Crop Profile for Blueberries in North Carolina

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General Production Information

- Two blueberry species are grown commercially in North Carolina: *Vaccinium corymbosum* (highbush blueberry) and *Vaccinium ashei* (rabbiteye blueberry).
- North Carolina ranked fourth nationally in the production of blueberries in 2003, representing 11.9 percent of U. S. production.
- In 2003, 4,200 acres of blueberries were harvested in North Carolina.
- In 2003, 22.5 million pounds of blueberries were produced in North Carolina for a value of $34,777,000.

Production Regions

More than 90 percent of highbush production is located in Bladen, Sampson, Pender, and Duplin counties (southeastern Coastal Plain) where the soil type favors growth and productivity of this species. Rabbiteye production is more scattered throughout the state because these plants tolerate a broader range of soil conditions.

Cultural Practices

In order to achieve optimum growth and productivity, blueberries must be grown in acidic soils (pH range from 3.5 to 5) and fertilized with materials that supply nitrogen in the form of ammonium ions (e.g., ammonium nitrate or diammonium phosphate). Many blueberry varieties bloom in early spring; they must be protected from freezing temperatures once the blossoms open. Insect pollination (honey bees and bumblebees) is critical to fruit set — most rabbiteye cultivars are self-sterile and require cross-pollination between varieties. Irrigation promotes maximum fruit yield and will relieve drought stress (or bush mortality) in dry seasons. Overhead irrigation can also be used for frost protection in early spring. Annual pruning of deadwood and older canes maintains plant vigor, eliminates disease inoculum, and reduces populations of bud mites and scale insects.

Worker Activities

Pruning: Blueberry plants are hand-pruned every second or third year in the dormant season (November to March). In years when hand pruning is not performed, mechanical hedging is used to manage crop load and bush height. Prunings are not removed from the field by hand, but are instead chopped in place using flail mowers.

Weed control: Preemergence herbicides are applied in early spring, primarily with tractor mounted spray equipment. Postemergence herbicide applications are made as needed after harvest using either tractor mounted spray equipment or backpack sprayers. Weed control in young bushes often relies on hand weeding or hoeing. Hand weeding is also occasionally used in older fields to remove woody perennial or other problem weeds.

Fertilizing: Fertilizer is applied as a liquid or granular using tractor mounted spreaders. Applications are made four times each year, at pre-bloom, post-bloom, after harvest and in late summer.

Cultivation: Tractor mounted disk harrows or sweep blades are used once or twice a year to shape and grade the row middles.

Insect and disease control: Insecticides and fungicides are applied as needed from early spring until late summer, primarily with airblast orchard-type sprayers or by fixed-wing aircraft.

Harvesting and handling: An estimated 60% of the crop is harvested by hand for the fresh market, 20% is harvested mechanically for the fresh market, and 20% is harvested mechanically for the processed (frozen) market. Blueberries ripen over a period of a few weeks, requiring multiple visits on a weekly basis for 3 to 4 weeks to completely harvest the crop. After harvest, berries are transported to a packing facility where they are sorted and packed in pint retail containers, using a combination of automated machinery and hand labor.

Insect Pests

Direct Pests

In late winter and early spring (before bloom), the buds of blueberry plants are often attacked and destroyed by blueberry bud mites (*Acalitis vaccinii*), cutworms (Lepidoptera: Noctuidae), and spanworms (Lepidoptera: Geometridae). The extent of damage varies from year to year and site to site. Bud mites are most effectively controlled by oil sprays applied in late summer or fall. Cutworms and spanworms are suppressed with a prebloom spray of azinphosmethyl, malathion, esfenvalerate, or a formulation of *Bacillis thuringiensis* (*Bt*).

Insecticide applications must be avoided during bloom to allow bee pollination, but as soon as possible thereafter, esfenvalerate or azinphosmethyl are needed to prevent infestations of cranberry fruitworm (*Acrobasis vaccinii*), cherry fruitworm (*Grapholita packardi*), and plum curculio (*Conotrachelus nenuphar*). These fruitworm species are key pests that require control every year in nearly all parts of the state.

Another direct pest, the blueberry maggot (*Rhagoletis mendax*), occurs in "hot spots" throughout North Carolina's piedmont and coastal plain. Adult flies emerge just before harvest and lay eggs in ripening fruit. This insect can be controlled only by pre-harvest sprays of a short-residual insecticide (malathion) applied before the females begin oviposition. Timing of applications is determined by monitoring adult emergence with yellow sticky traps.

Japanese beetles (*Popillia japonica*) can be a problem as frugivores in late-maturing blueberries (rabbiteye) planted on upland soils. Larval stages of this insect feed on grass roots. If larval populations are not suppressed by ecological or biological factors, an application of carbaryl may be needed to protect ripening fruit.

Indirect Pests

Sharpnosed leafhoppers (*Scaphytopius magdalensis*), terrapin scale (*Mesolecanium nigrofasciatum*), datana caterpillars (*Datana* spp.), and stem borers (*Oberea* spp.) are the most common indirect pests. The sharpnosed leafhopper is regarded as the most serious of these pests because it transmits a phytoplasma that is presumed to be the pathogen of blueberry stunt disease. Leafhoppers are abundant in the woods where they feed on wild blueberries and other Ericaceae. They complete three generations per year in North Carolina. The first generation is usually controlled by fruitworm sprays after petal-fall; the second generation is controlled by maggot sprays before harvest. An application of malathion is recommended in late September or early October to control the third generation. Natural host-plant resistance to the leafhopper has been found in several commercial cultivars of the rabbiteye blueberry and in selections from four other *Vaccinium* species that are not grown commercially. Efforts are currently under way to transfer this resistance into commercial highbush blueberries.

Three species of endemic Hymenoptera have been discovered as parasites of terrapin scale in southeastern North Carolina. All three of these species as well as several predators (lacewings and lady beetles) represent potential biological control agents for local infestations of terrapin scale. Further work is needed to develop cultural management strategies and mass rearing techniques for augmentative releases of these beneficial insects.

Husbandry Pests

Fire ants are the most significant husbandry pests of blueberries in North Carolina. Populations are spreading throughout the coastal plain, where they are a threat to people who prune, cultivate, and harvest blueberries.

Diazinon, used as a mound drench, is currently recommended for fire ant control. This practice gives about four to six months of protection.

Principal Insecticides and Miticides

Superior Oil
A superior oil is used as either a summer oil to suppress blueberry bud mites or a winter (dormant) oil for controlling scale insects. It is usually applied once or twice per season at 2 to 3 gallons per acre.

Malathion
This product is used as a short-residual, pre-harvest spray to control blueberry maggots. It is applied by air (ULV at 10 ounces per acre) or by ground (25WP at 2 pounds per acre or 57EC at 1 pint per acre). Malathion may also be used in the early season for fruitworm control, but it is not effective against plum curculio.

Azinphosmethyl (Guthion)
This is very effective at petal-fall for fruitworm control and tends to be more active than other materials at low temperatures. It gives good control of plum curculio (50WP formulation applied 2 to 3 times per year at 0.5 to 0.75 pounds per acre). Registration for this product is being terminated. Existing stocks may only be used through the 2005 growing season.

Carbaryl (Sevin)
This short-residual preharvest spray is used to control Japanese beetles. It may also be used at petal-fall for fruitworm control, but it is not effective against plum curculio. Applied by ground (50WP at 1 pounds per acre) 1 to 2 times per season.

Esfenvalerate (Asana)
It is very effective at petal-fall for fruitworm control and is a good alternative to azinphosmethyl for resistance management (0.66EC formulation applied 2 to 3 times per season at 4.8 to 9.6 ounces per acre).

Endosulfan (Thiodan, Phaser)
This product is sometimes tank-mixed with superior oil to give better control of blueberry bud mites (3EC formulation used on 20 percent of acreage, applied at 1 pint per acre once or twice per season).

Diazinon
This is used as a mound drench to control fire ants. One gallon of dilute material (50W at 1 pound per 100 gallons or AG500 at 1 pint per 100 gallons) is poured into each active nest site.

Phosmet (Imidan)
May be used after petal fall for fruitworm control or up to 3 days PHI for blueberry maggots. 70-W formulation is applied at 1 pound per acre. This product is not widely used because it is less effective than Guthion or Asana against plum curculio. Usage may increase after cancellation of Guthion's registration.

Table 1. Insecticide Use on Blueberries in North Carolina in 2003. Source: Agricultural Chemical Usage: 2003

Fruit Summary. August 2004. U. S. Department of Agriculture, National Agricultural Statistics Service.

Insecticide Active Ingredient	Area Applied[1] (Percent)	Number of Applications	Rate per Application (lbs./ acre)	Rate per Crop Year (lbs./ acre)	Total Applied (1,000 lbs.)
Esfenvalerate	73	2.1	0.03	0.07	0.2
Malathion	80	3.8	0.71	2.75	9.2

[1] Bearing acres in 2003 for North Carolina were 4,200 acres.

Current Insecticide Recommendations for Blueberries

Current North Carolina Cooperative Extension Service recommendations for insecticide use on blueberries (including information on formulations, application rates, and precautions/limitations) are provided in the following table from the *North Carolina Agricultural Chemicals Manual*:

Table 7-4: Blueberry Spray Program
http://ipm.ncsu.edu/agchem/chptr7/704.pdf

Diseases

Three major techniques are available to growers for controlling blueberry diseases: 1) Disease-resistant cultivars; 2) pruning and field sanitation; and 3) chemical control. All three tactics must be used together to successfully produce a crop.

Stem canker (*Botryosphaeria corticis*) and stem blight (*B. dothidea*) are best controlled by planting resistant cultivars and using disease-free cutting wood in the establishment of new fields. Selective pruning of old and diseased wood can reduce inoculum for twig blight (*Phomopsis vaccinii*), stem blight, and stem canker. Clean cultivation inhibits the spread of mummy berry (*Monilinia vaccinii-corymbosi*).

Blueberry stunt disease (an insect-vectored phytoplasma) is controlled by insecticide sprays for vector control and by roguing to remove infected plants. Phytophthora root rot *(Phytophthora cinnamomi*) occurs in excessively wet areas and is controlled by improving drainage. Metalaxyl (Ridomil) is labeled but not recommended.

The first few weeks following bud break are critical in the infection cycles of mummy berry and twig blight. *Phomopsis* blight can be controlled with two or three applications of an effective fungicide at 7- to 10-day

intervals from bud swell through full bloom. In wet bloom seasons it may be necessary to control botrytis blossom blight (*Botrytis cinerea*), which can be severe, following freeze damage to blossoms. Both primary (leaf stage) and secondary (fruit stage) infections of mummy berry require control with an effective fungicide.

Additional fungicide sprays are needed at bloom and petal-fall to protect developing fruit from infection by fruit rot fungi, especially ripe rot (Anthracnose fruit rot), caused by the fungus *Colletotrichum acutatum*.

Finally, several species of fungi cause leaf spots that develop in mid summer. Light infestations are generally inconsequential, but severe ones can cause premature defoliation, weaken the plant, and reduce fruiting potential for the following year. Biweekly applications of fungicides starting before harvest will give satisfactory control of Alternaria leaf spot (*Alternaria tenuissima*), Gloeosporium leaf spot (*Gloeosporium minus*), Septoria leaf spot (*Septoria albopunctata*), and double spot (*Dothichiza caroliniana*). Summer mowing (topping) has become a common practice in North Carolina as a means of maintaining proper bush height. An added benefit of this technique is the reduction of leaf diseases by removing older, infected leaves. New mid-summer foliage produced after topping persists well into fall.

Principal Fungicides

Benomyl (Benlate)
This material was used for control of twig blight, blossom blight, mummy berry (secondary infection), and leaf spots. It was voluntarily withdrawn from the marketplace during the 2001 growing season. No comparable material is currently available.

Captan
Widely used. This material is used at 2 pounds of active ingredient per acre for controlling fruit rots and in combination with other fungicides as an aid in controlling leafspot diseases.

Ziram
Rarely used. Recently re-labeled for use at 2 pounds of active ingredient per acre, comparable to captan.

Fenbuconazole (Indar)
Widely used. Since 1997 the US EPA has issued an annual Section 18 Emergency Exemption for the use of Indar to control mummy berry disease. This fungicide is used from budbreak through bloom (up to 5 applications) at 2.0 ounces of active ingredient per acre.

Azoxystrobin (Abound)
Some limited use, for fruit rot and leaf spot control. Limited by label to two sequential applications and a total of 3 applications per season.

Cyprodinil + Fludioxonil (Switch)
Not generally used, this is a new fungicide that may increase in popularity as it becomes better known.

Fenhexamid (Elevate)
Not generally used, effective only against Botrytis gray mold. Gray mold is not usually a problem on

blueberries in North Carolina.

Captan + Fenhexamid (Captevate)
Not widely used. Combination product, increased use is expected in wet seasons.

Pyraclostrobin (Cabrio)
Some limited use, for fruit rot and leaf spot control. Limited by label to two sequential applications and a total of 4 applications per season.

Pyraclostrobin + boscalid (Pristine)
Not generally used. This is a new product with efficacy against multiple fungal pests, and use is likely to increase over time. Limited by label to two sequential applications and a total of 4 applications per season.

Table 2. Fungicide Use on Blueberries in North Carolina in 2003. Source: Agricultural Chemical Usage: 2003 Fruit Summary. August 2004. U. S. Department of Agriculture, National Agricultural Statistics Service.

Fungicide Active Ingredient	Area Applied[1] (Percent)	Number of Applications	Rate per Application (lbs./ acre)	Rate per Crop Year (lbs./ acre)	Total Applied (1,000 lbs.)
Benomyl	17	1.0	0.49	0.50	0.4
Captan	39	1.5	1.45	2.23	3.6
Fenbuconazole	80	2.4	0.09	0.22	0.7

[1] Bearing acres in 2003 for North Carolina were 4,200 acres.

Current Fungicide Recommendations for Blueberries

Current North Carolina Cooperative Extension Service recommendations for fungicide use on blueberries (including information on formulations, application rates, and precautions/limitations) are provided in the following table from the *North Carolina Agricultural Chemicals Manual*:

Table 7-4: Blueberry Spray Program http://ipm.ncsu.edu/agchem/chptr7/704.pdf

Weeds

Although blueberries benefit from mulching for weed control, the process may not be economically feasible on commercial-size plantings in the coastal plain. Here, chemical control has been widely adopted to reduce weed competition for water, nutrients, and sunlight. Herbicides may be applied to both rows and middles; but more typically, they are applied only to the rows, while middles are cultivated with a tapered disk. All newly planted blueberries are hand-hoed. The selection of a given herbicide is based on specific weeds present in the field. These include annual or perennial grasses and broadleaf weeds such as goldenrod, greenbriar, red sorrel, broomsedge, red root, and smilax. A number of these problem weed species is not commonly found in other crops.

Organic matter is often highly variable within blueberry fields (from less than 1 percent to more than 8 percent). This complicates the selection of herbicide (and application rate) because many compounds lose effectiveness when applied on high-organic-matter soils. Enough herbicide to give satisfactory control in 6 percent organic matter on one end of a row is likely to damage or kill bushes on the other end of the row where organic matter may be only 1.5 percent. As a result, growers must use repeated applications or adjust tractor speed to compensate for differences in organic content of their soil.

Principal Preemergence Herbicides

Hexazinone (Velpar 2S)
Applications of 1 to 2 pounds of active ingredient per acre are currently used for preemergence weed control on blueberries in eastern North Carolina. This material offers broad-spectrum activity and is one of the most commonly used herbicides in NC blueberries.

Terbacil (Sinbar 80WP)
Applications of 0.4 to 1.6 pounds of active ingredient per acre are currently used on 20 to 30 percent of the acreage in eastern North Carolina primarily for preemergence control of annual grasses and broadleaf and broomsedge. Broomsedge is not controlled adequately by hexazinone.

Simazine (Princep 90WDG)
This material is used at 2 to 4 pounds of active ingredient per acre. It is used primarily on established blueberries in the piedmont and mountain regions of North Carolina where organic matter content is less than 2 percent.

Each of the following three herbicides is applied to blueberry acreage for preemergence control of annual grasses and broadleaf weeds. They are used primarily on young blueberry fields the first few years after establishment, a period when hexazinone and terbacil cannot be used due to potential crop injury.

Oryzalin (Surflan 4AS)
This is used at 2 to 4 pounds of active ingredient per acre. Oryzalin can be used on first-year plantings and is a viable option in the piedmont and mountain regions of North Carolina.

Napropamide (Devrinol 50DF)
This is used at 4 pounds of active ingredient per acre. Napropamide can be used on first-year plantings. It is

very safe, however, it must be watered in (irrigation or rainfall) for best results.

Norflurazon (Solicam 80DF)
This is used at 2 to 4 pounds of active ingredient per acre. Controls some annual grasses and broadleaf weeds including some perennial weeds from seeds.

Dichlobenil (Casoron)
Registered at 4 pounds active ingredient per acre. Must be applied in winter for best results. It has limited use in North Carolina.

Diron (Karmex, Direx)
Registered at 1.2 to 1.6 pounds active ingredient per acre. Blueberries must be at least one year in the field.

Principal Postemergence Herbicides

Glyphosate (Roundup 4L)
This material is used at 0.5 to 1.5 pounds per acre as a directed application to control emerged weeds in blueberries. It is currently used on the blueberry acreage to kill escaped weeds. Controls some perennial weed species.

Glufosinate (Rely)
This herbicide is used at 0.75 to 1.5 pounds active ingredient per acre. Kills small annual broadleaf weeds and annual grasses. Annual grasses tend to be more tolerant than broadleaf weeds. Current use is limited, however, it has great potential on blueberries in North Carolina.

Paraquat (Gramoxone 2.5L)
Used at 0.6 to 0.9 pound per acre as a directed application to control emerged annual weeds.

Sethoxydim (Poast 1.53 EC)
This material is used at 0.3 to 0.5 pound per acre as a postemergence application to control emerged grasses in blueberries. It is especially important in young blueberries.

Pronamide (Kerb)
Registered at 1 to 2 pounds active ingredient on established plantings. Controls small annual winter weeds and certain other weeds.

Table 3. Herbicide Use on Blueberries in North Carolina in 2003. Source: Agricultural Chemical Usage: 2003 Fruit Summary. August 2004. U. S. Department of Agriculture, National Agricultural Statistics Service.

Fungicide Active Ingredient	Area Applied[1] (Percent)	Number of Applications	Rate per Application (lbs./ acre)	Rate per Crop Year (lbs./ acre)	Total Applied (1,000 lbs.)

Glyphosate	36	1.6	0.81	1.34	2.0
Hexazinone	64	1.0	0.83	0.85	2.3
Paraquat	44	1.6	0.56	0.91	1.7

[1] Bearing acres in 2003 for North Carolina were 4,200 acres.

Current Herbicide Recommendations for Blueberries

Current North Carolina Cooperative Extension Service recommendations for herbicide use on blueberries (including information on formulations, application rates, and precautions/limitations) are provided in the following table from the *North Carolina Agricultural Chemicals Manual*:

Table 8-11A: Chemical Weed Control in Fruit Crops – Small Fruits
http://ipm.ncsu.edu/agchem/chptr8/814.pdf

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11. Tomlinson, W. E., P. E. Marucci, and C. A. Doehlert. 1950. Leafhopper transmission of blueberry stunt disease. *J. Econ. Entomol*. 43:658-662.
12. U. S. Department of Agriculture, National Agricultural Statistics Service. 2004. Agricultural Chemical Usage: 2003 Fruit Summary. August 2004.

On-Line Resources

Blueberry Pest Management: A Seasonal Overview
http://ipm.ncsu.edu/small_fruit/blueipm.html

North Carolina Pest News
http://ipm.ncsu.edu/current_ipm/pest_news.html

Fruit Rot Diseases of Blueberries
http://www.ces.ncsu.edu/depts/pp/notes/Fruit/blueberryinfo/berryrots.htm

Leaf Diseases of Blueberries
http://www.ces.ncsu.edu/depts/pp/notes/Fruit/blueberryinfo/leafspotdisease.htm

Mummy Berry Disease of Blueberry

http://www.ces.ncsu.edu/depts/pp/notes/Fruit/blueberryinfo/mummyberry.htm

Phytophthora Root Rot of Blueberry
http://www.ces.ncsu.edu/depts/pp/notes/Fruit/blueberryinfo/phytophthora.htm

Stem Blight of Blueberry
http://www.ces.ncsu.edu/depts/pp/notes/Fruit/fdin009/fdin009.htm

Twig Blight of Blueberry
http://www.ces.ncsu.edu/depts/pp/notes/Fruit/fdin010/fdin010.htm

Blueberry Maggot
http://www.ces.ncsu.edu/depts/ent/notes/Fruits/fruitb2.html

Blueberry Bud Mite and Its Control
http://www.ces.ncsu.edu/depts/ent/notes/Fruits/fruitb4.html

Four Economic Larvae of Bluberries at Harvest Time
http://www.ces.ncsu.edu/depts/ent/notes/Fruits/fruitb1.html

Postharvest Cooling and Handling of Blueberries
http://www.bae.ncsu.edu/programs/extension/publicat/postharv/ag-413-7/index.html

Forced Air Cooling
http://www.bae.ncsu.edu/programs/extension/publicat/postharv/ag-414-3/index.html

Blueberries, Horticultural Commodity of North Carolina
http://www.agr.state.nc.us/markets/commodit/horticul/blueberr/

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