opportunities exist in expanding the market for muscadine wine.

Bunch grape breeding in Arkansas should continue to yield new seedless table grape cultivars adapted to the Upper South. These new cultivars will be valuable to the areas of the region in which Pierce's disease does not occcur.

Biotechnology promises new dimensions to compliment conventional breeding programs and further improvement of muscadine and bunch grapes appears on the horizon.

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Blackberries and Raspberries in the Southern United States: Yesterday, Today, and Tomorrow

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Abstract

Blackberries have long been a popular fruit in southern U.S., and they are widely grown there, with excellent potential for expanded production. Raspberries are also well-liked, but not widely grown, due to lack of adapted cultivars. Great progress has been made, particularly in the past four decades, in improving blackberry cultivars for the South, but little effort has been given to raspberry improvement. Germplasm exists within *Rubus* to provide great advances in conventional cultivar improvement in both subgenera and for creating new types of fruits through interspecific hybridization. Germplasm and breeding strategies will be discussed that would result in new cultivars to serve as the foundation on which to build much expanded blackberry and raspberry industries in southern United States.

Blackberries (including dewberries) have long been a favorite fruit in the southern United States. Generations of southerners have harvested fruits from the abundance of wild plants found growing along fencerows and in fields in the South. Even today, it is common to see cars parked along roadsides with people harvesting blackberries nearby.

The love for raspberries among native southerners did not develop as rapidly as it did for blackberries, due to lack of familiarity since native stands of raspberry did not exist. However, raspberries were commonly grown in southern gardens in the 19th century, and the in-migration of northerners into the South in the second half of the 20th century has stimulated a great interest in commercial culture of red raspberries in southern growing areas.

Blackberries and raspberries are classified taxonomically in the genus *Rubus* (Tourn.) L. Blackberries are in the subgenus *Rubus* (formerly *Eubatus*) (1) while raspberries are placed in the subgenus *Idaeobatus*. Both subgenera are very diverse and taxonomically very complex, containing hundreds of species. It has been estimated that the genus *Rubus* contains as many as 740 separate species (7). This tremendous diversity makes classification difficult but provides great genetic variability for use, in improving cultivars through breeding. Several excellent reviews have been published on the breeding and development of blackberries and raspberries, including the use of *Rubus* species in cultivar improvement (7, 10, 14, 15, 26).

Yesterday

Blackberries

Interest in the cultivation of blackberries was slow to develop in the U.S., probably due to the ready availability of wild fruits and to the aggressiveness and thorny nature of the plants (23). However, in the 19th century, blackberry enthusiasts

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began to select superior clones from the rich diversity of wild plants and to propagate and cultivate them. Such superior types as 'Lawton' and 'Dorchester,' introduced in the 1850's; and later cultivars such as 'Snyder,' 'Eldorado,' and 'Early Harvest,' greatly stimulated interest in blackberry improvement. Private breeders were active in the latter half of the 19th century, and superior cultivars from those programs resulted in the beginning of commercial culture.

Blackberries are well adapted to the climatic conditions of southern United States, and it was in this region that most of the early genetic improvements were made. In fact, the first public blackberry breeding program in the United States was begun in 1909 by the Texas Agricultural Experiment Station.

While several public breeding programs were initiated early in the 20th century, most blackberry acreage was planted to chance seedlings selected from the wild until the 1940's (21). The first public variety to become significant in cultivation was 'Brainerd,' released by USDA in 1932 (24).

At the turn of the 20th century, and for several years thereafter, the leading blackberry cultivars (all from private programs) were: 'Early Harvest,' 'Logan,' 'Snyder,' 'Lawton,' 'Taylor,' 'Kittatiny' and 'Dallas,' and 'Lucretia' and 'Mayes' dewberries (19). Of these, 'Early Harvest,' a diploid *R. argutus* Link, hybrid introduced in Illinois in 1880, was especially popular. By 1937, 'Brainerd,' 'Young,' and 'Oregon Evergreen' were having an impact, but 'Eldorado,' 'Dallas,' 'Logan,' and 'Lucretia' were still important (4).

Raspberries

In contrast to blackberries, raspberries do not tolerate well the hot summer temperatures, high light intensities, and fluctuating winter temperatures of the South. While there was little early activity in improving raspberries for the South, there was some interest in cultivating the species in the latter half of the 19th century. Cultivars of red raspberries listed as popular at the turn of the 20th century were 'Turner,' 'Cuthbert,' 'Louden,' and 'Marlboro.' Popular black raspberries were 'Cumberland,' 'Gregg,' 'Doolittle,' and 'Ohio' (19). By 1937, several public cultivar developments were being grown, including red raspberries 'Chief,' 'Latham,' 'Newburgh,' and 'Van Fleet,' and black raspberry cultivars 'Bristol' and 'Dundee' (4).

The first southern experiment station to conduct red raspberry breeding was North Carolina in 1926. This program successfully utilized Asiatic species, especially *R. biflorus* Buch. as donors of genes for southern adaptation. The cultivar 'Dixie,' from *R. biflorus* x Latham,' was released in 1938, and 'Mandarin,' from a (*R. parvifolius* Hemsl. x 'Taylor') x 'Newburgh' cross, was introduced in 1955. The widely adapted southern cultivar 'Southland'

Table 1. *Rubus* species possessing traits that would be useful in breeding blackberries for southern United States [adapted from Daubeny (7)].

Species	Trait
R. procerus Muell.	Double blossom and verticillium resistance
R. laciniatus Willd.	Drought resistance, anthracnose resistance
R. allegheniensis Porter	Erect canes, large fruit size
R. argutus Link	Adaptation to heavy soils, erect, spineless
R. cuneifolius Pursh.	Low chill requirement, erect
R. setosus Bigel	Low chill requirement, high temperature tolerance
R. frondosus Bigel	Low chill requirement, high temperature tolerance, erect
R. trivialis Michx.	Low chill requirement, high temperature tolerance, double blossom resistance
R. rubrisetus Rydb.	Low chill requirement, high temperature tolerance, drought resistance
R. glaucus Benth.	Low chill requirement, large fruit size, small seed

was also released from the North Carolina-USDA program in 1968. It is a complex hybrid involving several Asiatic species. 'Southland' is highly resistant to leaf spot, mildew, and anthracnose, and is winter hardy under fluctuating winter temperatures (13).

Red raspberry breeding was initiated by the Tennessee Experiment Station in 1931. This program relied on the USDA cultivar 'Van Fleet,' a hybrid of the Asiatic species *R. kuntzeanus* Hemsl. (*R. innominatus* Moore) to provide genes for southern adaptation and disease resistance. From this program was introduced 'Tennessee Autumn' (1940), 'Tennessee Luscious' (1944), and 'Tennessee Prolific' (1948).

Today

Blackberries

A recent survey conducted by Clark, (3) shows that 78% of the blackberry acreage in 13 southern states is planted to erect cultivars and the remainder to semi-erect types. The leading erect cultivars are 'Shawnee' (35% of acreage), 'Rosborough,' 'Brazos,' and 'Cheyenne.' Rosborough' and 'Brazos' are limited primarily to Texas and Louisiana due to susceptibility to winter cold, while 'Shawnee' is grown in all areas of the South. Newer cultivars such as 'Choctaw,' 'Navaho,' and 'Arapaho' were just getting established at the time of the 1990 survey, and are now being extensively planted throughout the South. Projections of future plantings showed erect cultivars 'Shawnee,' and 'Rosborough' increasing while 'Brazos' and 'Cheyenne' were predicted to stabilize. Among semi-erect cultivars, 'Chester' and 'Hull' were expected to increase, while 'Black Satin' and 'Dirksen' remained stable or declined. Plantings in the South were projected to increase by 46% during the 1990-2000 decade.

The most significant blackberry breeding programs for southern U.S. in the last 30 years have been the University of Arkansas program for the development of erect cultivars, the Texas A & M program, and the USDA-Beltsville, Maryland program for development of semi-erect cultivars. From the Arkansas program has come 'Cherokee,' 'Comanche,' 'Cheyenne,' 'Shawnee,' 'Choctaw,' 'Kiowa,' and the erect thornless cultivars 'Navaho' and 'Arapaho.' The Texas program introduced 'Brison,' 'Womack,' and 'Rosborough.' The USDA program has introduced 'Thornfree,' 'Smoothstem,' 'Hull Thornless,' 'Black Satin,' 'Chester Thornless,' 'Dirksen Thornless' and 'Triple Crown.' Most of the acreage of blackber-

Table 2. *Rubus* species possessing traits that would be useful in breeding raspberries for southern United States.

Species	Trait
R. biflorus Buch.	Heat, drought and disease tolerance, erectness, low chilling
R. parvifolius Hemsl.	Heat, drought, and disease tolerance, low chilling
R. kuntzeanus Hemsl. (= *innominatus*)	Heat, drought, and disease tolerance, low chilling
R. albescens Roxb.	Heat tolerance
R. coreanus Miq.	Heat and drought tolerance
R. crataegifolius Bge.	Heat and drought tolerance, cane strength and erectness
R. ellipticus Sm.	Heat and drought tolerance
R. hawaiiensis A. Gray	Low chill, heat tolerance
R. macraei A. Gray	Low chill, heat tolerance
R. rosaefolius Sm.	Low chill, heat tolerance
R. rugosus Sm.	Heat tolerance
R. *lasiocarpus* Sm. (= niveus)	Heat tolerance
R. lasiostylus Focke	Heat tolerance
R. phoenicolasius Maxim.	Heat tolerance

ries in the South is planted to cultivars from these three breeding programs.

The foundation of the Arkansas breeding program was the cross of 'Darrow' x 'Brazos.' Neither 'Darrow,' a New York cultivar, nor 'Brazos,' from Texas, is well adapted to Arkansas. However, the hybrids, including cultivars 'Cherokee,' 'Comanche' and 'Cheyenne,' are not only well adapted to Arkansas but are generally adapted across the South and Southeast. It appears that a mixture of genes from parents of widely divergent climatic adaptation may combine to give wide area adaptation.

The original objective of the Arkansas program was to develop a series of large-fruited, high quality, erect cultivars ripening at different times to provide an expanded harvest season. This has been accomplished. Recently, emphasis has been shifted to achieving a similar objective with thornless cultivars. The genes for thornlessness being used are those from 'Merton Thornless,' via 'Thornfree.' The key crosses early in the program were 'Thornfree' x 'Darrow' and 'Thornfree' x 'Brazos.' Close genetic linkages between the thornless gene and genes for trailing growth habit, late ripening, and large seed size slowed progress in the program, but these obstacles have now been overcome, and rapid progress is expected in the future.

Recently, new breeding initiatives have been included in the Arkansas program. Efforts are being focused on breeding much firmer fruit to facilitate long distance marketing of fresh blackberries, and on the development of primocane-fruiting blackberries. Genes have been identified to achieve these objectives, and are being combined with genes for other superior plant and fruit characters. Additional effort is also being made to develop rosette resistant cultivars, in cooperation with Louisiana State University.

The breeding strategy being used in the Arkansas program is recurrent mass selection, in which superior phenotypes are selected for use as parents, controlled intermating based on complementarity of parents is performed, and selection of superior offspring is made in the segregating population. This process is continued indefinitely as long as genetic advance is being made (22). From 8000 to 14,000 seedlings are produced in this program each year from controlled hybridization.

In 1980, Moore (20) stated that blackberry cultivar susceptibility to the fungus disease rosette (double blossom) [*Cercosporella rubi* (Wint.) Plakidas] is the greatest limiting factor in the expansion of blackberry production in southern United States. That statement is still accurate today. Rosette is a very damaging disease in blackberry and infected plantings are short-lived. There is no good chemical control, and unfortunately, most modern cultivars are susceptible to the fungus. Recently however, hope has been provided by Buckley et al. (2) who reported that high levels of genetic resistance to rosette exist in the new thornless cultivars 'Arapaho' and 'Navaho' and in some advanced breeding lines. Such genetic resistance can remove much of the risk of growing blackberries in the South.

A second impediment to increased blackberry production is the perishability of harvested fruit, which limits distant marketing. Fruit of most blackberry cultivars is quite soft and can be successfully stored for only short periods of time. Because of this, most fresh blackberries are sold direct to consumers or to local markets. Recently, however, Perkins-Veazie et al. (28) have shown that 'Navaho' and 'Arapaho' have the fruit firmness that will allow shipment to distant markets. In fact, Perkins-Veazie et al. (29) found that 'Navaho' fruit could be successfully shipped by air to European markets.

A major concern for the future of blackberry production is the lack of effort being expended at present to develop cultivars for the future. Blackberry breeding programs continue to decline in the South. In 1980, Moore (20) reported that five southern experiment stations had blackberry breeding programs. By 1990 (3) this number had decreased to two: Arkansas and USDA-Poplarville, Mississippi. A modest program is also now being conducted at North Carolina State University with primocane fruiting and disease resistance being major objectives (J. R. Ballington, personal communication). Also, the USDA-Beltsville program is still active, and some cvs. from that program may be useful in the South. If blackberry culture in the South is to be sustained into the future, much more research on developing new cultivars will need to be done.

Raspberries

With the possible exception of Maryland and Virginia, raspberry production in the South is even less today than during 1900-1950. However, interest in the South is now at a high level. Unfortunately, raspberry production is still very limited by the lack of good quality cultivars adapted to southern climates.

In eastern U.S. at elevations of < 300m, native stands of red raspberries occur only > 41°N latitude. Thus, red raspberry production in the South is primarily limited to the Appalachian highlands (33). Frequent mid-winter episodes of warm air masses from the Gulf of Mexico often result in premature de-hardening and late winter bud break in many cultivars (33). Early fall freezes, before hardening, and high summer temperatures are also damaging to raspberries in the South. Hull (12) considered the limiting factors for red raspberry production in the South to be susceptibility to leaf spot and cane damage from fluctuating winter temperatures.

In 1991 (33), raspberry cultivar, recommendations among southern states were: 'Heritage,' 'Dormanred,' 'Latham,' 'Cherokee,' 'Citadel,' 'Mandarin,' 'Reveille,' and 'Royalty.' Of these, the most widely grown red raspberry cultivar is the fall-fruiting 'Heritage,' which appears to have wide geographic adaptation. In the deep South, 'Dormanred' is perhaps best adapted, but requires a trellis and is often damaged by winter cold. 'Southland' is also well adapted to summer heat, but is not widely grown.

Raspberry breeding programs are even more rare in the South than are blackberry programs. An aggressive program is conducted in Maryland, but mostly aimed at developing cultivars for the mid-Atlantic region. Recently, the program at North Carolina State University has been revived and is aimed largely at developing cultivars for the Appalachian Highlands. Species being used for heat tolerance are *R. parvifolius, R. innominatus* (*R. kuntzeanus*) and *R. niveus* (*R. lasiocarpus*) (J. R. Ballington, personal communication). There is no known raspberry breeding activity in the deep South.

Tomorrow

There is potential for much greater improvement in both blackberries and raspberries in the future than has been accomplished in all the history of improvement to the present. The following sections identify known genetic resources available for cultivar improvement and suggest some breeding strategies that might be used to combine genes to create new cultivars for the future.

Blackberries

Clark (3) has listed the major genetic limitations of modern blackberry cultivars. For the South, these include disease susceptibility (especially rosette/double blossom), fruit quality/storability, and thorny canes as major limitations. Lack of cold hardiness and late fall entry into dormancy, resulting in cane damage, may also be problems in some southern areas. All of these limitations are amenable to genetic improvement and donor germplasm is available. In fact, these genetic deficiencies are already being overcome with the recent development of cultivars such as 'Navaho' and 'Arapaho,' which are resistant to rosette, have high quality fruit of good storability, and produce erect, thornless canes. For the warm winter areas of the deep South, the challenge is to develop cultivars with a low chilling requirement for uniform bud break and with a high heat requirement for growth after dormancy to avoid too early growth and frost damage (31)

Genes exist among blackberry species for allowing significant improvements in other important plant and fruit characteristics in blackberries of the traditional type. These were outlined by Moore (21) and include much larger fruit size and much firmer fruits than presently found in cultivars. Seediness, an objectionable character of most blackberry cultivars, can be overcome by selecting for smaller seed size (25) or for seeds encapsulated in a layer of fleshy tissue. We have not yet begun to approach the genetic limits for maximum production in blackberries. Also, the harvest season can be expanded greatly by developing earlier and later ripening cultivars. Types that produce large clusters of fruit at the periphery of the plant canopy will greatly facilitate both hand and machine harvest. Genotypes that combine easy fruit abscission at fruit maturity and very firm fruits can be developed to allow mechanical harvest of fruits for the fresh market.

It is possible to select types that produce rapid growing, erect primocanes from the crown and roots so that plantings can be mowed following harvest to remove old floricanes, allowing new primocanes to be generated in midsummer for fruiting the following year. This would remove much of the labor now required in pruning blackberries, and possibly reduce the incidence of rosette disease and red-neck cane borer.

A development, now possible, with the potential to revolutionize blackberry culture is the development of primocane-fruiting (fall fruiting) cultivars. Recently primocane fruiting tetraploid blackberry germplasm (NC194) has been released (1) that can serve as the gene donor for breeding primocane fruiting blackberries. The gene for this character was transferred from an old diploid cultivar, 'Hillquist' which was crossed with the tetraploid cultivar 'Brazos' to produce a selection, Arkansas 593. Apparently, Ark. 593 originated from an unreduced male gamete of 'Hillquist' fusing with a normal reduced female gamete of 'Brazos,' since Ark. 593 is tetraploid. While Ark. 593 did not express the primocane-fruiting character, 3 of 46 seedlings resulting from selfing Ark. 593 showed the trait, and the best one was released as 'NC 194.' Preliminary observations indicate that the trait is recessive and probably simply inherited, with modifier genes affecting the degree of expression of the character (1).

If the primocane-fruiting trait in blackberry can be intensified to the degree developed in raspberry, several revolutionary possibilities in blackberry culture could be realized, including: 1) two crops per year could be harvested, spring and fall; 2) most pruning could be eliminated if only fall fruiting was practiced, since all canes could be mowed to the ground in winter and new primocanes would fruit in fall; 3) many over-wintering pests, such as anthracnose and red-neck cane borer would be eliminated; 4) cold injury to over-wintered canes would be eliminated, allowing blackberries to be grown in more northern areas; and 5) fruit would be produced in "off-season" (fall) with enhanced marketing opportunities (24). Also, multiple cropping per year might be realized in tropical and subtropical climates.

The potential also exists for creating entirely new types of fruit, by exploiting the tremendous genetic variability that exists within the genus *Rubus.* A vast array of genetically variable species and species hybrids occurs naturally throughout most regions of the world, and this resource has been largely unexploited in breeding. Many species are interfertile and can be directly inter-crossed, while some require only ploidy manipulation to be usable. The major centers of diversity for blackberries are Europe, North America, and South America (14), but breeding programs have used only a few species, mostly from Europe and North America (10).

Examples of new kinds of fruit created by hybridization of blackberry and raspberry include 'Loganberry,' 'Phenomenal Berry,' 'Youngberry,' 'Boysenberry,' 'Nessberry,' and more recently 'Tayberry,' 'Tummelberry and 'Sunberry' (15).

Except for the latter three, these cultivars were selected from very small populations utilizing parents being grown over 75 years ago. Thus, even more dramatic developments are now possible using this approach.

Additional investigations of hybridization between blackberry and raspberry are warranted, not only for producing new fruit types, but for improving blackberries of the traditional type. Raspberries could be additional sources of genes for the primocane-fruiting trait. Also, raspberries could be used as donors of genes for winter cold hardiness, a much needed trait in blackberries. Presumably, the strategy required for using raspberries as donors of specific genes would require a series of backcrosses to blackberry to recover blackberry fruit characteristics. Most successful raspberry x blackberry hybrids (i.e., 'Loganberry,' 'Boysenberry,' 'Youngberry,' 'Tayberry,' 'Tummelberry,' 'Sunberry') are hexaploids or septaploids. Lower ploidy levels have been less desirable as cultivars. However, 'Nessberry' and 'Veitchberry' are examples of tetraploids that have been valuable in breeding (14). In fact, 'Nessberry,' a third generation hybrid of *R. rubrisetus* Rydb. x 'Brilliant' red raspberry, is the progenitor of a large number of modern blackberry cultivars with southern climate adaptation including 'Brazos,' 'Brison,' 'Rosborough,' 'Womack,' 'Cherokee,' 'Comanche,' 'Cheyenne,' 'Shawnee,' 'Flordagrand,' and 'Oklawaha.' Darrow (5) suggested that cultivars should contain an uneven balance of blackberry and raspberry chromosomes to facilitate separation of fruit from the plant (i.e., 8x blackberry x 4x raspberry or 12x blackberry x 4x raspberry).

Interspecific hybridization should be a primary breeding strategy for developing blackberry cultivars for the future, of both traditional and "new" types. In fact, interspecific hybridization has been a potent force in the development of blackberry cultivars in the past, and few modern cultivars are of monospecies origin. Many of the original cultivars selected from the wild were considered by Darrow (4, 6) to be interspecific hybrids. Table 1 lists *Rubus* species that were suggested by Daubeny (7) as possible donors of specific traits that would be useful in blackberry breeding for the southern U.S.

Cultivars that offer genes for adaptation to the climate of the southern United States were listed by Daubeny (7) as: 'Flordagrand,' 'Oklawaha,' 'Smoothstem,' 'Thornfree,' 'Lawton,' 'Nessberry,' 'Brazos,' Brison , 'Ebano,' 'Rosborough,' 'Womack,' 'Olallie,' 'Cherokee,' 'Comanche,' 'Cheyenne,' 'Shawnee,' 'Choctaw,' 'Navaho,' 'Arapaho,' 'Boysenberry,' and 'Youngberry.' Daubeny (7) also gave as sources of double blossom (rosette) resistance: 'Himalaya Giant,'' 'Humble,' 'Flordagrand,' 'Brainerd,' 'Gem,' *R. procerus* Muell., and *R. trivialis* Michx. To that list can be added 'Navaho' and 'Arapaho' (2). Jennings et al. (15) suggested that the 'Mysore' raspberry (*R. albescens* Roxb.) is a potential source of high heat tolerance for blackberry breeding programs, but Sherman and Sharpe (31) reported that 'Mysore' was killed by exposure to 29°F (–1.7°C), so cold hardiness of its offspring is a concern.

Raspberries

As indicated earlier, there are few raspberry genotypes of good quality adapted to the climatic conditions of the southern U.S. For adaptation to this region, cultivars would need to be adapted to high summer temperatures, high light intensities, widely fluctuating winter temperatures, low numbers of chilling units (in some areas), high disease pressure, and frequent droughts. Probably no genotype possesses all of these traits, but some cultivars and species are available as donors for one or more of the needed characteristic.

According to Daubeny (7) cultivars that have some adaptation to high summer temperatures and have low chilling requirements are 'Citadel,' 'Dixie,' 'Dormanred,' 'Dorsett,' 'Mandarin,' 'Southland 'Tennessee Luscious,' 'Tennessee Prolific,' and 'Van Fleet.' Interestingly, all of these have one or more of the Asiatic species, *R. biflorus, R. kuntzeanus,* or *R. parvifolius* in their ancestry.

In Mexico, Rodriquez-A and Avitia-G (30) reported genes for low chilling requirement in 'Malling Exploit,' 'Sumner,' 'Amber,' 'Malling Jewell, and 'Heritage' (all *R. ideaus* L.). Two new Mexican cultivars, 'Anita' and 'Gina,' were selected for low chilling requirement from an open-pollinated progeny of 'Mailing Exploit.'

In New Zealand, 'Marcy,' 'Rakaia' and 'Algonquin' have low chilling requirement (8, 11). In Israel, 'Dormanred' had the lowest chill requirement, while 'Glen Clova,' 'Delmes,' 'Schoenemann,' 'Malling Exploit' and 'Heritage' had a somewhat higher requirement (32). In Chile, 'Chilliwack' has a low chilling requirement (7).

Several *Rubus* species have potential as sources of genes for southern adaptation. (Table 2). Tolerance to heat and drought can be found in *R. biflorus, R. coreanus* Miq., *R. crataegifolius* Bge., *R. kuntzeanus, R. parvifolius,* and possibly *R. ellipticus* Sm., *R. hawaiiensis* A. Gray, *R. macraei* A. Gray, and *R. rosaefolius* Sm., which fruit in subtropical and tropical regions (7, 14). However, Sherman and Sharpe (31) reported that *R. rosaefolius* and *R. ellipticus* were not cold hardy enough to survive at Gainesville, Fla. 'Keriberry' *R. rugosus* Sm.), which is cultivated on the north island of New Zealand, could be a source of heat resistance. Other Asiatic raspberry species that have potential for contributing to the improvement of red raspberries in the South are *R. lasiocarpus* Sm., *R. niveus* Thunb.), *R. lasiostylus* Focke, and *R. phoenicolasius* Maxim. (14).

Cultivars of pure *R. crataegifolius,* such as 'Jinju Jengal' and 'Jinju Whangal,' grown in Korea, and 'Agenuck' in the former Soviet Union, are reported to be heat and drought resistant (15). Jennings (14) considered' *R. crataegifolius* to be a potentially useful Asiatic species as a donor of cane strength, early ripening, and fruit rot resistance. Keep and Knight (16) reported that *R. crataegifolius* transmitted erect, sturdy canes to its progeny.

Three species have been proven to be excellent donors of genes for adaptation to the climatic conditions of the southern United States when used in crosses with *R. idaeus.* These are *R. biflorus, R. kuntzeanus,* and *R. parvifolius.* These species contribute genes for low chilling requirement and resistance to drought, high temperatures, and disease (7). These species were successfully used in the early raspberry breeding programs in North Carolina, Tennessee, and the USDA. As stated earlier, one or more of these three species is in the ancestry of most cultivars with adaptation to the South. Williams (34) reported that *R. parvifolius* hybrids were more resistant to leaf spot and produced larger fruit than did hybrids of *R. biflorus, R. coreanus* or *R. kuntzeanus,* but *R. parvifolius* transmitted a trailing growth habit and its hybrids had the least acceptable flavor. *R. kuntzeanus* hybrids had the best fertility and best flavor, but small fruit. Drain (9) in Tennessee also used *R. kuntzeanus* as a source of southern adaptation. One drawback to its use was that most of its seedlings started growth too early in the spring and suffered cold injury. Jennings (14) suggested that *R. biflorus* may be more useful than *R. parvifolius* since it gives better fertility and more erectness. The North Carolina cultivar 'Dixie' resulted from the cross *R. biflorus* x 'Latham.'

Hull (12) found that tetraploid hybrids of *R. parvifolius* x *R. idaeus* performed better than diploids. Hull (12) also reported that cane erectness and full fertility could be obtained in F_2 or first backcross generations of *R. parvifolius* x *R. idaeus.* However, Overcash (27) was unable to breed erectness into 'Dormanred,' a *R. parvifolius* derivative.

While the use of climatically adapted *Rubus* species is a good long-term strategy for breeding raspberries for the South, it is still possible to make progress by intermating available cultivars that have marginal adaptation or marginal fruit quality or by genetically enhancing fruit quality of poor quality but adapted genotypes. For example, crosses of adapted types such as 'Dormanred' or 'Southland' with higher quality but marginally adapted types such as 'Heritage' might result in segregates with improved adaptation and quality. An important development that would stimulate raspberry production in the South would be to develop a late season primocane fruiting cultivar. Many present cultivars begin fruiting in the South in late summer or early fall when temperatures are still high, which precludes both optimum production and optimum quality.

Conclusions

Significant advances have been made in the second half of the 20th century in developing superior cultivars of blackberries adapted to the southern United States. However, prevalent diseases and perishability of fresh fruit still limit expansion of the industry. In contrast, few raspberry cultivars are adapted to the southern region of the United States, and no industry can develop without significant cultivar development.

Genes are available within the vast germplasm resources of the genus *Rubus* to overcome all the present barriers to blackberry and raspberry culture in the South. Most of the needed genes are readily accessible to conventional breeding programs in cross-compatible cultivars and species, while some may require biotechnological intervention or ploidy manipulation for transfer into commercial types. It is possible to introduce exogenous DNA into blackberry and raspberry. Agrobacterium-mediated gene transfer has been accomplished in *Rubus,* and transformed tissues can be obtained following regeneration from leaf discs and internodal segments (15, 18). Interspecific hybridization should be considered as a primary breeding strategy to achieve the combinations of genes needed for adaptation to the climatic and biotic situations in southern United States. An excellent review of the success, potential, and problems of interspecific hybridization in *Rubus* is that of Lawrence (17).

While the availability of genetic resources encourages optimism for the development of needed cultivars of blackberry and raspberry for the South, the paucity of effort being devoted to the breeding of brambles for this region must be viewed with pessimism and alarm. Only two blackberry breeding programs are active in the South (Univ. of Arkansas; USDA-Poplarville, Miss.), and no effort is being given to developing raspberries for the deep South. If the tremendous potential that exists for developing thriving blackberry and raspberry industries in southern United States is to be realized, much more effort must be devoted to the breeding of superior, adapted cultivars. Lyndon Johnson once said, "Yesterday is not ours to recover, but tomorrow is ours to win or to lose." Certainly the winning or losing of blackberry and raspberry industries in the future South is dependent on what we do today.

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Apple Fruit Growth Effect of Temperature

Fruit temperatures were influenced by enclosing them in small containers. Although initial fruit growth was similar under black or transparent canisters, at harvest fruit diameter from the black canister treatment was significantly smaller. Early season temperatures under the black canisters were significantly higher than under silver canisters but the final fruit weights were similar and significantly lower than the other treatments. Despite the early differences in fruitlet growth, final fruit weight was largely determined by light rather than temperature over the first 37 days after full bloom. From Palmer and Stanley. 1994. ISHS Hort Congress Abstracts)-35-3 p. 76

Somoclonal Selection for Disease Resistance

Peach regenerates have demonstrated increased levels of bacterial leaf spot resistance. They have also demonstrated increased levels of bacterial canker and root-knot nematode resistance. This study demonstrates the feasibility of using tissue culture techniques to generate fruit trees with increased levels of disease resistance. From Hammerschlag et al. 1994. ISHS Hort Congress Abstract S-2-2 p.5.