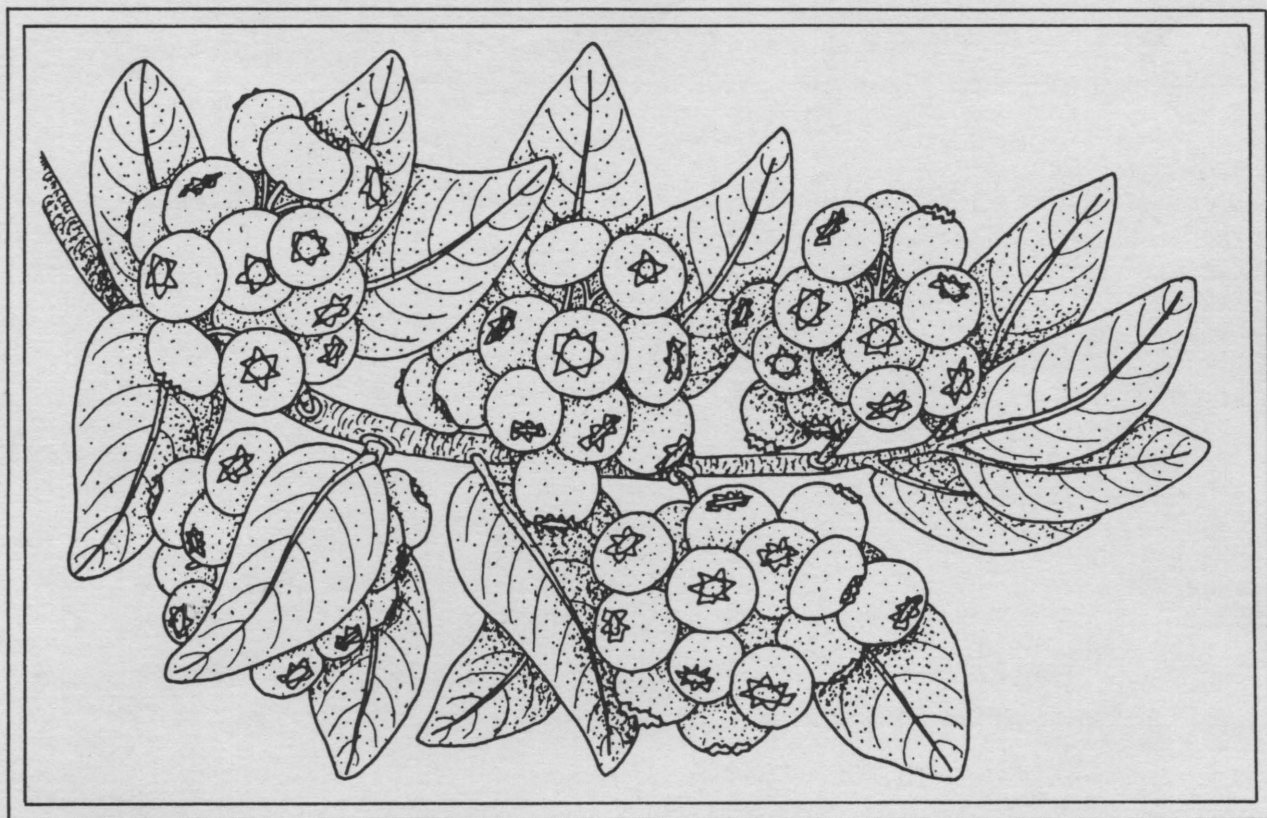


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HIGHBUSH BLUEBERRY PRODUCTION



A Guide for Commercial Growers in Virginia

Extension Division

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HIGHBUSH BLUEBERRY PRODUCTION

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INTRODUCTION

Cultivated "highbush" blueberries (*Vaccinium corymbosum* L.) are commercially produced in many sections of the United States from North Carolina northward to Michigan and Washington. A second type, the "rabbiteye" blueberry (*Vaccinium ashei* Reade), is adapted to warm climates and short cold seasons which occur in certain Southern states, and it may be useful in certain parts of Virginia. Another type, the "lowbush" (*Vaccinium angustifolium* Ait.) blueberry, is adapted to Northern states such as Maine, and it is not adaptable to commercial production in Virginia. This publication will deal only with practices for commercial production of highbush blueberries. Other sources of information will be prepared for those interested in commercial production of the rabbiteye type.

SITE SELECTION

Highbush blueberry plants are winter-hardy to temperatures as low as -25°F (-32°C) when satisfactorily hardened-off in the fall, and dormant flower buds can usually survive temperatures of -15°F (-26°C). All cultivars require several weeks between fruiting and the first killing frost in order to mature and harden-off for best winter survival. A growing season of 150 to 165 frost-free days is generally required for this crop. Acceptable conditions of temperature and length of growing season are available within the state of Virginia.

Length of growing season, minimum winter temperatures, and other climatic factors may determine whether or not a crop such as blueberries will survive and produce large crops in a given region or location. Equally important is the availability of an adequate market (whether retail or wholesale) and labor force which will determine whether a given location will be practical and profitable once the crops have been grown.

Harvest labor costs are much reduced if the location is favorable for Pick-Your-Own (PYO) sale of fruit, and this may be one of the most practical means for marketing Virginia-grown blueberries. Farms within 25 or 30 miles of large population centers are generally better for PYO sale of fruit than those at more remote locations.

CULTIVAR SELECTION

Blueberry cultivars differ in characteristics such as picking season, yield, fruit quality, amount of pruning required, disease resistance, winter hardiness, attractiveness to bees, and regional adaptation. When such differences are known (Appendix 1), they should be considered in making choices of kinds to plant. Not all of these characteristics have been catalogued for existing cultivars, so it is often wise to test preliminary choices in small plantings before committing larger areas for commercial production in given region or locality.

Cultivars may be selected with regard to the ripening season. The earliest cultivars start to ripen about 60 days after blossoms appear, while late-ripening cultivars may take 100 days or more. Harvest season length ranges from 2 to 5 weeks among individual highbush cultivars and it may total 9 weeks from earliest to latest cultivar.

Collins, Bluecrop (or Blueray), Herbert, and Lateblue constitute one series of cultivars which may be acceptable where fruit ripening is desired from early through very late harvest seasons.

Reputable nurseries specializing in blueberry propagation generally provide lower-cost, higher-quality, true-to-name cultivars. Most nurseries sell one-year-old rooted cuttings and two- or three-year-old field-grown, bare-rooted plants. It is generally a good idea to purchase certified disease-free, two-year-old plants which are 12 to 24 inches (30-60 cm) high. Avoid older plants, they may be culls which were too weak to sell as younger plants; such plants tend to perform poorly after transplanting.

SOIL REQUIREMENTS

The more critical factors in site selection are: soil texture, soil depth, soil type, pH of native soil, elevation of the site with respect to surrounding topography, availability of water for irrigation, and full exposure to sunlight.

The presence of plants such as huckleberries, azaleas, or laurel may indicate a suitable blueberry site. The best sites are large, open areas where air can move freely and where plants are exposed to full sunlight. Low areas may be frost pockets and should be avoided. Sites surrounded

by hills or dense stands of trees have relatively poor air circulation which may increase frost damage and the incidence of fungus disease.

Blueberry plants have fine, fibrous roots without root hairs; they do not grow well in heavy, compact soil. Well-aerated, loose-textured soils such as sands, peats, and loams, with very high organic matter contents are best. Chances of successful, long-lived plantings are greater on deep sands with particular layering or soil profile characteristics.

Best plant growth results when the soil pH is between 4.0 and 5.2. This low soil pH (acid soil) is important for prevention of iron chlorosis (deficiency) and for the maintenance of nitrogen in the ammonium form.

Ideal blueberry sites have stable water tables from 14 to 30 inches (35 to 75 cm) below the surface; however, blueberries are particularly sensitive to standing water during the growing season and may be killed in water-logged soils. Special water level control measures, such as ditching and tiling, may be required where water tables are likely to rise within 24 inches (60 cm) of the soil surface.

SOIL PREPARATION

Depending upon its condition and current use, the soil should be prepared at least a year in advance of the actual planting. Organic matter content of the soil may be increased by incorporating a cover crop with the soil and by adding sawdust, peat moss, manure, or leaf mold. Soil acidity should also be modified by the addition of sulfur or aluminum sulfate if pH is above 5.2, but sulfur applications will not make very high pH or calcareous soils acceptable for commercial blueberry production. Where sulfur or aluminum sulfate are required, they should be thoroughly worked into the soil to a depth of 6-10 inches (15-25 cm) the year prior to planting (Table 1). Use of sulfur in the planting hole at planting time can kill newly set plants. The cost and amounts of sulfur may be reduced by treatment of 6-foot-wide (1.8 m) strips centered on future row sites, as opposed to broadcast applications to the whole field. Liming is recommended only in cases of extremely low soil pH, i.e., below 3.7.

Noxious perennial weeds such as quackgrass, Johnson grass, morning glory, bindweed, greenbriar, and brambles should be eliminated by cultivation and systemic herbicides before planting. Current herbicide recommendations may be obtained from local Virginia Cooperative Extension Service offices.

Use of raised beds may increase the acceptability of sites with marginal soil aeration or drainage. Raised beds may also compensate, in part, for the sinking of plants which occurs as organic matter decays in the planting hole. Such sinking may increase the risks of certain root diseases.

Raised beds may be constructed by using a moldboard plow, or other equipment, to move topsoil from sites of the future row-middles to adjacent sites planned for use as the row-centers. An average bed height of 12 inches (30 cm) and width of 4 feet (1.2 m) is suggested if this system is to be used. It is especially important that irrigation be available when using raised beds because they tend to dry out more quickly than level soil during periods of drought. It is also important that the beds be constructed in such a way that surface water is permitted to drain along the middles and out of the field.

PLANTING TECHNIQUES

Plant in early spring as soon as the soil can be worked. Wetted peat moss or a 50-50 mixture of peat moss and soil should be added directly to the planting hole. Planting holes should be at least 4 inches (10 cm) larger in diameter than the spread of the plant roots and 12 inches (30 cm) deep to allow addition of organic matter around and under the plant. No root pruning is required except for the removal of damaged roots. Plants should be set at the same depth or no more than one inch (2.5 cm) deeper than they were in the nursery. Allow horizontal roots to retain this orientation and do not place roots any deeper in the soil than they occurred in the nursery row. Spread roots of potted plants so that they are no deeper than 4 to 6 inches (10 to 15 cm). Soil should be firmed around the plants to avoid drying of roots in large air spaces. All fruit buds should be pruned off at the time of planting. The tops of older plants may be pruned back 50-60% to balance the tops with the remaining roots and to stimulate new growth. New plants should be kept well irrigated to encourage survival and stimulate new growth. A surface-applied sawdust mulch will also benefit the plant.

Commercial planting distances are often dictated by sizes of equipment to be used in the planting (Table 2). Plants are usually set 4 to 6 feet (1.2 to 1.8 m) apart in the row with 9 to 12 feet (2.7 to 3.7 m) between rows.

POLLINATION

Most plantings will produce satisfactory crops when only one cultivar is included, but pollination by other cultivars will generally result in increased yields, larger fruit, and earlier ripening. A planting design in which 4 rows of one cultivar are alternated with 4 rows of another cultivar should encourage cross-pollination; placement of one strong bee colony per acre is recommended to further ensure it. Honey bees have definite preferences among blueberry cultivars, and more hives will be needed if bees appear to be neglecting flowers of certain unattractive cultivars. Timing the placement of hives is important; honey bee colonies should be placed in the field when 15-20% of the flowers have opened. A good commercial blueberry crop is possible when at least 80% of the blossoms set fruit.

SOIL MANAGEMENT

Weed Control

Weed control is especially important because blueberries are very poor competitors for moisture and nutrients. Clean cultivation has been a common practice, but care must be taken to avoid injury to the very shallow root systems of these plants. Use of sod strips between rows, with maintenance of a weed-free strip 3 to 4 feet (0.9 to 1.2 m) wide on row centers, is gaining popularity and may be preferable. However, this system precludes (or complicates) use of cultivation to control mummy berry disease and certain insects.

A thick layer of organic mulch can help control weeds, conserve moisture, maintain proper soil acidity, reduce soil temperature variation, and supply organic matter to the soil. Three to 6 inches (8 to 15 cm) of well-rotted sawdust or woodchips may be applied during the fall of the year of planting; a 50/50 mixture of sawdust and woodchips works well because the chips help prevent wind erosion and allow for better water movement through the sawdust. Approximately 1 inch (2.5 cm) of mulch should be added each year to compensate for decomposition of previously applied material. Chemical weed control practices are available and details may be obtained from local Extension offices. Mulching may, as noted for sod culture, conflict with the use of cultivation for control of mummy berry disease and certain insect pests.

Fertilization

Nutritional status of a planting may be affected by a number of plant, soil, and environ-

mental factors. The following suggestions should give acceptable results under usual circumstances. They are presented as guidelines from which producers may make necessary changes to fit local conditions.

First Year In The Field: Apply 100 pounds of 10-10-10 or 10-20-10 per acre in a band 6 to 8 inches (15-20 cm) wide, with no fertilizer closer than 6 inches (15 cm) to row centers after the first flush of growth has occurred (i.e., about 4 weeks after planting). Repeat this application once or twice more with 6-week intervals between applications. A minimum of 4 inches (10 cm) of water (either rainfall or irrigation) should be applied between any two fertilizations. Ammonium sulfate (50 lb/acre) may be substituted for the above mixed fertilizers if soil pH is in the range of 4.6 to 5.2 and phosphorus and potassium are in the medium soil test range; it should not be used, however, if pH is lower than 4.5. Urea (25 lb/acre) could be similarly substituted, and, because it has less effect upon soil pH, it would be a better choice than ammonium sulfate when pH is below 4.5. Do not apply nitrogen fertilizer after mid-July (or early July in short-season areas).

Second Year In The Field: Twenty pounds of actual nitrogen (200 lbs of 10-10-10 or equivalent) per acre should be applied in a uniform band 2.5 feet (0.8 m) wide and centered over the row just before bud-break in the second growing season. This application may be followed by two applications of ammonium sulfate (100 lbs/acre) at 4- to 6-week intervals.

Third And Later Years In The Field: Plants entering their third or subsequent growing seasons in the fruiting field should receive 20 to 40 pounds of actual nitrogen (i.e., 200 to 400 lbs of 10-10-10 or 10-20-10) per acre just before bud-break. Apply an additional 10 pounds of N as ammonium sulfate in each of 2 applications at 6-week intervals. All of these applications should be spread uniformly on the soil surface within bands which are as wide as the average spread between branches in the field. Nitrogen applications should be adjusted by the producer if plants appear to be deficient or if winter injury seems to be resulting from prolonged growth in the fall.

Notes on Fertilization

Fertilizers may be applied by hand on a per-plant basis in small plantings. In this case, 4 weeks after planting, sprinkle 0.7 oz (20 gm) of ammonium sulfate 12-18 inches (30-45 cm) from the crown of the plant. As a general rule, plants should receive about 0.7 oz (20 gm) of ammonium sulfate or its equivalent per each year of growth

each spring when the buds swell. Mature plants should receive about 4 oz (120 gm) of ammonium sulfate or its equivalent each year (Table 3). This rate will furnish about 65 pounds (30 kg) of elemental nitrogen per acre for mature plantings.

Sites with high quantities of organic matter or nitrogen residues remaining from previous crops may require little or no fertilizer during the establishment year, but this is not possible to predict on a generalized basis. Some growers indicate that chlorides, found in muriates of potash of commercial fertilizer mixes, may damage plants less than three years of age. But other growers obtain acceptable results with such mixes. Growers may request fertilizer suppliers to substitute potassium sulfate for muriate of potash if that is desired.

Ammonium sulfate is a convenient source of nitrogen in the ammonium form which should be used if soil pH is near the top of the desirable range. Other sources may be used when pH is in the acceptable range, and ammonium sulfate should not be used when pH is near the bottom of this range. Urea is another good source of nitrogen for blueberries. Natural Organic materials such as cotton seed meal are desirable, but may be difficult to obtain in sufficient quantities for commercial plantings.

Supplemental foliar or soil applications of iron in a chelated form may be useful or necessary for temporary alleviation of iron deficiency symptoms. Long-term solution of such deficiencies generally involves adjustment of soil pH, addition of organic mulches, and irrigation practices which maintain soil moisture within a desirable range.

Irrigation

Supplemental irrigation helps maintain adequate soil moisture throughout the growing season and may be essential for best growth and production. Water is critical for survival of new plantings, even if it must be hauled and hand-distributed. A mature planting should receive about one inch (2.3 cm) of water from rainfall or overhead irrigation per week throughout the growing season. Overhead sprinkler irrigation may be used when the fruit is ripening, but it should be applied in early morning in order to avoid fruit splitting. Trickle irrigation or similar methods may be substituted for overhead irrigation. For additional information on irrigation, consult your Extension agent.

PRUNING

As with many fruit crops, pruning can be used to control cropping and to stimulate strong shoot growth in the following year. Pruning of blueberries is best accomplished near the end of the dormant season. At this time, dormant fruit buds, borne near the ends of shoots which grew in the previous season, are larger and more plump than leaf buds so they are easy to recognize (Fig. 1). Each flower bud contains from 5-10 flowers. To prevent fruiting for the first 2 years in the field, in the spring remove all flower buds by pruning just below the dormant basal floral bud on each shoot. One half or more of the flower buds should be removed in each succeeding year of the highbush blueberries' life in the field.

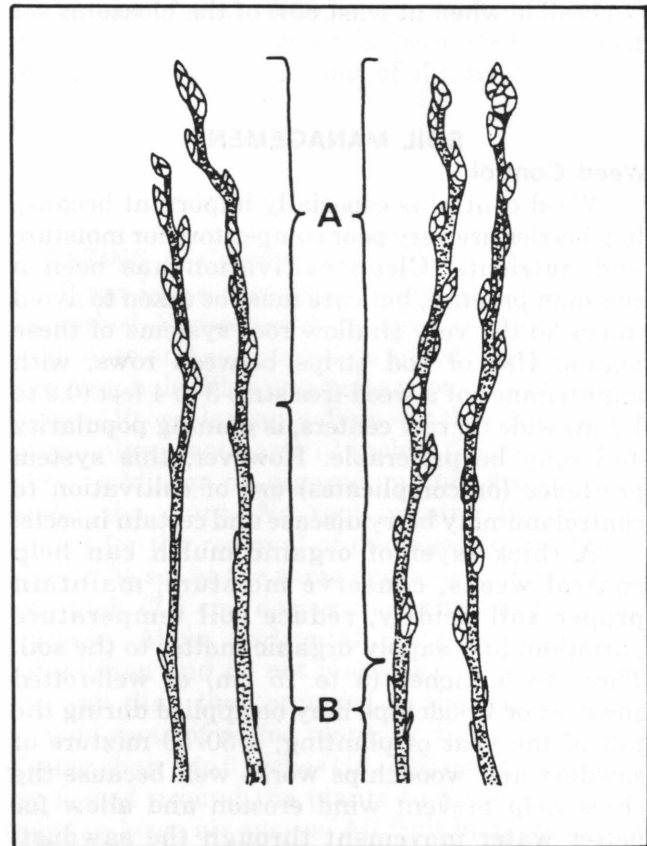


Figure 1. One-year-old stem sections showing fruit buds (A) and leaf buds (B).

Small, spindly, twiggy growth near the base of the plant, and branches which lie close to the soil surface, should be removed by pruning during dormancy in the third and subsequent years.

Retain as many vigorous canes as possible (6-8) while keeping the top and center of the bush open to admit light to interior foliage (Figure 2). Plant vigor can be maintained after the fourth

Table 1. Changing soil pH with sulfur or aluminum sulfate^a

Present pH of Soil	Desired pH Value															
	4.5 (Blueberry Range)				5.0				5.5				6.0			
	Sand	Loam	Clay	Sand	Loam	Clay	Sand	Loam	Clay	Sand	Loam	Clay	Sand	Loam	Clay	
	Pounds of Sulfur per 100 Sq. Ft.															
4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
4.5	0.4	1.2	1.4	0.4	1.2	1.4	0.4	1.2	1.4	0.4	1.2	1.4	0.4	1.2	1.4	
5.0	0.8	2.4	2.6	0.8	2.4	2.6	0.8	2.4	2.6	0.8	2.4	2.6	0.8	2.4	2.6	
5.5	1.2	3.5	3.7	1.2	3.5	3.7	1.2	3.5	3.7	1.2	3.5	3.7	1.2	3.5	3.7	
6.0	1.5	4.6	4.8	1.5	4.6	4.8	1.5	4.6	4.8	1.5	4.6	4.8	1.5	4.6	4.8	
6.5	1.9	5.8	6.0	1.9	5.8	6.0	1.9	5.8	6.0	1.9	5.8	6.0	1.9	5.8	6.0	
7.0	2.3	6.9	7.1	2.3	6.9	7.1	2.3	6.9	7.1	2.3	6.9	7.1	2.3	6.9	7.1	
7.5	2.7	8.0	8.2	2.7	8.0	8.2	2.7	8.0	8.2	2.7	8.0	8.2	2.7	8.0	8.2	

^aTo substitute aluminum sulfate for sulfur, multiply the number of pounds of sulfur required by 6.

Table 2. Number of blueberry plants needed to set one acre at various spacings.

In Rows	Between Rows				
	8'	9'	10'	11'	12'
4'	1361	1210	1089	990	908
5'	1089	968	870	792	726
6'	908	807	726	660	605

Example: At a spacing of 5' x 10', a total of 870 plants are needed for each acre.

Table 3. Suggested fertilizer rates for blueberries.

Age of Plantation (Years from planting)	Amount of Fertilizer Per Plant	
	10-10-10*	or Ammonium Sulfate
Newly Set	40 grams	20 grams
1	40 "	20 "
2	80 "	40 "
3	120 "	60 "
4	180 "	80 "
5	220 "	100 "
6 and older	260 "	120 "

*A typical acid base fertilizer analysis available in Virginia.

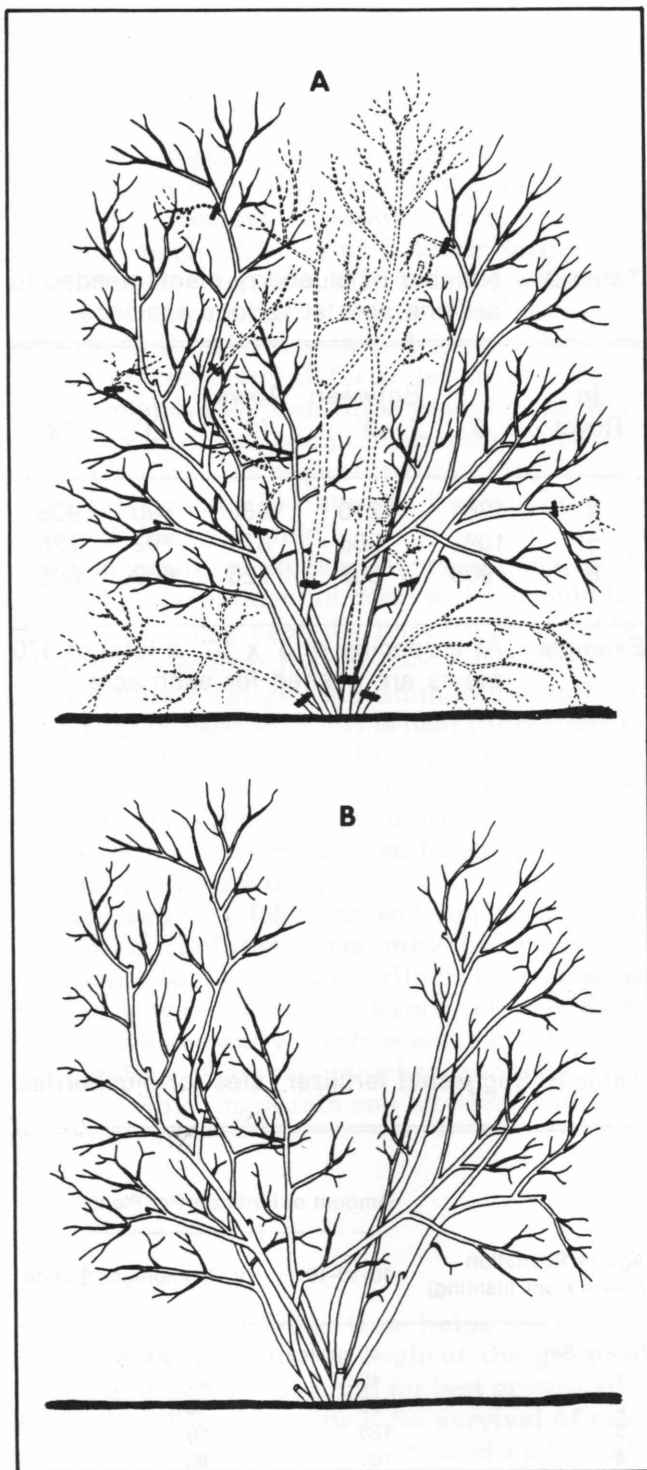


Figure 2. (A) Mature bush showing typical annual pruning cuts (solid bars) and wood to be removed (dotted lines). (B) Mature bush after pruning.

year by cutting 3-4 vigorous canes which grew from the crown during the previous year to heights of 12 to 36 inches (30-90 cm) and by allowing the resulting vigorous growths to replace the oldest, least vigorous fruiting canes in

the next year or two. Ages of individual canes may, in this way, be kept under 6 years for each plant. Pruning should thus be aimed to promote a more upright bush, to keep fruit off the ground, to adjust the fruit crop to the capacity of the bush and root system, and to stimulate strong, vigorous shoots for next year's crop.

Plants which are unpruned for several years will develop many small, weak branches which are susceptible to damage from drought, low winter temperatures, and disease. Heavy pruning of mature bushes will result in a smaller crop, larger berries, and earlier ripening. If the grower desires large, early-maturing berries, his pruning should be rather heavy. If larger crops of smaller, later-maturing berries are wanted, the pruning should be moderate or light. In summary:

1. Remove fruiting branches which are too close to the ground.
2. Remove all dead and injured branches.
3. Remove spindly, bush twigs on mature branches.
4. Limit the number of canes or main branches arising near the crown to one for each year of age of the plant, or for each foot of height of the bush. This will leave a maximum of 6-8 canes for old bushes. The productivity of a cane declines after about 5 years, so prune bushes to leave equal numbers of canes which are 1-5 years old. Canes older than 5 years should be pruned back to the crown each year during dormancy.
5. Thin out vigorous fruit wood to approximately one fruit bud per 3 inches (7.5 cm) of new shoot growth; the number of fruit buds to be left will thus be adjusted for the bearing potential of the bush. A bush which produced 300 to 450 inches of shoot growth in the previous year should be pruned to leave 100 to 150 flower buds which should then produce approximately 4 lbs (1.8 keg) of high-quality fruit.

HARVESTING

The fruit of cultivated blueberries is borne in clusters made up of 5 to 10 berries. The berries ripen in succession over a period of 2 to 5 weeks for a single cultivar. Bushes should be picked every 7 to 10 days to remove berries as they ripen. Berries with a reddish tinge are not yet ripe and they usually turn blue 3 or 4 days before they develop their sweetness, flavor, and size. Delaying harvest until the berries are fully ripe will result in higher quality, larger fruit and

greatly increased yields. Begin harvesting when about one-third of the berries are blue. Pick with both hands and use your thumbs to gently roll berries from the cluster into the palm of your hand. Be sure all the ripe fruit is removed so there will be no overripe berries at the next picking. Handle fruit as little as possible so that the attractive waxy bloom will not be rubbed off. Harvest labor costs are much reduced if the location is favorable for pick-your-own sale of fruit. (See Appendix 3 for establishment and maintenance costs.)

Yields

A blueberry bush will take from 6 to 9 years after field planting to reach full maturity. A mature, healthy plant may produce 7 to 10 pints or 6 to 9 pounds of blueberries. (About 200 to 300 blueberries equal 1 pound of fruit.) Average yields of mature blueberries in full production under good conditions should range from 6000 to 10,000 lbs per acre (7000 to 11,000 kg per hectare). Some growers estimate maximum blueberry yield potential at more than 9 tons/acre (approximately 20,000 kg per hectare).

PROTECTION FROM BIRDS

Crop loss to birds can be serious. There are several methods of bird control which vary in cost and effectiveness. Destructive methods of bird control are quite complicated and subject to state and federal laws. Repellents, either visual, auditory, or chemical, constitute a second kind of bird control. Some common types of visual repellents are balloons, plastic strips, or metal pans suspended above the bushes and artificial snakes and hawks. None of these visual repellents are effective for any length of time. Auditory or noise repellents range from periodic loud explosions, to devices which transmit a bird "distress call," or certain frequency sound waves. Some of these electronic devices have been reported to be effective.

A very effective, but more labor-intensive and expensive, method of bird control is to cover the plantation with protective netting. Netting life can be extended if it is put on just before the berries begin to ripen and is removed after the last harvest. Permanent posts and overhead wires must be installed to support the netting.

Chemical methods are not currently available or registered for use as bird repellents on Virginia blueberries, but Cooperative Extension agents will be provided with information if this situation should change.

BLUEBERRY DISEASES

Blueberry cultivars are subject to a number of diseases, several of which may cause severe crop reduction or plant losses. The general disease groups and their characteristics are covered below. It is important to remember that diseases are less severe where good production practices are followed. Growers should take great care to start with clean, high-quality stock and to carefully monitor their plantings for atypical or unhealthy looking plants. For specific chemical recommendations for disease and insect control, growers should consult their local Extension agent.

Virus Diseases

Several blueberry viruses are transmitted by insect or nematode vectors in the field. Suspect plants should be diagnosed and, where positive identification is made, removed from the field. No treatment exists for virus infected plants. Viruses occurring in blueberry include: Shoestring, Mosaic, Red ringspot, and Witches-broom.

Blueberry stunt disease causes severe growth reduction and may be treated as if it were a virus. The disease is actually caused by a microorganism similar to a bacterium and is insect-vectored. The best control of viruses is prevention. Start with clean, virus-free plants and practice insect control and strict removal of diseased plants.

Fungal Diseases

Fungi cause a variety of root rots, stem cankers, twig blights, leaf spots, and fruit rots. Only a few of these more commonly found diseases are described below.

Mummy-berry: The fungus *Monilinia vaccinii-corymbosi* causes twig, blossom, and fruit diseases. Soon after leaves emerge in the spring, the buds and new leaves become infected by spores discharged from the fungus which has overwintered on the ground in infected, dropped fruit. Cool, wet weather favors this twig blight phase. The infected leaves produce secondary spores in great abundance in about 2-3 weeks. These secondary spores blow or splash onto the flowers where they may destroy blossom clusters and infect developing fruit. The infected fruit grows normally at first but fails to color properly and at harvest results in white or reddish berries which fall from the bushes. These berries are filled with fungus tissues and are unmarketable.

Control of this disease can be achieved by removing infected berries, and then covering them with one or more inches of soil through

cultivation, or by treating the soil beneath bushes with chemicals to kill the spore-producing structures in the spring. Several effective fungicides are also available to reduce leaf or fruit infection.

Botrytis or Grey Mold: Several species of the fungus *Botrytis* can cause twig and fruit blights on many fruit crops. Since the fungus lives overwinter on plant debris, it can be considered to be present every year in most fields. It can cause severe problems in periods of cool, wet weather. On blueberries, the fungus is especially damaging during bloom. Botrytis often gets a start on frost-damaged leaves or twigs or from dead twigs left from previous years. Where excess nitrogen fertilizer is used, tissues are more susceptible. Problems are likewise greater in areas of poor air drainage. Chemical control is effective where applications are made prior to infection. The first application of fungicide should be by mid-bloom with 7-10 day repeated sprays through petal fall.

Stem Diseases

Blueberries are subject to a number of stem cankers, die-backs, or blights. A number of different fungi cause such problems. Two fungi, *Botryosphaeria* and *Phomopsis*, are a particular threat in our area. Different species of the first fungus cause stem cankers and blights. Cankers can kill large branches and are considered one of the most severe blueberry diseases in most areas.

Carefully inspect all new plants for discolored lesions or dead twigs on branches. Plant only the most healthy specimens. Remove all dead or dying branches or twigs yearly as soon as possible. The cultivars Croatan, Murphy, and Morrow are considered canker-resistant.

Phomopsis twig blight is now considered a major problem in North Carolina blueberry areas. This disease starts at the tips of branches and progresses rapidly downward. Pruning and preventive spraying are recommended for control.

Root Diseases

The primary fungus causing root rot is *Phytophthora cinnamomi*. This disease and other root problems occur especially in poorly drained areas. The only effective control is the planting of healthy plants in well-drained sites. Rabbiteye cultivars are considered somewhat more tolerant than highbush cultivars to *Phytophthora* root rot.

Leaf Spots

A large number of fungi cause discolored or

dead spots on leaves of blueberry. Many of these diseases cause insignificant problems; however, several leaf-spotters cause severe defoliation and reduce plant vigor. Leaf spot fungi may also spread to twigs, fruit, and stems. The most common diseases are *Gleosporium* leaf spot (*Gleosporium minus*), *Septoria* leaf spot (*Septoria albopunctata*), *Alternaria* leaf spot (*Alternaria tenuissima*), *Gleocercospora* Leaf spot (*Gleocercospora inconspicua*), Double spot (*Dothichiza caroliniana*), and Anthracnose (*Glomerella cingulata*). Control should be instituted where one or more of these fungi is causing problems. Recommended chemicals are applied each 10 days or two weeks from bloom through August (check specific chemicals for dates-to-harvest requirements).

Fruit Diseases

Several fungi mentioned before (*Monilinia*, *Alternaria*, *Gleosporium*, *Botrytis*, and *Glomerella*) can cause rots of fruit on the bush or post-harvest. Infection generally occurs early and is not evident until storage conditions and fruit ripening allow fast growth of the fungi. Warm moist conditions and damage at harvest are especially potent factors in increasing fruit rots. Pre-harvest sprays and proper post-harvest handling are both effective in reducing disease. Where feasible, move berries to refrigerated storage as soon as possible.

BLUEBERRY INSECTS AND MITES

Over 300 species of insects attack blueberries. Several of these may cause problems for blueberries grown in Virginia. These pests may be divided into 2 groups: those that affect the fruit (direct pests) and those that affect parts of the plant other than the fruit (indirect pests).

Direct Pests

Since these insects attack the fruit directly, it is critical that they be kept at very low numbers. Direct pests that are important in Virginia are as follows:

Plum curculio: The adult weevil (a type of beetle) is dark brown, one-quarter-inch long and is easily dislodged from the bushes early in the morning. The female lays eggs in crescent-shaped depressions in the blueberry fruit. The larva, upon hatching, feeds on the interior of the berry, usually causing it to drop to the ground. However, some of the berries may remain attached to the bush and will be harvested with undamaged berries.

Since the weevil spends much of its life cycle on the ground under the bushes, frequent thorough cultivation facilitates its control. Chemical treatments should be applied before too many oviposition scars are observed but after pollinating insects are gone.

Cranberry fruitworm: Found throughout the eastern U.S. wherever wild blueberries grow, the cranberry fruitworm affects cultivated blueberries which are poorly maintained.

The cranberry fruitworm overwinters as a fully grown larva in the litter near the soil surface under the bushes. The adult moths emerge, when the berries of early varieties begin to form, and begin inserting eggs along the rim of the calyx cup. After hatching from the egg, the larva enters the berry. It eventually webs together several berries, feeding inside as many as four. There is one generation per year.

One method of control is to pick and destroy infested berry clusters showing evidence of webbing. Repeated discing to eliminate weeds and trash also helps in its control. Chemical treatment may be necessary if populations are large. Sprays for plum curculio will usually result in control of cranberry fruitworm.

Cherry Fruitworm: The cherry fruitworm overwinters as a large larva in a burrow usually made in the dead wood on the bush. The small, dark grey moths with brown-banded wings emerge in the late spring. The green-white, flattened eggs are laid on the under surfaces of leaves and on the fruit. After hatching, the larvae enter the berries. The pink and red larva usually feeds on only one berry, after which it exits to pupate and overwinter. In Virginia, many of the pupae emerge to form a partial second generation.

Control is usually achieved by well-timed sprays directed at the adults, eggs, and newly-hatched larvae after bloom. The same sprays used for plum curculio work well for control of cherry fruitworm.

Blueberry Maggot: Overwintering as a pupa buried from just beneath the leaf litter to 6 inches deep in the soil, the blueberry maggot flies emerge from early through mid-summer. The adult is about the size of a housefly and has black bands on its wings.

The female lays eggs just beneath the skin of a ripe or nearly ripe berry. Upon hatching, the larva feeds on the berry, eventually liquifying the interior. After about 20 days, the larva leaves the berry and drops to the ground to pupate. In Virginia, the majority of these puparia will not produce flies until 2 and sometimes 3 years later.

The control of the insect is complicated by its long emergence period, its migration tendencies, and the fact that it does not attack fruit until harvest has begun. Relatively nontoxic, nonresidual pesticides should be used since they must be applied close to harvest. The use of insecticides in bait formulations is recommended in some areas.

Blueberry Bud Mite: Budmites (not true insects) are extremely tiny, only 1/128 of an inch long. They are white, sausage-shaped and have 4 pairs of legs. They are present throughout the year on buds and blossoms. However, in the late summer or fall their numbers can rapidly increase under the bud scales. These buds will become the next year's flowers and fruit. Feeding at this time may severely damage the next year's crop.

Control for blueberry bud mite is mainly achieved by pruning out infested parts of the bush. However, severe infestations may necessitate sprays shortly after harvest and before mites can penetrate deeply into the buds where they will be protected.

Indirect Pests

Indirect pests, since they do not attack the fruit directly, can be tolerated at higher levels. However, if they transmit a devastating disease, as do the sharp-nosed leafhoppers, they demand closer attention.

Sharp-Nosed Leafhopper: The sharp-nosed leafhopper is important in blueberry culture because it can transmit the mycoplasma which causes blueberry stunt disease. It is dark-mottled-brown with a distinctly sloped and pointed extension of the head in both the nymphal and adult stages. It is one-quarter-inch long in the adult stage. The nymph can be distinguished from other species because it has a white hourglass-shaped mark on its back. The adults are difficult to distinguish from other species.

This leafhopper overwinters as an egg embedded in fallen leaves. Eggs hatch in the spring with first-generation adults appearing by late May to early June. There are three generations per year.

Scale Insects: There are several species of scale insects that attack blueberries. They are potentially significant pests, especially when their parasites and predators have been destroyed by the misuse of pesticides or when pruning has been neglected.

Most of their lives are spent as sedentary legless individuals, usually clustered with other scale insects to form what appears to be a crust on the wood surface (although they sometimes

attack leaves and fruit). However, offspring issue forth in the spring in the form of "crawlers" and thereby effect the spread of this insect.

Good pruning practices are the first step in the control of scales on blueberries. Bushes that are not pruned regularly to remove old wood are the most heavily infested. If chemical control is necessary, a thorough delayed-dormant oil spray is effective.

Pest Management Techniques

Immediately after bloom: Control measures for plum curculio, cranberry fruitworm, and cherry fruitworm should be undertaken at this time. Consult the state spray guide or your Extension agent for recommendations.

Within two weeks after bloom: Yellow, sticky panels baited with protein hydrolysate (available commercially) should be placed in the field (2 panels/acre) at this time. Weekly inspections of these traps should be made to determine the

population levels of blueberry maggot adults (fruit flies) and sharp-nosed leafhoppers.

A spray is recommended after 3-4 fruit flies have been trapped in a field. However, if fruit flies do not appear on the panels, then sprays are probably not called for. *Note:* there are several other fly species present in the blueberry field that also may be attracted to the panels. Be sure that you count only blueberry maggot fruit flies.

If a spray is not needed for fruit flies, then continue monitoring the panels for the second generation of the sharp-nosed leafhopper. There will be a constant low number of leafhoppers in the traps throughout the summer. If a sharp increase in trap counts occurs between one week and the next, then chemical application is justified.

After harvest and approximately 6 weeks prior to the first killing frost, begin monitoring the traps again for the third generation of leafhoppers. Again, if a sharp increase in population is noted, then treat.

APPENDIX 1: Characteristics of Selected Cultivars.

Older cultivars that perform well in the mid-atlantic states:

Earliblue - Very early; bush vigorous, upright-spreading; fruit is large, firm, light blue, and has excellent flavor; appears to have some fruit set problems.

Bluetta - Very early; bushes are short, compact, and medium vigorous; fruit is medium sized, light blue, and good flavored; stem scars tend to be broad, and fruit tends to soften if allowed to remain on bush too long. Consistency of production may be a problem.

Collins - Early; ripens about 5-7 days after Earliblue; bush is vigorous and upright; fruit is large, firm, light blue, and has very good flavor; it has good, consistent production.

Blueray - Early-midseason; ripens just before Bluecrop; plant is vigorous and propagates easily; fruit is borne in small tight clusters; berries are large, light blue, with medium scar, but resist cracking; productive.

Bluecrop - Early midseason; bush is vigorous and upright; fruit is large, firm, small-scarred, good flavored, and resists cracking; it has consistent good production and hardiness.

Berkeley - Midseason; bush is vigorous, open and spreading but tends to drop fruit; fruit is large, excellent in color and flavor, and keeps well; clusters may be hidden by heavy foliage which slows hand picking.

Herbert - Late-midseason; bush is vigorous, open-spreading, and productive; cluster is medium loose; berry is very large, medium blue, aromatic, tender, of excellent dessert quality, has a medium scar, and is resistant to cracking.

Jersey - Late season; bush vigorous and erect with open fruit clusters; medium size fruit, good color and fair flavored, may have fruit set problems; tends to set without fertilization, but without pollination fruit remains small.

Darrow - Late season, ahead of Coville; size

drops off rapidly after first harvest; flavor is slightly acidic but aroma and flavor excellent; plant may not be fully hardy in some locations.

Coville - Late season; bush very vigorous, open spreading with open fruit clusters; berry is large, medium blue, highly aromatic, tart, and of excellent dessert quality; fruit is susceptible to anthracnose disease; does not set fruit well on occasion, limiting its productivity.

Lateblue - Very late season, about seven days after Coville; bush is erect and vigorous; fruit tends to ripen in a short period; berries are firm, light blue in color, have small stem scars, and are fine flavored; high temperatures during harvest may lead to excessive steminess.

New cultivars recommended for trial planting:

Morrow - Very early; fruit is firm, light blue, and medium size, has large and moist stem scar, a mild pleasant taste; bush is medium-sized, slow growing after fruiting age, semi-upright and broad, tolerant to stem canker; fruit clusters usually borne upright at periphery of bush; forms many short fruiting shoots that require numerous cuts during pruning.

Weymouth - Very early; low bush habit makes it difficult to harvest; fair dessert quality, fruit tends to crack in wet weather; production is consistent, but plants may suffer from winter injury.

Croatan - Early; bush is erect, vigorous, productive, and canker resistant; performs better on light soils than most varieties; tolerant to bud mite and has a short chilling requirement; fruit is aromatic, sweet to subacid, ripens very quickly in warm weather.

Harrison - Early; bush is semi-upright, vigorous, productive, and canker resistant; tolerant to bud mite; *Phytophthora*

root rot becomes a problem in wet locations; fruit is large, light blue, and firm; stem scar and flavor are good; superior keeping quality; majority of fruit ripens in 4-week period.

Spartan - Early; ripens about 3-5 days after Earliblue; plants are vigorous, upright and open; fruits are large, firm, light blue, and highly flavored; is partially resistant to mummy-berry; should not be planted where frost is a problem.

Meador - Early; the bush is upright, open-spreading, and productive; fruit clusters are loose; berries are large, firm, resist cracking, uniform in size, medium-blue color, and subacid flavor; stem scar is small and dry; ripens early to mid-season.

Bluechip - Early midseason; bush is 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 is large, excellent flavor, firm, light blue color, good keeping quality.

Bluehaven - Early midseason; the bush is upright, hardy, and productive; berries are large, firm, light blue, with excellent flavor; stem scar very small and dry; quality of berries holds well on bush.

Patriot - Early midseason; ripens with Collins; plant is upright and vigorous, attaining a height of 1.5 meters; fruit is large, firm with small, dry stem scar, and of excellent cold hardiness; plants are resistant to root rot; may require fruit bud thinning to concentrate ripening and harvest.

Ornablue - Midseason; a highbush-lowbush hybrid developed in West Virginia; plant grows to only 3' height with a spread of 5' in diameter; heavy yields (4-6 quarts per plant) of small, very dark blue fruit of good flavor; also very useful in landscape plantings and shrub borders; has very attractive red foliage in fall.

Elliott - Very late season; 7-10 days after Lateblue; bush vigorous and upright and can be mechanically harvested in one or two pickings; plants are productive, hardy, and resistant to

mummy-berry disease; berry size is medium, light blue, firm fleshed, and good dessert quality. (May be too late-ripening for the shorter growing season portions of Virginia.)

APPENDIX 2:Suggested References.

“Blueberry Culture”. 1966. 378 pp. Paul Eck and Norman Childers, Horticultural Publications, 3906 NW 31st Place, Gainesville, FL 32601.

“Highbush Blueberry Culture in New York.” Info. Bull. 151, Coop. Extension Service, Cornell, Ithaca, NY 14853.

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“Illinois Small Fruit School Proceedings”. Annual - covers blueberries, grapes, and brambles. Coop. Extension Service, Dept. of Hort., University of Illinois, Urbana, IL 61801. \$3.00.

“Blueberry Commercial Production Guide”. Coop. Extension Service, Washington State University, Pullman, WA 99164.

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“Highbush Blueberry Varieties for Michigan”. Ext. Bull. E-1456, Coop. Extension Service, Michigan State University, East Lansing, MI 48824.

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Office of Communication, U.S. Dept. of Agriculture, Washington, DC 20250.

Superintendent of Documents, Govt. Printing Office, Washington, DC 20402.

APPENDIX 3: Typical Production Costs and Returns—Highbush Blueberries (Pick-Your-Own harvesting, per acre/per year).

Production Inputs (Costs based on 1982 estimates)	Year						Total 20-year
	1	2	3	4	5	6-15	
Bush-1089/acre(4'x10') @ \$1.25/ea	\$ 1361.	\$ 136.	\$	\$	\$	\$	\$ 1497.
Preparing Site (4' strip every 10', Mow 10' section)	5.						5.
Sulfur (2 lb/plant) @ \$.30/lb, Apply previous season	653.						653.
Fertilizer - Establish, 1000 lb 5-10-10; Annual, Ammon. Sulfate 2 mos. after planting, ½ cup/plant, 200 lb/acre/year	64.	25.	25.	25.	25.	25.	539.
Sawdust or Bark - Establish, 15 lb (4-6 in./plant), 4 loads, 2 tons; Years 5-10-15 add 2 inches	120.				30.	30.	210.
Herbicides - Karmex, 4 lb annually, DO NOT use 1st yr; ½ fall-½ spring @ \$4./lb		16.	16.	16.	16.	16.	304.
Bird Control - Annual cost estimate.			14.	14.	14.	14.	252.
Labor - Planting 272 hr; Mow & Hoe 10 hr; Mulching 200 hr; Harvest 12 hr (Twice a week 2 wks.) (P-Y-O supervise)	1962.	148.	128.	128.	128.	128.	3614.
Yearly Costs	4165.	325.	183.	183.	183.	183.	7074.
Interest @ 16%	333.	746.	790.	408.	193.	15.	2695.
Accumulated Costs	4498.	5596.	6545.	5502.	2611.	198.	
Cost Per Gallon Produced			12.	5.05	2.39	0.17	0.54
Gross receipts - ½ gal/plant, Yr. 3; 1 gal/plant, Yr. 4-20 @ \$3/gal			1634.	3267.	3267.	3267.	57173.
Net Return (20-year average = + \$2334./acre/year	-4498.	-5569.	-4911.	-2235.	+656.	+3069.	46691.

