Reviews

Performance of Southern Highbush Blueberry Cultivars Released by the U.S. Department of Agriculture and Cooperating State Agricultural Experiment Stations

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Summary. **In the 1970s, the U.S. Department of Agriculture (USDA) began developing low-chill-adapted highbush blueberry *(Vacchzium corymbosum* L.) for the southern United States (lat. 29° to 32°N) by using germplasm of the native southern species, *V. darrowi* Camp. This breeding work resulted in the release of several low-chill southern highbush blueberry (SHB) cultivars in the mid-1980s. These cultivars have been evaluated for yield and adaptation at several locations through the southern regional blueberry germplasm evaluation trials. These trials have shown that organic mulch is required for good performance of SHB. The one-fourth *V. darrowi* composition of SHB cultivars presents problems of freeze damage at some locations. This problem may be resolved by breeding cultivars through several alternative approaches.**

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There has long been an interest in growing the highbush blueberry *(Vaccinium corymbosum)* in southern areas of the United States because of its fruit quality, early ripening, and the potential early-market economic return. A major barrier to growing highbush blueberries in this area, however, has been the high chilling requirement needed for proper flowering induction. Most cultivars adapted to northern locations have a requirement of 800 to 1200 h of chilling at 0 to 7C (Eck, 1988), whereas areas south of lat. 32°N often receive far less than this amount. Based on chilling requirements of rabbiteye (V. *ashei* Reade) cultivars grown in this region, a suitable chilling requirement for low-chill highbush blueberries should be 300 to 600 h at 0 to 7C (Eck, 1988). Blueberries in the southern United States also must tolerate high air and soil temperatures, an adaptation that apparently is lacking in most northern highbush cultivars.

All southern highbush blueberry (SHB) cultivars are based on the introgression of *V. darrowi* germplasm into northern *V. corymbosum,* which results in progeny with a lower chilling requirement than the highbush parent. *Vaccinium darrowi* is a lowbush to half-high diploid species found in Florida, southern Georgia, and along the Gulf Coast to Louisiana. It is characterized by small waxy leaves, a bushy evergreen habit, and little or no chilling requirement. It has small fruit ranging from blue to black and is resistant to some diseases (Eck, 1988; Luby et al., 1990). The earliest recorded breeding effort using *V. darrowi* can be traced to Darrow (1947), who considered it to have value for producing blueberries adapted to dry, hot climates. The major effort in developing SHBs, however, was initiated in 1948 by R.H. Sharpe, Univ. of Florida (Sharpe, 1954). Using native V. *darrowi* as a source of genes for low-chilling and general adaptation, Sharpe made crosses to highbush and rabbiteye blueberries. Because the plant and fruit characteristics of *V. darrowi* are inherited quantitatively, the initial hybrids were not of commercial quality. After further crossing and selection, cultivar-type material was selected that was usually a composite of *V. corymbo - sum* and several other native species *(V. ashei, V. angustfolium* Ait., *V. tenellum* Ait.) with about one-fourth *V. darrowi* germplasm. The low-chill highbush cultivars resulting from these complex crosses were 'Sharpblue', 'Flordablue', and 'Avonblue', released in 1976, 1976, and 1977, respectively (Sharpe and Sherman, 1976a, 1976b; Sherman and Sharpe, 1977). These cultivars performed well in Florida, but were not fully adapted to slightly more northern areas with more extreme winter temperatures. These cultivars also had early bud swell; thus, they were predisposed to late winter and early spring freeze damage. In 1971–72, to introduce low chilling requirements into more broadly adapted highbush material, A.D. Draper, USDA, Beltsville, Md., crossed *V. darrowi* with northern highbush

cultivars. The initial hybridization of this material involved Florida 4B (Fla 4B), a selection from a native population that had been collected near Winter Haven, Fla., by Sharpe and G.M. Darrow. In these diploid × tetraploid crosses, Fla 4B was used as a female and was relied on to produce a low number of 2n eggs that were used to obtain tetraploid hybrids. Two of the earliest hybrids generated in these crosses were US 74 and US 75 from crosses of Fla 4B × 'Bluecrop'. These hybrids had fruit that were larger than expected and with superior flavor, but they did not meet commercial quality standards for other traits. The Fla 4B × 'Bluecrop' cross was repeated later to evaluate more fully the progeny from this mating. Out of these later crosses came US 340, a plant of a better horticultural type, which has been used as a parent in the USDA and North Carolina breeding programs.

Among the early hybridizations of diploid *V. darrowi* with tetraploid *V. corymbosum,* several anomalous hybrids were produced. These hybrids, which initially were thought to be tetraploid, were found to be infertile when crossed to tetraploid highbush blueberries and later were shown to be diploid. Crosses of *V. darrowi* with hexaploid rabbiteye cultivars, which were intended to produce tetraploid hybrids for further crossing to highbush material, also produced anomalous hybrids. The few hybrids produced from these crosses had low fertility when crossed with tetraploids and, in most cases, were shown to be pentaploids, resulting from 2n eggs of *V. darrowi.* Despite low fertility, several of these pentaploids have been used in generating SHB cultivars (e.g., 'O'Neal'). A single hybrid resulting from a cross of *V. darrowi* with the rabbiteye 'Tifblue' was diploid. The mechanism of this apparent chromosomal reduction that produces diploid hybrids is unknown, but the results have been repeated by other researchers (A.D. Draper, unpublished data).

To produce cultivar-quality material from the initial *V. darrowi* × *V. corymbosum* hybrids, a further cross to highbush was necessary, as had been done to produce the Florida cultivars. Of the two earliest tetraploid hybrids, US 75 was consistently the better parent. Few selections were made from crosses of US 74, and only 'Blue Ridge' has this genotype in its pedigree. Many advanced selections came from crosses with US 75, and this clone is a common parent in the SHBs 'Cooper', 'Gulfcoast', 'Georgiagem', and 'Cape Fear' and northern highbush 'Sierra' and 'Legacy'. US 75 has been crossed to many cultivars and selections, but the most successful hybridizations have been with 1) G 180 (a USDA-New Jersey breeding selection with 'Collins', 'Ivanhoe', and 'Earliblue' in it's background) to produce 'Gulf coast' and 'Cooper', 2) G 132 (a selection with 'Bluecrop' as one parent) to produce 'Georgiagem', and 3) 'Patriot' to produce 'Cape Fear'. A joint USDA–New Jersey selection, JU 91, which originated from the cross 'Croatan' × US 75, also has considerable promise. Among USDA-released SHB cultivars, only 'O'Neal' has neither US 74 nor US 75 as a parent. It does, however, contain *V. darrowi* and *V. ashei* germplasm as 1/32 contributions of each within its pedigree.

The first USDA-produced highbush blueberry cultivar with southern adaptation, 'Georgiagem', was released in 1986 by the USDA and the Univ. of Georgia. This was followed closely by USDA releases of 'Cooper' and 'Gulfcoast' and joint releases with North Carolina State Univ. of 'Blue Ridge', 'Cape Fear', and 'O'Neal', all in 1987. These cultivars were developed to extend the zone of adaptation of highbush blueberry into the southeastern tier of states ranging from upper Florida and Georgia westward across Mississippi, Alabama, Louisiana, and into eastern Texas, roughly the area lat. 29° to 32°N. During the course of selection and ongoing evaluation, some of these cultivars have been observed at several locations for 6 to 7 years, and some preliminary conclusions have been drawn regarding their performance. The southern regional blueberry germplasm evaluation trials, initiated in 1984, have evaluated many of these selections; however, because of variable plant establishment, few of the test locations have had equal-aged plants of all cultivars for comparison. So far, the USDA- and cooperatively released SHB culti - vars are one-fourth *V. darrowi* (except 'O'Neal') and possess highbush characteristics, including good fruit size and quality and the desired low-chilling requirement. A decided advantage of cultivars with *V. darrowi* ancestry over pure *V. corymbosum* cultivars, however, is that they generally have outstanding flavor, usually better than that of either of the parents, and can retain ripe fruit in good condition under hot weather conditions.

Cultivars

The following descriptions offer a guide to some of the strengths and weaknesses of different cultivars and are arranged generally in the order of maturity season, although this may vary somewhat from location to location. Table 1 includes flowering and ripening dates in several areas. Yields are included to indicate their relative yield potentials. Chilling-hour values are estimates based only on observational data. Estimates of chilling-hour requirements may vary due to local climate and its interaction with physiological mechanisms of budbreak (G. Lang, personal communication).

'Gulfcoast'. Released in 1987 from the cross G 180 × US 75 (Gupton et al., 1994), 'Gulfcoast' produces a vigorous, semi-upright, very productive plant adapted to the same area as 'Sharpblue'. It is widely adapted and has a very low chilling requirement that is about 200 to 300 h. 'Gulf coast' flowers earlier than 'Climax', an early flowering rabbiteye, and therefore may be injured by early spring freezes. It has medium-sized fruit with good flavor and a small scar, but the pedicel tends to remain attached to the berry at harvest (stemming), which limits its commercial potential. 'Gulfcoast' can fruit repeatedly in a single season in central Florida, similar to 'Sharpblue' and 'Misty', and is being tried as a cross-pollination partner for 'Sharpblue'. It is the earliest ripening of the USDA SHB cultivars and, in general, ripens a few days earlier than 'Cooper'. It has been reported to be susceptible to stem canker caused by *Botryosphaeria corticis* (Demaree and Wilcox) Arx and Muller at Gainesville, Fla.

'Cooper'. 'Cooper' was released in 1987 from the cross G 180 x US 75 and is a sibling of 'Gulfcoast' (Gupton et al., 1994). 'Cooper' forms a vigorous, upright, good-sized plant. It has a chilling requirement of 400 to 500 h. 'Cooper' is moderately productive compared to 'Gulfcoast', which is very productive. Fruit are medium-sized and of excellent quality, with good scar and color. 'Cooper' flowers later than the rabbiteye 'Climax', but ripens about 2 weeks earlier than 'Climax'.

'Cooper' is reported to be highly susceptible to stem canker.

'Georgiagem'. Released in 1986 from the cross G 132 × US 75 (Austin and Draper, 1987), 'Georgiagem' is upright and moderately productive but less vigorous and less widely adapted than 'Cape Fear'. It has a chilling requirement of about 350 h. It flowers with 'Climax', but ripens 15 days earlier. It has medium-sized, firm fruit, a small dry scar, pleasant flavor, and light blue color. 'Georgiagem' may be susceptible to stem blight caused by *Botryosphaeria dothidea* (Mouq. ex Fr.) Les and de Not and stem canker, although this has not been confirmed.

'O'Neal'. 'O'Neal' was released in 1987 from the cross 'Wolcott' × Fla 64-15 (Ballington et al., 1990). It is vigorous, semi-upright, and has a chilling requirement of 400 to 500 h. 'O'Neal' begins flowering very early and may lose many flowers to frost; however, it often still has a sufficient number of flowers to produce a respectable yield. 'O'Neal' has large, good-quality fruit with excellent flavor. Fruit have a small stem scar, good firmness, and good color. 'O'Neal' is resistant to race 1 of stem canker, but is susceptible to other known races. It is susceptible to stem blight, but the causal organism does not move quickly into the crown. It is also susceptible to blueberry bud mite *(Acoria vaccini* Keifor).

'Cape Fear'. 'Cape Fear', released in 1987, resulted from the cross US 75 × 'Patriot' (Ballington et al., 1990). It, along with 'Flordablue', are the only SHB cultivars with *V. darrowi* cytoplasm. It is very productive, semi-upright, vigorous, precocious, and widely adapted. It has a chilling requirement of 500 to 600 h. 'Cape Fear' has the largest fruit of the SHB cultivars. The fruit have a medium-size scar and are of average quality with weak flavor. 'Cape Fear' ripens with 'Croatan' in North Carolina. It has exceptional field tolerance to stem blight, but is susceptible to stem canker. 'Cape Fear' appears to be susceptible to a soft-fruit disorder seen in North Carolina in 1992 to 1994 that may be caused by *Alternaria* sp. (J.R. Ballington, personal communication).

'BIue Ridge'. 'Blue Ridge' was released in 1987 from the cross 'Patriot' × US 74 (Ballington et al., 1990). 'Blue Ridge' is a vigorous, very upright plant that grows well at all locations tested. It is productive and is the latest ripening of the currently released SHB cultivars. 'Blue Ridge' has a chilling requirement of 500 to 600 h. Fruit are medium- to large-sized, very light blue, and very firm, with only a fair scar. Fruit are of good quality with a pleasant high-acid flavor; but are tart until fully ripe. Since fruit often turn blue before fill ripening is achieved, blue fruit should be left on the plant for several days to ensure full ripeness. Because of scar quality and ripening characteristics, 'Blue Ridge' is recommended mainly for local sales and pick-your-own operations. 'Blue Ridge' is field-tolerant to stem blight but susceptible to stem canker and mummyberry caused by the fungus *Monilinia vaccini-corymtbosii* Reade (Honey).

Table 1. ***Dates for stage 2 budbreak (swelled), 50% flowering, 50% ripe fruit, and yield for southern highbusb cultivars at four locations.***

Cultivar	Year	Location	Stage 2 bud break	50% open flowers	>50% ripe fruit	Plant yield (kg)
Cape Fear	1986	Castle Hayne, N.C.	---	---	6 June (43%)	---
	1988	Clarksville, Ark.	2 Mar	5 Apr.	6 June	2.69
	1989	Clarksville	---	4 Apr.	13 June	1.11[z]
	1990	Clarksville	12 Feb.	26 Mar.	---	---
Gulfcoast	1990	Clarksville	3 Feb.	23 March	13 June	0.98
	1990	Poplarville, Miss.	---	6 Feb.	15 May	1.09
	1991	Clarksville	6 Feb.	22 Mar.	5 June	4.32
	1991	Poplarville	---	11 Mar.	13 May	---
	1991	Castle Hayne	---	25 Mar.	26 May	---
	1992	Clarksville	---	21 Mar.	9 June	2.16
Cooper	1990	Clarksville	11 Feb.	5 Apr.	13–20 June	0.80
	1990	Poplarville	---	4 Mar.	19 May	0.43
	1991	Clarksville	8 Feb.	27 Mar.	5 June	2.25
	1991	Poplarville	---	21 Mar.	17 May	---
	1991	Castle Hayne	---	27 Mar.	28 May	---
	1992	Clarksville	---	24 Mar.	9–15 June	2.38
Georgiagem	1988	Clarksville	4 Mar.	7 Apr.	6 June	1.93
	1989	Clarksville	---	7 Apr.	6 June	0.20[z]
	1990	Clarksville	7 Feb.	25 Mar.	---	---
O'Neal	1986	Castle Hayne	---	---	6 June (65%)	---
	1988	Clarksville	26 Feb.	4 Apr.	31 May–6 June	1.28
	1989	Clarksville	---	4 Apr.	13 June	0.66[z]
	1990	Clarksville	7 Feb.	23 Mar.	---	---
Blue Ridge	1986	Raleigh, N.C.	---	---	2 June (77%)	---
	1988	Clarksville	2 Mar.	5 Apr.	13 June	1.94
	1989	Clarksville	---	3 Apr.	13 June	1.17[z]
	1990	Clarksville	10 Feb.	27 Mar.	---	---

[z]*Yields in 1989 were reduced due to two late freezes; –14C at stage 2 (swelled) buds and –3C 1 week after full bloom.*

Adaptations

SHBs possess adaptive characteristics intermediate to northern highbush and rabbiteye blueberries (Lang, 1993). Because of the upland soil adaptation of *V. darrowi,* it was hoped that SHB cultivars might be as vigorous as rabbiteye cultivars and could be grown, like rabbiteye, without mulching or organic soil amendments. Initially it appeared that this had been achieved in the one-fourth *V. darrowi* hybrids, but longer-term testing has proven otherwise. SHB cultivars have performed significantly better when mulched (Clark and Moore, 199 la, 1991b; Spiers, 1992). Recent experiments have shown that highbush roots may be less tolerant of high soil temperature than rabbiteye roots and, under high soil temperatures, their metabolic activity decreases (J. Spiers, personal communication). Mulching apparently helps the more shallowly distributed root system of the SHB plants to remain cool and allows metabolic functions to continue through the heat of summer. When grown in mineral soils, the existing SHB cultivars apparently need increased organic matter from decaying mulch, similar to that observed for standard highbush plants. Organic mulch has resulted in consistently better plant performance than inorganic mulch.

Much like the SHBs released from the Florida breeding program in the 1970s, the newer cultivars possessing one-fourth *V. darrowi* germplasm may not be ideally adapted to all southern areas. SHB cultivars have less bud hardiness than standard highbush material. In areas that have winter lows of about –18 to –23C, bud damage can occur. These cultivars also have a predisposition to early bud swell that may result in subsequent tissue damage from freezing. Both of these problems appear related to the percentage of *V. darrowi* germ plasm in these cultivars. Early bud swell, particularly, is related to chilling requirement and heat units required to bring about bud development. This problem may be remedied in the future by selecting for retarded budbreak after chilling requirements are satisfied or for intermediate chilling requirements (about 700 to 800 h). These goals may be achieved by selection within breeding populations that have about one-eighth *V. darrowi* or by recombination and selection within one-fourth *V. darrowi* germplasm, which may result in genotypes with effectively less than one-fourth *V. darrowi* composition.

A further perspective is offered by three new SHB cultivars released in late 1994 by the USDA–Agricultural Research Service blueberry breeding program at Poplarville, Miss. Unlike most of the earlier USDA releases, all contain significant amounts of*V. ashei* and one contains no *V. darrowi.* The cultivars, their parentage, and compositions are as follows: 'Jubilee' = 'Sharpblue' × MS 60 (MS 60 is a sibling of 'Georgiagem'), 62% to 64% *V. corymbosum*, 27% *V. darrowi*, 6% to 8% *V. ashei,* and 3% V. *angustifolium.* (variable percentages reflect uncertainty regarding the exact pedigree of 'Sharpblue'); 'Magnolia' = ('Harrison' × 'Avonblue') × Fla 2-5, 71% *V. corymbosum*, 12% *V. darrowi*, 8% *V. ashei*, 3% *V. tenellum,* and 6% *V. angustifolium;* and 'Pearl River' = G 136× 'Beckyblue', 69% *V. corymbosum*, 30% *V. ashei*, and 1% *V. angustifolium.*

The currently available SHB cultivars represent the initial phase of developing highbush materials with broad southern adaptation and offer new opportunities for early season production of quality blueberries. Much remains to be learned, however, about the adaptation and ideal cultural conditions of SHBs because of their relative newness. The information presented here offers some guidelines regarding cultivar adaptation and performance. However, local chilling and temperature records should be consulted when determining which cultivars are suitable for any given area. SHBs require more care than rabbiteye cultivars if they are to flourish; however, with care, they can be grown productively and profitably.

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