select the smallest subset of the k treatments that will have a preassigned probability of at least P of containing the best treatment; (c) pick the t(=2, 3, etc.) best treatments; or (d) rank the t best treatments.

Selecting the Best Treatment

Obviously, the best treatment will be taken to be that one for which the sample mean is the largest, but unless the number r of replications per treatment is sufficiently large, the probability will not be high that the best treatment will give the biggest sample mean. Given a probability P and a difference d of practical importance between the 2 best treatments, we can calculate r such that the probability is at least P that the best treatment will give the largest sample mean. (We have to specify d because if the 2 largest population means are almost equal, it is virtually impossible to ensure a high probability P that the best population will give the largest sample mean; furthermore, no serious loss is incurred in our selecting the second best instead of the best treatment.) We can use the published tables in reverse. Having done the experiment with r replications, we can calculate the probability P that the largest sample mean came from the best population.

Using Duncan's barley example, suppose we wish to have a probability $P = .95$ that the best population will give the highest sample mean if the 2 best populations differ by at least $d = 5$ bushels per acre. The formula for r is $r = [h(k, P)\ \sigma/d]^2$. Assume $\sigma = 9$. From tables (4), $h(7, .95) = 3.2417$, so that the required number of replicates is $r = [9(3.2417)/5]^2 = 35$. The actual experiment was done with $r = 6$ replications. Solving the above equation, we have $h(7, P) = d\sqrt{r/\sigma} = 5\sqrt{6/9} = 1.34$. From tables, $h(7, P) = 1.34$ gives $P = .52$ approximately.

The above formula assumes that the population standard deviation is known. If this is not available from previous experiments with similar material, sequential and two-stage procedures are available.

Subset selection

If k is large or if the 2 best treatments are close to each other, we may require a prohibitively large experiment to assure a high probability of correctly selecting the best treatment. We may be satisfied instead with picking a small subset for future more intensive study. We want the smallest subset such that the probability is P that the best treatment is in the selected subset. The rule is to include a treatment in the subset if its sample mean exceeds $\bar{x}_{max.} - h(k, P)\ \sigma/\sqrt{r}$ (if σ is known) or $\bar{x}_{max.} - \sqrt{2}\ t(l\text{-}p;\ k\text{-}l,\ n)\ s/\sqrt{r}$ (σ unknown). Values of t(l-P; k-l, n) are given in Table Fl in (3). In our previous numerical example, $\bar{x}_{max.} = 71.3$, $s = 8.92$, $r = 6$, $n = 30$ and $k = 7$. If $P = .95$, the table gives $t(.05;\ 6,\ 30) = 2.40$. The subset includes all those treatments whose means exceed $71.3 - 2.40(8.92)\sqrt{2/6} = 58.94$. The subset containing the 5 largest means has 95% probability of including the best variety. For the other objectives, we refer the reader to (5).

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BREEDING BLUEBERRIES FOR FLORIDA: ACCOMPLISHMENTS AND GOALS[1]

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Abstract. **Ten or more species of wild blueberries are native to Florida. Five species extend as far south as Manatee County, and** Vaccinium myrsinites **Lam. grows south of Miami. Development of a commercial blueberry industry in Florida is favored by the presence of these adapted species from which cultivars can be bred, by the availability of thousands of hectares of acid soils, and by Florida's low latitude, which enables Florida to market blueberries earlier than regions farther north. Accomplishments of the Florida blueberry breeding program to date include identification of low-chilling rabbiteye (**V. ashei **Reade) cultivars that are adapted as far south as Ocala and recent distribution to growers of 3 very early-ripening, low chilling cultivars derived from crosses between northern U.S. highbush cultivars and low-chilling Florida species. Goals of the program include breeding and selection of cultivars for all areas of Florida where blueberry species are native, greater disease resistance, better adaptation to Florida soils and climate, a greater range of ripening dates, and a range of flavors.**

Wild blueberries are widespread in the woods and swamps of Florida. At least 5 of the 10 *Vaccinium* species present in the state (9) are known to occur south of Tampa, and *V. myrsinites* is native in Dade County. The world's first commercial blueberry plantings, consisting of native rabbiteye *(V. ashei)* bushes transplanted from the woods and swamps, were made in north Florida beginning about 1893 (3). By the late 1920's there were an estimated 2,225 acres of cultivated blueberries in Florida (3). Berries were being shipped fresh by rail to northern markets, and at least one

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blueberry cannery was being operated in Northwest Florida. The industry declined rapidly after 1930, at least in part because the erratic quality of Florida blueberries put them at a disadvantage in competition with blueberries produced in New Jersey and Michigan with clonally-propagated cultivars developed by the U.S. Department of Agriculture. Efforts to breed improved blueberry cultivars for the southern United States finally began in Georgia in 1940 and in Florida in 1948 (7). This paper reviews factors favoring development of the Florida blueberry industry and describes some accomplishments and objectives of the Florida blueberry breeding program.

Perhaps the strongest indication that blueberries could be an important crop in Florida is the presence within the State of a highly heterogeneous group of native *Vaccinium* species. Camp (2) listed 12 species as occuring in Florida. Ward (9) combined 3 species which he found almost indistinguishable within the state, but noted that most of the 10 species contained great genetic diversity. These native blueberries indicate that much of the state is suited to blueberry culture, and they also provide the raw materials from which cultivars are being developed having various fruit flavors, seasons of maturity, and regions of adaptation.

In areas of North Florida where soils are sufficiently acid, blueberries are better adapted than presently available cultivars of such fruits as peaches, apples, and Japanese plums, which are native to drier or cooler regions. The rabbiteye blueberry *(V. ashei)*, is particularly vigorous, and abundant crops are still gathered from plantations that were abandoned fifty years ago and have been overgrown by pine, oak, and other trees. In addition, heavy crops are often produced on seedling blueberries that have sprung up in the forests surrounding the abandoned plantations.

The potential market for blueberries in Florida is large. Many residents have picked and eaten native wild blueberries, and demand at U-pick plantings has been good. Out-of-State shipments should develop with the newer cultivars which ripen early in the season before other areas come into production.

Accomplishments of the Florida Program

In the period between 1910 and 1930, when cultivation of wild rabbiteye blueberries was at its height in Florida, a number of land race varieties were developed by clonal propagation of superior bushes found among the highly-variable plants in commercial plantings. The first blueberry breeding program in which cultivars useful in Florida were produced from controlled crosses was begun at Tifton, Georgia in 1940 (1). A single generation of selection in populations obtained by intercrossing selected *V. ashei* bushes from the woods and swamps of Florida and Georgia produced such highly successful cultivars as 'Tifblue' and 'Homebell' (1).

In tests at Gainesville, Florida, some Georgia selections fruited fairly reliably. Others required more chilling than was provided by most winters in Gainesville and fruited well only after exceptionally cold winters (5). Rabbiteye cultivar 'Bluegem' was released from the Gainesville station in 1970, having originated from open-pollinated seed of an Tifton selection (6).

Despite the vigor and productivity of *V. ashei* in northern Florida, the Florida blueberry breeding program has not emphasized the improvement of the rabbiteye blueberry. In addition to the fact that Georgia had an active rabbiteye breeding program, there are several reasons why rabbiteye breeding has not been stressed in Florida. *V. ashei* is hexaploid, with $2n = 6X = 72$ chromosomes, and, except for *V. amoenum* Ait., which is hardly distinguishable from *V. ashei* (Ward), none of the *Vaccinium* species in Florida can easily be crossed with *V. ashei*, since 5 are diploid (2X) and 3 are tetraploid (4X). Early ripening and low chilling, 2 traits needed in Florida blueberry cultivars, are lacking or at least not readily available in Florida hexaploid species *V. ashei* and *V. amoenum*. Neither species has been reported native south of Gainesville (9). *V. ashei* fruit ripens late because the interval between flowering and ripening is about 30 days longer than for northern highbush cultivars (4). Thus, rabbiteye blueberries from Florida tend to ripen simultaneously with berries produced in the major highbush plantations of North Carolina and the advantages of early marketing are lost.

Use of interspecific crosses to develop tetraploid blueberry cultivars adapted to Florida has been described in 3 papers by Sharpe, Sharpe and Darrow, and Sharpe and Sherman, (4, 5, 7). In short, a Florida diploid species, *V. darrowi* Camp, was used as a source of low-chilling genes, and northern highbush tetraploids provided early ripening and high fruit quality. Tetraploid cultivars released from the Florida breeding program include 'Flordablue' and 'Sharpblue' in 1976 (8) and 'Avonblue' in 1977.

Goals of the Blueberry Breeding Program

Sharpe (4) noted in his 1954 paper discussing Florida's blueberry breeding program that the drought tolerance and low chilling requirement of diploid *V. darrowi* and hexaploid *V. ashei* might eventually make it possible to develop tetraploid cultivars having much wider adaptability than the rabbiteye cultivars then available. 'Flordablue' and 'Sharpblue', the first tetraploid cultivars containing genes from the low-chilling Florida diploid, *V. darrowi*, are more widely adapted than present rabbiteye cultivars in that they can be grown farther south in the state (8). As Sharpe and Sherman noted in 1971 (7), however, present tetraploid selections are not generally as vigorous as rabbiteye cultivars, requiring more frequent irrigation and being less tolerant of upland soils. In addition, the northern highbush cultivars used in breeding the Florida tetraploids were susceptible to cane canker *(Botryosphaeria corticis)*, a blueberry disease that causes little damage in the northern U.S. but is lethal to susceptible cultivars in the South, and many tetraploid lines have had to be discarded because of their susceptibility to this disease. The new Florida tetraploid cultivars 'Flordablue', 'Sharpblue', and 'Avonblue' appear to be resistant to cane canker.

One objective of the present breeding program is to increase the bush vigor of the early-maturing, low-chilling tetraploid lines developed in Florida since 1950. Good sources of resistance to cane canker appear to be available in 'Flordablue', 'Sharpblue', and 'Avonblue', in several native Florida blueberry species, and in North Carolina tetraploid cultivars. Canker has been a serious problem in North Carolina, and an extensive breeding program has been carried out for canker resistance. Canker-resistant North Carolina cultivars are now being crossed with the best Florida tetraploid lines.

V. elliottii Chapm., a native diploid species that is abundant in many woods of northwestern Florida, is another potential source of genes for increasing the vigor of early-maturing Florida tetraploid cultivars. Four desirable traits present in the species are early fruit ripening (which is suggested by the common name "Mayberry"), a tolerance for dry upland soils that probably equals or surpasses that of the rabbiteye, apparent resistance or tolerance to cane canker, and the delightful flavor and aroma of berries from some selections. An undesirable characteristic of the species is small berry size. The chilling requirement of the species has not been studied, but the fact that it has not been reported south of Levy County (9) suggests that it is not a good source of low-chilling genes. *V. elliottii* is diploid, but Sharpe's success in crossing diploid *V. darrowi* with tetraploid highbush cultivars suggests that *V. elliottii* might produce enough functional unreduced gametes to yield a few tetraploid hybrid seedlings in crosses with Florida tetraploid breeding lines.

Another goal of the Florida blueberry breeding program is to examine the possibility of developing earlier-ripening, low chilling hexaploid blueberry cultivars based primarily on *V. ashei*. Although *V. ashei* typically requires considerably more time between blooming and ripening than most tetraploid selections, the native populations of *V. ashei* are highly diverse, and have not been explored thoroughly. Early-maturing rabbiteye selections may yet be found. Early-ripening and low-chilling characteristics may also be introgressed into *V. ashei* at the hexaploid level by the use of synthetic hexaploids. Synthetic hexaploids can probably be produced by doubling the chromosome numbers of tetraploid Florida breeding lines to obtain octaploids, and then crossing these octaploids with other low-chilling, early-ripening Florida tetraploids. The advantage in using *V. ashei* as the predominant component of a Florida cultivar and introducing only as many genes from other species as are necessary to obtain earliness and low chilling is that *V. ashei* has proved extremely productive, long-lived, and tolerant to diseases, drought, and upland soils, whereas the northern highbush cultivars, which contributed over 50% of the genes present in 'Sharpblue' and over 60% of those in 'Flordablue' (8), are poorly adapted to Florida.

Opportunities also exist for development of late or fall-ripening blueberry cultivars. Such cultivars could be based on the native diploid sparkleberry, *V. arboreum* Marsh., which inhabits very dry sites as far south as Manatee and Hardee Counties (9). Fruit of the sparkleberry ripen from August through October, but are dry and mealy. The sparkleberry may be difficult to cross with the other *Vaccinium* species, since its tree-like stature and late ripening make it an atypical member of the genus.

Autumn-ripening blueberries might also be developed based on northern tetraploid cultivars. Some of these cultivars, when grown in Florida, develop fruit buds that mature on current-season growth during the summer and then flower and produce fruit as days shorten in the autumn. To obtain autumn-ripening cultivars, lines would have to be developed which can tolerate the heat, drought, and diseases of Florida, which omit the spring crop, and which produce a heavy fall crop.

No blueberry cultivars can presently be recommended for areas south of a line from Tampa to Cape Canaveral because not even the lowest-chilling cultivars are known to fruit reliably in the warm winters of southern Florida. The tetraploid lowbush blueberry species *V. myrsinites*, however, extends south to Miami and Naples (4), and this suggests that cultivars could be developed for those areas of southern Florida having acid soils. South-Florida cultivars would ripen their fruit very early in the season, when prices are usually quite high. A problem in breeding for southern Florida is that of maintaining and evaluating sizeable populations of experimental plants at such a great distance from the breeding station at Gainesville.

Surveys of the native rabbiteye blueberries in northern Florida reveal enormous differences in fruit flavor from bush to bush within the species, and if all native Florida blueberry species are considered, variations in sweetness, acidity, aroma, and texture are even greater. Unfortunately, with present marketing systems, such fruit characteristics as large size and blue color are often more important as profit factors than excellent flavors, at least in the short term. Furthermore, selection for desirable flavors is complicated by differences in personal taste preferences and by non-genetic variations in berry flavor from site to site and from year to year. Nonetheless, flavor must be considered if blueberries are to become a popular fruit in Florida.

Sharpe (4) reported in 1954 that hybrids involving *V. darrowi*, a diploid lowbush species, had possible ornamental value because they had small, evergreen leaves and compact growth when grown in full sun. He noted that combinations of these characters with improved fruit size would produce a plant valuable both for ornamental and for fruiting purposes. Such genotypes should be produced and tested.

Florida is blessed with a great diversity of native blueberry species. Although blueberry breeding is a very long-term project in which plans made in a few hours may take decades to implement, the potential benefits of such a program appear to justify the investments required.

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