berries and machine harvest the rest.

Most of the large Michigan blueberry crop is mechanically harvested for processing as frozen or canned fruit. An explosion drying process for blueberries has been developed and is being tested in Georgia.

A first goal of the Florida blueberry industry should be to supply fresh blueberries for Florida markets. At present, some fresh-pack blueberries enter the state from Georgia, New Jersey, and Michigan, but the market is not adequately supplied from these sources.

An important consideration in the possible export of fresh Florida blueberries to other states is season of availability from Florida compared to other important blueberry production area. The first blueberries from early cultivars are picked about May 15 in North Carolina, June 15 in New Jersey, and July 10 in southern Michigan. It might be expected that Florida blueberries would be earlier than all of these, but the rabbiteye blueberry is naturally a late ripener. When rabbiteye cultivars are grown in the same field with early highbush, the rabbiteyes ripen a full month later. Thus, the first shipment of early rabbiteyes from Gainesville, Florida would be about June 5 in an average year with current cultivars. This would overlap the second half of the North Carolina highbush harvest, but would precede the larger New Jersey harvest. Because the North Carolina blueberry industry is relatively small (3000 producing acres compared to 8000 for New Jersey and 10,000 for Michigan), the first half of June is still a good season for shipping fresh blueberries. Eventually, a May shipping season will be possible in Florida as earlier ripening rabbiteye cultivars and disease-resistant highbush cultivars are developed for Florida. Earlier ripening will become increasingly important in Florida as Georgia and other southeastern states become major blueberry producers.

Costs and Return for Blueberry Farms in Florida

Several independent cost-and-return analyses have been made for rabbiteye blueberries in the southeastern United States, and all reach the same general conclusions. The first is that starting a blueberry farm is very expensive if land, labor, and machinery are all purchased and charged to the cost-return ledger. When interest rates on borrowed money are high, a blueberry farm may take many years to break even. During the 4 years that pass before the first paying crop is harvested, accumulated interest costs may nearly equal the initial establishment cost. If a grower already owns suitable land and some of the necessary machinery, and if he can provide some of the labor himself, the time required for the farm to show an overall profit is greatly reduced. The inputs required in establishing and maintaining a blueberry farm are listed in Table 1. The total cost for the first year is about $3000 per acre plus land costs. Most of this goes for purchase of plants, installation of an irrigation system, mulch, peatmoss, and labor. Maintenance costs in years 2 to 4 are about $500 to $1000 per acre per year.

Table 1. Inputs per acre required in establishing a blueberry farm.

Year one
Land costs
Plant costs (604 plants per acre)
Irrigation installation costs
Plow land, once, 0.5 hours
(Tractor, plow, and driver)
Disk Harrow, twice, 0.3 hour each
(Tractor, disk, and driver)
Lay off rows, once, 0.5 hour
(Tractor and driver)

Open furrows, twice, 0.3 hour each
(Tractor and driver)
Apply peat moss, once, 2.0 hours
(Tractor, trailer, and driver)
Fertilize, 5 times
Set blueberry plants, 5.0 hours
(Tractor, trailer and driver)
Mulch beds 5.0 hours
(Tractor, trailer, and driver)
Irrigation electricity

Inputs per year, years 2 and 3
Fertilize 5 times
Spray 5 times, 0.5 hour each
(Tractor sprayer and driver)
(Herbicides & Fungicide as recommended)
Mowing 10 times 0.4 hour each
(Tractor mower and driver)
Pruning and hoeing, 20 hours
Irrigation electricity
Interest on establishment and pre-harvest costs

Harvesting and Marketing
Picking labor
Labor benefits
Containers
Market preparation (including marketing and advertising)
Transportation
Supervision

Site Selection

Climate, soil, and market considerations are important in site selection. The rabbiteye blueberry is deciduous and requires some cold weather each winter to induce strong flowering and good fruit set the following spring. North of Ocala, chilling is usually sufficient for good yields. Between Ocala and the northern edge of Lake Okeechobee, lack of chilling makes the feasibility of large rabbiteye blueberry plantations uncertain, and south of Okeechobee City, large blueberry plantations should not be made without extensive preliminary trials. We expect that part of the region between Ocala and Lake Okeechobee will become suitable for large-scale blueberry culture as new cultivars are developed and more information is accumulated on how blueberries react to marginally insufficient chilling. In the meantime, only small, experimental plantations should be considered for this area.

A problem with growing blueberries on the central Florida peninsula is that the colder valley locations, which would seem best suited for blueberry production because they provide the most chilling and are not used for citrus, are notorious frost pockets. By sunrise following still nights, temperatures may be 15°F colder in frost pockets than on surrounding hills. Blueberries are far less prone to crop loss from spring frost than are peaches and apples. Nonetheless, frost pockets should not be used for blueberry plantations anywhere in the state.

Rabbiteye blueberries usually flower in March and ripen in June.

One factor that favors central Florida as a blueberry production area is season of ripening. In the fresh fruit market, the earliest blueberries that ripen in Florida will receive the best markets and the highest prices. This will become increasingly true in the future, as rabbiteye production expands in Georgia and other southeastern states. Lower yields on currently available cultivars for central Florida may be offset by higher prices, but it will probably be years before experience shows whether central Florida will come out ahead or behind of northern Florida in this trade-off. Meanwhile, research is continuing on the breeding of cultivars to overcome the low chilling problem. Carefully planned blueberry you-pick farms located near central Florida population centers do seem to be feasible, albeit somewhat risky ventures at present, a primary risk being possible low yields following mild winters.

Soils

Blueberries have specialized soil requirements, and although Florida has vast acreages of soils suitable for blueberries, there are many Florida soils on which blueberry cultivation should not be attempted. In some areas, suitable and unsuitable soils occur in close proximity and care must be used in choosing a site.

Blueberries require acid, well-drained soils. Soil pH should be in the range 4.0 to 5.2. If necessary, ask your county agent how to take a proper soil sample. Soil pH readings from a plot of land sometimes require interpretation in light of the past use of the land. Woodlands that have never been farmed or planted to improved pasture should not be used for blueberries if the pH is above 5.5. On the other hand, farm and pasture land which has been limed in the past may have an artificially high pH which can easily be lowered by addition of sulfur. A pasture with a pH of 6.5 may be separated by a barbed-wire fence from woodland with a pH of 4.0. In such a case, the pH of the pasture can usually be made suitable for blueberries if powdered sulfur is harrowed into the soil 6 months or more before the blueberries are planted. Soils high in phosphorus or calcium do not make good blueberry sites. Growers in Arkansas have found that blueberries grow poorly on soils with more than 2000 lbs per acre of available calcium.

Soil texture and moisture status are important considerations in choosing a site for a blueberry farm. Very coarse, droughty sands, such as those on which sand pines were native, should not be used for blueberries. Coarse sands that are slightly less droughty, such as those inhabited by the longleaf pine-turkey oak association, may be suitable for blueberries, but the timing of irrigation and feritilization are more critical on soils with such low water and nutrient-holding capacities. The sandy-clay soils found in parts of the Florida panhandle are excellent for blueberries if sufficiently acid, as they frequently are.

With respect to wetter soils, Florida has large areas of acid flatwoods, where surface soils are underlain at various depths by a hardpan layer. These soils can be excellent for blueberries if they are not too wet and if Phytophthora-resistant blueberry cultivars are planted. The best way to determine whether flatwood soils are too wet for blueberries is to examine them after a period of very wet weather. If the water table stays higher than 2 feet below the surface for longer than 24 hours after a heavy rain, the land is too wet. Sometimes such land can be made suitable for blueberries by digging drainage ditches and planting the blueberries on beds, the height of which is determined by the wetness of the land.

Preparing Land to Plant Blueberries

After land has been located that is in the proper climatic zone and has a suitable pH and water status, it must be prepared for planting. What needs to be done depends on the condition of the land. Forest land must be cleared. It should be noted in land clearing that blueberries grow poorly where piles of wood have been burned in the previous 5 years because ashes raise the soil pH. On flatwood soils underlain by hardpan and on other poorly-drained soils, provisions must be made for drainage. These may include land leveling to eliminate low pockets where water settles and construction of drainage ditches. On soils that occasionally become too wet, beds should be prepared at least 1 foot high. It is critical that such beds be oriented to facilitate water runoff. Blueberries should not be planted on beds if drainage is no problem. Ditch digging, bed construction, and other operations that mix soil horizons may have an adverse effect on soil pH. Problems should not be severe if the pH was originally suitable, but high-pH spots caused by soil mixing should be treated with sulfur before planting.

Any necessary adjustments to soil pH should be made well before planting. Soil pH can be lowered by discing in powdered sulfur. As discussed earlier with respect to site selection, there are limitations on how far downward the pH can practically be adjusted. On soils that are naturally high in pH, the pH tends to rise back to its original level as the effects of the sulfur wear off. Blueberries should not be planted on such soils. Sulfur can be used effectively on soils that are naturally at 5.5 or lower and on soils that were acid in their native condition but have been limed.

The pH adjustment with sulfur should be done at least 6 months before planting, because the chemical reaction by which sulfur lowers the pH is slow. If the pH is 5.2 or lower, no adjustment should be made. Otherwise, the amount of sulfur to add is 1 pound per 100 square feet (500 pounds per acre) for every pH point above 5.2. The entire field should be treated without regard to where the rows will be. The soils should be harrowed after the sulfur has been broadcast to mix the sulfur with the top 4 inches of soil.

In addition to clearing the land and making any necessary provision for drainage and pH reduction,

you should also begin a weed control program in preparation for planting blueberries. Weed control is very difficult in blueberries for the first 2 years after planting, and everything possible should be done before planting to reduce later problems. Bahiagrass, bermudagrass, and othe aggressive perennial grasses should be eliminated by spraying with glyphosphate in September before winter planting. In old fields, weeds should be repeatedly destroyed before maturity for one full year prior to planting blueberries in order to reduce the population of weed seeds.

Irrigation

Provision should be made for irrigating blueberries in Florida. On moist soils with good water-holding capacity blueberries could be grown without irrigation, but the risk of plant loss during establishment years and crop reduction in subsequent years makes this inadvisable. Drip irrigation, sprinkler irrigation, and overhead irrigation are three types that can be used. Drip systems have been the most popular with Florida growers because of lower installation costs and more efficient placement of water which reduces the amount of water that must be added. A reason for minimizing the amount of water applied, aside from pumping costs, is that most Florida groundwater has a pH above 7.0 and contains dissolved calcium carbonate which raises the pH of the soil if added in large amounts. The irrigation system should be installed before planting. Blueberries should be irrigated with discretion. Rainfall, soil type, plant age, and season of the year should be considered when deciding whether or not to turn on the irrigation. In wet years, irrigation may not be needed at all. Newly-set plants have the most critical water needs: they are most sensitive to overwatering and underwatering. Too much water is as damaging as too little. In dry years, irrigation is important on fruiting plants during the fruit development period. Dry weather during this period followed by heavy rains during ripening can result in much fruit loss due to split berries. This problem can be minimized by irrigation during dry periods in the spring and early summer.

Planting the Blueberries

Rabbiteye blueberries should be planted in rows 12 feet apart with no more than 6 feet between plants within rows. This requires 604 plants per acre. Higher yields per acre could be obtained in years 4, 5, and 6 by reducing within row plant space to 3 feet, but this would double the cost of plants. Eventually plants will sprout enough suckers to form a continuous hedge down the row. Plant rows should be thoroughly disced before planting. Rows should be run so as to facilitate drainage if drainage is a problem.

December is the best month for planting blueberries in Florida. January and February are also acceptable, but give plants less time to establish roots before spring growth begins. Vigorous two-year-old plants are best for setting in the field. Small plants are harder to protect from weeds, and older plants suffer more transplanting shock. Two-year old plants have been grown for one year in a field nursery following propagation. If plants grown in pots are set in the field, it is important to break up the root ball with several vertical slashes of a knife. In transplanting blueberries, care should always be taken to prevent the roots from drying out.

Several studies have shown that burying a gallon of moist acid peat moss beneath each plant at the time of planting will result in faster plant growth. Sawdust and wood chips should not be used in this way because they take nitrogen from the soil as they decay. If the planting is made on good blueberry soil, burying peat moss is not essential, and the cost of the operation may exceed its benefits. If peat moss is used, a 2-gallon hole should be dug for the plant. One gallon of topsoil should be mixed with 1 gallon of moist peat moss and this mix should be placed under and around the plant's roots as it is planted. Another way of applying peat moss is to spread it in the planting row and mix it with the soil by use of a rototiller. The peat-soil mixture is then placed around the blueberry roots when the planting hole is refilled. Never put fertilizer in the hole at the time of planting. Blueberries should be pruned when transplanted to remove 50% of the top. All flower buds should be removed in this pruning.

Mulching

Mulching blueberries is expensive in Florida but highly beneficial. Mulch helps control weeds and helps to keep the soil moist and cool. Pine bark and pine straw make the best mulches. Wood chips and rotten sawdust are satisfactory but fresh sawdust should be avoided. A good mulch is 4 to 6 inches deep and covers a band 4 feet wide centered on and running continuously down the plant row. An alternative which requires less mulch is to mulch only the area within a circle two feet around each plant.

Weed Control

Weed control during the first two years is probably the most difficult problem in establishing a blueberry plantation. Blueberries grow rather slowly for the first year or two and their growth and survival can be severely reduced by weed competition. Perennial grasses should be eliminated by ploughing or with herbicides the summer and fall before planting. The planting rows should be thoroughly disced and weed-free at the time of planting. Mulching is extremely helpful in weed control. Most blueberry growers try to maintain a weed-free strip at least 4 feet wide centered on the plant row throughout the life of the plantation. The middles between rows can be allowed to cover with grasses which are maintained by mowing. Native grasses or centipede are much superior to Bahiagrass, which grows too fast and requires very frequent mowing.

Herbicides can be useful in controlling weeds in blueberries if used with great care. Paraquat, glyphosphate, and pre-emergence herbicides can all destroy blueberry plants if misused, and some are highly toxic to man. Carefully read the safety precautions on the label before using any herbicide. If necessary, check with your county agent as to safe use. When plants are small, herbicides are usually applied with a backpack sprayer. When plants become larger, herbicides can be applied to the soil around the plants with a tractor-drawn sprayer that is shielded to keep the spray from touching the blueberry plants. For proper herbicides to use in young and older blueberry plantations consult Table 2.

Table 2. Some herbicides used for weed control in blueberries.

Common Name	Trade Name	Formu-* lation	Rate**	Time of Application	Weeds Controlled and Remarks
Dichlobenil	Casoron	WP G	8-12 lbs. 100-150 lbs.	Early spring before weed seed germination or after cultivation.	Annual broadleaf weeds and grasses. Follow application immediately with shallow mechanical incorporation. Do not use on light sandy soil. Do not graze livestock in treated area. Do not apply within 1 month of harvest.
Dinoseb	General Weed Killer	OS,WE	1-2 qts.	Anytime during growing season.	Controls broadleaf weeds and grasses. Use 10-20 gals diesel oil or weed oil. Up to 4 applications per yr. Use only on plantings 2 yrs. or older. Do not treat 30 days before harvest. Apply before weeds reach 6 in. tall. Avoid contacting crop foliage, blossoms, or fruit clusters.
Paraquat	Paraquat	CL	1-2 qts.	Apply before emergence of new shoots.	Controls most annual grasses and broadleaf weeds. Perennial weeds are desiccated. Use a non-ionic spreader at 8 oz/100 gals. Apply as a coarse spray to avoid drift injury from fine spray mist.
Simazine	Princep	G WP WDG	50-100 lbs. 2 ½-5 lbs. 2.2 - 4.4 lbs.	Early spring or split application in the spring and fall.	Controls certain annual grasses and broadleaf weeds. Use ½ the rate recommended on plantings less than 6 months old. Do not apply when fruit is present. Rate depends on soil texture.
Terbacil	Sinbar	WP	2-4 lbs.	Apply either in the spring or after harvest in the fall before weeds emerge or during early seedling stage of weed growth.	Controls annual grasses and broadleaf weeds with partial control of perennials at higher rates. Amount of product used will vary according to soil texture and organic matter. Do not use on sand or loamy sand with less than 3% organic matter. Avoid contact of foliage and fruit with spray or mist. Do not use on eroded areas where subsoil or roots are exposed. Do not use on unhealthy bushes.

* WP-wettable powder, G-granule, OS,WE-oil soluble, water emulsifiable, CL-concentrated liquid, WDG-water dispersible granule

** Product per treated acre.

Fertilization

The primary goal in fertilizing blueberries is to promote rapid vegetative growth in young plants (usually the first 3 growing seasons) and heavy fruiting thereafter. A key to obtaining rapid early growth is frequent application of fertilizers that contain nitrogen in the ammonium form. Ammonium sulfate is most often used. Ammonium nitrate and other nitrate-containing fertilizers should be avoided because nitrate ions are very damaging to blueberries on certain soil types. Fertilizers of any kind can damage or kill blueberries when applied in excess. Blueberries have a low tolerance for fertilizers, and fertilization rates that are ideal for other crops may kill blueberries. Because of variable interactions between fertilizers and soil types, soil moisture status, mulching practices, plant age and plant growth status, it is hard to give simple rules for fertilizing blueberries. Each grower needs to adjust his fertilization rate based on the plant response he observes on his farm. A generalized rule is that plants during the first 4 or 5 growing seasons should be given as much ammonium sulfate as possible without causing fertilizer injury. Mild fertilizer injury is indicated by brown-colored leaf spots, particularly around leaf margins and on younger leaves. These appear 1 to 5 days after the fertilizer has been dissolved by rain or irrigation. More severe fertilizer burn causes leaf drop and possibly plant death. Blueberries should not be fertilized when the leaves are wet, because even small amounts of granular fertilizer that sticks to the leaves and dissolves in water can burn the leaves.

A new blueberry plantation should be fertilized according to the schedule described below for the first year. The schedule starts with a plantation set out in December at 6 ft X 12 ft spacing. Do not fertilize at the time of planting. On February 1, an azalea-camellia fertilizer mix (approximately 5-10-10 with the nitrogen mainly in the ammonium form or in the form of water insoluble N) should be broadcast evenly over a circle of 2 ft diameter centered on the plant, with 1 ounce used per plant (37 pounds per 600 plants on an acre). Six weeks after this fertilizer has been dissolved by 0.5 inch of rain or more, plants should be fertilized with ammonium sulfate, using 3/4 ounce per plant (28 pounds/acre) in a circle of 2 ft diameter. Ammonium sulfate should be added at 3/4 ounce per plant three more times during the growing season, on approximately the following dates: May 15, July 1, and September 1. If rainfall over 0.5 inch does not occur within 2 weeks after a fertilizer application, the subsequent fertilization should be delayed until at least 6 weeks after rain has dissolved the previously applied fertilizer.

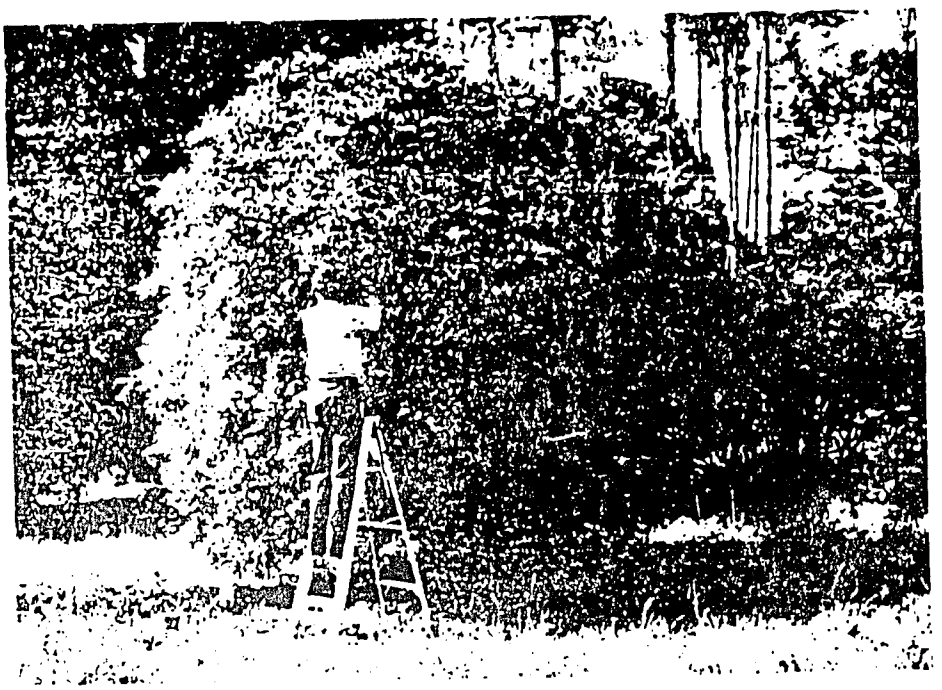
Fertilization the second year follows the same pattern as for the first with two exceptions: (1) because the plants are larger, the fertilizer should now be braodcast evenly within a circle of 3 ft diameter surrounding each plant; (2) the amount of ammonium sulfate applied per plant per application should be increased to 1 ounce. After the second growing season, the best fertilization procedure will depend on the growth of the plants. On relatively fertile soils where plant growth is rapid and plants are approaching the optimum size for production, fertilization could be reduced by reducing the frequency of ammonium sulfate applications.

Two other possible fertilization concerns with blueberries are pH maintenance and micronutrient provision. Soil pH should be maintained in the range 4.0 to 5.2. Fertilizer practices, irrigation with high pH-water, and other processes may cause gradual changes in soil pH. If soil pH rises above 5.5, powdered sulfur should be broadcast at the rate of 1 pound per 100 square fee (450 pounds per acre) over the entire field. This should not be disced in as was recommended for pre-planting sulfur application, because discing would damage the blueberry roots which lie just below the soil surface. Ammonium sulfate applied as fertilizer will also help to keep the soil pH low.

Iron deficiency is a common problem with blueberries. The most visible symptom is intervenial leaf cholorsis, most conspicuous on new growth flushes. Iron deficiency in Florida is almost always caused by high soil pH or by excessive calcium or phosphorous levels in the soil rather than by lack of soil iron. High pH immobilizes iron within the soil, making it unavailable to the plant. The best cure for iron deficiency is to lower the soil pH. In the short term the problem can be alleviated by application of iron chelates (sequestered iron) either to the soil or directly to the chlorotic leaves as a water spray.

Pruning

Blueberries should be pruned by removing 50% of the top at the time they are transplanted to the field, and all flower buds should be removed at the same time. One year later, plants should be pruned to remove all flowers before they begin to develop into fruit. Fruit production during the first 2 years in the field can slow the growth of the plant, and should be prevented by pruning. Most blueberry flowers are clustered at the tips of the branches,



If left unpruned, a rabbiteye blueberry bush will eventually reach a height of 4 to 7 meters.

and these flowered tips should be pruned off at or before the time of flowering. Alternately, the flowers could be picked off by hand.

Except for flower removal, no pruning is necessary until the plants get too large for easy fruit harvest. Detailed pruning will promote the highest yields and greatest plant vigor but requires more time than most growers consider practical. This involves removal of dead or damaged wood, removal of weak, twiggy growth, and selective removal of older canes to promote bush renewal. Growers have tested various other pruning systems that give acceptable results. These range from sawing the plant back to a height of 1 foot with a chain saw every 5 years to removal of 1 year's growth with a hedger. The best time to prune bearing plants is shortly after the fruit has been picked. This gives the plant time to grow new fruiting twigs that will produce fruit the following year.

Diseases and Insects

The established highbush blueberry industries in other parts of the country are afflicted by many diseases and insects. Currently, blueberry disease problems in Florida are being controlled primarily through resistant cultivars, use of disease-free plants for planting and by avoiding wet soils as planting sites. Disease and insect problems can be expected to increase as the Florida blueberry industry gets older and larger. Insecticides should never be used on blueberries or any other crop until they are absolutely essential to prevent serious damage. Overuse of insecticides kills insect predators, many of which are other insects, and sets into motion a vicious cycle in which more and more sprays are necessary to control insects that were previously controlled by natural predators. If insects appear to be a problem, consult a county agent before spraying.

Birds

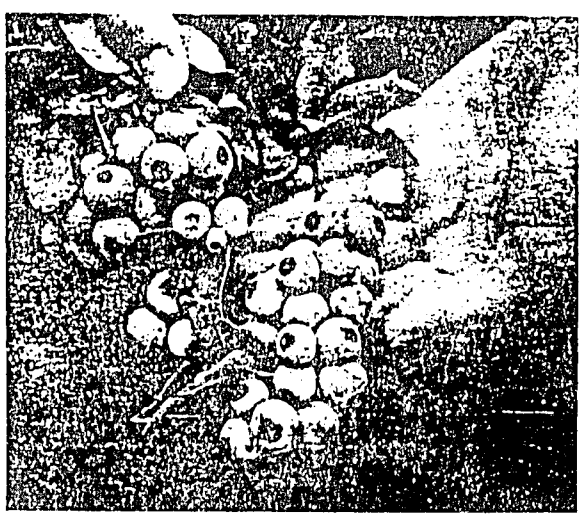
Birds can be a problem in blueberries. This is particularly true with small plantings in urban areas. Bird damage can be prevented by covering individual plants or entire plantings with nylon or plastic nets. Various noise-making devices have been tested with only limited effectiveness. A chemical bird repellent (Mesurol), which deters but apparently does not injure birds, has been tested by some growers and has been cleared for use in Michigan.

Rabbiteye Cultivars

The blueberry cultivars discussed in this section all produce high-quality berries that are essentially indistinguishable in the marketplace. Although av-

ailable cultivars differ somewhat in such berry characteristics as flavor, size, color, and seediness, these characteristics are not as important in the choice of cultivars for Florida as ripening time, suitability for mechanical harvesting, yield potential, ability to set crops after mild winters, and compatibility in cross-pollination. Which cultivars are best to plant will depend on plantation size and location and on harvest method and marketing strategy.

Rabbiteye blueberries require cross-pollination between different cultivars for acceptable yields. A minimum of two different culitvars that bloom together must be interplanted, and there are reasons for expecting even higher yields when three or more compatible cultivars are interplanted. Cultivars should be planted in alternating rows so that each row is bordered by a row containing a different cultivar. New cultivars are continually being developed and tested in Florida, and growers should check with the county agent for the latest recommendations.



Fruit of improved rabbiteye cultivars are large, light blue in color, and have a longer shelf life than most other kinds of berries.

Table 3 gives 1983 cultivar recommendations grouped according to area of adaptation and marketing strategy. For early shipping, Aliceblue, Beckeyblue and Climax should be interplanted for good cross-pollination. For you-pick, Woodard, Bluebelle and Delite should be added. To get the best cross-pollination among these six cultivars, the three early cultivars (Aliceblue, Beckyblue, Climax) should be planted in three-row groupings (ABC, ABC, ABC, etc.) on one side of the field and Woodard, Bluebelle, and Delite should be planted in three-row groupings (WBD, WBD, WBD) on the other side. In the panhandle and north of Lake City, where Tifblue is recommended, it should be added to the Woodard-Bluebelle-Delite group.

Table 3. List of Recommended Blueberry Cultivars for Florida

	Use Category					
Cultivar name	**1**	**2**	**3**	**4**	**5**	**6**
Aliceblue	1	2		4		
Beckyblue	1	2		4		
Climax	1	2		4		
Woodard	1			4		
Bluebelle	1		3	4		
Delite	1		3			
Tifblue*	1*		3*			
Premier					5	
Powderblue					5	
Brightwell					5	
Sharpblue				4		6

Use categories:
(1) You-pick farm Ocala northward
(2) Early shipping (May 25-June 15) Ocala northward
(3) Late shipping (June 15-July 5) Ocala northward
(4) For test, you-pick, Orlando to Ocala
(5) New. Not thoroughly tested in Florida. Try one test row from Ocala northward.
(6) Highbush. Plant on well-drained soils.
* Tifblue should be planted only in the panhandle and north of Lake City

Fruit from Aliceblue, Beckyblue, and Climax can be picked from June 1 to June 15 at Gainesville in an average year. This fruit would be the earliest rabbiteye blueberries on the market. It ripens with the last half of the North Carolina highbush crop, but the volume of blueberries available at that season is still low and fresh markets should be good. Woodard was excluded from the list of shipping berries in Table 3 because its fruit is less firm than is desirable for shipping. It is, however, a reliable producer and is highly recommended for you-pick farms. The ripening season for Woodard averages about one week after Aliceblue, Beckyblue, and Climax. For any one cultivar, the harvest period typically extends over about 3 weeks. By using early and late cultivars, a grower could extend his harvest season to a period of about 6 weeks if this were desirable.

Yields

Blueberry yield reports vary widely, depending on farm location, plant age, cultivars, level of management, and whether or not one averages the

poorer years in with the better. Pruning and flower removal prevent fruiting for the first 2 years after planting. A crop can be expected the third year, and by the fifth year, the plantation should be nearing full production. Good growers in north Florida report long-term average yields of about 3 tons per acre per year. If rejuvenated by periodic pruning, plantations can be expected to maintain these yields for 30 years or more.

Southern Highbush Cultivars

The northern highbush has long been the most important cultivated blueberry in the U.S. The large Michigan and New Jersey industries are based entirely on highbush cultivars, and 90% of North Carolina's production is from highbush. The highbush cultivars used in these areas are early ripening and produce high-quality fruit. Unfortunately, they cannot be grown profitably in Florida because of their high chilling requirement and disease susceptibility.

Efforts were begun more than 30 years ago to develop varieties of highbush that could be cultivated in the humid southeast, and these efforts are continuing. Three cultivars have been released for Florida: Sharpblue and Flordablue mature their crops between April 25 and May 15 in an average year in Gainesville, and these are the earliest blueberries available in the U.S. Avonblue ripens at Gainesville from May 10 to May 20. Sharpblue berries are not firm enough to ship well, but Flordablue and Avonblue berries are firmer.

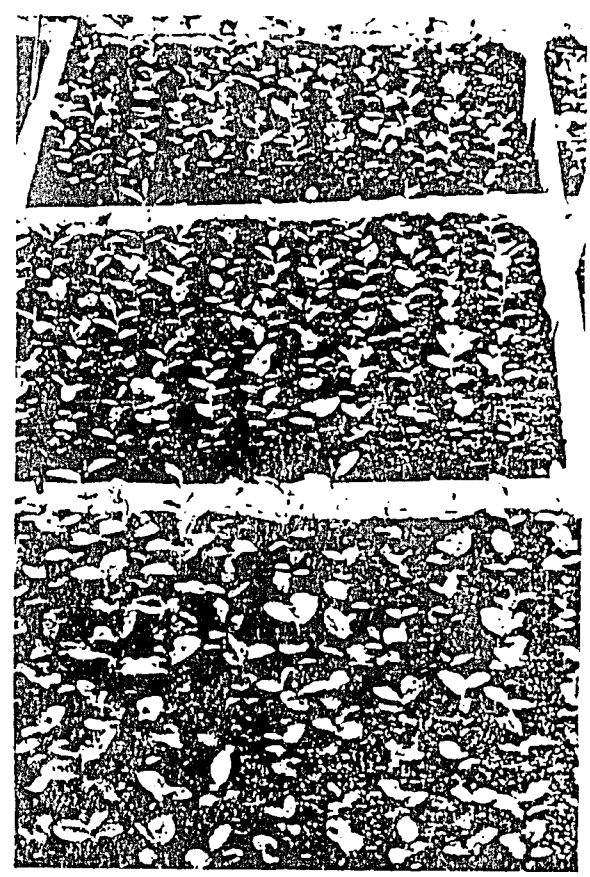
Experimental plantings of these cultivars in Florida have shown that they yield well and that fruit has high quality. They have also shown two major problems: birds and root rots. Birds have been more serious a problem with highbush than with rabbiteyes for at least two reasons: (a) Birds have less other food to eat at the earlier, highbush ripening season, and some migratory species, among them the cedar waxwing, are abundant in Florida during highbush season but have left the area by rabbiteye season. (b) Most experimental highbush plantings have been small. Birds do proportionally more damage in small plantings than in larger ones.

In some locations in Florida, the southern highbush cultivars have failed because of root rots. Highbush are much more susceptible to this problem than rabbiteyes. Root rots are more severe on heavy or poorly-drained soil than on lighter, well-drained soils.

Production of highbush blueberries in Florida will probably someday become an important industry because of the great advantages of early ripening. At present, however, highbush plantations in Florida are still experimental. Growers who produce highbush blueberries in Florida must be able to obtain a higher price for their fruit than is received for rabbiteyes, because of higher production costs. Growers attempting highbush production should choose well-drained soils, mulch heavily, and be on the lookout for birds and root rots. Bird-repellant chemicals that do not injure the birds and systemic fungicides are being tested and may facilitate highbush production in the future.

Propagation

Blueberries are propagated by hardwood or softwood cuttings. Experienced propagators in Florida can sometimes produce plants large enough to set in the field in one year from hardwood cuttings, but 2 years is a more reasonable expectation. A 50-50 volume mixture of Canadian peat moss with Perlite or of finely-ground pine bark with Perlite is ideal for rooting blueberries. Ground beds or raised



Rabbiteye blueberry seedlings are used to develop new cultivars. Plants for production fields are propagated by softwood or hardwood cuttings under mist.

benches may be used. To build a ground bed, first construct a cold frame with sides 12 inches high. Place 4 to 6 inches of gravel or pine bark on the bottom to improve drainage. Cover this with 8 inches of rooting mix. An intermittent mist system should be provided for softwood cuttings. Hardwood cuttings can be rooted under mist or under 50% shadecloth with frequent brief periods of overhead irrigation.

Hardwood cuttings are taken in January and early February when stock plants are dormant. Cuttings should be about 6 inches long. They should be taken from strong wood from the previous growing season that has no flower buds. Such wood can be obtained from large stock plants that were pruned severely the preceding spring. Hardwood cuttings should be stuck 4 inches deep in the rooting medium, leaving only an inch or two above the medium. Both hardwood and softwood cuttings should be spaced 1 1/2 inches apart in rooting beds. The most critical period during the rooting of hardwood cuttings is the 2 months after the cuttings begin to leaf out. Leafing occurs at least a month before roots form, and even temporary wilting of the leaves during this period can greatly reduce the rooting percentage. Intermittent mist, or shadecloth combined with frequent light irrigation (once each hour of daylight for 2 minutes each time) can prevent wilting.

Softwood cuttings are taken after the first flush of new growth becomes semi-hard in May. Good cutting wood can be obtained in large quantities from strong stock plants from which all the flowering branches were removed in early March. Cuttings should be about 4 inches long. No leaves should be removed except from the bottom 1 inch of the cutting. Cuttings should be stuck 1 inch deep in the rooting medium. Intermittent mist should be provided. Leaves should never be allowed to dry at any time. A major cause of loss with softwood cuttings is power outages or pump failures that interrupt the delivery of mist during hot, sunny weather. Cuttings frequently defoliate after such an incident, and rooting rate may be severely reduced. Most mist systems are equipped with two timeclocks. One turns the whole system on at sunrise and off at sunset. Mist at night is unnecessary and promotes the growth of damaging fungi. The second timeclock activates a 5-second burst of mist approximately once every 5 minutes. One way to reduce the risk of cutting loss during power outages is to install a mist system that mists continuously during power outages.

Hardwood cuttings stuck in ground beds in February will generally have roots by May 15. They should then be fertilized once every 2 weeks until October 1. One good fertilization schedule is to alternate ammonium sulfate with water-soluble 20-20-20. These should be dissolved in water and applied as uniformly as possible with a sprinkling can. For 20-20-20, dissolve 1/2 pound water-soluble 20-20-20 in 16 gallons of water. Sprinkle 1 gallon per 25 square feet over the plant bed and wash the leaves immediately with irrigation water.

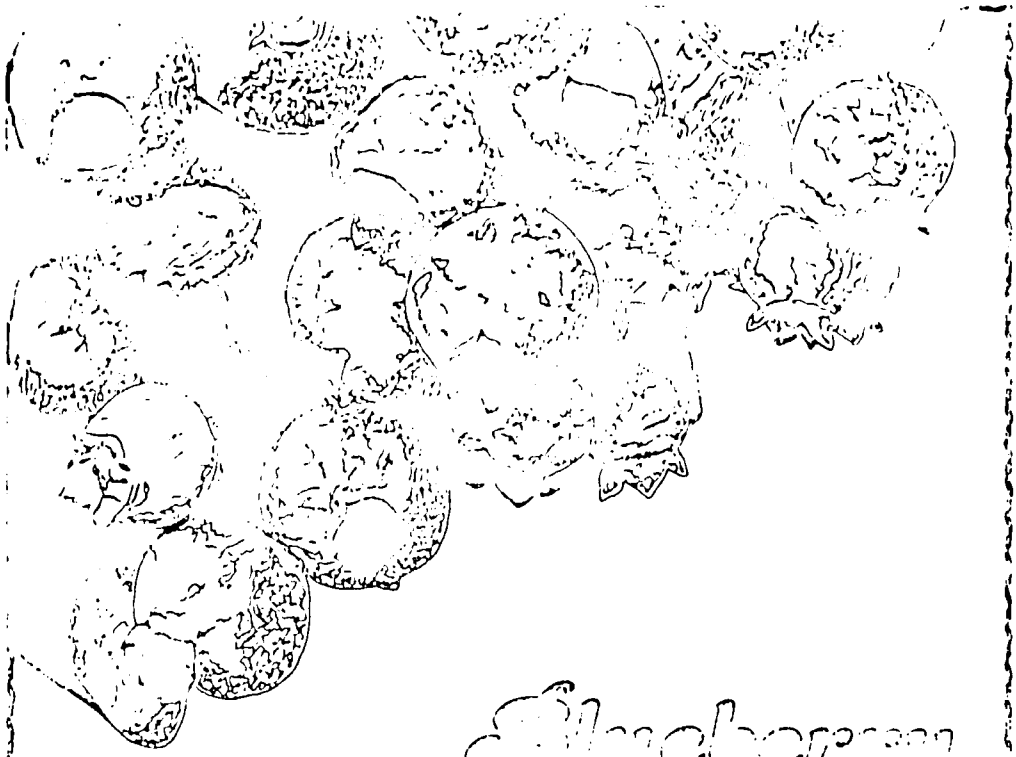
Softwood cuttings stuck on May 15 will be rooted by July 15. They should then be fertilized every 2 weeks as described for rooted hardwood cuttings. Rooted softwood cuttings should be grown for an additional year before being planted in a production field. One way to do this is to move them during December from the rooting bed to a high-density nursery equipped with overhead irrigation. Plants should be set 6 inches apart in rows 1 foot apart. Starting on February 15, plants should be fertilized every 6 weeks by broadcasting ammonium sulfate at the rate of 1/2 pound per 100 square feet over the tops of the plants when the leaves are dry. If the soil is good and weeds are controlled, very nice plants with excellent root systems can be obtained by the following December.

For More Information

Check first with your county agent if you have questions or problems with blueberries. He may have the needed information or know where to get it. The Florida Blueberry Growers' Association is a grower organization which has as one of its goals the dissemination of information on blueberry production in Florida. The Association normally sponsors half-day blueberry growing workshops each spring and fall. Your county agent can put you in touch with association officers. Large libraries frequently have books and circulars on blueberry production. Most of this information pertains to northern highbush blueberries, but some is relevant to rabbiteyes. A particularly thorough book is *Blueberry Culture*, edited by Paul Eck and Norman F. Childers, Rutgers University Press, 1966, 378 pages.

Summary

Blueberries appear to be one of the most promising fruit crops that can be grown in northern Florida. Markets are excellent in early June when early rabbiteye cultivars mature in Florida. Blueberries are an excellent crop for pick-your-own markets. Blueberry growing is a very specialized kind of farming, and prospective growers need to learn all they can about blueberries before planting.



Mushroom Production Guide

FOR SOUTH CAROLINA

EC 594
June 1979

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Blueberry Production Guide for South Carolina

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The southeastern region of the United States including South Carolina, North Carolina, Georgia, and Florida has many wild blueberries representing several species. North Carolina produces one of the largest highbush blueberry *(Vaccinium corymbosum x australe)* crops in the United States. Florida and Georgia have developed a profitable rabbiteye blueberry *(V. ashei)* industry. For years many South Carolinians have harvested wild blueberries throughout the state. Today there is a great interest in blueberry production in South Carolina whose climate and soils are suitable for high quality blueberry production.

With modern research and improved cultivars (cultivated varieties), the homeowner as well as the commercial grower in South Carolina has the potential to produce a good-tasting and profitable blueberry crop. Depending on the location in the state, a grower should be able to produce either highbush or rabbiteye blueberries. With careful attention to location, site, soil, moisture, and a good understanding of the required cultural practices, there should be few problems in growing a successful blueberry planting in South Carolina.

Cultivar Selection

Only recently have blueberries been developed as a major fruit crop, and blueberries are one of the few fruit crops grown primarily in the United States. Dr. F.V. Coville initiated research on blueberries in 1906 and in 1920 introduced 'Cabot,' 'Katherine,' and 'Pioneer' as the first hybrid highbush blueberries. This was the beginning of the modern highbush blueberry industry. By the 1970's Michigan, New Jersey, and North Carolina have reported nearly 20,000 acres in highbush blueberry production.

Highbush blueberries are grown from New England to the Carolinas. Highbush plantings in the South are restricted because they have a rather long chilling-hour requirement. All except N.C. cultivars are susceptible to stem canker disease and require specific soil types. Highbush blueberries are strong, productive plants that produce large, sweet, light-blue fruit which ripens during a short concentrated harvest period. The fruit is valued for fresh consumption as well as its culinary qualities.

Note: "Cultivar" has replaced "variety" as a term to label a cultivated plant. [illegible] "cultivar" is now an internationally accepted term with a universally accepted definition. Most the plants that we grow today can be considered to be "cultivars," although nursery and seed catalogs may still use the outdated term, "variety."

The cultivation of rabbiteye blueberries began in Florida in 1893. Plantings were made using wild seedlings, and the industry flourished until the early 1920's when the industry declined because of poor horticultural quality and increasing labor problems. G.M. Darrow, G. Woodard, and F.B. Morrow started a cooperative breeding program in the late 1930's, and today many new and improved cultivars have become the basis for a renewed rabbiteye industry.

The rabbiteye blueberry, which is genetically different from the highbush, is native to southeastern parts of the United States from southern Georgia to northern Florida and west into Alabama. The plants are vigorous, tall growing, long lived, productive, have a very short chilling-hour requirement, and have tolerance to heat, drought, a wide variety of soil variations, and many types of fungal organisms. The firm and slightly acidic fruit has a dry pedicel scar and good keeping quality. Rabbiteyes, however, have a few drawbacks: Plants may not bear at an age as young as highbush, they have an extended period for fruit ripening and harvesting; the fruit is somewhat smaller than the highbush fruit and tends to be seedy or gritty in texture; the berries color before they are ripe and may crack under wet conditions. Since rabbiteye blueberries are self-sterile, two or more cultivars must be planted together.

South Carolina has locations with environmental and soil qualities compatible with either the highbush and/or the rabbiteye blueberry. Both highbush and rabbiteye have good and bad qualities. Depending on the location, site, available cultivation practices, and intended use, the potential grower should find one or the other satisfactory for cultivation. Investigations are currently being conducted to develop and evaluate cultivars specifically for South Carolina.

The following descriptions of highbush and rabbiteye blueberries will help the grower decide on potentially successful cultivars for a given location or site.

Highbush Cultivars

In eastern North Carolina the fungus *Botryosphaeria corticis* causes stem canker in highbush blueberry. This disease is a limiting factor in highbush blueberry production, and only resistant cultivars should be planted.

'Morrow' is the earliest ripening cultivar with a medium-sized, semi-upright growth habit; it has canker resistance and has a pleasant tasting light blue fruit. 'Morrow' was developed as a replacement for 'Angola.'

'Angola' is a very early ripening cultivar with a large, semi-upright growth habit; it has dark, soft, fair-flavored fruit, and is canker resistant. 'Angola' is sensitive to soil and water variations.

'Croatan' is a midseason cultivar with a vigorous, erect growth habit; it has moderate canker resistance and produces good quality fruit. 'Croatan' performs better on lighter soils than many other cultivars.

'Murphy' is a midseason cultivar with a medium-low, spreading growth habit; it is susceptible to some races of canker; and it has good-flavored medium blue fruit.

'Harrison' is a midseason cultivar with a semi-upright growth habit; it has canker resistance and large, good quality fruit.

'Bluechip' is a midseason cultivar about a week later than 'Woldos' having erect, vigorous, and productive characteristics. Susceptible to three races

of stem canker in greenhouse, but has shown field tolerance during testing.

'Jersey,' 'Weymouth,' 'Berkeley,' 'Bluecrop,' and 'Earliblue' are canker-susceptible cultivars and if grown in South Carolina will probably have to be restricted to the upper Piedmont and mountains. Plants should be obtained from canker-free nurseries in the North.

Three new highbush-type cultivars recently developed in Florida will not be available for retail sales for a year or two. 'Floridablue,' 'Sharpblue,' and 'Avonblue' were developed as high quality, low-chilling-requiring plants that may eventually have potential in the lower part of South Carolina.

Rabbiteye Cultivars

The rabbiteye cultivars are vigorous and productive. Most have an extended harvest period which may begin in late June and last into August. The following list includes rabbiteye blueberries with good fruit qualities, and many may be successfully grown in South Carolina. Because of pollination problems, select two or more cultivars for any one planting site.

'Woodard' plants are medium-sized plants; are early in ripening; have large, light blue, high quality fruit with small soft seeds. Woodard fruit has been rated high for dessert quality.

'Homebell' plants have a vigorous upright growth habit, are early midseason in ripening with fruit turning blue only when ripe; and produce medium to large, slightly dark, fair to good quality fruit with small soft seeds and deep, but dry, scar.

'Delite' plants have an upright growth habit; are midseason in ripening; and have medium to large, slightly dark fruit with fine texture, excellent flavor, and a small, dry scar.

'Southland' plants have a compact upright growth habit; are midseason to late in ripening; and they produce medium to large, good quality fruit with a small dry scar. 'Southland' also has good ornamental qualities.

'Tifblue' is at present the standard among rabbiteye blueberries. Plants are upright and vigorous; are early to midseason in ripening; and they produce medium to large, light blue, good quality fruit with a small, dry scar and small seeds.

'Briteblue' plants are moderately vigorous and spreading in growth habit; have bright blue, large, and fair-flavored, firm fruit. Fruit ripens shortly after 'Tifblue.'

'Garden Blue' plants have a vigorous upright growth habit; are early midseason in ripening; and have medium sized, light blue, fine flavored fruit.

'Bluebelle' plants have an upright growth habit; are early midseason in ripening; and have large berries. The berry size makes this cultivar especially suited for home plantings.

'Climax' plants have an upright growth habit; are early in ripening; and produce large, sweet fruit.

Several new rabbiteye cultivars have recently been developed but will not be ready for the retail market for another year or two. 'Premier,' 'Powderblue,' and 'Centurion' may eventually have potential for success in all parts of South Carolina; whereas 'Aliceblue' and 'Beckyblue' two introductions from Florida, may eventually be suited only for the more southerly sections of the state.

Location Selection

For the grower who is considering the purchase of new land, or for the grower interested in commercial production, the location selection is critical and may be the single most important factor in determining success or failure. Economic and climatic considerations constitute the major factors in location selection. Market, labor, equipment, materials, and transportation availability are important economic factors. For a pick-your-own operation, consider demand and interest of people in your area.

The climate of South Carolina is suitable for growing highbush and or rabbiteye blueberries. However, temperature and precipitation are critical for an appropriate blueberry location.

Cold Limitations and Chilling Hour Requirements

The highbush blueberry requires (depending on cultivar) between 650 and 850 chilling hours or hours where temperatures are below 45° F. Many cultivars need at least 800 chilling hours (Figure 1) about the same requirements for peaches. Except for a few of the newest cultivar introductions, Florida, southern Georgia, and Louisiana cannot fulfill the highbush cold requirements, and the plants often die without fruiting. Therefore, highbush may not be successful in the more southerly regions of South Carolina and may be limited to the eastern and the northeastern to northwestern regions.

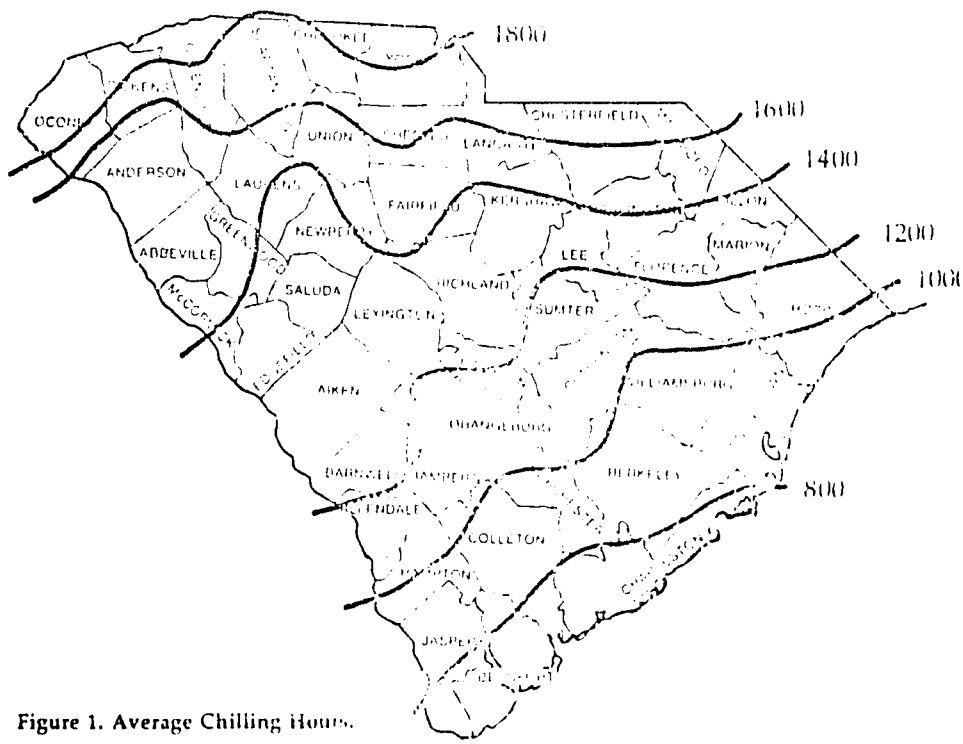

Figure 1. Average Chilling Hours.

Rabbiteye needs less than one-third the chilling hours that highbush requires. Two hundred chilling hours does not allow normal shoot development, but as little as 250 chilling hours allows normal shoot growth and

fruit production. All areas of South Carolina can fulfill this chilling hour requirement.

The highbush is moderately tolerant to midwinter cold and may survive temperatures as low as -20° F, but the rabbiteye is far less tolerant. Thus, rabbiteye plantings may not succeed in the northeastern and higher elevations of the South Carolina Piedmont.

In many areas of the country late spring frosts will kill or permanently damage open blueberry flowers. In the Southeast the highbush blueberry may flower slightly later than the rabbiteye and thus may be less susceptible to spring frosts.

Precipitation and Irrigation

Depending on the climate and soil type, highbush will require 1 to 2 inches of water per week during the growing season, especially during berry development, ripening, and bud development. The shallow roots of blueberries tend to dry out faster than other crops; so adequate moisture is critical to proper fruit growth and ripening. Rabbiteye is more tolerant to drought than highbush, but it too is shallow rooted and has similar water requirements. Select a location with adequate precipitation and good seasonal distribution or one that may be irrigated.

Any one of several irrigation systems may be used. Depending on the system, water sources, labor, and frost protection can be critical. For example, overhead, solid-set sprinkler systems are versatile and can provide effective frost protection during late spring frosts. Large gun-type or pivotal systems are effective but require large quantities of water. Drip irrigation systems designed to emit small quantities of water over long periods are efficient water users and are rather trouble-free. But they require a constant supply of good clean water and do not provide frost protection.

Site and Soil Selection

Site

Evaluate the topography, soil, and water requirements when selecting potential blueberry sites. Good air drainage is important for frost protection and disease prevention. A site should not be in a "frost pocket." As blueberries may be susceptible to frost damage from the time flower buds swell in the spring until after "fruit set," do not choose a site in a "frost pocket." Flowers are sensitive to frost after they have opened.

Planting sites with slopes facing either north or south and sites with lighter or heavier soils may extend the picking season of a given cultivar. Sites with southern slopes and/or lighter soils tend to produce earlier ripening crops than northern slopes and/or heavier soils.

The availability of water may be an important factor in selecting a blueberry site. Large bodies of water, such as lakes and rivers, may alter the spring and fall temperatures. Consider water from surface sources or from wells since irrigation may dramatically improve blueberry production.

Soils

Light, well-drained, acidic soils are best for highbush production. They should be open, porous soils with good aeration. Sandy loams with a high organic matter make good blueberry soils. Heavier soils that have good structure and a high organic content will also do well if properly managed. Blueberries can be grown on clay soils if they have enough organic matter

and are well drained, but most clay soils will not support adequate growth. Many desirable blueberry soils are fairly shallow having water tables at least 14 but no more than 30 inches below the surface. Organic content helps retain moisture for the shallow-rooted highbush.

Rabbiteye will grow well on a wider range of soils than the highbush, and it is commonly found on some of the heavier upland soils in the Southeast. In clay soils rabbiteye performs far better than highbush. Typical rabbiteye soils are sandy to loamy soils and may have heavier clay subsoils. Rabbiteye is more drought tolerant and tends to grow over a wider range of soils, but a good organic content in the soil is still important.

Peat and peat muck soils usually are not suitable for blueberries. They warm up slowly in the spring, delaying growth; they are often too wet; they may release nitrogen too late and thus promote frost-susceptible, succulent fall growth. These soils are often found in low, frost-susceptible sites.

Soil pH and pH Modifications

Planting sites should be prepared at least one year before planting date. Initial soil pH and nutrient adjustments can be made at this time. A cover crop will add organic matter to the soil and also reduce weed problems during initial planting. Eliminate perennial weeds, such as bermudagrass and johnsongrass, before planting. Take soil tests at least 6 months before planting, and use the resulting analysis to apply fertilizer needed at least 4 weeks before planting. In newly cleared fields, avoid areas on which logs have been burned. Remove roots which interfere with cultivation and drain and till low areas.

The best soil pH for highbush ranges from 4.3 to 4.8; the best pH for rabbiteye ranges from 4.5 to 5.5. To lower the soil pH on a limited basis, incorporate an acidic peat into the soil at planting time. The soil pH can be kept at a desirable level by supplying nitrogen in the form of ammonium sulfate rather than ammonium nitrate or calcium nitrate. Acidification can also be accomplished with aluminum sulfate, but blueberries have a rather low tolerance to aluminum, and this material must be used with care.

If great reductions in the soil pH are required, elemental sulfur can be applied. Either the fine-grained flowers of sulfur or the coarse-grained ground sulfur produces a rapid and rather long-lasting drop in soil pH. For sandy loam soils the pH adjustment can be calculated on a 1/10 of a degree drop in pH for every 100 lbs/A of sulfur (¾ to 1½ lbs/100 ft^2 to drop the pH by one full degree). For medium loamy soils, and soils with more organic content, the pH adjustment can be calculated on a 1/10 of a degree drop in pH for every 200 to 300 lbs/A of sulfur (1½ to 2¼ lbs/100 ft^2 to drop the pH by one full degree). The effectiveness of sulfur in lowering the pH decreases significantly when sulfur applications go above 1000 lbs/A per year.

Conduct soil tests regularly, following carefully both fertility and pH recommendations.

Propagation

Hardwood Cutting

Highbush blueberries can be easily propagated from either hardwood or softwood stem cuttings. Hardwood cuttings are collected in late winter or early spring (March to April) before buds begin to swell. By this time of the year chilling hour requirements necessary for shoot growth have been

satisfied, but some growers claim to get better rooting and growth if cuttings are refrigerated for an additional 30 days.

Collect 12- to 30-inch shoots of the previous season's growth. Cuttings should be 4 to 5 inches long and slightly less than one-half inch in diameter. Do not include spindly, weak, diseased, and winter-injured growth. Make the basal cut of a cutting just below a bud and the upper cut just above a bud. Use wood with the small pointed vegetative buds, and avoid wood with large round flower buds. For a short period of time cuttings can be stored at 35 to 40° F in moist (not wet) sphagnum moss in a sealed polyethylene bag or held in boxes of sphagnum if large numbers are being taken.

Provide cuttings an environment with warm, but not hot, temperatures and high humidity and with as much light and air circulation as possible. Two types of propagation structures are used for hardwood cuttings: the Michigan-type cold frame (Figure 2a) and the ground bed or raised ground bed structure (Figure 2b). The cold frame is constructed with a raised propagation tray made with a hardware-cloth bottom and 4- to 6-inch sides. The ground bed is built on 3 to 4 inches of coarse sand or gravel, and the raised ground bed is built with a hardware-cloth bottom attached to 8-inch side walls and supported 6 inches above the ground level with cedar poles. Frames are filled with a mixture of one part coarse sand and one part peat moss. Fertilizer is never added to this mixture. Cuttings are spaced 1 inch apart in rows that are 2 inches apart. Cuttings are buried to a point where only the upper bud remains exposed. Cuttings are stuck at a slant in the Michigan box to avoid pushing the basal ends through the hardware-cloth and are stuck vertically in ground beds. Cold frames must be carefully shaded and covers adjusted to provide adequate air circulation, temperature, and humidity. Ground beds or raised ground beds can be shaded with overhead lath, or they can be left in the full sun if frequent misting or sprinkling is used.

Cuttings will "leaf out" in the spring before they have rooted; take care at this time to maintain adequate moisture. By June, cuttings should have rooted (often indicated by a second flush of growth). After rooting, cuttings should be lightly fertilized with a weak fertilizer solution at 10-day intervals. One pound of 8-8-8 (or a comparable water-soluble fertilizer) should be dissolved thoroughly in 16 gallons of water; use 1 gallon of this solution to cover 25 square feet of bed. Thoroughly rinse excess fertilizer off the young leaves before they are burned.

Plants are left in the propagation frames until the following spring when they are transplanted to a nursery bed at 18-inch intervals. Within [illegible] weeks of transplanting, apply 150 to 200 lbs/A of 8-8-8 and repeat 4 weeks later. Plants will be ready to transplant into the field the following winter or early spring.

Softwood Cuttings

The rabbiteye is not easily propagated by hardwood cuttings, but it is easily propagated by softwood cuttings. The highbush can also be successfully propagated by softwood cuttings. Cuttings of the rabbiteye can be taken throughout the growing season, but as with the highbush, rooting percentages are higher if cuttings are taken soon after the first flush of growth in the spring. When shoots are succulent, but not tender, and snap cleanly when broken, they are ready for propagation. A 4-inch softwood

Figure 2a

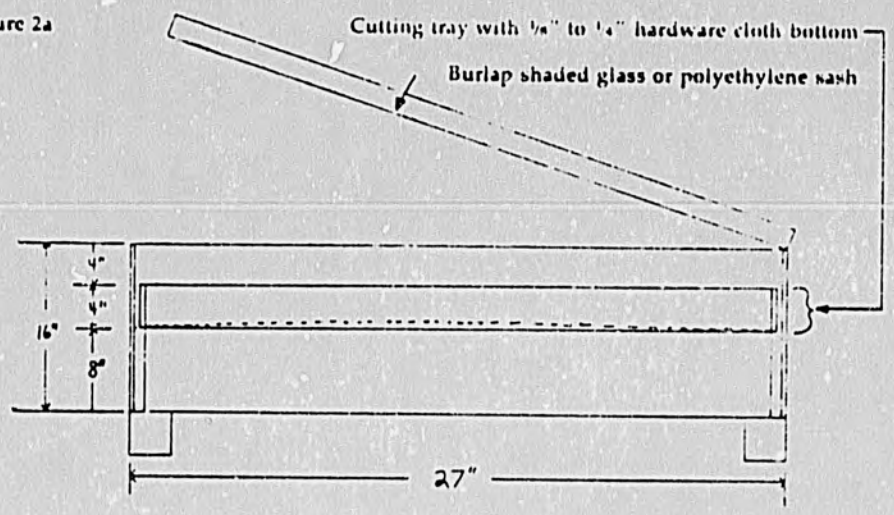

Figure 2b

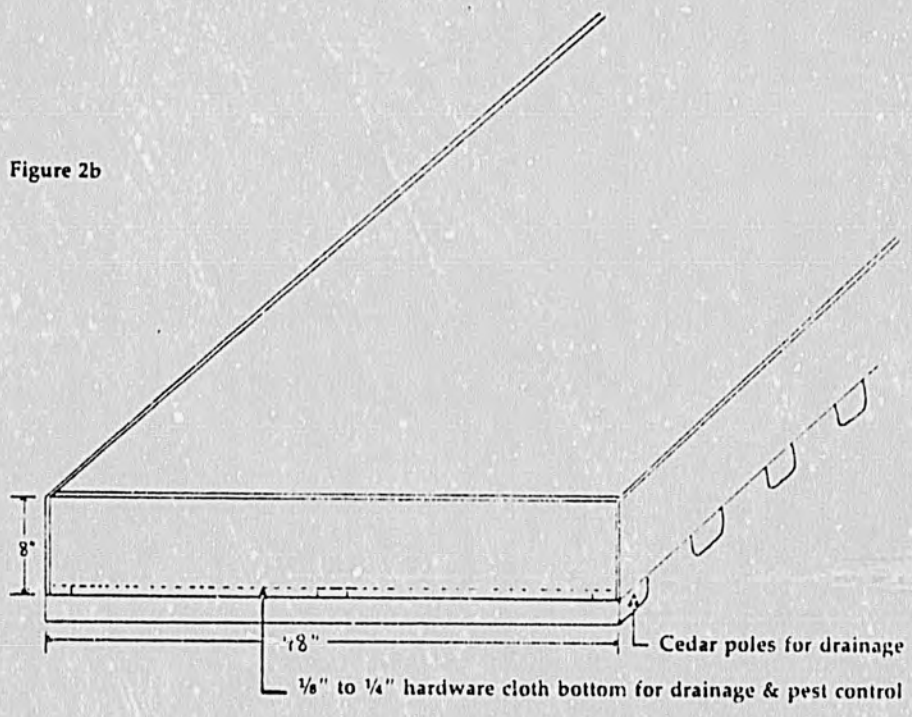

Figure 2a & b. Michigan-type and raised ground bed blueberry propagation structures. Fig. 2a. The Michigan-type hardwood and/or softwood cutting frame which is typically 6 feet long, by 27 inches wide by 16 inches high. The cuttings are stuck in the media placed within the 4-inch high movable interna ray with a hardware cloth bottom. Fig. 2b. The New Jersey-type ground bed is usually 48 inches wide, 8 inches deep, and is built at varying lengths. In North Carolina the frames are built on gravel beds instead of cedar poles, and frames are built under lathe shade structures.

cutting is made by stripping all but the top 3 to 4 leaves off a terminal shoot and cutting the basal end at the sharp angle just below a bud (node or leaf).

To be successful softwood cuttings need to be maintained in an environment with nearly 100% humidity. A heavily shaded cold frame can be used. The Michigan-type frame has been used for highbush cuttings. By spreading 2 inches of coarse cinders on the bottom of the frame for drainage, followed by 5 inches of propagation medium, the Michigan-type frame can be modified for rabbiteye blueberries. Softwood cuttings are also successful when stuck in heavily shaded open beds that are misted. For optimum humidity use a mist system designed to deliver 2 gallons of water per nozzle, per hour, at 30 pounds pressure. Misting 6 seconds every 2 minutes during the daylight hours has proved satisfactory.

The rooting medium for softwood cuttings of highbush is the same as that for hardwood cuttings. The media used for rabbiteye are less well defined but in the past native Georgia peat has been used. Other media include 2:1:1, native Georgia peat:sand:coarse sawdust; 2:1:1, Canadian peat:sand:sawdust; or 1:1, German peat:perlite.

As cuttings produce roots, reduce water applications or open cold frame sashes to allow plants to harden. Rooted softwood cuttings should be grown under partial shade during their first summer. In late fall plants can be planted into nursery rows or into 3-inch peat pots and placed in protective cold frames until spring. New plants are grown in the nursery for a second season and then planted in the field either in late fall or early spring.

Planting

Before planting a new blueberry field, it is best to seed and plow under one to two green manure crops. This practice will increase the organic content of the soil and will improve the water-holding capacity. Blueberries should be planted in late winter or early spring or as soon as the soil becomes workable.

Soil Preparation

Plow and disc the soil just before planting, leveling low areas. Where the water table is shallow or where the soil is heavier than desired, the soil can be mounded in the rows. In planting highbush, it may be advantageous to fumigate or treat soils for insects and diseases. Contact your local Clemson University county Extension agent for suggested materials and procedures.

In heavier soils and soils with low organic content, rabbiteye can be planted after an additional ⅛ to 1 bushel of peat is mixed with the soil in the planting hole. For a limited number of plants the heavy, but well-drained, clay soils containing little organic matter can be modified to accommodate the highbush. Remove one bushel of soil from the planting hole and replace it with a 1:1, peat:soil or a 1:1:1, peat:sand:soil mix.

Spacing and Planting

Two-year-old highbush plants are planted 4 to 5 feet apart in rows 8 to 10 feet apart. Two-year-old rabbiteye plants can be planted at a minimum of 5 feet apart in rows that are 10 feet apart, but a 6 x 12 foot spacing is most often used and a 12 x 12 foot spacing will allow complete cross cultivation. A 4 x 8 foot planting requires 1360 plants per acre; whereas a 6 x 12 foot planting requires only 605 plants per acre. Spacings can be modified according to the

size of available equipment, but the grower should remember that rabbiteye blueberries are more vigorous than highbush and must be given adequate room to grow. Plants should be planted at the same depth, or just slightly deeper than, they were in the nursery. In transplanting take care to prevent the delicate fibrous roots from drying out. Do *not* put fertilizers and other chemicals in the hole at the time of planting. Either before or soon after planting, remove flower buds.

Pollination

Highbush has been successfully planted in large single-cultivar blocks. However, as with other fruit crops, blueberry fruit that develops from self-pollinated flowers may be smaller in size and may mature later than fruit grown from cross-pollinated flowers. Also, highbush blueberries are usually self-fertile but instances of pollen sterility or self-sterility have been found frequently. Well-grown plants may have as much as 100% flower fertilization where at least 80% fertilization seems to be needed for a successful crop.

Considering the advantages of cross-pollination, it is recommended that culturally compatible cultivars be planted together for improved fruit yield and fruit quality. The rabbiteye is almost always self-sterile, and most new cultivars are introduced in cross-fertile pairs. These paired cultivars must bloom at the same time and must be thoroughly interplanted.

Blueberry pollen is heavy and is not carried by the wind. The flowers have small terminal openings which force insects to contact both male and female flower parts while collecting pollen and nectar. The blueberry flower is also fragrant, and has quantities of nectar and pollen that attract honeybees. Thus, blueberries are almost exclusively insect pollinated. Both honeybees and bumblebees are frequent blueberry flower visitors, but bumblebees are not common enough and may break through the side of the flower without effective cross-pollination. It is a common practice to move honeybee hives into blueberry fields during flowering. Five to ten honeybee hives per acre will effectively pollinate both the attractive and the less attractive flowers.

Fertilization

Blueberries are sensitive to fertilization since their limited fibrous roots grow near the soil surface. In the past 1-1-1 ratio fertilizers such as 7-7-7, 8-8-8, or 10-10-10, have been recommended. Currently it is recommended that a 1-2-1 ratio fertilizer, in the form of 10-20-10, be used instead. The higher analysis fertilizers are easier to handle, but they are more likely to burn roots if not properly applied.

For the fertilizer to be used efficiently by the plant, make applications within the root area. Roots of blueberries do not generally extend beyond the drip line of the plant. On established plants broadcast the fertilizer under the plants in a band that is the same width as the branch spread.

Calibrate fertilizer applications on the basis of a linear length of row instead of on a square-foot basis. Fertilizer applications will be based on 5,445 linear feet of row (length of a row x number of rows). Calibrate the fertilizer spreader using the formula below:

$$\frac{\text{lbs/A of fertilizer desired}}{54.45} = \text{lbs of fertilizer applied/100 linear feet of row}$$

10

If fertilizer is to be applied at the rate of 200 lbs/A, then divide 200 by 54.45. The result will be 3.7 lbs/100 foot row.

$$\frac{200 \text{ lbs/A}}{54.45} = 3.7 \text{ lbs/100 foot row}$$

The spreader is pulled at a constant speed over a 100-foot distance. The amount of fertilizer that is applied over this distance is caught in a tray and weighed. The spreader is adjusted until the proper amount per 100 feet of row is being delivered. After calibrating the spreader, apply fertilizer to the whole planting with no further adjustments.

Depending on the soil test results, potential blueberry fields should be brought to a high phosphorous level and a medium potassium level at least one month before planting. Use a fertilizer such as 10-20-10. Adequate levels of copper should be insured during this early test period. Young, two year old highbush blueberries should NOT be fertilized at the time of planting. After the first flush of growth, about 4 weeks, apply 100 lbs/A (¼ cup per plant) of 10-20-10 in a 6- to 12-inch band around the plants. Repeat every 4 to 6 weeks until mid-August. Extend application intervals during drought until rain, and/or irrigation, has equaled at least 4 inches.

In the second year broadcast 150 to 200 lbs/A (½ cup per plant) of 10-20-10 at bloom date, repeating this application every 4 weeks through July. However, at least 3 inches of rain or irrigation is needed between each application.

In the third year, and for bearing plants, broadcast 200 lbs/A (½ cup per plant) of 10-20-10 before bloom and an additional 100 lbs/A (¼ cup per plant) after 4 to 6 weeks. If growth is poor during the season, then apply 100 lbs/A (1/3 cup per plant) of ammonium nitrate after harvest for acid soils or around 150 lbs/A (½ cup per plant) of ammonium sulfate for more basic soils.

Rabbiteye is very sensitive to readily soluble fertilizers even though it produces a deeper root system than highbush. For young plants, use same fertilization as described for highbush. For mature plants, 400 to 600 lbs/A (1-3 cups per plant) of 8-8-8 can be applied at flower bloom and a total of 200 to 300 lbs/A (¾ cup per plant) of ammonium sulfate can be sidedressed annually if needed as late as mid-July.

Cultivation Practices

Both highbush and rabbiteye respond favorably to clean cultivation which will eliminate weeds, decrease certain disease problems, and give the grower a good opportunity to incorporate fertilizers in the early spring. Since the roots are shallow, till the soil no deeper than 3 inches and no closer to the plants than just under the drip line. With borderline soils, frequent cultivation may decrease the organic content of the soils to a point below suitable levels. Herbicides have proved effective in blueberry plantings. On some of the heavier upland soils susceptible to erosion, it may be desirable to have a sod strip between clean or mulched rows.

To maintain a constant moisture supply, gradually improve soil structure and organic content. To decrease weed problems, use mulching on small acreages of both highbush and rabbiteye. Leaves, straw, peat, sawdust or wood chips can be spread 3 to 8 inches deep in strips 1½ to 2 feet on each side or around each plant. About ¾ of an inch of mulch will break down each year and will have to be replaced; to compensate for nitrogen that is tied up

while the mulch breaks down, nitrogen applications may have to be nearly doubled.

Pruning

Pruning blueberries, as with other fruit crops, requires a balance between fruit production and shoot production. Heavy pruning reduces the crop, increases the berry size, and tends to shorten the ripening period. Light or no pruning results in a large number of very small berries ripening over an extended period. A light annual pruning will promote light penetration and help keep the plant in a highly productive condition.

Blueberry flower buds begin to develop during the summer and continue during the cool short days of fall, lying dormant in the stems until warm spring days force them to bloom. Blueberries can be pruned any time during dormancy, but it is best to prune in late winter or early spring just before buds begin to swell. Late winter pruning will allow the grower to eliminate winter-damaged wood while thinning. Pruning done after the buds have begun to expand will result in injury or loss of valuable, and delicate, flower and shoot buds. When pruning, remember that the wood being cut off contains a portion of the buds for the upcoming fruiting season. Also if the plant is allowed to overproduce, then it will not have the energy to produce enough flower buds for the next season.

Highbush

Two-year-old plants growing in the field for the first year should have all fruiting and all weak and twiggy wood removed. The objective in the first year is to develop a strong stem system for the future. In the second year very little pruning is needed, but limited pruning to promote strong plant structure may be of value.

The main canes of mature (Figure 3) highbush blueberries are allowed to grow for 4 to 6 years; then they are removed at the ground level. Thus, the oldest cane out of every six will be removed every year. Young strong canes can be cut back to a strong side-shoot away from the center of the plant, and cultivars that are heavy bearers can be tip pruned to improve fruit quality. The thinning cuts open up the center of the plant to light. Cultivars with an upright growth habit may need more center thinning, and cultivars with spreading growth habits will require more lateral growth thinning. Soft, succulent shoots rising from the base of the plant should be removed because they are not productive, are often killed in the winter, and are susceptible to fungus diseases.

Rabbiteye

Rabbiteye blueberries are very vigorous and require very little pruning to maintain production. However, limited pruning may be required to keep the plant in bounds, to reduce the density of the plant, and to promote light penetration. When required, pruning cuts are similar to those made on highbush plants.

GENERAL PRUNING OUTLINE

- remove diseased wood
- cut out oldest canes
- remove succulent shoots
- thin tips

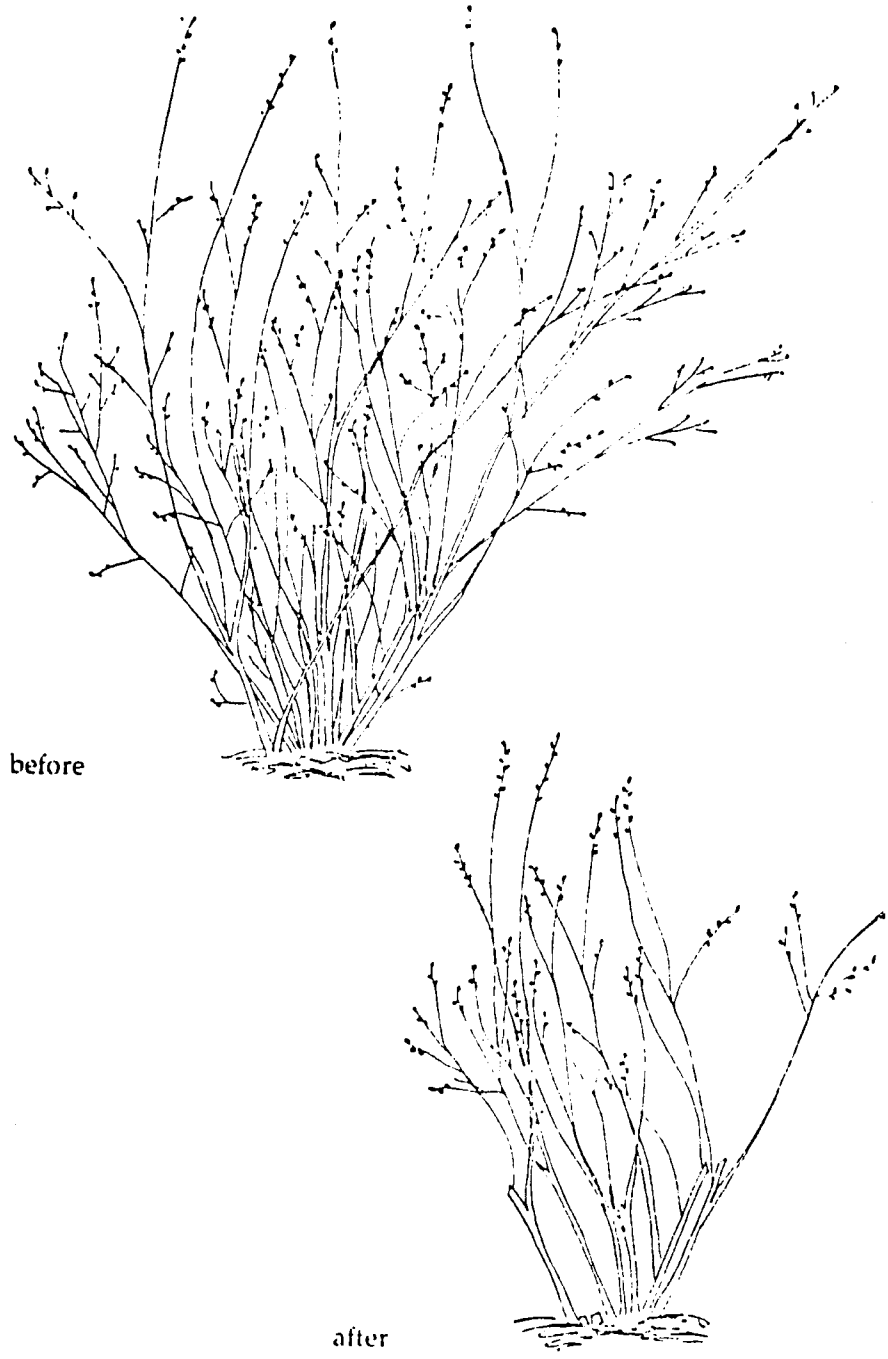

Figure 3. Pruning an established highbush blueberry plant (the before and after). Two older main branches have been removed at the soil line. Weak shoots and water sprouts have been cut out. Main branches have been pruned back to healthy laterals.

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Commercial Rabbiteye Blueberry Culture

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The rabbiteye blueberry *(Vaccinium ashei)* is a native to southern Georgia, northern Florida, and southeastern Alabama. It can be found growing to a height of 10 feet along the banks of large streams in these areas. From these native areas selections were made in the early 1920's for a breeding program to improve the fruit quality and productivity of the rabbiteye blueberry. Such varieties as Tifblue, Briteblue, Climax, Woodard, Bluebelle, Delite, and Southland have been developed at the Coastal Plain Experiment Station at Tifton. These varieties of rabbiteye blueberries produce fruit in quality, size, and volume comparable to any other type of blueberry grown in the United States. With these improved varieties Georgia has the potential for an expanding commercial blueberry industry.

A commercial planting of rabbiteye blueberries, although costly to establish and manage, can return sizeable profits when recommended practices are followed. If properly managed, the first commercial crop, though small, can occur during the third season. Yields increase as the plants grow larger. Once the planting reaches maximum size for high production and easy harvesting, yields of 12,000 to 18,000 pounds per acre can be maintained annually, provided all the recommended cultural practices, including irrigation, are carried out. The length of time that rabbiteye blueberry plantings will remain highly productive is not yet known, but early plantings made in 1958 still remain profitable.

Current information is available at your local county Extension office on the cost of establishing a blueberry planting and the potential profits that can be expected.

Rabbiteye blueberry plants have successfully fruited from the mountainous area of north Georgia, where there is an average of 160 frost-free days, to north central Florida, where the average frost-free period is 266 days. However, not all varieties are adapted to this wide range of growing conditions. The variety Woodard, because of its low chilling requirement, does well in north central Florida, but the flowers are subject to frost damage when planted in northern Georgia since plants tend to bloom before the danger of frost has passed. Tifblue has a longer chilling requirement and thus does well in north Georgia but receives insufficient chilling in central Florida for reliable fruit production.

Varieties

Because the rabbiteye blueberry requires cross-pollination for maximum fruit set, two or more varieties should be planted. If a long picking season is desired, early, mid-season, and late varieties should be included in the planting.

In south Georgia harvest begins for early varieties from June [illegible] June 20, with harvest of the late varieties being completed between July 10 and 20. In the Georgia mountains harvest normally begins [illegible] July and is completed in mid to late August. The recommended varieties listed below are in the order of ripening.

Climax (early season) plants grow upright and open, berries [illegible] medium in size and medium [illegible] blue in color, have a small scar and good flavor. Fruit ripening begins to 5 days before Woodard, [illegible]

[illegible] ated ripening with few shriveled or overripe fruit. This variety should be excellent for mechanical harvesting.

Woodard (early season) plants are the shortest and most spreading of these varieties. The plant sprouts over an area of 3 to 4 feet in 6 to 10 years. Plants do not grow as tall as Tifblue, so they may be picked more easily. Berries are light blue, firm, and very large early in the season. The quality of the berries is excellent when they are fully ripe but are very tart until ripe. Woodard ripens 7-10 days before Tifblue. It does not do well in the Georgia mountains.

Briteblue (mid-season) is moderately vigorous and grows upright and open. Berries are light blue, large, very firm with a good flavor when fully ripe. The season of ripening is generally before Tifblue. Berries are easily hand picked because they grow in clusters. Mature berries have a long retention on the plant.

Bluebelle (mid-season) plants are moderately vigorous with upright growth. Berries are large, round, light blue, and have excellent flavor. Fruit ripening begins in mid-season and extends over a relatively long period. Under favorable conditions the berries size well throughout the season, thus being an excellent pick-your-own variety. Berries tend to tear when harvested; therefore this variety is not recommended for shipping.

Tifblue (mid-to-late season) plants make vigorous, upright growth. This has been the best commercial variety from the standpoint of appearance, productivity, and shipping qualities. The large, light blue berries are very firm and are highly flavored. Berries of this variety, like Woodard, are very tart until fully ripe. Berries remain on the plant several days after fully ripe.

Southland (mid-to-late season) is moderately vigorous and produces a dense upright plant. Berries are light blue, medium large and have good flavor when fully ripe. Southland is a good companion variety for cross-pollination with Tifblue, ripening in the same season.

Delite (late season) is moderately vigorous, producing an upright plant. Berries are light blue, sometimes being a reddish blue when ripe. They are large and firm, and have excellent flavor, not sharply acid before fully ripe. Season is slightly later than Tifblue.

Pollination

Rabbiteye blueberries require cross-pollination for maximum fruit set. All rabbiteye varieties are almost completely self-sterile. Cross-pollination enhances the development of larger and earlier maturing berries.

In a planting of two varieties where equal numbers of each variety are to be planted, rows of each variety should be set as shown in Figure 1. Where two varieties are to be planted with a ⅔ to ⅓ ratio, set rows of the varieties as shown in Figure 2. In all blueberry plantings, regardless of the number of varieties planted, always make sure that each variety is adjacent to a different variety to insure maximum cross pollination.

Figure 1
Two Varieties
½ Variety A-½ Variety B

A B A A B B A B
A B A A B B A B
A B A A B B A B
A B A A B B A B
A B A A B B A B

Figure 2
Two Varieties
⅔ Variety A-⅓ Variety B

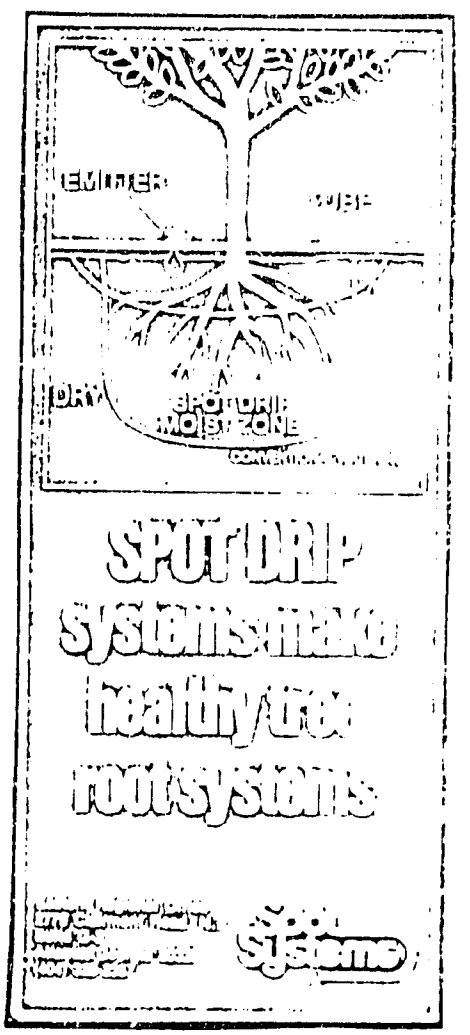
A B A A B A A B A
A B A A B A A B A
A B A A B A A B A
A B A A B A A B A
A B A A B A A B A

Bees are necessary to cross-pollinate rabbiteye blueberries. Wild bees, as well as the honeybee, are of inestimable value in promoting fruit set.

Soil Requirements

Blueberry plants have a very fine and fibrous root system, but the roots themselves lack root hairs. The roots develop best in moist, well-aerated soil of good fertility. Adequate soil drainage is essential to prevent root injury from excessive soil moisture. Therefore, the water table should be at least 20 inches below the surface. Blueberry plants may be planted in peaty bogs only if drainage ditches are provided or the plants are set on raised beds. Deep sands or heavy clay soils are the least desirable soil types for blueberry production.

Rabbiteye blueberry plants will grow well on nearly every soil type in Georgia but do best on light, well-drained, acid soils with the soil pH between 4.5 and 5.2. Recently limed land should be avoided. When the soil pH is too high, poor growth occurs, due to either iron deficiency, resulting in a chlorotic condition of the plant characterized by yellowing of the terminal leaves or to the lack of the ammonia form of nitrogen most easily assimilated by the plant. Where the pH is higher than 5.5, ground sulfur or ammonium soifate should be applied to increase soil acidity. Elemental sulfur does not in itself affect soil acidity but must



[illegible] to sulfate sulfur by soil microorganisms. Elemental sulfur must be incorporated into the soil a year before planting blueberries. Sulfur will injure blueberry plants if it comes in direct contact with the roots. Approximately 500 pounds of sulfur per acre will change the pH of a light sandy soil from 5.5 to 4.5 when completely oxidized by soil microorganisms. A heavier loam soil may require from 1.3 to 1.7 tons of elemental sulfur to produce the same reduction in soil pH.

When the soil pH is too low, dolomitic limestone can be applied to raise the soil pH. The amount of limestone needed to bring the pH up to the optimum range will depend upon the present pH level and soil type. A soil test recommendation should be followed so that the appropriate pH adjustment can be made.

Areas in newly cleared fields where large amounts of wood or logs have been burned should be avoided for planting blueberries. The basic minerals in the ash will raise the soil pH above the range for best plant growth.

Soil Preparation

The soil should be prepared at least one season ahead of planting. Persistent weeds such as bermudagrass, johnsongrass, and honeysuckle need to be eradicated to avoid the difficulty of weed control after the plants are set.

During the season before planting, plant a cover crop of millet in early summer and incorporate into the soil that fall. Then plant a cover crop of winter rye. Fertilize according to soil test recommendations to produce the maximum of lush growth from the cover crops. Plow under the winter rye crop in early spring and harrow or rototill to prepare the soil for planting.

Selecting, Handling, and Setting Plants

Obtain healthy, true-to-name rabbiteye blueberry plants from a reputable nursery. When the plants arrive, immediately open the shipping containers to check to see that the roots are still moist. If the plants cannot be set out immediately, store in a cool place (35-40°F.) until planted, always making sure that the roots remain moist. Before planting, cut back all plants to a height of 4 to 6 inches.

If you set plants 6 feet apart in rows 12 feet apart, 605 plants will be required per acre. If you are planning to machine harvest the fruit with an over-row harvester, plants set 5 feet apart in the row may increase harvesting efficiency. This spacing arrangement will require 726 plants per acre. For U-pick operations, a spacing of 8 feet by 14 feet (389 plants per acre) is desirable.

Blueberries may be transplanted at any time during the dormant season (early December through March) except in the north Georgia mountains where March or early April planting is desired. Soil preparation and planting should be avoided when the soil is excessively wet.

To prepare the planting holes, first open the rows with a middle buster. Apply ⅛ to ⅓ bushel of peat moss at each plant location. Close the furrows, bedding slightly. After the peat moss is damp from soil moisture, reopen the furrows in two directions to mix the peat moss with the soil. When the peat moss is wet and thoroughly mixed with the soil, the plants can be set.

Another system of soil preparation is to dig individual planting holes approximately 2 feet in diameter and 2 feet deep. Thoroughly incorporate ⅙ to ⅓ bushel of Canadian peat moss with the soil taken from the hole. Be sure to soak the peat moss before or after incorporation. Up to 2 pounds of cottonseed meal may be incorporated along with the peat moss to increase early growth.

Plants should be set ½ to 1 inch deeper than they grew in the nursery. Care should be taken to prevent drying of the fine, fibrous root system during the transplanting operation. Since young blueberry plants are poor competitors with weeds, keep the area within 2 or 3 feet of the base of each plant weed free. Weeds compete for light, moisture, and nutrients, thus suppressing plant growth. A mulch of 4 to 6 inches of well rotted sawdust, finely ground pine bark or pine straw around the base of the blueberry plant will discourage weed growth.

Fertilization

The ideal soil pH range for blueberries is 4.5 to 5.2. Rabbiteye blueberry plant roots are very sensitive to readily soluble fertilizers and can be injured by excessive amounts. The use of liberal quantities of peat moss when setting plants usually results in good growth, however, best growth is realized if the young plants are fertilized twice during the first growing season. When growth begins, apply in a circle one foot in

diameter around each plant 1½ ounces of 12-4-8 or 16-4-8 fertilizer (sold as either nursery or turf fertilizer that contains slow release nitrogen) and repeat again in late July or early August. If yellowing of the terminal growth occurs, which is generally due to iron deficiency caused by a high soil pH, one ounce of ammonium sulfate should be used in July instead of the nursery or turf fertilizer. Periodic applications of chelated iron until the soil pH drops below 5.2 will also increase plant growth by correcting iron deficiency.

The second year each plant should receive 2 to 3 ounces of nursery or turf fertilizer in spring (March) just before growth begins and again in late July. The amount should be increased (doubled on a yearly basis) as the plants grow older. Research has shown that about 60 pounds of actual nitrogen per acre on 6-year-old plants on sandy soils produce the highest yields.

Changes in the fertilization program may be necessary if the following plant signs are observed: 1) **pale green or yellowish leaves and lack of vigor** that may be caused by nitrogen, iron, or magnesium deficiency or lack of soil moisture; and 2) **browning of the tips and margins of the leaves** that may be caused by too much fertilizer or too little water. If any of these plant signs occur, soil and foliar samples should be taken for laboratory analysis to determine the cause of the problem. Nitrate of soda or calcium nitrate should not be used around blueberry plants.

Since most Georgia soils are low in magnesium, the application of magnesium sulfate (Epsom Salts) may be necessary to obtain maximum plant growth. A soil test is the easiest means to determine the need for magnesium. When the calcium/magnesium ratio exceeds 8:1, then blueberry plants will likely respond to an application of magnesium.

Irrigation

During the two years following planting the root system of blueberry plants is shallow and requires between ¾ and 1¼ inches of water per week during the growing season to keep the plants growing vigorously. Supplemental watering of these young plants during dry periods will increase plant growth and thus will bring them into commercial production at a younger age.

Irrigation of producing blueberry plantings during dry periods before harvest results in larger berries and higher yields. Also irrigation during dry periods in August and September will increase fruit bud formation, thus increasing potential yield for the next season.

Mulching

Blueberries grown on the heavier soils of north Georgia benefit greatly from mulching. Mulches such as well rotted sawdust, pine bark, and pine straw reduce evaporation of soil moisture, reduce soil temperature, and increase water uptake by the soil. On clay soils mulching is essential if the planting is without supplemental irrigation, and it is beneficial with irrigation.

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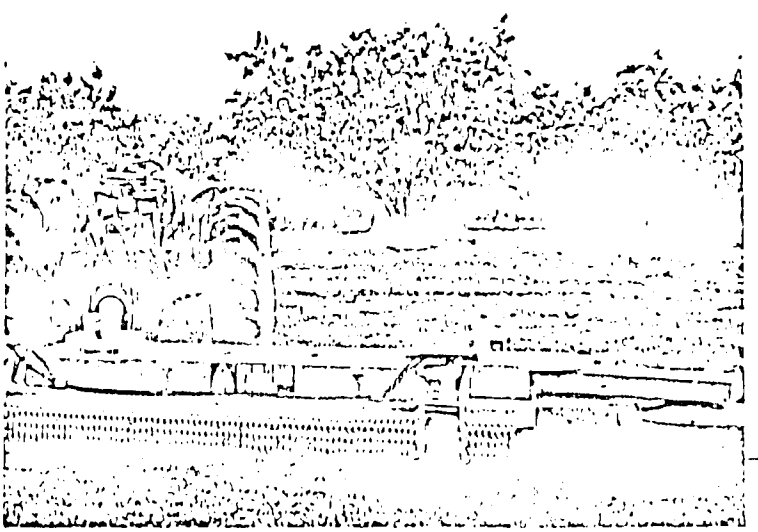

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ABOUT THIS BULLETIN. This publication combines information about blueberry production in western Washington and Oregon. Specific pesticide recommendations are not included because of frequent changes in materials and rates. Annually updated spray guides are available at Extension Service offices in each state.

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HIGHBUSH BLUEBERRY PRODUCTION IN WASHINGTON AND OREGON

By Charles C. Doughty, E. Blair Adams, and Lloyd W. Martin

Blueberries are native North American fruits. Each year several million pounds are harvested from wild plants, representing 30 to 35% of the annual blueberry harvest.

The commercial blueberry industry started from selections of wild plants of the species *Vaccinium corymbosum* L. and *Vaccinium australe* Small made by F. V. Coville in 1909. Newer cultivars have been developed by crossing these two species. Breeding programs, in the U.S. Department of Agriculture as well as the experiment stations of Michigan, New Jersey, North Carolina, and others, have developed cultivars which produce berries up to three times the size of the largest wild berries. The cultivars grown in Washington, Oregon, and British Columbia are from these programs.

The United States and Canada produce 110 to 120 million pounds of blueberries annually. Table 1 lists acreage and production in 1979; Table 2 lists the commercial harvest from wild plantings for 1979.

Washington ranks fifth and Oregon sixth in commercial production, for a combined total of about 8% of the market supply produced in North America. Table 3 shows the statistics for Washington and Oregon. Variations in production in other regions affect the demand for Pacific Northwest blueberries. Historically, prices have been reasonably stable with less seasonal fluctuation than most other berry crops.

Northwest blueberries are marketed fresh, processed, and frozen. Table 4 shows the average nutritive value of blueberry fruit.

THE HIGHBUSH BLUEBERRY

Highbush blueberries are perennial, long-lived, deciduous, woody shrubs

TABLE 1. CULTIVATED HIGHBUSH BLUEBERRY PRODUCTION, 1979

	Acres	Million lbs.	Lbs./acre
Michigan	8,000	35	4,375
New Jersey	7,000	22	3,150
North Carolina	4,000	7	1,750
British Columbia	2,000	6	3,000
Washington	800	4.8	6,000
Oregon	600	3.4	5,800
Georgia	600	1.5	2,500
Arkansas	200	.5	2,500
Other States	300	--	–
Total	23,500	78.3	

Source: Phil Sheridan, Executive Secretary, North American Blueberry Council, Marmora, NJ, January 1980.

TABLE 2. COMMERCIAL HARVEST OF LOWBUSH BLUEBERRIES, 1979

	Million lbs.		Million lbs.
Maine	17	New Brunswick	4
Nova Scotia	10	Newfoundland	2.5
Quebec	5	Prince Edward Island	8
Total			39.3

Source: See Table 1.

TABLE 3. BLUEBERRY PRODUCTION

	Washington			Oregon	
	1977	1978	1979	1978	1979
Acres harvested	800	800	790	450	500
Yield, lbs. per acre	5,120	6,030	6,070	5,000	5,800
Utilized production					
Fresh (000 lbs.)	642	928	1,412	750	1,500
Processed (000 lbs.)	3,454	3,896	3,383	1,000	1,900
Price per pound					
Fresh, ¢	56.3	68.4	67.3	64.0	66.5
Processed, ¢	60.3	63.1	46.0	67.0	46.6
Combined, ¢	59.7	64.1	52.3	66.0	53.5
Value of production (000 $)	2,083	2,522	2,506	1,150	1,883

Source: Washington and Oregon Crop and Livestock Reporting Service.

growing from 5 to 10 feet tall at maturity. Blueberries belong to the family Ericacea, which also includes such plants as azalea, rhododendron, mountain laurel, and heather. Like the other ericaceous plants, blueberries thrive in acid soils. They do best in soils with a pH between 4 and 5.

The highbush blueberry is a shallow-rooted plant, characterized by a lack of root hairs. The fine, fibrous roots of the blueberry require an open, porous soil for ease of growth. Cultivation, therefore, should be shallow so as not to injure the root system. The plants usually require 6 to 8 years to reach full production. Flower buds form on last year's wood. Blueberries are native to moist soils, but the root zone should be well drained. Vigorous, productive plantings can develop only where the soil is not saturated with water during the growing season and is saturated only for short periods during the dormant season. The optimum soil is a loose silt or sandy loam or an organic soil (peat or muck) that has good internal drainage and a water table at least 14 to 30 inches below the soil surface. This allows the fine roots to develop and penetrate the soil for absorption of moisture and nutrients.

In general, the climate and soils between the coastal ranges and Cascade mountains in Washington and Oregon are ideal for blueberries. There are, however, areas where soils are not suitable, such as compact clay soils that allow very poor internal drainage and root penetration. Coarse sandy or gravelly soils present problems because of their poor nutrient and water-holding capacity.

COLD INJURY

Blueberries are cold hardy to at least −20 °F. in areas where there is enough low temperature to develop full hardiness. Many areas of the Pacific Northwest, however, do not have sufficient low temperatures to develop deep hardiness. Cold injury can occur when warmer temperatures are followed by severe freezes (Figs. 1 and 2). Blueberry plants, like many other deciduous plants, lose hardiness when temperatures rise higher than about 28 °F. during the dormant period. They will reharden, to some extent, if temperatures drop below 28 °F., but generally not to the original degree of hardiness.

The basal tissue, which connects the flower bud to the shoot and contains the vascular vessels, is the part of the bud that is most easily injured during the dormant period. Frequently, the florets in a bud show no injury following a freeze, but the bud base tissue is injured. This type of injury can be seen by slicing the bud longitudinally through the bud base. When the flower buds begin swelling in the early spring, the florets are the most easily injured area of the bud. The amount of growth a new shoot or flower cluster makes sometimes depends on the amount of injury the bud base has experienced. If the injury restricts the flow of nutrients and water, the growth of the shoot or flower cluster is slow and restricted, or completely inhibited.

Frosts during the spring flower bud development period also can produce considerable damage. The tip buds on a shoot or the tip florets on a cluster generally are injured first as they are the ones that develop first. The nutrients in the growing bud should be kept at optimum levels because a deficiency of any nutrient will make buds more susceptible to frosts during this period. If plants are deficient, foliar sprays containing P, K, Zn, and sometimes B applied every week to ten days during the spring will reduce injury or aid in recovery from frosts.

Growing sites with frost pockets should be avoided. The area should be open to the prevailing air currents so cold air can drain out. Trees and brush around the site should be removed to allow air drainage.

Full coverage sprinkler systems are very efficient in reducing frost injury if sufficient water is available. Applications of about 1/4 inch of water per hour will prevent injury. The sprinkler systems should be operated continuously until the temperature warms sufficiently to prevent freezing.

CULTIVAR SELECTION

Blueberry cultivars are classified as early, early mid-season, mid-season, late mid-season, and late. The fruit on each cultivar ripens over a two- to five-week period (Tables 5 and 6). Some cultivars ripen and hang on the bush with very little shattering, making them suitable for machine harvest. Normal harvest involves picking once or sometimes twice a week during the ripening period. Cultivars differ in their ripening season from year to year and from location to location in Washington and Oregon. Early cultivars begin ripening in the first or second week of July. Late cultivars can ripen fruit until early October. Cultivars that ripen after early September are rarely used in the Pacific Northwest because wet weather often disrupts harvest.

Growers should choose cultivars that best fit their overall farm operations. U-pick and fresh market growers may select several cultivars

TABLE 4. NUTRITIVE VALUE OF BLUEBERRY FRUIT

	Composition of 100 grams of raw fruit		
Water, %	83.2	Minerals P, mg.	13
Food energy, cal	62.0	K, mg.	81
Protein, g	0.7	Fe, mg.	1.0
Fat, g	0.5	Na, mg.	1.0
Solids, %	15.3	Vitamin A, IU	100
Carbohydrate, total g	15.3	Thiamine, mg.	0.03
Pentosans, %	0.98	Riboflavin, mg	0.06
Fiber, g	1.5	Niacin, mg.	0.05
Invert sugar, %	4.89	Ascorbic acid	
Ash, g	0.3	Vitamin C, mg.	14.0
Minerals, Ca, mg	15	Acids (as citric), %	0.93

Source: Watt and Merrill, 1964

FIG. 1. Dixi blueberry branch in full bloom showing lack of cold injury from a mid-winter low temperature of + 1°F. All these flower buds have developed normally.

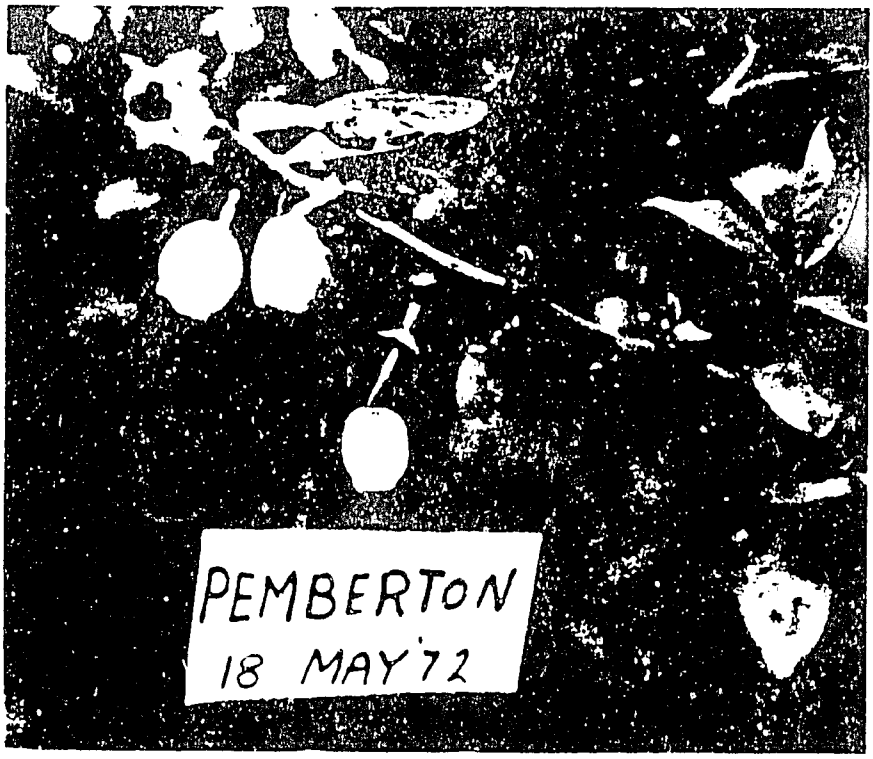

FIG. 2. Pemberton branch showing severe freeze injury with seven dead flower buds from mid-winter low temperature of + 1°F.

that succeed each other to extend their market season. Growers who sell to processors may choose cultivars that ripen over a shorter season to shorten their harvest period. Early cultivars ripen during the raspberry harvest season, so growers of both berries may want to avoid early cultivars. If the berries are to be hand harvested, cultivars should ripen when picking labor is available. Since most berry pickers are school children, it is desirable to complete the harvest in August. It takes 10 to 20 pickers per acre to harvest blueberries.

If the berries are to be machine harvested, cultivars with a short harvest season are preferable. Cultivars that ripen over a relatively long period or shatter from the bush as soon as they ripen are not suitable for mechanical harvest. Berries should hang on the bush for a period of time but drop off when the harvester shakes them. Cultivars adapted to machine harvest are identified by an asterisk in the following descriptions. Tables 5 and 6 show the relative harvest period for each cultivar.

CULTIVARS OF HIGHBUSH BLUEBERRIES

The cultivars listed below are arranged by harvest period. Those that ripen earliest are listed first.

*Earliblue. Berries are large with light-blue skin, very firm flesh, good flavor, subacid, mild, resistant to cracking. Ripens very early with Weymouth or Bluetta. Plant is hardy, upright, vigorous, well shaped, and productive. Fruit does not shatter.

*Spartan. Fruits are firm, light blue, large, with high flavor, and ripen early, three to five days after Earliblue. Plants are vigorous, upright, open growth habit, well adapted to machine harvest. Both shoots and fruits are resistant to mummy berry. In Washington, ripens mid- to late July.

Blueray. Fruit very large with a medium light-blue skin, flesh firm, flavor strong, aromatic and good, resistant to cracking. Ripens early mid-season. Plant is upright, hardy, spreading, consistently productive,

and tends to overproduce unless carefully pruned.

*Patriot. Bush vigorous, open, upright, hardy, productive. Fruit good color, good flavor, early mid-season, tends to overproduce, adapted to machine harvest, concentrates harvest. Bush resistant to Phytophthora root rot.

Stanley. Has medium to small berry with medium-blue skin, flesh firm, flavor highly aromatic, pronounced spiciness, resistant to cracking. Ripens early mid-season. Plant is vigorous, erect, main branches few, easy to prune, heavy producer.

*Meader. Vigorous, productive, erect plants tending to overbear like Bluecrop. Adaptable to machine harvest. Fruit large, clusters loose, firm uniform size, 80% can be harvested at first picking, does not shatter or crack. Flavor mild subacid. Ripens early mid-season.

Ivanhoe. Berries large with a light-blue skin, flesh firm, flavor is tart and highly aromatic, and good for pies. Ripens early mid-season. Plant is very vigorous, upright, not consistently productive. Fruit cluster is medium tight.

Concord. Berries are medium sized, medium blue, flesh firm. Flavor is slightly aromatic, fruit cluster small and tight. Ripens mid-season. Plant is of medium vigor, upright, spreading, and productive. Tends to produce too much fine wood and can be difficult to prune.

*Berkeley. Berries are very large, very light-blue skin, and firm flesh. Berry stores well and does not shatter from bush. Flavor is mild. Ripens in mid-season. Plant is vigorous, open, spreading, and easy to grow. Resistant to cracking.

*1613-A. Berries medium size, light blue, flavor fairly sweet, does not shatter from bush, tends to shrivel when fully ripe. Adapted to machine harvest, cluster open, medium size. Bush erect upright, average vigor. Can be harvested in one or two pickings. Ripens with Bluecrop and Berkeley.

*Bluecrop. Berries are medium large, skin light blue and the flesh firm, resistant to cracking. Berries shatter somewhat from bush. Fruit cluster loose. Flavor is good, moderately aromatic, ripens mid-season. Plants are vigorous, spreading, consistently productive, drought resistant. Plant tends to overproduce unless carefully pruned.

Pemberton. Berries are medium to large, with a very dark-blue skin, flesh is firm, flavor fair and slightly aromatic, fruit cluster very loose (Fig. 3). Ripens late mid-season. Plant is vigorous, very productive, erect. Easy to grow and prune, difficult to pick.

*Herbert. Fruits are very large, medium blue, flesh tender, flavor is very good and aromatic. Fruit cluster medium loose, resistant to cracking. Does not shatter from bush. Ripens late mid-season. Plant is consistently productive, vigorous, and open spreading.

*Jersey. Medium size berry with medium-blue skin, firm flesh, resistant to cracking. Flavor is fair with aroma lacking. Berries keep well. Ripens late. Plant is vigorous, erect, hardy, and productive. Easy to prune, easy to pick, fruit cluster loose.

*Coville. Large berry with medium-blue skin; flavor is tart and aromatic, firm. Does not shatter from bush, fruit cluster loose. Ripens late. Plant is vigorous, open, spreading, and productive. Is easily pruned.

Dixi. Large berry with medium-blue skin, and pronounced aromatic flavor, firm, subject to cracking. Ripens late. Plant is productive, vigorous, and open spreading. Easily picked and pruned.

*Lateblue. Bush erect, vigorous, productive. Fruit high flavor, firm, light blue, ripens late, seven days after Coville, ripens in a short period of time.

*Elliot. Fruit is firm light blue, medium size, good mild flavor, ripens late, seven to ten days after Lateblue. Bush productive, clusters loose, moderately resistant to both phases of mummy berry. Good for machine harvest, concentrates harvest to one to two pickings. Washington season is mid-August to early September, vigorous grower, upright, winter hardy.

PROPAGATION

Large-scale propagation of blueberry plants requires considerable in-

*Suitable for machine harvest.

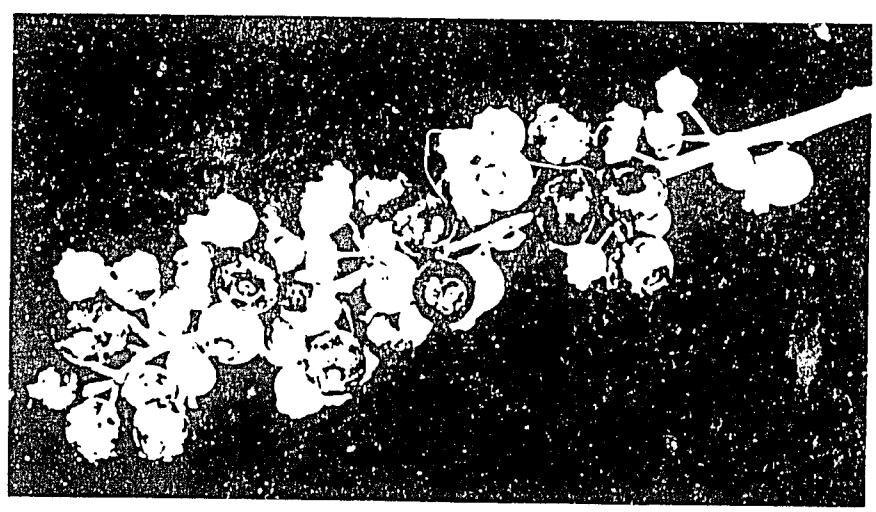

FIG. 3. A normal size fruit cluster of Pemberton blueberries.

west sides, and one-half shade on the other sides. One-half shade is enough for the top. For large-scale propagation, build the lathhouse 7 feet high so workmen can walk under it. The roof can be flat.

Heating cables. Electric heating equipment is available in complete sets, including thermostats and pilot lights. Instructions for installation are provided by the manufacturer. There are at least two types of heating cables. One is lead-covered; the other is insulated with a special type of rubber or plastic covering. The lead-covered cable is more durable but costs more. Cables can be obtained in units of several lengths. Cable length is determined by the area to be heated, the amount of heat delivered per foot of cable, and the total amount of heat desired, or the difference between temperatures inside and outside the bed. The power supplier or a qualified dealer can help select the proper equipment.

Location of frames. The most important considerations are: 1) convenience for daily inspection and care; 2) access to water supply and source of electricity; and 3) good, natural drainage to remove excess water from underneath the frames.

To provide drainage, place a 3- or 4-inch layer of coarse gravel or cinders over the area to be covered by the frames, extending it a foot or more beyond each end and side. On clay soils, add tile drains to carry off the excess irrigation and rain water.

Installation of propagating beds and cables. On top of the coarse gravel or cinders, place the wooden frame or frames built to accommodate one or more 3 × 6 foot hotbed sash. Inside the frames, on the gravel or cinders, put a layer of sand at least 1 inch deep. Place the heating cable on this layer of sand. Sand is recommended because the cable must be in contact with a material that will conduct heat uniformly to the mixture of sand and peat above it. There must be no air pockets around the cable or it will become hotter in those spots and eventually burn out there.

Lay the cable in loops back and forth across the surface of the sand at intervals of a few inches. Put the cable loops closer together near the edges of the bed where heat loss is greatest. Cable loops should not touch each other or they will get too hot and burn out.

Lead-covered cable can be laid loosely on the sanded surface of the bed and covered with an inch of sand. To protect the sand and cable from being displaced or damaged, put a sheet of 5/8-mesh hardware cloth, cut to fit the frame, on the sand.

If rubber-covered cable is used, fasten it in a suitable arrangement on to hardware cloth and place it, cable down, on the first layer of sand; cover both cable and hardware cloth with another layer of sand.

After the cable has been put in place and protected, add a mixture of the best grade horticultural peat and medium (not coarse) clean sand. The mixture should be three parts peat to one part sand by volume and 5 inches deep. The peat must be moistened so it can be mixed uniformly with the sand. It is best to do the mixing outside the propagating frame. After putting the mixture in the frame, press it down until the surface is smooth, firm, and level. Give special attention to the corners of the frame. You are now ready to insert the cuttings.

Taking cuttings. Hardwood cuttings root best when taken directly from the bushes in late March, just before the buds start to grow. Be sure the wood comes from productive plants that are true to cultivar. Make cuttings from vigorous unbranched shoots of the previous year's growth. The wood should be about the thickness of a lead pencil and 4½ to 5 inches long. Most cuttings of this length will have three to five buds. Make cuts with a very sharp knife to *avoid bruising* the bark. Make the upper cut close above the bud. Discard wood which bears flower buds because even one fruit bud may prevent rooting. Discard the basal portion and the slender tip end of each long shoot used to make cuttings. On cultivars that are hard to root, make the bottom cut close to a bud. To stimulate rooting, wound the cuttings by slicing a 1/2- to 1-inch long layer of bark from both sides of the base of the cutting. Protect the cuttings from drying out.

Storage of whips for cuttings. Late fall and early winter are *poor* times to take blueberry cuttings. Late March is best. If the cutting wood must be removed from the mother plants during January or February, cut the "whips" from the bushes, pack them in damp peat, and store them at 32° to 45°F. to make sure the cutting wood has sufficient chilling to grow. They can then be taken out and made into cuttings during the last two weeks of March.

Inserting cuttings. Insert cuttings vertically into the peat-sand to half their length. In unfertilized beds they can be spaced as close as 1½ × 4 inches. If the beds are to be fertilized, space them 3 × 4 inches to allow for larger root development. Be sure to press the peat-sand mixture tightly around the base of the cuttings. More cuttings are probably lost from failure to do this than from any other cause. Keep the surface of the peat and sand level so water absorption will be even.

Bottom heat. Regulate electric bottom heat to keep the peat-sand mixture as near as possible to 70°F. at the base of the cuttings. Good results have been obtained by providing bottom heat only during April and May.

Ventilation. As soon as the cuttings are in place, put the sash on the frames and keep it tightly closed until the first leaves begin to appear on the cuttings. Then provide slight ventilation by raising one end of the sash about 3/16 inch. Ventilation is continuous from this time on. Watch the frames closely on clear, sunny days and provide additional shade if the temperature starts to rise in the frames.

Root formation. During April and May, the cuttings will make top growth. About June 1 this will stop and rooting will begin. In about a month, top growth will be resumed, indicating that a root system has been formed. At this time, gradually increase ventilation until the sash can be removed permanently.

Watering. Watering is important. Water as soon as the cuttings are in place. Keep the peat-sand moist but

not waterlogged. *It is sufficiently moist if some water can be squeezed out of it.* Watering once a week usually is enough at first, but more frequent watering is necessary when new leaves have developed, especially in warm, sunny weather.

Removal of rooted cuttings. Hardwood cuttings usually remain in the frames until the following spring. Then they are removed to be sold or set out in nursery rows.

SOFTWOOD CUTTINGS

Softwood or summer cuttings can be used to good advantage to speed the propagation of plants of special value or new cultivars. They are also useful for propagating such cultivars as Concord, Herbert, Ivanhoe, Stanley, and Bluecrop which are difficult to propagate from hardwood cuttings. However, softwood cuttings are more perishable than hardwood cuttings. Softwood cuttings are started in plastic-covered frames that must be given careful attention to regulate temperature, moisture, and humidity. Softwood cuttings must be carried over an extra year to produce plants as large as those from hardwood cuttings. Softwood cuttings are started under a misting system that will keep the cutting leaves moist but will not waterlog the rooting medium. An automatic system that turns on for 12 to 20 seconds every hour is usually used.

Propagating structure. Temperature and humidity must be controlled to succeed with softwood cuttings. A shaded glasshouse, glass propagation case, or any structure suitable for softwood cuttings of other kinds should be satisfactory for the blueberry. The lathhouse with sash-covered beds (as described above) and plastic greenhouses have given good results. Mist systems are necessary whatever structure is used.

Bottom heat. Bottom heat is not required in rooting softwood cuttings since they are rooted in mid summer when soil and air generally are warm enough. However, bottom heat keeps the rooting medium temperature constant and helps maintain uniform growth. Bottom heat will also compensate for the cooling effect on the rooting medium of the misting water.

Time of taking. Take softwood cuttings during the growing season. Early June, as soon as the shoots are of sufficient length, is the best time in western Washington. *The date is not as important as the condition of the wood.* Take cuttings before flower buds start to form. Formation of these buds inhibits shoot growth on the cuttings.

Type of wood. Take softwood cuttings from shoots that would bear fruit the following year. Make the cuttings from new side shoots or laterals growing out of the previous year's growth. The best cuttings are made from shoots that are *6 to 8 inches long* and *still growing*, but old enough so that the basal portion is firm, but not brittle. Longer lateral shoots can be used, but usually the basal portion of a long lateral is too mature to root well.

Making cuttings. The following instructions apply to laterals *6 to 8 inches* long. When longer ones are available, make them into two cuttings. Strip the shoots from the plant with a downward motion to remove a bit of wood and bark (a heel) with each cutting. Remove the soft upper portion of each shoot, leaving a cutting about 5 inches long with the "heel" attached. Remove only two or three basal leaves—just enough so the cutting can be plunged into the peat-sand medium to about half its length. The more leaf area on the upper portion, the better. The cuttings do best when set upright in the medium.

Chemical treatment. In experiments at Puyallup, 90% or more of all softwood cuttings rooted without benefit of hormones or chemicals. Therefore, special treatment with chemicals does not seem worthwhile.

Ventilation. Softwood cuttings which receive too little ventilation are subject to a soft rot or "tip blight" (*Botrytis*) that attacks the succulent foliage and new growth. On the other hand, too much ventilation causes the unrooted cuttings to wilt readily. This means the frames must have adequate shade whenever the sun is out and some ventilation almost constantly; and they must be observed often, regardless of the weather. A safe rule to follow is to ventilate just enough to prevent water from condensing on the plants, but avoid ventilating enough to cause wilting.

If tip blight becomes troublesome, spray the cuttings with Ferbam or Benlate. If blight persists, spray the cuttings and the inside of the propagating frames three to six times, at intervals of one week, covering all surfaces.

Shading. The most dangerous days for softwood cuttings are the partly cloudy ones when the sun comes out suddenly and runs the temperature up very rapidly under the sash. This can happen even under a lathhouse. Be prepared for such days, and for clear ones, with extra protection, such as muslin-covered frames that can be placed over the propagation beds. It is best to fasten such extra shading on the inside of the lathhouse rather than directly on top of the sash. The same principles apply when cuttings are rooted in a glass house or propagating box.

Watering. In general, water softwood cuttings the same as hardwood cuttings. The peat-sand should be moist when the cuttings are inserted. "Water-in" the cuttings to settle the peat-sand firmly around them. Softwood cuttings have leaves on them when set and so are in more danger from drying out than hardwoods. In hot weather, open the frames each morning and syringe the foliage with clear, cool water, or set the mist system timer to keep the cuttings moist.

FERTILIZERS IN THE CUTTING BED

Try to produce as much shoot growth as possible on cuttings while they are in the propagating frames. Hardwood cuttings first make a little shoot growth, then stop growing while they form roots. With bottom heat, they form roots by the first of July. They then start to make additional shoot growth. Thus, they have three to four months to grow before hardening

and dropping their leaves in preparation for winter.

There is little available nitrogen in peat and sand. Nitrogen (N) fertilizer must be used to obtain maximum growth. In experiments, hardwood cuttings rooted with bottom heat made 12 to 24 inches of shoot growth by fall when fertilized; unfertilized cuttings made one-third to one-half as much growth.

The only fertilizer element required is N. This can be supplied as ammonium sulfate, ammonium phosphate, urea, or any other fertilizer containing N in the *ammonium* form. The amount of N in 3/4 ounce (1 1/2 tablespoon) of ammonium sulfate (21% N) is enough for a 3 x 6 foot frame. More is likely to injure the cuttings. The amount of other fertilizers to use depends on the percentage of N they contain. Soluble fertilizers must be kept off the leaves since they are likely to burn them. Soluble fertilizer can be dissolved in water and sprinkled over the bed if this is followed by a spray of water to wash all the fertilizer off the leaves.

It makes little difference whether the fertilizer is applied soon after the cuttings are set, or as late as the first of July.

Softwood cuttings, like hardwood cuttings, make more top growth when fertilized with N, but not as much total growth in the propagating frames as do the hardwood cuttings.

Blueberry plants are grown one or two years in the nursery before transplanting to the field. Three-year-old plants make the best growth with the least mortality after setting in the field.

PLANTATION ESTABLISHMENT

SITE

The environment is extremely important for blueberry production. Soils should drain well and not become waterlogged for prolonged periods. Blueberries are not tolerant of drought, so adequate soil moisture in the growing season is a necessity, especially during July and August. In most locations some irrigation is required.

SOIL

The blueberry is very demanding of certain soil conditions and these conditions must be maintained for successful blueberry culture. Blueberries require a soil pH of 4.0 to 5.0. Good production in some soils with pH 5.5 or even 6.0 occurs. However, in soils with pH above 6.0, plants are apt to be stunted and have yellow leaves and reduced production. The fine fibrous root system makes open, porous soils a necessity; the fine blueberry roots cannot penetrate a compact, heavy soil. Light, well-drained, sandy loam soils with high organic matter make ideal blueberry soils.

Cultivation. The spread of the roots of the highbush blueberry during the first few years usually is no greater than the spread of the branches. As the plants become older, the roots may extend out beyond the branch tips to some extent. Downward penetration is influenced by drainage, soil structure, aeration, moisture, and organic matter. Deep cultivation, or soil compaction, may check the spread of blueberry roots into the row middles. Since blueberry roots are shallow and do not grow into the subsoil, cultivation must also be shallow. Growers used to believe that cutting off roots near the surface would force the plant roots to go deeper. However, the depth of root development is fixed by the depth of the topsoil, so deep cultivation merely reduces the total volume of roots and the plant's ability to absorb moisture and nutrients. On soils low in organic matter, shallow cultivation avoids excessive aeration and decomposition of organic matter.

Drainage. Although the blueberry requires readily available moisture, it will not tolerate poor drainage. Roots held in soil saturated with water may be killed in only a few days. Depressions or pockets where water collects should be drained. Bedging rows before planting will aid in draining excess water away from the plant roots. Blueberry plants will grow on clay soils if they have adequate organic matter, but clay soils generally have poor internal drainage and lack aeration. Organic mulches increase organic matter content and improve soil structure.

Soil preparation. Blueberries planted on deep, well-drained soils are the most productive. A loam or sandy loam soil with high organic matter 2 to 4 feet deep is best suited for blueberries. With ideal soil conditions and good cultural maintenance, plantings may remain productive for 20 years or more. On poor sites, growth is slow and plants are weak and production is low. Plantings on poorly drained soils are less vigorous and are more apt to develop root problems.

A soil improvement program before planting is recommended unless the area has been in sod, hay, or other soil-improving crops. A green manure crop plowed under before planting will help establish organic matter and improve soil tilth. Cereal rye is good. It should be planted in early September and worked into the soil in the spring before planting. If the cover crop is allowed to grow longer it may use so much water that the blueberry plants will suffer. The cover crop should not be allowed to develop beyond the heading stage, even if irrigation is present. Breakdown of heavy straw requires large quantities of nitrogen (N). When large quantities of straw are plowed under or mixed with the soil, additional N must be provided or the available N will become depleted and not be available for plant growth. If shavings or sawdust are added to the soil, additional N should be added.

Barnyard and poultry manure are good sources of organic matter and plant nutrients. If available, apply annually during early spring. Use 8 to 12 tons of barnyard manure, or 5 or 6 tons of poultry manure per acre. Manure may be a source of weed seed. Since manures are low in phosphorus, applications of commercial fertilizers will likely be needed. A soil test will identify specific needs. See discussion on fertilizers.

Eliminate noxious weeds such as Canada thistle, quackgrass, and sheep sorrel before planting. Areas that have been in sod should be cultivated or cropped for at least one year to kill the grass. A nematode test to determine number and kinds of nematodes is essential. Fumigation may be advisable

if nematodes are present.

In most soils, compaction sometimes develops in the subsurface levels, therefore, it is advisable to subsoil all mineral soils to an 18-inch depth before planting. This improves aeration, drainage, percolation of soil moisture, and root penetration.

PLANTATION DESIGN

Mature highbush blueberries form shrubs from 5 to 8 feet tall and 4 to 6 feet wide. Size can be controlled by pruning, but ample spacing should be allowed for growth.

The most practical plantation design will depend upon the cultural practices to be used, the method of harvesting and, to some extent, the marketing plan.

Spacing. Spacing in the rows can be from 4 to 8 feet. If cultivation in both directions is desired, an 8-foot space is required. Row spacing can be from 8 to 10 feet. If over-the-row mechanical pickers are to be used, rows should be a minimum of 9 feet apart. See Table 7 for number of plants per acre.

TABLE 7. PLANTING DISTANCES IN ESTABLISHED BLUEBERRY FIELDS

Plant spacing	Plants per acre
5 · 7	1,244
5 · 8	1,089
5 · 10	871
4 · 10	1,089
8 · 8	680
6 · 10	726
7 · 7	890
6 · 8	907

If the planting is to be picked with a mechanical harvester, a 25-foot headland should be left at the ends of the rows to provide turning room for the machine. Long rows are preferable for mechanical pickers, but short rows or cross alleys in which to collect the fruit are preferred for hand picking and 1-pick harvesting.

Plant spacing depends on cultivars and soil type. Plants growing in peat, muck, or mineral soils with a high level of organic matter will produce larger bushes than light sands or sandy loams. For over-the-row mechanical pickers, a row spacing of 10 feet or more and spacing in the row of 4 to 5 feet is suggested. In this arrangement, the bushes are pruned as a continuous hedgerow.

For hand harvesting, especially where cultivation in both directions is desired, a row spacing of 10 feet with plants 7 to 8 feet apart is recommended. In this arrangement, each plant is maintained as an individual free-standing shrub.

Closer spacing will produce higher yields per acre during the first few years of production, but will make the plantings too crowded when the plants mature in 10 to 12 years. Many older plantations which were planted in rows 6 to 7 feet apart have had alternate rows removed without significantly reducing yields.

Planting the fields. Blueberries should be transplanted during the dormant season. The best time is early spring before the resumption of growth. When transplanting established plants (older plants from fruiting fields), prune to remove all the top growth.

Set nursery-grown plants at about the same depth as they were growing in the nursery row. Dig holes in the soil large enough to accommodate the root ball. Spread the roots and fill soil around them. Firm the soil as it is placed to ensure that no air pockets remain to dry out the fine roots.

The field to be planted should be marked off by a tractor-drawn marker or by a wire stretched across the field. Mulches around young plants will aid in weed control, conserve moisture, and improve the soil structure.

Prune broken roots and branches at the time of plant setting.

PLANTATION MAINTENANCE

Blueberry plantings require a number of annual maintenance procedures such as pruning, fertilization, irrigation, pest control, and weed control. These cultural operations are timed to the annual growth cycle of the plants which varies from year to year with climatic and soil conditions. See Yearly Calendar, Table 8.

PRUNING

The basic job in pruning is to promote the growth of strong new wood, increase plant size, and maintain good fruit production (Dodge, 1969). If too little pruning is done, the plants are crowded, with weak, twiggy growth, and fail to develop strong new wood for future production. Severe pruning produces fewer, larger berries and more new wood. Experience is the best guide on how hard to prune.

The best time to prune is January to mid-March. However, blueberries can be pruned any time from the end of harvest to the start of growth in late March.

Pruning two- and three-year-old plants at the time of planting is limited to removing the older twiggy growth from the base of the plants, leaving the strong new growth. The blossoms should be stripped off young plants the first year or two in the field. Permitting young plants to set fruit slows growth. Long-run production will be best if plant growth, rather than berry production, is emphasized.

Pruning established mature plants consists of cutting out, or cutting back, old canes that have little strong new wood, and eliminating the weak twiggy growth in the top or outer areas of the bushes. Following a series of steps may systematize your pruning job and make it easier. The first-year canes are not branched and will not produce much fruit during the coming season, but they are essential to crops in succeeding years. The second- and third-year canes have laterals or twigs with good vigor and many strong fruit buds. They are the best fruiting wood.

Fourth year and older wood with small, weak laterals and few fruit buds is not productive. It crowds and weakens young wood and should be removed. Cut canes back to the ground or a strong new side shoot. If one or two old canes are removed each year and one or two new ones produced, none will be over four to six years old—a good goal to work for.

The following is a summary of the

steps to take in pruning:

1. Cut out any canes damaged by disease, insects, or mechanical causes.
2. Cut out some (usually one or two) older canes. Choose those with the least strong growth on them. Sometimes it will be possible to cut the cane back to a strong new side branch.
3. Cut out low branches and short, soft, new shoots that developed from the base of the plant late in the season.
4. Remove weak, twiggy wood from the top and outer parts of the plant. Remove enough from the top to let light down into the plant center. Weak, twiggy wood generally has few flower buds and produces small berries.
5. If your plants tend to overbear, tip back some of the small shoots carrying a heavy load of flower buds. Cut off about one-third of the fruit buds.

Blueberry flower buds are near the tips of the past season's growth. Flower buds are larger, fatter, and less pointed than vegetative buds. Vegetative buds are farther back from the shoot tips. They produce the new shoots for the next season's crop.

Good plant nutrition, soil moisture, freedom from damage by root weevils, and freedom from competition with grasses and weeds, as well as proper pruning, are essential to growth of strong new wood and berry production. If your plants do not respond to pruning, work more on other factors affecting growth.

IRRIGATION

Because they are shallow rooted, blueberry plants are subject to drought injury. A uniform and adequate supply of moisture is essential for optimum growth. If this is not supplied by natural soil water or rainfall, irrigation is necessary. In most areas of western Washington and Oregon, irrigation is required to maintain adequate soil moisture from mid-June to mid September. The demand for moisture is greatest from the time of fruit expansion until harvest. July and August are the lowest rainfall months and this is the period when the developing fruit makes the greatest demand. This is also the period when floral initiation for next year's crop begins. If soil moisture and nutrients, especially N, are lacking, a reduced set of buds will occur.

Some of the newer cultivars are resistant to fruit cracking (see cultivar list). However, with a continuous supply of moisture the fruit skin remains elastic and cracking is less likely to occur. Cracking often occurs after a period of drought. Fruit growth is slowed and the skin becomes less elastic. Then when precipitation or a period of high humidity occurs, the fruit flesh swells faster than the skin can accommodate it and the skin splits.

Sprinklers are the most common irrigation method in the Pacific Northwest. Drip irrigation is used to some extent. It is best to irrigate thoroughly before fruit ripening and again immediately after each picking if irrigation is necessary.

Irrigation should be frequent enough to prevent wilting of the leaves. The amount of water applied during each irrigation depends on the water-holding capacity of the soil. Enough water should be applied so that it penetrates as deep as most of

TABLE 8. YEARLY CALENDAR

Growth period	Approximate dates	Cultural operations
Dormant	November to mid-March	Apply fall herbicides, November to December Prune Apply pre-emergent herbicides before weed growth starts, late February to mid-March Apply dormant spray for scale control Remove diseased tissue
Leaf bud break and flower bud development	Late March to late April	Apply fungicide for primary mummy berry and botrytis control (3 sprays) Make first fertilizer application Control weeds by cultivation and/or herbicides Apply mulches
Bloom period	Late April to late May	Apply fungicides for secondary mummy berry and botrytis on fruits (2 sprays) Apply insecticides to control fruitworm and aphids, if needed Introduce bees for pollination Make second fertilizer application late May Apply mulches
Fruit development	June and July	Control aphids, if present Cultivate for weed control in row middles Make third fertilizer application, mid-July, if needed Irrigate as needed Install bird netting
Harvest	July to September	Spray for bird control if not netted Pick and market fruit Irrigate as needed
Post harvest growth	September to mid-October	Cultivate to control weeds Irrigate as needed Remove bird netting

the roots. About 1 inch per week is a general rule of thumb. If evaporation data is available, use it as a guide to the amount of water to apply. During warm dry weather, 1/2 inch of water is evaporated in a single day. Under these conditions 1 inch of water per week isn't sufficient. Excessive irrigation that penetrates beyond the root zone is undesirable because it may leach fertilizer nutrients beyond the reach of the roots. Too light an application that does not reach most of the roots is just as undesirable. Mineral soils require more frequent irrigation to maintain an adequate moisture level for the plants.

MULCHING

Since blueberry roots grow mostly near the soil surface, to prevent root damage any cultivation must be very shallow and not too close to the plant. Blueberries grow better on mineral soil if mulched. Mulching to a depth of 5 or 6 inches with sawdust or some other suitable material keeps the soil cool, helps conserve moisture, adds organic matter to the soil, improves soil structure, and aids in preventing weeds from becoming established. When mulches are used, two to three times the normal amount of N may be necessary for the first few years to compensate for increased microbial activity.

POLLINATION

Cross pollination of highbush blueberries causes greater fruit set and an increase in seed numbers, which results in larger and earlier ripening berries. Therefore, at least two cultivars of blueberries should be planted. Ten rows of one cultivar alternated with 10 rows of a different cultivar should ensure good cross pollination. Highbush blueberry cultivars overlap enough in time of bloom to be effective pollinators for any other cultivar.

Pollination depends largely on visits by insects, principally bees. When wild bee populations are not sufficient, honeybees are recommended. Honeybees work most efficiently when hives are placed in a checkerboard pattern throughout the field. The bees fly further along the rows than they do across them. One to 1 1/2 hives per acre are required. In plantings with a 9-foot row spacing, place hives in every tenth row with about 300 feet between hives. For best results hives should be placed so they are not shaded, face the east so they obtain the morning sun on the entrances, and be provided with windbreak structures. Growers should be aware of the importance of bees in blueberry culture and make every effort to protect honeybees and native bee populations (see section on protecting pollinators) and to bring in a sufficient number of hives to ensure good fruit set. When weather conditions are adverse to good pollination (cool, wet weather during bloom), honeybees are even more important.

FERTILIZATION

SOILS AND FERTILIZATION

Blueberries are grown on two distinctly different types of soil: 1) organic soils; and 2) mineral soils, such as clay loam, silt loam, loamy sands, or sandy loams.

Organic soils yield more nitrogen (N) and hold more water than most mineral soils. Peat and muck soils hold so much moisture that they warm up more slowly than mineral soils in the spring. Release of native N depends on the activity of soil bacteria and decomposition of organic matter. The level of readily available N remains low until the soil begins to warm in the spring and N release takes place. It may be necessary to apply a small amount of N to promote early spring growth, for example 1 to 8 tablespoons of ammonium sulfate per plant, depending on age of plant (Table 9).

Blueberries growing on mineral soils usually need both early spring and late spring applications of N to maintain steady growth.

Blueberries grow best in soils with a pH between 4.0 and 5.0, although they will grow and produce fairly good crops at 5.5 or even 6.0. The acidity or alkalinity of soil is affected, and can be partially adjusted by, the types of fertilizers which are used to supply mineral nutrients. Ammonium sulfate, for example, used over a period of years will gradually lower the pH. Nitrate fertilizers, however, tend to raise the pH.

NUTRIENT NEEDS OF BLUEBERRIES

Blueberry plants need many elements for normal growth. The three primary elements, nitrogen (N), phosphorus (P), and potassium (K), are used in larger quantities than the other elements. They require frequent replacement in soils from which crops are regularly harvested.

Three secondary elements, calcium (Ca), magnesium (Mg), and sulfur (S), are used in smaller amounts but may require periodic replacement in some soils. These elements are replaced by adding such minerals as ground limestone, gypsum, dolomite, or powdered sulfur to the soil. A single application of these minerals usually lasts several years.

Micronutrients such as boron, manganese, copper, zinc, iron, molybdenum, and chlorine are used by plants in small amounts. Most soils contain sufficient micronutrients, so they are added only if abnormal plant response (generally foliar symptoms) or a soil or leaf analysis indicates a deficiency (Tables 10 and 11).

Only small quantities of micronutrients are needed by plants, so they can be applied as leaf sprays, injected in the irrigation water, or added to other fertilizer applications. Blueberry plants respond more rapidly to leaf sprays than to soil treatments. Soil treatments last longer, but under some conditions soil-applied micronutrients are tied up and are unavailable to the plants, and therefore, leaf sprays are necessary. Certain micronutrients such as boron (B) and copper (Cu) can injure plants if applied at higher amounts than necessary for plant growth and can cause extensive damage to blueberries.

NITROGEN (N)

How to determine needs. Nitrogen needs can best be determined by the appearance and vigor of plants and by having a leaf analysis. Healthy blueberry plants receiving sufficient N

TABLE 9. NITROGEN (N) RATES FOR BLUEBERRY PLANTS[a]

Age of plants from transplants	Ounces of nitrogen to apply/plant[b]			Total lbs. N/acre per year (1089 plants/acre)
	March 15 to April 15	June 1	July 1[c]	
Newly set	—	0.2	0.2	25
1 year	0.1	0.2	0.2	31
2 years	0.2	0.2-0.4	0.2-0.4	38- 63
3 years	0.3	0.2-0.4	0.2-0.4	44- 70
4 years	0.4	0.4-0.6	0.2-0.4	63- 88
5 years	0.5	0.4-0.6	0.2-0.4	70- 94
6 years	0.6	0.4-0.6	0.2-0.4	75-100
7 years	0.7	0.4-0.6	0.4-0.6	90-119
8 years or more	0.8	0.6-0.8	0.4-0.6	125-154

[a]Rates are for mineral soils. On organic soils, normally only March 15 to April 15 application is necessary.

[b]0.1 oz. N = 1 level tablespoon ammonium sulfate, or 2/3 level tablespoons ammonium nitrate, or 2 level tablespoons 10% N fertilizer, such as 10-10-10 or 10-20-20.

[c]Nitrogen should be applied after July 1 only if plants need it and *only if irrigation water* is available.

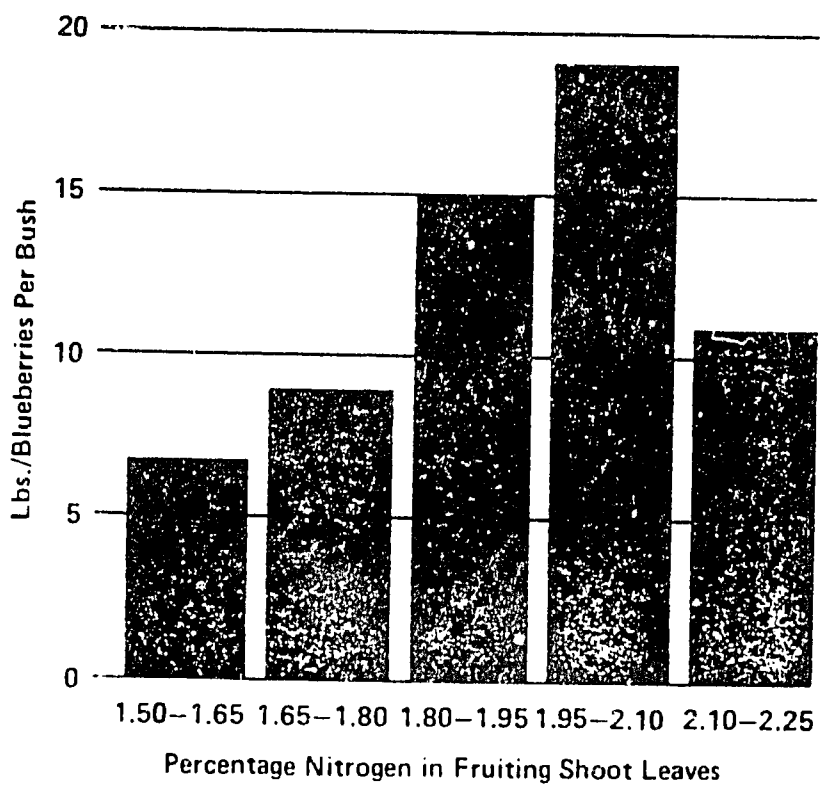

FIG. 4. Nitrogen content of fruiting-shoot leaves and yield per bush (Source: Ballinger, *et al.*, 1958).

have relatively large, uniformly deep-green leaves and vigorous growth. Healthy young plants should increase in size each year; mature plants should produce enough unbranched new shoots to replace the old canes and twiggy growth taken out in annual pruning.

Blueberry plants that do not have sufficient N show reduced size, poor leaf color, weak or stunted growth, and stopping of growth before the end of the season. A deficiency of N serious enough to cause reddening of the foliage will stop growth and reduce yield. Leaf analysis will detect an approaching N deficiency before it becomes serious enough to cause deficiency symptoms (see standard range for N, Table 10).

Blueberry plants should remain green and actively growing until mid-September in western Washington and Oregon. Active growth too late in the fall may result in increased winter injury.

Red-leaves and poor growth are a danger signal. More N may be needed, but these symptoms can also mean lack of soil moisture, too much competition from weeds, root weevil injury, root injury from too much water, or damage to the roots from any cause. Providing irrigation, controlling weeds, controlling weevils, or putting in adequate drainage may be much more important than more N fertilizer.

Types of nitrogen fertilizer. Blueberries generally respond better when N is applied as ammonium sulfate, ammonium phosphate, or urea than when fertilized with nitrate fertilizers. Plants respond well to ammonium nitrate fertilizer and growth continues later in the summer than with only ammonium or urea fertilizers. Fertilizers which contain only nitrate N (nitrate of soda) may cause injury or reduced growth and should be avoided. Sulfate forms of fertilizers contain considerable amounts of S (sulfur), usually enough for blueberry plant needs.

How much nitrogen fertilizer? If plant growth or leaf analysis indicates a need for N fertilizer, Table 9 suggests amounts to apply. The amounts can be adjusted up or down to change N fertility for optimum growth and

production in successive years.

Control of N levels is of primary concern in blueberry plantings. Applications of N should be at a rate of about 125 to 154 pounds per acre on fully mature plantings after 10 years of age. See Table 9 for younger plantings.

Excessive N should be avoided as berry production can be reduced (Fig. 4). Leaf N levels above 2.10% of dry weight of the leaves will reduce production.

Balance the amount of N fertilizer against the number and length of fruiting shoots and new canes growing from the crowns. This will vary from one soil type to another. However, the amount of new growth largely depends on the quantity of N available to the plant. Sufficient N must be present to supply the needs of the developing berries, shoot growth, and development of flower buds, but not be excessive.

Number of applications. Relatively small amounts of N applied two or three times, as suggested in Table 9, are preferable to single heavy applications. Nitrogen supplies should be available to the plant throughout the growth period. The greatest demand for N is when the fruit is maturing rapidly, shoot growth is taking place, and floral initiation occurs. This generally occurs from late July until after harvest. If N is low during this period, flower bud development for next year's crop will be reduced because the maturing fruit has first chance at available N. Consequently, flower bud development and shoot growth suffer.

Application of N in July depends on the condition of the plants. If the plants have made sufficient growth, a third treatment will not be necessary. On the other hand, if growth is not adequate, additional N will keep plants growing throughout the season and let flower bud development proceed normally for next year's crop.

Make the third application of N only if good soil moisture or supplemental irrigation is present. Fertilizer applied to a dry soil will remain there until rains occur. It may cause excessive growth too late in the fall and make plants susceptible to winter injury.

TABLE 10. FOLIAR NUTRIENT LEVELS OF BLUEBERRIES

Element	Deficiency below	Standard Range Minimum	Standard Range Maximum	Excess above
Nitrogen (N)	1.70%	1.80%	2.10%[a]	2.50%
Phosphorus (P)	0.10%	0.12%	0.40%	0.[illegible]7%
Potassium (K)	0.30%	0.35%	0.65%	0.95%
Calcium (Ca)	0.13%	0.40%	0.80%	1.00%
Magnesium (Mg)	0.08%	0.12%	0.25%	0.45%
Sulfur (S)	0.10%	0.125%	0.20%	
Manganese (Mn)	23 ppm	50 ppm	350 ppm	450 ppm
Iron (Fe)	60 ppm	60 ppm	200 ppm	400 ppm
Zinc (Zn)	8 ppm	8 ppm	30 ppm	80 ppm
Copper (Cu)	5 ppm	5 ppm	20 ppm	100 ppm
Boron (B)	20 ppm	30 ppm	70 ppm	200 ppm

Source: C. C. Doughty, unpublished data, W. E. Ballinger, et al., 1958.

[a]Leaf N levels of 2.10% dry weight or higher will cause reduction in yield. See Fig. 4

TABLE 11. BLUEBERRY LEAF NUTRIENT LEVELS IN MATURE PLANTS 6 TO 15 YEARS OLD AND IN FULL FRUIT PRODUCTION

	Weeks after first leaf sample June 12						
	0[a]	2	4	6	8	10	12
N %	2.43	2.27	2.02	1.97	1.96	1.99	2.06
P %	0.19	0.15	0.16	0.12	0.12	0.13	0.14
K %	0.42	0.41	0.41	0.49	0.34	0.40	0.39
Ca %	0.65	0.32	0.51	0.58	0.63	0.62	0.73
Mg %	0.18	0.15	0.16	0.18	0.19	0.19	0.19
Fe ppm	77	73	79	85	107	144	125
Mn ppm	133	155	167	171	172	188	144
B ppm	24	29	31	34	36	43	42
Cu ppm	9	7	7	7	8	7	7
Zn ppm	12	11	9	10	8	10	9
S %	0.10	0.14	0.14	0.13	0.13	0.15	0.15

[a]Starting date for each year was about June 12. The first year, nine varieties on five farms were sampled, 21 samples each date. The second year, nine varieties on four farms, 18 samples each date, were analyzed.

PHOSPHORUS (P) AND POTASSIUM (K)

The best way to determine if P and/or K are needed is by soil test and leaf analysis. A soil test will indicate the parts per million of P and K available for plant use; leaf analysis will indicate levels of these elements in the leaves. Take leaf samples from late July to mid-August (Table 11) when P and K tend to be at their lowest levels. Compare soil test results to Tables 12 and 13 and leaf analyses to Table 10 to determine P and K needs. Consult your local Extension Service for interpretation of test results.

If soil tests and leaf analyses indicate that P and K are needed in addition to N, ready-mixed fertilizers of the proper ratio, for example 10-20-20, 10-20-10, or 10-10-10, should be applied each spring. If N is not needed but P and K are, then a ready-mixed fertilizer such as 0-20-20 may be used. If P alone is needed, use 0-18-0 (superphosphate) or 0-54-0 (triple superphosphate). If N and P are needed, but not K, use 16-20-0. When K only is needed, use 0-0-52 (potassium sulfate).

TABLE 12. PHOSPHORUS (P) RATES FOR BLUEBERRY PLANTS

Soil test reading	Apply this amount	
	P	P_2O_5
ppm	Lbs.	Lbs.
0 to 1.0	40	91
1.0 to 3.0	26	59
3.0 to 6.0	13	30
6.0 to 10.0	0	0
10.0 or more	0	0

TABLE 13. POTASSIUM (K) RATES FOR BLUEBERRY PLANTS

Soil test values[a]		Apply this amount	
High K reserve soils	Low K reserve soils	K	K_2O
ppm	ppm	lbs.	lbs.
0 to 30	0 to 50	75	90
30 to 60	50 to 100	50	60
60 to 90	100 to 150	25	30
90 to 125	150 to 200	0	0
125 or more	200 or more	0	0

[a]High K reserve soils in Washington are Agnew, Bow, Chehalis, Dungeness, Felida, Gee, Kelso, Puget (except Puget in Clallam County), Puyallup, Ridgefield, Salkum, Sultan, and Wapato. They can supply more K than low reserve soils. Oregon growers contact your county Extension service for recommendations.

Sulfate of potash-magnesia (21% K, 11% S, and 10% Mg) may be used to supply K as well as Mg, if both are needed. Use only the sulfate form of potassium fertilizer (potassium sulfate). Chloride types (muriate of potash) may cause reduced growth and injury to blueberries under certain conditions.

CALCIUM (Ca), MAGNESIUM (Mg), AND pH

Soil test values of Ca less than 1.50 milliequivalents and of Mg less than 0.25 milliequivalents indicate a need for these elements. Values of less than pH 4.0 or above pH 5.5 indicate a need for correction of soil acidity.

On peat soils, 1/2 ton of agricultural lime will provide Ca or 1/2 ton of dolomite lime will provide Ca and Mg without changing the pH appreciably. Lime, gypsum, and dolomite should be applied in the fall to allow time for interaction with the soil before the next growing season.

If the soil test shows that Ca is needed on mineral soils, and the pH is 4.0 or below, apply 1/2 ton of agricultural lime per acre.

If both Ca and Mg are needed on mineral soils, and the pH is 4.0 or below, apply 1/2 ton of dolomite lime per acre.

If Ca is needed, and the pH is above 5.0, apply 1/2 ton of gypsum per acre.

If Mg is needed, but not Ca, apply 500 pounds of sulfate of potash-magnesia or magnesium sulfate (Epsom salts) over the rows. Epsom salts or sulfate of potash-magnesia may be mixed with other fertilizers and applied as a regular part of the fertilizer program. If this is done, a soil test should be made every 3 to 5 years to be sure the soil Mg or K is not getting out of proportion to Ca. A ratio of Mg to Ca of 1:10 or a ratio of 1:5 of K to Ca is about right.

On most blueberry soils (including mineral and peat soils), the addition of approximately 4% Mg to the regular fertilizer will assist greatly in maintaining Mg levels in the soil. Most blueberry plants will show some Mg deficiency symptoms in late summer. Generally this is not enough to significantly affect yield unless it continues for several years, when it will reduce vigor, growth, and yield.

FERTILIZER APPLICATION

Nutrients in fertilizers are carried down to the root area by rainfall or irrigation. Too much highly soluble fertilizer, such as ammonium sulfate or potassium sulfate, concentrated in a small area above the roots will injure them. Spread fertilizer evenly over the outer edge of the root zone. The root zone generally extends to the outer edge of the branches (drip line) or slightly beyond. Rainfall usually will be adequate to carry the early spring (bud break) fertilization down to the root zone. Late spring (May) and summer (July) applications of fertilizer should be followed by irrigation where possible.

Fertilizer can be side-dressed by placing it 2 to 3 inches below the soil surface at the outer edge of the root zone. Side-dressing too close to the blueberry plant will seriously injure the roots.

Urea may be applied as a leaf spray when plants show a need for additional N during times of stress when demands are high. Apply at the rate of 4 to 6 pounds of N per acre in 150 to 200 gallons of water per acre.

LEAF SAMPLING FOR ANALYSIS

Leaf sampling in Michigan indicated that nutrients varied least during the first week in which 35% of the crop is harvested and the three weeks before that (Amling, 1960). This suggests that leaf samples for diagnostic purposes should be taken during this period.

Leaf sampling in Washington from the second week of June (Table 11) to the first week of September indicated that N, P, K, Zn, S, and Cu were at the lowest levels during the last week of

TABLE 14. FOLIAR SPRAYS FOR CORRECTION OF MICRONUTRIENT DEFICIENCIES

Nutrient	Material	Rate/100 gal.	Timing
B (Boron)	Borospray	1.5 lbs. product	Any time leaves are present
	Solubor	1.5 lbs. product	
	Borax	3.0 lbs. product	
Fe (Iron)	Iron chelate	Follow label instructions	Apply to leaves when symptoms appear
Mn (Manganese)	Manganese sulfate	2 lbs. product	Any time leaves are present
	Manganese chelate	Follow label instructions	
Zn (Zinc)	Zinc chelate	1-2 lbs. product	1 to 3 times during growing season
Cu (Copper)	Copper sulfate	1 lb. product	Ar[illegible] leaves a[illegible]
Mo (Molybdenum)	Sodium molybdate	¼-½ lb. product/A	Any time leaves are present

TABLE 15. MICRONUTRIENT SOIL APPLICATION RATES FOR BLUEBERRIES

Nutrient	Material	Soil application rate, lbs./A
Boron (B)	Borax, 11.3% B	10-20
	Tronobor, 14.5% B	8-16
	Polybor, 20.5% B	5.5-11
Iron (Fe)	Ferrous sulfate, 34% Fe	10-20
	Iron chelate, 10% Fe	15-30
	Ferrous ammonium sulfate, 14% Fe, 7% N	15-30
Manganese (Mn)	Manganese sulfate, 28% Mn	50-100
Zinc (Zn)	Zinc sulfate, 36% Zn	10-30
	Zinc chelate, 14% Zn	10-30
Copper (Cu)	Copper sulfate, 25% Cu	30-50
	Highly toxic if excessive rate is used. Trial application on small area should be made before a general application	
Magnesium (Mg)	Magnesium sulfate	500
	Sulfate of potash-magnesia	500

leaves first and on the lower part of the bush.

Boron (B). Boron deficiency in blueberries is recognized by a bluish color of the terminal leaves, which suddenly stop growth. This is followed by slight yellowing between leaf veins and yellowish spotting along the edges of the younger leaves just below the growing point. Leaves become distorted, growth ceases, and shoots die at the tip. Shoot dieback is probably the most common symptom in boron-deficient blueberries. The dieback at times creates a witch's broom, since branches develop lower down on green tissue and, in turn, die if the deficiency is not corrected.

Iron (Fe). A green-veined yellowing of the youngest tip leaves may indicate iron deficiency in blueberries. This deficiency takes the form of a green net over the entire leaf with the veins, even the subveins, standing out as green, while the tissue between the veins is a distinct lemon yellow. This interveinal chlorosis affects younger leaves first.

Manganese (Mn). Manganese deficiency, like iron deficiency, occurs on younger leaves first. It also produces interveinal yellowing and can readily be confused with iron deficiency. The veins generally have a little broader band of green than in the case of iron deficiency. The veins of the leaves stand out and the tissue between the veins is a distinct yellow color. As the deficiency becomes more severe, the interveinal yellowing along the edges, resembling magnesium deficiency, develops into dead areas. At times the first noticeable symptom is a yellow spotting in the center portion of the leaves. Other symptoms appear as dead spots scattered over the leaf. As the deficiency becomes more severe, these spots will merge and the entire leaf will die. Generally manganese deficiency is not a problem in the blueberry growing areas of western Washington and Oregon.

Zinc (Zn). Zinc deficiency also appears as a yellowing of younger leaves. In this case, the entire leaf becomes lemon-yellow. If the deficiency is only slight, the symptom may appear in the

fields. Choice of which herbicides to use depends upon several interrelated factors: weed species present, soil type, and weather conditions. For current recommendations, check with your county Extension office.

BIRD CONTROL

Many species of birds feed on blueberries. The principal species are starlings, robins, and finches. Birds can harvest 100% of the berries if not controlled. Two types of controls are effective: netting the fields to exclude the birds, and spraying with a bird repellent. Use of netting on large fields is seldom practical, especially where large mechanical harvesters are used.

Bird netting is a light plastic fabric which is supported over the entire field on a lattice of wires and posts. Properly installed, netting effectively excludes all birds from the blueberry plants. Initial cost of installing netting is relatively high, but the increased harvest normally will amortize the cost in one or two years. Netting should be removed after harvest and replaced before the time of fruit coloring each year. If left up through the winter, it can collect ice and snow, collapse the framework, and damage the planting.

Methiocarb is an effective bird repellent. A Washington State registration has recently been granted for this use. Repellent sprays should be applied every week to ten days from first fruit color until completion of harvest. Follow manufacturer's directions.

DISEASE CONTROL

Mummy berry. In the Pacific Northwest, the most common and most serious blueberry disease is mummy berry. This fungus disease affects shoots, leaves, flowers, and fruits, and can reduce yields by up to 70%. In mummied berries, fungus tissue replaces the fruit flesh. This tissue forms a hard, mummified berry called a sclerotium, which carries the fungus through the winter. The sclerotia fall on the ground around the bushes.

In the spring, fungus spore cups (Fig. 7A) grow from the overwintering mummies on or near the surface of the soil. Spores from the fruiting cups infect blueberry buds shortly after the overwintering buds open in early spring. Infected shoots and blossoms turn brown and wither, much as if they had been frosted (Figs. 7B and C). Leaf and shoot growth, expanding from newly opened vegetative buds, is blackened in the center and eventually wilts and dies. About three weeks after the initial infection, a brownish-gray mass of spores develops on the affected shoots and blossoms. These spores drift on air currents and infect the embryo fruit through the flower.

During the early part of berry development, the diseased fruits are not distinguishable from the healthy. As the berries approach maturity, however, infected berries become a reddish buff or tan color, in contrast to the waxy green of healthy fruits (Fig. 7D). Many of the diseased berries fall before the healthy fruit is harvested. However, if they do not, the mummies are lighter in weight than sound berries and can be removed mechanically when the fruit is cleaned.

This disease is controlled both mechanically and chemically. Clean cultivation in the spring destroys or buries many of the mummies and reduces the number of spores released. However, blueberry fields often are too wet for cultivation at this time of year. Chemical fungicides applied to the twigs and emerging buds every seven days have given excellent con-

FIG. 7A. Mummy berry disease. Fungus spore cups.

FIG. 7B. Mummy berry disease. Blighted leaves.

FIG. 7C. Mummy berry disease. Blighted blossoms.

FIG. 7D. Mummy berry disease. Infected berries

trol. Three to four sprays are required. Additional fungicide applications during the blossom period reduce the secondary infection and improve control. For the latest chemical recommendations, check with your county Extension office.

Botrytis twig and blossom blight is another serious disease in the Pacific Northwest (Fig. 8). This gray-mold fungus can be a problem in prolonged rainy springs. Fungicides applied at the beginning of petal fall and repeated at 10-day intervals until all petals have dropped give excellent control. Check with your Extension office for recommendations or refer to the *Pacific Northwest Plant Disease Control Handbook*.

Godronia cane canker is a serious disease in some fields. Spores from old cankers infect leaf scars and mechanical wounds and new cankers develop around the buds on one-year-old canes in the spring (Fig. 9). They continue to develop and frequently girdle the cane, causing death.

Several other fungus and virus diseases attack blueberries but none so far have caused serious problems in the Pacific Northwest.

NEMATODES

Damage from nematodes is most severe on young cuttings. Both the stubby root nematode (*Trichodorus* [illegible]) and the sheath nematode (*Hemicycliophora* [illegible] *similis*) attack young cuttings, causing stunting and reduced root growth. The dagger nematode (*Xiphinema americanum*), while probably causing little direct damage, transmits tobacco ringspot virus. This virus is the cause of necrotic ringspot disease of blueberries, which can seriously affect production.

Presently, there is no way of controlling nematodes in established plantings. For new plantings, soil fumigation is the only available method. Soil fumigation is expensive and does not completely eliminate nematodes. Before soil fumigation is even considered, soil samples from a proposed site should be analyzed for the presence of nematodes. In propagation beds, steamed or fumigated soil should be used, and sanitation should be practiced to prevent the reintroduction of nematodes. Plants for commercial plantings should be obtained from a knowledgeable propagator who follows good sanitation.

INSECT CONTROL

Only a few species of insects are pests of blueberries and many of these are pests as contaminants, particularly in machine-harvested berries. Most are sporadic in frequency and location and should be treated only as the need arises. This requires constant vigilance so that a problem, if it does occur, will not advance beyond remedy. However, the reward is a lower bill for pesticides and application, as well as protection of natural control agents. Should sprays be necessary, refer to WSU EB0849, *Insect, Disease, and Weed Control Guide for Commercially Grown Blueberries*, or to the *Pacific Northwest Insect Control Handbook*. Pay particular attention to timing since this can be a key factor in a successful control program. Additionally, give serious attention to the insecticide hazard to your honeybees. Many insecticides recommended for prebloom are highly toxic to bees and should not be used during bloom. Honeybees are necessary for complete pollination of blueberry flowers. Poor pollination results in lower yields with smaller berries. Contact nearby beekeepers when you plan to use a material hazardous to bees. This will pre-

FIG. 8. *Botrytis* blight on blossoms and young fruit

FIG. 9. *Godronia* canker around buds on current season shoots

FIG. 10 Orange Tortrix adult.

vent accidental bee kills and help establish better relations between growers and beekeepers.

Aphids. The most common aphid on blueberries is the green peach aphid, *Myzus persicae*. This pest has many weed and crop hosts. These aphids can be red or green, and their feeding may deform leaves and devitalize plants. Aphids secrete honeydew which becomes a sticky film on the berries and leaves and on which black sooty mold grows. Although aphids can be present and begin to build up before bloom, in many areas buildup does not occur until after bloom. Sprays often can be avoided by allowing natural control agents, such as ladybird beetles, to build up. Local populations of beetles can be supplemented by the purchase and release of ladybird beetles. Several growers have practiced this method in the Puyallup Valley for several years. Although the practice has never been experimentally tested, there are claims that no sprays for aphids have been needed after employing this method for a period of years.

FIG. 11 Lecanium scale adults

Cherry fruitworm. The cherry fruitworm, *Grapholitha packardi*, is a relatively new pest to blueberries in Washington. It has been found on blueberries only in the Puyallup Valley. It is present in other parts of the United States and is a serious pest of blueberries in New Jersey and North Carolina. As its name implies, it has other host plants which include cherry, apple, rose, and hawthorn.

The fruitworm is a moth with one generation per year. It overwinters as a mature larva. The larva is a smooth caterpillar about 1/2 inch in length with a brown head and pinkish body. As temperatures begin to rise in early spring, it changes to a pupa and after about two weeks in the pupal stage, emerges as an adult. The adult is a small brownish moth that is rarely seen, as it hides by day and is active at night. Mating and egg laying commence in a few days. Eggs are laid about the time of blossom drop on small developing berries and on leaves. The larvae feed within the berries and are well hidden. When a berry has been hollowed out, adjoining berries are also mined, frequently ruining an entire cluster, which is often webbed together. Damage is not noticed until just before harvest. A field inspection may reveal that only 2 to 5% of the berries have larvae in them, but 25 to 50% of the berries can be destroyed or rendered to culls. Mature larvae choose a hibernation site when development is complete. This may be a dead weed stem or a pruning stub in which they excavate a burrow.

When this pest infests a field, chemical controls are necessary. The proper time to spray is at blossom drop.

Orange Tortrix. The orange tortrix, *Argyrotaenia citrana*, is the most frequent pest of the leafroller group in blueberries. It also feeds in caneberries and strawberries. The larvae of this moth feed on the tender leaves and buds, but the damage they do is negligible. They are a pest mainly as a contaminant of harvested berries. They have a habit of wiggling vigorously when disturbed and dropping out of their shelters. When pickers or machines shake the canes, the disturbed larvae can drop into the container and cause the harvested berries to be rejected by processors. It would be best to spray for this pest only if it known to be present in the field. This requires frequent inspection for leaves webbed together, generally at the tips of the branches.

Orange tortrix caterpillars are light cream to greenish in color with light brown heads and are about 1/2 inch in length when fully developed. The moths are buff colored and have a wingspan of 1/2 to 3/4 inch (Fig. 10). They overwinter as caterpillars in various stages of development, and there are several overlapping generations each year. Larvae appear as early as March and are present well into the fall.

Scales. Lecanium scale is the major scale pest of blueberries. This scale attacks a wide variety of plants. When abundant, it can devitalize plants and retard growth. The scale is actually a covering produced by maturing

FIG. 12D. Damage to foliage by root weevil adults.

Adult obscure root weevils sometimes remain high on raspberry or blueberry canes during the day and become a contaminant of the berries.

Weevil control is almost entirely dependent upon chemicals. Fall plowing of suspect virgin land to be planted to blueberries will help protect the planting to be made the following spring.

It is very important to know if weevils have invaded a planting, and if so, which species, because some insecticides will not control all species. A field free of weevils needs no treatment. This saves the grower money and reduces the possibility of secondary problems because of killing beneficial predators and parasites.

A field should be inspected every week or two during July and August for evidence of weevils, especially around the edges of the field where invasion would first be noticed. Look for the characteristic notches chewed in the leaf margins. If notching is seen, examine the foliage for adults at night with the help of a flashlight. If adult weevils are found, take them to your county Extension agent for identification. Appropriate controls should be applied to even lightly infested fields to prevent egg laying and build up of weevils, which can be rapid.

Yellowjackets. Yellowjackets are not direct pests of blueberries. Actually, by their predatory nature they are beneficial. However, in some years, their populations reach levels that, because of danger to workers, make culture and harvesting of berries nearly impossible. The potential for yield loss where nests are present is quite real. Some growers have left whole sections of their fields unharvested because of the danger to pickers when yellowjacket populations were severe. Yellowjackets may nest in the ground or build paper nests in the bushes, depending on species. Because of visibility, aerial nests can be dealt with more readily than ground nests, which are often impossible to locate and exterminate. Yellowjacket bait traps are available and are useful because of their effectiveness and because they obtain control without direct human contact with these dangerous insects. Bait stations are hung and charged with a protein bait and slow-acting insecticide. After procuring the bait, worker yellowjackets are not immediately killed and are allowed to return to the nest and feed the brood the poison bait. Complete nest destruction can be realized in a week or less. Instructions for use of bait traps are outlined in WSU EB 0643, *Yellowjackets and Paper Wasps*. This technique should be employed if there is an obvious yellowjacket buildup by no later than midsummer. Traps placed later in the summer are not nearly as effective.

HARVESTING AND MARKETING

The first berries from the early varieties are picked in early July. Late cultivars may ripen fruit until about October 1; however, few late cultivars are grown in the Pacific Northwest since wet weather normally interferes with harvesting after early September.

Each cultivar ripens fruit over a two- to five-week period. Most growers try to pick over the fields every 5 to 10 days, but pickings can be extended to 14-day intervals on some cultivars without serious loss if birds are controlled. Mature plantings in full bearing will require from 10 to 20 pickers per acre on a 5- to 10-day schedule.

Picking is done by cupping both hands under a cluster of berries and running fingers lightly over the cluster to shell off the ripest berries. The fruit is placed in boxes or cans held at a convenient height. The most common practice is to use containers tied around the picker's waist. The harvested berries should be promptly taken to a packing area to be cleaned, packed, and placed in cool storage.

Blueberries are a moderately firm fruit and have a shelf life of two to four weeks if handled properly. Care should be taken not to bruise or crush the berries during harvest. Damaged berries should be sorted out during the cleaning operation immediately after picking. As soon as the berries are cleaned and sorted, they should be placed in cold storage at 38°F. to remove the field heat and reduce the respiration rate.

Blueberries for fresh market are most commonly packed in 12-ounce baskets and covered with clear-plastic film attached with a rubber band. Twelve baskets are packed to a crate.

Nearly all fresh market berries are hand harvested. However, machine harvesting is increasing. Mechanical harvesting causes somewhat more bruising of fruits, which reduces shelf life, so most machine-harvested berries are canned or frozen.

Two types of machines are in use. One is a hand-held vibrator powered by electric batteries. The berries are shaken off the bushes and collected in catching frames placed beneath the bush.

The second type of mechanical harvester is a self-propelled, over-the-row machine which shakes off the fruit, collects the fruit on conveyer belts, passes it through an air blast to remove leaves and twigs, and conveys the fruit to field boxes. The fruit is then transported to packing and cleaning rooms where it passes through an air blast cleaner, washer, over a sorting belt, and finally to packaging. Packaging varies from fresh market baskets and trays to 30 pound bags which are frozen, to 50 gallon drums which are used in various types of processing. Most berries are packaged according to U.S. standard grades.

Not all cultivars are adaptable to machine harvest. Some of the newer ones (see list of cultivars) have been selected for mechanical harvesting. These generally have loose clusters

with berries that do not shatter easily and tend to hang on the plant longer. Certain cultivars mature their fruit so the total crop can be harvested in two or three pickings. Other fruit characteristics advantageous to mechanical harvesting are dry stem scar, resistance to splitting, and firmness that facilitates handling. Mechanical harvesters are expensive machines but when operated at full capacity, costs are competitive or slightly lower than hand-picking costs. When the harvesters operate at less than capacity, picking costs may exceed hand-harvest costs. The increased use of mechanical harvesters has been more a response to shortages of pickers and and high cost of labor than economic advantages.

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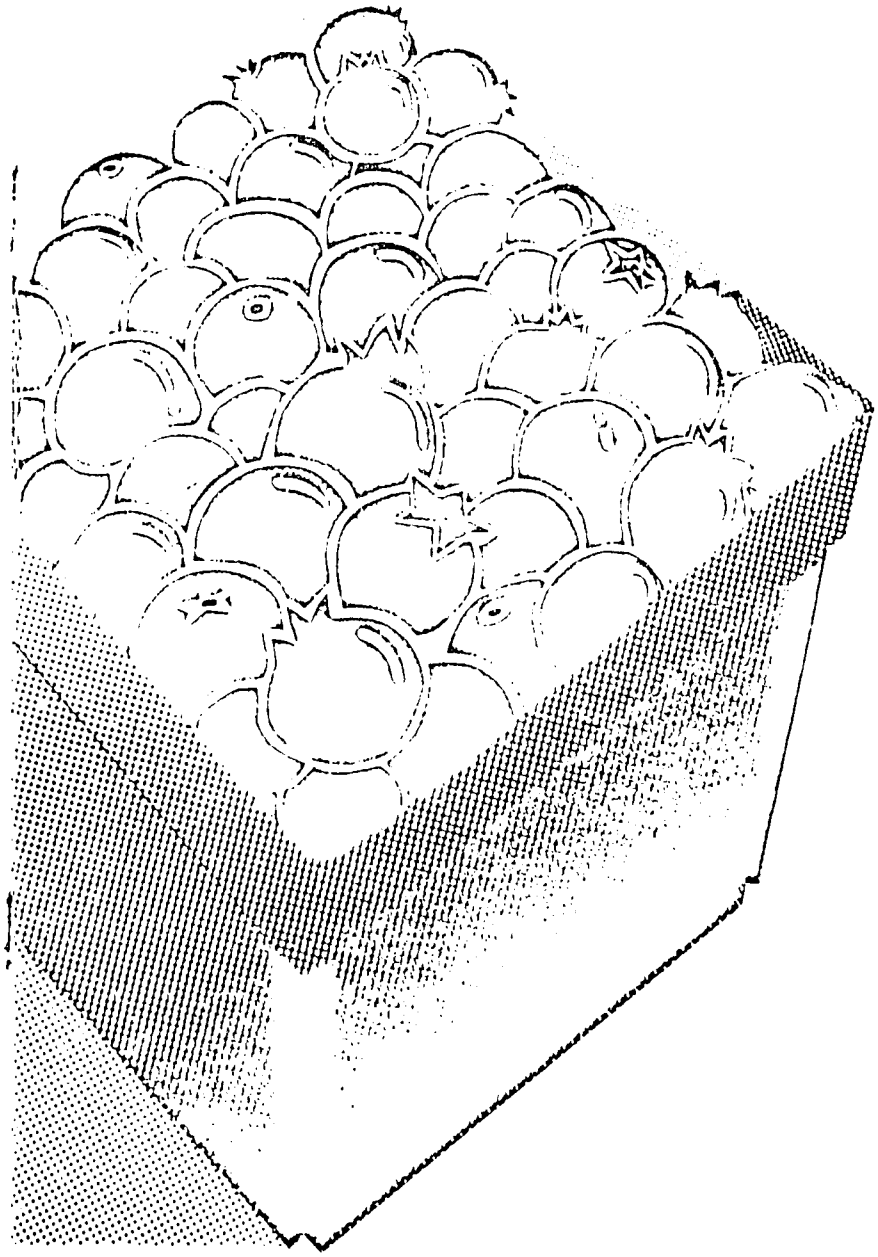
Commercial Blueberry Growing



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On January 24, 1978, four USDA agencies—Agricultural Research Service (ARS), Cooperative State Research Service (CSRS), Extension Service (ES), and the National Agricultural Library (NAL)—merged to become a new organization, the Science and Education Administration (SEA), U.S. Department of Agriculture.

This publication was prepared by the Science and Education Administration's Federal Research staff, which was formerly the Agricultural Research Service.

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COMMERCIAL BLUEBERRY GROWING

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Fruit from several species of blueberries is harvested commercially in the United States from cultivated and wild plantings. The most important of these species are highbush *(Vaccinium australe* and *V. corymbosum)*, rabbiteye *(V. ashei)*, lowbush *(V. lamarckii)*, dryland *(V. pallidum* and *V. altomontanum)*, evergreen *(V. ovatum)*, and mountain *(V. membranaceum)*. Although all of these species are harvested wild, cultivated blueberries are the most important.

In addition, commercial quantities of the Canada blueberry *(V. myrtilloides)* are harvested wild in Maine and the Adirondack Mountains of New York. In the mountains of western North Carolina, two wild highbush blueberries *(V. altomontanum* and *V. constablaei)* are harvested commercially.

Blueberry varieties have been originated by hybridization and breeding of native wild species. This breeding has produced cultivated blueberries that are about three times the size of the largest wild berries (fig. 1).

The cultivated varieties are better than wild ones for marketing fresh.

Most wild blueberries are harvested for processing and for home use.

CULTIVATED BLUEBERRIES

The two cultivated species are highbush and rabbiteye. Highbush is native from southeastern North Carolina to southern Maine and west to southern Michigan. The native range of rabbiteye blueberries is southern Georgia, southern Alabama, and northern Florida.

Highbush

Highbush blueberries grow best in moist soil. The plants grow 10 to 15 feet high and are not drought resistant.

Weather conditions affect the flavor and other characteristics of the fruit. Generally, the berries are better flavored toward the northern limits of

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the growing area where the days are long and the nights are cool during the ripening season. In southern regions, the flavor is much better when the days are sunny and the nights cool.

Varieties

Varieties are classed as early, early midseason, midseason, late midseason, and late. Berries are picked about once each week for 3 to 5 weeks. Table 1 gives the approximate percentage of the fruit that is harvested each week during the ripening season for the most common varieties, going from the earliest to the latest.

Varieties differ in their ripening season from year to year and to some extent from section to section. Also, the heavy pruning commonly practiced in North Carolina causes the fruit to ripen earlier and in a shorter time than does the lighter pruning practiced in Michigan. The ripening times given in table 1 are for moderately pruned plants.

Of the principal varieties, the best for western North Carolina, Maryland, and New Jersey are Bluetta,

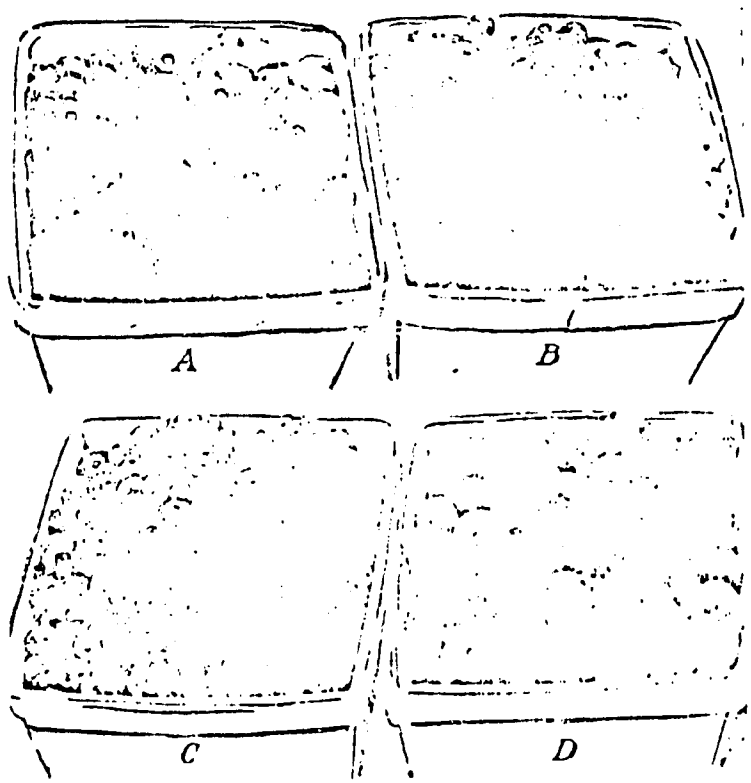

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Figure 1.—Berries from different sources: *A*, Rubel, the best highbush selection from the wild; *B*, wild highbush blueberry of eastern United States; *C*, wild lowbush blueberry of the Northern States; *D*, cross of two highbush varieties. Note the large size of the berries from the cross.

TABLE 1.—*Percentage of fruit gathered each week during the ripening season for common highbush varieties*

Variety	First week	Second week	Third week	Fourth week	Fifth week	Sixth week	Seventh week	Eighth week	Ninth week
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Morrow	40	40	20						
Angola	35	30	20	15					
Wolcott	20	40	25	15					
Earliblue	30	40	30						
Weymouth	30	40	30						
Bluetta	40	50	5	5					
Croatan		40	40	20					
Harrison		40	40	20					
Murphy		20	30	30	20				
Collins		30	40	30					
Meader		30	40	30					
Blueray		30	30	20	10	10			
Rancocas		30	30	20	10	10			
Bluecrop			20	40	30	10			
Bluehaven			20	40	30	10			
Berkeley				40	30	30	10		
Rubel				20	40	30	10		
Jersey				20	40	30	10		
Dixi					50	40	10		
Herbert					50	40	10		
Burlington					20	40	30	10	
Darrow					30	40	30		
Coville						30	30	30	10
Lateblue							35	35	30
Elliott								70	30

Collins, Blueray, Bluecrop, Berkeley, Jersey, and Lateblue. In eastern North Carolina, the most important varieties are Morrow, Wolcott, Croatan, Murphy, Berkeley, and Jersey. In Michigan and New England, the best varieties are Jersey, Bluecrop, Earliblue, Blueray, Collins, Coville, and Lateblue. In western Oregon and Washington, the most commonly grown varieties are Bluecrop, Dixi, Collins, Blueray, Berkeley, Herbert, Darrow, and Coville.

Descriptions of the most commonly grown highbush varieties follow.

Angola.—Bush vigorous, spreading, productive; leaf large; fruit cluster loose; berry medium size, somewhat soft, good aroma, good flavor, early, undesirable dark color; scar medium size; grown only in North Carolina.

Berkeley.—Bush vigorous, spreading, productive; leaf large; fruit cluster loose; berry very large, light blue, firm with slight aroma; less acid than most varieties; good flavor; scar small; stores well; resistant to cracking; late midseason; well liked for its good color, large size, firmness, and productiveness.

Bluecrop.—Bush average vigor, upright, productive; hardier and more drought resistant than most varieties; fruit cluster loose; berry large, light blue, firm, resistant to cracking, slight aroma; scar very small.

Bluehaven.—Bush medium vigor, hardy, productive, upright; fruit large, firm, light blue, small scar, mild flavor; tight cluster; ripens in midseason; variety for Michigan and the Northeast.

Blueray.—Bush very vigorous, upright, hardy, productive; fruit cluster small, tight; berry very large, light blue, firm, resistant to cracking, excellent flavor, aromatic; scar medium size; ripens in midseason if pruned heavily.

Bluetta.—Bush medium vigor, spreading, productive; fruit medium size, firm, light blue, good flavor, resistant to cracking; scar medium size; early variety for New Jersey and Michigan.

Burlington.—Bush vigorous, upright; leaf large; fruit cluster medium tight; berry small, blue, firm, slight aroma, good flavor, resistant to cracking; scar small; superior to most other highbush varieties for its hardiness and good cold-storage qualities.

Collins.—Bush vigorous, upright, moderately productive; fruit cluster medium tight, attractive; berry large, firm, light blue, excellent flavor; variety for early midseason from Maryland northward.

Coville.—Bush vigorous, spreading, productive; leaf large; fruit cluster loose; berry very large, light blue, firm, aromatic, good flavor but tart till ripe, resistant to cracking; ripens late, does not drop; scar small.

Croatan.—Bush vigorous, spreading, productive; leaf large; fruit cluster loose; berry medium to large, dark blue, medium firm, slightly aromatic, good flavor; scar very small.

Darrow.—Bush erect, vigorous, productive; fruit cluster medium size; berry large, light blue, firm, tart until completely ripe but excellent flavor when fully ripe.

Dixi.—Bush vigorous, spreading, productive; leaf large; fruit cluster medium tight; berry large, blue, firm, aromatic, excellent flavor, subject to cracking; scar large.

Earliblue.—Bush vigorous, upright, not productive; fruit cluster loose; berry large, light blue, firm, resistant to cracking, aromatic, good flavor; scar small; early variety for Maryland and northward.

Elizabeth.—Bush average vigor, slightly spreading, productive; fruit cluster loose; first berries large, light blue, good flavor, average firmness. Fruit ripens over a long period beginning after Bluecrop.

Elliott.—Bush vigorous, upright, productive, and winterhardy; fruit cluster loose, berry firm, light blue, medium sized, good mild flavor; ripens late, ripening 7 to 10 days after Lateblue.

Flordablue and **Sharpblue.**—Highbush-type bushes, originated for low-chilling areas of the deep South, particularly along the Gulf Coast and southward in Florida to Tampa; fruit ripens in late April or early May, well ahead of the rabbiteye varieties adapted to the same areas; recommended for U-pick and local markets.

Harrison.—Bush vigorous, semi-upright; berry large, high quality; resistant to races of cane canker fungus prevalent in North Carolina; ripens between Croatan and Murphy.

Herbert.—Bush vigorous, upright; productive; fruit cluster loose; berry very large, medium firm, medium blue, resistant to cracking, aromatic, excellent flavor, scar medium size.

Jersey.—Bush vigorous, erect, productive; leaf large; fruit cluster long and very loose; berry medium size, light blue, firm, no aroma, fair flavor; scar small.

Lateblue.—Bush moderately vigorous, upright, productive; fruit cluster loose; leaf large; berry medium large, firm, good flavor; scar medium size; ripens late with many berries ripe at same time.

Meader.—Bush vigorous, upright, productive, and winterhardy; fruit clusters loose, medium size, mild, subacid taste; ripens with Collins.

Morrow.—Bush spreading, slow growing; berry large, medium blue, good flavor, medium firm; ripens earliest of all varieties; grown only in North Carolina.

Murphy.—Bush vigorous, spreading, productive; leaf large; fruit cluster loose; berry medium size, dark blue, firm, slightly aromatic, fair flavor; scar medium size.

Rancocas.—Bush moderately vigorous, erect, productive; leaf small; fruit cluster very tight; berry small, medium blue, firm, crisp, very slight aroma, good flavor, cracks badly after rain.

Rubel.—Bush erect, vigorous, productive; leaf medium size; fruit cluster very loose; berry small, medium blue, firm, slight aroma, fair flavor; small scar.

Weymouth.—Bush erect, spreading, below average vigor; leaf medium size; fruit cluster medium loose; berry large, dark blue, lacking aroma, usually poor flavor; scar medium size.

Wolcott.—Bush very vigorous, upright, productive; leaf large; fruit cluster loose; berry medium size, dark blue, firm, aromatic, good flavor; scar small.

Culture

Cultivated highbush blueberries are raised commercially on acid soils from eastern North Carolina northward to southern New England, in western New York, in southern Michigan, and in western Oregon and Washington.

The plant is not hardy in temperatures lower than about -20° F. Instances have been reported of the tops being killed at a temperature of -30°. However, even in sections where the blueberry is not generally hardy, local conditions of air drainage or protection by deep snow may make blueberry growing possible.

The southern limit for highbush varieties is about 300 miles north of the Gulf of Mexico from Georgia to Louisiana. Highbush blueberry varieties are not successful in Florida, southern Georgia, and southern Louisiana because the winters are too short for the plants to break their winter rest period and blossom normally.

Highbush varieties begin to ripen the latter part of May in Georgia and eastern North Carolina, the last of June in New Jersey, and mid-July in Massachusetts and Michigan.

The highbush blueberry grows best where the soil is very acid and moist. Usually the best growth occurs where the acidity ranges from pH 4.3 to 4.8.

Good growth may occur in soils with a pH as low as 4. However, where the pH is as low as 4, ground magnesium limestone should be applied to bring the soil pH up to 4.5.

Where the soil pH is as high as 5.5, finely ground sulfur or ammonium sulfate may be used. If the soil is sandy or sandy containing peat, ammonium sulfate should be used as it both acidifies the soil and furnishes nitrogen. If the soil is a loam, it may contain enough nitrogen, and sulfur may be used to acidify it. Iron chelates are used to correct chlorosis of blueberry foliage that results from high pH.

The best indication that blueberries may succeed on a soil is that they or some related plants such as huckleberries, azaleas, or laurel are growing there naturally. Open porous soils of sand and peat that contain a mixture of loam, and have a water table 14 to 30 inches below the surface, are best for blueberries.

The blueberry plant is shallow rooted; therefore, cultivation should be shallow. Deep disking that cuts off roots near the base of the plant is destructive. Clean cultivation has been the usual practice, but cover crops should be used to prevent erosion and soil impoverishment. A summer cover crop sown just after harvest is recommended.

The plants can be set 4 to 5 feet apart in one direction and 9 to 10 feet apart in the other as early in the spring as the soil can be worked. Setting the plants 4 by 9 feet (1,210 per acre) or 4 by 10 feet (1,089 per acre) is best for new plantings.

Plants are set in spring in most areas, but in New Jersey some planting is done in the fall; in eastern North Carolina, planting is done in late fall and winter.

For growing blueberries successfully, the plants must be vigorous and produce good crops each year. On fertile soils very little fertilizer may be required, but on poor soils larger amounts may be necessary to maintain satisfactory growth.

In locations that do not have special fertilizer requirements, use 400 to 600 pounds per acre of a complete fertilizer (about 8-8-8 not neutralized) in the spring after the buds start. This should be followed about 6 weeks later, if the soil is pH 4.8 or above, by an application of 100 pounds of ammonium sulfate per acre and followed by one or possibly two similar applications at intervals of 6 weeks.

The more fertile fields in the Northern States should not have the later fertilizer applications. The fertilizer should be broadcast to within 6 to 12 inches of the plant and out as far as the roots extend.

In New Jersey and North Carolina, additional nitrogen is often needed.

The blueberry plant is not drought resistant. It is a native of moist lands, but fields should be well drained. Low-lying soils usually selected for blueberries often have depressions or pockets from which the water does not drain and the blueberry plants are drowned unless drainage is provided.

Vigorous productive bushes can grow only where the soil is not saturated with water during the growing season and only for short times during the dormant season.

Under favorable conditions, an extensive root system develops that can support a large bush and crop. If the roots are soaked for several days because of heavy rains or poor drain-

age, the root system may be weakened or the plants killed. Sometimes, when the lower part of the root system is killed by water injury and a drought follows, the whole plant may die.

In most areas where blueberries are grown, droughts are severe enough to injure plants and reduce crops. When this is the case, growers should provide for irrigation. Many blueberry growers use an overhead sprinkler system, which can be used for frost protection also. Irrigation drainage ditches can be used to remove excess water quickly during or after storms.

In times of drought, 1 to 2 acre-inches of water should be applied about 10 days apart during the picking season and as needed later in the season during the heat of summer.

Mulching with sawdust, hay, or straw to a depth of several inches keeps down weeds, keeps the soil cooler in summer, helps to retain soil moisture, and helps to control erosion. The plant rows may be covered 2 to 2-1/2 feet on each side, or the entire area may be mulched.

Leguminous hay mulches such as clover or soybean have sometimes been injurious and should not be used unless a thorough trial has shown no injury over a period of a year or more. When sawdust, leaves, hay, or straw are used, additional nitrogen must be applied to get good growth.

Where mulches are not used, 100 pounds of ammonium sulfate per acre should be applied. On mulched areas, applications of 300 pounds per acre each should be used 6 weeks apart.

Cross-pollination by bees is necessary for maximum production of all commercial varieties of blueberries. Bees increase the number of berries set, shorten the ripening period, and cause the berries to be larger. To improve pollination, the grower should alternate one or two rows of one variety with one or two rows of another that overlaps in flowering time.

Native wild bees usually are inadequate so they should be supplemented by one to five strong colonies of domestic bees per acre. For most efficient use of the bees, they should be distributed so that flights do not exceed 200 to 300 yards.

Pruning

The blueberry produces fruit on wood of the previous season's growth. The largest fruit is borne on the most vigorous wood. Most varieties tend to overbear, and unless some of the buds are pruned off, the berries are small and there is too little vigorous new growth for the next year's crop.

The erect-growing varieties need to be thinned at the center, and the spreading varieties are likely to need their lower drooping branches pruned. Sometimes, when the crop is heavy and no pruning is done, few berries mature.

Heavy pruning should rarely be practiced. It consists of thinning the small branches, heading back clusters, and cutting out some of the old stems. This reduces the crop greatly and hastens ripening. The heavier the pruning, the larger the berry size, the earlier the ripening, and the smaller the total crop for that year.

Light pruning consists of thinning out some of the small branches and an occasional stem. Although this reduces the crop for a particular year,

it increases the size and earliness of the berries and tends to produce more vigorous new growth for the next year's crop.

It is possible to shift the ripening period by the amount of pruning done. In North Carolina and other Southern States, heavy pruning at a sacrifice of yield may be practiced to obtain an early maturing crop. In the Northern States, the practice of light pruning may spread the ripening season over several weeks.

Less pruning is needed on vigorous plants. Heavily fertilized plants that have plenty of soil moisture at all times are much stronger and produce many more large berries than plants lacking in fertilizer and soil moisture.

Usually very little pruning is necessary until the end of the third season, when regular annual pruning should ordinarily begin. The general practice is as follows:

(1) The low-spreading branches next to the ground should be cut out, leaving only the more erect branches or shoots.

(2) If the center of the bush is dense, the weak and the older branches at the center should be cut out.

(3) Most of the small slender branches should be removed, leaving the strong branches and shoots (fig. 2).

Small weak branches cause the bush to become too dense, make picking difficult, and leave inadequate space for strong new shoots. The small branches of Rubel, Bluetta, and Rancocas bushes require much thinning out and are, therefore, expensive to prune.

To increase the size of the berries,

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Figure 2.—Four-year-old blueberry bush: *A*, Before pruning; *B*, after pruning. Pruning reduced the fruit buds by about 75 percent. In very fertile soils, a large number of fruit buds might be left for a heavier crop.

the fruiting shoots of small-fruited varieties should be cut back, the amount depending on the number of fruit buds on the shoots. Earliblue, Collins, Bluecrop, Blueray, Berkeley, Herbert, and Coville require very little cutting back. The amount of cutting back necessary depends on growing conditions and varies from year to year.

Cutting back is usually done after danger of cold injury is past. General pruning may be done at any time from leaf fall in the autumn to the beginning of growth in the spring. The yield of fruit from blueberry plants under different types of pruning is shown in table 2.

TABLE 2. — *Yield of fruit from blueberry plants under different types of pruning*

Type of pruning	Berries per plant	
	First season	Second season
	Pounds	*Pounds*
None	23.4	20.1
Light	17.3	19.9
Medium	16.3	14.3
Heavy	7.6	8.1
Very heavy	3.9	9.1

Propagation

With careful attention, blueberry plants can be propagated by either hardwood or softwood cuttings. Softwood cuttings are used very little commercially.

Hardwood cuttings, 4 to 5 inches long, are made from dormant shoots of the previous season's growth; the lower cut is made just below a bud and the upper cut just above a bud (fig. 3). Wood with fruit buds should be cut off and discarded because cuttings with fruit buds seldom root or make good plants.

The cuttings may be rooted in ground beds covered by lath shade screens about 7-1/2 feet above the ground (fig. 4), in covered frames, in unshaded beds with automatic watering, and in plastic covered ground beds. Ground beds are those made directly on the ground: they are usually filled with a mixture of half peat and half sand to a depth of 6 inches.

The most commonly used covered frames are 6 feet long, 27 inches wide, and 16 to 40 inches high. The frames contain trays 4 inches deep with the bottom made of one-eighth-inch to one-fourth-inch mesh hardware cloth or fly screen. The trays rest on cleats 8 to 10 inches below the top of the frame. The trays are filled with peat or peat and sand, and the cuttings are placed in a slanting position about 1 inch apart in rows 2 inches apart.

An advantage of the tray is that it can be moved to a coldframe or to the nursery; cuttings in the ground bed require transplanting. The practice in Michigan is to cover each frame with a sash and then with coarse burlap; in New Jersey, shade is not essential but sometimes either slat or lath covers are used.

In cool areas, bottom heat at 70° F improves the rooting of hardwood cuttings.

Varieties that are relatively easy to root from cuttings are Angola, Croatan, Morrow, Murphy, Wolcott, Earliblue, Collins, Blueray, Bluetta, Herbert, Rancocas, Rubel, Berkeley, and Coville; those that are less easily rooted from cuttings are Bluehaven,

Darrow, Lateblue, and Jersey. Bluecrop is difficult to root from cuttings.

Cuttings are made during winter when the plants are dormant. They may be stored in a cool, moist place until they can be set in the propagating beds in early spring. Usually they have rooted by June (fig. 3) but are left in the ground beds or, if propagated in covered frames, they are placed in coldframes until the following spring.

Cuttings usually are grown for a year in the nursery before being planted in the fields. The nursery rows usually are 18 inches apart and the plants 6 to 10 inches apart in the row. After a year in the nursery, they are called 2-year plants. Well-grown 2-year plants are considered most desirable for field planting.

Rabbiteye

Some cultivated rabbiteye varieties bear large, juicy, aromatic fruit that compares favorably with that borne

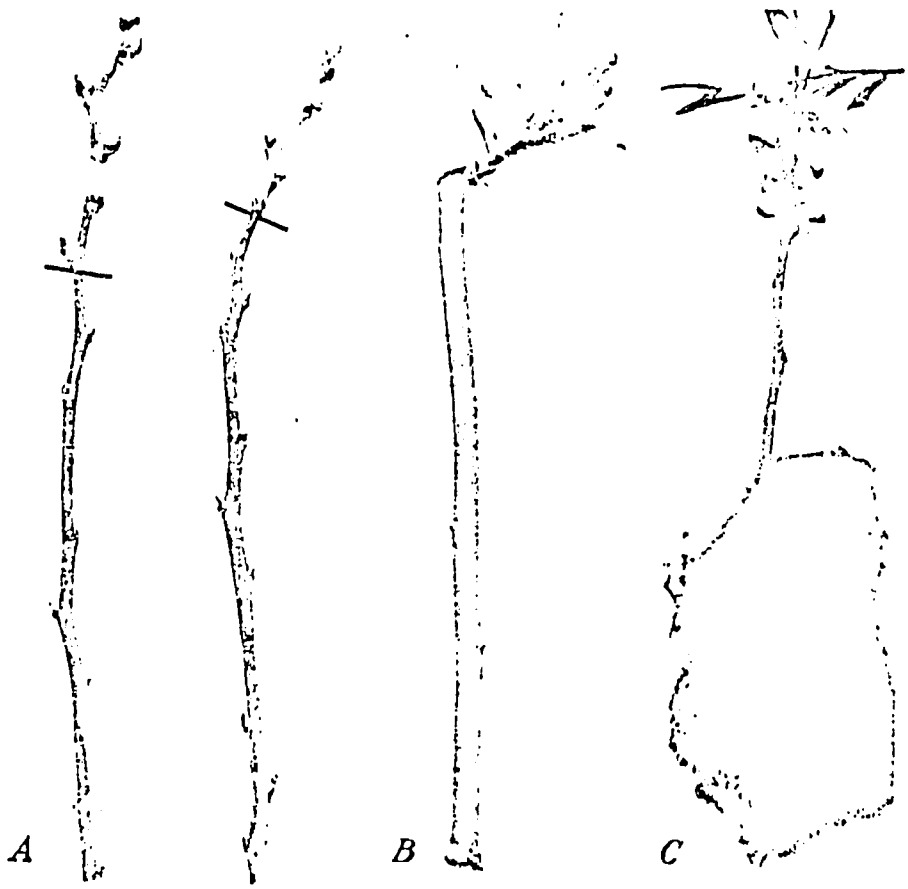

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Figure 3.—*A*, Hardwood cuttings with fruit buds at tip; these should be cut off as indicated. *B*, Cutting with a shoot at the upper end and a good callus but no roots at the base. Roots should appear within a few days. *C*, Well-rooted cutting.

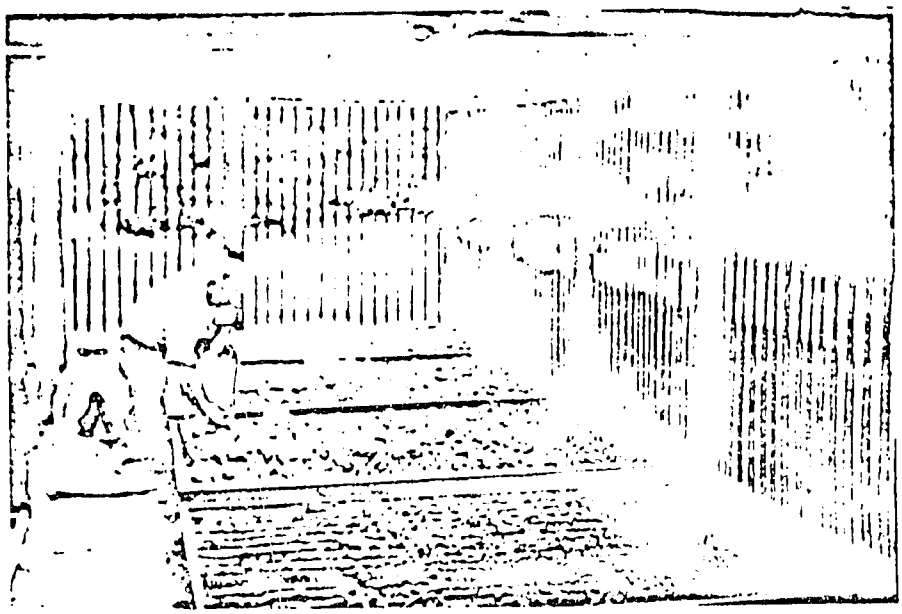

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Figure 4.—Propagation of blueberries by hardwood cuttings in ground beds made of half peat and half sand in a shade house with lath sides and top that gives about one-half shade.

by highbush varieties. Rabbiteye berries from the wild are mostly black and less attractive than the large, blue-fruited, cultivated varieties.

Rabbiteye blueberries are chiefly important because they grow in upland areas where highbush will not and because they require a very short rest period in winter. Also, rabbiteye varieties are not so sensitive to soil type and are far more resistant to heat and drought than highbush.

Rabbiteye succeeds from eastern North Carolina south to central Florida and west to Arkansas and east Texas (fig. 5).

Varieties

Characteristics of some of the most common rabbiteye varieties are given in table 3. Woodard is the earliest and largest of the rabbiteye varieties and Woodard and Tifblue have the best flavor. Homebell has large fruit and a very vigorous, productive bush. Tifblue is the lightest blue of all the rabbiteye varieties.

Culture

Rabbiteye blueberries (fig. 6) are generally set in midwinter in rows 12 feet wide with the plants 6 to 12 feet apart, depending on cultivation practices in the area. Use liberal quantities of peat moss at time of planting. Under good conditions, plants grow rapidly and bear small commercial crops by the third year. Two rows alternating with two other rows of a different variety should be planted because cross-pollination is necessary.

Cultivation of rabbiteye blueberries is the same generally as for highbush.

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Figure 5.—A planting of rabbiteye blueberry. Plantings of 50 to 100 acres are not uncommon.

They respond to tilling, mulching, and fertilizing. However, young plants are sensitive to fertilizer so only small amounts or none should be applied the first growing season.

Yields increase rapidly after the fourth year. In one experiment, Tifblue plants averaged 2.2 pints in the fourth season, 5.1 in the fifth, and 14.1 in the sixth. Twenty pints per plant are not unusual.

Pruning is not generally practiced, but the fruiting habit of the rabbiteye is similar to the highbush, and some pruning of older bushes is desirable. The older stems and smaller young shoots may need thinning to prevent the bushes from becoming too dense.

Pruning should be relatively light because rabbiteye plants are sufficiently vigorous to support and develop heavy crops of large-sized fruit. Heavy pruning results in excessive water—sprout growth.

Under the same growing conditions, the fruit of most rabbiteye blueberries ripens later and over a longer season than highbush. Picking in northern Florida usually begins near the end of May.

Although rabbiteye varieties generally ripen their fruit over a longer period than highbush, some of the newer rabbiteye varieties ripen most of their fruit within a 30-day period. Some rabbiteye varieties have firmer fruit and a much smaller scar than do highbush varieties.

Rabbiteye plants can be propagated by offshoots, or suckers, which grow from the roots at distances of a few inches to 8 feet from the parent plant. Suckers usually are grown in the nursery for a year before they are set in their permanent location.

Propagation by softwood summer cuttings under intermittent mist is very successful. Hardwood cuttings of rabbiteye varieties root poorly.

Softwood cuttings with three or

TABLE 3.—*Rabbiteye blueberry varieties ranked according to certain characteristics*

Rank	Season	Size of fruit	Flavor	Color	Firmness	Yield	Bush size
	Early to late	*Large to small*	*Good to fair*	*Light to dark*	*Firm to soft*	*High to low*	*Large to small*
1	Climax	Delite	Delite	Tifblue	Southland	Bluebelle	Tifblue
2	Woodard	Menditoo	Homebell	Southland	Delite	Tifblue	Bluebelle
3	Briteblue	Bluebelle	Woodard	Briteblue	Tifblue	Southland	Homebell
4	Delite	Briteblue	Tifblue	Delite	Briteblue	Briteblue	Delite
5	Homebell	Climax	Climax	Garden Blue	Climax	Homebell	Garden Blue
6	Southland	Homebell	Garden Blue	Woodard	Woodard	Garden Blue	Southland
7	Tifblue	Woodard	Southland	Climax	Bluebelle	Menditoo	Climax
8	Bluebelle	Tifblue	Briteblue	Bluebelle	Garden Blue	Climax	Woodard
9	Garden Blue	Southland	Bluebelle	Homebell	Homebell	Woodard	Menditoo
10	Menditoo	Garden Blue	Menditoo	Menditoo	Menditoo	Delite	Briteblue

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Figure 6.—Mature rabbiteye blueberry bushes, showing the many shoots and great height of some varieties of this species.

four leaves per cutting are superior to those with one or two leaves per cutting. Peat or a one to one mixture by volume of peat and perlite is used as a rooting medium in a ground bed or coldframe with partial shade to protect against direct sunlight.

WILD BLUEBERRIES

Fruit worth several million dollars annually is harvested from the wild, especially in the New England States and from Gifford Pinchot and Mt. Hood National Forests in Washington and Oregon where several million pounds are picked each year. Other national forest areas where wild blueberries are harvested are the Dolly Sod and Spruce Knob areas of Monongahela National Forest in West Virginia, and the Shining Rock and Tanasee Bald areas of Pisgah National Forest in North Carolina.

Wild blueberries are also harvested in several other widely separated areas. They are the blueberry barrens and uplands of New York, Pennsylvania, West Virginia, Michigan, Wisconsin, and Minnesota; the swamp-

lands along the Atlantic coast and in the Northeastern States; the upland sections of Alabama, Georgia, and other Southern States; the Cascade Mountains section of Oregon and Washington; and the coastal section of northern California, Oregon, and Washington.

Figure 7 shows the location of the areas in the United States from which wild berries are most extensively harvested and marketed.

Lowbush

The lowbush blueberry, the most important commercial wild species, is native to Northeastern United States and parts of Canada. In the United States, fruit from this species is gathered in commercial quantities from Maine to Minnesota and southward in the Alleghenies to West Virginia.

Lowbush is an upland species. The plants are 6 to 18 inches high and grow into large colonies by means of underground shoots. No varieties have been propagated for commercial planting, but selections have been made for breeding because this species crosses readily with the highbush blueberry.

The fruit, which is usually light blue, ripens earlier than the fruit of highbush; the flavor is similar. Although the fruit ripens during July and August, harvesting may extend into September in the most northern areas.

The fruit is gathered for the freezers with rakes (fig. 8) that are similar to cranberry scoops, but much smaller. For the fresh-fruit market, the fruit is harvested by hand as well as with rakes.

After a forest has been cut or

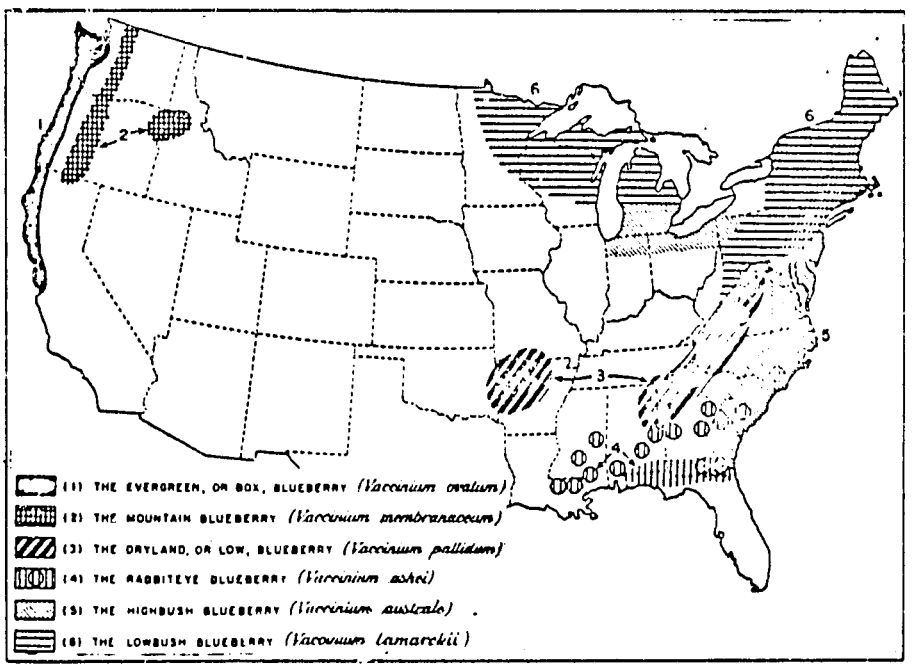

Figure 7.—Map of the United States, showing areas in which wild blueberries are extensively harvested.

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Figure 8.—Harvesting lowbush blueberries for the freezers. The rake is 10 to 12 inches wide and has 18 to 40 teeth.

burned over, lowbush blueberries come in naturally in large areas of some of the Northern States. If burning is prevented, the area grows up in brush and woodland again. Therefore, areas that yield large quantities of berries for a few years may produce none later because the brush crowds out the blueberry bushes.

In eastern Maine and in some smaller areas elsewhere, the fields are reburned every second or third year in spring while the ground is still wet. This kills weeds and underbrush and prunes the blueberry plants. Most of the burning is done with machines that use oil or liquefied petroleum gas.

As a further aid in control, weeds and brush may be cut or pulled in the fall previous to burning or they may be killed by brush-killing chemical sprays. Burning over does not seriously injure the blueberry plants if properly done during the dormant season, but repeated burning lowers soil fertility.

The fruit should be picked as early as possible before the berries are infested by the blueberry fruitfly. In Maine, picking for the fresh-fruit market begins about July 20 and for the freezers about August 10. Fruit is harvested from about 150,000 acres of native, wild blueberries in Maine (fig. 9).

Dryland

The dryland blueberry, also commonly called the low huckleberry, is native from Georgia and Alabama to Maine and westward to Michigan and Oklahoma. It is important chiefly in northern Alabama and Georgia and northward to Maryland and West Virginia. The plants grow in the dry, relatively poor soils of ridges and hills and are very drought resistant.

The fruit is gathered most extensively in northeastern Alabama, northwestern Georgia, West Virginia, and western and northwestern Arkansas. Dryland blueberry plants grow from 1 to 3 feet high and spread in colonies much as do lowbush blueberries.

The berries are light blue and their flavor is good. They have a small, rather dry scar where the stem was attached. Dryland blueberries commonly ripen later than either lowbush or highbush.

Evergreen

The evergreen blueberry, commonly known as the evergreen or coast huckleberry, is a native along the Pacific coast from central California to British Columbia. The fruit is gathered extensively in northern California, along the coast of Oregon and Washington, and in the Puget Sound district.

The plant is an attractive ornamental shrub (fig. 10) and may grow to 20 feet in open woods. Branches of this blueberry are used as decorations. They are shipped chiefly from December to March to eastern cities under the name of evergreen huckleberry.

The berries ripen from August to November, but the peak ripening period is in September and October. The berries usually are small and shiny black and have a strong flavor that is not like that of other blueberries. This flavor makes them less desirable than other blueberries for eating fresh. A large part of the crop is stored frozen for use by pie makers.

The evergreen blueberry grows only in the mild climate near the Pacific coast and around Puget Sound. It has not been hardy in Eastern United States.

Mountain

The mountain blueberry, also called broadleafed huckleberry, is a native of the high slopes of the Cascade Mountains of Oregon and Washington and eastward to Wisconsin. It is most abundant near Crater Lake, Mount Hood, Mount Adams, and Mount Rainier.

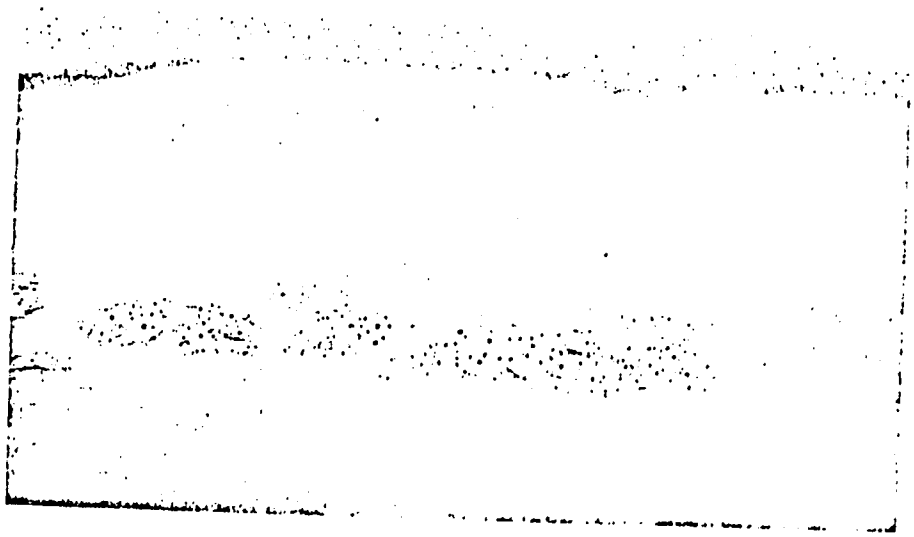

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Figure 9.—Part of the blueberry barrens, which cover more than 100,000 acres in Maine. Most of the blueberries are lowbush.

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Figure 10.—Shoots of evergreen blueberry: *A*, Showing flower buds and flowers at most nodes; *B*, fruiting clusters.

It is a very drought-resistant plant, matures its fruit in the late summer even after 3 or 4 rainless months, and is important for forage. The plants grow 3 to 5 feet high and are abundant in burned-over areas.

In the Cascade Mountains area, the mountain blueberry is one of the best flavored and largest fruited of all wild blueberries. The berries are somewhat pear shaped, black or maroon in color, juicy, highly flavored, and rather tart but not too tart to be eaten fresh.

Because the berries are borne singly (fig. 11) or in pairs rather than in clusters like those of other blueberries, the bushes are not highly productive.

HARVESTING AND MARKETING

The first berries from the early varieties are picked about May 15 in North Carolina, June 15 in New Jersey, and July 10 in southern Michigan. From three to seven pickings are made at 5- to 7-day intervals. In any one locality the season usually lasts 6 to 7 weeks.

To provide the best possible supply to markets, the North Carolina

growers are mainly interested in early to midseason varieties and the New Jersey and Michigan growers in midseason and late ones. In 8 hours, a picker can harvest 60 to 80 pints, or even more, where the crop is heavy. Pint baskets are used mostly as containers, but they must be made tighter than those used for larger fruits such as strawberries.

Machine harvesting of the fruit is increasing. Two types of machines are in use. One type is a hand-held vibrator that is powered by electricity and has a catching frame (fig. 12). The other type is a self-propelled over-the-row machine that shakes off the fruit (fig. 13). Three sizes of the self-propelled machine are available.

Fruit harvested by machine usually must be cleaned and sorted before it can be sold. Most machine-harvested fruit is processed and not marketed fresh.

Most of the crop in North Carolina, New Jersey, and Michigan is marketed cooperatively. The berries are sold according to size-grades. Larger berries usually bring a higher price than smaller ones. However, in early and late parts of the harvesting season, small berries sometimes bring higher prices than large berries do in midseason.

Yields vary greatly. In some areas, yields from the second to the sixth year may increase from 50 to 6,000 pints per acre. Larger yields are possible. Full production is reached in 6 to 10 years, but it may be reached earlier if the plants are cared for properly.

Plants should produce a little fruit 1 year after planting. When mature, they usually bear 14 to 16 pints per plant with medium pruning, and they may produce 20 to 23 pints per plant with no pruning (table 2).

Although much of the crop from

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Figure 11.—A branch of the mountain blueberry.

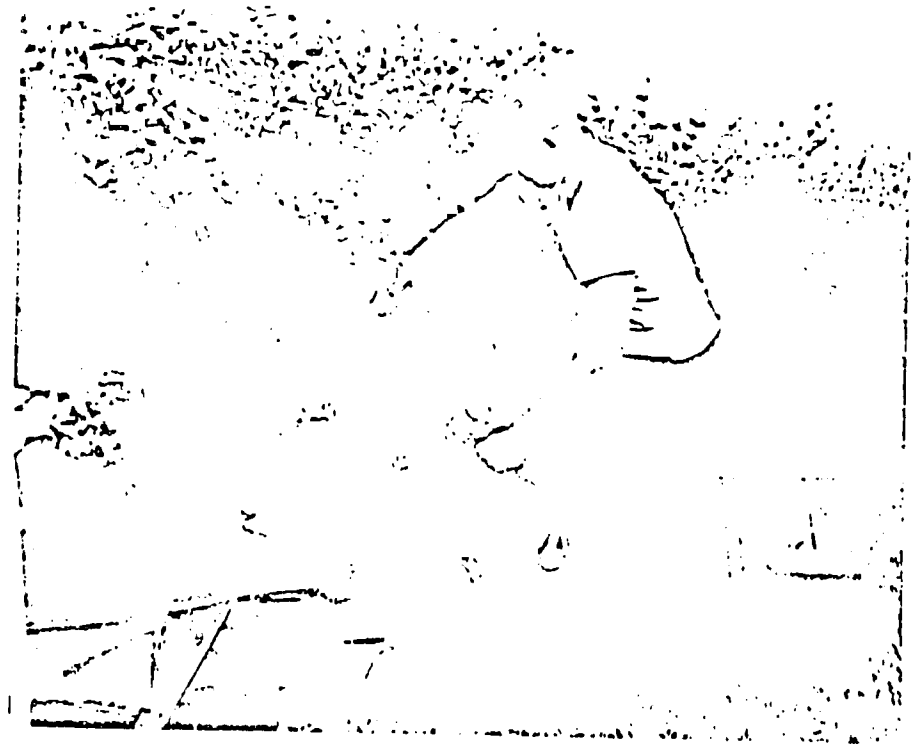

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Figure 12.—An electric-powered, hand-held, blueberry harvester that shakes the berries into a catching frame.

cultivated fields is marketed fresh, large quantities of highbush blueberries are canned or frozen. Canned and frozen berries are used mostly for pies.

PEST CONTROL

Several kinds of pests attack blueberries. These include weeds; fungus, virus, and bacterial diseases; nematodes; and insects. Measures that may be taken to control these pests are discussed in this section.

Weeds[2]

Weeds may be controlled with preemergence or postemergence herbicides, depending on the weed problem. Preemergence herbicides are applied to the soil before weeds appear; postemergence herbicides are applied to the weeds after they appear. Herbicides that may be used are listed in this section. The amounts given for each herbicide are in pounds of active ingredient per acre.

Some preemergence herbicides are as follows:

Diuron [3 - (3,4 - dichlorophenyl-1,1 - dimethylurea].—Use 2 to 2.4 pounds.

Simazine [2 - chloro - 4,6 - bis

[2]Prepared by W. V. Welker, Jr., SEA horticulturist, Rutgers University, New Brunswick, N.J. 08903

(ethylamino) - *s* triazine].— Use 2 to 4 pounds.

Dichlobenil [2,6 - dichlorobenzonitrile].—Use 4 to 6 pounds.

Dichlobenil will control certain established perennial weeds but the other preemergence herbicides generally will not control established weeds.

Preemergence herbicides may control weeds for 3 to 6 months.

Diuron and simazine are usually applied in spring prior to bloom. Diuron should not be applied until the blueberry plants have been established at least one year. Dichlobenil is more effective when applied in cool weather; therefore, it should usually be applied in fall or winter. None of these herbicides should be applied to the foliage of the blueberry plant.

Caution: Carefully follow the instructions and cautions on the container label.

Diseases[3]

The loss of blueberries from diseases is more serious in North Carolina than in other sections. Stem canker causes the most damage, followed by foliage diseases, stunt virus, stem blight, and phytophthora root rot.

In New Jersey, stunt virus and mummy berry are the most serious diseases, followed by ringspot virus and anthracnose.

[3]Prepared by A. W. Stretch, SEA plant pathologist, Chatsworth, N.J. 08019

BN-39105

Figure 13.--A self-propelled, over-the-row blueberry harvester.

Trade names are used in this publication solely to provide specific information. Mention of a trade name does not constitute a guarantee of the product by the U.S. Department of Agriculture nor does it imply an endorsement by the Department over comparable products that are not named.

In Micnigan, blueberries are most seriously damaged by fusicoccum canker, phomopsis canker, and mummy berry. Stunt virus and shoestring virus cause some damage.

In the Pacific Northwest, mummy berry is serious and difficult to control. Botrytis twig and blossom blight also causes damage.

Botrytis twig and blossom blight, red leaf, mummy berry, and powdery mildew are serious diseases on lowbush in Maine.

Fungus Diseases

Mummy berry.—Mummy berry attacks blueberries in all producing areas, but it is primarily a problem in the North.

Newly emerging stems and flower clusters are blighted by the initial fungus infection in the spring. Spores then infect healthy blossoms and eventually kill the developing fruit. As the berries approach maturity they become mummified and drop to the ground where they overwinter. The following spring a new cycle of the disease is started from the overwintered mummies.

Varieties differ in their susceptibility to the mummy berry fungus. Burlington, Collins, Jersey, Darrow, Rubel, Bluetta, and Dixi are most resistant to the fungus. Rancocas, Weymouth, Berkeley, Bluecrop, Herbert, and Coville are less resistant. The most susceptible varieties are Earliblue and Blueray.

The disease is controlled by mechanical or by chemical destruction of the mummies, or by protection of the bushes with fungicide. Clean cultivation in the spring destroys the mummies and helps stop the disease.

A chemical that may be used to control mummy berry is benomyl. Apply 1 pound of 50-percent wettable powder per acre in enough water to give thorough coverage. Apply four sprays at 7-day intervals beginning at green tip.

On lowbush blueberries, use 7-percent ferbam dust at 15 pounds per acre to control the blight phase. Start applications at budbreak and continue them until berries form. Burning lowbush plants when they are dormant will stimulate new growth and destroy the mummies.

Powdery mildew.—Powdery mildew attacks blueberries in most growing areas. It may not cause direct yield losses, but it causes premature leaf drop in the fall and weakens the plants. Leaf surfaces are whitened by the fungus.

Varieties of highbush blueberries differ in their susceptibility to powdery mildew. Berkeley and Earliblue are highly resistant; Bluecrop, Coville, Dixi, Rancocas, and Weymouth are moderately resistant; and Blueray, Burlington, Collins, Darrow, Herbert, Jersey, and Rubel are susceptible.

Fungicides are seldom used to control powdery mildew on highbush.

However, the disease can be controlled by using 20-percent sulfur dust at 25 pounds per acre, beginning just after bloom and continued at 2-week intervals through the season.

Use resistant varieties where possible.

A 7.6-percent ferbam dust applied at 15 to 20 pounds per acre just after bloom and again 10 to 14 days later will control mildew on lowbush.

Fusicoccum canker.—Fusicoccum canker attacks blueberries in northern growing areas, particularly in Massachusetts and Michigan.

The first symptom is the appearance of small, reddish spots on the canes, which are frequently centered about a leaf scar near the ground. As the canker enlarges, a bull's-eye pattern develops. Sudden wilting and dying of canker-girdled canes in warm, dry weather is the most obvious symptom.

Jersey is very susceptible to fusicoccum canker, followed closely by Earliblue and Bluecrop; Coville, Berkeley, Blueray, Burlington, and Rubel are moderately susceptible; and Rancocas is resistant.

Diseased prunings from plants should be removed and burned to aid in control.

Phomopsis twig and cane blight.—Phomopsis twig and cane blight attacks blueberries in most commercial producing areas but is especially serious in Michigan.

Plants infected by this fungus usually are in a weakened condition. Symptoms of blight occur on young succulent twigs and then progress downward as the fungus invades the crown. Older canes are girdled and the foliage on such canes may suddenly wilt and die during hot weather.

The disease is best controlled by maintaining plants in vigorous condition and by burning diseased parts when they are pruned.

Botrytis twig and blossom blight.—The gray mold fungus causes botrytis blight in the coastal blueberry areas of Maine, Washington, and Oregon where cool temperatures, long periods of rainfall, and high humidity favor botrytis development. Favorable conditions for botrytis develop occasionally in New Jersey also.

Blight symptoms first appear at the tips of young twigs and may progress down the entire length of the twig. Blighted flowers remain on the plant much longer than undamaged flowers, and later in the season, fruit may rot in the field or after it is picked.

Heavy fertilization and frequent irrigation stimulate succulent plant growth that encourages botrytis infection. To control the infection on lowbush blueberries, use dusts of 7.6-percent ferbam or ziram applied at 15 to 20 pounds per acre when the blossoms first open. Repeat the treatment twice more, depending on the duration of wet periods.

On highbush blueberry, apply captan at the rate of 5 pounds of 50-percent wettable powder per acre. Use 200 to 250 gallons of water per acre. Apply at 10-day intervals beginning at the start of petal fall and continue until all petals have dropped.

Anthracnose.—The anthracnose fungus causes fruit rot of mature berries, but it also infects leave, twigs, and green fruit. In recent years, losses have increased at harvest and during marketing. Anthracnose occurs in New Jersey, North Carolina, Michigan, and Illinois.

Anthracnose produces salmon-col-

ored spore masses on the surface of mature fruit. This disease has attacked Bluecrop, Blueray, Coville, Jersey, and Rancocas in New Jersey and Wolcott in North Carolina.

For control, prune all dead branches and remove and burn all prunings. An effective fungicide program consists of six to seven sprays beginning at midbloom. Use captan at 5 pounds of 50-percent wettable powder per acre applied at 10-day intervals up to harvest. Use 200 to 250 gallons of water per acre.

Botryosphaeria stem canker.—Botryosphaeria stem canker is especially destructive on highbush blueberries in North Carolina and other Southern States. The disease is rare in New Jersey and remains localized.

The first symptom is a small reddish, conical swelling on new twigs that enlarges in summer and early fall. Fungus growth spreads in succeeding years and causes swollen, fissured cankers that girdle and kill the stems.

Varieties of highbush differ widely in their susceptibility to the stem canker fungus. Murphy, Morrow, Wolcott, Jersey, Angola, and Croatan are resistant to one or more races of the fungus but not to all races. Varieties of rabbiteye listed in table 3 are highly resistant to stem canker.

The only control is the use of resistant varieties.

Phytophthora root rot.—Phytophthora root rot attacks blueberries in North Carolina, Maryland, and New Jersey. The symptoms of the disease are leaf yellowing, weak growth with some drying up of leaf margins, small terminal leaves, defoliation, root rot, and plant death.

Cultivated highbrush varieties, except Patriot, are very susceptible to root rot, but cultivated rabbiteye varieties are highly resistant to the fungus.

When planting new fields, avoid low, poorly drained areas because the fungus thrives in these places.

Blueberry stem blight.—Blueberry stem blight attacks plants in North Carolina and New Jersey.

One or more dead branches near living branches that have normal green leaves is the most conspicuous symptom. Leaves on affected branches may be yellow or reddish in the early stages of infection. Infected woody stem tissue turns a pecan brown.

No control is known for this disease.

Leaf spot.—Both septoria leaf spot and double spot are found in the southern growing areas. Septoria occurs in North Carolina, Georgia, and Florida, but double spot appears only in North Carolina.

The septoria fungus causes small, circular, white lesions that have a purple border. The lesions appear on leaves and new stem growth. Severe defoliation may result from septoria infections.

Double spot can be serious in May and June if rains are frequent. Initially the spots are small and circular and have a dark brown ring around a light brown center. The fungus grows through the outer ring about midsummer and produces a larger spot, which gives the disease the name double spot.

Both septoria and double spot can be controlled with ferbam spray. Use 1-1/2 pounds of active ferbam per 100 gallons of water. Apply spray in sufficient quantity to wet foliage completely. Spray after the plants

have finished blooming. In North Carolina, continue spraying at 2-week intervals until early September.

Red leaf disease.—Red leaf is a fungus disease that is serious on lowbush blueberries in Maine and other New England States. It sometimes attacks cultivated highbush blueberries in Massachusetts, New Jersey, and Michigan.

The symptoms are reddening of the leaves and fungus growth on lower leaf surfaces. Affected leaves drop off in midsummer and plants produce few berries.

The only control is to kill the diseased plant by spot treatment with the herbicide 2,4-D. Follow the directions on the container for mixing the spray.

Witches'-Broom.—Witches'-broom attacks both highbush and lowbush blueberries in the northern blueberry region.

The fungus causes lateral buds to grow and gives rise to a broomlike mass of swollen shoots. The fungus that causes the disease must complete part of its life cycle on balsam fir as an alternate host. The fungus must go from blueberry to fir and back to blueberry again because spores produced on blueberry will not infect other blueberries.

Where witches'-broom is a serious pest, it may be necessary to remove or destroy all balsam fir within several hundred yards of the blueberry field.

Leaf rust.—Leaf rust is serious on lowbush blueberries in Maine, and it appears sporadically on highbush in the Eastern United States, particularly in the South.

The fungus completes part of its life cycle on hemlock, where it overwinters. Infected leaves have light green to reddish areas on the upper surface and rust-colored pustules on the lower surface.

Highbush varieties differ in their resistance to leaf rust. Jersey and Rubel are susceptible; Dixi, Rancocas, and Weymouth are resistant.

Measures have not been established to control attacks on highbush blueberries. On lowbush, a 7-percent ferbam dust applied at 15 to 20 pounds per acre at petal fall and again 10 to 14 days later is recommended.

Virus Diseases

Blueberry stunt.—The most widespread, destructive virus disease of highbush blueberries is stunt. It is found from North Carolina to eastern Canada and west to Michigan.

Stunt slows down growth and gives the plant a yellow, dwarfed appearance. Characteristic symptoms are small, cupped leaves yellowed along the margins and between lateral veins, and short twig growth.

Branches become twiggy and a premature, brilliant red coloring develops in the yellowed areas of the diseased leaves. The fruits are small, lack flavor, and remain attached to the plant much longer than normal.

Cultivated highbush varieties are all susceptible to stunt, but Rancocas is more resistant than other varieties.

The use of virus-free plants, removal of diseased bushes, and control of the sharp-nosed leafhopper provide excellent control of stunt. Insecticide applications of parathion at 2 pounds of 15-percent wettable powder per acre in late spring, late summer, and early fall will control leafhopper.

In new plantings, use certified virus-free plants and in established plantings, remove diseased plants after each leafhopper insecticide application. Destruction of wild blueberries along the edges of fields will also eliminate a source of infection.

Mosaic.—Mosaic is common on highbush blueberries in New Jersey, North Carolina, and Michigan.

Infected leaves have mottled patterns of yellow and yellow-green areas. Diseased plants are unproductive.

The only recommended controls are prompt removal of diseased plants and use of disease-free planting stock.

Shoestring.—Shoestring virus disease is common on highbush blueberries in New Jersey and Michigan. Infected plants produce little new growth and no fruit.

The first symptoms of shoestring virus appear in the spring as red streaks on new shoots and red vein-banding on the leaves. The shape of diseased leaves varies from narrow and straplike to wavy and sickle shaped. Infected flowers are deformed and streaked with pink. Immature fruit develops a premature red to purple color on the surface exposed to the sun.

The only controls are prompt removal and destruction of diseased plants and the use of virus-free planting stock.

Red ringspot.—Red ringspot is a virus disease of wild and cultivated highbush blueberries. The disease attacks wild blueberries only in New Jersey, but it attacks cultivated plantings in Michigan, Connecticut, North Carolina, Long Island, Massachusetts, and New Jersey.

The greatest loss from the disease is the difficulty it causes in the propagation of virus-free plants. However, it can cause some berry losses from small, misshapen fruit.

The first symptoms of the disease are red spots or rings on older leaves. The earliest appearance of the disease is in New Jersey in June or early July. The symptoms are less severe in younger leaves. The leaf spots have well-defined margins and do not show on the lower surface of the leaves. Red ringspot may also cause red spots or rings to develop on stems.

Powdery mildew symptoms may be confused with red ringspot, but powdery mildew causes dead looking irregular spots on the underside of the leaves.

Most cultivated highbush blueberry varieties are susceptible to red ringspot. Of the major varieties, only Jersey appears immune; Bluecrop and Weymouth have high resistance.

The only controls are to use virus-free planting stock and to promptly remove disease bushes.

Necrotic ringspot.—Necrotic ringspot is caused by a virus commonly known as tobacco ringspot virus. Necrotic ringspot attacks both wild and cultivated blueberries in Michigan, New Jersey, Connecticut, New York, and Illinois, but it is not serious in most cultivated fields.

The disease causes stunting, extensive dieback, and unproductivity. Young leaves show yellowed spots, rings, and line patterns. Dagger nematode *(Xiphinema americanum)*

is a vector of tobacco ringspot virus and is probably the vector of necrotic ringspot.

Control measures are removal of diseased bushes, treatment of soil with nematicides, elimination of other hosts of the tobacco ringspot virus, and the use of disease-free plants. See the section entitled "Nematodes."

Bacterial Diseases

Bacterial canker.—Bacterial canker occurs in cultivated highbush plantings in Washington and Oregon.

The symptoms are water-soaked areas on 1-year-old stems that rapidly become reddish brown to black cankers. The first symptoms usually appear in January or early February; the earliest appearance of the disease is in Oregon.

Susceptibility varies among varieties. Jersey and Coville are severely affected; Rubel and Burlington are seldom affected; and Weymouth and Rancocas are highly resistant.

To control the disease, spray with a fixed copper compound during the dormant season.

Crown gall.—Crown gall is found in all northern highbush growing areas where it is primarily a problem in nurseries but is occasionally a problem in cultivated fields.

Tumorlike outgrowths appear on low branches, small twigs, and the base of canes near the ground line. The outgrowths are black or dark brown, rough, and hard.

The best control is to propagate only from healthy plants and to remove immediately and destroy all prunings suspected of having crown gall. Sterilize contaminated pruning tools with an antiseptic before reuse on healthy plants.

Nematodes[4]

Blueberries are attacked by several species of nematodes. The most damaging are root-knot (*Meloidogyne* spp.), sting (*Belonolaimus* spp.), root-lesion (*Pratylenchus* spp.), stunt (*Tylenchorhynchus* spp.), spiral (*Helicotylenchus* spp.), stubbyroot (*Trichodorus* spp.), and dagger (*Xiphinema* spp.) nematodes.

Nematodes cause poor stands, slow plant growth, and reduced fruit size and yields. The root systems of severely injured plants are galled (root knots), greatly restricted, and often matted and rotted. The foliage may be yellow and leaves may drop early, especially during a drought.

Nematodes can cause extensive damage in both nurseries and field plantings. No varieties are resistant to nematodes.

The use of nematicides provides the best nematode control (table 4). DD, 1,3-D, and EDB control only nematodes. DD+MENCS, methyl bromide, and SMDC also control many weeds, insects, and soil-borne diseases; they are especially desirable for use in nurseries (fig. 14).

Rates of application of nematicides vary according to soil conditions and method of application. Always follow the manufacturer's directions on the

[4]Prepared by J. M. Good, SEA nematologist, Extension.

package label for specific recommendations.

If they can be obtained, use only nematode-free plants for established field plantings.

Insects[5]

The number of insects attacking blueberries is extensive. The most common ones are the blueberry maggot, the cranberry fruitworm, the cherry fruitworm, the blueberry bud mite, the plum curculio, and the cranberry weevil.

Other insects that attack blueberries are leafhoppers, budworms, tent caterpillars, webworms, datana worms, leaf rollers, scale insects, stem borers, and cranberry rootworm. For help in identifying insect pests and their control, you may wish to consult your local county agricultural agent or State agricultural experiment station.

[5]Prepared by Paul H. Schwartz, Jr., SEA entomologist, Beltsville, Md. 20705

Fruit Worms

Adult moths of the cranberry fruit worm appear during late May and early June. They lay their eggs in the calyx cup at the base of newly set fruit. The larvae are greenish underneath and on the sides, brownish red on the back, and up to one-half inch long.

The small gray moths of the cherry fruit worm appear late in the blooming season and do not lay eggs in large numbers until the bloom is nearly off. The larvae are uniform reddish orange and up to three-eighths inch long.

Green fruit is attacked by the larvae of fruit worms; a few worms can destroy large numbers of berries.

Both of these insects are distributed from Maine to Texas.

Apply azinphosmethyl, carbaryl, or malathion, using three applications at

TABLE 4.—*Suggested nematicides for control of nematodes on blueberries*

Chemical	Active ingredient per acre as overall treatment
	Pounds
DD (mixture of 50% 1,3-dichloropropene and 50% 1,2-dichloropropane)	250 to 600.
1,3-D (100% 1,3-dichloropropene and related chlorinated C hydrocarbones)	200 to 480.
DD + MENCS (mixture of 80% DD and 20% methyl isothiocyanate)	145 to 240.
EDB (83% ethylene dibromide)	90 to 108.
SMDC (sodium methyldithiocarbamate)	124 to 338.
DBCP (1,2-dibromo-3-chloropropane)	14 to 26.
Methyl bromide[1]	175 to 412.
Methyl bromide[2]	435 to 872.

[1]This methyl bromide treatment is for general use.

[2]This methyl bromide treatment is only for nursery use on plant beds.

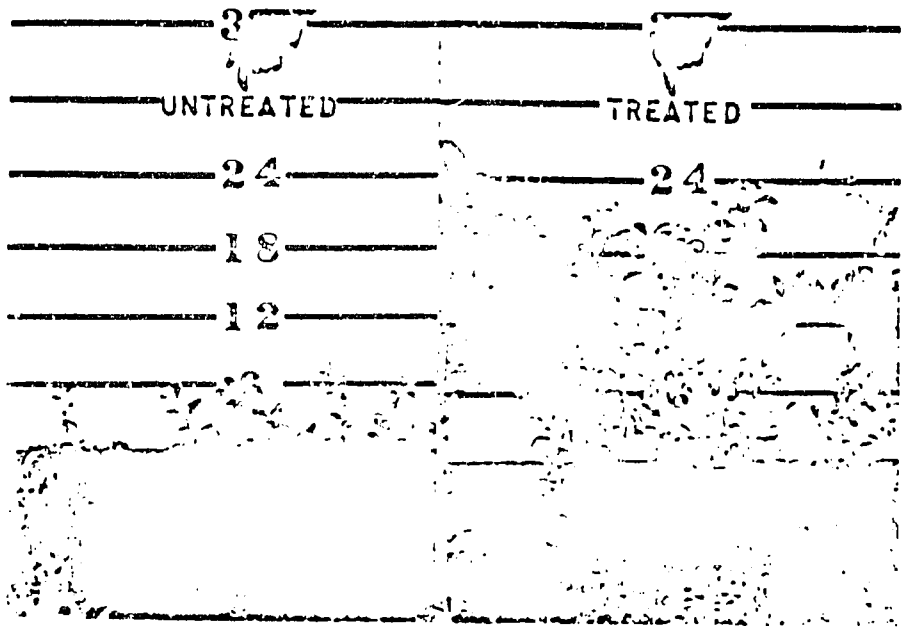

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Figure 14.—A comparison of the size of blueberry plants: *Left*, Plants grown in untreated soil; *right*, plants grown in soil treated with nematicides.

10-day intervals beginning just after petal fall.

Blueberry Maggot

Adult blueberry maggots are similar to houseflies in shape. They are about three-sixteenths inch long, have a brown face and shiny black body, are white on the sides and rear of the thorax, and have several white bands on the abdomen. The wings are clear with black bands. The larvae are yellow-white maggots up to three-eighths inch long.

The larvae attack the berries. Infested berries may drop, reducing the crop yield. The maggots puncture the skins and feed on the flesh, causing the berries to collapse due to loss of flesh. Usually only one maggot is found per berry.

The blueberry maggot is distributed from New Jersey northward.

Apply malathion, beginning near the end of June and reapply at 10-day intervals.

Blueberry Bud Mite

Blueberry bud mites are only about 1/128-inch long, are soft bodied, have eight legs, and are not classified as insects.

The blueberry bud mite sucks juices from the buds. Flowers may be distorted and fail to set fruit. Berries may only partially develop and the skin of the berries may be rough. Red, blistered, misshapen berries are the first signs of injury.

This mite is a serious pest in North Carolina and to a lesser extent in New Jersey.

Apply endosulfan immediately after harvest and repeat 6 to 8 weeks later. Do not apply endosulfan after buds are well formed.

Cranberry Weevil

Adult cranberry weevils are dark reddish brown, about one-third inch long, have white patches across the wings, and have a slightly curved snout one-third as long as the rest of the body. The larvae have a whitish, legless body up to one-ninth inch long and a yellow head.

Adult weevils bore into leaf and fruit buds and eat the flesh. When the blossoms start turning white, the weevils lay their eggs in the flower. After the larvae hatch, they eat the entire contents of the flower. Crops are severely reduced.

These weevils are distributed east of the Rocky Mountains.

For control, keep fields clean by cultivation; kill hibernating weevils by burning the trash and dry weeds off the unused land immediately surrounding fields in spring before buds begin to swell.

Plum Curculio

The adults are dark brown beetles one-fourth inch long that have grayish or whitish patches on the back and four humps on the wing covers. The larvae are grayish white, legless, and curved-bodied; they have a small brown head and are up to one-third inch long.

Adults appear early in the blooming period, feed, and lay their eggs in small green berries. Usually there is one larva in each berry. The larvae feed on the fruit, causing the fruit to drop.

This insect is distributed east of the Rocky Mountains.

Apply carbaryl or malathion using three applications at 10-day intervals beginning just after petal fall.

USE OF PESTICIDES

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

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

EPA has interpreted this Section of the Act to require that the intended use of the pesticide must be on the label of the pesticide being used or covered by a Pesticide Enforcement Policy Statement (PEPS) issued by EPA.

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

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

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

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

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

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

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Commercial Blueberry Production Guide for North Carolina

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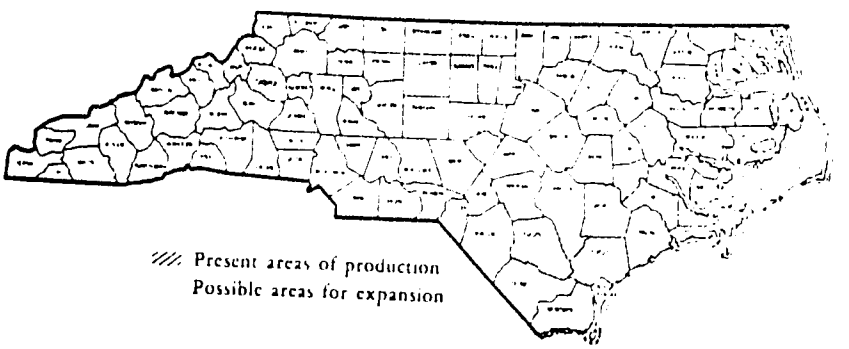
Commercial BLUEBERRY Production Guide for North CAROLINA

North Carolina is one of the largest producers of commercial highbush blueberries in the nation. Since the crop in North Carolina is earlier than other areas, a good market is usually available.

Acreage planted to blueberries has been expanding rapidly. During the past 25 years the industry has grown from 100 acres to more than 4,000 acres with an annual farm value of over $3 million. Most of the acreage is in Pender, Bladen, Duplin, and surrounding southeastern North Carolina counties; however, a few small commercial plantings are found in the western North Carolina mountains.

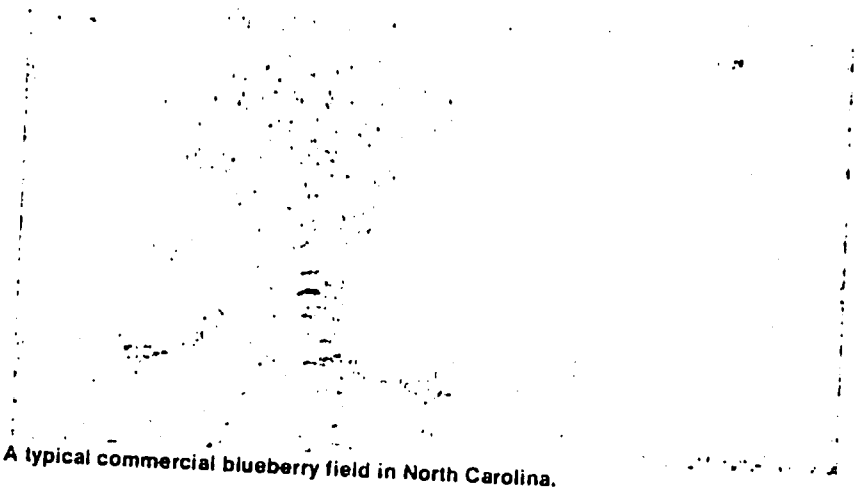
Highbush blueberries (*Vaccinium corymbosum L.*) account for over 95 percent of commercial acreage. Some rabbiteye blue-



Commercial blueberry production in North Carolina is now mostly confined to the southeastern Coastal Plain; only a few acres are grown in the mountains of western North Carolina.

berries (*V. ashei*) are grown in home gardens, small commercial plantings, and in "pick-your-own" operations.

Although grown in many countries of the world, blueberries are traditionally American. When the first white settlers arrived, the Indians were already enjoying this wild fruit. Today we relish blueberries for their fine flavor, their attractiveness, and their versatility. Probably best of all, blueberries come to us ready to eat. It is no surprise that we get three to four servings from a pint of fruit.



A typical commercial blueberry field in North Carolina.

Site Selection

Highbush Blueberries

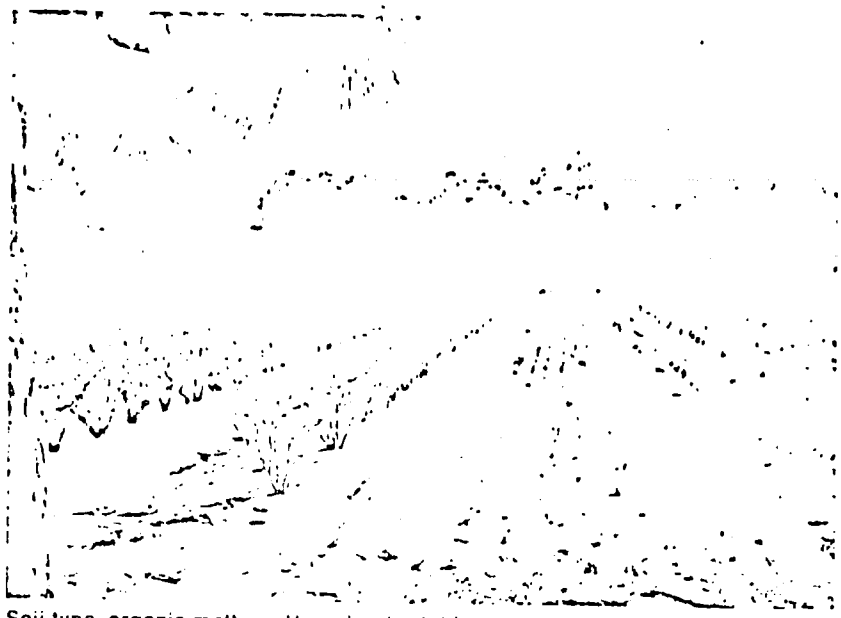
Soil Type—Most commercial plantings of highbush blueberries in eastern North Carolina are growing on either a Lynn Haven or Leon type soil. These sandy soils are characterized by an organic matter content of 2 percent or greater in the surface layer, under-

lain with a white sand layer above an organic hardpan. The white sandy layer underneath the topsoil, referred to as the A_2 horizon, is extremely important. Production, vigor, and livability of bushes are much higher in soils where this A_2 horizon is present, compared to soils where it is absent.

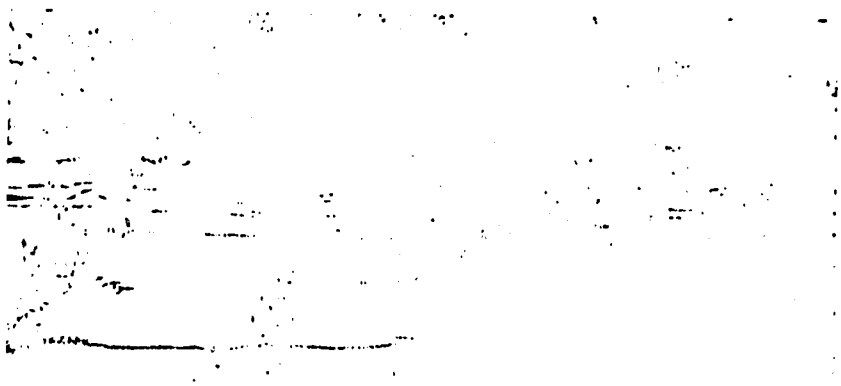
Plantings are also being grown successfully on Rutledge and peat soils. By adding organic matter to the planting hole and/or mulching with sawdust, blueberries can be grown in upland mineral soils. Most desirable soils are primarily coarse sands with an organic base, open, porous, and with a water table at least 14 inches but not more than 30 inches below the surface.

Most blueberries are grown on either a Lynn Haven or Leon soil, both poorly drained. Above is "blueberry land" rough cleared. Notice the drainage ditch at the edge of the newly cleared field.

Soil pH—Acid soils (pH 3.8 to 4.5) usually promote best growth. However, plants grow well at even lower native pH levels found within the blueberry growing area. Lime is seldom, if ever, needed. A soil test by the Soil Testing Division, North Carolina Department of Agriculture, Raleigh, will determine the acidity (pH), organic content, phosphorus, and potassium levels. Your local agricultural Extension or Soil Conservation office can advise you concerning this service and offer valuable assistance.



Soil type, organic matter, pH, and water table are extremely important in growing blueberries. The dead and dying bushes in the right foreground were planted on soil not suited for blueberry growing.



The blueberry bushes on the right are growing in soil with optimum pH and organic matter. Bushes on the left are the same age but the soil has low organic matter and high pH.

Soil Moisture—Soil moisture is a critical factor in blueberry production. Blueberry bushes are very shallow rooted and will not tolerate either extreme drought or prolonged periods of excessive water in the root zone. Consequently, they require a well-drained soil but one which has a continuous moisture supply. In some areas this condition can be maintained by regulating the water table at 14 to 30 inches below the surface with ditches, canals, etc. In other locations, supplemental irrigation is needed.

Indicator Plants—Probably the best indication that blueberries will grow successfully in a particular location is that they or some related plants are naturally growing there. These indicator plants include blueberries, huckleberries, wild azaleas, gallberries, laurel, rhododendron, and leatherleaf.

Rabbiteye Blueberries

The rabbiteye type is more widely adapted to different soil types than highbush blueberries, but poor plant growth has been associated with soil pH levels above 5.4. Rabbiteye blueberries will not tolerate the cold climate of the mountains. They are also more drought and heat resistant than highbush.

Rabbiteye blueberries grow well in typical highbush blueberry soil as described earlier. Modify other soils by adding organic matter, supplying supplemental irrigation, and by mulching around the plants with 4 to 6 inches of sawdust.

Highbush Varieties and Their Characteristics

Canker-Resistant Highbush Varieties

In eastern North Carolina, the stem canker disease caused by the fungus *Botryosphaeria corticis* is one of the most important limiting factors in producing highbush blueberries. Seven varieties have been developed by the North Carolina Agricultural Experiment Station with resistance to this disease; however, there are strains of the canker fungus which will attack plants of varieties that were highly canker resistant when introduced in the early 1950s. Growers should consider canker-resistant varieties for the major part of their

planting. They should be aware that canker-susceptible varieties readily develop canker, decline in production, and eventually many of the bushes of these susceptible varieties die.

Varieties introduced for Coastal Plains North Carolina are described as follows in their order of ripening.

Angola: Introduced 1951.

Parentage: Weymouth x (Stanley x Crabbe 4).

Season: Very early (mid-May)—Usually the first to ripen.

Fruit: Dark, soft, has good flavor, and ripens over a long period. About same size as Wolcott under favorable conditions. This variety is highly canker resistant and productive. However, the bush is very sensitive to soil and water variations. Heavy annual pruning is required to maintain bush vigor and fruit size.

Morrow: Introduced 1964.

Parentage: Angola x Adams.

Season: Very early. As much as 5 to 7 days ahead of Wolcott. Also ripens over a shorter period than any other North Carolina variety.

Yield: About that of Wolcott and Murphy.

Fruit: Lighter blue than Wolcott, Croatan or Murphy. Much lighter blue than Angola. Size about the same as Croatan. Large and moist stem scar, a mild, pleasant taste and as firm as Wolcott. Comparative ease of harvest (shakability) = 94[1].

Bush Description: Medium-sized, slow growing after fruiting age. Semi-upright and broad. Has more tolerance to stem canker than Wolcott. Fruit clusters are usually borne upright at the periphery of the bush. Forms many short fruiting shoots that require numerous cuts during pruning. Morrow was introduced as a replacement for Angola, and is a canker-resistant, very early commercial variety with improved size and color.

Wolcott: Introduced 1950.

Parentage: Weymouth x (Stanley x Crabbe 4).

Season: Early—usually begins ripening mid- to late May in southeastern North Carolina.

[1] Ideal ease of harvest or shakability = 100.

Bush: Semiupright, large, well-shaped, susceptible to bud mite. Susceptible to many races of the stem canker fungus. Should not be planted in areas where stem canker is a problem.

Fruit: Berries generally round, medium blue, firm to slightly soft, sub-acid to sweet, good flavor, small scar, does not size well under dry conditions. Comparative ease of harvest (shakability) = 93.

Croatan: Introduced 1954.

Parentage: Weymouth x (Stanley x Crabbe 4).

Season: Early mid-season.

Bush: Erect, vigorous, productive. More canker resistant than Wolcott. Performs better on light soils than most varieties. Tolerant to bud mite and has a short chilling requirement.

Fruit: Slightly larger than Angola, Wolcott or Murphy. Aromatic, sweet to subacid, ripens very quickly in warm weather. Not quite as firm as Wolcott and Murphy. Comparative ease of harvest (shakability) = 98.

Harrison: Introduced 1974.

Parentage: Croatan x US 11-93.

Season: Mid-season several days after Croatan.

Bush: Semiupright, vigorous, productive. More canker resistant than Wolcott. Tolerant to bud mite. Phytophthora root rot becomes a problem in wet locations.

Fruit: Larger than Croatan. Light blue and much more firm than most North Carolina varieties. Stem scar and flavor are good. Superior keeping quality. A majority of the fruit ripens in a 4-week period. Comparative ease of harvest is similar to Bluecrop.

Bluechip: Plants will be available to growers in spring of 1979.

Parentage: Croatan x US 11-93.

Season: Mid-season-approximately a week later than Wolcott.

Bush: Erect, vigorous, productive. Few short shoots, easily pruned. Susceptible to three races of stem canker in greenhouse tests, but has shown field tolerance during limited testing.

Fruit: Larger than Harrison. Excellent flavor, firm, light blue color, good keeping quality.

Murphy: Introduced 1950.

Parentage: Weymouth x (Stanley x Crabbe 4).

Season: Mid-season—approximately a week later than Wolcott.

Bush: Medium-low, spreading, large leaves, more canker resistant than Wolcott.

Fruit: Round to round-oblate, firm, subacid to sweet, good flavor, large but shallow scar. Long clusters, loose, open, excellent type. Medium light blue. Crops annually and consistantly. Comparative ease of harvest or shakability = 98.

Canker Susceptible Varieties for the North Carolina Mountains

Stem canker is as yet not a problem in western North Carolina or in the northern producing areas. To avoid importing the disease into western North Carolina, order plants only from canker-free northern nurseries (New Jersey, Michigan, etc.). The most widely planted variety is **Jersey**, but several varieties have performed well in tests and in commercial plantings in the mountains, and are described briefly as follows. For more detailed description, refer to USDA Farmers Bulletin No. 1951. *Blueberry Growing.*

Weymouth: Very early, dark fruit, medium large, fair quality. Bush medium size and spreading.

Earliblue: Very early, light blue, large fruit, firm, good flavor, good scar. Bush vigorous, upright. Pollination a problem. Shakability = 74.

Blueray: Midseason, fruit large, light blue, firm, highly flavored. Bush very vigorous, hardy, upright. Shakability = 70.

Bluecrop: Midseason, fruit firm, acidic, large, very light blue, medium quality. Bush average vigor, upright, spreading, hardy, very productive. Shakability = 76.

Berkeley: Late midseason, fruit lightest blue, medium firm, very large, medium quality. Bush vigorous, open spreading. Shakability = 81.

Jersey: Late season, medium size fruit, good blue color, medium dessert quality. Bush very vigorous, hardy, with some tolerance to stem canker.

[1] Ideal ease of harvest or shakability = 100.

Table 1. Highbush blueberry varieties ranked approximately in order of merit for certain characteristics

Varieties Developed for North Carolina

Season (Early to Late)	Fruit Size (Large to Small)	Shipping Quality (Good to Poorer)	Dessert Quality (Good to Poorer)	Color (Light to Dark)	Yield (High to Low)
Angola[1]	Bluechip	Harrison	Bluechip	Bluechip	Croatan
Morrow	Harrison	Bluechip	Harrison	Harrison	Harrison
Wolcott	Morrow	Wolcott	Murphy	Morrow	Bluechip
Croatan	Croatan	Morrow	Morrow	Murphy	Morrow
Harrison	Murphy	Murphy	Wolcott	Wolcott	Wolcott
Bluechip	Angola	Croatan	Angola	Croatan	Murphy
Murphy	Wolcott	Angola	Croatan	Angola	Angola

Varieties Developed in New Jersey[2]

Weymouth	Berkeley	Bluecrop	Blueray	Berkeley
Earliblue	Blueray	Jersey	Bluecrop	Bluecrop
Blueray	Bluecrop	Berkeley	Earliblue	Earliblue
Bluecrop	Earliblue	Earliblue	Berkeley	Blueray
Berkeley	Weymouth	Blueray	Jersey	Jersey
Jersey	Jersey	Weymouth	Weymouth	Weymouth

[1] Varieties bracketed together do not appreciably differ in that characteristic
[2] Farmer's Bulletin No. 1951, U.S. Dept. of Agric. 1966 (Revised).

Rabbiteye Varieties

Rabbiteye blueberries (*Vaccinium ashei*) are well known for their vigor and productiveness and can be grown successfully in coastal plain and piedmont North Carolina. They ripen later and over a longer period than the highbush type. Generally, highbush blueberries begin ripening in late May and harvest is concluded by late June. Rabbiteye harvest, on the other hand, begins in late June and continues into August.

Two or more varieties should be planted to ensure adequate pollination. Rabbiteye varieties with desirable qualities suggested for planting in North Carolina are described in ripening order. See Table 2.

Premier: Plants will be available to growers in spring of 1979. Very early (mid-June). Ready to harvest as the highbush season is ending.

Bush is sturdy, disease tolerant, vigorous and easy to manage. Fruit is unusually large, flavorful and fine-textured. Early blooming characteristic often results in spring frost damage.

Woodard: Introduced 1960. Early, large, high-quality fruit, light blue. Berries withstand shipment well, although the stem scar is large. Bush size medium, many suckers produced.

Homebell: Introduced 1955. Medium dark blue fruit, rather soft, and subject to cracking. Blossoms often damaged by spring frosts. Recommended only for home gardens.

Delite: Introduced 1969. Very good flavor, medium blue, large, round berries with a small-dry scar. Fruit is sweet as soon as it turns blue. Green fruit is easily detached during harvest. Columnar shaped bush with few suckers.

Southland: Introduced 1969. Firm, light-blue fruit with a waxy bloom and small stem scar. Fruit resists decay during shipment. Bush size medium, productive.

Garden Blue: Introduced 1958. Firm, medium blue, good flavored, and small to medium-size fruit of good quality. Bush vigorous, upright, and high yielding.

Tifblue: Introduced 1955. Firm, light blue, good flavored fruit when fully ripe. (This variety will appear to be ripe several days before full flavor developes.) Loose fruiting clusters, ease of ripe fruit detachment, and a small dry stem scar make the variety desirable for mechanical harvesting and commercial shipment. Bush very productive, vigorous, and widely adapted. Resists blooming during warm winter periods.

Powderblue: Plants will be available to growers in spring of 1979. Ripens 1 to 2 days later than Tifblue. The plant is sturdy, disease resistant and very productive. Fruit is very light blue, firm, medium size and suitable for mechanical harvesting. A good pollinator for Tifblue. Time of ripening and fruit appearance are sufficiently similar that the two varieties can be harvested together and the fruit combined.

Centurion: Plants will be available to growers in the spring of 1979. The plant is strongly upright, disease tolerant and bears consistently because it blooms late enough to escape spring frost. Fruit is medium blue, firm, medium large and sweet.

Climax is a recent variety that is suggested for trial.

Table 2. Rabbiteye blueberry varieties ranked approximately in order with reference to certain characteristics

Season (Early to Late)	Fruit Size (Large to Small)	Dessert Quality (Good to Poorer)	Color (Light to Dark)	Bush Size (Large to Small)
Premier	Premier	Delite	Powderblue	Garden Blue
Woodard	Delite	Premier	Tifblue	Centurion
Homebell	Woodard	Woodard	Premier	Tifblue
Delite	Tifblue	Powderblue	Southland	Homebell
Southland	Southland	Tifblue	Woodard	Premier
Garden Blue	Centurion	Garden Blue	Garden Blue	Delite
Tifblue	Powderblue	Centurion	Centurion	Powderblue
Powderblue	Homebell	Southland	Delite	Woodard
Centurion	Garden Blue	Homebell	Homebell	Southland

Propagation

Commercial Highbush

Most commercial highbush blueberries are reproduced from hardwood cuttings. (Softwood cuttings as described for rabbiteye propagation also root well.) Hardwood cuttings are taken during the dormant season (late winter). Make the cuttings from previous season's growth. Select only vigorous, disease-free shoots, remove wood with fruit buds, and make cuttings 4 to 5 inches long. Avoid winter-injured wood. The best cuttings are made from mature, vegetative wood about the diameter of a lead pencil. If the shoots are cut by hand, make the lower cut just below a bud and the upper cut just above a bud. Cuttings can also be made on a bench saw. Tie the shoots into bundles and cut into 4- to 5-inch lengths without considering the position of the cut with respect to the leaf buds. When long shoots are available, saw cutting saves labor with only a slight reduction in rooting.

Shoots collected and made into cuttings in March can be stuck directly into the propagation bed. In larger-scale operations the collection of cutting wood is started in February and stored at 35 to 40° F. in plastic bags lined with damp sphagnum. Following unusually warm winters, refrigeration of cutting wood prior to sticking in the bed will cause more uniform leafing and improved rooting.

Good drainage is essential in the rooting bed. Raise the bed 4 to 6 inches off the ground and support the bottom with hardware

Highbush blueberries are generally propagated from dormant hardwood cuttings. From left to right: a well rooted cutting, a cutting just calloused, an ideal cutting ready to be placed in the bed, and an undesirable cutting taken from the fruiting portion of the stem. Notice the large fruit buds on the cutting to the extreme right.

cloth on a frame. Media can be placed directly on ¼-inch hardware cloth, but Saran screen or burlap must be placed over coarser hardware cloth to retain the media. Ground beds placed in a well-drained location have also been used successfully, but injury from excessive water during prolonged periods of rain have been a more serious problem than in suspended beds.

Fill the bed to a 4- to 6-inch depth with a mixture of one part coarse sand and one part shredded horticultural peat. Replacing the peat with well-rotted sawdust has given variable results. If sawdust is to be used, it must be fumigated to destroy termites. Since the water-holding capacity of sawdust is much lower than peat, beds containing a sawdust medium must be watered more often. Old media should be removed and replaced with fresh media each year.

Place the cuttings, large end down, about 1 to 2 inches apart in rows 2 inches apart. Stick the cuttings vertically into the medium one-half to two-thirds of their length. Water the bed and continue watering at intervals to keep the media moist but not too

wet. It is almost impossible to overwater if proper drainage described above is provided. On the other hand, if drainage is incomplete, rooting is poor unless a very careful watering schedule is maintained.

Tender new shoots and leaves develop rapidly on the cuttings, but roots do not appear until about 8 weeks after sticking. Do not allow the cuttings to wilt during this period before roots have formed. Wilting of the cuttings even for a short period seriously reduces the rooting percentage. In addition to maintaining adequate moisture in the media, a windbreak around the bed, shade, and misting or sprinkling will help prevent excessive moisture loss from the plants and subsequent wilting. Lath or Saran shade providing 50 to 60 percent reduction in light intensity have been used successfully. Misting or sprinkling during periods of high temperature have proven beneficial. Usually, cuttings will root by June. This is indicated by a second flush of new growth. Leave these young plants in the rooting bed until winter. Fertilize lightly *after the cuttings are well rooted* (usually about July 1). A good fertilizer is 1 pound of ammonium phosphate dissolved in 4 gallons of water per 100 square feet of bed applied every 2 weeks until mid-August. Rinse the leaves with water immediately after fertilization to prevent injury.

Remove the cuttings the following spring and plant them in nursery rows 18 inches apart. About a month after planting, fertilize with 100 to 150 pounds per acre of 10-10-10 or 10-20-10. Repeat every 4 to 6 weeks until mid-August. Extend application interval during dry periods until rainfall has totaled 4 inches. Control weeds and grass and leaf spot diseases throughout the summer. Nursery-grown plants should have made sufficient growth to be transplanted to the field the following winter or early spring.

Rabbiteye

The method for rooting cuttings of the rabbiteye varieties is very similar to that of commercial highbush varieties, with a few exceptions.

Generally, softwood cuttings are taken in May when the first flush growth becomes mature enough to stick the cutting into the media without problems of bending and breaking. Cuttings taken from second flush growth that has reached the stage of maturity described previously also root well, but little plant development occurs before cold weather. Using only the most vigorous wood, make cuttings 4 to 5 inches long. Remove the leaves from the lower

half of the cutting and place immediately in the rooting bed.

Maintain humidity near 100 percent by mist nozzles that deliver about 2 gallons of water per hour at 30 pounds pressure. Six seconds of mist every 2 minutes has been satisfactory. No misting is needed at night or on very humid days.

When cuttings have rooted well, gradually reduce misting and allow the plants to harden. Water only when the surface soil becomes dry. Plants may be left in the bed for protection during the winter. Grow rooted plants at least a year in a nursery row before moving them to their permanent location.

Planting

Soil should be well drained and in good tilth before planting. Level the land to eliminate any wet or low areas. Before fumigating and treating the soil for insects and diseases, contact the Entomology and/or Plant Pathology Departments, N. C. State University, Raleigh, for suggested materials and procedure.

Transplant any time during the dormant season (late November through March). Set plants the same depth or slightly deeper than they grew in the nursery.

Set strong-rooted cuttings or nursery-grown plants 4 to 5 feet apart in rows 8 to 10 feet apart. A 4- by 8-foot planting requires 1360 plants per acre; a 5- by 10-foot planting requires 870 plants per acre. Closer spacing will give a greater yield on young plants if your equipment will allow this closer spacing.

Rabbiteye plants are more vigorous and grow larger than highbush. Generally, they are planted 5 to 6 feet apart in rows 10 or 12 feet apart.

Fertility and Fertilizers

Blueberry bushes respond to applications of the proper fertilizers. Because of their limited root system, they need frequent fertilizer applications and are injured if too much fertilizer is applied at any one time. For efficient utilization, fertilizer must be applied in the region of the roots. The region of absorbing roots generally extends as far out as the branches. On established plants, fertilizer should be uniformly spread in a broad band down the plant row. The branch spread will determine the width of the band. Fertilizer

dropped in lumps or piles under the bushes can cause serious root damage and possible bush death. Special care must be taken not to apply heavy concentrations of fertilizer over the root system of young plants.

Before planting, have a soil analysis made by the N. C. Department of Agriculture, Agronomic Division, Raleigh. Use this analysis as a guide in building and maintaining fertility in the soil. To ensure adequate soil copper, apply 5 pounds of actual copper per acre before planting and repeat every 5 years. Do not apply lime or fertilizers high in calcium or sulfur.

Fertilizer recommendations in this circular are based on the results of field tests in North Carolina. The bushes in these experiments were planted in rows 8 feet apart. At this spacing, there are 5,445 linear feet of row per acre. *Use the recommended amount of fertilizer on 5,445 linear feet of plant row independent of bush and row spacing.* Determine the amount of fertilizer to be applied to 100 feet of row for calibrating your spreader by using the following formula.

$$\frac{\text{pounds of fertilizer desired per acre}}{54.45 \text{ (hundreds of linear feet of row per acre)}} = \text{pounds to apply per 100 linear feet of row}$$

For example, if you want to apply 200 pounds of fertilizer per acre, divide 200 by 54.45 and find that 3.7 pounds per 100 feet are required.

$$\frac{200 \text{ pounds/acre}}{54.45} = 3.7 \text{ pounds per 100 feet of row}$$

Calibrate your spreader by measuring and marking 100 feet and adjusting the spreader to apply the desired amount. Catch and weigh the fertilizer from the spreader and adjust the spreader until the desired rate is applied to 100 linear feet. Be sure to operate the tractor at the same speed when fertilizer is applied in the field. *Once the spreader is calibrated by this method, the application rate will be correct for all row spacings without further adjustment.*

As the spacing between rows increases, less fertilizer is required per acre planted to blueberries. If your rows are 8 feet apart, order enough fertilizer to apply the recommended rate per acre of land planted in blueberries. When rows are 9 or 10 feet apart, order 89 and 80 percent, respectively, of the recommended rate.

At least two applications of fertilizer must be applied each year.

The planting year never fertilize newly planted bushes until the roots have become reestablished. After the first flush of growth, apply 100 pounds of 10-20-10 or equivalent per acre[1] and repeat every 4 to 6 weeks until mid-August. Extend application interval during dry periods until rainfall or irrigation has totaled 4 inches.

The second year apply 200 pounds of 10-20-10 or equivalent per acre when new growth begins in the spring. Follow the planting year timing and rate schedule for the rest of the season.

On bearing plants apply 300 pounds per acre of 10-20-10 or equivalent two-thirds prior to bloom and one-third 4 to 6 weeks later (early May). Apply 30 pounds N per acre (100 pounds of ammonium nitrate or equivalent from other sources per acre after harvest) if growth is poor. Use a complete fertilizer after harvest if soil phosphorus is low or leaching has been severe.

Cultivation and Weed Control

Blueberry bushes are very shallow rooted. Ninety percent of their root system is in the top 6 inches of soil. To avoid damage

[1] One hundred pounds per acre is equivalent to approximately ½ cup per bush.

to the roots, cultivate shallow and only as frequently as is necessary to control weeds and grass. Frequent stirring of the soil depletes the soil organic matter by increasing its exposure to the sun and speeds its oxidation and decomposition.

Chemical weed control has been used successfully on a commercial scale in North Carolina. Some practical aspects of using chemicals are as follows: (1) can be applied in late winter; (2) reduces labor costs; (3) roots are not disturbed.

A disadvantage of chemical weed control is the chance of injury to plants if used improperly.

Information on chemical weed control is being developed rapidly. Therefore, it will be updated each year, published in the *North Carolina Agricultural Chemical Manual*, and made available to growers through N. C. State University and local county agricultural Extension offices. Be extremely careful when using herbicides. Read and follow label directions exactly.

Pruning

Why Prune?

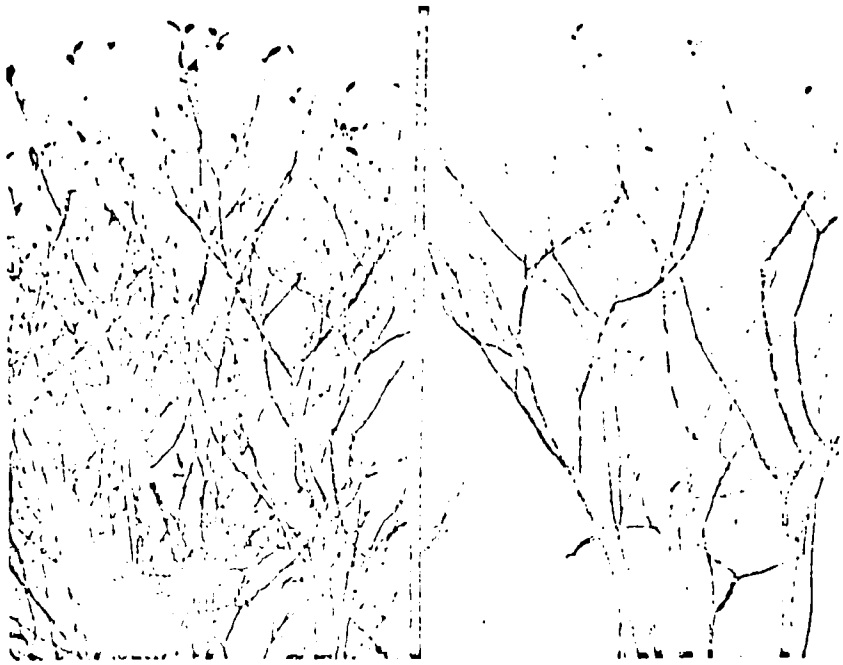
Blueberry bushes tend to overbear if not pruned. Overbearing results in small, poor quality fruit and may shorten the life of the plant because of greater drought injury during periods of low rainfall.

Pruning initiates new, vigorous growth on which next year's fruit is borne. This new growth is also needed for rejuvenation of the plant. In addition, correct pruning removes dead wood which may harbor diseases and insects.

Moderate to heavy pruning reduces the crop, increases berry size, and shifts the ripening period forward so that the fruit ripens in a shorter period of time and earlier than on lightly pruned bushes. Light pruning results in a long season of ripening, small fruit, late harvests, and more fruit per plant.

How to Prune

Prune young plants so as to establish a large bearing area in the shortest possible time. Remove all fruit buds immediately after planting and each year until the third year in the field. Prune moderately heavy at the beginning of the third year in the field to stimulate strong, new growth on selected canes.



Mature highbush plant before (left) and after (right) pruning.

Prune bearing plants so as to have the flower buds well distributed on the plants by wise selection of canes and lateral shoots. Start by making large, shaping cuts. Remove all low-spreading branches and the oldest, weaker canes. Cut back upright "bull shoots." Essentially, you have now automatically selected the remaining, more upright canes to bear next season's and the following season's crop.

On the remaining canes, systematically thin out the shorter, weaker shoots, leaving enough of the thick shoots to bear the crop and provide new growth. Finally, tip back long fruiting shoots to leave four to six buds to ensure adequate fruit size. Fruiting clusters should have enough leaves around them to provide adequate food materials (mostly sugars) for the developing fruit but not enough to overshade the fruit, or to reduce spray or dust coverage, or to hinder harvesting operations.

Blueberries are borne on 1-year-old wood (previous season's growth). Pruning, therefore, regulates not only the current spring's crop but the fruiting potential of the following year. Prune severely enough to strengthen the plant so that sufficient new growth is

produced the next summer for a crop the following spring. Generally, *weak bushes require more severe pruning than vigorous bushes.* Heavy pruning causes thicker and more leafy shoots than light pruning. These thick and late developing shoots tend to set fewer fruit buds than early and weak shoots.

Renewal Pruning (Rejuvenation)

When blueberry bushes are 8 to 10 years old, they are at their productive peak. At this point, renewal growth (new growth arising at or near the ground which later provides the main framework of the bush) has reached a minimum. Production will also decline markedly from year to year unless new growth is stimulated. Before yields decline too much, make some provision either before or at this point to rejuvenate the plant and prolong its productive growth.

To renew old bushes, remove weak or diseased canes entirely. Cut the remaining canes back to a strong lateral or to within 1 foot of the ground. New, lateral branches will usually develop from below the cut. It is from these new shoots that a new bush framework is developed.

This method of renewing old bushes reduces crop yields for 1 or 2 years, but the plants should then bear several more good crops. However, when rejuvenation becomes necessary, consider systematic replanting to newer and better varieties.

Irrigation

Rainfall data have been collected since 1928 from Wilmington, Willard, Southport, Lumberton, and Elizabethtown, North Carolina. On the average, late April, May, and early June are the driest months of the growing season for that section of North Carolina. During May and June, the water use rate (evapotranspiration) is the highest of the year, averaging 0.14 inch per day in May, and 0.17 inch per day in June. Another critical moisture period for blueberries is August and September when bud formation is occurring. Rainfall amounts are normally higher during these months, but long drought periods occur on the average of once every 3 to 4 years. Because of their shallow root system, blueberries require

[1] This section prepared by Dr. R. E. Sneed, Biological and Agricultural Engineering Specialist, N. C. State University.

between 1 and 1¾ inches of water per week during the growing season, either from rainfall or irrigation.

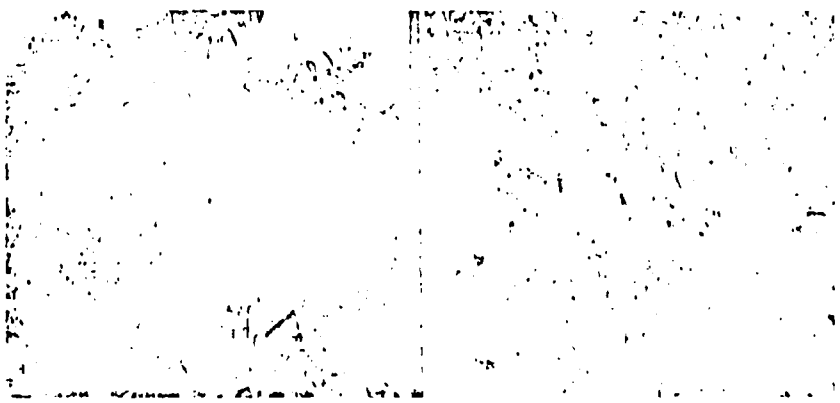
Irrigation is valuable in many ways:

- Higher yields, better quality and larger berries can be obtained.

- Plants can be kept alive during dry weather. Plants that are weakened by dry weather are more subject to disease and insect damage, resulting in increased plant mortality.

- Overhead sprinkler irrigation can be used for frost and freeze protection. An application rate of 0.12 to 0.14 inch per hour begun when the air temperature surrounding the plant is 34°F. will give protection to 23 to 25°F. under conditions of no wind. A special fast rotating sprinkler should be used and the application should be continued until the air temperature outside the field goes above 32°F. and *all ice on the plant has melted.*

  The principle of frost and freeze protection using sprinkler irrigation is that water gives off heat as it freezes. As long as liquid water is applied to the plant at all times during freezing conditions and as the ice melts, blossoms and young fruits will be protected. Be certain of an adequate water supply and reliable irrigation equipment before attempting frost control irrigation. If the application of water stops while ice is on the bush, more damage is likely to occur than if sprinkler irrigation had not been used at all.



Adequate moisture is extremely important. The bush on the left was irrigated. The bush on the right in the same field had died of drought while trying to mature its fruit.

- Plantings can be located on well-drained, more desirable soils, rather than depending on naturally wet or poorly drained soils to carry plants through a drought period. Optimum soil moisture is possible with supplemental irrigation and surface and/or subsurface drainage.

Irrigation Equipment

Blueberries can be irrigated using either portable, solid-set or permanent sprinkler irrigation equipment, self-propelled gun-traveller systems or with drip irrigation. The portable system has above ground aluminum lateral lines which are moved one or more times per day during the irrigation period. The solid-set system uses above ground small diameter aluminum lateral lines and small sprinklers on the entire acreage to be irrigated. The main and supply lines for both of these types of systems may be either above ground or underground.

The permanent system consists of underground laterals and supply lines with only the sprinklers and risers above ground. The self-propelled gun-traveler system is a unit designed to irrigate fairly large areas. It consists of a single gun sprinkler mounted on a four-wheel trailer. Water is supplied by a flexible rubber hose. The unit propels itself through the field. Normally an area from 800 to 1320 feet long and 200 to 320 feet wide is irrigated with each traverse through the field.

Drip irrigation is a relatively new type of irrigation. It consists of hose with external emitters attached to the hose or hose with integral orifices. A line of hose is laid down each row of blueberries. Application rate is very low, on the order of 1.5 to 6.0 gallons per day (gpd) per foot of pipe. The system is operated for several hours daily or every other day depending on plant water need at pressures ranging from 2 to 30 pounds per square inch (psi) pressure.

Clean water is a necessity for drip irrigation and filtration is a major component of the system. The major advantages of drip irrigation are maintenance of a uniform moisture supply to the plant roots, reduced water usage and potentially increased production as compared to other types of irrigation.

The initial cost of the portable sprinkler irrigation system will be less than the permanent system with the solid-set system being intermediate between the portable and permanent. However, the labor cost will be greatest with the portable system. The cost of the

self-propelled gun-traveler system, where the acreage to be irrigated is 40 acres or more, will be about the same to somewhat less than for the portable system. Labor requirements will be low, intermediate between the solid-set and permanent systems. However, operating cost will be higher because of the high operating pressure required. The initial cost of the drip irrigation system will be about the same as that for the portable system. Labor requirements will be low and operating cost will be lower than for any of the other types of systems because of the low operating pressure.

The permanent irrigation system should be considered for young plantings of blueberries because of the potential labor savings during the life of the planting. If there is a need for frost and freeze protection, this protection can only be accomplished with the solid-set and permanent systems which must be designed to operate over the entire area at one time.

Aluminum tubing is the only material recommended for above-ground sprinkler irrigation lines. Below-ground sprinkler irrigation lines will be either polyvinyl chloride (PVC) plastic pipe or asbestos-cement (AC) pipe. For drip irrigation, above-ground lines will normally be low density, high-carbon polyethylene (PE) tubing. Either PVC, AC, or PE pipe can be used below ground.

Medium pressure (40 to 60 psi), medium gallonage (5 to 20 gpm), single or double nozzle sprinklers should be used for portable, solid-set and permanent systems.

Normally, single-nozzle, low-gallonage sprinklers will be used for solid-set and permanent systems. These can be used for both irrigation and frost-and-freeze protection. When operating the system for frost and freeze protection, the pressure at the sprinkler should be 10 to 15 psi higher than for irrigation. The sprinkler used with the self-propelled gun traveler should have a capacity of 150 to 500 gpm operating at 80 to 95 psi.

For the fixed sprinkler systems (portable, solid-set and permanent), sprinklers can be placed in the field on a square, rectangular, or triangular pattern. Spacing between sprinklers and between lateral lines will depend somewhat on average wind conditions, with the spacing decreasing as the average wind speed increases. However, under no conditions with triangular spacings should the distance between laterals and sprinklers exceed 70 percent of the rated sprinkler diameter. For square or rectangular spacings, the distance between laterals and sprinklers should not exceed 60 percent of the rated sprinkler diameter.

The pump to be used will depend on the water source. For surface sources of water, such as impounded ponds, excavated ponds and streams, a straight centrifugal or self-priming centrifugal pump will normally be used. Power may be an air-cooled or water-cooled gasoline engine, diesel engine, or electric motor. For ground water, where the dynamic water level is more than 15 feet below the surface, either a vertical turbine pump or submersible pump will be used.

Harvesting and Sorting

Harvesting of the commercial highbush blueberries begins in mid- to late May in southeastern North Carolina and continues through late June. Peak harvest usually occurs during the first 2 weeks of June.

Rabbiteye blueberries begin ripening in late June and continue into August.

Hand-Harvesting. A particular highbush variety is generally harvested three to four times at approximately weekly intervals. Unless special conditions demand, more frequent harvests are inefficient and less frequent harvests result in overripe berries with a poor shelf life.

Harvest all fully ripe berries so that berries left do not become overripe by the next harvest. Pick the fruit carefully so as not to damage the "bloom" or light blue color of the fruit. Handle the fruit as little as possible when harvesting to minimize bruising and the spread of organisms that cause fruit decay. Do not drop the fruits more than 3 to 4 inches into the picking containers.

A good picker can harvest up to twenty 12-pint flats per day if the crop is heavy and the bushes are of optimum size. In event of a poor crop or tall bushes, this rate could drop to six to eight flats per day. Generally, 10 to 15 pickers per acre are needed during the peak of the season. Pickers are recruited by the grower wherever available. The grower will have to decide how many pickers to recruit based on his acreage, size of bushes, and expected yield. Many growers operate buses to transport pickers to the farm.

Mechanical Harvesting. Over the years, labor has tended to decrease in availability, decrease in quality, and increase in cost. In an attempt to reduce the costs and problems associated with hand harvesting, many growers have turned to mechanical har-

vesters. A single mechanical harvester can replace up to 100 hand pickers. The cost per pound of fruit harvested is usually reduced; however, many new problems have been created by mechanical harvesting.

Mechanical harvesters detach berries by vibrating the bush. The vibration principle of harvesting is generally successful because green berries are attached to the bush more securely than ripe berries. Careful machine adjustment makes possible the removal of a high percentage of the ripe fruit, while most of the green fruits remain on the bush to ripen for a future harvest. However, removal of green fruit is a serious problem early in the harvest season and on varieties with tight fruit clusters. The use of hand labor to remove first-ripened berries on the bush is often a means of reducing the loss of green fruit during the first machine harvest.

Machines harvest overripe, shriveled, soft, diseased, insect and bird-damaged, green, or other fruit that a good hand picker would normally drop on the ground or leave on the bush. Overripe and damaged fruits, when mixed with high-quality fruits, are difficult to sort. Hand-harvested fruit has traditionally been picked from the bush and placed directly into pint cups. No additional direct handling of the fruit was necessary. Much more handling is required with mechanical harvesting. Bruising occurs each time a berry is dropped, squeezed, or rubbed. Keeping quality (shelf life) of the fruit is reduced in proportion to the severity of the bruise. In the mechanical harvesting and sorting operation, bruising can occur at any of the following operational steps:

- Fruit-machine contacts during detachment.
- Impacts with branches and catcher.
- Rubbing and bumping on the harvester conveyor.
- Drop from harvester to field box.
- Dumping of fruit from field boxes onto the air-blast sorter conveyor.
- Bouncing over the air blast.
- Rolling onto the inspection belt.
- Contacts with sorter's hands on inspection belt.
- Drop from inspection belt into pint cup.

The following measures will help reduce bruising:

- Harvest during cool periods of the day (morning or evening).

- Avoid excessive bush impacts and vibration. Adjust machine vibration to the minimum level required to remove ripe fruit.
- Minimize distance of drop from harvester to field container.
- Do not fill field containers to a depth of more than 4 to 5 inches and do not level the berries in the containers with the hands.
- Use a softly suspended trailer or truck to reduce bruising on the way to the packing house.
- Handle and dump field containers gently.
- Limit fruit depth to 2 inches on the feed conveyor of the air-blast cleaner.
- Adjust the air volume of the air-blast cleaner to avoid lifting and dropping ripe fruit more than 1 inch.
- Do not allow individuals operating the inspection belt to rub or squeeze the fruit.
- Minimize the distance of drop from the inspection belt to the shipping container.

Research workers are investigating many methods of reducing the amount of bruising and fruit damage that occurs as the result of mechanical harvesting and sorting. Catching and handling the fruit in water is one method that affords an improvement. The use of light to measure blue pigments (which increase as fruit ripens) is a reliable method for detecting overripe fruit. Fungicides and hot water treatments have reduced the decay of fruit. If a method for removing bruised fruit can be developed, the quality of machine-harvested fruit for fresh market sales will be greatly improved. Although mechanical harvesting and packaging equipment is expensive, every grower should become familiar and keep pace with developments in mechanization. He should use such developments in his enterprise when and where they will make his operation more efficient.

Sanitation. Remind employees that they are handling a food product. Demand cleanliness and sanitary habits among workers that come in contact with the fruit. Constant supervision of the harvesting and packaging operation is required to ensure a wholesome and high-quality product.

Many opportunities for fruit contamination occur during me-

chanical harvesting and sorting. Juice from overripe, bruised and split fruits leaks onto other fruits, the harvester, field containers, and the sorting equipment. Decay-causing spores from diseased berries contaminate the juice. Every healthy berry that comes in contact with the contaminated juice on berries or equipment surfaces will also be infected with the decay-causing organism. Any equipment or containers that come in contact with the fruit must be kept clean. Harvesters should be cleaned at least twice a day and sorting equipment much more often. A solution of 10 percent laundry bleach (5 to 6 percent sodium hypochlorite) in water will disinfect the equipment and containers.

Prevention of infection through proper sanitation is an effective method for controlling fruit decay. Once infection has occurred, the fungus grows into the fruit very rapidly and begins breaking down the fruit tissue. A fungus cannot be reached by chemical dusts or sprays after it has entered the fruit. Any treatment drastic enough to destroy a fungus within the fruit usually will also destroy the fruit.

Refrigeration. Cooling the fruit after harvest retains quality and prolongs shelf life. Cool as quickly as possible to 40° F. or lower, but not below 32° F. If cooled promptly and *kept cool*, quality blueberries packaged ready for retail sale can be expected to hold up well at 32° F. for 2 weeks and at 40° F. for 1 week, but only 2 days at 70° F.

As is common for most fruit crops, mechanically harvested blueberries to date have been accepted much more readily by processors than by fresh-marketing outlets. Only by carefully observing the recommendations just mentioned for regulated operation of mechanical harvesters, handling, sorting, sanitation, and disease control can consideration be given to sending mechanically harvested blueberries to the fresh market.

Diseases, Mites and Insects

Diseases and insects are problems wherever blueberries are grown. Injury caused by mites is also important in the southeastern United States. All commercial growers should follow a rigid spray program beginning in early spring and continuing until fall.

In North Carolina the most destructive diseases of highbush blueberry are stem canker, stem blight, stunt, and foliage disease.

Refer to N.C. Extension Circular 466, *Blueberry Diseases in North Carolina*, for descriptions and control measures of these and other blueberry diseases.

Generally, rabbiteye varieties are more resistant to diseases and insects than highbush varieties. As more plantings of the rabbiteye type are made, the need for pest control measures will probably increase.

The blueberry bud mite is a major pest in North Carolina. Feeding by large numbers of this mite results in failure of buds to grow in the spring, thereby reducing fruit yield. Insects causing direct damage to blueberry fruit are the blueberry maggot, plum curculio, cranberry fruitworm, and cherry fruitworm. Insects that attack the buds, leaves, stems, crowns and roots include caterpillars, beetles, sawflies, leafhoppers (that spread stunt), scale insects (that weaken the plant), stem borers, rootworms and crown girdlers (that may completely kill the plant), and even termites (that sometimes attack weakened plants). Refer to Experiment Station Bulletin 427 (Revised) *Insect and Mite Pests of Blueberry in North Carolina*, for description and control measures of these and other blueberry insects.

The blueberry grower should plan to protect his plants by becoming familiar with and learning the control measures against all these pests.

Each year the Entomology and Plant Pathology departments, N. C. State University, review recent research and demonstrational work and publish current insect and disease control recommendations. These spray schedules are available from both N. C. State University and the local agricultural Extension office in each county.

Conclusion

There is usually something challenging about growing a new crop. Many people have been tempted to grow blueberries who did not have proper growing conditions available. Blueberry growing, especially highbush varieties, is highly specialized, demanding very exact soil, moisture, and climatic conditions. Prospective growers should acquire all available information before attempting to grow blueberries. Consult successful growers, experiment stations, and agricultural extension agents for advice before planting. After you have decided to plant, use this information wisely.

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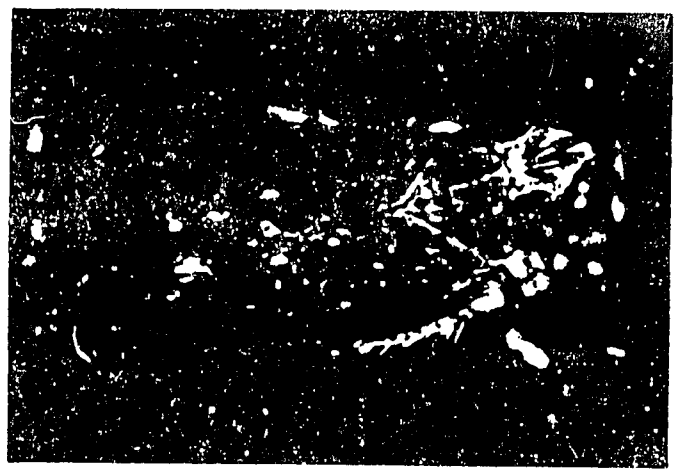
Diseases and Arthropod Pests of Blueberries



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North Carolina State University
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Diseases and Arthropod Pests of Blueberries

Introduction

Blueberries (*Vaccinium* spp.) are native American plants valued both for their delicately flavored fruit and for their ornamental qualities. At least 10 different species are grown for fruit in various parts of the United States and several others are cultivated as ornamentals. Most of the blueberry acreage in North Carolina is devoted to fruit production; highbush blueberries (*V. australe* Small and *V. corymbosum* L.) are the principal species, but there is growing interest in rabbiteye blueberries (*V. ashei* Reade) among commercial producers, nurserymen, and home gardeners.

Blueberry growers face many challenges in producing high quality fruit. Diseases and insects are a constant threat, affecting appearance and yield of the fruit as well as health and vigor of the plants. Successful control of these pests is an unending task which demands a combination of good cultural practices, carefully timed applications of pesticides, and a thorough knowledge of the pest's biology and seasonal development.

The information presented in this publication will help growers (both private and commercial) identify blueberry pests, recognize the conditions that may damage their crop, and understand what must be done to minimize losses.

Blueberry Diseases

Blueberry diseases and their control are a major concern of commercial growers and home gardeners alike. Blueberries are affected by several diseases; however, their severity and economic importance vary from one blueberry growing region to another. Only those diseases that are considered to be of economic importance in commercial highbush and rabbiteye plants will be discussed.

Fungus diseases such as stem canker (*Botrosphaeria corticis*), and stem blight (*B. dothidea*) are very prevalent and destructive in the southeastern United States, but are of little or no importance in most northern areas. Godronia canker caused by the fungus *Godronia cassandrae* is important in British Columbia, Michigan, Maine, Massachusetts, and Nova Scotia, but not in southern blueberry plantings.

Symptoms produced by a pathogen also can vary from region to region. *Phomopsis vaccinii* causes a stem canker on highbush blueberry in Michigan and twig blight in North Carolina. Some fungi may affect one species of blueberry but not another (e.g. stem blotch occurs only on rabbiteye blueberry). Losses from blueberry diseases vary from season to season and with the susceptibility of the cultivar. Rabbiteye blueberry plants grown in home plantings of the southeast are generally less affected by diseases than highbush blueberry plants; however, commercial plantings of rabbiteye blueberry have been severely affected by several diseases.

A list of diseases, their causes, and their relative importance on highbush and rabbiteye blueberry in North Carolina is given in Table 1.

Stem Canker

Importance: Botryosphaeria canker is a major factor limiting the production of blueberries in southeastern United States. It occurs on cultivated and wild highbush blueberries and on the wild rabbiteye blueberry in North Carolina, Georgia, Florida, Alabama, and Mississippi. The use of infected wood for propagation has contributed to the increased importance of this disease. Disease incidence is often so great that new plantings are either severely reduced in productivity or entirely destroyed before they come into full production.

Causal Agent: ***Botryosphaeria corticis.*** Both perithecia and pycnidia are produced in stem cankers (Taylor, 1958). The perithecia average 280 μm high and 200 μm wide containing 8-spored, clavate, bitunicate asci with apically thickened filamentous pseudoparaphyses; the spores are hyaline, ellipsoid to fusoid, continuous, 24 to 37 μm by 9.6 to 16 μm. The pycnidia average 118 μm high and 82 μm wide. Conidia are fusiform, elliptical, hyaline, and average 25 by 9 μm.

There are at least six pathogenic races of *B. corticis* with race 1 being the most prevalent in North Carolina in 1969

(Milholland and Galletta 1969). Only race 6 has been isolated from stem cankers on rabbiteye from a commercial planting of rabbiteye blueberry (Tifblue cv.) in North Carolina and Georgia. Race 4 was initially isolated from wild *Vaccinium* spp. in North Carolina, and is the most virulent of the six races. Most cultivars grown in North Carolina are susceptible to race 4; however, race 4 is not widespread in North Carolina commercial blueberry plantings.

Symptoms and Disease Development: Several stem diseases may be confused with certain stages of stem canker. Infection of stems in the spring is by ascospores and conidia that are released during wet weather and disseminated by wind from April through September (Taylor 1958). The young and actively growing shoots are more susceptible to infection than are the older stems. The infection process, spore germination, penetration, and establishment of *B. corticis* in blueberry stems occurs rapidly; however, the development of the disease is a relatively slow process. The fungus penetrates the stem only through open stomata. Canker symptoms first appear as small, red lesions on succulent shoots. Stem lesions slowly enlarge and become swollen within 4 to 6 months after infection (Plate 1A). Cankers enlarge through increased cell numbers. As the fungus continues to grow and invade the wood, large cankers with deep fissures and cracks develop on susceptible cultivars and the stem finally becomes girdled, weakened, and eventually dies (Plate 1B). Cankers are scattered and restricted in size or absent on the more resistant cultivars. The susceptibility of the major cultivars grown in North Carolina to the prevalent races of *B. corticis* is presented in Table 2.

Godronia Canker

Importance: Godronia canker has been found on highbush blueberry in Quebec, British Columbia, Nova Scotia, Massachusetts, Michigan, New Brunswick and Maine, but has not been reported to occur on highbush cultivars in North Carolina or on rabbiteye cultivars in the southeastern United States. The disease generally kills one or two branches on a bush, but may kill the entire plant. The disease is an important factor in reducing yield and vigor of blueberries grown in the northern regions (Weingartner and Klos, 1975).

Causal Agent: *Godronia cassandrae (Fusicoccum putrefaciens).* The apothecial stage is found on old prunings and pruning stubs. The asci are cylindrical and measure 96 to 118 by 4 to 6 μm. Ascospores are filiform, septate, and measure 51 to 68 by 1.6 to 2.2 μm. Pycnidia are subglobose to pyriform, brownish, sessile or subsessile and embedded initially but erumpent when mature. Conidia are elliptic to fusiform, hyaline, continuous or pseudoseptate and measure 8 to 19 by 2 μm.

Symptoms and Disease Development: Symptoms first appear in the spring on 1- to 2-year-old stems as dark-red, circular to elliptical lesions. Lesions enlarge and eventually girdle the stem. Lesions most often develop around a leaf

Table 1. Blueberry diseases: Common name, cause, and relative importance to highbush and rabbiteye in N.C.

Disease	Causal Agent	Relative Importance in North Carolina	
		Highbush	Rabbiteye
Stem Canker	*Botryosphaeria corticis*	+++	++
Godronia Canker	*Godronia cassandrae*	—	—
Stem Blight	*Botryosphaeria dothidea*	+++	++
Mummy Berry	*Monilinia vaccinii-corymbosi*	++	++
Twig Blight	*Phomopsis vaccinii*	++	++
Ripe Rot	*Glomerella cingulata*	++	+
Stunt	Mycoplasma	+++	+
Root Rot	*Phytophthora cinnamomi*	+	—
Gloeosporium Leaf Spot	*Gloeosporium minus*	++	+
Septoria Leaf Spot	*Septoria albopunctata*	+	+
Double Spot	*Dothichiza caroliniana*	+	—
Gloeocercospora Leaf Spot	*Gloeocercospora inconspicua*	+	+
Alternaria Leaf Spot	*Alternaria tenuissima*	+	—
Powdery Mildew	*Microsphaera alni*	+	+
Stem Blotch	*Cercospora* spp.	—	++
Botrytis Blight	*Botrytis cinerea*	+	+
Root-Knot	*Meloidogyne carolinesis*	+	—
Red Ringspot	Virus	—	—
Mosaic	Virus	+	—
Necrotic Ringspot	Virus	+	—
Shoestring	Virus	+	—

Table 2. Relative susceptibility of the major blueberry cultivars grown in North Carolina to stem canker and other important diseases.

Cultivar	Stem canker races[a] 1	4	6	Twig Blight	Mummy Berry	Ripe Rot	Stem Blight	Stunt
Murphy	R	R	R[b]	VS	S	S	S	S
Croatan	R	S	R	S	VS	VS	VS	S
Wolcott	S	S	S	S	R	R	S	S
Harrison	R	S	—	VS	S	VS	VS	S
Jersey	S	R	S	S	S	S	S	S
Bluechip	R	S	—	S	S	S	VS	S
Morrow	R	R	S	S	S	R	S	S
Rabbiteye	R	S	S	S	VS	S	S	S

[a]Races 1, 4 and 6 of *B. cortis* are the most prevalent in North Carolina.
[b]R=resistant; S=susceptible; VS=very susceptible.

scar. The canker may appear in a "bull's eye" pattern around the locus of infection (Plate 1C). During periods of warm, dry weather, stems may wilt and die. Numerous pycnidia develop within the cankers, and spores are released during rainy periods in the spring and early summer.

Stem Blight

Importance: The incidence of stem blight in North Carolina highbush blueberry plantings increased from 9 percent in 1959 to 17 percent in 1975. Wounding of blueberry stems by mechanical harvesters has contributed to this increase in stem blight incidence, since infection of blueberry stems by the stem blight fungus takes place primarily through wounds. This disease has not been reported to occur in the northern blueberry regions.

Causal Agent: ***Botryosphaeria dothidea.*** The perithecia and pycnidia are scattered, subepidermal, becoming erumpent at maturity (Witcher and Clayton 1962). Ascospores are oblong to fusoid, hyaline, continuous, and measure 18 to 22 by 8 to 11 μm. Conidia are hyaline, continuous, ovate to broadly ellipsoid, 16 to 22 by 6 to 7 μm.

Symptoms and Disease Development: Infection of blueberry stems by *B. dothidea* results from both wounded and unwounded inoculations (Milholland, 1972). Mode of penetration and stage of plant development influences both the type and extent of disease development. Penetration of stems by the fungus through open stomata results in small raised lesions that fail to develop further. Infection of succulent stems through wounds results in a rapid breakdown of all tissues. Infection in older plants usually results in the loss of one or more branches and not the entire plant.

In an early stage of infection, characteristic symptoms are yellowing, reddening, or drying of leaves on one or more shoots. The most conspicuous symptom of stem blight is a dead branch among living branches (Plate 1D). When affected branches are cut, they show a brown discoloration of the woody tissues (Plate 1E). This discolored stem tissue may extend from a few inches to the entire length of the stem. The highest mortality rate occurs with younger plants when infection develops at or near the crown (Plate 1F). Infections near the tip of twigs may be confused with winter injury and certain twig blight diseases. This is particularly true on rabbiteye cultivars.

Mummy Berry

Importance: Mummy berry is of major importance in the northern and southern highbush blueberry regions, where it causes considerable damage to the fruit (Batra, 1983; Milholland, 1974; Ramsdell et al, 1976). In addition, severe blighting of the leaves, shoots and flower buds of rabbiteye cultivars Delite, Southland, and Tifblue have occurred in North Carolina plantings.

Causal Agent: ***Monilinia vaccinii-corymbosi.*** The overwintering structure is a sclerotium that is composed of an outer rind of melanized thick-walled cells cemented together by a thick gelatinous deposit and a medulla of loosely arranged hyphae embedded in a dense matrix (Milholland, 1976). Several apothecia may be produced from a single sclerotium. Ascospores are oval to elliptical in shape, binucleate, and measure 12 to 15 by 5 to 7 μm. Large macroconidia measuring 15 to 25 by 12 to 20 μm are produced in chains on short, club-shaped conidiophores. Conidia may be connected by small disjunctors (2-3 μm long) that help to separate the mature conidia.

Symptoms and Disease Development: In early spring, small cup-shaped spore-bearing structures called apothecia are produced from sclerotia (Plate 1G). In southeastern North Carolina, overwintered sclerotia break dormancy around the first week in February and develop mature apothecia about one month later (Milholland, 1974). Spores (ascospores) produced by the apothecia are liberated during cool, wet weather and are carried by air currents to the young emerging leaves. Secondary spores (conidia) are produced in great abundance on the blighted leaves and are

carried by wind or insects to open flowers where the ovaries become infected (Plate 1H). Prior to harvest, infected berries become light cream-color rather than normal blue (Plate 1I) and drop to the ground and form overwintering sclerotia (Fig. 1).

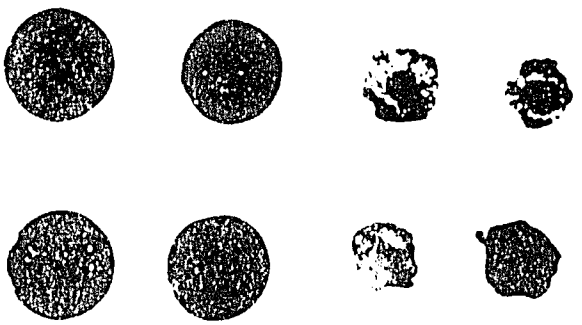


Figure 1. Healthy fruit (left) and overwintering sclerotia (right).

Twig Blight

Importance: The prevalence and severity of Phomopsis twig blight has increased tremendously over the past 10 years and is now considered a disease of major importance in North Carolina (Milholland, 1972; Wilcox, 1939). Twig blight can be found in almost every blueberry planting in North Carolina with disease incidence in individual plantings ranging from 1 to 50 percent. Fruit loss from twig blight infections can amount to 3 pints of berries per plant when plants are not sprayed with an effective fungicide.

Causal Agent: ***Phomopsis vaccinii.*** Pycnidia are dark, ostiolate, immersed, erumpent, nearly globose with two types of conidia. Alpha conidia are hyaline, 1-celled, ovate to fusoid measuring 7 to 9 x 3 to 5 μm. Beta conidia are hyaline, 1-celled, filiform, curved or bent measuring 12 to 18 by 0.8 μm. The ascomycetous stage of *P. vaccinii* is *Diaporthe vaccinii* (Wilcox, 1940).

Symptoms and Disease Development: The fungus overwinters in twigs infected the previous year and conidia are disseminated from late February to early August in North Carolina (Milholland 1982). The greatest number of conidia are released from overwintered twig blight lesions during the early part of the growing season from blossom budbreak through bloom. Conidia from current season infection are disseminated from the end of May through July in North Carolina. Blueberry twig blight develops from infections of flower buds at bud break through bloom. The open flower buds not only act as a trap for rain-dispersed conidia but also provide the fungus with an entrance into the vascular tissue of the stem. Penetration of unwounded succulent stems results in small, raised lesions that fail to develop further. Twig blight lesions range from 50 to 150 mm in length with an average of six buds killed per twig (Plate 2A). The entire stem is not killed.

In southern Michigan and northern Indiana, the fungus causes a serious canker disease of highbush blueberry (Parker and Ramsdell 1977, Weingartner and Klos 1975). Cankers are long and narrow and often covered with bark or epidermis. Leaves often turn yellow-red before they wilt, and wilted stems exhibit a brown discoloration in the xylem tissue. Most cankers develop in the upper portion of the plant. The entire plant may be killed.

Phomopsis vaccinii also causes a fruit rot of blueberry at harvest in North Carolina (Milholland and Daykin 1983). The fungus apparently penetrates the fruit at all stages of development and remains latent until fruit maturation. Infected fruit are typically soft and often split resulting in leakage of juice. The infected fleshy tissue is reddish brown and watery.

Ripe Rot (Anthracnose Fruit Rot)

Importance: The common name for this disease, "Ripe Rot", is used instead of anthracnose fruit rot because it is more descriptive of the disease and its development on blueberry fruit. This disease can be a serious problem in the northern and southern blueberry growing regions (Varney and Stretch 1966). Its importance varies with the cultivar and the season. In North Carolina, ripe rot of blueberry has increased in prevalence and severity and is now considered a major disease. The introduction of susceptible new cultivars and the lack of effective control measures are the primary reasons for this increase in occurrence of what was once a disease of minor importance.

Causal Agent: ***Glomerella cingulata (Colletotrichum gloeosporioides).*** The conidia are hyaline, oblong or cylindrical, some slightly curved and measure 10 to 28 by 4 to 7 μm. A mass of sticky salmon-colored conidia are exuded from the acervuli. Perithecia are subspherical, asci subclavate, 55 x 70 μm; ascospores 12 to 22 by 3 to 5 μm.

Symptoms and Disease Development: The fungus survives the winter in blighted twigs. Conidia are released from blighted twigs throughout the growing season during rainy periods to initiate latent infections on immature green fruit (Hartung et al, 1981). These fruit remain symptomless until maturity. At harvest or soon after, the infected fruit rapidly decay and exude large masses of spores capable of starting new infections (Plate 2B). The fungus is primarily a fruit rotter, but leaf infections can occur. Leaf infections vary from small brown circular to irregular-shaped lesions to large, black, poorly defined necrotic lesions (Fig. 2). Losses in North Carolina from preharvest rots caused by *C. gloeosporioides* are estimated at 3-5 percent while losses from postharvest decays are probably much higher.

Stunt

Importance: Stunt is a serious and widespread disease of blueberry (Demaree 1946; Varney 1977). The disease has been found in most blueberry plantings in southeastern North Carolina and has been reported to occur in New Jer-

Figure 2. Leaf symptoms caused by *Colletotrichum gloeosporioides*.

Figure 3. Blueberry plant severely affected by stunt. Shortening of internodes gives branches a bushy appearance.

sey, Michigan, Massachusetts and New York. All of the major cultivars grown in North Carolina are susceptible; however, some are more severely affected than others.

Causal Agent: Mycoplasma. The morphology of this microorgnism is similar to those observed in yellows-infected plants (Chen 1971). The mycoplasmalike bodies are located in the sieve tube elements of the vascular tissue, and their shape ranges from spherical to oval to irregular. Their size ranges from 160 to 700 nm.

Symptoms and Disease Development: The stunt organism overwinters in the vascular tissue of infected stems and roots. When leaf symptoms become apparent in early spring, the mycoplasmalike bodies increase in number in the sieve tubes of the leaves with yellowing along the margins and between lateral veins and reduced plant vigor (Plate 2 C). Shortened internodes give the young branches a bushy appearance (Fig. 3). In late summer or early fall, the chlorotic areas in leaves redden brillantly. Fruit on infected plants never develop normal sugar content and ripen late or not at all. The causal agent is transmitted in the field by the sharpnosed leafhopper (*Scaphytopius magdalensis*) and by cuttings taken from stunt-infected plants.

Phytophthora Root Rot

Importance: Most highbush cultivars are susceptible to root rot; however, the disease is normally of minor importance unless plants are grown in wet soils brought about by poor drainage (Milholland and Galletta 1967). Rabbiteye cultivars are more tolerant to Phytophthora root rot.

Causal Agent: *Phytophthora cinnamomi*. Sporangia are nonpapillate, measuring 19 to 60 by 14 to 62 μm (avg. 43 x 35 μm). Chlamydospores are thick-walled, globose to pyriform, and measure 31 to 50 μm in diameter; oospores range from 31 to 42 μm in diameter; biflagellate zoospores measure 10 to 11 μm in diameter. Zoospore germination, appressoria formation and penetration of root tissue is usually completed within 4 hours at 25 C. Appressoria measure 7 to 8 μm in diameter and develop immediately after germination or after extensive growth by the germ tube. Hyphae grow intracellularly within the root and measure 2 to 3 μm in diameter.

Symptom and Disease Development: The infection process, zoospore germination, penetration and establishment of the fungus in blueberry roots, occurs rapidly (Milholland 1975). In highly susceptible highbush blueberry rootlets, the fungus penetrates the epidermis and invades the vascular tissue within 24 hours. Infection of highbush blueberry roots by large masses of hyphae results in the collapsing of epidermal cells followed by disorganization of the cortex.

Early symptoms include yellowing of leaves with some burning of the margins, killing of roots and lack of new growth. As the disease progresses, terminal leaves become small, and excessive defoliation occurs because of severely damaged roots (Fig. 4). The fungus is soilborne and root infection is favored by abundant soil moisture.

Figure 4. Phytophthora root rot. Healthy (left), and infected (right).

PLATE 1

A. Stem canker lesions caused by *Botryosphaeria corticis* 6 months after infection.

B. Stem canker development on susceptible cultivar 3-4 years after infection.

C. Godronia canker caused by *Godronia cassandrae*. (Photo by D. P. Weingartner.)

D. Blueberry stem blight caused by *Botryosphaeria dothidea*. The most conspicuous symptom of stem blight on older bushes is a dead branch among living branches.

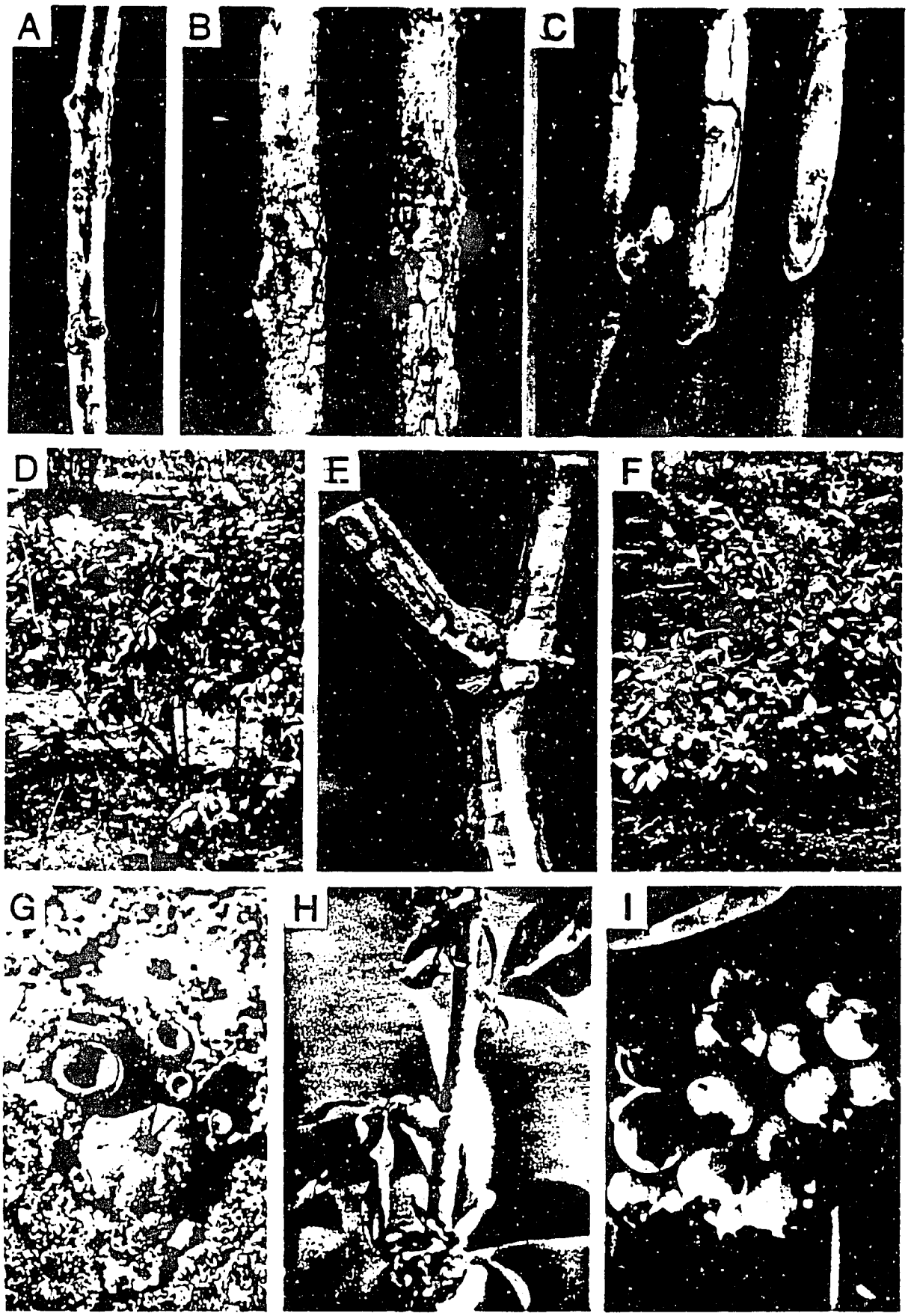
E. Blueberry stem blight. Discolored area in blighted stem marking the extent of infection.

F. Stem blight symptoms on young bush with characteristic yellowing and reddening of leaves. Leaves usually remain attached.

G. Mature apothecia produced from overwintered sclerotium of *Monilinia vaccinii-corymbosi*.

H. Blighted leaves resulting from ascospore infection by *Monilinia vaccinii-corymbosi*. Note white mass of secondary spores (conidia).

I. Mummy berry disease showing infected berry (light cream color) and healthy berry (blue).


A
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Gloeosporium Leaf Spot

Importance: Leaf spot diseases can cause considerable damage each year in North Carolina. Most commercial blueberry plantings in eastern North Carolina are affected with Gloeosporium leaf spot which can cause severe defoliation and reduction in yield (Milholland 1970).

Causal Agent: ***Gloeosporium minus.*** The acervuli are subepidermal, extruding a mass of hyaline, oblong, elliptical conidia measuring 6 to 9 by 3 to 4 μm. The conidiophores are simple and are borne on the surface of the area exposed by rupture of the epidermis, and along the vertical sides of the acervuli.

Symptoms and Disease Development: Gloeosporium leaf spot was first described as a stem and leaf fleck disease of blueberry (Taylor and Clayton 1959). Symptoms first appear as small reddish flecks on young leaves and stems of succulent shoots. Leaf flecks do not develop further, and cause enlarging leaves to become puckered and malformed. Large brown lesions are the characteristic symptoms in the field (Plate 2 D). Development of the large anthracnose lesions results primarily from infection through hydathodes at the margins of the leaf, and to a lesser extent through wounds. Numerous acervuli develop on both sides of the lesion.

Stem lesions develop from leaf infections by growing through the petiole into the stem, and from bud infections late in the season. Stem lesions first appear on current season's growth as dark red circular to elliptical lesions around leaf scars (Plate 2E). As the lesions enlarge, the affected stems turn brown and eventually become gray and die. On highly susceptible cultivars such as Jersey, the disease results in severe dieback, measuring up to 20 inches (Milholland 1974). Numerous acervuli are produced over the entire lesion.

Septoria Leaf Spot

Importance: Septoria leaf spot is prevalent on most of the cultivated highbush and rabbiteye blueberry cultivars grown in North Carolina (Demaree and Wilcox 1947). Damage is most serious in rooting beds, causing severe defoliation and poor growth.

Causal Agent: ***Septoria albopunctata.*** The fruiting body is a well developed pycnidium on the upper leaf surface. The pycnidia are ovoid and average 118 by 90 μm. The pycnospores are hyaline, straight or curved, 5 to 11 septate, filiform, obclavate to spindle-shaped, and measure 42 to 96 by 3 to 5 μm.

Symptoms and Disease Development: The fungus overwinters in infected leaves on the ground and in stem lesions. Spores are produced in abundance on new lesions throughout the season with heaviest infection occurring between June and September. Spots on leaves are usually small with a white to tan center and a purple border (Plate 2F). Stem lesions are flat or slightly sunken with a tan to gray center and a reddish brown margin. Stem lesions and leaf spots are most severe on small plants or on the lower parts of large plants.

Double Spot *(Dothichiza caroliniana)*

This leaf spot is initially 1 to 4 mm in diameter and light to dark brown in color (Demaree and Wilcox 1947; Taylor and Clayton 1959). In late summer, the fungus develops a secondary necrotic area around the original lesion spreading in an irregular to fanshaped pattern. The dark border surrounding the original lesion persists and the large necrotic area surrounds or is to one side of the original lesion (Fig. 5). The number of pycnidia varies from one to five per lesion. Pycnidia occur primarily on the upper leaf surface and within the confines of the original lesion.

Pycnidia are subepidermal, erumpent, black, conical to irregular, nonostiolate, and measure 80 to 130 by 48 to 95 μm. The conidia are hyaline, obtuse, and 7.0 by 2.2 μm.

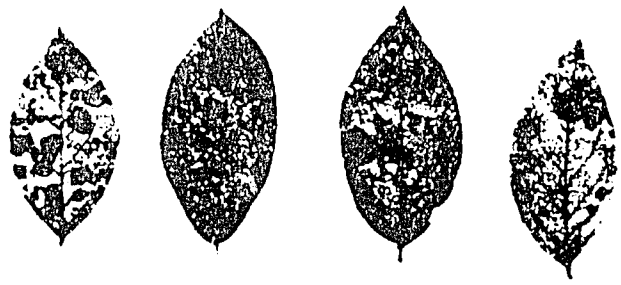


Figure 5. Leaf symptoms caused by *Dothichiza caroliniana* (Double spot).

Gloeocercospora Leaf Spot *(Gloeocercospora inconspicua)*

The disease appears on the foliage by mid-summer as large dark brown, circular to angular lesions surrounded by a dark border (Demaree and Wilcox, 1947) (Plate 2G). Spores usually form on the lower leaf surface. The sporodochia are slightly embedded in the epidermis and measure from 40 to 90 μm wide and 36 to 60 μm high. Conidia are hyaline, usually curved, septate, and about 35 μm long and 3 μm wide.

Alternaria Leaf Spot *(Alternaria tenuissima)*

Alternaria leaf spot occurs primarily in the spring during prolonged periods of cool wet weather, when spores are produced in abundance (Milholland 1973). In most cases only lower leaves are affected; however, instances do occur when severe infection completely defoliates the plant. Because of its importance as a postharvest fruit decay organism, an increase of the fungus on blueberry leaves in May can result in considerable damage to fruit after harvest (Fig. 6). Leaf symptoms appear as circular to irregular-shaped brown to gray lesions surrounded by a red border. Prolonged periods of high humidity favor disease development.

Figure 6. Post harvest fruit decay caused by *Alternaria* spp.

Powdery Mildew *(Microsphaera alni)*

Mildew usually does not develop on blueberry leaves until midsummer after the crop is harvested. The disease may appear as a white fungus growth on the upper leaf surface of some cultivars, or it may be indistinct and confined to the lower leaf surface (Varney and Stretch 1966). Chlorotic spots with reddish borders are common on the leaf surface and may be mistaken for symptoms caused by the red ringspot virus.

Stem Blotch *(Cercospora* sp.)

Symptoms of stem blotch appear as light to dark red discolorations on previous season's growth (Milholland 1977). Lesions do not conform to any particular shape or size but occur as a blotching of the stem (Plate 2H). Only rabbiteye cultivars are affected by this disease. Conidia are hyaline, obclavate-cylindrical, straight to slightly curved, with obconic-truncate base and subacute tip; septations are indistinct in many spores. Conidia with 3 to 8 septa measure 35 to 90 by 1.5 to 3.0 μm.

Botrytis Blight (*Botrytis cinerea*)

This disease is of minor importance in North Carolina but can be a serious problem in the Pacific Northwest (Varney and Stretch 1966). Under conditions of high humidity and cool temperatures, the fungus can infect blossoms, twigs, and fruit causing serious damage. The fungus is capable of living as a saprophyte, producing tremendous numbers of spores that are carried by wind to susceptible blueberry tissue. Symptoms of winter injury can be easily mistaken for blossom or twig blight. Blighted blossoms and twigs turn brown and an abundance of mycelium and spores are produced on the dead tissue. Preharvest rot caused by *Botrytis cinerea* is of little or no importance in North Carolina, however, postharvest decay by this fungus can be of major importance.

Root-Knot Nematode (*Meloidogyne carolinesis*)

The blueberry root knot nematode has been found in several cultivated highbush blueberry plantings in North Carolina. The nematode causes small galls on the roots of several blueberry cultivars resulting in stunting of plants. The blueberry root knot nematode is not the same species that commonly occurs on many other crop plants (Eisenback, 1983). The nematode was found in 24 of 63 North Carolina commercial blueberry plantings sampled in 1967 and is probably indigenous to that state.

Red Ringspot (Virus)

This disease is of minor importance in North Carolina, but it is a problem in New Jersey and has spread to other areas on diseased plants (Varney and Stretch 1966, Varney 1977). Symptoms of red ringspot are distinct red spots and rings, and oak-leaf patterns that first develop on older leaves (Plate 2I). Symptoms occur only on the upper leaf surface, and may or may not develop on the stem. Differences in cultivar susceptibility range from apparent immunity (Jersey) to very susceptible (Darrow and Burlington). Berries produced on infected cultivars are small, often deformed, and ripen late. On some cultivars (Darrow), the berries may develop blotches and rings before stem and leaf symptoms appear.

Mosaic (Virus)

Mosaic occurs in many commercial blueberry plantings (Varney and Stretch 1966, Varney 1977). Affected leaves are mottled with yellow and yellow-green areas. The degree of mottling will vary with cultivar and leaf position on the plant. Lower leaves may be mottled while the upper leaves show no symptoms.

Necrotic Ringspot (Virus)

Symptoms caused by this virus are stunting, twig dieback, and chlorotic spots and rings on new leaves (Varney and Stretch 1966, Varney 1977). Severe leaf infections may result in reduced leaf size and distortion.

Shoestring (Virus)

Leaves, twigs, flowers and fruit are affected by this virus disease (Varney and Stretch 1966, Varney 1977). Affected leaves are narrow, wavy and often distorted, and are usually found at the base of the bush. Red streaks or blotches may be present on affected twigs. Flowers on affected twigs may be deformed, and immature fruit develop a red to purple cast on part or all of the upper half of the berry. Shoestring is a serious virus disease of blueberry in Michigan.

PLATE 2

A. Phomopsis twig blight caused by *Phomopsis vaccinii.*

B. Ripe rot (anthracnose fruit rot) caused by *Colletotrichum gloeosporioides.* Note orange-colored spores on infected fruit.

C. Blueberry stunt. Characteristic symptoms are small leaves with yellowing along the margins and between lateral veins, and shortening of internodes.

D. Gloeosporium leaf spot caused by *Gloeosporium minus.*

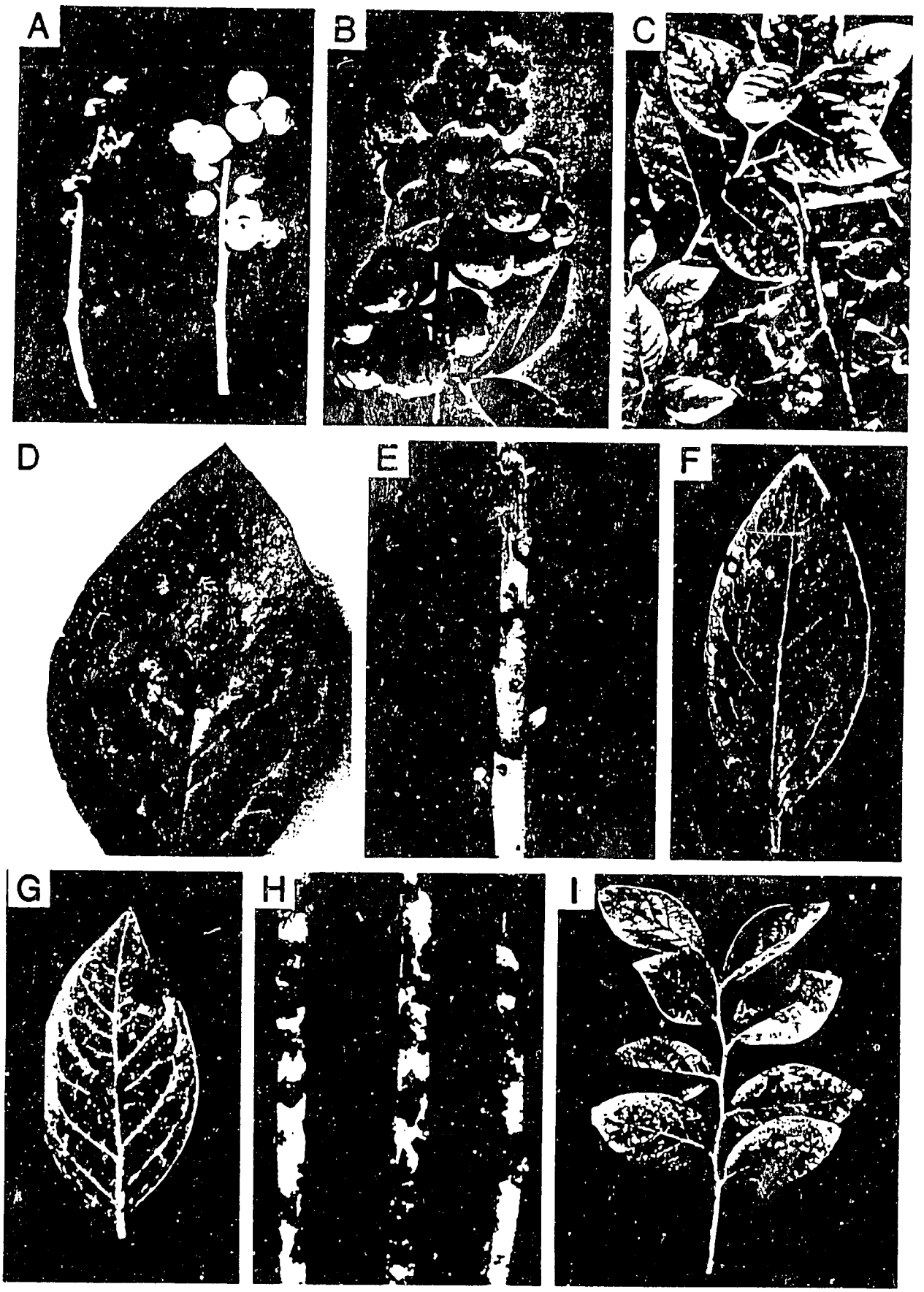
E. Gloeosporium canker and dieback caused by *Gloeosporium minus.*

F. Septoria leaf spot caused by *Septoria albopunctata.*

G. *Gloeocercospora leaf spot caused by G. inconspicua.*

H. Stem Blotch disease of rabbiteye blueberry caused by *Cercospora* spp.

I. Red ringspot disease. Symptoms develop only on upper leaf surface.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Blueberry Arthropods

Over 300 species of arthropods (insects and mites) have been reported feeding on blueberries (Phipps 1930). Fortunately, most of these species are never abundant enough to be considered pests, and of the 20 to 25 which occasionally inflict economic loss only 5 or 6 are chronic problems which require some type of control every year. The following sections describe the appearance, life history, type of injury, methods of detection, and recommended control for the arthropod pests which are most likely to damage blueberries in North Carolina. Although most of these are minor pests, it is important to recognize their presence and to understand what conditions may precipitate an outbreak. The pests are grouped according to the part(s) of the blueberry plant attacked. As a rule, the most damaging pests are those which attack the buds, destroy the fruit, or transmit disease from one plant to another.

Buds

Blueberry Bud Mite

The blueberry bud mite [*Acalitus vaccinii* (Keifer)] occurs in blueberries and huckleberries (both wild and cultivated) growing throughout much of eastern North America from the maritime provinces of Canada to southern Florida and Texas (Jeppson et al. 1975, Keifer et al. 1982). These mites are rarely a problem in the northern half of their range where cold winters limit population growth, but severe infestations become increasingly common from Massachusetts southward—particularly in coastal areas where winters are mild (Marucci 1966).

The bud mite is a translucent white arthropod with a soft, spindle-shaped body and two pairs of short legs near the anterior end (most other mites have four pairs of legs). At maturity, the adults are only about 0.2 mm in length (1/125 inch), and are not visible without aid of magnification (Fig. 7). The short legs and sac-like body allow these mites only feeble powers of locomotion (Keifer 1941).

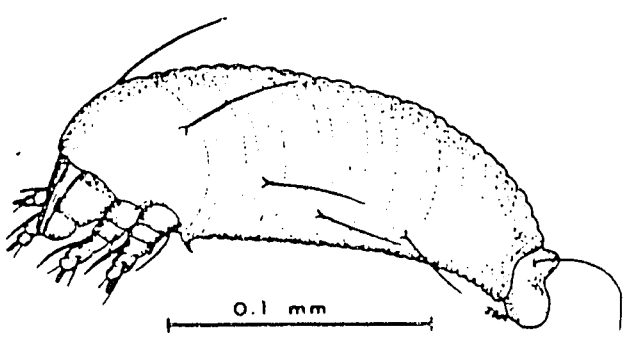

Figure 7. Blueberry bud mite (greatly enlarged).

Most of the mites spend their entire life within the buds of blueberry plants. Eggs are laid throughout the year on the inner surfaces of bud scales, and all developmental stages may be present in the buds simultaneously. Under optimal conditions, the young are able to complete their life cycle in 15 days (Baker and Neunzig 1970). As the buds open in the spring, mites are exposed to desiccation and gradually leave their overwintering sites. They migrate along the stem to the base of new shoots where they feed until new buds begin to form. Eventually, the mites move into these buds and resume reproduction. As the colony increases in size the mites move farther into the center of the bud. By the beginning of September some mites can usually be found deep within infested buds (Jeppson et al. 1975). Feeding, egg laying and an increase in the mite population occurs throughout the fall and winter, with maximum populations usually reached by December or January. Population growth seems to be greatest during cool weather, and consequently, bud injury tends to be most severe following a mild winter (Baker and Neunzig 1970).

The blueberry bud mite feeds on the bud scales and on the leaf and floral parts within the blueberry bud. Injured tissues develop a red, blistered appearance within 2 weeks (Plate 3A), and continued feeding kills the fruit primordia, eventually resulting in complete death of the bud. Developing fruit is also subject to feeding injury; the affected berries appear roughened or misshapen and are frequently covered with small reddish blisters (Plate 3B). Persistent feeding by a large number of mites can result in extensive loss of fruiting potential, and irreversible damage may occur by the middle of August (Keifer 1941, Baker and Neunzig 1970).

No blueberry cultivars are completely immune to the blueberry bud mite, but infestations are usually more common in varieties which ripen early in the season and begin to set new fruit buds by the end of June. In North Carolina, Wolcott and Murphy plantings seem to be most susceptible to mites, while Croatan, Jersey, and Elizabeth are least susceptible.

From February through April the presence of bud mites is relatively easy to detect by looking for the distinctive red blisters on bud scales, flowers, or fruit. From August through March, the infestations can be found by examining the scales of dissected buds under at least 40x magnification (Keifer 1941).

Selectively pruning out old canes will help to reduce bud mite populations in established plantings. Non-susceptible varieties often need no additional mite control, but when infestations are severe (or invade susceptible cultivars) two applications of an approved miticide (one in July and one in August) should give adequate control. It is important that these sprays be applied before mites penetrate too deeply into the buds and destroy the tissues that produce next year's fruit.

Buds and Flowers

Cutworms and Measuringworms

Early in the growing season, cutworms (*Rhynchagrotis* sp.) and measuringworms (*Eupithecia* sp.) are occasionally found in blueberry plantings. These insects apparently are not restricted to blueberry, but occur on a wide variety of plants (Forbes 1948).

Adults of both the measuringworm and cutworm are medium-sized, grayish-brown moths with a wing spread of about 32mm (1.25 inches). Apparently both species overwinter as adults and lay their eggs in blueberry fields very early in the spring. Since moths fly only at night, they are seldom seen by growers (Dyar 1901, Cook 1920).

The full-grown measuringworm is about 25 mm long (1 inch) with a brownish-gray body and a light-colored head speckled with dark spots. Two distinctive, light-colored, V-shaped stripes occur about midway on the upper surface of the body. Like other members of this family, the immature measuringworm has only two pairs of fleshy legs near the end of the abdomen.

The fully developed cutworm caterpillar is about 32 mm in length (1.25 inches) with a light brown body and a dark brown head. The upper surface of the body is marked by a series of dark brown triangles on each segment. The abdomen possesses five pairs of fleshy legs (Plate 3G).

These caterpillars are found in North Carolina blueberry plantings during February, March, and early April. Measuringworms are found on the plants only at night; days are spent under debris or in soil near the crown of the plant. The larval stage lasts about two months, and pupation usually occurs in the soil during April.

Both kinds of caterpillars chew large irregular holes in blueberry buds. Most of these buds turn brown and die. Expanded buds and flowers are also attacked, with large portions of the petals and other floral parts usually consumed by the caterpillars.

These insects are seldom numerous enough to warrant control measures. With heavy infestations, a single application of a contact insecticide should be made just before bloom. To avoid killing pollinating insects, do not apply insecticides during bloom.

Buds, Flowers, and Foliage

Cranberry Weevil

The cranberry weevil (*Anthonomus musculus* Say) ranges from Ontario and New England south to Florida and west to the Rocky Mountains. It is commonly found on chokeberry or huckleberry in the wild, and can become a serious pest of commercial blueberries and cranberries in the northeast (Lacroix 1926). The cranberry weevil occurs in North Carolina, but seldom in populations large enough to cause economic loss.

The adult weevil is a dark reddish-brown beetle about 3 mm (⅛ inch) long. The front part of the weevil's head is elongated into a slender, curved snout (proboscis) which is about one third to one half as long as the rest of the body. The larva is smooth, slender and legless. It has a yellowish-white body and brown head (Lacroix 1926).

Adults overwinter under trash in wooded areas adjacent to blueberry plantings. When the blueberry buds begin to swell in late February or early March, adults leave their winter quarters and congregate on blueberries. Eggs are laid in unopened flowers as soon as the individual blossoms stand out separately in the cluster. Larvae hatch from the eggs in 3 to 9 days and eat the floral parts. The infested blossoms soon fall to the ground; larvae complete their development and pupate within these detached blossoms (Doehlert and Tomlinson 1951). New adults begin to emerge toward the end of May, and are usually present in the fields during summer and fall. There is only one generation per year in the blueberries, but a few individuals may produce a second generation on late-fruiting species of blueberry or huckleberry in the woods (Marucci 1966).

Weevils begin damaging blueberry plants in early spring after adults emerge from hibernation and start feeding and laying eggs. They puncture both leaf and flower buds with their mouthparts (Fig. 8): heavily damaged flower buds fail to open, and injured leaf buds produce an abnormal cluster of dwarfed foliage. Larvae feeding within the buds cause the infested blossoms to turn purple, remain unopened, wither, and fall from the plant (Marucci 1966). Later in the growing season, the feeding of adult weevils causes numerous small, irregular holes in the leaves, usually within a brownish dead area on both sides of the midrib (Franklin 1948). Frequently this injury occurs within leaves tied or rolled by other insects which have abandoned the structure.

Figure 8. Terminal bud of blueberry shoot with typical feeding puncture of the adult cranberry weevil.

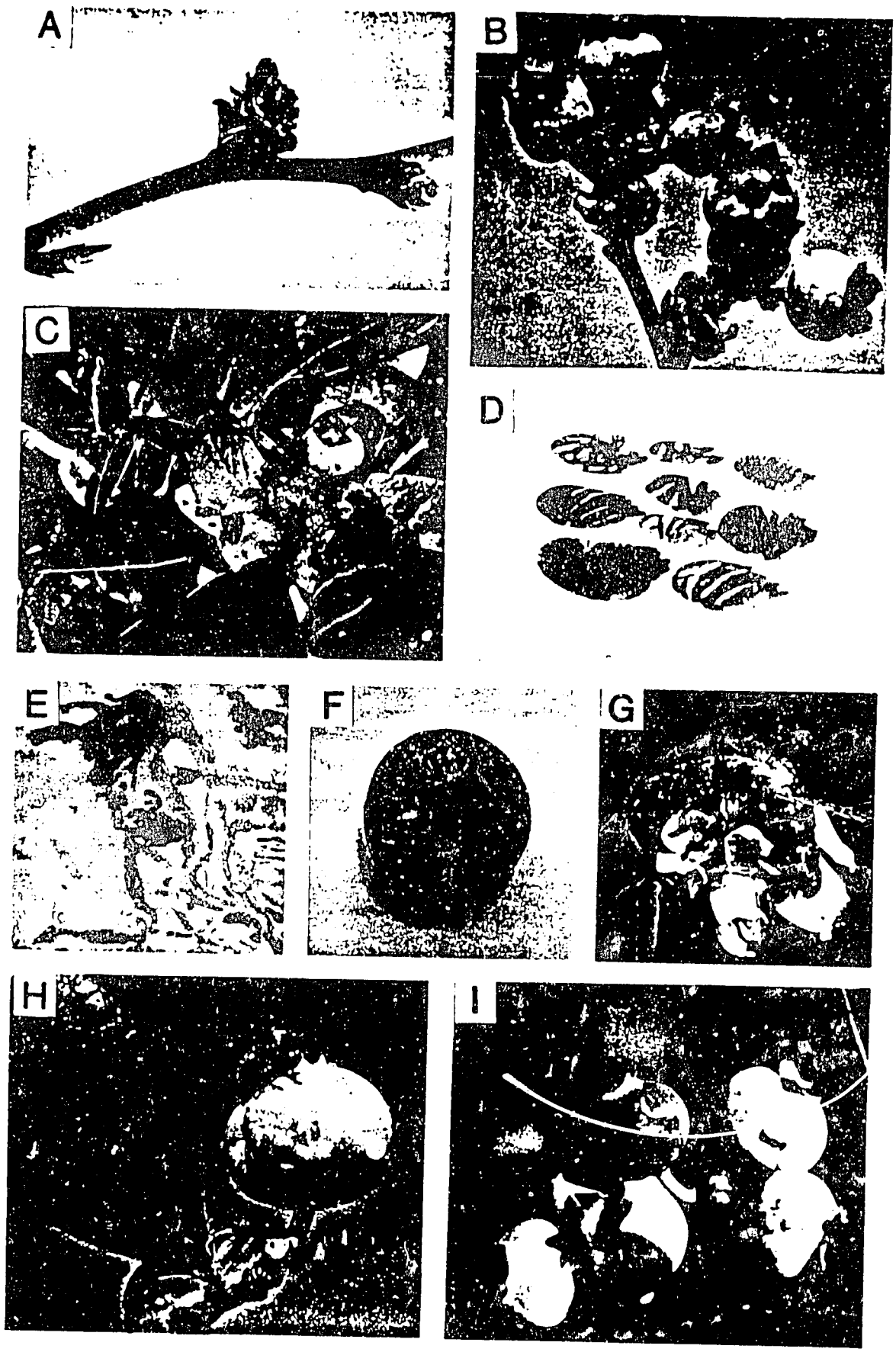
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PLATE 3

A. Partially expanded bud shows typical symptoms of injury (reddish blisters) caused by blueberry bud mites.

B. Fruit injury due to feeding by blueberry bud mites.

C. Evidence of infestation by the cranberry fruitworm. The brown frass is excrement produced by a larva inside the fruit.

D. Wings of various flies which may be found on sticky traps. The blueberry maggot's wing is in the center (second from the top). The other flies are not pests of blueberries.

E. Adult blueberry maggot fly on a yellow sticky trap. There is a characteristic white bar on the side of the fly's thorax between the wing and the head.

F. A green blueberry cut open to show a larva of the cherry fruitworm.

G. A cutworm caterpillar feeding on blueberry flower buds.

H. The adult stage of the plum curculio.

I. Crescent-shaped scars on blueberry fruit where a plum curculio has laid an egg.

Adult cranberry weevils may be collected from blueberry plants with a sweep net or by shaking the foliage onto a white ground cloth. North Carolina populations are usually very small (even in abandoned blueberry fields), and natural control factors appear to keep this insect well below damaging levels. If supplementary chemical control is necessary, a short-residual contact insecticide should be applied about a week before buds begin to open.

Fruit

Blueberry Maggot

The blueberry maggot (*Rhagoletis mendax* Curran) is the most serious pest of commercial blueberry production in the northeastern and northcentral United States (Marucci, 1966). This fly occurs commonly in Canada as a pest of lowbush blueberries, and has extended its range southward since the early 1960's to encompass most of the middle Atlantic states. In North Carolina this species may be found developing in wild or cultivated blueberries and huckleberries, but the infestations tend to be localized and sporadic.

Blueberry maggots overwinter as pupae buried 2.5 to 15 cm deep (1 to 6 in.) in the soil (Lathrop and Nickels 1932). Warm temperatures in the spring trigger pupal development (Tomlinson 1951), and in southeastern North Carolina, adult flies usually begin to emerge during the last week of May or the first week of June. Maximum numbers typically occur during mid-June, but flies may continue to be present well into August.

An adult blueberry maggot is about 4 mm long (3/16 in.), and has a characteristic pattern of black bands running diagonally across each wing (Plate 3D,E). The body is black, but it is marked with a distinctive white bar on each side of the thorax (anteriorly from the wing), a white spot on the scutellum (posterior tip of the thorax), and a white stripe along the distal edge of each abdominal segment (Fig. 9).

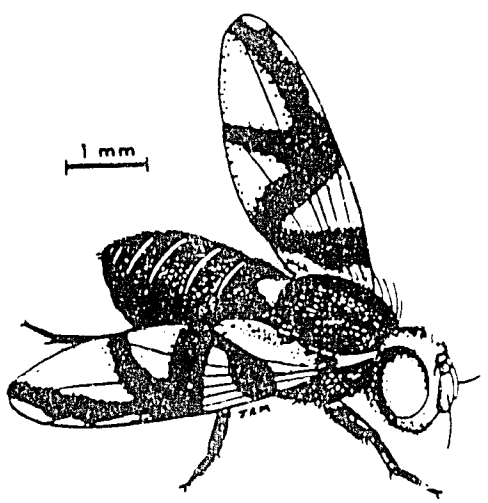


Figure 9. Adult stage of the blueberry maggot. The white scutellum, white bars on the thorax, and black banding of the wings are useful characters for identification.

After a pre-oviposition period of about one week, a female fly will actively seek out large berries which are beginning to ripen. She deposits an egg just under the skin of the fruit, and in about 5 days, a small larva hatches and begins to feed just under the skin. As the larva grows larger, it tunnels throughout the berry causing the pulp to become soft and watery. A fully grown larva measures about 1 cm in length (½ in.). It is almost entirely white in color, and has a tapered, legless body with an indistinct head at the narrow end. There are no eyes or antennae (Fig. 10A). About 18 days after hatching, the mature larva leaves its berry and burrows into the soil to pupate. There is only one generation each year, but a few pupae may remain in the soil for 2 to 3 years (Lathrop and Nickels 1932).

During the early stages of the maggot's development it is nearly impossible to separate infested from non-infested fruit. If wormy berries are harvested and packaged together with sound berries, the larvae will continue to mature within the fruit and may emerge for pupation at

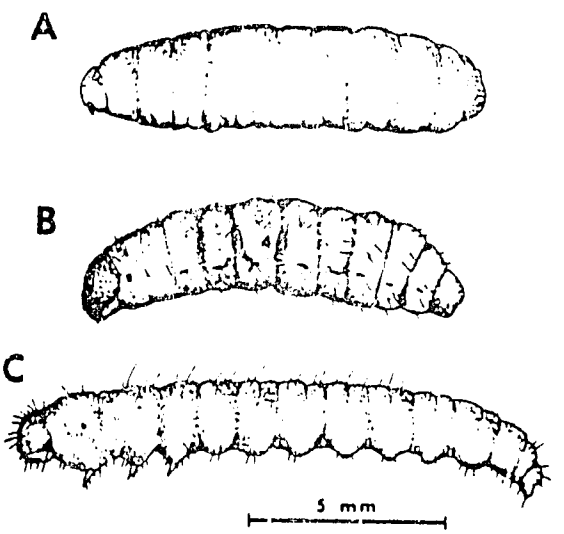


Figure 10. Larval stages of three blueberry pests which may be found in the fruit at harvest. A) blueberry maggot B) plum curculio C) cranberry fruitworm.

the point of sale (Lathrop and McAlister 1931). Entire shipments of berries have been condemned by federal inspectors or processors when the number of larvae exceeded USDA standards for fresh fruit.

Infestations of blueberry maggot can be detected before they reach damaging levels by trapping the adult flies on yellow sticky boards (Plate 3E) baited with ammonium

acetate or protein hydrolysates (Howitt and Connor 1965). A treatment threshold of three adults per trap per week gives adequate lead time for chemical control if the traps are in place before the first flies emerge in late May.

In southeastern North Carolina, the highbush blueberry harvest usually begins in mid-May. Since early-bearing varieties constitute a major proportion of the acreage, much of the fruit has already been harvested by the time adult maggots begin to lay eggs. Infestations, therefore, tend to develop in late season varieties (such as Blueray, Jersey, and the rabbiteye cultivars). The highest populations of blueberry maggots are generally associated with fields where soil moisture remains high enough throughout the summer (due to irrigation, high organic matter, or tall bushes that shade the ground) to prevent desiccation of the pupae. Pest populations also tend to increase following years when wet field conditions delay harvest and a cold winter breaks pupal diapause.

When control is necessary, a short-residual pesticide should be used during harvest. Apply this spray from the ground whenever possible to get maximum coverage on the lower half of the bushes. Use a ULV spray by air only when weather, labor, or harvest conditions make ground sprays impractical. Spot infestations can be eradicated over several years if they are sprayed every 7 to 10 days until no fruit at all remains on the bushes.

Plum Curculio

The plum curculio [*Conotrachelus nenuphar* (Herbst)] is a native American insect which ranges from Florida to southern Canada and west to Montana and Colorado. Although plum and peach appear to be its preferred hosts, adults will feed and reproduce on many other fruits including apple, cherry, blueberry, huckleberry, grape and persimmon (Snapp 1930, Bobb 1952).

The adult stage (Plate 3H) is a hard-shelled snout beetle (weevil) about 4 mm long (3/16 inch). It is usually dark brown in color with a pair of mottled gray patches near the back of the wing covers. The top surface of each wing cover has three distinct bumps which are most obvious when the insect is viewed from the side. Larvae are white legless grubs with a distinct brown or tan head capsule (Fig. 10B). Fully grown larvae reach a length of about 12 mm (½ inch) (Snapp 1930, 1940).

Adults overwinter under debris usually in wooded areas adjacent to blueberry fields. In southeastern North Carolina, they emerge from hibernation during late March or early April when the average daily temperature is near 10 to 15°C (50 to 60°F) for 3 or 4 consecutive days and the high temperatures are 24°C (75°F) for 2 or more consecutive days (Whitcomb 1932). These conditions usually occur about the time blueberry plants finish blooming. Nearly all weevils will have emerged from hibernation and returned to blueberry fields by the time daily temperatures reach 32°C (90°F).

Female weevils lay their eggs in shallow pits excavated on the surface of green berries. Usually a single egg is laid in each berry, and a crescent-shaped scar develops on the surface at this oviposition site (Plate 3I). Upon hatching, larvae burrow into the fruit where they feed on the pulp for about 2 weeks. Fully grown larvae leave the fruit, burrow into the soil and pupate within an earthen chamber. Adult weevils emerge about 4 weeks later. Most of these adults enter diapause after several weeks of active feeding, but if green berries are still present, a few will mate and produce a second generation (Mampe and Neunzig 1967).

Infestations of plum curculio can usually be detected by examining green berries for the characteristic oviposition scar. These berries are usually the first to turn blue, and will often drop to the ground before uninfested fruit is ready for harvest. Adult weevils are secretive and nocturnal, but they can be found early in the morning or late in the evening by shaking the branches of a bush over a white ground cloth. Weevils disturbed in this manner will drop from the bush and feign death, folding their legs tightly against the body as they lie on the white cloth.

The plum curculio can be controlled with insecticides if applications are properly timed. Two applications of a contact insecticide are usually necessary to obtain complete control. The first spray should be applied as soon as adult weevils begin returning to the fields, and the second spray should be timed to coincide with the end of the spring migration (after daily high temperatures reach 32°C (90°F)). Additional applications may be necessary for heavy infestations or during cool seasons when berry development is unusually slow.

Cranberry Fruitworm

The cranberry fruitworm (*Acrobasis vaccinii* Riley) is found throughout the eastern United States and Canada. Its food plants include cranberry, huckleberry, and many species of wild and cultivated blueberries (Maxwell and Morgan 1951, Hutchinson 1954, Marruci 1966, Neunzig 1972).

Fully grown larvae of the cranberry fruitworm overwinter in silken hibernacula spun near the surface of the soil. Toward the end of winter, these larvae pupate and emerge about a month later as small, brownish gray moths with a 16-18 mm wingspan (⅝ to ¾ inch). In North Carolina the emergence period begins in late March and continues through most of April (Neunzig 1972). This is a fairly common species, but adults are not often seen because they are active only at night.

After mating, female moths usually lay their eggs within the calyx cup of green berries. First instar larvae emerge in 4 to 5 days and burrow into the berry near its junction with the stem (Hutchinson 1954). Larvae are smooth, elongate caterpillars with three pairs of thoracic legs and five pairs of fleshy abdominal prolegs (Fig. 10C). They grow to about 15 mm in length (⅝ inch), and are usually a pale yellowish green in color with an amber head capsule. Older larvae

PLATE 4

A. Adult stage of the sharpnosed leafhopper.

B. Injury to blueberry foliage by the larva of a leaf roller.

C. First instar nymph of the sharpnosed leafhopper.

D. Fifth instar nymph of the sharpnosed leafhopper. Note the hourglass pattern on the dorsal surface.

E. Injury to blueberry leaves caused by the adult stage of the cranberry rootworm.

F. The larva of a blueberry gall fly, and its typical feeding damage on the underside of a leaf.

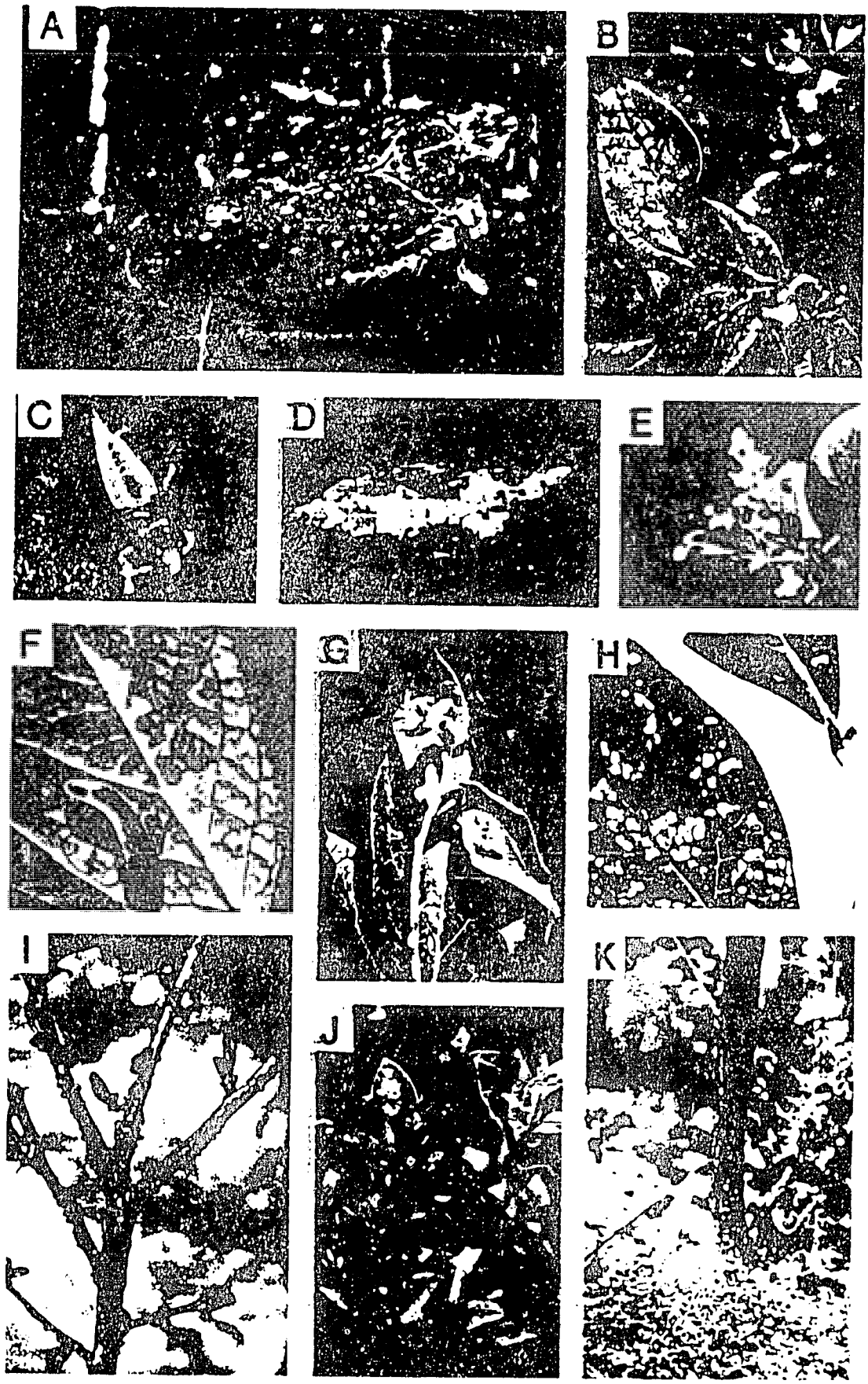
G. Infestation by the terminal borer (*Recurvaria* sp.) causes the growing tip to wilt and eventually die.

H. Feeding damage to a blueberry leaf by adults of the Japanese beetle.

I. Terrapin scale on the stems of a blueberry plant.

J. Sooty mold on blueberry foliage during the summer is a symptom of scale infestation. The mold grows on honeydew excreted by the scale insects.

K. A mound of light brown frass at the base of a blueberry plant is caused by a larva of the *Oberea* stem borer.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may develop a light pink coloration on the dorsal surface. First-instar larvae have been found in North Carolina as early as mid-April, but they are more commonly seen around May 1 (Fulton 1946, Neunzig 1972).

Larvae feed inside the berry until most of the contents have been consumed. An infested berry usually becomes filled with frass from the insect, then shrivels, and turns prematurely blue. As larvae develop, they move from one berry to another within the cluster and may feed on 3 to 6 berries before they pupate. While feeding, larvae web together infested and uninfested fruit with strands of silk and pellets of frass (Plate 3C), making the entire cluster unsuitable for harvest (Fulton 1946).

By the end of May, most larvae are fully grown. They drop to the ground under blueberry plants and build silken chambers where they remain throughout the rest of the year. There is usually only one generation per year, but a few individuals may continue development and produce a second generation on deerberry (*Vaccinium stamineum* L.) in July (Neunzig 1972).

Adult moths of the cranberry fruitworm can be attracted to black-light (UV) traps as they emerge in March and April. This technique may be useful to optimize the timing of insecticide applications, but it is not an effective control strategy (Tomlinson 1962). Larval infestations can be detected by looking for a tiny entry hole near the stem of small, shrunken berries which have turned blue. The distinctive frass and webbing produced by this species does not usually appear until the middle of April when larvae begin moving between berries.

Two spring applications of insecticide are usually needed to control cranberry fruitworms. The first spray is applied shortly after bloom, with a second application in 10 to 14 days. In most cases, timing these sprays to give optimum control of the plum curculio (q.v.) will also provide excellent control of cranberry fruitworms.

Cherry Fruitworm

The cherry fruitworm (*Grapholita packardi* Zeller) is generally distributed throughout the northern two-thirds of the United States where it feeds on a number of host plants including apple, cherry, blueberry, rose and hawthorn (Chapman and Lienk 1971). This species is fairly common in North Carolina—at times even more abundant than the cranberry fruitworm.

Cherry fruitworm larvae are smooth caterpillars with brown heads, three pairs of thoracic legs and several pairs of short, fleshy abdominal legs. Physically, they resemble larvae of the cranberry fruitworm, but are more reddish in color (Plate 3F). Larvae grow to about 9 mm (⅜ inch) in length. The adult stage is a small, dark grey moth with chocolate colored markings on the wings. These moths have a wingspan of 8 to 11 mm (⅜ inch), but they are seldom seen because they are active at night and hide under leaves during the day (Vergeer 1954).

In North Carolina, adults emerge during April and lay their eggs on both the fruit and foliage of blueberry plants. Most larvae hatch in mid-April; they bore into the first fruit encountered, often entering the calyx cup of the berry. When larvae are about one-half to three-quarters grown, they move to an adjacent berry in the cluster, boring from one fruit to the other at the point of contact and lining the junction with silk. Some larvae attain their full size within the second fruit, while others may feed on additional berries. Upon completion of larval development, caterpillars leave the fruit and excavate small burrows in a dead blueberry cane, a pruning stub, or the stem of a dead weed nearby (Marucci 1966). Larvae remain inactive within these burrows for the remainder of the growing season and throughout the following winter. With the onset of mild temperatures in March and early April, larvae pupate within their burrows and emerge about two weeks later as adults.

Detection of infested fruit is difficult because there is little external evidence of the insect's presence, and larvae remain well-concealed inside berries that have been tightly, but inconspicuously, silked together. In early spring, adults can be collected at light traps or in jars baited with a mixture of lignin pitch and terpinyl acetate. Both of these methods are useful for monitoring population size, but neither can provide effective control.

In order to prevent damage by cherry fruitworms, two applications of a residual insecticides are usually needed during the adult's flight period in the spring. Sprays applied against the plum curculio (q.v.) should also give adequate control of cherry fruitworms.

Plant Bugs

Several plant bugs, including the leaffooted bug, *Leptoglossus phyllopus* (L.), and the stink bug, *Banasa dimidiata* (Say), are frequently found in North Carolina blueberry plantings. These insects are not host specific, but occur on many plants having comparatively large, succulent fruit.

Adult leaffooted bugs are about 20 mm long (¾ inch), somewhat elongate, with a dark brown body and a narrow cream-colored stripe across the back. The head is small, much narrower than the thorax, and bears a long, slender beak. The tibia of the hind legs are distinctively flattened and leaf-like (Fig. 11A). Nymphs or young of the leaffooted bug are similar to the adult in general shape, but are smaller, lack wings, and are bright red in color.

Stink bug adults are green with dark brown markings. The body is shaped like a shield (Fig. 11B), about 10 mm long (⅜ inch), and produces a distasteful odor when handled. The head is short and flat with a long slender beak. Immature stink bugs are smaller and lack wings but in general they resemble adults. They are brown in the early instars and mostly green in the fourth or last instar.

Both the leaffooted bug and the stink bug overwinter in the adult stage. Stink bug adults occur on blueberry plants from April through June, while adults of the leaffooted bug occur on plants from mid-May through June. Eggs and nymphs of both species are found on the foliage and fruit

during the months of May and June. Plant bugs are only rarely encountered on blueberry bushes after harvest.

Both adults and nymphs of plant bugs suck juices from developing blueberries. Tiny openings are left in the skin of fruit pierced by the slender, tube-like mouthparts of these insects. The cells surrounding these openings fail to turn the color of a ripe berry and the fruit becomes slightly mottled in appearance. However, no discoloration within the berry or shriveling of the fruit occurs. Since these insects cause no obvious injury to the fruit, there is no reason to control them.

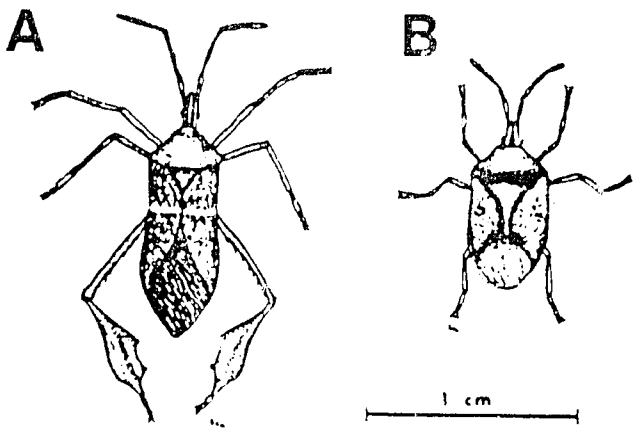

Figure 11. Plant bugs which may feed on blueberries. A) leaffooted bug B) stink bug.

Fruit and Foliage

Japanese Beetle

The Japanese beetle (*Popillia japonica* Newman) is an introduced species which has spread throughout the eastern United States. Adults feed on a wide variety of host plants including tree and bush fruits, shade trees, vegetable crops, and broadleaf weeds. Larvae live in the soil and feed on the roots of grasses. This species is present throughout North Carolina, but it is most common in the Piedmont and Mountains.

The adult beetle is 10 to 12 mm long (3/8 to 1/2 inch) with a metallic green body and bronze wing covers. Distinctive tufts of white hair are visible along the sides of the abdomen and behind the wing covers. Larvae are small white grubs with a light brown head capsule. They grow to about 15 mm in length (5/8 inch).

In North Carolina, adult Japanese beetles may be found in blueberry fields during June and July. Near the end of July and beginning of August they migrate to grassy areas and lay their eggs. Larvae hatch in a few weeks and feed on roots until they become dormant for the winter. They resume feeding again in early spring, and usually pupate in May. The new adult generation flies to flowering or fruiting plants where they feed and mate.

Feeding by the adult beetles can skeletonize the leaves (Plate 4H) and cause large, irregular holes in the fruit. Severe damage to the foliage may retard growth in young plants. Infestations are usually easy to detect because the adults tend to congregate on fruit and fly off noisily when disturbed.

Japanese beetles are usually not abundant enough in blueberry fields to cause much damage. Occasionally, large localized populations may develop in the Mountains or Piedmont, but these plantings are usually small and commercial bait formulations can be used to trap the adults. Insecticide applications should probably be avoided except in extreme cases or on small, non-bearing plants.

Foliage

Sharpnosed Leafhopper

Several kinds of leafhoppers may be found feeding on blueberry foliage, but the sharpnosed leafhopper [*Scaphytopius magdalensis* (Provancher)] is the only species which is considered a serious pest. It has earned this distinction because it transmits a mycoplasma-like pathogen which causes stunt disease (q.v.) in highbush blueberries (Tomlinson et al. 1950). This leafhopper is common throughout the eastern United States where it feeds and reproduces on blueberry, huckleberry, cranberry,and other related plants in the family Ericaceae (Hutchinson 1955).

Sharpnosed leafhoppers overwinter as eggs laid inside the leaf tissue of host plants. In North Carolina, these eggs hatch around the middle of March (about the time blueberry leaf buds begin to open). Nymphs are ivory in color (Plate 4C), and develop an hourglass pattern of brown or red markings on the dorsal surface as they grow (Plate 4D). Leafhoppers reach the adult stage after five molts. Adults are approximately 5 mm long (3/16 inch), and are mostly brown with small cream-colored patches on the body and wings (Plate 4A). Both nymphs and adults have a pointed head which is shaped like the horn of an anvil.

There are three generations of the sharpnosed leafhopper each year in North Carolina. Peak adult populations occur near the end of May, the middle of July, and the beginning of October. The highest populations are found in abandoned blueberry fields and in wooded habitats where huckleberry (*Gaylussacia* spp.) and blueberry (*Vaccinium* spp.) are common in the ground cover. Adults are able to fly long distances (probably carried on air currents), and they tend to disperse out of the woods during the spring (first) generation, and back into the woods during the fall (third) generation (Meyer 1984).

Feeding by sharpnosed leafhoppers causes very little direct injury to blueberry plants. But economic losses do occur when these insects feed on stunt-infected plants, acquire the pathogen, and transmit the disease to other plants in subsequent feedings.

Yellow sticky traps, like those used to catch adult blueberry maggots, seem to be the best way to monitor changes in populations of sharpnosed leafhoppers. These traps should be hung directly on the bushes, in a clear spot about 0.5 m (20 inches) above the ground. Counts of the trap catch should be made at least once a week throughout the growing season. Most of the individuals collected on these traps are adults, and males usually outnumber females by 5 to 1. Both adults and nymphs can be collected from blueberry plants with a sweep net; this technique gives a better estimate of the sex ratio and population structure, but it tends to give highly variable estimates of population density. Best results are usually obtained late in the day (near sunset) using a single upward sweep along the side of each bush in the row.

Sharpnosed leafhoppers are quite susceptible to the insecticides registered for use on blueberries. Spring applications to control the plum curculio and fruitworms should also kill nymphs of the first leafhopper generation. At least two more sprays are needed later in the season to prevent re-infestation by migrant adults of the second and third generations. These sprays should be timed to coincide with the periods of peak flight activity (mid July and early October). It is also extremely important to keep a healthy stand of bushes by promptly removing all plants which show symptoms of stunt disease.

Leaf Tiers and Leaf Rollers

Larvae of several moth species feed on blueberry leaves which they roll or tie together with silken webs (Plate 4 B). In North Carolina, the most common representative of this group is the leaf tier *Aroga trialbamaculella* (Chambers). This insect is a frequent pest of cranberries in the Northeast where growers call it the red-striped fireworm (Franklin 1948). Two other species, *Dichomeris vacciniella* Busck and *Acleris maculidorsana* (Clemens), are also found from time to time in North Carolina. These insects have no common names.

As adults, all three of these species are small and dusty brown or black. They have a wingspan of about 16 mm (⅝ inch), but are seldom seen because they fly only at night (Darlington 1952). Larvae of *A. trialbamaculella* are elongate, hairless caterpillars with light brown heads, three pairs of thoracic legs, and several pairs of fleshy abdominal legs. When fully grown, they reach a length of 10 to 13 mm (⅜ to ½ inch), and have four distinctive reddish stripes running the length of the body. Larvae of *D. vacciniella* and *A. maculidorsana* are similar in size and appearance to *A. trialbamaculella*, but differ in coloration. Immatures of *D. vacciniella* have dark brown or black heads, purplish-brown on the thorax, and yellowish-white abdomens. Larvae of *A. maculidorsana* have light yellow heads with two small, black patches, and their bodies are mostly yellowish-white.

A. trialbamaculella has several generations each season (Scammell 1921). In North Carolina, larvae may be found feeding on leaves near the terminal of the stem from May through September. Two or more leaves are tied together and a tube-like shelter of black frass and silk is constructed between the leaves. Feeding is generally confined to the upper tissues of the leaves and this results in a skeletonized appearance within the leaves and a discolored region externally (Fig. 12).

Larvae of *D. vacciniella* and *A. maculidorsana* are found on blueberry foliage in North Carolina during April and May. These larvae also feed on leaves near the stem terminal. Two leaves are webbed together, a path of silk webbing is laid down along the midrib of one leaf, and the tips of the leaves forming this enclosure are consumed (Fig. 13). Several of these structures are formed during the development of each larva.

Control of leaf tiers and leaf rollers is usually obtained with spring applications of insecticides directed against major pests such as the plum curculio and fruitworms. Numerous natural parasites of these caterpillars are also helpful in keeping these pest populations at a low level.

Figure 12. Leaves tied together by a larva of *Aroga trialbamaculella*. The larva feeds only within the enclosure on the upper surface of the leaves.

Figure 13. Leaves tied together by a larva of *Dichomeris vacciniella*. This insect eats the tips of the tied leaves.

Sawfly

Sawflies are closely related to bees and wasps. These insects are widely distributed throughout the United States and their larvae feed on a wide variety of host plants including most of the flowering fruit trees. In North Carolina, there is one species of sawfly (*Caliroa* spp.) which feeds on the foliage of blueberry.

Adults of the blueberry sawfly are black insects which look like small wasps. They are secretive, and are seldom seen flying in the blueberry fields. Immature stages of the sawfly are soft, elongate, and slug-like in appearance. The body is yellow-orange and is covered with a moist, sticky mucous. Legs are present, but they are very small and inconspicuous (Plate 4F). The full-grown larva reaches a length of approximately 10 mm (⅜ inch).

Caliroa sawflies have several generations each year in North Carolina. Fully developed larvae are usually present on blueberry plants in May, July, and also in September. After hatching, larvae usually move only a short distance and generally all individuals emerging from a group of eggs remain relatively close to each other through their entire larval development. All feeding is done on the underside of blueberry leaves. Only the lower leaf tissue between leaf veins is removed. Irregular brown areas appear on the upper surface of injured leaves (Plate 4F).

Early generation sawfly larvae are killed by insecticide applications made for plum curculio and fruitworms. Later generations are usually not numerous enough to warrant treatment with insecticides. Since larvae remain in groups, they can be readily located and removed by hand.

Leaf Miners

There are at least two species of leaf miners which may be found in the foliage of cultivated blueberries in North Carolina. One species, *Paronix preciosella* (Dietz), is considered a minor pest of blueberries grown in the northeastern United States and has also been found in the leaves of wild cherry (Darlington 1952). The other species probably belongs to the genus *Caloptilia* (subgenus *Gracillaria*); it is closely related to several northern species of leaf miners which have been found in the foliage of blueberry and dogwood (Forbes 1948). There are no common names for these insects.

The larva of *P. preciosella* is caterpillar-like and about 6 mm long (3/16 inch) when fully grown. The head is whitish-yellow with brown spots and the body is mostly creamy-white. Thoracic and abdominal legs are present, but difficult to see because of the insect's small size. The entire larval period is spent between the upper and lower surface of a blueberry leaf. When the larva is fully grown, it cuts a small exit hole in the leaf tissue on the lower surface of the mine, and leaves the excavation to pupate. The adult is a tiny brown moth with a wingspan of only about 6 mm (3/16 inch).

The larva of *Caloptilia* sp. is a tiny green caterpillar which feeds inside a small, oval mine. As it matures, the insect cuts around the edge of its mine and causes the damaged area to fall out of the leaf. The larva pupates within this detached mine, and emerges in two or three weeks as a tiny adult moth with a wingspan of 3 to 4 mm (⅛ to 3/16 inch). The adult moth is light brown in color with tiny gold spots on the wings.

The mine of *P. preciosella* is irregular or blotch-like in shape and is restricted to the lower surface of the leaf. Tissue immediately above the excavation is also injured by the insect and eventually turns brown and dies (Figs. 14 and 15). The mine formed by *Caloptilia* sp. is almost always oval in shape and rarely larger than 2 by 3 mm (1/16 by 1/8 inch). Both species have several generations each year in North Carolina. Larvae of the first generation occur in May and early June. A second generation attacks the plants in late June and July, and a third generation is present later in the season.

Leaf miners usually destroy a very insignificant proportion of a plant's leaf surface area, and never become common enough to cause noticeable damage. Since the plant suffers no injury, there is no reason to control either of these species.

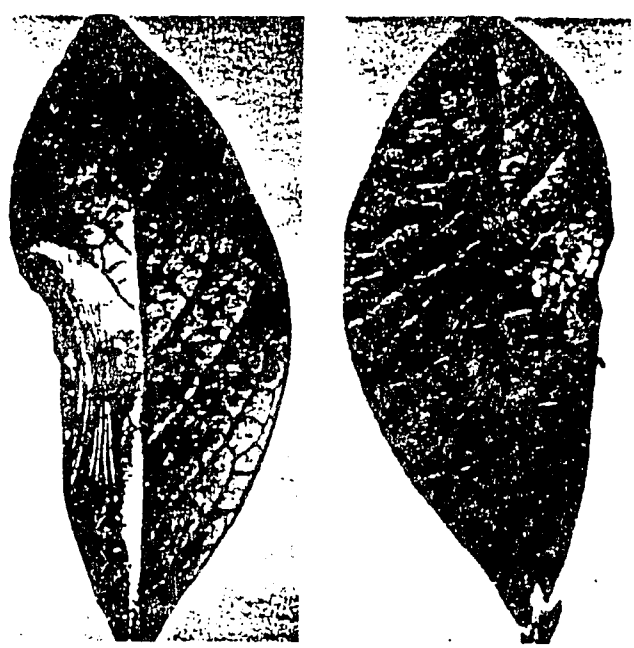

Figure 14. (left) Underside of blueberry leaf showing feeding injury or mine of the leaf miner, *Paronix preciosella*.

Figure 15. (right) Upper surface of the same blueberry leaf as in Fig. 14 showing appearance of mined leaf from above.

Yellownecked Caterpillars

Several species in the genus *Datana* are known to occur on blueberries in North Carolina. One species, the yellownecked caterpillar [*Datana ministra* (Drury)], is found throughout the eastern United States and southern Canada; its larvae feed on apple, birch, basswood, cherry, elm, oak, and many other plants in addition to blueberry. The other species, *Datana drexelii* Hy. Edwards, *Datana vanaeceps* (Guérin-Méneville) and *Datana major* Grote and Robinson, are restricted to the Atlantic coast states where they feed on most Ericaceae as well as apple, basswood, sassafras, and witch-hazel (Craighead 1949, Darlington 1952). These species occur only sporadically in North Carolina, but when present on blueberry, they are likely to cause concern because of their large size and voracious appetites.

The larval stage of all three species is colorful and moderately clothed with long, white hairs. The head is usually black, the neck is narrowly ringed with yellow or orange and the body is conspicuously marked with longitudinal yellow lines against a black background. Fully grown larvae reach a length of about 5 cm (2 inches). When disturbed, these insects often elevate the anterior and posterior ends of their body, clinging to the substrate by only a few middle pairs of prolegs (Fig. 16).

Adults of these caterpillars are light brown moths with a wingspan of 4 to 5 cm (1.5 to 2 inches). The forewings are usually banded with dark brown lines, and the hind wings are somewhat lighter in color than the forewings. Moths are seldom seen because they are active at night.

All of these species pass the winter as pupae in the soil. Adults emerge in June or July and lay their eggs in groups of 50 to 100 on the undersides of leaves. After hatching, young larvae often feed together on a single leaf for several days and then gradually disperse to nearby foliage where they remain clustered throughout their entire larval development. In North Carolina, larvae are usually found on the blueberry foliage during late August. There is only one generation per year.

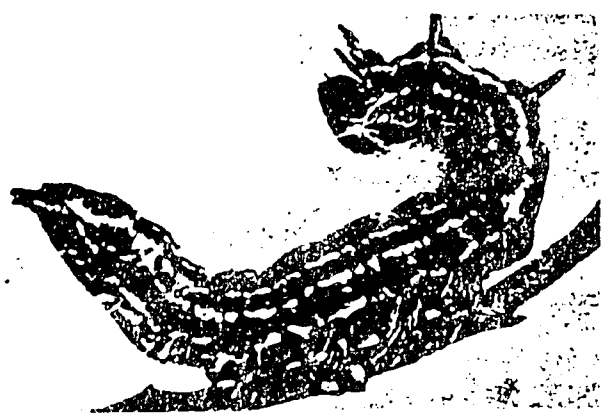

Figure 16. Larva of the yellownecked caterpillar. When disturbed, these insects often elevate the anterior and posterior ends of the body.

Although young *Datana* larvae only skeletonize the blueberry foliage, older larvae are able to consume entire leaves and may completely defoliate small plants. Extensive feeding may retard growth, but plants are seldom killed because injury occurs late in the growing season. Since infestations tend to be localized and readily detected in the field, growers can prevent severe defoliation by manually removing the caterpillars or by destroying colonies with insecticide from a small, portable sprayer.

Dagger Moths

There is at least one species of dagger moth, *Acronicta tritona* (Hübner), which feeds on blueberry huckleberry, azalea, and a few other Ericacious plants. This species ranges along the eastern seaboard from southeastern Canada to Florida, and along the northern half of the United States from New Jersey to Oregon (Forbes 1948). In North Carolina, the larvae are most commonly found on wild highbush blueberries, but they also occur sporadically in commercial fields.

The adult has a wingspan of about 4 cm (1.5 inches); it is grayish-brown in color and marked with dark, wavy lines on the front wings. Larvae are elongate and sparsely hairy. The head is yellowish with lateral dark brown spots, and the rest of the body is mostly green. Short, black converging bands occur immediately behind the upper region of the head, and red, brown and yellow longitudinal lines are also present on the upper surface of the thorax and abdomen (Fig. 17). Both thoracic and abdominal legs are present. Full-grown larvae are approximately 3 cm long (1.25 inches).

A. tritona overwinters as pupae in the soil under blueberries. There are evidently two generations per year in North Carolina with large larvae present on blueberry foliage during May or June, and again in September.

Early-stage larvae make small, irregular holes in leaves. As they grow, the amount of leaf injury increases until eventually the larger larvae are able to consume entire leaves. Insecticides applied for the control of plum curculio

Figure 17. A dagger moth caterpillar *(Acronicta).*

and fruitworms usually give satisfactory control of the first dagger moth generation. Second-generation larvae are not very common; if present, they can be removed and destroyed by hand.

Fall Webworm

The fall webworm [*Hyphantria cunea* (Drury)] is a native of North America and occurs throughout most of the United States and Canada. It is a general feeder which attacks most deciduous shade trees, ornamentals, some fruit trees (apple, plum, etc.), and a few bush fruits including blueberry and huckleberry (Craighead, 1949).

Fall webworms overwinter as pupae in cocoons under trash or the bark of trees. Adults emerge in the spring and lay their eggs on the leaves of their host plants. After hatching, larvae remain together as a group and construct a silk enclosure (tent) over the leaves as they feed (Fig.18). Larvae are pale yellow or brownish in color with a broad, dusky longitudinal stripe on the back and a yellowish stripe along each side. The body is covered with light colored hairs which arise from black and orange warts (Fig. 19B,C). Full-grown caterpillars are about 2.5 cm long (1 inch). In North Carolina, large larvae of the first generation are found on blueberry from mid-June to late July.

Upon completing their larval development, these insects drop from the plant and construct cocoons near the soil surface. The adults emerge in late summer. They are mostly white in color (Fig. 19A), occasionally with small black dots on the front wings, and have a wingspan of about 3 cm (1.25 inches). In North Carolina, eggs of a second generation are laid on host plants in late summer; larvae from this brood pupate in early fall and emerge as adults the following spring (Warren and Tadic 1970).

All leaves of an average sized blueberry plant can be destroyed by a single colony of larvae. Such complete defoliation retards growth but seldom kills the plant unless it occurs every year. First-generation larvae are usually destroyed by insecticides applied for control of the plum curculio and fruitworms. Since few second-generation fall webworms are usually encountered in blueberry plantings, the most practical means of control is to cut out the nests and destroy them by hand.

Figure 18. Nest of the fall webworm. Note that all of the leaves have been eaten in the vicinity of the nest.

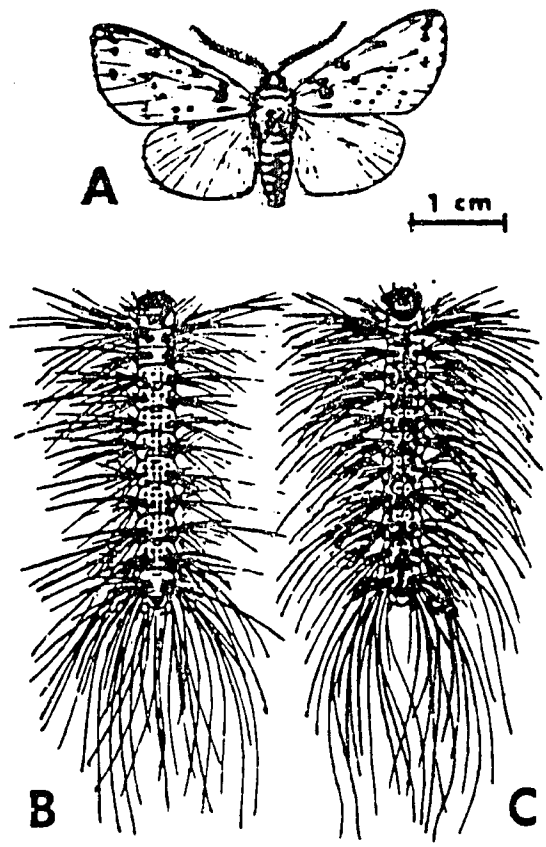

Figure 19. The fall webworm. A) adult B,C) larvae.

Foliage and Roots

Cranberry Rootworm

Several species of leaf beetles (Chrysomelidae) feed on blueberry plants, but the cranberry rootworm (*Rhabdopterus picipes* Oliver) is probably the most abundant and most damaging of these species found in North Carolina. Although its range extends from Mississippi to Quebec (Phipps 1930, Franklin 1950), the beetles are usually most common in blueberry or cranberry fields near coastal lowlands.

Both the immature and adult stages of the cranberry rootworm feed on blueberry, cranberry or closely related host plants. Alternate host plants may include apple, cherry, dogwood, grape, plum, strawberry, and myrtle (Harman 1940). Adult beetles usually consume the foliage, while larvae, which live in the soil, feed primarily on small roots or, occasionally, on the outer covering of large roots (Scammell 1915).

Larvae of the cranberry rootworm are elongate, ivory-colored grubs with a brown head and three pairs of small thoracic legs. The body is usually held in a slightly curved position, reaching a length of 7 to 9 mm (5/16 inch) when fully grown. Larvae overwinter in small earthen chambers near the crown of the plant, pupate in early May, and begin to emerge as adults in 3 to 4 weeks. Adults are 4 to 5 mm long (3/16 inch), with an oblong-oval body which is mahogany to dark metallic-green in color. They are usually present in the fields during June and July. Females lay their eggs in the soil, and young larvae begin to hatch in late June (Scammell 1921).

Cranberry rootworms occasionally cause significant economic losses in commercial blueberries by reducing plant vigor and by shortening the life of a stand. Yellow foliage and wilted terminals may be signs of larval feeding, but these symptoms must be confirmed by digging beneath the plant to find grubs or evidence of their damage to the roots. When adults are present (June and July) they can be collected from the foliage with a sweep net. Their feeding usually produces irregular, elongate, and often angulate holes along the leaf margins (Plate 4E). Although this feeding may cause a significant loss in leaf area, it is usually less important than larval injury to the roots (Franklin 1950).

In areas where rootworms are a problem, the land should lie fallow for a full year before it is replanted to blueberries (Marucci 1966). In severe cases, a soil insecticide also should be disked into the ground just before new plants are set. Satisfactory control measures to kill the larvae in established plantings have not been developed.

Stems

Terminal Borer

Larvae of moths in the genus *Recurvaria* are commonly found infesting the growing terminals of blueberry canes and other similar plants in North Carolina.

Recurvaria adults are tiny moths with a wing-spread of only about 6 mm (¼ inch). They are grayish-white with numerous black and brown markings on the body and wings. Larvae are smooth, caterpillar-like and approximately 8 mm long (5/16 inch) when fully developed. Small thoracic and abdominal legs are present. The most distinctive characteristic of larvae of all ages is the dark reddish color of most of the body. The head is dark brown.

Recurvaria larvae are associated with the blueberry plant for only a relatively brief period during the growing season. Early in the season, eggs are laid in the tips of expanding terminals, and larvae bore into these tips. Larval feeding and development occurs within the terminals during the months of April and May. Pupation occurs in late May or June, probably in the soil.

The tender growing terminals of the plants are hollowed out by the larvae for a distance of about 1 to 2 inches. The terminal leaves become wilted and are usually partially consumed (Plate 4G). At times, a short frass or excrement tube is constructed at the upper opening of the tunnel. Eventually, the terminal of the infested stem shrivels, becomes dry, and turns dark purplish-brown (Fig. 20).

Unless plants are heavily infested with terminal borers, the injury apparently has little effect on productivity. Insecticides applied in the spring for the major blueberry pests usually cause a sharp decrease in *Recurvaria* populations, no additional control of this species is necessary.

Figure 20. Injury by the terminal borer (*Recurvaria*).

Blueberry Tip Borer

Although the blueberry tip borer, *Hendecaneura shareana* (Kearfott) was first described in 1907, it was not recognized as a blueberry pest until the 1950's when it was found damaging commercial plantings in New York (Schaefers 1962). In North Carolina, this species has never been found in the coastal plain, but it has been reported several times on blueberries grown in the western part of the state.

Blueberry tip borers overwinter as larvae in the hollow blueberry canes where they feed during the summer. These larvae are slender caterpillars with both thoracic and abdominal legs. At first, young larvae are light pink with a brown head capsule, but the coloration fades as they mature (Marucci 1966). Fully developed larvae have a white body and grow to about 12 mm (½ inch) in length.

In western North Carolina, larvae pupate in May and adults emerge from the canes in June. These moths are mostly brown in color, but each front wing has orange marks near the tip and a silver spot along the hind margin. They have a wingspan of 9.5 to 14.5 mm (3/8 to 9/16 in-

ches). Female moths lay their eggs on the lower surface of leaves and young larvae bore into the canes 5 to 15 cm (2 to 6 inches) from the tip (Schaefers 1962). Larvae feed throughout the summer and early fall, excavating a tunnel toward the base of each infested cane.

During July and August, the portion of the stem above the tunneled out cane wilts and turns brown in color. At first, this injury may resemble the primary infection of mummy berry or damage caused by *Recurvaria* larvae, but the blueberry tip borer usually kills a greater length of the cane (20-25 cm or 8-10 inches). In the spring, infested terminals show very conspicuous symptoms of dieback.

It is difficult to assess the overall effect this damage has on the plant. Usually when tips are injured, secondary growth occurs which compensates, at least in part, for injury to the main stem. Heavy infestations will probably not kill the plants, but they are likely to cause some reduction of yield.

If dead canes containing the tip borer are cut out at pruning time, damage caused by this insect will be light. The cut pieces can be left in the field because the tip borer will die within a short time when the shoots dry out. Beneficial wasps parasitize larvae of tip borers, and they also help control this insect in North Carolina.

Scale Insects

In general, scale insects are stationary (sessile) organisms which feed on plant juices by inserting their mouthparts into the vascular tissues of a host plant. Most species secrete a hard, rigid, or waxy covering over their body and pass much of their life cycle under this protective shell. Only the first instar nymphs and adult males are mobile and bear any physical resemblance to other insects.

Scale insects are not frequent problems on blueberries in North Carolina, but there are several species including the terrapin scale (*Lecanium nigrofasciatum* Pergande), the Putnam scale (*Aspidiotus ancylus* Putnam), and the cottony maple scale (*Pulvinaria innumerabilis* (Rathvon)) which may occur sporadically in commercial plantings (Marucci 1966). All of these species are widely distributed throughout the eastern United States where they infest a variety of fruit crops and ornamental plants (Johnson and Lyon 1976).

The terrapin scale, probably the most serious scale insect on blueberries, secretes a round, rigid covering over its body which is brown or reddish-brown and marked with black bands like the shell of a turtle (Plate 4I). These scale coverings increase in size as the insect grows, eventually reaching a diameter of 3 to 4 mm (about ⅛ inch). The Putnam scale also produces a round protective shell, but it is brownish gray, has a brick red nipple near the center, and seldom grows larger than 1 mm in diameter (1/25 inch). The cottony maple scale forms a white, waxy covering which may be 5 to 10 mm in diameter (¼ to 3/16 inch) and roughly oval in shape (Fig. 21).

All of these species have only one generation per year. They overwinter as full grown nymphs or as fertile adults and produce young in the spring of the year. At first, these young scale insects, known as crawlers, actively move about on the plant. Within a few days, they select a feeding site, settle down, and begin to secrete the shell which covers and protects their body. Adult males emerge in late summer, mate with the females, and die within a few days (Williams and Kosztarab 1972).

As they feed, scale insects (particularly the terrapin scale) produce large quantities of honeydew, a sugary waste product, which covers the foliage and stimulates growth of a sooty mold. Heavy scale infestations can often be detected by the presence of this gray coating on the foliage (Plate 4J).

Since scale insects feed by removing sap from the plant, they can reduce vigor, decrease yield, and even shorten the life span of infested plants. The scale covering is impervious to many insecticides, so it is difficult to control these insects with cover sprays applied during the growing season. Best results are obtained when applications are timed to coincide with the active period of the crawlers or when dormant oil sprays are applied before bud break in the spring. Careful pruning can also help control light or scattered infestations of scale insects.

Figure 21. Cottony maple scale on a dormant blueberry cane.

Stems and Crowns

Stem Borer

A stem borer in the genus *Oberea* is a sporadic pest of blueberries, huckleberries, azalea, rhododendron, and laurel. This species (or its close relative) occurs throughout much of the eastern United States (Craighead 1949).

The adult of this stem borer is an elongate, slender beetle with a light brown or yellowish body. There are two dark spots on the dorsal surface of the thorax and a dark lateral margin on each elytron (wing cover). The beetle is about 15 mm in length (⅝ inch) and has slender antennae which are nearly as long as its body. Adults are present in blueberry fields during June and July.

Females select young blueberry canes and insert their eggs under a flap of bark cut near the cane's terminal end. The larvae hatch in about 2 weeks. These slender, legless worms tunnel upward within the cane (often killing the terminal) and then reverse direction and burrow slowly toward the crown of the plant. From 5 to 25 cm (2 to 10 inches) of the stem may be excavated during the first year.

Larvae become inactive with the approach of winter, but resume feeding in the spring. After reaching the crown of the plant, they move to adjacent stems, continue feeding for the rest of the year, and complete their development during the spring of the third year (Driggers 1929). Fully grown larvae are about 3 cm long (1.25 inches); they have hard, brown heads and soft, white bodies (Fig. 22). A distinctive patch of tiny, dark colored spines is present on the upper surface of the body just behind the head.

In some cases, stem borers cause extensive damage by destroying the growing tips or by killing entire canes. However, in other cases, infested plants seem to suffer very little injury. Recent infestations are often difficult to detect, but as larvae grow and begin to tunnel downward in the stem, they periodically chew open small holes in the bark. Pellets of light yellow frass are ejected from these holes during the summer and accumulate in distinctive mounds on the ground beneath the plant (Plate 4K).

Stem borers are not a frequent problem in commercial blueberry fields. Dama[illegible] these insects can be minimized if infested [illegible] or wilted terminals are removed by hand during the summer. Cutting the stems well below their hollow section insures that larvae will never reach the crown of the plant.

Figure 22. Larva of the *Oberea* stem borer within a blueberry cane.

Crowns and Roots

Crown Girdlers

The larvae of June beetles (*Phyllophaga* spp.) and elephant beetles (*Strategus* spp.) are occasionally found damaging the roots and crowns of blueberry plants in North Carolina. These insects are widely distributed throughout the eastern United States, and feed on a variety of host plants in addition to blueberry.

Both *Strategus* and *Phyllophaga* have two-year life cycles in North Carolina. Adult June beetles (Fig. 23B) are robust, brownish insects about 16 mm long (⅝ inch) which emerge in late May or early June and remain in the field until the latter part of July. The elephant beetles are usually active in August. They are larger than June beetles (about 3 cm or 1.25 inches) and are usually dark reddish brown in color with long, distinctive horns on the thorax (one in females and three in males). Adults of these species are often attracted to lights at night.

Eggs are laid in the soil under host plants and small, white grubs emerge in the summer or fall. These young larvae feed on tiny roots throughout the rest of the year and then, as winter approaches, they burrow deep into the soil and remain inactive until spring. Warm temperatures in March and April stimulate renewed feeding. Larvae continue to grow throughout the year, pass a second winter in the soil, and finally pupate after a brief, but intensive feeding pe[illegible]d the following spring. Fully grown larvae are elongate, "C"-shaped insects with three pairs of thoracic legs (Fig. 23A). The head capsule is brown to reddish brown and the rest of the body is yellowish or grayish-white. *Phyllophaga* larvae grow to 20 to 25 mm (¾ to 1 inch) while *Strategus* larvae may be as much as 40 mm long (1.5 inches).

Young larvae feed on small roots and usually cause no serious damage as long as the infestation is light and the plants are healthy. More severe injury, however, can occur as the larvae grow and begin to attack the main roots or the crown of the plant. Older larvae often feed on bark and wood just below the soil line; they can completely girdle the crown and rapidly kill an entire plant. Infestations are usually difficult to detect until the plants begin to die, but digging around the base of weak or questionable plants should expose any feeding injury or the grubs themselves. In plantings where these insects prove to be a problem, a band of soil insecticide about 30 cm (1 foot) wide should be cultivated into the soil around the base of each plant.

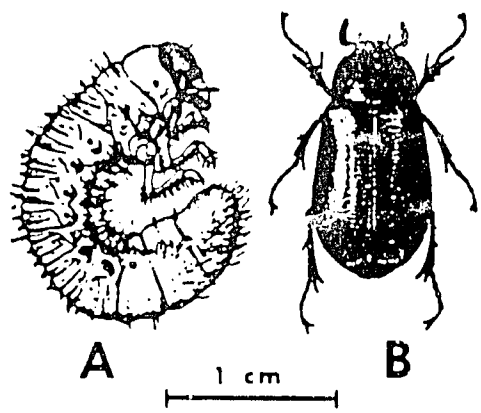

Figure 23. The June beetle (*Phyllophaga*). A) larva B) adult.

Roundheaded Borers

Larvae of beetles in the genus *Prionus* feed on the roots and crowns of many trees, shrubs, and herbaceous plants. In North Carolina, these borers may occasionally attack blueberries, but other host plants generally seem to be preferred (Craighead 1949).

Adult borers are large, reddish-brown beetles with long antennae and small, distinctive teeth on the lateral margins of the prothorax. They are slow, clumsy fliers which are occasionally attracted to lights at night. Females may be 30 to 45 mm in length (1.25 to 1.75 inches); males are slightly smaller. *Prionus* larvae resemble those of the blueberry stem borer (*Oberea* spp.), but have tiny thoracic legs, lack spines behind the head, and grow to a much larger size (Fig. 24). Fully developed *Prionus* larvae are usually about 65 mm long (2.5 inches).

Figure 24. Larva of the (*Prionus* borer. Note the very small legs on the thorax.

Little is known of the life history of these borers on blueberry, but it is probably similar to that observed on other host plants. On oak or pine, females lay their eggs in crevices in the bark near the base of the plant or in partially exposed roots. Small larvae feed just under the bark or root epidermis, while larger larvae tunnel extensively throughout the roots and crown. The larval galleries are usually packed with coarse, shredded shavings and excrement. Three to five years are spent feeding before the fully developed larvae leave their host plant and pupate in the soil nearby.

Since larvae feed on subterranean parts of the plant, they are difficult to detect and control. Arrested plant growth is usually the first sign of an infestation, and careful examination of these plants will show large feeding galleries in the crown and primary roots (Fig. 25). Without prompt treatment, these plants usually die.

As in the case of crown girdlers, a soil insecticide can be applied in a band around the base of a blueberry plant to kill *Prionus* larvae. This strategy is usually most effective against young individuals which have not penetrated too deeply into the crown or roots. Older larvae may be exceedingly difficult to kill.

Figure 25. The crown and a portion of the roots of a blueberry plant showing holes made by *Prionus* larvae.

Termites

The eastern subterranean termite, [*Reticulitermes flavipes* (Kollar)], is abundant throughout the eastern United States where it lives in association with dead and decaying wood. Since blueberry plantings in North Carolina are often grown on land which has been recently cleared of trees and shrubs, there is often a considerable amount of termite-infested debris left in the soil. When the supply of this wood becomes depleted, termites may begin to attack the living roots and crowns of blueberry plants.

Termites are social insects which live beneath the ground in nests containing reproductive forms (winged and wingless) as well as sterile workers, nymphs, and soldiers. A sprawling network of tunnels and enclosed passageways connects the nest with many suitable feeding sites. Workers and soldiers are most frequently encountered in the field; these are wingless individuals with soft, white bodies. The workers are about 5 mm long (3/16 inch) and resemble ants, while the soldiers are slightly larger and have brown, cylindrical heads with stout mandibles.

New termite colonies become established in early spring when new reproductive forms leave an established nest. These individuals are black with long slender wings, quite different in appearance from the workers. After an initial mating flight, the male and female burrow into wood, construct a small nest chamber, and rear their first brood of workers. Eventually, workers take over duties in the nest, forage for food, and care for the young. An average size colony with several thousand individuals takes four or five years to develop.

It is difficult to assess how much injury termites actually cause in blueberry fields. Most infestations probably do not result from the establishment of new colonies but occur instead as established colonies enlarge their range of feeding. In many cases, termites appear to be secondary invaders, feeding upon plants which have already been weakened or killed by other insects or diseases. Damage to living plants is generally confined to the small roots; larger roots occasionally may be injured, but termites rarely invade an entire crown and kill the plant. Termite galleries are rather distinctive because they follow the grain of the wood and are usually packed with dirt and spotted with dark excrement.

Complete control of termites in established plantings is difficult to obtain because the insects remain protected within the wood. Soil insecticides applied around the base of the plants and disked into the soil will usually help reduce populations, but careful site preparation before planting is the best way to prevent termite damage. Remove all large roots, branches, and other wood debris from the field, plow the land thoroughly to encourage decomposition of organic matter, and finally, incorporate an insecticide into the soil before new plants are set.

Disease Control

The blueberry grower should be able to recognize disease and arthropod problems so that effective control tactics can be applied at the proper time. Commonly employed control measures include the use of fungicides, insecticides, resistant cultivars, rogueing diseased plants, and the production of blueberry propagating stock free of disease.

Canker diseases of blueberry are best controlled by planting canker-free plants of canker-resistant cultivars. In general, the use of fungicides for stem canker control has proven to be ineffective. This is also true for the **stem blight** disease. Prompt removal of all dead or dying branches, 6 or 8 inches below any sign of diseased wood, and the use of blight-free cuttings for propagation are suggested control practices for stem blight. The relative susceptibility of the major blueberry cultivars grown in NC to stem canker and other important diseases are given in Table 2.

The only means of controlling **stunt** or **virus diseases** of blueberry is through a rigorous and continual eradication program, the use of stunt—or virus-free plants, and insect control. Inspections of plants for stunt should be made annually in late spring and again in late summer. Affected plants should be removed promptly.

The blueberry nursery at the Castle Hayne Research Station near Wilmington, NC will provide NCARS project leaders and growers who wish to establish propagation blocks with quality true-to-type plants that are free of stunt. Plants of the major cultivars grown in NC and indexed for blueberry stunt will be maintained in a screenhouse located at the Castle Hayne Research Station. Small blocks of mature bushes also will be maintained at the Research Station to provide limited cutting wood for interested growers and experimental purposes.

Losses from blueberry fruit rots (**mummy berry, ripe rot,** and **phomopsis rot**), leaf spots (**Gloeosporium, Septoria, Double Spot** and **Gloeocercospora**), and twig blight diseases (**Phomopsis**) can be reduced by spraying with fungicides. Preharvest treatment for ripe rot control is best achieved with two to three applications of an effective fungicide at 7 to 10 day intervals beginning at petal fall. With a highly perishable fruit such as blueberry, the need for control of postharvest fruit decay organisms (*C. gloeosporioides, P. vaccinii, Botrytis* spp., and *Alternaria* spp.) also is essential. The best means of prolonging shelf life and reducing fruit decay of blueberries is storage of the fruit at cool temperatures (40°F) as soon after harvest as possible. Avoid overloading cold-storage facilities to the point the berries cannot be cooled and maintained at the desired temperature.

Control of mummy berry is best achieved by eliminating the primary source of spores, the apothecia. Clean cultivation between rows and beneath plants in the spring and early summer will aid in control of this disease. Timely applications of effective fungicides at the green tip stage (onset of vegetative growth), and again during bloom will help to reduce losses from mummy berry.

To control Phomopsis twig blight, fungicides need to be applied at blossom bud break and repeated at 10-14 day intervals through bloom. There are various fungicides that are effective in controlling these diseases of blueberry; however, the rate and time of application will vary depending upon the disease, weather and spray equipment. Recommended control practices will vary from one region to another; therefore, it is important to consult state extension service recommendations before applying any chemicals. North Carolina blueberry growers should consult the blueberry spray program in the *N.C. Agricultural Chemicals Manual*

Arthropod Control

Maintaining a clean, healthy stand of blueberry bushes is one of the most effective ways to insure good control of arthropod pests. Weedy fields and field margins provide shelter and overwintering sites for some insects, and dead canes or dying bushes can serve as breeding sites for other species. Regular cultivation of the soil kills insects which pupate under dead leaves or near the soil surface, and a good program of fertilization and water-management keeps plants vigorous and better able to withstand a small amount of injury.

In addition to clean cultural practices, a successful blueberry grower also needs a carefully planned strategy for applying insecticides and miticides. The effectiveness of these pest control operations is influenced not only by the types of chemicals used, but also by the method and timing of their application. Since chemical formulations and labelling undergo frequent changes, no specific suggestions for insecticides or miticides are included here. Current recommendations for specific materials and information on application rates is available in the *N.C. Agricultural Chemicals Manual.*

In general, there are six time periods throughout the year when it may be appropriate to use pesticides to suppress insects or mites on blueberries. The following synopsis describes which pests can be controlled during each period, how to estimate optimal timing for treatments, and what other management options should be considered. Since a different spectrum of pests can be controlled during each interval, growers have some flexibility in the management of some minor pests (such as scales). Although some species require multiple treatments, individual fields should rarely need treatment during more than three or four of these periods. Although this summary is no substitute for experience, it does outline some of the important considerations that should go into making sound pest management decisions.

Dormant Season. A severe infestation of scale insects is the only arthropod problem which must be treated in the dormant season. Two applications of an oil suspension in January or February usually give satisfactory results. Timing of these sprays is not critical as long as they are applied on relatively warm days (>50°F) before the flower buds begin to open. Dormant sprays are not economical for treating small or scattered populations of scale insects. These minor infestations should be controlled with petal-fall sprays which coincide with the scale's crawler stage.

Cultural practices during the dormant season can kill overwintering insects and mites. Pruning out older wood tends to reduce bud mite populations, and clearing the ground cover in surrounding woods and field margins destroys overwintering plum curculio and the eggs of sharpnosed leafhoppers.

Pre-Bloom. In rare situations where cutworms or cranberry weevils have been diagnosed as a problem, a pre-bloom spray applied when the buds are beginning to swell will protect the plant from injury. Use a residual insecticide that will provide good activity at low temperatures and avoid micro-encapsulated formulations which bees might mistake for pollen grains.

Petal-Fall. Petal-fall sprays are probably the most important ones of the year. These applications provide control of plum curculio, cranberry fruitworm, cherry fruitworm, the crawler stage of scale insects, and the first generation of sharpnosed leafhoppers. Ideally, the first spray should be applied after the bees finish working the plants AND average daily temperatures reach 70°F. Applications made too early in the season are wasteful of time and materials because the pests are not yet active in the fields. Usually two cover sprays are needed after petal fall to obtain satisfactory control of fruitworms. However, when plum curculio are present, these sprays should be continued weekly until daytime temperatures reach 90°F.

Petal-fall is also an excellent time to control bud mites because they are no longer sheltered by the plant. At the present time, there are no miticides which can be used before harvest, but changes in registration are expected in the future.

Pre-harvest. Blueberry maggots are the only insect pests which may need to be treated just before harvest. Monitor populations with yellow sticky traps baited with protein hydrolysate and apply a short-residual insecticide only in locations where more than two flies are collected per trap per week. If berries are not yet ripe in an affected field, apply the insecticide by ground, spraying every middle. If ripe berries are already present, the available crop should be harvested just before the field is treated. Spray around the perimeter of a field to block immigration of flies from the surrounding woods. If weather or labor conditions prevent harvest and ground application with 5 days, the affected fields should be sprayed by air immediately.

Once a field reaches its treatment threshold, continue insecticide applications every 7 to 10 days until all unharvested fruit has dropped. If possible, use a picking machine to strip all remaining fruit; this eliminates oviposition sites and should reduce future populations. Following this strategy for several years should allow growers to gradually eradicate spot infestations of the blueberry maggot.

Post-harvest. Blueberry bud mites, Japanese beetles, many of the foliage and stem feeders, and the second generation of sharpnosed leafhoppers can be treated with pesticide applications in July. Monitor the sharpnosed leafhoppers with yellow sticky traps and apply one spray near the peak of their activity. If bud mites are also a

problem, include a miticide and repeat its application two weeks later. Since the mites are well protected under the bud scales, adequate spray material must be applied at high pressure to cover and penetrate the buds. Good coverage may require 200 to 400 gallons of spray per acre (depending on plant size) applied with approximately 200 lbs of pressure.

Autumn. Continue monitoring sharpnosed leafhopper populations and apply a final spray near the peak of the third generation. In North Carolina this application usually comes during the first or second week of October.

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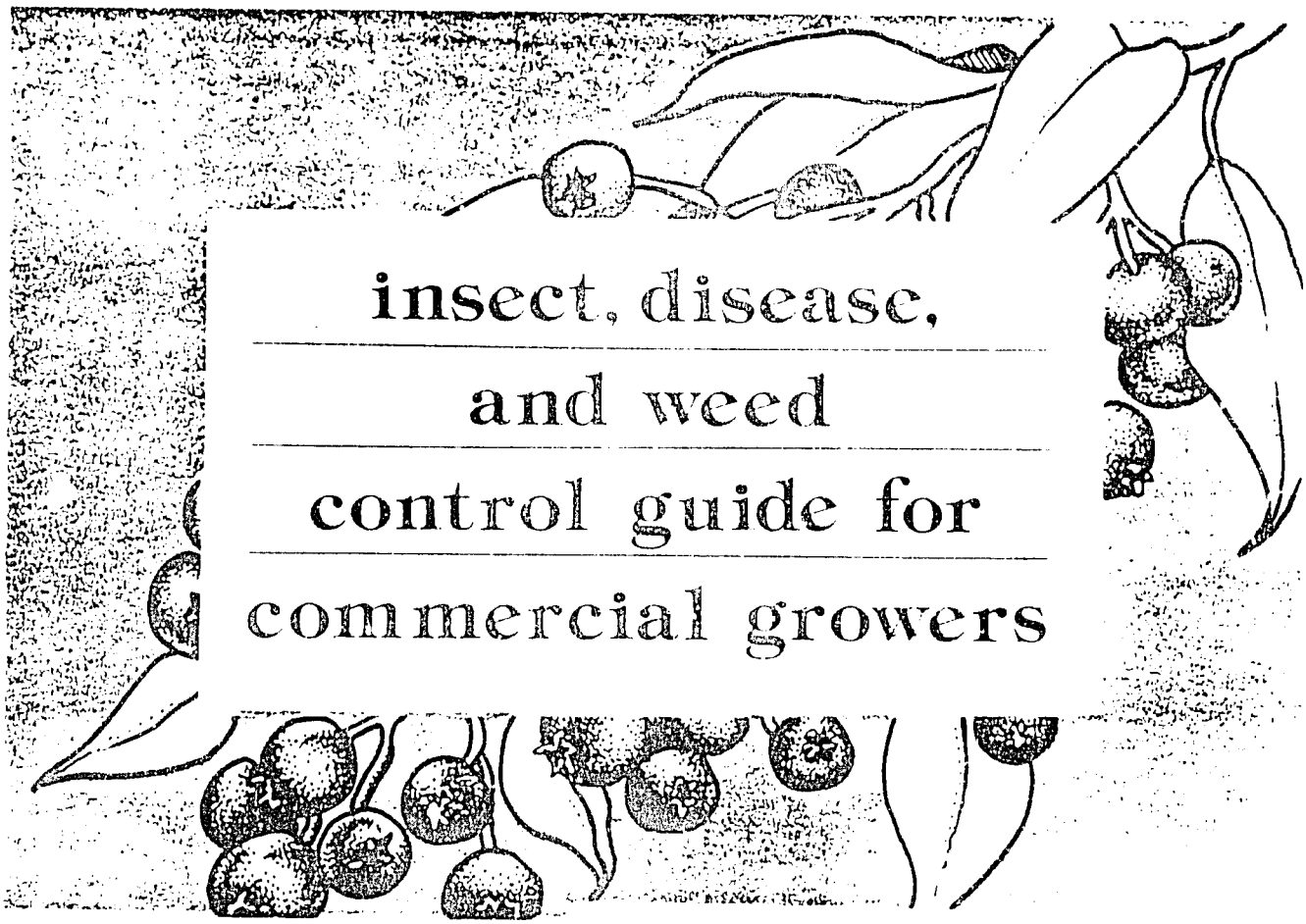
blueberries



IMPORTANT NOTICE—PNW 232

EDB (ethylene dibromide) was banned Sept. 30, 1983 by EPA for use as a soil fumigant. It is an ingredient in some of the products suggested for control of nematodes on page 5 of this publication. The specific products affected by the ban are Terr-o-cide 54-45, Terr-o-cide 15, Terr-o-cide 72-27, and Terr-o-cide 30.

The fumigant DD does not contain ethylene dibromide but the manufacturer has discontinued production of the chemical. Existing supplies of DD may be used in accordance with label directions.

PNW 232

A Pacific Northwest
Cooperative Extension Publication
Washington Oregon Idaho

DISEASE AND INSECT CONTROL GUIDE

Disease or Insect and Relative Occurrence	Pesticide (use one)	Actual Toxicant Per Acre	Minimum Days Between Last Application and Harvest	Remarks
		PREPLANT TREATMENT		
Nematodes rare	★ DD ★ or Telone or ★ Terr-o-cide	Follow manufacturer's directions.	Preplant only	Have nematode analysis made and base need to fumigate on results. It is best to fumigate in late summer or early fall before anticipated planting in spring.
Strawberry root weevil Black vine weevil Rough strawberry root weevil (occasional) Woods weevil Obscure root weevil (occasional)	There are no legally registered materials available that can be applied as preplant treatment.			Fumigation prior to planting will kill weevils present in the field. It will not protect the planting from weevils that migrate into the field at a later date.
		ESTABLISHED PLANTINGS **Dormant & Prebloom Periods**		
Aphids (common)	diazinon or malathion△	1 lb 1.5-2.0 lb	7 1	Apply to foliage as dust or spray in 100 gallons of water per acre. Apply when aphids appear and repeat application if necessary. Do not use diazinon if there is any bloom present—highly toxic to bees.
Godronia Canker (occasional)	Difolatan (4 flowable)	2-4 lb	21	Apply at bud break and repeat at 4-6 week intervals.
Lecanium scale△ (occasional)	Dormant oil Superior (98%) Dormant spray oil	2-2½ gal 4 gal		Use 4 gallons dormant oil emulsion (80%) or 2-2½ gallons Superior-type oil (98%) in 100 gallons of water. Apply while plants are dormant and when temperatures are above freezing. An insecticide such as diazinon may be added to the oil to control large scale populations.

△ Pest is not included on product label. See explanation on page 3.

★ This material is very dangerous to the applicator and should be handled with extreme caution.

Established Plantings, continued

Disease or Insect and Relative Occurrence	Pesticide (use one)	Actual Toxicant Per Acre	Minimum Days Between Last Application and Harvest	Remarks
Mummy Berry.△ (common)	Funginex	0.3 lb (24 fl oz of 18.2% EC)	See remarks	Apply in 20-50 gallons water or in 5 gallons water for aerial application. Apply at bud break and 7-10 days later. If season is cold and buds develop slowly, second application may be delayed. A 14-day interval has given excellent control in Puyallup valley experimental plots.
		Bloom Period		
Aphids.△ (common)	malathion△	1.5-2.0 lb	1	Apply to foliage as a spray in 100 gallons of water per acre. Apply when aphids appear and repeat application if necessary. *Apply in late evening to avoid bee kill. Do not use dust formulation.*
Lecanium scale△ (occasional)	malathion△	1.25 lb	1	Apply malathion as a spray in 100 gallons of water per acre. After June, use 150-200 gallons water per acre.
Mummy Berry.△ (common)	Funginex	0.3 lb (24 fl oz of 18.2% EC)	See remarks	Apply at pink bud stage and repeat 7-10 days later. Make final application at only 16 fluid ounces per acre between full bloom and petal fall.
Mummy Berry (common)	Benlate	0.5 lb	21	Apply at early bloom and at 10-14 day intervals through petal fall. Do not make more than four applications.
and/or	or			
Botrytis gray mold (common)	Captan	1 lb	0	Less effective than Benlate but can be used as a tank mixture with Benlate, or as an alternative spray to help prevent build up Benlate tolerant strains.
		Postbloom Period		
Aphids (common)	Same treatments as in Prebloom Section			
Cherry fruitworm (occasional)	malathion	1 lb	1	Apply to foliage in 100 gallons water per acre at blossom drop and again 2 weeks later. Cover foliage thoroughly.

△ Pest is not included on product label. See explanation on page 3.

Postbloom, continued

Disease or Insect and Relative Occurrence	Pesticide (use one)	Actual Toxicant Per Acre	Minimum Days Between Last Application and Harvest	Remarks
Godronia canker (occasional)	Difolatan (4 flowable)	2-4 lb	21	Apply immediately after harvest and repeat at 4-6 week intervals until leaf drop.
Leafrollers△ (common)	carbaryl (Sevin)	2 lb	0	Apply to foliage in 100 gallons of water per acre. Can be applied up to time of harvest. Make the first application May 15 unless there are still blossoms, in which case apply it after bloom. One or two additional applications may be necessary at 2-week intervals if infestations are heavy. *Warning:* Sevin is highly toxic to bees, so never apply it if there is any bloom in the field.
	methoxychlor△	2-3 lb	14	
	Dipel (B.t.)	0.5-1.0 lb of formulation	0	Other B.t. formulations are available.
Lecanium scale△ (occasional)	malathion△	1.5-2.0 lb	1	Apply malathion or parathion as spray 100 gallons water per acre. After June, use 150-200 gallons water per acre.
	★parathion	0.5 lb	14	These materials effective only when scale is in crawler stage. *Warning:* Parathion is highly toxic to bees, so never apply if there is any bloom in the field.
Obscure root weevil△ (occasional)	Azinphosmethyl (Guthion)△‡	0.5 lb	3	Apply to foliage in 100 gallons water per acre. Cover foliage thoroughly. Spray about mid-June to kill adults before egg deposition. Use malathion if additional sprays are needed. *Warning:* To avoid bee poisoning, do not apply Guthion if there is any bloom in the field. Guthion is highly toxic to bees.
	malathion△	2.5 lb	1	

△ Pest is not included on product label. See explanation on page 3.

★ This material is very dangerous to the applicator and should be handled with extreme caution.

‡ No Guthion products are registered for use on blueberries in the Pacific Northwest, however, there are at least two azinphosmethyl products registered for use on blueberries in Washington and Oregon. No azinphosmethyl products are registered for use on blueberries in Idaho.

SPRAY COMPATIBILITY (ABILITY TO MIX) CHART FOR FUNGICIDES AND INSECTICIDES

Combining chemicals

It may be to your advantage to control several problems with one spray by combining several chemicals. *Read the label* and follow the manufacturer's directions when making these mixtures. This compatibility chart is provided to help you in preliminary planning only. Compatibilities can vary from those indicated on this chart because of change in solvents and emulsifying agents, etc. It is a good idea before making a tank mixture to mix the chemicals in a jar of water at approximately the recommended dilution rate and look for any reactions that would cause solids to form and separate out of the solution. Some mixtures may create phytotoxicity problems (plant injury), so unless a label specifies otherwise, either experiment on a few plants or avoid doing it.

	Sevin	Parathion	Methoxychlor	Malathion	Guthion	Diazinon	Benlate
Benlate							
Diazinon							
Guthion							
Malathion							
Methoxychlor							
Parathion ★							
Sevin							

Blank = Normally compatible. As indicated, all chemicals in this chart are presumably compatible, but growers should be cautious in mixing new chemicals which do not appear in this chart. Consult the annual revisions of this publication for new chemicals. It is suggested that growers not mix chemicals unless approved by the manufacturer.

Note: Dipel is not listed. Refer to label for compatibility information.

★ This material is very dangerous to the applicator and should be handled with extreme caution.

BIRD CONTROL

Mesurol

This chemical has received registration for use on blueberries as a repellent for starlings, grackles, redwing blackbirds, jays, finches, and robins. Apply 2-2⅔ pounds 75% WP per acre by air or ground equipment in a minimum of 5 gallons water per acre. Repeat as necessary with a minimum of 7 days between applications. A maximum of 8 pounds of product may be applied per season. Applications may be made up to the day of harvest.

Note: For maximum repellency of birds, apply as berries first begin to ripen. Experience in Oregon has shown that control has been achieved by spraying bushes on the perimeter of the fields and every third or fourth row. *Caution:* Application of Mesurol to blooming crops or weeds will kill bees.

WEED CONTROL GUIDE

Make sure all perennial weeds have been eliminated before establishing a new planting. Chemicals will provide good weed control in established plantings as well as control annual weeds in new blueberry fields. Herbicide treatment of new plantings must be done with caution, because very young plants have small root balls that are near the soil surface and may be seriously injured by chemicals applied at too high rates. A wise policy would be to apply no herbicides until the blueberry plants have been in the field 6 months to 1 year.

Good weed control requires accurate application, correct timing, and the appropriate herbicide if weeds are to be controlled without injury to the blueberry plants.

NEW PLANTINGS

Sawdust applied around the base of new plants will suppress annual germinating weeds. *Caution:* Excessive sawdust piled at the base of established plants has in some cases resulted in severe crown damage. Otherwise, new blueberry plantings may be treated for control of annual weeds at reduced rates of certain herbicides in the spring after plants have started to grow.

Simazine (Princep)

Apply simazine at 1.0-1.6 pounds active ingredient per acre. Use lower rate on light textured soils. Simazine has very little effect on growing weeds, so it must be applied before weeds emerge from the soil. Follow application with sprinkler irrigation if soil is dry. This treatment is not effective in muck or mulched soils. See bee warning in Established Planting section.

ESTABLISHED PLANTINGS

Herbicides will provide selective control of many annual and perennial weeds. Since several may be safely and effectively used, the choice depends on several interrelated factors: weed species present, soil type, weather conditions, etc.

Dichlobenil (Casoron, Norosac)

Dichlobenil is effective against many annual and perennial weeds. For horsetail and annual weeds, apply at 4-6 pounds active ingredient (100-150 pounds of Casoron or Norosac 4 G) per acre in the spring before weeds emerge. Application must be followed by rain or sprinkler irrigation. For perennials, such as sheep sorrel, quackgrass, orchardgrass, and Canada thistle, apply the higher rate per acre while weeds are dormant in late fall to January.

Precautions:
1. Do not make more than one application per year.
2. Do not apply during new shoot emergence.

Follow dichlobenil applications after 2-4 weeks with a complete coverage of weed foliage using a contact herbicide such as paraquat at 0.5-1 pound active ingredient (1-2 quarts of Paraquat CL or Gramoxone) per acre as a coarse, directed spray at 30 p.s.i. to avoid drift injury to young canes from fine mist. Add Ortho X-77 spreader (non-ionic) at 1 quart per 100 gallons of spray.

Simazine (Princep)

A single simazine application at 2-4 pounds active ingredient (2.5-5 pounds of 80W) per acre is effective against a number of weeds and grasses. Apply in winter while plants are dormant. A split treatment of 2 pounds active ingredient applied in October or November, and repeated in March or April, usually provides better residual control.

Precautions:
1. Do not apply when fruit is present.
2. Is not effective on muck soil or mulched plantations.
3. Apply only during late evening, night or early morning to protect bees foraging on blooming crops or weeds.

For more effective control of perennial weeds, follow simazine application with complete coverage of weed foliage using a contact herbicide such as paraquat at 0.5-1 pound active ingredient (1-2 quarts of Paraquat CL or Gramoxone) per acre. Add Ortho X-77 Spreader (non-ionic) at 1 quart per 100 gallons of spray. Using a contact herbicide will stop weed growth and improve overall weed control.

Diuron (Karmex)

In western Oregon and western Washington only: diuron at 2.4 pounds active ingredient (3 pounds of 80W) per acre can be used during the winter. A split application of diuron at 1.6 pounds active ingredient (2 pounds of 80W) per acre, may be used to control annual weeds. Apply in October and again in the spring before emergence of annual weeds. This treatment is not effective against perennial weeds or weeds growing in muck or mulched soils.

Precautions:
1. Avoid spraying foliage during spring treatment.
2. Do not use within 1 year after planting.
3. Do not use on soil with less than 2% organic matter.

Pronamide (Kerb)

Pronamide will control most perennial grasses. Apply at 1-2 pounds active ingredient (2-4 pounds of 50W) per acre. Use lower rate for annual grass and/or light textured soil, and a higher rate on perennial grass. Applications must be followed by irrigation or precipitation. Make applications from October through January. Pronamide will not control groundsel, pineappleweed, sowthistle, wild lettuce, or Canada thistle. For control of these weeds, use with an early spring application of dichlobenil, terbacil, or simazine.

Precautions:
1. Do not apply when soil is frozen.
2. Is not effective on muck soil or mulched plantations.

Chlorpropham (Furloe CIPC)

Chlorpropham will control primarily grasses, but has short residual activity. For annual grasses, use 6 pounds active ingredient (1.5 gallons of 4 EC) per acre in late fall or early spring when the crop is dormant. Low rate on the label is 8 quarts (8 pounds active ingredient). Six quarts not recommended in Idaho.

For hard to kill grasses, make fall application and repeat in the spring before grasses emerge from the soil. For perennial grasses, apply in late fall at 12 pounds active ingredient (3 gallons of 4 EC) per acre.

Terbacil (Sinbar)

Terbacil is effective in controlling many different weed species (including cinquefoil, hawkweed, red sorrel, crabgrass, orchardgrass, quackgrass, and annual sedge) in blueberry plantings that are at least one year old. Make a single band or broadcast application beneath bushes during late February to late March. Fall applications have not provided adequate control in western Washington due to heavy rainfall. Spring applications made after late March have caused severe injury on the lighter textured soils.

Terbacil has been used for weed control in blueberries grown on Camas clay loam, Puyallup sandy loam, Mossy Rock silt loam, and muck soils. Control has been excellent in most cases. Rates to use are governed by soil texture:

	Pounds of Active Ingredient	
Soil Texture	**1 to 3% Organic Matter**	**More than 3% Organic Matter**
1. Sandy, loamy sand	DO NOT USE	1.6 (2 lb 80W Sinbar)
2. Sandy loam	1.6 (2 lb 80W Sinbar)	2.4 (3 lb 80W Sinbar)
3. Loam, silt loam, silt, sandy clay, sandy clay loam	2.4 (3 lb 80W Sinbar)	3.2 (4 lb 80W Sinbar)
4. Silty clay, silty clay loam, clay, clay loam	3.2 (4 lb 80W Sinbar)	3.2 (4 lb 80W Sinbar)

Terbacil should be applied before the weeds emerge from the soil or in the seedling stage, for best results. If weed growth is beyond the seedling stage use a surfactant, such as DuPont's Surfactant WK, Accutrol, Multifilm, X-77, or Adjuvant-T, at the rate of 1 pint per 25 gallons of water per acre. If weed growth is heavy, use 50 gallons or more of water per acre.

Precautions:

1. Do not apply after March since injury can result to plants grown on coarse-textured soils.
2. Do not use on sands or sandy loams containing less than 3% organic matter.
3. Do not make more than one application per year.
4. Do not permit spray to contact blueberry plant foliage.
5. Do not apply to soils where water may be standing for prolonged periods. Terbacil has a water solubility of 710 ppm and will be readily absorbed by blueberry roots causing injury.

Terbacil may be followed in 2-4 weeks with complete weed foliage coverage of a contact herbicide such as paraquat at 0.5-1.0 pound active ingredient (1-2 quarts of Paraquat CL or Gramoxone) per acre as a coarse, directed spray at 30 p.s.i. to avoid drift injury to young canes from fine mist. Add Ortho X-77 spreader (non-ionic) at 1 quart per 100 gallons of spray.

METHOD OF APPLICATION

Uniform application is absolutely necessary if herbicides are to provide the desired results. Treatment rates are low. For example, only 2 pounds of 80% simazine powder are needed per acre. Such a small amount of material spreads very thinly over an acre. Variations in the spray pattern, speed of the rig, worn nozzle tips, etc., will change the application rate sufficiently to damage the crop or reduce the weed control. To get uniform application, be sure that your spray rig:

1. Can apply material at low pressures, 30–40 pounds per square inch.
2. Can apply 40-60 gallons of spray per acre.
3. Has nozzles evenly spaced, 12-18 inches apart, along a boom that can be adjusted for height.
4. Can move at a constant ground speed between 2 and 4 miles per hour.
5. Has nozzle tips that deliver the rated volume of spray (test the output of the individual tip to determine its accuracy relative to the anticipated).

Diuron, oronamide, terbacil and some formulations of simazine and dichlobenil are wettable powders that do not dissolve in water. Consequently, you must take several additional precautions to insure maintaining a uniform application.

Additional Precautions:

1. Screens in the lines and nozzles should be no smaller than 50 mesh to avoid clogging.
2. The material will settle to the bottom of the tank if not constantly agitated. Either continuous mechanical agitation by paddles in the tank or hydraulic agitation by return-flow jets is necessary.
3. Wettable powders are abrasive; therefore, these herbicides should not be used in gear, roller, or impeller pumps. The clearances in these positive-displacement pumps are close; therefore, they wear quickly when abrasives are pumped.
4. Nozzles wear readily, too. As a result, the amount of spray being pushed through the nozzle will constantly increase. The spray rig must, therefore, be properly designed and calibrated often if you are to be sure of the amount of material being applied per acre.

Note: All rates of application are given in pounds active ingredient per acre. Rates of application are based on complete (overall) coverage, not just banded or over the row.

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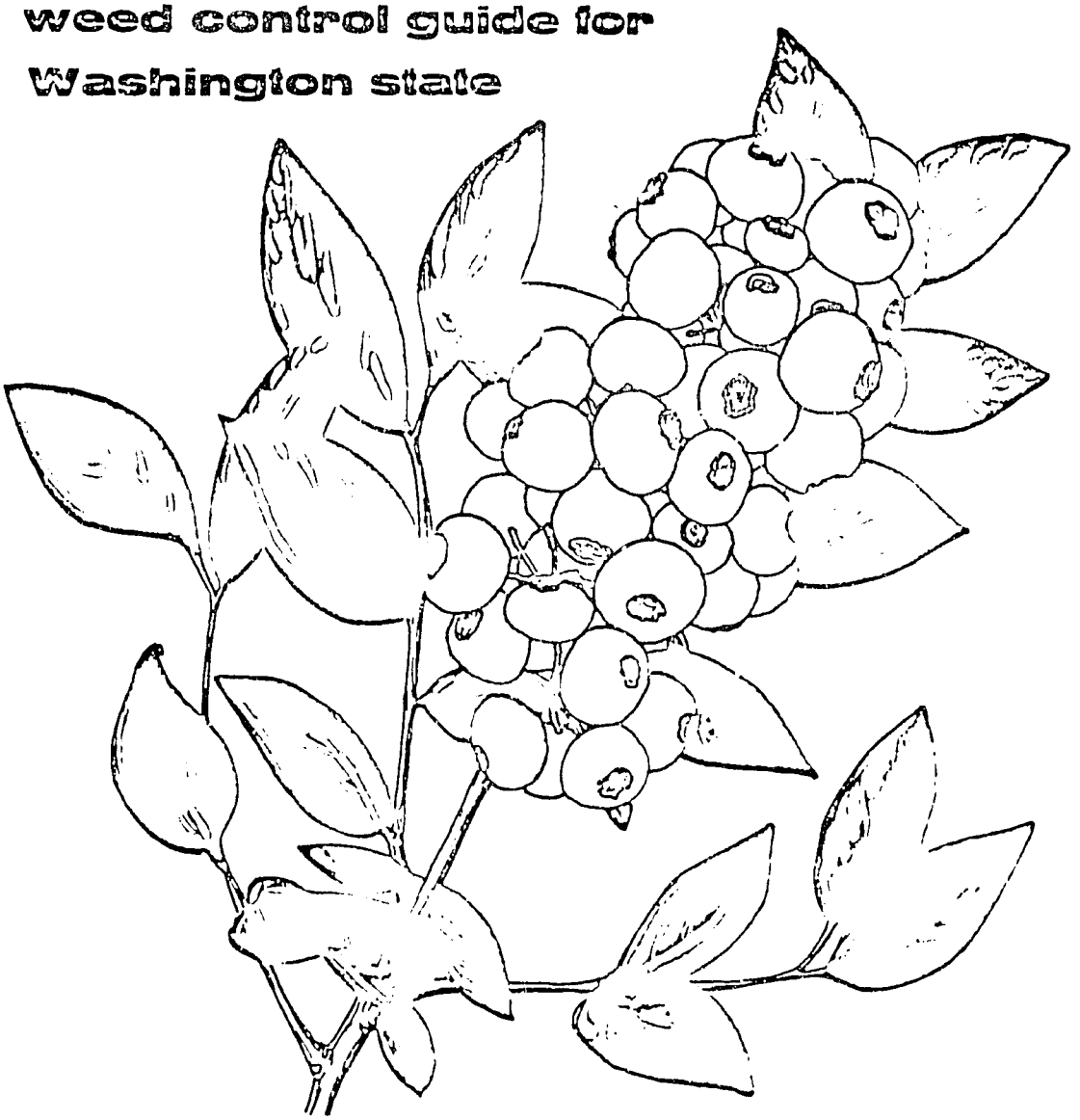
COMMERCIALLY GROWN BLUEBERRIES

insect, disease, and weed control guide for Washington state



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NOTE

- Lists of chemicals in this publication indicate legally registered materials, and sequence of listing does not indicate better performance of one material over the other.

PESTS NOT ON PRODUCT LABEL

Some suggested uses of pesticides in this publication are for pests not listed on product labels. These are indicated by the symbol Δ. Such uses comply with the federal law (FIFRA) which says a use is consistent with label directions provided the crop or site is on the label and directions concerning rates and interval before harvest are followed.

WHEN TO SPRAY

The purpose of this spray schedule is to help growers know when to be on the lookout for various diseases, insect pests, and weeds. The purpose is not to recommend routine sprays for all the problems listed. Some diseases and other pests of blueberries occur almost every year and require routine preventative treatments. Possible examples are fruit rot, leafrollers, and annual weeds. However, other problems, e.g., nematodes, are sporadic in frequency and location and should be treated only as the need arises. This requires constant vigilance by the grower, so a problem, if it does occur, will not advance beyond remedy. The reward for vigilance is a lower bill for pesticides and application, as well as protection of natural control agents which help to further reduce the "cost" of pesticides.

Note that diseases and insects are listed according to relative occurrence: rarely encountered, occasionally encountered, or commonly encountered. These terms serve as a guideline in order to prevent or avoid continuous prophylactic or preventative sprays for pests that do not occur regularly.

BEE POISONING

Honey bees are necessary for complete pollination of blueberry flowers. Poor pollination results in lower yields, with small berries.

Many of the insecticides recommended for the prebloom or postharvest periods are highly toxic to bees and should not be used during bloom. The chemicals methoxychlor and malathion may be used during bloom if they are applied in the following manner: methoxychlor, during late evening, night, or early morning; malathion EC, only during late evening. None of the recommended fungicides or herbicides applied during bloom are toxic to bees.

Contact nearby beekeepers whenever you plan to use a material that is hazardous to bees. This will prevent accidental bee kills and help establish better cooperation between growers and beekeepers.

DISEASE AND INSECT CONTROL GUIDE

Disease or Insect and Relative Occurrence	Pesticide (use one)	Actual Toxicant Per Acre	Minimum days Between Last Application and Harvest	Remarks
PREPLANT TREATMENT				
Nematodes (rare)	DD or Telone or Vidden D or Vorlex	Follow manufacturer's directions	Preplant only	Have nematode analysis made and base fumigation on results. It is best to fumigate in late summer or early fall before anticipated planting in spring.
Strawberry root weevil Black vine weevil Rough strawberry root weevil (occasional) Woods weevil Obscure root weevil (occasional)	There are no legally registered materials available that can be applied as preplant or prebloom treatment.			
ESTABLISHED PLANTINGS Dormant & Prebloom Periods				
Aphids△ (common)	diazinon malathion△	1 lb 1.25 lb	7 1	Apply to foliage as dust or spray in 100 gal of water per acre. Apply when aphids appear and repeat application if necessary. Do not use diazinon if there is any bloom present—highly toxic to bees.
Godronia canker (occasional—rare)	Difolatan (4 flowable)	2-4 lb	21	Apply at bud break and repeat at 4-6 week intervals.
Lecanium scale (occasional)	Dormant oil Superior (98%) Dormant spray oil (80%)	2-2 1/2 gal 4 gal		Use 4 gal Dormant oil emulsion (80%) or 2-2 1/2 gal Superior-type oil (98%) in 100 gal of water. Apply while plants are dormant and when temperatures are above freezing.

CONTROL GUIDE (continued)

Disease or Insect and Relative Occurrence	Pesticide (use one)	Actual Toxicant Per Acre	Minimum Days Between Last Application and Harvest	Remarks
Mummy Berry (common)	Funginex	0.3 lb (24 fl oz of 18.2% EC)	See remarks	Apply in 20-50 gal water or in 5 gal water for aerial application. Apply at bud break and 7-10 days later. If season is cold and buds develop slowly, second application may be delayed. A 14-day interval has given excellent control in Puyallup valley experimental plots.
		Bloom Period		
Aphids△ (common)	malathion△	1.25 lb	1	Apply to foliage as a spray in 100 gal of water per acre. Apply when aphids appear and repeat application if necessary. *Apply in Late Evening to Avoid Bee Kill. Do Not Use Dust Formulation.*
Lecanium scale△ (occasional)	malathion△	1.25 lb	1	Apply malathion as a spray in 100 gal of water per acre. After June, use 150 to 200 gal water per acre.
Mummy Berry (common)	Funginex	0.3 lb (24 fl oz of 18.2% EC)	See remarks	Apply at pink bud stage and repeat 7-10 days later. Make final application at only 16 fl oz/A between full bloom and petal fall.
Mummy Berry (common) and/or	Benlate or	1/2 lb	21	Apply at early bloom and at 10- to 14-day intervals through petal fall. Do not make more than four applications.
Botrytis gray mold (common)	Captan	1 lb	0	Less effective than Benlatate but can be used as a tank mixture with Benlate, or as an alternative spray to help prevent build up of Benlate tolerant strains.
		Postbloom		
Aphids (common)	Same treatments as in Prebloom Section			

CONTROL GUIDE (continued)

Disease or Insect and Relative Occurrence	Pesticide (use one)	Actual Toxicant Per Acre	Minimum Days Between Last Application and Harvest	Remarks
Cherry fruitworm (occasional)	malathion	1 lb	1	Apply to foliage in 100 gal water per acre at blossom drop and *again* 2 weeks later. Cover foliage thoroughly.
Godronia canker (occasional—rare)	Difolatan (4 flowable)	2-4 lb	21	Apply immediately after harvest and repeat at 4-6 week intervals until leaf drop.
Leafrollers△ (common)	carbaryl (Sevin)	2 lb	0	Apply to foliage in 100 gal of water per acre. Can be applied up to time of harvest. Make the first application May 15 unless there are still blossoms, in which case apply it after bloom. One or two additional applications may be necessary at 2-week intervals if infestations are heavy.
	methoxychlor△	2-3 lb	14	
	Warning:	Sevin is highly toxic to bees, so never apply it if there is any bloom in the field.		
Lecanium scale△ (occasional)	malathion△	1.25 lb	1	Apply malathion or parathion as spray in 100 gal water per acre. After June, use 150-200 gal water per acre.
	parathion	0.5 lb	14	
	Warning:	Parathion is highly toxic to bees, so never apply if there is any bloom in the field.		
Obscure root weevil△ (occasional)	azinphos-methyl (Guthion)△	1 lb	14	Apply to foliage in 100 gal water per acre. Cover foliage thoroughly. Spray about mid-June to kill adults before egg deposition. Use malathion if additional sprays are needed.
	malathion△	2.5 lb	1	
	Warning:	To avoid bee poisoning, do not apply Guthion if there is any bloom in the field. Guthion is highly toxic to bees.		

• Registration of heptachlor has been suspended for this use by EPA; however, existing stocks with these uses on the label can be used according to label directions. No substitute is registered for this use.

△ Pest is not included on product label. See explanation on page 2.

SPRAY COMPATIBILITY (ABILITY TO MIX) CHART FOR FUNGICIDES AND INSECTICIDES

It may be to your advantage to control several problems with one spray by combining several chemicals. *Read the label* and follow the manufacturer's directions when making these mixtures. This compatibility chart is provided to help you in preliminary planning only. Compatibilities can vary from those indicated on this chart because of change in solvents and emulsifying agents, etc. It is a good idea before making a tank mixture to mix the chemicals in a jar of water at approximately the recommended dilution rate and look for any reactions that would cause solids to form and separate out of the solution. Some mixtures may create phytotoxicity problems (plant injury), so unless a label specifies otherwise, either experiment on a few plants or avoid doing it.

	Sevin	Parathion	Methoxychlor	Malathion	Heptachlor	Guthion	Diazinon	Benlate
Benlate					C			
Diazinon								
Guthion								
Heptachlor								C
Malathion								
Methoxychlor								
Parathion								
Sevin								

Blank=Normally compatible however it is suggested in newer compatibility charts to not mix unless approved by manufacturer.
C=Caution

BIRD CONTROL

Mesurol has received a Washington State registration for use on blueberries as a repellent for starlings, grackles, redwing blackbirds, jays, finches, and robins. Apply 2-2 2/3 pounds 75% WP per acre by air or ground equipment in a minimum of 5 gallons water per acre. Repeat as necessary with a minimum of 7 days between applications. A maximum of 8 pounds of product may be applied per season. Applications may be made up to the day of harvest.

Note: For maximum repellency of birds, apply as berries first begin to ripen.

EB 0849

WEED CONTROL GUIDE

Chemicals will provide good weed control in established plantings as well as control annual weeds in new blueberry fields. Herbicide treatment of new plantings must be done with caution, because very young plants have small root balls that are near the soil surface and may be seriously injured by chemicals applied at too high rates. A wise policy would be to apply no herbicides until the blueberry plants have been in the field 6 months to 1 year.

Good weed control requires accurate application, timing, and amount of materials, if weeds are to be controlled without injury to the blueberry plants.

A. NEW PLANTINGS

New blueberry plantings may be treated for control of annual weeds at reduced rates of certain herbicides the spring following the setting of plants.

Simazine (Princep)

Apply simazine at 1.6 pounds active ingredient (2 pounds of 80 W Princep) per acre. It has very little effect on growing weeds, so it must be applied before weeds emerge from the soil. Follow application with sprinkler irrigation.

B. ESTABLISHED PLANTINGS

Herbicides will provide selective control of many annual and perennial weeds. Since several may be safely and effectively used, the choice depends on several interrelated factors: weed species present, soil type, and weather conditions.

Dichlobenil (Casoron)

Dichlobenil is effective against many annual and perennial weeds. For horsetail and annual weeds, apply at 6 pounds active ingredient (150 pounds of Casoron 4 G) per acre in the spring before weeds emerge. Application must be followed by rain or sprinkler irrigation. For perennials, such as sheep sorrel, quackgrass, orchardgrass, and Canada thistle, apply the same amount per acre while weeds are dormant in late fall to January.

Precautions:
1. Do not make more than one application per year.
2. Do not apply to plants which have been established in the field for less than one year.

Follow dichlobenil applications after 2 to 4 weeks with a complete weed foliage coverage of a contact herbicide, such as: (1) dinoseb (Dow General, Premerge, Sinox General) at 2.5 pounds active ingredient (.5 gallon of 5 pounds/gallon Dow General) plus 2 gallons of Summer Spray Oil in 50 gallons or more of water per acre; or (2) paraquat (Paraquat CL) at 1 pound active ingredient (.5 gallon of 2 EC Paraquat CL) per acre as a coarse directed spray at 30 p.s.i. to avoid drift injury to young canes from fine mist.

Simazine (Princep)

Simazine at 4 pounds active ingredient (5 pounds of 80 W Princep) per acre is effective against a number of weeds and grasses. Apply in winter while plants are dormant.

Precautions:
1. Do not make more than one application per year.
2. Do not apply to plants that have been in the field less than one year.

For a more effective control of perennial weeds, follow simazine application with a complete weed foliage coverage using a contact herbicide, such as: (1) dinoseb at 2.5 pounds active ingredient (.5 gallon of 5 pounds/gallon Dow General) per acre plus 2 gallons of Summer Spray Oil per 50 gallons of water per acre; or (2) paraquat at 1 pound active ingredient (.5 gallon of 2 EC Paraquat CL) per acre. Using a contact herbicide will stop weed growth and give a simazine a better chance to work.

Diuron (Karmex)

Diuron at 1.6 pounds active ingredient (2 pounds of 80 W Karmex) per acre, or simazine at 2 pounds active ingredient (2.5 pounds of 80 W Princep) per acre may be used to control annual weeds. Apply in October and again in the spring before emergence of annual weeds. This treatment is not effective against perennial weeds or weeds growing in muck or mulched soils.

PERENNIAL GRASS CONTROL

Perennial grasses are most easily controlled by herbicide applications in November to January while grasses and crop plants are dormant.

Pronamide (Kerb)

Pronamide will control most perennial grasses. Apply at 2 pounds active ingredient (4 pounds of 50 W Kerb) per acre. Applications must be followed by irrigation or precipitation. Make applications from November to January. Pronamide will not control groundsel, pineappleweed, sowthistle, wild lettuce, or Canada thistle. For control of these weeds, use with an early spring application of dichlobenil, terbacil, or simazine. Pronamide is not effective on muck soils or mulched plantations.

Chlorpropham (Furloe, CIPC)

Chlorpropham will control some perennial grasses. Make application in late fall at 12 pounds active ingredient (3 gallons of 4 EC Furloe) per acre. For hard-to-kill grasses, make fall application and repeat in the spring before grasses emerge from the soil. Chlorpropham will control annual grasses: make application in spring before grasses emerge from the soil.

PERENNIAL AND ANNUAL BROADLEAF AND GRASS WEED CONTROL

Terbacil (Sinbar) is effective in controlling many different weed species (including cinquefoil, hawkweed, red sorrel, crabgrass, orchardgrass, quackgrass, and annual sedge) in blueberry plantings that have been established in the field for at least one year. Make a single band or broadcast application

beneath bushes during late February to late March. Fall applications have not provided adequate control in western Washington due to heavy rainfall. Spring applications made after late March have caused severe injury on the lighter textured soils.

Terbacil has been used for weed control in blueberries grown on Camas clay loam, Puyallup sandy loam, Mossy Rock silt loam, and muck soils. Control has been excellent in most cases. Rates to use are governed by soil texture (see the table):

	Lb Active	
Soil Texture	1 to 3% Organic Matter	More Than 3% Organic Matter
1. Sandy, loamy sand	DO NOT USE	1.6 (2 lb 80 W Sinbar)
2. Sandy loam	.6 (2 lb 80 W Sinbar)	2.4 (3 lb 80 W Sinbar)
3. Loam, silt loam, silt, sandy clay, sandy clay loam	2.4 (3 lb 80 W Sinbar)	3.2 (4 lb 80 W Sinbar)
4. Silty Clay, silty clay loam, clay, clay loam	3.2 (4 lb 80 W Sinbar)	3.2 (4 lb 80 W Sinbar)

Terbacil should be applied before the weeds emerge from the soil or in the seedling stage, for best results. If weed growth is beyond the seedling stage use a surfactant, such as DuPont's Surfactant WK, Accutrol, Multifilm, X-77, or Adjuvant-T, at the rate of 1 pint per 25 gallons of water per acre. If weed growth is heavy, use 50 gallons or more of water per acre.

Precautions:
1. Do not apply after March since injury can result to plants grown on coarse-textured soils.
2. Do not use on sands or sandy loams containing less than 3% organic matter.
3. Do not make more than one application per year.
4. Do not permit spray to contact blueberry plant foliage.
5. Do not apply to soils where water may be standing for prolonged periods. Terbacil has a water solubility of 710 ppm and will be readily absorbed by blueberry roots causing injury.

Terbacil may be followed in 2 to 4 weeks with complete weed foliage coverage of a contact herbicide to knock down existing weed growth. The following herbicides may be used in 50 gallons of water per acre.

Herbicides	Lb Active Ingredient Per Acre
Paraquat	1.0 (.5 gal of 2 EC Paraquat CL)
Dinoseb (plus 2 gal Summer Spray Oil per 50 gal of water per acre)	2.5 (.5 gal of 5 lb/gal Dow General)

METHOD OF APPLICATION

Uniform application is absolutely necessary if herbicides are to provide the desired results. Treatment rates are low. For example, only 2 pounds of 80% simazine powder are needed per acre. Such a small amount of material spreads very thinly over an acre. Variations in the spray pattern, speed of the rig, worn nozzle tips, etc., will change the application rate sufficiently to damage the crop or reduce the weed control. To get uniform application, be sure that your spray rig:

1. Can apply material at low pressures, 30 to 40 pounds per square inch as read on the gauge.
2. Can apply 40 to 60 gallons of spray per acre.
3. Has nozzles evenly spaced, 12 to 18 inches apart, along a boom that can be adjusted for height.
4. Can move at a constant ground speed between 2 and 4 miles per hour.
5. Will cover the entire area with a broadcast application, instead of just covering the row.
6. Has nozzle tips that deliver the rated volume of spray (test the output of the individual tip to determine its accuracy relative to the anticipated).

Simazine, dichlobenil, diuron, pronamide, and terbacil are wettable powders that do not dissolve in water. Consequently, you must take several additional precautions to insure maintaining a uniform application.

Additional Precautions:
1. Screens in the lines and nozzles should be no smaller than 50 mesh to avoid clogging.
2. The material will settle to the bottom of the tank if not constantly agitated. Either continuous mechanical agitation by paddles in the tank or hydraulic agitation by return-flow jets is necessary.
3. Wettable powders are abrasive; therefore, these herbicides should not be used in gear, roller, or impeller pumps. The clearances in these positive-displacement pumps are close; therefore, they wear quickly when abrasives are pumped.
4. Nozzles wear readily, too. As a result, the amount of spray being pushed through the nozzle will constantly increase. The spray rig must, therefore, be properly designed and calibrated often if you are to be sure of the amount of material being applied per acre.

Note: All rates of application are given in pounds active ingredient per acre; also, rates of application are based on complete (overall) coverage, not just banded or over the row.

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EB 0849

APPROXIMATE METRIC WEIGHTS AND MEASURES

COMMON EQUIVALENTS

Metric	U.S.
Millimeter	0.039 inches
Centimeter (10 mm)	0.39 inches
Meter (100 cm)	39.4 inches
Kilometer (1,000 m)	0.62 miles
Square Centimeter	0.155 square inches
Square Meter	1.2 square yards
Hectare (10,000 sq m)	2.47 acres
Square Kilometer (100 ha)	247 acres
Gram	0.035 ounces
Kilogram (1,000 g)	2.2 pounds
Ton (metric) (1,000 kg)	1.1 tons (US)
Milliliter	0.034 fluid ounce
Liter (1,000 ml)	1.056 quarts
Cubic Meter (1,000 l)	264.17 gallons (US)

U.S.	Metric
Inch	2.54 centimeters
Foot (12 in)	30.5 centimeters
Yard (3 ft.)	0.91 meters
Mile (5,280 ft.)	1.6 kilometers
Square Inch	6.5 square centimeters
Square Foot (144 sq. in.)	930 square centimeters
Square Yard (9 sq. ft.)	0.84 square meters
Acre—43,560 sq. ft.	0.405 hectares
Square Mile—640 acres	259 hectares
Ounce	28.3 grams
Pound—16 oz.	0.454 kilograms
Ton (US)—2,000 lb.	0.907 tons (metric)
Tablespoon—3 teaspoons	14.79 milliliters
Fluid Ounce—2 tablespoons	29.6 milliliters
Cup—8 fl. oz.	0.237 liters
Pint—2 cups	0.473 liters
Quart—4 cups	0.946 liters
Gallon (US)—4 qts.	3.8 liters
Cubic Foot	28.3 liters

PROPORTIONS

Metric	U.S.
100 g/ha	1.4 oz./acre
1 kg/ha	0.9 lb./acre
1 ton (metric)/ha	0.446 tons (US)/acre
1 l/ha	0.4 qt./acre
1 kg/1000 l	1 lb./100 gals.
1 g/1000 kg	1 ppm
1 km/hr	0.6 mph

U.S.	Metric
1 oz./acre	70 g/ha
1 lb./acre	1.12 kg/ha
1 ton (US)/acre	2.24 tons (metric)/ha
1 fl.oz./acre	73 ml/ha
1 gal./acre	9.39 l/ha
1 lb./100 gals.	1 kg/1000 l
1 ppm	1 g/1000 kg
1 mph	1.6 km/hr

TEMPERATURES

Celsius (Centigrade)	Fahrenheit
-30	-22
-20	-4
-10	14
0	32
10	50
20	68
30	86
40	104

Fahrenheit	Celsius (Centigrade)
0	-18
10	-12
20	-7
30	-1
40	4
50	10
60	16
70	21
80	27
90	32

To convert: Celsius to Fahrenheit — multiply by 9/5 (1.8) and add 32.
Fahrenheit to Celsius — subtract 32 and multiply by 5/9 (0.56).

ABBREVIATIONS

mm — millimeter, cm — centimeter, m — meter, km — kilometer, ha — hectare, mg — milligram, g — gram, kg — kilogram, l — liter
ml — milliliter

GROWER'S SPRAY RECORD

Date Applied	Stage of Growth	Field Identification	Pest Controlled	Chemical Used	Rate Used	Remarks (weather, notes, etc.)

BLUEBERRIES

Rates of materials for blueberry are based on standard amounts/acre used in air applications. NOTE: Do not apply any fungicides (except Funginex) listed by airplane. Thorough coverage by ground sprayers is essential with the recommended fungicides. See Extension Bulletin E-840, "Tractor-Mounted Air Blast Sprayers in Small Fruit Crops," for calibration of sprayers.

GREEN TIP (1/16")

Pest	Efficiency	Suggested Chemicals (Rate/acre)
DISEASES		2. Funginex 20 EC* (24 fl oz) 8. Difolatan 80% "Sprills"** (2½ lb) 8. Difolatan 4 F** (2 qt)
Fusicoccum Canker	8	
Mummyberry (Shoot blight phase)	2	***Comments:*** *Asterisk (*)—Apply in 20 gallons water/acre by ground sprayer or in 5 gallons water/acre by airplane.* *Double asterisk (**)—A new label registration for Difolatan on blueberries allows for chemical control of Fusicoccum canker. Although Phomopsis canker is not on the label, Difolatan will give some control. Conidiospores of both fungi are spread from cankers on stems with each rain beginning at bud break and continuing into the fall.* ***Do not** apply Difolatan by airplane. Coverage is too poor to get good results.*

GREEN TIP (1/4"-1/2")

Pest	Efficiency	Suggested Chemicals (Rate/acre)
DISEASES		2. Funginex 20 EC (24 fl oz)
Mummyberry (Shoot blight phase)	2	

PINK BUD

Pest	Efficiency
DISEASES	
Mummyberry (blossom infection stage)	1, 2
Fusicoccum Canker	1, 2, 8
Anthracnose	1, 2, 8
Alternaria Fruit Rots	2, 8
INSECTS	
Oblique Banded Leafroller	11a
Spring Canker Worm	11e

Suggested Chemicals (Rate/acre)

1. Benlate 50 WP (1 lb), plus
   Difolatan 4F** (2 qt), OR
   Difolatan 80% "Sprills" (2½ lb)
2. Funginex 20 EC* (24 fl oz), plus
   Difolatan 4F** (2 qt), OR
   Difolatan 80% "Sprills" (2½ lb)
8. Difolatan 4 F** (2 qt)
8. Difolatan 80% "Sprills" (2½ lb)
11. Methomyl 1.8 (2 pt)
11. Methomyl 90 SP (½ lb)
11. Lannate 2.4 LV (3 pt)

Comments:
Phomopsis canker will be partially controlled by Difolatan.

Asterisk (*)—Funginex controls mummyberry only. Difolatan or Captan needed for control of other diseases listed.

Double asterisk (**)—Substitute Captan 50 WP at 5 lb/acre for Difolatan if allergic to Difolatan.

25% BLOOM

Pest	Efficiency
DISEASES	
Mummyberry (blossom infection stage)	1, 2
Fusicoccum Canker	1, 2, 8
Anthracnose	1, 2, 8
Alternaria Fruit Rots	2, 8

Suggested Chemicals (Rate/acre)

1. Benlate 50 WP (1 lb), plus
   Difolatan 4 F** (2 qt), OR
   Difolatan 80% "Sprills" (2½ lb)
2. Funginex 20 EC* (24 fl oz), plus
   Difolatan 4 F** (2 qt), OR
   Difolatan 80% "Sprills" (2½ lb)
8. Difolatan 4 F** (2 qt)
8. Difolatan 80% "Sprills" (2½ lb)

Comments:
Asterisk (*)—Funginex controls mummyberry only.

Double asterisk (**)—Substitute Captan 50 WP at 5 lb/acre for Difolatan if allergic to Difolatan.

Phomopsis canker will be partially controlled by Difolatan.

BLUEBERRIES

FULL BLOOM (EARLY PETAL FALL)

Pest	Efficiency
DISEASES	
Mummyberry (blossom infection stage)	1, 2
Fusicoccum Canker	1, 8
Anthracnose	1, 2, 8
Alternaria Fruit Rots	2, 8

Suggested Chemicals (Rate/acre)

1. Benlate 50 W (1 lb), plus Difolatan 4 F** (2 qt), OR Difolatan 80% "Sprills" (2½ lb)
2. Funginex 20 EC* (16 fl oz)
8. Difolatan 4 F** (2 qt)
8. Difolatan 80% "Sprills" (2½ lb)

Comments:
Asterisk (*)—Funginex controls mummyberry only. The rate of Funginex must be reduced at fruit formation.

Double asterisk (**)—Substitute Captan 50 WP at 5 lb/acre for Difolatan if allergic to Difolatan.

Phomopsis canker will be partially controlled by Difolatan.

Difolatan applied at full bloom may interfere with bee activity.

FIRST COVER

Pest	Efficiency
DISEASES	
Fusicoccum Canker	8
Anthracnose	8
Alternaria Fruit Rots	8

Suggested Chemicals (Rate/acre)

8. Difolatan 80% "Sprills"* (2½ lb)
8. Difolatan 4 F* (2 qt)

Comments:
Asterisk (*)—Substitute Captan 50 WP at 5 lb/acre for Difolatan if allergic to Difolatan.

Phomopsis canker will be partially controlled by Difolatan.

INSECTS	
Plum Curculio	8e, 9e, 23g
Blueberry Tip Borer	8e, 9e, 23g
Oblique Banded Leafroller	8e, 9e, 11e, 23g
Cranberry Fruitworm	8e, 9e, 23e
Cherry Fruitworm	8e, 9e, 23e
Aphids	11e

Comments:
For aphid control, sprays should be applied with a ground sprayer.

8. Guthion 50 WP (1 lb)
9. Imidan 50 WP (2 lb)
11. Methomyl 1.8 (2 pt)
11. Methomyl 90 SP (½ lb)
11. Lannate 2.4 LV (3 pt)
23. Sevin 80 S (2½ lb)

SECOND COVER

Pest	Efficiency
DISEASES	
Fusicoccum Canker,	8, 59
Anthracnose	8, 59
Alternaria Fruit Rots	8, 59
INSECTS	See First Cover

Suggested Chemicals (Rate/acre)

8. Difolatan 80% "Sprills"* (2½ lb)
8. Difolatan 4 F* (2 qt)
59. Captan 50 W (5 lb)

Comments:
Phomopsis will be partially controlled by Difolatan.

Asterisk (*)—Substitute Captan 50 WP at 5 lb/acre for Difolatan if allergic to Difolatan.

THIRD COVER

Pest	Efficiency	Suggested Chemicals (Rate/acre)
DISEASES		8. Difolatan 80% "Sprills" (2½ lb) 8. Difolatan 4 F (2 qt) 59. Captan 50 W (5 lb)
Fusicoccum Canker.	6, 59	
Anthracnose	8, 59	
Alternaria Fruit Rots	8, 59	
INSECTS	See First Cover	

Comments:
Interval between last application and harvest for Difolatan is 21 days.

Phomopsis canker will be partially controlled by Difolatan.

FOURTH COVER

Pest	Efficiency	Suggested Chemicals (Rate/acre)
DISEASES		8. Difolatan 80% "Sprills" (2½ lb) 8. Difolatan 4 F (2 qt) 59. Captan 50 WP (5 lb)
Fusicoccum Canker	8, 59	
INSECTS		8. Guthion 50 WP (1 lb) 9. Imidan 50 WP (2 lb) 13. Malathion LV Concentrate* (10 fl oz) 13. Aqua Malathion 8 EC* (1 pt) 13. Malathion 25 WP* (8 lb) 38. Mesurol 75 WP** (2 lb)
Blueberry Maggot	8e, 9e, 13g	
Aphids	13g	
BIRDS		
Bird Repellent	38e, See Comments	

Comments:
Asterisk (*)—24 hour interval between treatment and harvest.

Double asterisk (**)—A maximum of 4 lb of product may be used per season. Applications may be made up to 7 days before harvest for maximum repellency of birds. Apply as berries first begin to ripen and repeat if necessary to maintain repellency with at least 7 days between applications.

NOTE: ULV Malathion + Difolatan can burn blueberry fruit and leaves when applied as a tank mix.

FIFTH COVER

Pest	Efficiency	Suggested Chemicals (Rate/acre)
INSECTS	See Fourth Cover	

SIXTH COVER

Pest	Efficiency	Suggested Chemicals (Rate/acre)
INSECTS	See Fourth Cover	

BLUEBERRIES

PRE-HARVEST

Pest	Efficiency	Suggested Chemicals (Rate/acre)
DISEASES		11. Methomyl 1.8* (2 pt) 11. Methomyl 90 SP (½ lb) 11. Lannate 2.4 LV 23. Sevin 80 S** (2½ lb) 59. Captan 50 WP*** (5 lb)
Fusicoccum Canker	59	
INSECTS		
White Marked Tussock Moth	11e, 23e	
Oblique Banded Leafroller	11e, 23e	
Canker Worms	11e, 23e	

Comments:
Asterisk (*)—3 days between treatment and harvest.

Double asterisk (**)—No interval between treatment and harvest.

Triple asterisk (***)—If canker is a serious problem, and it has been 4 to 6 weeks since the last canker spray, apply a spray at this time.

POST HARVEST

Pest	Efficiency	Suggested Chemicals (Rate/acre)
DISEASES		8. Difolatan 80% "Sprills" (2½ lb) 8. Difolatan 4 F (2 qt)
Fusicoccum Canker	8	

Comments:
If canker is a serious problem, apply the spray if it has been 4 to 6 weeks since the previous canker spray. Continue spray applications on a 4 to 6 week interval through leaf drop in the fall.

SMALL FRUITS

BLUEBERRIES, BRAMBLES

(Year of Planting)

Weed Problem	Chemical	lb/acre active ingredient	Time of Application	Remarks and Limitations
Annuals	oryzalin (Surflan)	2 to 4	Apply to weed-free ground after planting.	Use lower rate on lighter soil.
Grasses	Fluazifop-butyl (Fusilade)	0.25 to 0.5	To actively growing grasses.	Apply to grass 4 to 8 inches tall. Add surfactant or oil concentrate as label specifies. Apply only to nonbearing plants. Blueberry only.

BLUEBERRIES, BRAMBLES

(Established One Year or More)*

Weed Problem	Chemical	lb/acre active ingredient	Time of Application	Remarks and Limitations
Annuals	diuron (Karmex)	2 to 4	In spring before weed growth starts.	Apply at least 60 days before harvest. Not effective on organic soils. Use low rate on young plantings.
	simazine (Princep)	2 to 4	Late fall or in spring before growth starts.	Use low rate on young plantings.
	Napropamide (Devrinol)	1 to 2	Apply before weeds emerge in spring.	
Quackgrass and annuals	dichlobenil (Casoron)	4 to 6	November	Granular formulation is most effective on quackgrass. Do not exceed 4 lb./acre on brambles.
	pronamide (Kerb)	1 to 2	November	Apply to dormant quackgrass or before emergence of annual weeds. Do not use on muck soils. Blueberry only.
	terbacil (Sinbar)	1.6 to 3.2	In spring before weed growth starts.	Use only in plantings that have been established at least a year. Apply the lower rate on sands and sandy loams and the higher rates on clay loams.
	simazine (Princep)	4	October or November	Granular formulation is most effective on quackgrass.
	norflurazon (Solicam)	2 to 4	Fall to early spring before weeds emerge.	
Emerged weeds	paraquat (Paraquat CL, Gramoxone)	½ to 1	Spring	Apply as a directed spray to emerged weeds. On brambles, apply before growth starts in the spring. Avoid contact on new canes or shoots of brambles or blueberries or injury will occur.
Woody perennials	hexazinone (Velpar)	1 to 2	Early spring before bud break.	Do not apply on light sandy soils or in successive years. **Blueberry** only.

*Chemicals listed for Year of Planting may be used as specified.

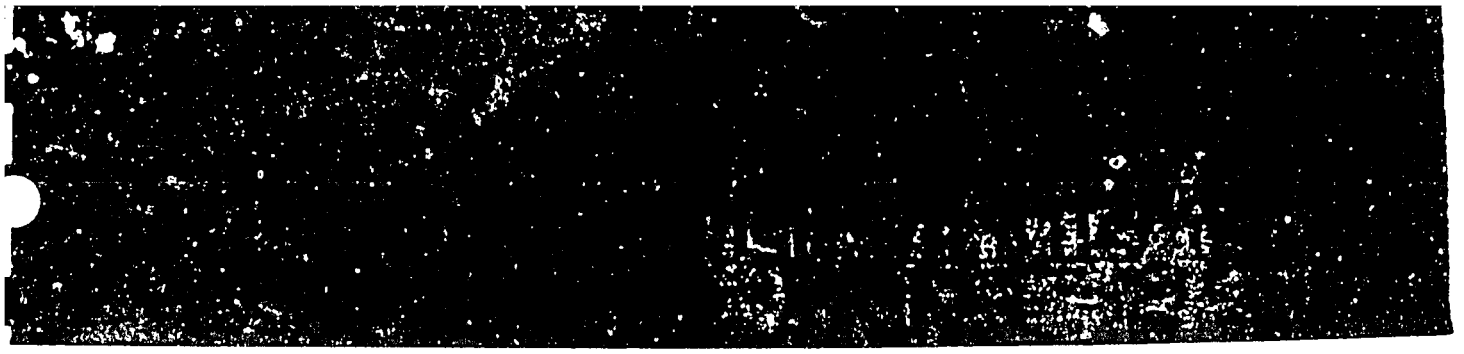
VINEYARDS AND SMALL FRUIT PLANTINGS

PREPLANT APPLICATION

Nematicide	Application rate/acre	Limitations and/or Directions
1,3-D (Dichloropropene and related chlorinated hydrocarbons) Telone II	Broadcast: 30 gal.	Apply as a pre-plant treatment at least 21 days prior to planting when soil temperature is between 50° and 80° F. Inject at an 8-inch soil depth. Seal soil immediately after application. Allow additional time before planting if temperatures are below 60° F. or if soil has become very wet.
1,3-D and Chloropicrin Telone C	Broadcast: 35 gal.	Same as 1,3-D
Methyl Bromide and Chloropicrin (98% and 2%, respectively) Brom-o-gas	Broadcast: 450 lb.	Apply as a pre-plant treatment in plant beds for production of transplants only. Prepare plant bed as if for planting. Seal with airtight cover. Inject material, treating when soil temperature is above 50° F. Expose to fumigation for 48 hours. Aerate treated area for 2 days before planting.
Methyl Bromide and Chloropicrin (67% and 33%, respectively) Terr-o-gas 67	Broadcast: 250-350 lb.	Apply as pre-plant treatment. Inject material at 6- to 8-inch depth. Seal treated soil with airtight cover. Expose to fumigation for 48 hours. Aerate for 2 days before planting in transplant bed. Allow at least two weeks soil aeration between field fumigation and planting when transplants are for fruit production. Do not treat soil if temperature is below 45° F. at 5-inch depth.
MIC (Methyl Isothiocyanate and 1,3-D) Vorlex	Broadcast: 20 gal.	Apply as pre-plant treatment. For broadcast application, use shanks spaced 8 inches apart injecting at a depth of 8 inches. For row application, use two chisels spaced 8 inches apart per row. Seal soil immediately after application. If soil is 70° F. or more at 6-inch depth, seal soil surface with plastic tarp. Keep soil moist and undisturbed for 4 to 7 days. Colder soils require longer fumigation periods. Cultivate soil and allow to aerate one week for each 10 gal./acre of material.
Fenamiphos Nemacur 3S Nemacur 15G	Strip: 6 gal. Strip: 120 lb. Broadcast: 120 lb.	For root-lesion and dagger nematode control for apple, peach and cherry nurseries. Apply in 20-40 gal. of water per acre as an emulsion spray to the soil. Band width should be 4-6 ft. and rate is for treated area. Incorporate to 2-4 inch depth. Do not use more than 3 applications, 6 gal. or 120 lb./acre/site/year. Do not use site for grazing or for feed.
Oxamyl Vydate L	Broadcast: 3-10 gal. Strip: 3-10 gal.	Apply in a minimum of 20 gal. of water per acre. Thoroughly incorporate with a rotary tiller to a depth of 4 to 8 inches immediately after application. READ LABEL WARNINGS CAREFULLY! NOT REGISTERED FOR USE ON GRAPES OR BRAMBLES.
Oxamyl Vydate L	Foliar Spray: 2 qt./100 gal.	NOT REGISTERED FOR USE ON BRAMBLES OR GRAPES! Use only on strawberry plants that will not bear fruit within one year after application. Mix 2 qt. of Vydate L with 100 gal. or water and add 4 oz. of a recommended surfactant. Apply to run-off as a foliar spray. Make 4 applications on a 14 to 21 day schedule. READ LABEL WARNINGS CAREFULLY!

POSTPLANT TREATMENT

Nematicide	Application rate/acre	Limitations and/or Directions
Fenamiphos Nemacur 3S Nemacur 15G	Strip: 6 gal. Strip: 120 lb. Broadcast: 120 lb.	For root-lesion, root-knot and dagger nematode control for vineyard only. Apply in 20-40 gal. of water per acre as an emulsion spray to the soil. Band width should be 4-6 ft. and rate is for treated area. Incorporate to 2-4 inch depth. Do not use more than 3 applications, 6 gal. or 120 lb./acre/site/year. Do not use site for feed or grazing.



by D. C. Ramsdell
Department of Botany and Plant Pathology

Fungus Diseases

Mummyberry

Mummyberry is probably the most commonly known disease of blueberry. It is caused by the fungus *Monilinia vaccinii-corymbosi*.

Symptoms and Disease Cycle

Shoot blight is the first symptom seen after dormancy has broken (Fig. 1). Blighted shoots are the result of ascospore infection of emerging leaf buds. Ascospores of the fungus are dispersed from mushroom-like apothecia (Fig. 2) that form on last year's mummyberries which overwinter on and in the soil under the bushes. Conidiospores form on the blighted shoots (Fig. 3). These conidiospores infect the blossoms as they open.

Evidence of blossom infection does not appear until the fruit begins to ripen. Then, the berries begin to shrivel and turn a pinkish color (Fig. 4). These are "mummyberries," filled with the pathogenic fungus. They fall to the ground, shrivel, turn dark brown and become pumpkin-shaped. They serve as an inoculum source the following spring when apothecia form and the disease cycle begins again. Crop losses of 30 to 40% are experienced where no fungicidal control is practiced. There is no effective varietal resistance.

Control

Calcium cyanamid or dinitro chemicals applied to the soil does not effectively destroy apothecia. Applying fungicides to the bushes prebloom and during bloom can result in excellent control. Refer to the MSU Fruit Pesticide Handbook (Extension Bulletin E-154) for fungicides, rates and timing.

Fusicoccum (Godronia) Canker

This disease is serious in the northern Lower and the Upper Peninsula. If an east-west line is drawn through Grand Haven, the area north of this line will be where Fusicoccum canker is a problem. The area south of this line is where

Fig. 1. Shoot blight phase of mummyberry disease.

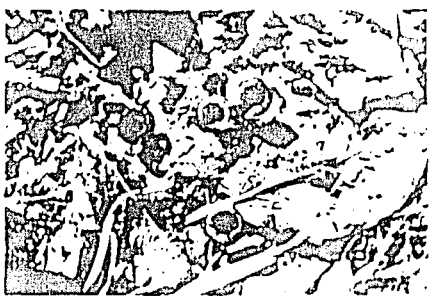


Fig. 2. Mushroom-like apothecia that germinate from mummyberries on the ground in the spring. These contain ascospores which cause shoot blight.

Fig. 3. A blighted shoot showing the cream colored sporulation (arrow). This sporulation contains conidiospore masses. The conidiospores infect the blossoms, causing mummyberries to form.

Phomopsis canker (discussed later) is a problem.

Symptoms and Disease Cycle

This disease is caused by the fungus *Godronia cassandrae* (*Fusicoccum putrefaciens*). Infected stems (current season, 1-, 2-year old) develop elliptical, brownish-purple lesions 1 to 6 inches long (Fig. 5). The lesions are found in the lower third of the bush, especially in the crown area. They contain small black pimple-like fungal fruiting bodies called pycnidia. The pycnidia contain conidiospores that infect more canes when they are rain splashed. Infection eventually results in wilting and dieback of the whole stem, (usually in mid-summer) (Fig. 6), due to a damaged vascular system.

Fig. 4. Whitish pink mummyberries form among healthy blue fruit near harvest time.

Fig. 5. A stem canker caused by *Fusicoccum putrefaciens*.

The disease cycle starts at about budbreak in the spring. Each rain causes the release and spread of conidiospores. Conidiospores infect current year canes as well as 1- and 2-year-old canes. Infections first appear as small, reddish areas on the stems, eventually developing into the previously described cankers. New infections continue to occur throughout the growing season each time it rains, until leaves drop in the autumn.

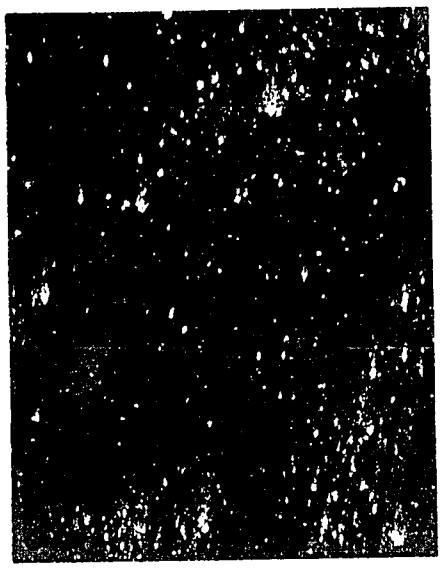


Fig. 6. Stem wilt and dieback caused by Fusicoccum canker disease.

Control

Prune out and burn cankered stems. Use a fungicide spray program throughout the growing season. Refer to Extension Bulletin E-154 for fungicide rates and timing. There are no resistant varieties.

Phomopsis Canker

This disease is caused by the fungus *Phomopsis vaccinii*. Phomopsis canker occurs in the southern Lower Peninsula and in Indiana and Illinois. This disease can be devastating to bushes planted in low areas, where winter injury and spring frosts are a problem.

Symptoms and Disease Cycle

The cankers on 1-, 2-, and 3-year old stems are not as well-defined as those of Fusicoccum canker. A Phomopsis canker appears as an elongated, flattened canker (Fig. 7). An infected stem feels flattened. Older cankers are covered by small, pimple-like pycnidia (Fig. 8) which contain conidiospores. The conidiospores are spread by splashing rain. In the early stages of canker formation, current year stems may have 1- to 2-inch-long reddish-brownish areas. These areas are the beginning symptoms of phomopsis canker.

After the stems have been infected for a season, they will wilt during the summer months (Fig. 9). Under severe disease conditions it is common to see bushes with a half dozen or more wilting stems. The infectious conidiospores are spread each time rain occurs during the growing season from bud-break through about August 1. Winter injury and spring frost injury afford an entry point for infection.

Fig. 7. A stem canker caused by Phomopsis vaccinii.

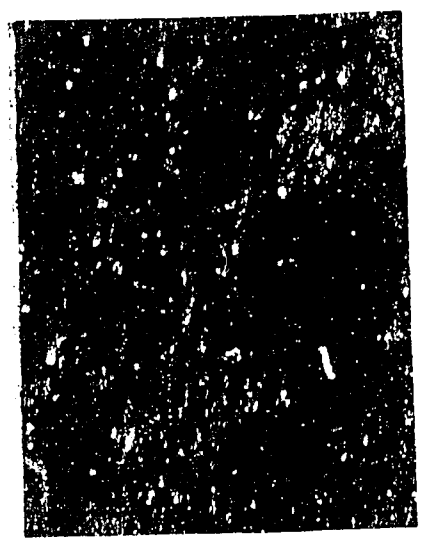


Fig. 8. Pimple-like pycnidia (arrow) on a Phomopsis canker. These pycnidia contain infectious conidiospores.

Control

Prune out and burn infected cankers. Pruning cuts should be made as deep into the crown as possible to insure removing the canker. Use season-long fungicidal sprays. Use Extension Bulletin E-154 for fungicides, rates and timing.

Botrytis Blight

Botrytis blight, a sporadic disease, is caused by the fungus *Botrytis cinerea*. When conditions are favorable for the disease it can cause considerable crop loss.

Fig. 9. Stem wilt caused by Phomopsis canker.

Symptoms and Disease Cycle

The first symptom (seen in the spring) is a blossom cluster blight or blast (Fig. 10). This symptom is similar to the shoot blight caused by mummyberry disease, except that the blossom and cluster blight/blast caused by *Botrytis cinerea* does not have the cream-colored sporulation present. A week or two later, some leaves will show a dead or necrotic symptom (Fig. 11). Usually the disease doesn't progress any further. The fungus probably overwinters on old leaves and trash on the ground. Fungal structures called sclerotia may overwinter on twigs also.

Control

Although not specifically labeled for the control of Botrytis blight on blueberries, Benlate® plus captan sprays applied during bloom for the control of mummyberry disease will control Botrytis blight fairly well.

Anthracnose

Anthracnose is caused by *Colletotrichum gloeosporioides*. This disease is thought of as a post-harvest fruit rot, but infection has occurred much earlier than harvest. Crop losses may run as high as 10 to 20%.

Symptoms and Disease Cycle

The earliest symptom is the presence of a shoot blight (Fig. 12). Usually a few blossom clusters will turn brown or black. Spores are not formed on these blossom clusters. Later in the season when fruit are ripening and turning blue, the blossom end of the fruit will soften, pucker and exhibit some salmon-colored sporulation (Fig. 13). There are vast numbers of spores on each fruit and these spread to other fruit

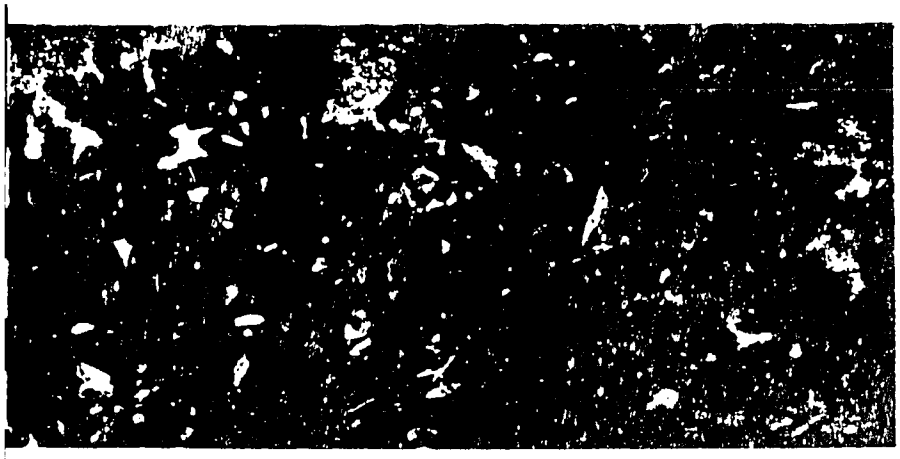


Fig. 10. Blossom blight (arrow) caused by *Botrytis cinerea*.

Fig. 11. Leaf necrosis caused by *Botytris cinerea*.

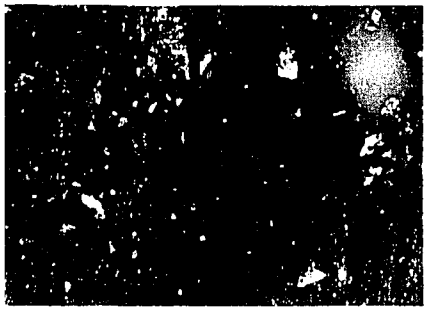


Fig. 12. Shoot blight/blossom blight (arrow) phase of anthracnose.

Fig. 13. Fruit rot phase of anthracnose. Note puckered blossom end of fruit showing salmon colored sporulation.

Fig. 14. Sporulation on [illegible] diseased twigs.

Fig. 15. Blackish, dark-greenish sporulation on fruit diseased with Alternaria fruit rot.

Fig. 16. Red leaf disease lesion. Note reddish upper surface and whitish lower leaf surface.

in the bush by rain or after harvest, when one fruit touches another.

The fungus overwinters in and on twigs. If conditions are very warm and humid in the spring around blossom time, sporulation may occur on these twigs (Fig. 14). The spores cause blossom cluster blight, thus building up the level of inoculum. Some green fruit is infected if there is a lot of rain. The ripening fruit is the most susceptible tissue.

Control

If there is a recent history of this disease in a given field, use a well-timed, thorough fungicidal spray program. Use Extension Bulletin E-154 for specific fungicides, rates and timing.

Alternaria Fruit Rot

This disease is caused by *Alternaria* sp. The major effect is a leaky, watery fruit rot near harvest. In some seasons 20 to 30% crop loss can occur.

Symptoms and Disease Cycle

The earliest symptom is the presence of a blackish, dark-greenish sporulation on the blossom end of the fruit (Fig. 15). This appears a week or two before harvest. The causal fungus overwinters in and on the twigs and in debris on the ground. Infection occurs mainly after the fruit begins to ripen.

Control

Use Extension Bulletin E-154 for fungicides, rates and timing.

Red Leaf Disease

Red leaf disease is caused by the fungus *Exobasidium vaccinii*. The disease seems to be increasing in importance. Not many plants in Michigan suffer from it, but where it exists, there is cause for concern. Bushes become systemically infected and must be removed and destroyed.

Symptoms and Disease Cycle

During the middle of summer terminal leaves on some bushes will turn a reddish color (Fig. 16). The underside of these leaves will be whitish due to the development of fungus spores. Later, the leaves will turn black and dry up.

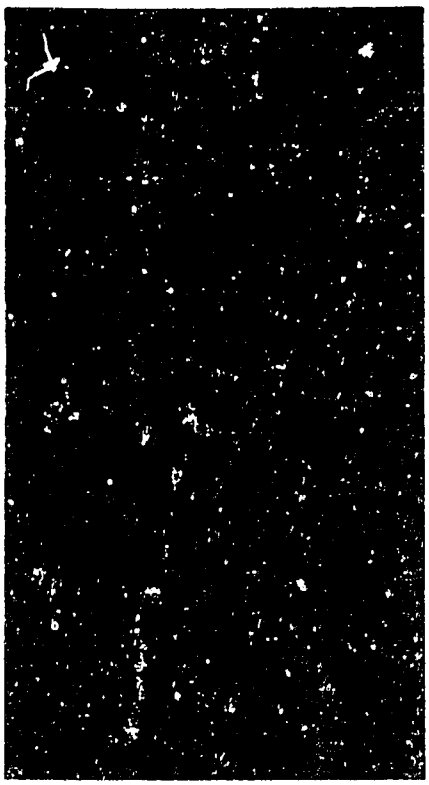


Fig. 29. Red ringspot stem symptoms on Blueray cultivar infected with red ringspot virus.

Fig. 30. Red, circular spots on leaves of Blueray cultivar infected with red ringspot virus.

Fig. 31. Fruit spot symptoms sometimes associated with red ringspot virus infection.

Fig. 32. Downward cupping and yellow margins of leaves on a stunt diseased bush.

Powdery mildew disease can also cause similar spots. However, powdery mildew spots go through the leaf, so that the underside is spotted also. Red ringspot lesions are only on the top side of the leaf. There is possible confusion because of a genetic disorder associated with the Bluetta cultivar. Dark, reddish spots can appear on this cultivar, which may be caused by either red ringspot virus or a genetic disorder. In this case, diagnostic tests such as the enzyme-linked immunosorbent assay (ELISA) are necessary to determine whether the symptoms are caused by the virus or by a genetic disorder. Fruit will sometimes exhibit bleached out circular blotches (Fig. 31), although this symptom is not always present. Yield is reduced on diseased bushes, but the extent of the reduction is not known. A mealy bug is suspected of spreading the disease in New Jersey.

Control

Remove and burn all bushes showing symptoms. Before removing Bluetta cultivar, take further confimatory tests. Replant with clean stock.

Stunt

Stunt is a serious disease in Michigan caused by a mycoplasma-like organism (MLO). An MLO is a pathogen that is in between a virus and a bacterium. Almost all cultivars are susceptible to stunt. Only Rancocas cultivar has resistance.

Symptoms and Disease Cycle

The disease causes a stunting of bushes. Leaf symptoms are the best evidence for disease diagnosis. Leaves show downward cupping and yellowish margins (Fig. 32). Normal green coloration of the leaf is usually retained along the midvein and lateral veins. Leaf size is usually reduced. Berries are smaller than normal on infected bushes. The sharpnosed leafhopper *(Scaphytopius magdalensis)* spreads this disease.

Control

Remove and burn infected bushes. The normal full-season insecticidal control program for blueberries usually keeps the leafhopper population in check. Replant with disease-free stock.

United States
Department of
Agriculture

Agricultural
Research
Service

Agriculture
Handbook
Number 66

The Commercial Storage of Fruits, Vegetables, and Florist and Nursery Stocks

By
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Chien Yi Wang

found in outside air (*540*). After 24 hours of ethylene treatment the rooms should be ventilated. Such a treatment assures uniform coloration on a predetermined schedule and allows use of lower-than-normal ripening temperatures, which will result in increased shelf life (*33*). The recommended temperature of boxed and gassed bananas is 16° to 17°C (*731*).

The best holding temperature for ripe bananas is 13°C for Gros Michel and 14° for Valery. Even at these temperatures ripe fruit cannot ordinarily be held for more than 2 to 4 days. Ripening should be timed so that holding ripe fruit is kept to a minimum. Exposing ripe bananas to temperatures higher than those in the ripening range hastens softening and decay, weakens the neck and peel, and may cause poor color. The term "cooked" is normally used to describe this type of injury in its extreme stage.

Shelf life of green bananas may be extended during storage by continuous removal of ethylene within containers or storage room and/or by use of a controlled atmosphere (*539, 541, 695, 743*). Research has shown that the combined use of both a reduced level of oxygen and an increased level of carbon dioxide delays ripening. The shelf life may be extended 2 to 3 times by using an atmosphere of 4 percent oxygen and 5 percent carbon dioxide (*616*). Carbon dioxide inhibits the effect of ethylene on ripening, so bananas stored in controlled atmosphere should be ventilated with fresh air when ripening is desired.

For further information on handling and ripening bananas consult references *317, 584, 840, 853, 913, 963, 989*.

Berries

Blackberries and Related Berries

(Temperature, −0.5° to 0°C (31° to 32°F); relative humidity, 90 to 95 percent)

Blackberries, dewberries, loganberries, boysenberries, and youngberries are not adapted to storage and usually are not stored commercially. If brief holding is necessary, prompt precooling to −0.5° to 0°C is desirable. This temperature should be maintained with a relative humidity of 90 to 95 percent. These berries cannot be stored satisfactorily for more than about 2 to 3 days because longer storage results in loss of good marketing quality. An atmosphere high in carbon dioxide (20 to 40 percent) can be used to maintain the quality of machine-harvested blackberries destined for processing during storage at 20° for up to 48 hours (*639*).

Blueberries

(Temperature, −0.5° to 0°C (31° to 32°F); relative humidity, 90 to 95 percent)

Blueberries in good condition can be stored at −0.5° to 0°C with high relative humidity for about 2 weeks. With some loss in quality, storage can be extended to 4 to 6 weeks (*126, 415*). Rapidly precooling fresh blueberries to near 0° and maintaining that temperature suppresses decay development and preserves the market quality (*418*). Mixtures of the soft-ripe berries with hard-ripe berries, as may occur with late pickings, have poor storage potential because overmaturity contributes to deterioration. The ratio of soluble solids to acids increases with increasing ripeness. When the ratio exceeds 30, the fruit should not be sent to fresh markets but should instead be processed within 24 hours (*60*). Also, blueberries with more than a trace of visible decay at harvest have a poor storage potential; hence, they should be marketed promptly rather than be allowed to contribute to storage losses.

Moisture losses can be kept to 2 to 3 percent or less during storage and marketing through use of proper packaging, film caps, and maintenance of 90 to 95 percent relative humidity (*415*). Handling of blueberries should be minimized to avoid damaging the bloom. Blueberries stored at temperatures of 4.5°C and above gradually develop an undesirable tough-textured skin.

Research with controlled atmospheres showed that CA storage retarded breakdown and decay but caused off-flavors (*126*). Use of sealed 1.5-mil polyethlene lug liners increased storage life by reducing weight loss and maintaining turgidity, appearance, and flavor. However, prolonged storage beyond 6 weeks at 0°C in film liners sometimes resulted in off-flavored fruit (*415*).

See *367* for market diseases of blueberries.

Cranberries

(Temperature, 2° to 4°C (36° to 40°F); relative humidity, 90 to 95 percent)

Part of the cranberry crop is stored in field boxes for marketing as fresh fruit during the peak Thanksgiving and Christmas holiday seasons. Common (air-cooled) ventilated storages located near the bogs are often used. However, refrigerated storage at 2° to 4°C with 90 to 95 percent relative humidity provides better conditions and reduces spoilage and moisture losses (*241, 414, 507, 762, 1068*). In addition, cranberries from cold storage have an extended shelf life during marketing. Fresh cranberries are usually not stored longer than 2 months. However, they can be stored for 3 to 4 months at 2° to 4°. Storage for more than 4 months is usually not satisfactory because of shrinkage due to moisture loss, physiological breakdown, end rot, and other fungus diseases that can develop even at low temperature (*367, 587, 1068*). Extended storage at −1° or 0° will cause chilling and physiological breakdown, described below (*507, 1068*).

Poorly colored fruit can be held at 7° to 10°C for a few weeks to permit more rapid coloring than would occur at lower temperatures (*507*).

Keeping quality is determined to some extent by maturity and cultivar. However, storage life of fruit from the same bogs may vary from year to year. Early harvested berries usually have a longer storage potential than late-harvested fruit (*214*).

Most cranberries are still stored unscreened and "in the chaff," just as they come from the field. They keep better this way than if handled additionally to clean, sort, and

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EXTENSION BULLETIN 0933

1981 Blueberry Establishment and Production Costs and Returns, Western Washington

Richard W. Cankren, Blair F. Wolfley, William P.A. Scheer

Farm Business Management Reports

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1981 BLUEBERRY ESTABLISHMENT AND PRODUCTION COSTS AND RETURNS, WESTERN WASHINGTON

Richard W. Carkner, Blair F. Wolfley, and William P.A. Scheer*

INTRODUCTION

This publication presents estimated 1981 costs and returns for establishing and producing blueberries in western Washington. This information will be helpful to producers, lenders, and others interested in making better farm management decisions, including profit planning, financing, marketing, and resolving numerous related farm business-management problems.

The total cost per pound for producing blueberries under full production given all the assumptions noted in the text and tables of the budget is 61 cents per pound (page 12). Note that this budget is based on the indicated assumptions, it does not represent a particular farm or mathematical average of many farms. It is highly recommended that individual producers use the blank spaces provided ("YOUR FARM") to adjust the budgets to individual farm circumstances. Cooperative Extension agents and fieldmen should be consulted for recommendations on field operations and operating inputs.

SOURCES OF INFORMATION

Personal interviews of area producers and data from a Washington Blueberry Growers Association member survey served as the basis for identifying the field operations and machinery complements. The budgets presented are considered to be representative of well-managed farms. The quantities and types of material, for example: plants, fertilizer, herbicides and insecticides, used in the budgets are based on recommended and widely used practices. Local farm suppliers were contacted for input and service prices. Machinery costs were based on recent purchase prices and rates of annual use considered typical.

DISCUSSION OF BUDGET INFORMATION

Blueberry enterprise data are divided into four separate budgets. The first is for the establishment year one and includes land preparation, planting, and other plant development activities. The second establishment year includes pruning and continued establishment activities. The third budget is for establishment years three through seven. During this period, there is continued plant establishment as well as a partial harvest. The fourth budget is for full production. All four of these budgets are developed for a 10-acre farm, totally devoted to blueberry production. Approximately one-third of the production is direct marketed and the balance sold to processors.

Four tables are used to present enterprise budget information. The first and second tables are for establishment years and full production. The first is the schedule of field operations and selected costs. The second is a summary of costs and breakeven commodity prices. For full production, third and fourth

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tables are provided. The third table is a summary of receipts, costs, and profitablity per acre. Both Tables 2 and 3 provide space for individual farm adjustments. The fourth table summarizes cash costs and labor requirements by month. Also included are hourly machine ownership and variable operating costs.

Schedule of Operations and Selected Costs - Table 1

This table outlines the schedule of field operations by calendar month, the type of machine used, and the number of times used per acre. The costs of field operations are divided into two categories. The first is the cost of machinery ownership, or fixed costs. The second category (variable costs) is associated with operating machinery, hiring labor, and purchasing services and materials. Total cost is the sum of machinery fixed and all variable costs.

Machinery fixed costs include depreciation and interest on investment, property taxes, and insurance. These costs do not vary with the crops produced and are incurred whether or not a crop is grown or harvested. Machinery fixed costs for a specific field operation are estimated by multiplying the machine hours per acre times per hour fixed costs.

Variable costs vary directly with the number of units or acres produced. Variable costs include fuel, oil and repairs, and all the inputs such as fertilizer, chemicals, and custom work. Machine operating labor is also included in variable costs.

Summary of Costs and Breakeven Prices - Table 2

For establishment years 1, 2, 3-7 and full production, Table 2 summarizes variable, fixed and total production costs. For years 3-7 and full production, breakeven prices necessary to cover variable costs are included. The land charge under fixed costs is based on 12 percent of estimated net market value. Net market value is gross sales price less selling costs and capital gains taxes.

Breakeven prices are estimated by dividing costs by units of production. Total production or yield per acre is shown in Table 3 for full production. Breakeven prices to cover variable costs are calculated by dividing variable costs by units of production. The result is the minimum product price necessary to cover all out-of-pocket costs identified in the budget. When total costs are divided by units of production, the result is the minimum price necessary to cover all production costs identified, including machinery, operator labor, and land charges.

Summary of Receipts, Costs, and Profitablity Per Acre - Table 3

This table summarizes the per-acre returns, costs, and various measures of profitablity. The first measure of profitability is the return over variable costs calculated by subtracting total variable costs from gross receipts.

A second measure of profitability, returns to land and management, is calculated by subtracting machinery fixed costs and prorated establishment costs from returns over variable costs. The result is the payment for owners' risk and return to land.

Gross returns to land are calculated by subtracting a management charge from the returns to land and management. The management charge is estimated at 5 percent of gross receipts. The net returns to land can be estimated by

subtracting real estate taxes from the gross returns to land. The rate of return on the land investment can be estimated by dividing the net returns to land by the current land market value.

Monthly Summary of Direct Cash Expenses and Labor Requirements - Table 4

This table contains some supporting details for the costs outlined in the schedule of operations. Direct cash operating expenses (at the top of the table) include outlays for materials, hired labor including harvesting, fuel and lubrication and machinery repairs. The righthand side of the table provides unit prices and quantities for each operating input. Farmers and lenders attempting to estimate monthly operating costs should use the total cost figures at the bottom of this section. Note that machinery, labor and interest on operating capital costs are not included. The bottom of the table is a summary of monthly machinery, labor and irrigation requirements.

Returns Over Total Costs at Various Yields and Prices - Table 5

This table presents returns over total costs identified in Table 2 for ranges of yield and price combinations. The combinations of yield and price that provide positive returns are to the right of the heavy black line, those to the left show returns below total production costs. Yield and price combinations falling on the line itself represent breakeven price and yield combinations, i.e., gross returns (yield X price) equal to total costs. Total production costs for each yield level are adjusted for harvest costs ($0.24/lb) only.

This information can be used to estimate the impact of yield and/or price changes on returns. It can also be used to estimate yield and price combinations necessary to produce a specified dollar return over total costs. For example, prices of 75 cents or greater combined with yields of 8,000 pounds or greater will generate $1,000 or more over total costs.

Establishment Costs

Establishment costs must be recovered over the useful life of the blueberry stand. The process involves carrying forward total production costs plus interest less the annual value of production. The result, accumulated establishment cost, is then amortized over the useful life of the stand, 30 years.

These calculations are presented in Table A, below. Production is estimated to increase from 800 pounds per acre in year 3 to 7,200 pounds in year 7, full production (8,000 pounds) is assumed in year 8. Production is valued at $0.55 per pound and presented in Table 2 for budget years 3-7. These total costs include interest on the accumulated establishment investment for previous years (column 5). To obtain accumulated establishment costs, returns in each year (3-7) are subtracted from total costs and the difference is added to the previous year's total. For example, the accumulated establishment cost in year 2 is $4,665.79. Third year total costs, $2,167.97, less the value of production in year 3, $440.00, is $1,727.97. When this is added to year 2 accumulated establishment cost, $4,665.79, the accumulated establishment cost for year 3 is $6,393.76.

This process is continued through the seventh establishment year where the accumulated establishment cost is $9,730.77. The annual payment to recover the establishment cost at 10 percent interest over a 30 year useful life is $1,032.00. This is identified as prorated establishment cost on Table 2, page 12, under fixed costs.

TABLE A -- PER ACRE ESTABLISHMENT COST CALCULATIONS

(1) YEAR	(2) PRODUCTION LBS/ACRE	(3) PRODUCTION[a] VALUE $	(4) PRODUCTION[b] COSTS	(5) INTEREST ON[c] ESTABLISHMENT COSTS	(6) TOTAL[d] PRODUCTION COSTS	(7) ACCUMULATED[e] ESTABLISHMENT COSTS
1	0	0	$3,432.25	0	$3,432.25	$3,432.25
2	0	0	890.32	$343.22	1,233.54	4,665.79
3	800	$ 440.00	1,701.39	466.58	2,167.97	6,393.76
4	2,400	1,320.00	2,084.50	639.37	2,723.87	7,797.63
5	4,000	2,200.00	2,468.80	779.76	3.248.56	8,846.19
6	5,600	3,080.00	2,852.80	884.62	3,737.42	9,503.61
7	7,200	3,960.00	3,236.80	950.36	4190.33	9,730.77

[a] An average price of $0.55/lb is multiplied times production/acre (column 2).

[b] A harvest and marketing cost of $0.24 per pound is assumed.

[c] Interest is on accumulated establishment costs for previous years at a rate of 10 percent per year.

[d] Total production costs are the sum of columns 4 and 5.

[e] Accumulated establishment costs for any year are the sum of the previous year's establishment cost, plus total production costs for the year in question, less the value of fruit produced in that year.

BLUEBERRY ESTABLISHMENT COST - YEAR 1
WESTERN WASHINGTON - 10 ACRE ENTERPRISE - 1981

TABLE 1--SCHEDULE OF OPERATIONS AND SELECTED COSTS PER ACRE*

OPERATION	TOOLING	MONTH	MACH. HOURS	LABOR HOURS	MACH. FIXED COST	VARIABLE COST: FUEL, OIL, LUBE, AND, REPAIRS	VARIABLE COST: MACH LABOR	VARIABLE COST: SERVICE	VARIABLE COST: MATERIALS	TOTAL VARIABLE COST	TOTAL COST
					$	$	$	$	$	$	$
PLOW	CUSTOM	SEPT						30.00	0.0	30.00	30.00
ROTOVATE	CUSTOM	SEPT						30.00	0.0	30.00	30.00
APPLY HERBICIDE	30HP, AIR BLAST SPRAYER SOIL**	SEPT	0.82	0.99	15.34	1.30	5.94	0.0	58.95	66.19	81.54
DISK	CUSTOM	OCT						60.00	0.0	60.00	60.00
CULTIVATE	30HP, 5' FIELD CULTIVATOR	OCT	1.47	1.78	12.79	0.43	10.70	0.0	0.0	11.13	23.91
SOILTEST	LAB WORK	JAN						9.00	0.0	9.00	9.00
MARK ROWS	HAND LABOR	MAR						10.00	0.0	10.00	10.00
SMOOTH FURROW	HAND LABOR	MAR						10.00	0.0	10.00	10.00
PLANTING FURROW	30HP,1BTM PLOW	MAR	2.26	2.74	24.41	0.53	16.42	0.0	0.0	16.95	41.36
SETTING PLANTS	HAND LABOR	MAR						48.00	2000.00	2048.00	2048.00
FERTILIZE	30HP, TRAILER	MAY	0.31	0.37	2.74	0.07	2.22	4.00	7.15	13.44	16.18
CULTIVATE	30HP, 5' FIELD CULTIVATOR	MAY	1.47	1.78	12.79	0.43	10.70	0.0	0.0	11.13	23.91
WEEDING	HAND HOEING	MAY						32.00	0.0	32.00	32.00
CULTIVATE	30HP, 5' FIELD CULTIVATOR	JUNE	1.47	1.78	12.79	0.43	10.70	0.0	0.0	11.13	23.91
CULTIVATE	30HP, 5' FIELD CULTIVATOR	JULY	1.47	1.78	12.79	0.43	10.70	0.0	0.0	11.13	23.91
WEEDING	HAND HOEING	JULY						32.00	0.0	32.00	32.00
INSECT CONTROL	30HP, AIR BLAST SPRAYER FOL**	JULY	0.82	0.99	15.34	1.30	5.94	0.0	7.60	14.84	30.17
CULTIVATE	30HP, 5 FIELD CULTIVATOR	AUG	1.47	1.78	12.79	0.43	10.70	0.0	0.0	11.13	23.91
WEEDING	HAND HOEING	AUG						32.00	0.0	32.00	32.00
TOTAL COST PER ACRE					121.77	5.36	84.00	297.00	2073.70	2460.06	2581.83

*GROUNDWATER IS USED FOR IRRIGATION, APPLIED AT A RATE OF 4" PER MONTH FOR THE MONTHS OF JULY AND AUGUST, USING A HAND MOVE IRRIGATION SYSTEM.

**SPRAY APPLICATIONS ARE EITHER APPLIED TO FOLIAGE (FOL) OR TO THE SOIL (SOIL)

EB 0933

BLUEBERRY ESTABLISHMENT COST - YEAR 1
WESTERN WASHINGTON - 10 ACRE ENTERPRISE - 1981

TABLE 2--SUMMARY OF PRODUCTION COST PER ACRE

	UNIT	PRICE OR COST/UNIT	QUANTITY	VALUE OR COST	YOUR FARM
VARIABLE COSTS					
SOIL TEST	ACRE	9.000	1.00	$ 9.00	----------
CUSTOM PLOW	ACRE	30.000	1.00	30.00	----------
CUSTOM DISK	ACRE	30.000	2.00	60.00	----------
HAND LABOR	HR.	4.000	2.50	10.00	----------
CUSTOM ROTOVATE	ACRE	30.000	1.00	30.00	----------
PLANTING LABOR	HR.	4.000	12.00	48.00	----------
BLUEBERRY PLANTS	EACH	2.500	800.00	2000.00	----------
HAND LABOR	HR.	4.000	2.50	10.00	----------
ROUNDUP	GAL.	78.600	0.75	58.95	----------
10-10-10	LBS.	0.130	55.00	7.15	----------
FERT LABOR	HR.	4.000	1.00	4.00	----------
HAND HOEING	HR.	4.000	24.00	96.00	----------
OVERHEAD	DOL.	0.050	2630.54	131.53	----------
MALATHION	LBS.	3.800	2.00	7.60	----------
MACHINERY REPAIR	ACRE	2.77	1.00	2.77	----------
TRACTOR FUEL, LUBE, REPAIR	ACRE	2.58	1.00	2.58	----------
IRRIGATION ELEC. & REPAIR	ACRE	38.48	1.00	38.48	----------
LABOR(TRACTOR & MACHINERY)	HOUR	6.00	14.00	84.00	----------
LABOR(IRRIGATION)	HOUR	4.00	1.69	6.75	----------
INTEREST ON OP. CAP.	DOL.	0.12	1065.68	127.88	----------
TOTAL VARIABLE COST				$2764.70	----------
FIXED COSTS				$	
MACHINERY	ACRE	45.28	1.00	45.28	----------
TRACTORS	ACRE	76.49	1.00	76.49	----------
IRRIGATION MACHINERY	ACRE	85.78	1.00	85.78	----------
TAXES (LAND)	ACRE	100.00	1.00	100.00	----------
LAND (NET RENT)	ACRE	0.12	3000.00	360.00	----------
TOTAL FIXED COSTS				$ 667.55	----------
TOTAL COSTS				$3432.25	----------

EB 0933

BLUEBERRY ESTABLISHMENT COST YEAR 2
WESTERN WASHINGTON - 10 ACRE ENTERPRISE - 1981

TABLE 1-- SCHEDULE OF OPERATIONS AND SELECTED COSTS PER ACRE*

OPERATION	TOOLING	MONTH	MACH. HOURS	LABOR HOURS	MACH. FIXED COST	VARIABLE COST: FUEL, OIL, LUBE, AND, REPAIRS	VARIABLE COST: MACH LABOR	VARIABLE COST: SERVICE	VARIABLE COST: MATERIALS	TOTAL VARIABLE COST	TOTAL COST
					$	$	$	$	$	$	$
SPRAY WEEDS	30HP, AIR BLAST SPRAYER SOIL**	OCT	0.82	0.99	6.05	1.30	5.94	0.0	9.87	17.12	23.17
PRUNE	HAND LABOR	FEB						14.00	0.0	14.00	14.00
SPRAY WEEDS	30HP, AIR BLAST SPRAYER SOIL**	APR	0.82	0.99	6.05	1.30	5.94	0.0	9.87	17.12	23.17
FERTILIZE	30HP, TRAILER	APR	0.31	0.37	2.74	0.07	2.22	8.00	13.00	23.29	26.03
FERTILIZE	30HP, TRAILER	MAY	0.31	0.37	2.74	0.07	2.22	8.00	13.00	23.29	26.03
WEEDING	HAND HOEING	MAY						16.00	0.0	16.00	16.00
FERTILIZE	30HP, TRAILER	MAY	0.31	0.37	2.74	0.07	2.22	8.00	4.99	15.28	18.02
WEEDING	HAND HOEING	JUNE						16.00	0.0	16.00	16.00
CULTIVATE	30HP, 5' CULTIVATOR	JUNE	0.98	1.19	8.52	0.29	7.13	0.0	0.0	7.42	15.94
WEEDING	HAND HOEING	JULY						16.00	0.0	16.00	16.00
FERTILIZE	30HP, TRAILER	JULY	0.31	0.37	2.74	0.07	2.22	8.00	4.99	15.28	18.02
CULTIVATE	30HP, 5' CULTIVATOR	JULY	0.98	1.19	8.52	0.29	7.13	0.0	0.0	7.42	15.94
INSECT CONTROL	30HP, AIR BLAST SPRAYER FOL**	JULY	0.82	0.99	6.05	1.30	5.94	0.0	3.80	11.04	17.09
WEEDING	HAND HOEING	AUG						16.00	0.0	16.00	16.00
CULTIVATE	30HP, 5' CULTIVATOR	AUG	0.98	1.19	8.52	0.29	7.13	0.0	0.0	7.42	15.94
TOTAL COST PER ACRE					54.69	5.06	48.09	110.00	59.52	222.67	277.37

*GROUNDWATER IS USED FOR IRRIGATION, APPLIED AT A RATE OF 4" PER MONTH DURING THE MONTHS OF JULY AND AUGUST, USING A HAND MOVE IRRIGATION SYSTEM.

**SPRAY APPLICATIONS ARE EITHER APPLIED TO FOLIAGE (FOL) OR TO THE SOIL (SOIL)

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BLUEBERRY ESTABLISHMENT COST YEAR 2
WESTERN WASHINGTON - 10 ACRE ENTERPRISE - 1981

TABLE 2--SUMMARY OF PRODUCTION COST PER ACRE

	UNIT	PRICE OR COST/UNIT	QUANTITY	VALUE OR COST	YOUR FARM
VARIABLE COSTS					
HAND PRUNE	HR.	4.000	3.50	$ 14.00	----------
PRINCEP 80WP	LBS.	3.950	5.00	19.75	----------
10-10-10	LBS.	0.130	200.00	26.00	----------
HAND HOEING	HR.	4.000	16.00	64.00	----------
FERT LABOR	HR.	4.000	4.00	16.00	----------
AMMONIUM SULFATE	LBS.	0.095	105.00	9.98	----------
FERT LABOR	HR.	4.000	4.00	16.00	----------
OVERHEAD	DOL.	0.050	275.65	13.78	----------
MALATHION	LBS.	3.800	1.00	3.80	----------
MACHINERY REPAIR	ACRE	3.58	1.00	3.58	----------
TRACTOR FUEL, LUBE, REPAIR	ACRE	1.48	1.00	1.48	----------
IRRIGATION ELEC. & REPAIR	ACRE	38.48	1.00	38.48	----------
LABOR(TRACTOR & MACHINERY)	HOUR	6.00	8.02	48.09	----------
LABOR(IRRIGATION)	HOUR	4.00	1.69	6.75	----------
INTEREST ON OP. CAP.	DOL.	0.12	67.99	8.16	----------
TOTAL VARIABLE COST				$ 289.84	----------
FIXED COSTS				$	
MACHINERY	ACRE	10.90	1.00	10.90	----------
TRACTORS	ACRE	43.79	1.00	43.79	----------
IRRIGATION MACHINERY	ACRE	85.78	1.00	85.78	----------
TAXES (LAND)	ACRE	100.00	1.00	100.00	----------
LAND (NET RENT)	ACRE	0.12	3000.00	360.00	----------
ESTAB. INV. INTEREST				343.22	----------
TOTAL FIXED COSTS				$ 943.70	----------
TOTAL COSTS				$1233.54	----------

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BLUEBERRY PRODUCTION COSTS - ESTABLISHMENT YEARS 3-7
FOR DIRECT MARKETING AND PROCESSING
WESTERN WASHINGTON - 10 ACRE ENTERPRISE - 1981

TABLE 1--SCHEDULE OF OPERATIONS AND SELECTED COSTS PER ACRE*

OPERATION	TOOLING	MONTH	MACH. HOURS	LABOR HOURS	MACH. FIXED COST	VARIABLE COST: FUEL,OIL, LUBE,AND, REPAIRS	VARIABLE COST: MACH LABOR	VARIABLE COST: SERVICE	VARIABLE COST: MATERIALS	TOTAL VARIABLE COST	TOTAL COST
					$	$	$	$	$	$	$
WEED CONTROL	30HP, AIR BLAST SPRAYER SOIL**	OCT	0.82	0.99	15.34	1.30	5.94	0.0	9.87	17.12	32.46
PRUNE	HAND PRUNE	FEB						160.00	0.0	160.00	160.00
APPLY FUNGINEX	30HP, AIR BLAST SPRAYER FOL**	MAR	0.82	0.99	15.34	1.30	5.94	0.0	37.50	44.74	60.09
APPLY FUNGINEX	30HP, AIR BLAST SPRAYER FOL	APR	0.82	0.99	15.34	1.30	5.94	0.0	37.50	44.74	60.09
FERTILIZE	30HP, TRAILER	APR	0.31	0.37	2.74	0.07	2.22	8.00	48.10	58.39	61.13
APPLY BENLATE	30HP, AIR BLAST SPRAYER FOL	APR	0.82	0.99	15.34	1.30	5.94	0.0	14.70	21.94	37.29
WEED CONTROL	30HP, AIR BLAST SPRAYER SOIL	APR	0.82	0.99	15.34	1.30	5.94	0.0	9.87	17.12	32.46
POLLINIZATION	BEE HIVE RENTAL	APR						17.00	0.0	17.00	17.00
FERTILIZE	30HP, TRAILER	MAY	0.31	0.37	2.74	0.07	2.22	8.00	16.63	26.92	29.66
WEEDING	HAND HOEING	MAY						16.00	0.0	16.00	16.00
WEEDING	HAND HOEING	JUNE						16.00	0.0	16.00	16.00
BIRD CONTROL	30HP, AIR BLAST SPRAYER FOL	JULY	0.82	0.99	15.34	1.30	5.94	0.0	20.45	27.69	43.04
INSECT CONTROL	30HP, AIR BLAST SPRAYER FOL	JULY	0.82	0.99	15.34	1.30	5.94	0.0	3.80	11.04	26.39
HARVEST	HAND PICKING	JULY						238.00	137.50	375.50	375.50
DIRECT MARKET	SALES LABOR	JULY						40.00	0.0	40.00	40.00
HAULING FRUIT	30HP, TRAILER	JULY	0.31	0.37	2.74	0.07	2.22	0.0	0.0	2.29	5.03
HAUL TO PROCESS	PICKUP	JULY	1.30	1.56	9.64	6.29	9.36	0.0	0.0	15.65	25.28
HAUL TO STAND	30HP, TRAILER	JULY	0.12	0.15	1.10	0.03	0.89	0.0	0.0	0.92	2.01
WEEDING	HAND HOEING	JULY						16.00	0.0	16.00	16.00
OUTHOUSES	PICKER CONVENIENCE	JULY						4.00	0.0	4.00	4.00
CLEANING	CLEANING LABOR	JULY						30.00	0.0	30.00	30.00
BIRD CONTROL	30HP, AIR BLAST SPRAYER FOL	AUG	0.82	0.99	15.34	1.30	5.94	0.0	20.45	27.69	43.04
HARVEST	HAND PICKING	AUG						442.00	0.0	442.00	442.00
DIRECT MARKET	SALES LABOR	AUG						106.00	0.0	106.00	106.00
HAULING FRUIT	30HP, TRAILER	AUG	0.31	0.37	2.74	0.07	2.22	0.0	0.0	2.29	5.03
HAUL TO PROCESS	PICKUP	AUG	2.20	2.64	16.31	10.64	15.84	0.0	0.0	26.48	42.79
HAUL TO STAND	30HP, TRAILER	AUG	0.18	0.22	1.65	0.04	1.33	0.0	0.0	1.37	3.02
WEEDING	HAND HOEING	AUG						16.00	0.0	16.00	16.00
OUTHOUSES	PICKER CONVENIENCE	AUG						4.00	0.0	4.00	4.00
CLEANING	CLEANING LABOR	AUG						70.00	0.0	70.00	70.00
TOTAL COST PER ACRE					162.39	27.71	83.83	1191.00	356.37	1658.91	1821.29

BLUEBERRY PRODUCTION COSTS - ESTABLISHMENT YEARS 3-7
FOR DIRECT MARKETING AND PROCESSING
WESTERN WASHINGTON - 10 ACRE ENTERPRISE - 1981

TABLE 2--SUMMARY OF PRODUCTION COST PER ACRE AND BREAKEVEN SELLING PRICES PER UNIT

	UNIT	PRICE OR COST/UNIT	QUANTITY	VALUE OR COST	YOUR FARM
VARIABLE COSTS					
PREHARVEST					
HAND PRUNE	HR.	4.00	40.00	$160.00	----------
FUNGINEX	GAL	75.000	1.00	75.00	----------
HAND HOEING	HR.	4.000	16.00	64.00	----------
FERT LABOR	HR.	4.000	2.00	8.00	----------
10-10-10	LBS.	0.130	370.00	48.10	----------
FERT LABOR	HR.	4.000	2.00	8.00	----------
BENLATE	LBS.	14.700	1.00	14.70	----------
AMMONIUM SULFATE	LBS.	0.095	175.00	16.63	----------
MALATHION	LBS.	3.800	1.00	3.80	----------
MESUROL	LBS.	20.450	2.00	40.90	----------
PRINCEP 80WP	LBS.	3.950	5.00	19.75	----------
POLLINATION	HIVE	17.000	1.00	17.00	----------
SANITATION EQUIP	ACRE	4.000	2.00	8.00	----------
CLEANING LABOR	HR.	4.000	25.00	100.00	----------
OVERHEAD	DOL.	0.050	1724.86	86.24	----------
MACHINERY REPAIR	ACRE	8.96	1.00	8.96	----------
TRACTOR FUEL, LUBE, REPAIR	ACRE	1.60	1.00	1.60	----------
IRRIGATION ELEC. & REPAIR	ACRE	38.48	1.00	38.48	----------
LABOR(TRACTOR & MACHINERY)	HOUR	6.00	8.66	51.97	----------
LABOR(IRRIGATION)	HOUR	4.00	1.69	6.75	----------
INTEREST ON OP. CAP.	DOL.	0.12	187.09	22.45	----------
SUBTOTAL, PRE-HARVEST				$ 800.33	----------
HARVEST COSTS[1/]					
HAND PICK	CWT.	17.000	8.00	136.00	----------
FLATS & CONT	EACH	0.550	40.00	22.00	----------
SALES LABOR	HR.	4.000	2.60	10.40	----------
MACHINERY	ACRE	16.94	.50	8.47	----------
TRACTORS	ACRE	0.20	.50	0.10	----------
LABOR(TRACTOR & MACHINERY)	HOUR	6.00	2.65	15.92	----------
SUBTOTAL, HARVEST				$ 192.39	----------
TOTAL VARIABLE COST				$ 993.22	----------
FIXED COSTS				$	
MACHINERY	ACRE	109.00	1.00	109.00	----------
TRACTORS	ACRE	53.39	1.00	53.39	----------
IRRIGATION MACHINERY	ACRE	85.78	1.00	85.78	----------
TAXES (LAND)	ACRE	100.00	1.00	100.00	----------
LAND (NET RENT)	ACRE	0.12	3000.00	360.00	----------
ESTAB. INV. INT.				466.56	----------
TOTAL FIXED COSTS				$1174.76	----------
TOTAL COSTS				$2167.97	----------

[1/] HARVEST COSTS AND INTEREST ON ACCUMULATED ESTABLISHMENT INVESTMENT ARE FOR YEAR 3. SEE TABLE A FOR ESTABLISHMENT COST DETAILS.

BLUEBERRY PRODUCTION COSTS -FULL PRODUCTION
FOR DIRECT MARKETING AND PROCESSING
WESTERN WASHINGTON - 10 ACRE ENTERPRISE - 1981

TABLE 1--SCHEDULE OF OPERATIONS AND SELECTED COSTS PER ACRE*

						VARIABLE COST					
OPERATION	TOOLING	MONTH	MACH. HOURS	LABOR HOURS	MACH. FIXED COST	FUEL,OIL, LUBE,AND, REPAIRS	MACH LABOR	SERVICE	MATERIALS	TOTAL VARIABLE COST	TOTAL COST
WEED CONTROL	30HP, AIR BLAST SPRAY SOIL**	OCT	0.82	0.99	15.28	1.31	5.94	0.0	9.87	17.13	32.40
PRUNE	HAND PRUNE	FEB						400.00	0.0	400.00	400.00
APPLY FUNGINEX	30HP, AIR BLAST SPRAY FOL**	MAR	0.82	0.99	15.28	1.31	5.94	0.0	37.50	44.75	60.03
APPLY FUNGINEX	30HP, AIR BLAST SPRAY FOL**	APR	0.82	0.99	15.28	1.31	5.94	0.0	37.50	44.75	60.03
APPLY BENLATE	30HP, AIR BLAST SPRAY FOL**	APR	0.82	0.99	15.28	1.31	5.94	0.0	14.70	21.95	37.23
FERTILIZE	30HP, TRAILER	APR	0.61	0.74	5.49	0.14	4.44	8.00	91.00	103.58	109.07
WEED CONTROL	30HP, AIR BLAST SPRAY SOIL**	APR	0.82	0.99	15.28	1.31	5.94	0.0	9.87	17.13	32.40
POLLINIZATION	BEE HIVE RENTAL	APR						17.00	0.0	17.00	17.00
FERTILIZE	30HP, TRAILER	MAY	0.31	0.37	2.74	0.07	2.22	8.00	31.35	41.64	44.38
WEEDING	HAND HOEING	MAY						16.00	0.0	16.00	16.00
WEEDING	HAND HOEING	JUNE						16.00	0.0	16.00	16.00
BIRD CONTROL	30HP, AIR BLAST SPRAY FOL**	JULY	0.82	0.99	15.28	1.31	5.94	0.0	20.45	27.70	42.98
HARVEST	HANDPICK	JULY						425.00	192.50	617.50	617.50
HAUL TO PROCESS	PICKUP	JULY	2.00	2.40	14.82	9.67	14.40	0.0	0.0	24.07	38.90
DIRECT MARKET	SALES LABOR	JULY						68.00	0.0	68.00	68.00
HAUL TO STAND	30HP, TRAILER	JULY	0.15	0.18	1.37	0.04	1.11	0.0	0.0	1.15	2.52
INSECT CONTROL	30HP, AIR BLAST SPRAY FOL**	JULY	0.82	0.99	15.28	1.31	5.94	0.0	3.80	11.05	26.33
CLEANING	CLEANING LABOR	JULY						58.00	0.0	58.00	58.00
OUTHOUSES	PICKER CONVENIENCE	JULY						4.00	0.0	4.00	4.00
WEEDING	HAND HOEING	JULY						16.00	0.0	16.00	16.00
BIRD CONTROL	30HP, AIR BLAST SPRAY FOL**	AUG	0.82	0.99	15.28	1.31	5.94	0.0	20.45	27.70	42.98
HARVEST	HANDPICK	AUG						935.00	0.0	935.00	935.00
HAUL TO PROCESS	PICKUP	AUG	5.00	6.00	37.06	24.18	36.00	0.0	0.0	60.18	97.24
DIRECT MARKET	SALES LABOR	AUG						164.00	0.0	164.00	164.00
HAUL TO STAND	30HP, TRAILER	AUG	0.31	0.37	2.74	0.07	2.22	0.0	0.0	2.29	5.03
CLEANING	CLEANING LABOR	AUG						140.00	0.0	140.00	140.00
OUTHOUSES	PICKER CONVENIENCE	AUG						4.00	0.0	4.00	4.00
WEEDING	HAND HOEING	AUG						16.00	0.0	16.00	16.00
TOTAL COST PER ACRE					186.43	44.64	107.92	2295.00	469.00	2916.56	3102.99

*GROUND [illegible] USED FOR IRRIGATION, APPLIED AT A RATE OF 4" PER MONTH IN JULY, AUGUST, USING A HAND MOVE IRRIGATION SYSTEM.

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BLUEBERRY PRODUCTION COSTS -FULL PRODUCTION
FOR DIRECT MARKETING AND PROCESSING
WESTERN WASHINGTON - 10 ACRE ENTERPRISE - 1981

TABLE 2--SUMMARY OF PRODUCTION COST PER ACRE AND BREAKEVEN SELLING PRICES PER UNIT

	UNIT	PRICE OR COST/UNIT	QUANTITY	VALUE OR COST	YOUR FARM
VARIABLE COSTS					
PREHARVEST					
HAND PRUNE	HR.	4.000	100.00	$ 400.00	----------
FUNGINEX	GAL	75.000	1.00	75.00	----------
FERT LABOR	HR.	4.000	4.00	16.00	----------
10-10-10	LBS.	0.130	700.00	91.00	----------
HAND HOE	HR.	4.000	16.00	64.00	----------
BENLATE	LBS.	14.700	1.00	14.70	----------
AMMONIUM SULFATE	LBS.	0.095	330.00	31.35	----------
MALATHION	LBS.	3.800	1.00	3.80	----------
MESUROL	LBS.	20.450	2.00	40.90	----------
POLLINATION	HIVE	17.000	1.00	17.00	----------
SANITATION EQUIP	ACRE	4.000	2.00	8.00	----------
CLEANING LABOR	HR.	4.000	49.50	198.00	----------
PRINCEP 80WP	LBS.	3.950	5.00	19.75	----------
OVERHEAD	DOL.	0.050	3009.65	150.48	----------
MACHINERY REPAIR	ACRE	9.02	1.00	9.02	----------
TRACTOR FUEL, LUBE, REPAIR	ACRE	1.67	1.00	1.67	----------
IRRIGATION ELEC. & REPAIR	ACRE	38.48	1.00	38.48	----------
LABOR(TRACTOR & MACHINERY)	HOUR	6.00	9.03	54.19	----------
LABOR(IRRIGATION)	HOUR	4.00	1.69	6.75	----------
INTEREST ON OP. CAP.	DOL.	0.12	436.41	52.37	----------
SUBTOTAL, PRE-HARVEST				$1292.46	----------
HARVEST COSTS				$	
HAND PICK	CWT.	17.000	80.00	1360.00	----------
FLATS & CONT	EACH	0.550	350.00	192.50	----------
SALES LABOR	HR.	4.000	58.00	232.00	----------
MACHINERY	ACRE	33.86	1.00	33.86	----------
TRACTORS	ACRE	0.10	1.00	0.10	----------
LABOR(TRACTOR & MACHINERY)	HOUR	6.00	8.95	53.73	----------
SUBTOTAL, HARVEST				$1872.19	----------
TOTAL VARIABLE COST				$3164.64	----------
BREAKEVEN PRICE, VARIABLE COSTS AT	80.00	CWT./AC		39.558	----------
FIXED COSTS				$	
MACHINERY	ACRE	134.05	1.00	134.05	----------
TRACTORS	ACRE	52.38	1.00	52.38	----------
IRRIGATION MACHINERY	ACRE	85.78	1.00	85.78	----------
TAXES (LAND)	ACRE	100.00	1.00	100.00	----------
PRORATED ESTAB. COST	ACRE	9730.77	0.106	1032.23	----------
LAND (NET RENT)	ACRE	0.12	3000.00	360.00	----------
TOTAL FIXED COSTS				$1764.44	----------
TOTAL COSTS				$4929.08	----------
BREAKEVEN PRICE, TOTAL COSTS AT	80.00	CWT./AC		61.61	----------

BLUEBERRY PRODUCTION COSTS -FULL PRODUCTION
FOR DIRECT MARKETING AND PROCESSING
WESTERN WASHINGTON - 10 ACRE ENTERPRISE - 1981

TABLE 3--SUMMARY OF RECEIPTS, COSTS, AND PROFITABILITY PER ACRE

	UNIT	PRICE OR COST/UNIT	QUANTITY	VALUE OR COST	YOUR FARM
GROSS RECEIPTS FROM PRODUCTION				$	
BLUEBERRIES	CWT.	60.000	24.00	1440.00	----------
BLUEBERRIES	CWT.	50.000	56.00	2800.00	----------
1. TOTAL RECEIPTS				$4240.00	----------
LESS: TOTAL VARIABLE COST				$3164.64	----------
2. RETURNS OVER VARIABLE COST				$1075.36	----------
LESS: MACHINERY FIXED COST				$ 272.21	----------
PRORATED ESTAB. COST				$1032.23	----------
3. RETURNS TO LAND AND MANAGEMENT				$-229.18	----------
LESS: RETURNS TO MANAGEMENT (0.050 OF RETURNS)				$ 212.00	----------
4. GROSS RETURNS TO LAND				$-441.18	----------
LESS: REAL ESTATE TAXES				$ 100.00	----------
5. NET RETURNS TO LAND INVESTMENT				$-541.18	----------
6. RATE OF RETURN ON CURRENT MARKET VALUE OF LAND (4000. PER ACRE)				% 0.0	----------

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BLUEBERRY PRODUCTION COSTS -FULL PRODUCTION
FOR DIRECT MARKETING AND PROCESSING
WESTERN WASHINGTON - 10 ACRE ENTERPRISE - 1981

TABLE 4--MONTHLY SUMMARY OF DIRECT CASH EXPENSES AND LABOR REQUIREMENTS

CATEGORY	UNIT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	PRICE/ UNIT	NO. UNITS	TOTAL VALUE
OPERATING INPUTS:																
HAND PRUNE	HR.	0.0	100.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.00	100.00	400.00
FUNGINEX	GAL	0.0	0.0	0.50	0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	75.00	1.00	75.00
FERT LABOR	HR.	0.0	0.0	0.0	2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.00	2.00	8.00
FERT LABOR	HR.	0.0	0.0	0.0	0.0	2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.00	2.00	8.00
10-10-10	LBS.	0.0	0.0	0.0	700.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.13	700.00	91.00
HAND HOE	HR.	0.0	0.0	0.0	0.0	4.00	4.00	4.00	4.00	0.0	0.0	0.0	0.0	4.00	16.00	64.00
BENLATE	LBS.	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.70	1.00	14.70
AMMONIUM SULFATE	LBS.	0.0	0.0	0.0	0.0	330.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.10	330.00	31.35
MALATHION	LBS.	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	3.80	1.00	3.80
HAND PICK	CWT.	0.0	0.0	0.0	0.0	0.0	0.0	25.00	55.00	0.0	0.0	0.0	0.0	17.00	80.00	1360.00
FLATS & CONT	EACH	0.0	0.0	0.0	0.0	0.0	0.0	350.00	0.0	0.0	0.0	0.0	0.0	0.55	350.00	192.50
SALES LABOR	HR.	0.0	0.0	0.0	0.0	0.0	0.0	17.00	41.00	0.0	0.0	0.0	0.0	4.00	58.00	232.00
MESUROL	LBS.	0.0	0.0	0.0	0.0	0.0	0.0	1.00	1.00	0.0	0.0	0.0	0.0	20.45	2.00	40.90
POLLINATION	HIVE	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.00	1.00	17.00
SANITATION EQUIP	ACRE	0.0	0.0	0.0	0.0	0.0	0.0	1.00	1.00	0.0	0.0	0.0	0.0	4.00	2.00	8.00
CLEANING LABOR	HR.	0.0	0.0	0.0	0.0	0.0	0.0	14.50	35.00	0.0	0.0	0.0	0.0	4.00	49.50	198.00
PRINCEP 80WP	LBS.	0.0	0.0	0.0	2.50	0.0	0.0	0.0	0.0	0.0	2.50	0.0	0.0	3.95	[illegible]	19.75
OVERHEAD	DOL.	0.0	0.0	0.0	0.0	0.0	3009.65	0.0	0.0	0.0	0.0	0.0	0.0	0.05300[illegible]		150.48
TRACT REPAIR COST	ACRE	0.0	0.0	0.17	0.62	0.06	0.0	0.36	0.23	0.0	0.17	0.0	0.0			1.61
EQUIP FUEL COST	ACRE	0.0	0.0	0.0	0.0	0.0	0.0	7.50	18.75	0.0	0.[illegible]	0.0	0.0			26.25
EQUIP LUBE COST	ACRE	0.0	0.0	0.0	0.0	0.0	0.0	1.12	2.81	0.0	0.0	0.0	0.0			3.94
EQUIP REPAIR COST	ACRE	0.0	0.0	1.13	3.38	0.00	0.0	3.30	3.75	0.0	1.13	0.0	0.0			12.69
IRRIG FUEL COST	ACRE	0.0	0.0	0.0	0.0	0.0	0.0	4.00	4.00	0.0	0.0	0.0	0.0			8.00
IRRIG REPAIR COST	ACRE	0.0	0.0	0.0	0.0	0.0	0.0	15.25	15.25	0.0	0.0	0.0	0.0			30.50
TOTAL COST	ACRE	0.0	400.00	38.79	182.08	55.42	166.48	81[illegible].29	1324.24	0.0	11.17	0.0	0.0			2997.46
LABOR REQUIREMENTS BY MONTH																
MACHINERY LABOR	HR.	0.0	0.0	0.90	3.37	0.34	0.0	4.37	7.24	0.0	0.90	0.0	0.0			17.11
IRRIGATION LABOR	HR.	0.0	0.0	0.0	0.0	0.0	0.0	0.84	0.84	0.0	0.0	0.0	0.0			1.69
TOTAL LABOR	HR.	0.0	0.0	0.90	3.37	0.34	0.0	5.21	8.08	0.0	0.90	0.0	0.0			18.80

IRRIGATION

TABLE 5 -- BLUEBERRY RETURNS OVER TOTAL COSTS AT VARIOUS YIELDS AND PRICES

YIELD LBS.	CENTS PER POUND												
	40	45	50	55	60	65	70	75	80	85	90	95	1.00
4,000	-2416	-2216	-2016	-1816	-1616	-1416	-1216	-1016	-816	-616	-416	-216	-16
5,000	-2256	-2006	-1756	-1506	-1256	-1006	-756	-506	-256	-6	243	493	743
6,000	-2096	-1796	-1496	-1196	-896	-596	-296	3	303	603	903	1203	1503
7,000	-1936	-1586	-1236	-886	-536	-186	163	513	863	1213	1563	1913	2263
8,000	-1776	-1376	-976	-576	-176	223	623	1023	1423	1823	2223	2623	3023
9,000	-1616	-1166	-716	-266	183	633	1083	1533	1983	2433	2883	3333	3783
10,000	-1456	-956	-456	43	543	1043	1543	2043	2543	3043	3543	4043	4543
11,000	-1296	-746	-196	353	903	1453	2003	2553	3103	3653	4203	4753	5303
12,000	-1136	-536	63	663	1263	1863	2463	3063	3663	4263	4863	5463	6063

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APPENDIX TABLE A - MACHINERY COMPLEMENT

ITEM	DESCRIPTION	LIST PRICE	HOURS USED ANNUALLY	TOTAL COST/ HOUR USE
1	Air Blast Sprayer	$ 4,400.00	60	$13.43
2	Field Cultivator	500.00	10	2.14
3	Pickup, ½ T	4,050.00	100	12.25
4	1 BTM Plow	250.00	10	.24
5	Trailer	432.00	30	2.38
6	30HP Diesel Tractor	8,000.00	200	6.21

APPENDIX TABLE B - IRRIGATION EQUIPMENT

ITEM	DESCRIPTION	COST
1	SPRINKLER HEADS, LATERAL PIPE, MAIN LINE, & RISERS	$2,034.00
2	PUMP AND MOTOR	3,092.00
3	WELL	2,500.00
	TOTAL	$7,626.00

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