

Strawberry Cultivar Use in North America

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SUMMARY. Strawberry (*Fragaria × ananassa* Duch.) cultivars used by commercial producers in North America often change rapidly due to several factors including modified cultural practices, processing and marketing practices, the desire for new cultivars with larger and higher quality berries, resistant insect and disease pests, loss of traditional chemical control methods, and private sector breeding programs. Within the past decade, the annual plastic-mulched production system has quickly expanded into eastern North America prompting the need for cold-hardy cultivars adapted to that system. The continuing loss of traditional chemical controls for strawberry insects and diseases, including the impending loss of methyl bromide, has prompted the need for increased insect and disease resistance. In addition, consumer demands for a healthier food product with lower chemical residues has heightened this need. Small fruit experts from across North America provided information on the primary strawberry cultivars used in the recent past, the present, and potential cultivars for the future, as well as on current strawberry acreage in their respective states and provinces.

In a 1968 review of strawberry cultivars in the United States, Smith and Scott stated “the selection of strawberry varieties for commercial production can change faster than any other kind of fruit” (Smith and Scott, 1969). In 1989, Daubeny commented on the decision to review the current cultivar situation for major fruit crops grown in North America with regards to strawberry, “This crop started the series and is the one which has undergone the most changes with respect to cultivars. Moreover, it is anticipated that there will be more changes in the next decade” (Daubeny, 1989). Much the same can be said at this juncture in time. The cultivar picture has changed and will continue to change for many of the same reasons cited by Daubeny. In particular, the influence of the genotype by environment interaction, a double-edged sword for the strawberry breeder, will continue to provide a home for new strawberry cultivars and strawberry breeders. The other edge of the sword dictates that regionally specific climatic conditions, suites of pathogens, and regional industry demands will severely limit the potential for one cultivar to serve all needs. As stated in previous reviews, the continued loss of chemical controls for insects and diseases and the growing negative disposition towards their use continues to be a driving force in strawberry cultivar development. In particular, the probable future loss of methyl bromide as a soil fumigant intensifies the need for cultivars that are genetically resistant to known and future strawberry pathogens.

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Table 1. Estimated total strawberry hectares and hectares planted in a plastic mulch production system for the Eastern U. S. and Canadian Provinces in 1996-97 and the contributors of the information.

State or Province	Total area (ha)	Area on plastic (ha)	Contributor
Arkansas	120	≈81	J. Clark (Univ. of Ark.)
Alabama	220	200	D. Himelrick (Auburn Univ.)
Connecticut	170	0	R. Helrich (N.E. Agr. Stat. Service) N. Gauthier (Univ. of Conn.)
Delaware	56	≈4	T. Feurer (Delaware Agr. Stats.) E. Kee (Univ. of Del.)
Florida	2,400	2,400	C. Chandler (Univ. of Fla.) C. Hinton (Fla. Straw. Growers) M. Brown (BBI Produce, Inc.)
Georgia	40	40	G. Krewer (Univ. of Georg.)
Illinois	320	≈30	A. Otterbacher (U. of Ill.)
Iowa	240	≈1	G. Nonnecke (Iowa State Univ.)
Indiana	200	0	B. Bordelon (Purdue Univ.) S. Erwin (Indiana Plant and Berry Co.)
Kentucky	192	≈4	D. Archbold (Univ. of Kentucky)
Louisiana	340	340	R. Constantin (Louisiana St. Univ.)
Maine	140	≈2	D. Handley (Univ. of Maine)
Maryland	200	≈16	G. Galletta (USDA-ARS, Beltsville) C. Homann (Mary. Agr. Stats.) B. Rouse (Univ. of Mary.)
Massachusetts	200	≈3	R. Helrich (N.E. Agr. Stat. Service) T. Nourse (Nourse Farms, Inc.) S. Schloemann (Univ. of Mass.)
Michigan	680	0	J. Hancock (Mich. State Univ.) E. Hanson (Mich. State Univ.)
Minnesota	400	0	J. Luby (Univ. of Minn.)
Mississippi	30	≈16	B. Smith (USDA-ARS, Poplarville)
Missouri	200	≈8	P. Byers (S.W. Missouri St. Univ.)
New Hampshire	80	≈2	B. Lord (Univ. of N.H.)
New York	880	≈12	K. Maloney (Cornell Univ.) M. Pritts (Cornell Univ.)
North Carolina	960	480	J. Ballington (N.C. State Univ.) B. Poling (N.C. State Univ.)
New Jersey	180	≈24	J. Fiola (Rutgers Univ.)
Ohio	520	≈10	J. Scheerens (Ohio State Univ.) T. Wall (Ohio State Univ.)
Pennsylvania	520	≈10	B. Goulart (Penn. State Univ.)
Rhode Island	24	0	R. Helrich (N.E. Agr. Stat. Service) K. Menezes (Univ. of R.I.) L. Tewksbury (Univ. of R.I.)
South Carolina	120	≈108	D. Layne (Clemson Univ.)
Tennessee	283	67	A. Rutledge (Univ. of Tenn.)
Vermont	120	≈4	V. Grubinger (Univ. of Vermont)
Virginia	80	≈50	C. O'Dell (Virg. Polytechnic Univ.)
West Virginia	16	≈2	D. Yoder [Univ. of West Virg. (Ret.)]
Wisconsin	600	≈3	B. Smith (Univ. of Wisc.-River Falls)
New Brunswick	336	0	A. Jamieson (Agr. Canada-N. Scotia)
Newfoundland	96	0	A. Jamieson (Agr. Canada-N. Scotia)
Nova Scotia	448	0	A. Jamieson (Agr. Canada-N. Scotia)
Ontario	2298	≈20	A. Dale (Univ. of Guelph) K. Schooley (Ont. Ministry of Agr.)
Quebec	2639	0	S. Khanizadeh (Agr. Canada-Quebec) M. Lareau (Agr. Canada-Quebec)

The rapid growth in popularity of the annual hill production system (plasticulture) in the southeastern United States and portions of the Atlantic seaboard are also influencing the cultivar picture in the eastern United States. Older cultivars such as 'Chandler' and 'Allstar' are experiencing a resurgence in popularity in the system in these regions. As the system is employed further north, there is a great need for northern-adapted cultivars that will perform well in the plasticulture system. In addition, anthracnose (*Colletotrichum* sp.) fruit and crown rots, formerly southeastern problems, are now becoming issues for the whole of the eastern industry as well. Simply stated, the strawberry cultivar picture will continue to change in the future, necessitating the presence of several regional strawberry breeding programs and a periodic review of the strawberry cultivar situation in North America.

In a manner similar to the previous North American strawberry surveys, (Bringhurst and Voth, 1979; Caldwell, 1989; Dale, 1989; Daubeny, 1979; Galletta, 1979; Lawrence, 1989; Luby, 1989; Ourecky, 1979; Smith and Scott, 1969), we have considered the current strawberry cultivar situation on a regional basis. The current treatment deviates slightly in that the eastern North America is broken up into seven regions. Like the previous survey efforts, information was gathered from small fruit experts on a state by state, province by province basis (Table 1). Without their generous cooperation, preparation of this manuscript would not have been possible. We wish to extend all the credit for the contents of this article to our participating colleagues while we will accept all criticism for any shortcomings or mishandling of the information they so generously provided.

Strawberry cultivars in eastern North America

STRAWBERRY CULTIVARS FOR THE NORTHEASTERN UNITED STATES—CONNECTICUT, MAINE, MASSACHUSETTS, NEW HAMPSHIRE, NEW YORK, RHODE ISLAND, AND VERMONT. In general, the strawberry industry in the Northeastern region of the United States is made up of growers who produce their crop on <2 ha (5 acres) of land and use the matted-row production system (Table 1). Generally these operations are concentrated around population centers

where the growers market the crop via U-pick or prepicked on-farm sales. Most strawberry operations in the region are part of a diverse multicrop farming operation in which the strawberry crop is the lead-in commodity for the season. However, the existence of specialized operations of up to 40 ha (100 acres) dedicated to strawberries should not be overlooked.

The availability of land for rotation in the Northeast is a significant factor in cultivar selection. Growers who were not land restricted, e.g. Vermont, and who practiced longer crop rotations, often relied more heavily on the red stele root rot, (*Phytophthora fragariae* Hickman var. *fragariae*) susceptible cultivars such as 'Honeoye' and 'Jewel'. If not cited specifically, cultivar descriptions can be found in *The Brooks and Olmo Register of Fruit and Nuts Varieties* (3rd ed.). In more populated states such as Connecticut, growers are land limited and cannot practice long rotation schedules. In these situations the growers rely more heavily upon red stele resistant cultivars such as 'Allstar' and 'Earliglow', despite their lower yield potentials.

From the mid-1980s to the present, 'Earliglow' and 'Honeoye' have been the primary early-season cultivars in the Northeast (Table 2). Although 'Earliglow' acreage has declined due to its small fruit size, it is still widely planted due to its early fruiting season and outstanding flavor characteristics. 'Earliglow' is still the third-highest selling cultivar in the Northeast (Table 3) and is one of the few strawberry cultivars that has name recognition with consumers. 'Honeoye' has been popular in the Northeast because it is winter hardy and it reliably produces a large crop of bright red fruit, which are prominently displayed, all important characters for the U-pick growers. However, 'Honeoye' is susceptible to at least eight of the ten American races of the red-stele pathogen (Maas et al., 1989). Some growers report that 'Honeoye' gets poor flavor ratings with customers, which has led to some decline in acreage. In addition, it has poor shelf life (dark red skin color) a liability for wholesale marketing. Despite these shortcomings, 'Honeoye' is still the number two selling strawberry cultivar in the Northeast (Table 3).

Currently, 'Annapolis' is planted in the Northeast as an early-season

alternative to 'Earliglow' and 'Honeoye'. Although it is smaller in size and does not yield as well as 'Honeoye', 'Annapolis' is red stele resistant with better fruit size and yield than 'Earliglow'. For the early-season, 'Northeast' has very good potential producing well in the U-pick and wholesale markets. The early-season fruit are attractive and the flavor, which gets mixed reviews, has been said to rival that of 'Earliglow' by some proponents. Conversely, the grape-like flavor characteristic, which is inherited from its 'Holiday' parent, may limit the broad-scale appeal of the cultivar.

For the midseason, the primary cultivars in the recent past were 'Allstar', 'Kent', and 'Redchief'. Presently, the cultivar picture looks much the same with 'Redchief' having been replaced by 'Cavendish'. 'Cavendish' is currently competing with 'Kent' and 'Allstar' as the predominant midseason cultivar in the region. However, 'Cavendish' has not lived up to early expectations due to ripening problems (white shoulders) that develop in high temperature conditions. Some growers are managing the problem through the use of evaporative cooling. 'Allstar' continues to be the most widely grown midseason cultivar in the region despite light-colored fruit and average flavor. It continues to be the top yielding cultivar in the midseason despite having been released over 15 years ago (Galletta et al., 1981). 'Mira', a 1996 midseason release from Nova Scotia, has attracted attention from the region's growers due to its productivity, large fruit size and good quality. The new releases 'Mira', 'Primetime', 'Delmarvel', and 'Winona' have not been evaluated enough in the region to determine how much potential they have.

'Blomidon' was a promising late-season cultivar in the mid-1980s and was quickly replacing 'Sparkle' and 'Micmac' as the primary late-season cultivar in the region. Unfortunately, June yellows developed in 'Blomidon', leading to its demise (Jamieson and Sanford, 1996), leaving northeastern growers in need of a good late-season cultivar. 'Jewel' is currently the top selling cultivar in the northeastern U.S. (Table 3) and the number one late season cultivar (Table 2). 'Jewel' has proven to be highly productive with good fruit and flavor characteristics making it useful for the wholesale and

U-pick trades. The biggest drawback for 'Jewel' is its susceptibility to red stele root rot.

Since the 1980s, the USDA, under the direction of Dr. Gene Galletta, has been involved in a cooperative program with the University of Maine to produce winter-hardy cultivars that were resistant to a new race of red stele root rot that appeared in the state (Maas et al., 1988). This collaboration has produced ≈30 MEUS (Maine USDA) selections since 1990 that are at various stages of evaluation. Selections that yield with 'Honeoye' and produce high quality fruit suitable for the U-pick market may find a place in the New England region. One of the most often cited needs for the future in the region is a high quality late-season cultivar to replace 'Blomidon'. Grow-

ers would also like an early-season cultivar with the fruit quality characteristics of 'Earliglow' and the yield potential of 'Honeoye'. Cultivars with resistance to red stele root rot, verticillium wilt (*Verticillium* sp.) and elements of the black root rot complex (*Pythium* sp., *Rhizoctonia* sp.) and root-lesion nematodes (*Pratylenchus* spp.) are also prominently mentioned future needs.

STRAWBERRY CULTIVARS FOR THE MID-ATLANTIC UNITED STATES—DELAWARE, MARYLAND, NEW JERSEY, VIRGINIA, AND WEST VIRGINIA. Unlike the northeastern strawberry production region, the mid-Atlantic region is currently experiencing a fairly distinct dichotomy in strawberry production systems. Directly adjacent to the Atlantic seaboard and increasing in a southerly progression,

more acreage is being planted in the annual, raised-bed, plastic-mulched (plasticulture) production system (Table 1). This production system has generated excitement among the region's growers due primarily to the earlier crop that can be produced and the higher price that is paid for this early crop. In addition, growers appreciate the ease of harvest of clean fruit, larger fruit, and higher yields compared to the traditional matted row. Presently, the plasticulture growers have been using cultivars developed in the University of California, Davis, program, (UCD), e.g., 'Chandler' and 'Camarosa', or from the University of Florida program, e.g., 'Sweet Charlie'.

Growers in the mid-Atlantic region are interested in northern-adapted cultivars that will perform well in the

Table 2. Principal strawberry cultivars grown in eastern North America in the early, middle, and late seasons in the recent past,^z present,^y and predictions for the future.^x

Season	Past	Present	Future
Northeastern United States (Maine, Vermont, New Hampshire, Massachusetts, Rhode Island, Connecticut, and New York)			
Early	Earliglow, Honeoye	Annapolis, Earliglow, Honeoye	Northeaster
Mid	Allstar, Kent, Redchief	Allstar, Cavendish, Kent	Mira
Late	Blomidon, Sparkle	Jewel	Winona
Mid-Atlantic United States (Delaware, Maryland, New Jersey, West Virginia, and Virginia)			
Early	Earliglow, Honeoye	Annapolis, Earliglow, Honeoye	Northeaster
Mid	Allstar, Redchief	Allstar, Cavendish, Jewel	Primetime
Late	Delite, Jerseybelle, Lateglow	Lateglow	Latestar
Southeastern United States (Alabama, Florida, Georgia, Louisiana, Mississippi, North Carolina, and South Carolina)			
Early	Earlibelle, Earliglow, Sunrise	Earliglow	Unknown
Mid	Atlas, Titan, Cardinal	Allstar, Atlas, Cardinal	Unknown
Late	Apollo, Delite, Tennessee Beauty	Apollo, Jewel	Unknown
Plastic	Chandler, Cardinal, Douglas, Earlibelle, Selva, Pajaro, Oso Grande, Tangi	Camerosa, Chandler, Sweet Charlie, Pajaro, Selva, others ^w	Unknown
Midsouthern United States (Arkansas, Kentucky, Missouri, and Tennessee)			
Early	Earliglow, Sunrise, Pocahontas	Earliglow	Chambly
Mid	Allstar, Cardinal, Guardian, Honeoye, Redchief, Surecrop	Allstar, Cardinal, Honeoye, Jewel, Redchief	Unknown
Late	ArKing, Lateglow	ArKing, Lateglow	Unknown
Midwestern United States (Illinois, Indiana, Ohio, and Pennsylvania)			
Early	Earliglow, Honeoye	Earliglow, Honeoye	Northeaster
Mid	Allstar, Cardinal, Raritan, Redchief, Surecrop	Allstar, Kent, Raritan	None
Late	Blomidon, Guardian, Jewel, Scott, Sparkle	Jewel, Lateglow	None
Upper-midwestern United States (Iowa, Michigan, Minnesota, and Wisconsin)			
Early	Earliglow, Honeoye, Veestar	Annapolis, Earliglow, Honeoye, Veestar	Chambly, Northeaster
Mid	Allstar, Kent, Redchief, Redcoat	Allstar, Cavendish, Kent, Glooscap	Mesabi, Mira
Late	Blomidon, Bounty, Sparkle	Bounty, Jewel, Lateglow, Sparkle	Latestar, Winona
Eastern Canada (Ontario, Atlantic Provinces (Nova Scotia, New Brunswick, Prince Edward Island, and Newfoundland), and Quebec)			
Early	Veestar	Annapolis, Veestar	Mohawk
Mid	Kent, Redcoat, Glooscap, Honeoye	Cavendish, Kent, Honeoye, Jewel	Mira
Late	Blomidon, Bounty, Micmac, Sparkle, Vantage	Bounty, Governor Simcoe, Micmac, Sparkle	Startyme

^zThe recent past was considered to be from ≈1985–90.

^yThe present was considered to be from ≈1990–97.

^xThe future was considered to be ≈5 to 10 years into the future.

^wOthers were proprietary cultivars and older cultivars such as 'Oso Grande'.

plasticulture system. Northern-adapted June-bearing cultivars such as 'Latestar' and 'Northeast' have been mentioned as highly promising options for the plasticulture system (O'Dell, 1998). The other consideration for the region will be the option of carrying the planting over for one or more years. In California, Florida, and the southeastern U.S., the plastic-mulched systems are most commonly fruited only one year. The high planting densities used in these systems, upwards of 43,000 plants/ha (17,400 plants/acre), create ideal conditions for the spread of many strawberry diseases, including anthracnose fruit and crown rots (*Colletotrichum* sp.), which were formerly considered southeastern problems. In addition, after a year, the plants generally develop so many crowns that fruit size is significantly compromised. These conditions make it difficult for carryover plantings to be economically viable. Cultivars will need to be developed that do not proliferate an excessive number of crowns when grown in the plasticulture system for more than one year. Interestingly, one of the big problems cited with the plasticulture system in the region has been voles (*Microtus* spp.), which eat the plants (particularly those under floating row cover), tunnel in and out of the plastic mulch and chew through drip irrigation tubing.

Historically, the matted row has been the predominant production system in the region and it continues to be of significance in areas removed from the seaboard and at higher elevations. 'Earliglow' and 'Honeoye' were the primary early-season cultivars grown in the matted-row system (Table 2) and continue to be the predominant cultivars to this day with some 'Annapolis' acreage occurring, primarily

in the northern portions of the mid-Atlantic. For the near future, 'Northeast' appears to be a cultivar with significant promise. 'Northeast' is performing well over the entire region in both production systems. As mentioned previously, its only apparent limitation seems to be a grape-like flavor, which some individuals find objectionable.

The primary midseason cultivars used in the region were 'Allstar' and 'Redchief' (Table 2), although 'Raritan' and 'Lester' were more prominent in Maryland and New Jersey. Currently 'Allstar', 'Cavendish', and 'Jewel' are the principal midseason cultivars for the region in the matted-row system. For the future, the verdict is still out regarding the most recently released midseason cultivars; although, 'Primetime' is often mentioned as having considerable potential.

Late-season strawberry production in the mid-Atlantic region is a dubious proposition. Most of the region begins experiencing high temperatures and humidity by mid-June, which severely limits the interest of U-pick customers as well as the interest of growers to harvest pre-picked berries. Historically, 'Delite' has been the primary late-season cultivar in the southern part of the region, with 'Jerseybelle' and 'Lateglow' predominating in the northern part of the region (Table 2). Currently, 'Lateglow' is the most widely used late-season cultivar with considerable interest being shown in 'Latestar' in the matted-row and plasticulture production systems. Availability of a firm, high-quality late-season or bicropping everbearer type cultivar could stimulate more interest in later season strawberry production.

In the future, the interest in the plasticulture system will continue to

grow and northern-adapted cultivars that will perform on the plasticulture system in either an annual or perennial fashion should be developed. Strawberry production in the mid-Atlantic region is subjected to high disease pressures due to the use of plastic mulches, longer growing seasons, higher heat and humidity and, as a result, future cultivars will need to have increased disease resistance, particularly to anthracnose fruit and crown rots caused by *Colletotrichum* sp.

STRAWBERRY CULTIVARS FOR THE SOUTHEASTERN UNITED STATES—ALABAMA, FLORIDA, GEORGIA, LOUISIANA, MISSISSIPPI, NORTH CAROLINA, AND SOUTH CAROLINA. The southeastern region is now almost completely dominated by the annual plasticulture production system (Poling, 1994) (Table 1). Florida and Louisiana were the first in the region to adopt the system. Louisiana began producing strawberries in the California type system in the mid-1950s and Florida has been using this system since the mid-1960s. Until the mid-1980s the Louisiana growers relied almost entirely on 'Tangi' (Caldwell, 1989). Anthracnose epidemics in grower-produced 'Tangi' nursery stock forced the growers to experiment with the cultivar 'Chandler' in the mid-1980s. 'Chandler' quickly became, and continues to be, the number one cultivar used in the state despite the fact that it is anthracnose susceptible as well. Currently, Florida is the only state in the region for which 'Chandler' is not the primary plasticulture cultivar.

The Florida strawberry industry is directed entirely towards the winter fresh market. Strawberries are produced in 19 Florida counties; however, 90% of the crop is produced in Hillsborough County. The first fruit are generally

Table 3. Top five selling strawberry cultivars in terms of volume for 1996–97 season for seven eastern North American strawberry nurseries.

Nursery	1	2	3	4	5
Allen Plant Co. ² , Fruitland, Md.	Allstar	Earliglow	Delmarvel	Honeoye	Redchief
Brittingham Plant Farms Inc., Salisbury, Md.	Earliglow	Allstar	Honeoye	Jewel	Cavendish
G.W. Allen Nursery Ltd., Kings County, Nova Scotia, Can.	Kent	Annapolis	Honeoye	Cavendish	Veestar
Daisy Farms, Decatur, Mich.	Honeoye	Jewel	Allstar	Earliglow	Winona ³
Indiana Berry & Plant Co., Huntingburg, Ind.	Honeoye	Earliglow	Jewel	Allstar	Cavendish ^x
Krohne Plant Farms, Dowagiac, Mich.	Jewel	Allstar	Earliglow	Honeoye	Kent
Nourse Farms, Inc., South Deerfield, Mass.	Jewel	Honeoye	Allstar	Earliglow	Cavendish
Strawberry Tyme Farms, Inc., Simcoe, Ontario, Can.	Veestar	Kent	Honeoye	Annapolis	Jewel

²Sales primarily to homeowners.

³Sales heavily influenced by nursery sales.

^xSeveral cultivars were about equal (fifth) in sales volume including 'Cavendish', 'Northeast', 'Delmarvel', 'Winona', 'Mohawk' and 'Primetime'.

harvested in late October, with the primary shipping season beginning in late November. Harvests continue until early April when the price is no longer competitive with that of California-produced fruit. Some Florida growers with good local markets will continue to harvest into April or early May. The industry has tripled over the last 12 years and the state ranks as the number two producer of fresh market strawberries in the United States.

Florida growers used cultivars developed in the UCD program, such as 'Pajaro', 'Selva', and 'Oso Grande' (Table 2). 'Pajaro' was planted on 65% of the Florida acreage until the crop was devastated by anthracnose fruit rot caused by *Colletotrichum acutatum* J.H. Simmonds in the 1986–87 season. By 1989, 'Selva' was the leading cultivar in the state due in large part to its early fruit production. 'Selva's' extreme susceptibility to two-spotted spider mite (*Tetranychus urticae* Koch) led to its downfall. 'Oso Grande' reached its peak in Florida in 1993–94 when it occupied 55% of the Florida strawberry acreage. Currently, 'Sweet Charlie', released from the University of Florida breeding program (Chandler et al., 1997), is the number one cultivar in the state, occupying 37% of the acreage, while 'Camarosa' is planted on 35%. 'Selva' is still planted on 9% of the acreage due to its extremely early production and 'Oso Grande' is still planted on ≈5% of the state's acreage. The remaining 15% of the state's acreage is planted in proprietary and other cultivars.

Recent releases from the UCD program, including 'Gaviota', may have an impact in Florida. 'Gaviota' reportedly has more flavor and fewer disease problems than 'Camarosa'; however, it may not fruit early enough for Florida market needs. In addition, several advanced selections from the University of Florida breeding program show considerable promise for the future with good fruit quality and high early-season yields.

The southeastern region is also home to the third largest fresh market strawberry producer in the United States, North Carolina. The state mirrors the remainder of the region in several respects. First, strawberries are often produced as one component of a diversified small fruit and vegetable operation. Secondly, most of the strawberries in the region are produced on

smaller farms ranging in size from 0.4 to 16 ha (1 to 40 acres) in size. Most of the fruit is sold as U-pick or prepicked and marketed on-farm. Generally, wholesale marketing is a small proportion of sales for the region; however, some growers are actively developing niche wholesale markets with local chain stores and attaining premium prices for fruit labeled as ripe, locally grown.

High temperatures and high humidity render 'Chandler' susceptible to epidemic episodes of fruit and crown rotting anthracnose outbreaks. In response, growers are experimenting with 'Camarosa' and 'Sweet Charlie', neither of which yields as well as 'Chandler'. In addition, the early flowering 'Sweet Charlie' can suffer frost/freezing damage and subsequent yield reduction due to fluctuating late winter/early spring temperatures. Several breeding programs including the North Carolina State University and USDA Beltsville, Md., programs are currently directing substantial effort at developing more regionally adapted strawberries that are resistant to fruit and crown rotting forms of anthracnose and that perform well in the annual production system.

STRAWBERRY CULTIVARS FOR THE MID-SOUTHERN UNITED STATES—ARKANSAS, KENTUCKY, MISSOURI, AND TENNESSEE. In the mid-southern U.S., strawberries are often produced on relatively small farms as one component of a diversified farming operation. Nearly all the strawberry crop in the region is marketed on-farm as U-pick or prepicked on-farm sales with a marked shift towards prepicked sales. Some growers in the region are branching out and selling prepicked strawberries in various retail outlets off the farm such as farmers markets and roadside stands.

Currently, Arkansas grows more than half of its crop in the plasticulture system while Tennessee produces nearly one-fourth of its crop on plastic. Relatively little acreage in Missouri and Kentucky is currently grown in the annual plasticulture system (Table 1). Most all the acreage planted into the plasticulture system is currently planted with 'Chandler'. Growers in the region are experimenting with 'Sweet Charlie' and 'Camarosa' and are interested in finding more cold-adapted cultivars that will perform well in the plasticulture system.

Growers in the region have been quite conservative in regard to trying new cultivars in the matted-row production system. It has been said that Missouri growers embrace an element of their state motto, the Show Me State, when it comes to using new cultivars. The sentiment probably holds true for the region. From the mid-1980s to the early 1990s, the primary early-season cultivars were Earliglow, Pocahontas, and Sunrise (Table 2). 'Earliglow' continues to be the primary cultivar for the early season. There is little impetus for changing from 'Earliglow', although growers consistently mention they would like a larger fruited, heavier yielding 'Earliglow'-type cultivar in the future. In cultivar trials conducted by Southwest Missouri State University researchers, the early-season cultivar Chambly has produced high yields of good quality berries and shows some promise for the region's growers.

For the midseason, growers in the region depended on 'Allstar', 'Cardinal', 'Guardian', 'Honeye', 'Redchief', and 'Surecrop' in the recent past (Table 2). Currently, the picture looks much the same with the exception that 'Guardian' and 'Surecrop' are rarely used while 'Jewel' has become one of the top cultivars for this season. There are no new midseason cultivars that promise to make an impact in the region in the near future.

The mid-southern region has never had a strong late strawberry season. High temperatures that prevail by this time dampen customer and grower interest in picking the crop. Growers in Arkansas found that once the 'Cardinal' crop was in, the strawberry season was largely over. In a similar sense, Kentucky growers generally consider 'Allstar' and 'Jewel' to be their late-season crop although some 'Lateglow' is grown in the state. From the mid-1980s to the present, the primary late-season cultivars used in the region have been 'ArKing' and 'Lateglow' (Table 2). No newer late-season cultivars appear to be capturing any market hold in the region.

Future cultivars destined for either production system will need to have high quality and postharvest longevity to suit the region's direct-marketing scheme. Resistance to common root and fruit rots will be important, especially in light of the probable loss of methyl bromide. There is consider-

able interest in finding more adapted plasticulture cultivars for the region, particularly some with good cold hardiness. The industry is interested in types that produce an upright, thrifty canopy with reduced runnering that allows good air penetration, easier picking and increased fruit size. The growers in the region are also interested in plasticulture-adapted cultivars with increased resistance to root diseases such as red stele, fruit and crown rots such as anthracnose, gray mold caused by *Botrytis cinerara* Pers.:Fr. and leather rot caused by *Phytophthora cactorum* (Lebert & Cohn) J. Schrt. These resistances will be particularly important as many of the region's growers feel they need to carry a plasticulture planting over for one or two additional years to make the up-front investment in planting economical.

STRAWBERRY CULTIVARS FOR THE MIDWESTERN UNITED STATES—ILLINOIS, INDIANA, OHIO, AND PENNSYLVANIA. The midwestern states produce their strawberry crop almost exclusively in the traditional matted-row production system. However, in Illinois there are ≈ 30 ha (75 acres) of strawberries planted into the annual plasticulture system (Table 1). Like many other regions in the eastern U.S., the Midwest has seen a fairly dramatic shift from predominantly U-pick marketing in the late 1970s and 1980s to prepick direct marketing. In Illinois, Indiana, and Pennsylvania, there has been an overall decrease in strawberry acreage from the mid-1980s, although the decrease is not so dramatic as that witnessed from the 1960s into the 1980s. Generally, the acreage has stabilized within the last 5 years with the current trend being for fewer small acreage operations and more larger-scale operations. In Ohio, strawberry acreage has remained fairly constant at ≈ 520 ha (1300 acres) since 1968 (Scheerens and Brenneman, 1990) (Table 1).

Similar to the situation in the upper southern U.S., the cultivar picture in the Midwest is largely the same today as it was in the mid-1980s (Table 2). The standard early-season cultivars were Earliglow and Honeoye and that is still the case today. However, as in most of the east, acreage of 'Honeoye' has increased while 'Earliglow' acreage has decreased. The early season cultivar Northeaster, released in 1994 (Galletta et al., 1995a), is considered to be a promising cultivar for the region.

The midseason cultivar story is a bit more complex due to interstate variation. 'Redchief' was one of the primary midseason cultivars in each state in the region in the recent past; however, from that point each state seemed to have its own particular suite of cultivars. Currently, 'Allstar' is the primary midseason cultivar in all states with 'Kent' popular in Pennsylvania, Illinois, and Ohio. Notably, growers in the region feel that even though 'Allstar's' yields are lower than some newer cultivars, few if any cultivars can match its percent marketability.

The loss of 'Blomidon' to June yellows left the Midwest searching for a late-season cultivar. Along with 'Blomidon', the Midwest used 'Guardian', 'Jewel', 'Scott', and 'Sparkle' to varying degrees in the late season, although there was no consensus regarding late-season cultivars (Table 2). Currently, 'Jewel' and 'Lateglow' are the primary late-season cultivars in the region. As is often the case in the Midwest, growers who can avoid or manage red stele choose the higher yielding red stele susceptible cultivar 'Jewel'. Alternatively, growers who have a red stele problem choose the resistant cultivar 'Lateglow'. At present, there is no new late-season release that has been seen enough by growers to gain any widespread favor. Growers in the northern parts of these states are quite interested in 'Winona', a 1996 USDA–University of Minnesota jointly released late-season cultivar adapted to the upper Midwest.

In the future, Midwest growers would like to see a high-quality late-season cultivar that could fill the void left by the loss of 'Blomidon'. Because the primary market in the region is on-farm sales for fresh market, any cultivars used in the region will need to be comparable to, if not better than, existing cultivars such as 'Earliglow' and 'Allstar'. Traditionally, the strength of the eastern strawberry industry has been the excellent flavor of its cultivars. However, because consumers are becoming accustomed to a California-type fruit, future cultivars will need to be larger-fruited and have good shelf life. Finally, because the strawberry crop is and probably will continue to be produced in the matted-row production system in the midwest, (Hancock et al., 1997), disease resistance will continue to be of great importance in new cultivars.

STRAWBERRY CULTIVARS FOR THE UPPER-MIDWESTERN UNITED STATES—IOWA, MICHIGAN, MINNESOTA, AND WISCONSIN. The four states considered as the upper-midwestern United States in this report roughly correspond with the northern province delineated by Luby (1989) in his report on strawberry cultivars for the Midwest and Plain states. The region experiences extreme winter cold and a protracted winter season. These winter conditions make cold hardiness and cold/frost protection major considerations for the region's growers. Due to the length and severity of the winter season, growers have relied, and will in all likelihood continue to rely, on the matted-row production system (Hancock et al., 1997). In the 1996–97 growing season it was estimated that there were only 4 ha (10 acres) of strawberries planted into the annual plasticulture system in the entire region (Table 1).

Nearly the entire crop in the region is direct-marketed. In contrast to most of the eastern United States, the upper midwestern growers still market the majority of their crop through U-pick. However, prepicked on-farm marketing and sales in local farm markets are becoming more popular. In Michigan, the amount of the strawberry crop that is processed has been steadily dropping such that only $\approx 10\%$ of the crop is processed in contrast to the 30% that was processed 20 years ago.

In his 1989 review, Luby stated that a number of new strawberry cultivars had been introduced in the previous decade and that most new plantings were including some of these. The current cultivar situation is somewhat different in that most of the changes in cultivar usage in the region involve shifts to cultivars that were released in the 1979–89 period. From the mid-1980s to early 1990s the predominant early-season cultivars for the region were 'Earliglow', 'Honeoye', and 'Veestar' (Table 2). The current cultivar situation is the same except for a strong shift to 'Annapolis', particularly in the more northern parts of the region. 'Earliglow' and 'Honeoye' are more widely used in the southern portions of the region with 'Honeoye' acreage increasing at the expense of 'Earliglow' (Table 2). For the future, two newer releases seem to be attracting a lot of attention from the region's growers. In a Michigan cultivar trial,

'Chambly', a 1990 release from McGill University and Agriculture Canada, Quebec, (Khanizadeh et al., 1990), produced high-quality medium-sized fruit and yielded second only to 'Honeoye' among early-season types (Hanson, 1997). 'Northeast' is also gaining favor in the region and is being more widely planted in Iowa.

In the midseason, 'Allstar', 'Kent', 'Redchief', and 'Redcoat' had been the primary cultivars in the region. Currently, 'Glooscap' and 'Cavendish', releases from the Kentville, Nova Scotia breeding program have replaced 'Redchief' and 'Redcoat' and in combination with another Nova Scotia release, 'Kent', now dominate the midseason acreage in the region (Table 2). For the future, two new releases are gaining much attention from growers in the region. 'Mira', a 1996 release from the Kentville breeding program, is a midseason cultivar that is comparable to 'Kent' in many characteristics including yield, fruit size, and taste. In addition, it is resistant to most common foliar diseases and the common races of red stele. 'Mesabi', released in 1998, is the second cultivar from the joint USDA–University of Minnesota breeding program following 'Winona'. The program was designed to develop matted-row type cultivars adapted to the upper Midwest that provided growers with increased resistances to root rot diseases, primarily red stele. Both 'Mira' and 'Mesabi' have produced good yields of large fancy fruit in various yield trials in the region.

Late-season cultivars that dominated the region from the mid-1980s to the early 1990s were 'Blomidon', 'Bounty', and 'Sparkle' (Table 2). As has been mentioned previously, 'Blomidon', another Kentville release, (1985), was quickly gaining favor throughout eastern North America. The loss of the cultivar created a gap that still exists. Presently, 'Jewel' and 'Lateglow' are being used in the late season in addition to 'Bounty' and 'Sparkle' (Table 2). However, some growers report that neither cultivar fruits significantly later than other late midseason cultivars such as 'Allstar'. Two recently released late-season cultivars have performed well in regional yield trials and appear poised to make a market impact. 'Latestar', a 1995 release from the USDA breeding program in Beltsville (Galletta et al., 1996), was the highest yielding late-season cultivar in a Michigan trial, and second in fruit size to its 'Allstar' parent (Hanson,

1997). 'Latestar' has also produced well in Wisconsin trials. 'Winona' also shows promise in the region and is resistant to the common leaf diseases and to the common races of red stele root rot. In Minnesota trials it has yielded at least as well as any of the other late-season cultivars used in the region.

Growers in the upper midwest will continue to be interested in disease resistant cultivars due to the fact that the traditional matted-row production system used by the region's growers generally carry over for 2 to 7 years, with an occasional 12-year planting not unheard of. Winter hardiness will always be an important trait for any new cultivars for the area, as will be the ability to produce ample runners for bed formation. Because so much of the crop is direct-marketed on-farm, future cultivars will need to be of high quality with good flavor, firmness, color, and shelf life. Growers are interested in seeing larger-sized fruit that compare more favorably with the California fruit consumers have grown accustomed to seeing on grocery shelves.

More than anywhere in the eastern U.S., growers in the upper midwest region have used and continue to show interest in day-neutral or everbearing type strawberries. Less extreme heat in the summer growing months in the north leads to more flower bud initiation, allowing these day-neutral types to more freely express the everbearing character. Growers in the region are interested in the possibility of producing a strawberry crop on an annual basis, thereby avoiding the problems of bringing a crop through harsh winter conditions. It is fair to say that expectations have outstripped progress in the development of new day-neutral cultivars. Luby (1989) lists eight day-neutral cultivars that were trialed in Minnesota in the late 1980s and significantly, no new cultivars have been added to this list in subsequent years. The 1981 USDA releases 'Tribute' and 'Tristar' are still the most widely planted day-neutrals in the region. Growers throughout the region would welcome a larger-fruited, higher-yielding replacement for the currently available day-neutral cultivars.

STRAWBERRY CULTIVARS FOR THE EASTERN CANADIAN PROVINCES—ATLANTIC PROVINCES, ONTARIO, AND QUEBEC. More than 5,900 ha (14,750 acres) of strawberries were planted in the eastern Canadian provinces in the 1996–97 season (Table 1). Roughly one-fourth to one-

third of the crop is marketed as U-pick, with ≈70% being prepicked for on-farm or wholesale fresh market sales. Less than 10% of the crop is used for processing.

Due to harsh winter conditions, a very small percentage of the strawberry acreage in the region is produced in the annual plasticulture system (Table 1). Current estimates suggest there may be up to 20 ha (50 acres) of June-bearing strawberries planted in the annual plasticulture system currently in production in Ontario. The remainder of the strawberries planted on black plastic mulch in eastern Canada are day-neutral types, primarily 'Seascape', planted in Quebec.

Despite the vast area encompassed by this regional treatment, the cultivar situation in eastern Canada is fairly uniform, a situation attributed to the broad adaptability of the cultivars grown in eastern Canada (Dale, 1989). In the recent past, 'Veestar' was the primary early-season cultivar in the region, but presently 'Annapolis' has overtaken 'Veestar' as the most popular early-season cultivar (Table 2). There is no consensus concerning an early-season cultivar for the future, although the 1994 release 'Mohawk' is attracting considerable attention (Galletta et al., 1995b).

From the mid-1980s to the early 1990s, the principal midseason cultivar was 'Redcoat' (Table 2). However, 'Kent' displaced 'Redcoat' in this period (Dale, 1989). More recently, 'Glooscap' and 'Honeoye' have also been rapidly gaining in popularity and acreage. Currently, 'Kent' and 'Honeoye' are the primary midseason cultivars with 'Cavendish' being planted despite its tendency for uneven ripening. Due to its excellent shipping characteristics, 'Jewel' is being planted also. The primary new midseason cultivar growers are considering is 'Mira' (1996), which is productive and has good fruit shape and size, and shipping characteristics.

In the past, the primary late-season cultivars for the region were 'Blomidon', 'Bounty', 'Micmac', 'Sparkle', and 'Vantage' (Table 2). However, due to the large seasonal gradation between the southern and northern most extremes of these provinces, there has not been a large need for late-season cultivars in eastern Canada. Generally, by the time the southern growers are finishing up with their midseason cultivars, the north-

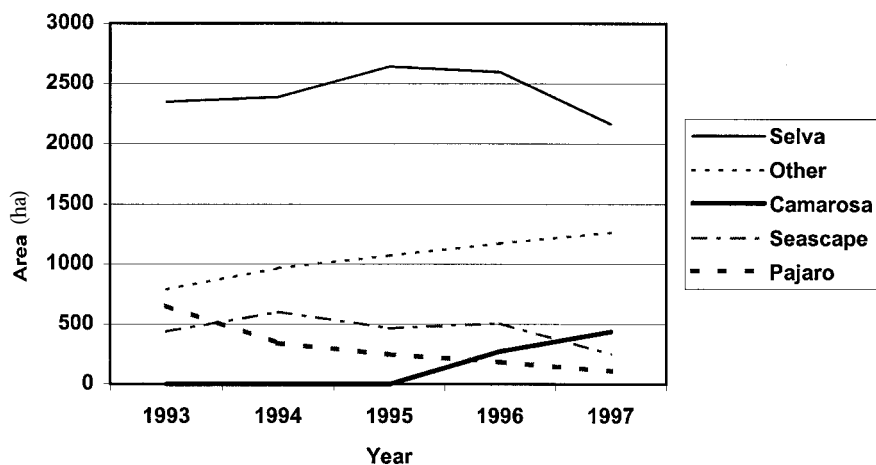
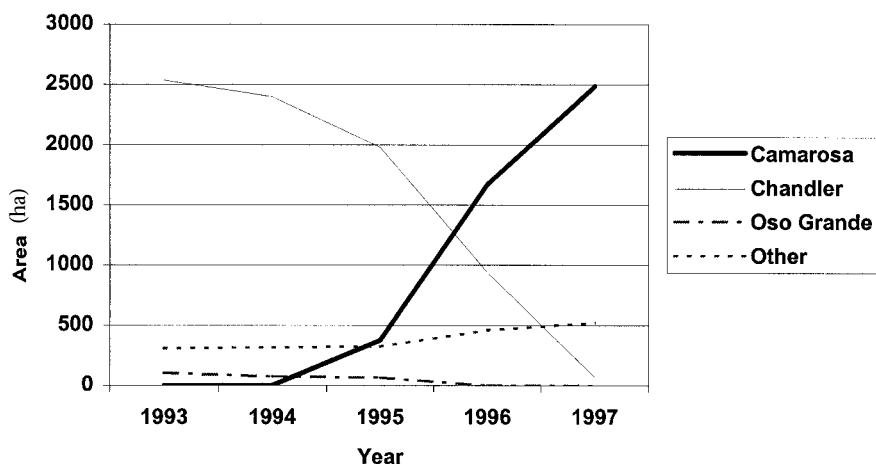


Fig. 1. (above) Acres of the major strawberry cultivars planted in northern California from 1993-97 (California Strawberry Commission, 1997); 1 ha = 2.47 acres. (below) Acres of the major strawberry cultivars planted in southern California from 1993-97 (California Strawberry Commission, 1997).



ern growers are just beginning to harvest their midseason cultivars. As a result, the acreage devoted to these late-season types is not extensive. The late-season cultivars that are used are generally older cultivars such as 'Bounty', 'Micmac', and 'Sparkle' (Table 2). Two releases from the Horticultural Crops Research Institute of Ontario, 'Governor Simcoe' (1985) and 'Startyme' (1995) are being planted to a small degree in Ontario as late-season cultivars.

Strawberry production and cultivars in the western United States

Strawberry production in the western U.S. is dominated by California and the Pacific Northwest (PNW)

(Oregon, Washington, and British Columbia). The California industry dwarfs the industries in all other parts of the U.S. and has been the world leader for many years. New cultivars that will produce fruit that are visually appealing and that can be shipped throughout the world while maintaining acceptable quality are being developed. New cultivars, if accepted, can quickly dominate the acreage planted. Fruit for the fresh market are expensive to produce and are generally sold at a premium price. California is also the leading producer of fruit for the processed market; however, this is largely a by-product of the fresh market industry. While the industry has major concerns with Mexican and other offshore production areas, the elimination of methyl bromide fumigation,

harvest labor, and, especially in southern California, urban encroachment, the industry continues to be very strong. Concerted cooperation among industry commissions, growers, researchers, and packers suggests that these major problems will be overcome.

Unlike the eastern U.S. and California, much of the industry in the PNW is devoted to producing high-quality strawberries for the processing industry. Although the region is the second most important in North America for the production of processing fruit, it produces the world's highest quality processing strawberries. While there is substantial production for the local fresh markets in the Puget Sound area near Seattle-Tacoma, Wash., the Fraser River Valley near Vancouver, B.C. and Willamette Valley near Portland, Ore., a very high percentage of the acreage in the region is devoted to producing solely for processing. New cultivars developed for processing must cap (removal of calyx in the field as the fruit are picked) easily, have intense flavor, deep red exterior and interior color, maintain integrity after being processed (low drip-loss), and have high acid and sugar levels. In contrast to the cultivar situation for the fresh market, the processing industry relies on a very small number of cultivars that maintain market share for long periods of time, which renders the region's strawberry cultivar situation somewhat static.

While California continues to increase its production, the PNW industry is trying to find their place in the world strawberry market. The PNW cannot profitably sell fruit at the low prices that are common in California. In 1996 the price paid for processing strawberries in California was as low as \$0.37 to 0.44/kg (\$0.17 to 0.20/lb) while the northwest price was at \$0.92/kg (\$0.42/lb). In the PNW, \$0.92/kg is not generally considered high enough a price to break even. In addition, the June-bearing cultivars grown in the PNW only average yields of 16,000 to 23,000 kg·ha⁻¹ ((14,080 to 20,240 lb/acre), much less than the 110,000 kg·ha⁻¹ (96,800 lb/acre) that California growers are capable of producing with California-adapted cultivars.

East of the Cascade and Sierra Nevada mountain ranges, the strawberry production picture changes dra-

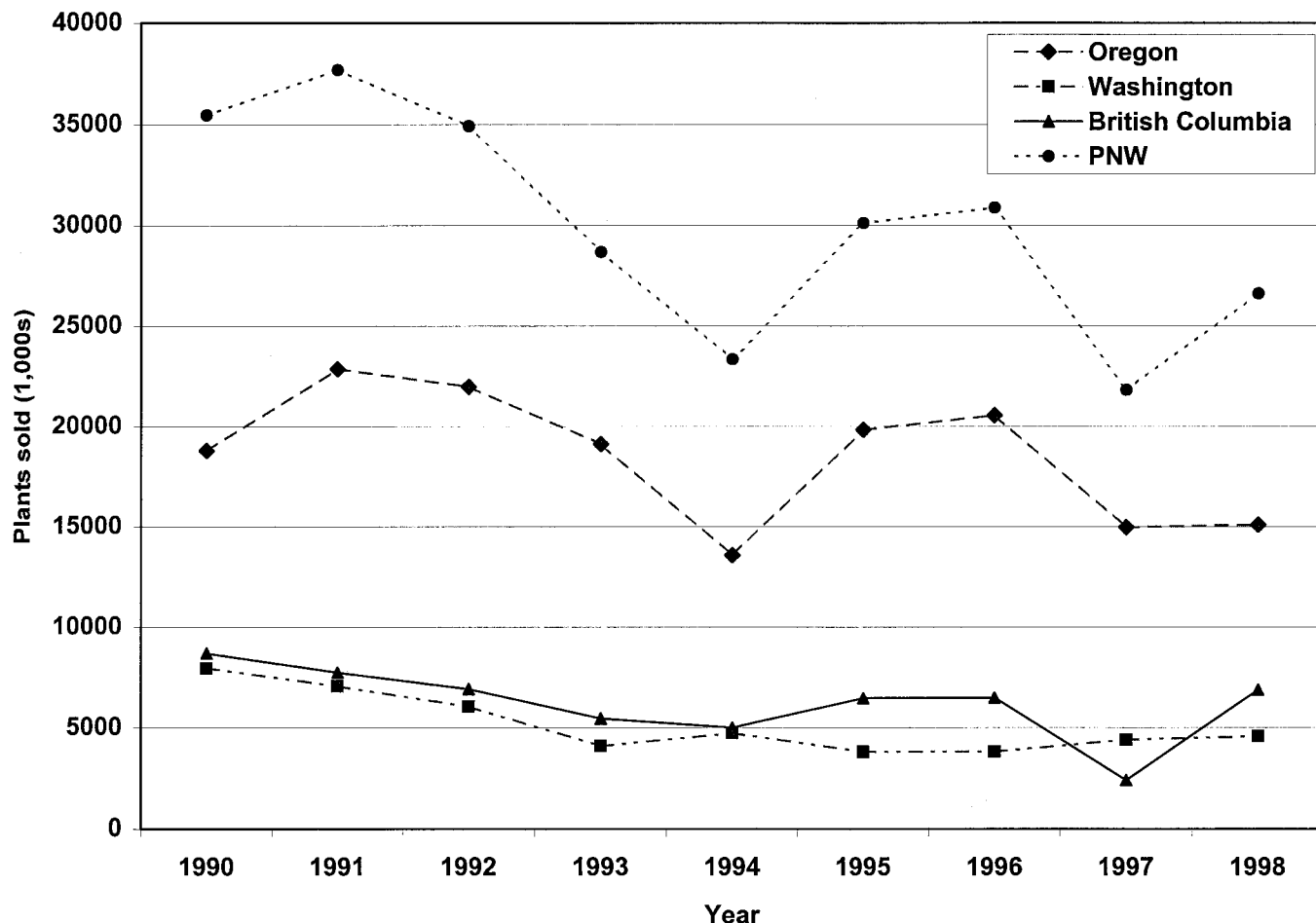


Fig. 2. Total number of strawberry plants sold in British Columbia, Washington, Oregon, and overall in the Pacific Northwest (P. Moore, personal communication); 1 ha = 2.47 acres.

matically and begins to more closely resemble traditional eastern U.S. production. In these regions, a wide variety of cultivars are grown in small acreages for pick-your-own or local market sales. These areas tend to be planted with older cultivars that have proven reliable in specific regions. Due to the small acreages and the fact that strawberries are usually produced as part of a diversified farming operation, there are very poor statistics available on the acreage in production in these western states and the mix of cultivars that are grown.

CALIFORNIA. In California, nearly all of the strawberries are produced in an annual production system on fumigated soil on raised beds, mulched with plastic. The California industry is properly viewed as two major regions. Production in the southern California region (e.g., Orange County near Los Angeles) is dominated by June-bearing (short-day) cultivars that ripen fruit from early January until April or May. Production of day-neutral types in the northern California region (e.g.,

Watsonville and surrounding areas) begins in April, and continues until October or November. As northern California comes into production with a crop of primary fruit, the southern California fruit crop begins to be diverted to processing. Thus, most of the California processing crop comes from southern California.

SOUTHERN CALIFORNIA. The acreage planted to different cultivars in southern California has shown a remarkably quick and dramatic shift from 1995–97 (Fig. 1a). Whereas ‘Chandler’ had dominated this market during the first half of the 1990s, it had all but disappeared by 1997. While ‘Chandler’ was excellent for the fresh market, its predominance could also be attributed to the fact that it had better internal color and flavor than many of the major California cultivars of the 1980s, making it much better for processing. ‘Chandler’ has also proven to be remarkably adaptable in terms of its cultural requirements, e.g., date of planting, fertilizer regimes, and temperature limitations.

The rapid success of ‘Camarosa’, while remarkable, was not completely surprising. Before the introduction of ‘Camarosa’, southern California was not a major supplier to the fresh market until the beginning of February. With the introduction of ‘Camarosa’, southern California became capable of producing a marketable crop in early January. While ‘Camarosa’ has excellent firmness, size, shipping quality and earliness, it does not have ‘Chandler’s’ fresh market eating quality or its processing quality. In 1996, the year just prior to ‘Camarosa’s’ complete domination of the market, the environmental conditions were ideal for its production. In the last 2 years, environmental conditions have been less conducive to outstanding performance, prompting the recognition that ‘Camarosa’ is not the perfect cultivar. Subsequently, while not as obvious as in northern California, there has been a steady increase in the “Other” category of cultivars in southern California, due in large part to the increased importance of proprietary cultivars.

NORTHERN CALIFORNIA. The northern California industry, centered near Watsonville and Salinas, has been dominated by the day-neutral 'Selva' (Fig. 1b). 'Selva' reliably produces a large crop of mild-flavored, firm fruit that have excellent shipping characteristics. 'Pajaro' and 'Seascape', which had been important cultivars for this region, are slowly disappearing from plantings. Surprisingly, 'Camarosa', a short-day cultivar, has been planted on 440 ha (1,100 acres) in this region. The other major trend has been the increase in importance of proprietary cultivars. There are at least five active private breeding programs in California that have developed their own cultivars and these are grown along with the UCD developed cultivars. While these proprietary cultivars account for signifi-

cant acreage in northern and southern California, they are not available to noncontracted growers. Increasingly, European strawberry breeding companies are testing their selections in California in hopes of capitalizing on the lucrative plant sales market there.

The new series of cultivars released from the UCD program in 1998 are starting to be tested enough to see their potential. The latest estimates are that 'Diamante' (Shaw, 1996a) and 'Aromas' (Shaw, 1996b) may make a significant impact on 'Selva' and 'Seascape' acreage worldwide (D. Shaw, personal communication). 'Gaviota' (Shaw, 1996c) has garnered some interest as it has fresh market potential and has processing characteristics more similar to 'Chandler'. 'Gaviota' is also unique because, while it is a short-day

type plant, it tends to return to fruiting in northern California with a pattern that is not distinguishable from many day-neutral cultivars.

The California industry will continue to be the world leader in fruit production, development of new production systems, and new cultivars. New cultivars with increased yield, quality, and horticultural characteristics will continue to arise from the various California programs due to the potential financial payoff if a new cultivar gains a significant market share, and the intense competition within the industry to have the best cultivar possible.

PACIFIC NORTHWEST. The PNW presents two somewhat different faces. In general, the predominant industry is for processing, centered in Oregon

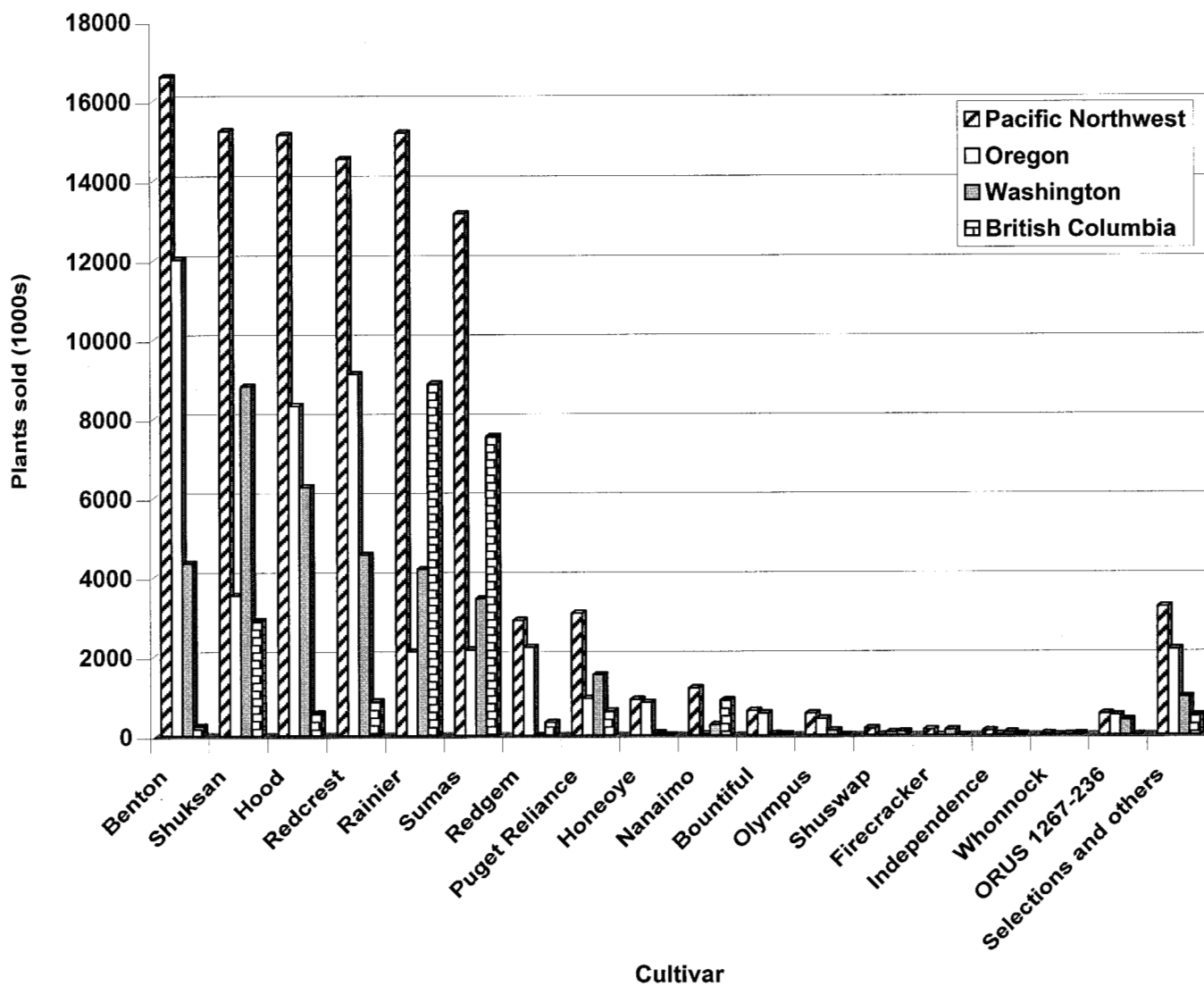


Fig. 3. Strawberry plant sales in British Columbia, Washington, Oregon, and overall in the Pacific Northwest for cultivars other than 'Totem' from 1990-97. 'Totem' is not included on this figure because it skews the graph so substantially that any other evaluations are difficult. (P. Moore, personal communication).

and based on the cultivar 'Totem' (Fig. 2). Another much smaller component of the industry involves production for the fresh market on smaller farms that market on the farm (U-pick, prepicked) and in small, local wholesale markets. Whether fruit are produced for fresh or processed markets, the plants are grown in a matted row production system. The plantings are cropped for two and occasionally three fruiting seasons. Farms producing for the processing market average around 15 to 25 ha (37.5 to 62.5 acres) with some operations ranging up to 80 ha (200 acres). For fresh market and local sales, the farms are small with strawberry plantings ranging from 0.5 to 2 ha (1.25 to 5 acres) in size.

PROCESSING MARKET. In 1997, 'Totem' accounted for 82% of the strawberry acreage planted in Oregon. Over the last 9 years, 74% of the acreage in Oregon and 62% of the entire PNW has been planted in 'Totem' (P. Moore, personal communication). 'Totem' was released in 1971 and it is amazing that it is still so popular today (Daubeny et al., 1993). 'Totem' has maintained its popularity for several reasons. First, it is an outstanding genotype with excellent processing characteristics including intense flavor, high acidity, high sugar levels, solid red internal color, and the capacity to maintain integrity after processing. Second, 'Totem' is well adapted to the region with tolerance to most disease and virus pressures. Because 'Totem' has been grown in nearly a monoculture for 15 to 18 years, there are increasing concerns that it is now succumbing to a new resistance-breaking strain of the red stele root rot pathogen. Lastly, 'Totem' is popular due to the familiarity processors have with its processing characteristics; they know how it behaves in all their different product formulations. Adding new cultivars necessitates many adjustments to these formulations and the processing lines, therefore, it is very difficult to convince the processors to accept a new genotype.

Figure 3 depicts strawberry plant sales in the PNW by cultivar, excluding 'Totem'. Inclusion of 'Totem' in the figure obscured an illustration of many of the region's less significant cultivars. 'Totem' accounted for more than 160 million plants sold over the last 9 years in the PNW; 121 million in Oregon, 33 million in British Columbia,

and 12 million in Washington. 'Hood' and 'Redcrest' are currently the second and third most popular cultivars for processors in the region respectively (Fig. 3). Relatively similar numbers of these cultivars have been sold in the PNW over the last 9 years with a high proportion of the 'Hood' plants being sold in Washington. While 'Hood' produces an excellent crop in Washington, the high percentage of this cultivar used in the state is influenced by contract sales to a few large processing operations. 'Hood' was released in 1964, before 'Totem', and its popularity has fluctuated over the years, although a blend of 'Hood' and 'Totem' for premium ice cream manufacturers is considered ideal. While 'Hood' is outstanding for processed flavor and excellent for other processing characteristics, it is virus susceptible and without adequate vector [strawberry root aphid (*Aphis forbesi* Weeed), strawberry aphids (*Chactosiphon fragaefolii* Covkerell, *C. jacobi* H.R.L., *C. minor* Forbes, *C. thomasi* H.R.L.)] control, the plants may succumb to virus soon after their first crop. 'Redcrest' is similar to 'Hood' in many ways. Overall, 'Redcrest', released in 1990, (Stahler et al., 1995) may be the most outstanding PNW cultivar for processed fruit quality and it can produce very high yields. Unfortunately, on some sites it can succumb to root rot, it is susceptible to virus pressure and powdery mildew [*Spaerotheca macularis* (Wallr.:Fr.) Jacz. f. sp. *fragariae* Peries], and ripens its fruit late. While late ripening has some advantages, processors are often anxious to move on to the next fruit or vegetable in the season and do not like keeping their strawberry lines running late in the season.

A number of processing cultivars have had and continue to have a minor impact on the PNW industry. Most prominent among these are 'Redgem' and 'Bountiful'. 'Bountiful', released in 1993, fell into disfavor with the region's growers due to a relatively small average fruit size, particularly in the second year. More recently, growers in colder regions of British Columbia found 'Bountiful' suitable for their processing needs. 'Puget Reliance', released in 1994, (Moore et al., 1995) may yet prove to be an important cultivar. 'Puget Reliance' is similar to 'Totem' in most processing characteristics but has a lighter internal color

and a higher drip loss. 'Puget Reliance' is virus tolerant, high yielding and produces large fruit. 'Nanaimo', another 1995 release (Daubeny and Kempler, 1997), was expected to be planted for the processed and fresh market; however, its size drops too quickly to justify picking costs for processing.

FRESH MARKET. As in the eastern U.S., the PNW fresh market strawberry industry is concentrated around population centers. A larger number of cultivars are included in the fresh market mix compared to the processing market, and big differences in cultivar popularity can be seen in the region (Fig. 3). 'Benton', originally released for the processing market in 1975, is now widely planted for the fresh market, primarily in Oregon. 'Benton', a late midseason cultivar, has excellent fresh flavor, medium-sized fruit, and an extremely vigorous plant even under virus pressure. 'Shuksan', a midseason cultivar, has been much more popular than 'Benton' for Washington growers, partly due to its cold hardiness. Released as a dual-purpose berry, 'Shuksan' has largely found its home as a reliable berry for roadside market and U-pick sales. 'Hood' is also grown for the early-season fresh market and has strong name recognition among consumers. Further north, 'Rainier', and 'Sumas' have become popular, particularly in British Columbia. 'Rainier', a sister seedling of 'Shuksan', was released in 1972. While it garnered some interest with the processors in the 1970s, it has primarily been used as an attractive, high-quality berry for local fresh market sales in the late midseason. 'Sumas' (Daubeny, 1987) is a reliable, early-season producer that is winter hardy, tolerant of virus, and resistant to red stele root rot. Some interest in 'Honeoye' as a very early-season berry developed in the late 1980s and early 1990s but difficulties in reliable cropping led to few new plantings.

Generally, cultivars developed in the PNW were selected for the processing market and therefore have characteristics more suitable for processing. These processing types can be very desirable for a U-pick customer who intends to immediately freeze the fruit. The processing-type berries are difficult to sell retail for fresh use because they have a very short shelf-life. Some growers who are oriented towards the

wholesale market are choosing California cultivars such as 'Selva'.

The trends of the last 20 years will continue in the western U.S. The California industry will continue to prosper with its ever-changing mix of cultivars that are ideal for shipping around the world. The PNW will continue to dominate some of the processing niches that have defined it for some time with a gradually shifting complex of cultivars and a fresh market largely dependent on a mix of cultivars developed for processing. The regions between the western Great Plains and the Cascades will continue to rely on a wide mix of cultivars for their diverse locations.

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