What's Going on in the World of *Rubus* Breeding?

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Abstract

"Only one more generation" has been the breeder's cry in the past, the present and will continue in the future. As we look around the world, we are faced with many of the same challenges we have always faced as the industry needs cultivars with excellent quality, higher yield, greater pest resistance and adaptation. We rely on a mixture of strong science, a keen eye and traditional breeding approaches to meet these demands. As we move forward, old issues are resurfacing, new problems are arising, and whole new production systems, business systems, and production areas are being developed and will soon dominate parts of the industry. As breeders, we are asked to meet these demands with new cultivars.

INTRODUCTION

A recent survey indicated that there are roughly 30 *Rubus* breeding programmes, predominantly red raspberry, in 19 countries that will be a source of these new cultivars. New germplasm, molecular tools and active, imaginative breeders are helping us to attack old problems in new ways, adapt to the changing production and business systems of the international market, develop whole new crops such as primocane fruiting blackberries, and berries for completely new markets (e.g. nutraceuticals). Private companies with their own breeders and proprietary cultivars or public breeders with some part of their programme privatized are no longer an anomaly and no longer regional. They are driven and effective as they apply their skills far from home but the proprietary nature of the material leads to concern about long term effects on germplasm exchange. While administrators are primarily concerned with the potential monetary returns that patents will bring into a programme and use it as justification to decrease funding to programmes, breeders face the fact that few cultivars generate the amount of return that the administrators envision. While we are still largely using conventional approaches, good science, and a keen eye, the world of *Rubus* breeding continues to change.

THE CURRENT SITUATION

A survey was sent out to all known *Rubus* breeders in early 2001 to assess the state of their breeding programmes. While we know we are underestimating the world picture, the survey indicated that there are at least 30 *Rubus* breeding programmes in 19, primarily European and North American, countries that will be a source of new cultivars (Table 1). These programmes have produced at least 105 red raspberry and 50 blackberry cultivars in the past 20 years (Table 2). The bulk of these programmes emphasize red raspberry rather than blackberry. Within the red raspberry programmes, there are programmes solely devoted to floricane fruiting types but the emphasis on primocane fruiting types ranges from zero to 100% more compared to floricane types. There are about seven programmes that include black raspberry breeding but none cited black raspberries as their main programme. Of the 15 programmes that are breeding blackberries, only the USDA-ARS in Oregon and the University of Arkansas have large programmes and listed these as their primary *Rubus* breeding programme. These programmes work with two different blackberry types (erect and trailing) derived from very different species background.

Despite budgetary cutbacks, most breeders reported that their programmes were either maintaining their current size or expanding. Breeding programmes vary in their mix of federal, state, commodity and royalty support. The portion of the support coming from the

government is generally decreasing, with commodities being asked to pay more and royalties becoming more important. Many programmes feel that, while they have been able to maintain their programmes fairly well to date, more budget cuts will result in significant modification of their programmes.

Unsurprisingly, the core primary objectives in raspberry and blackberry breeding programmes have remained consistent and include: high quality fruit, good yields, suitability for shipping if fresh market, machine harvestability and suitability for processing for the processing market, adaptation to the local environment and improved pest and disease resistance. In raspberry, resistance to *Phytophthora fragariae* var. *rubi* is a universal goal and with the loss of effectiveness of most root rot fungicides the need is even more acute. In our survey European programmes were very concerned with cane *Botryti*s, spur blight (*Didymella applanata*), and cane spot (*Elsinoe veneta*) on raspberry, but in America resistance to raspberry bushy dwarf virus (RBDV) was of much greater concern particularly in the Pacific Northwest where RBDV has reached epidemic proportions. Now RBDV has been found in 'Marion' blackberry and research has shown a substantial drop in yield for these infected plants. It is too early to tell, but we may soon have to begin searching for resistance in blackberry for RBDV. In blackberry, spineless types are essential and there are an increasing number of erect spineless cultivars. While there are only a handful of thornless trailing cultivars, it is expected that within a few years there will be a wider choice. As raspberries are grown in hotter, more humid climates, and blackberries are grown in colder climates, there is an increased effort to develop cultivars adapted to the biotic and abiotic stresses that come with these "new" environments.

Molecular genetics, including transgenic technologies, has been cautiously added to the *Rubus* breeder's toolbox. The public discourse on this subject has yet to run its course and until it does it will be difficult to embrace this technology fully. Survey responses ranged from strongly negative to actively positive, with RBDV-resistant transformed raspberries being tested in commercial fields. In addition to RBDV-resistant 'Meeker' and parthenocarpic 'Ruby', attempts have been made to develop other transformed raspberries. While regeneration tends to be easier in blackberry than raspberry, there were no examples of successfully transformed and regenerated blackberry. Transformation for greater cold tolerance has been successful in 'Marion', and attempts to regenerate transformed plants are underway. The programmes that were using molecular tools were most commonly looking at marker assisted selection, mapping, and genetic fingerprinting in raspberry.

While not a molecular tool, techniques to utilize the power of flow cytometry have been developed and used to estimate ploidy and DNA content in *Rubus*, better plan crosses, identify truly hybrid progeny in wide crosses, and for taxonomic purposes.

Most programmes have some of their program devoted to the evaluation and incorporation of species germplasm. At least 16 species, primarily raspberry types but many from Asia, have been evaluated and used as sources of new traits in Europe. In North America, at least 58 species have been similarly evaluated and the observations presented elsewhere in this *Acta*. While European efforts, particularly at Horticulture Research International (HRI), are generally further along in utilization of species material, there are examples of red and black raspberry cultivars recently developed in America that have species other than *R. idaeus* or *R. occidentalis* in their background. Species material has proven to be an outstanding source of pest and disease resistance and new or novel traits. The tremendous diversity of wild *Rubus* germplasm suggests that there are many other potential sources of new traits. Since this germplasm pool is so dauntingly large, it serves as an excellent example where cooperation and continued germplasm exchange is essential. No one programme can do it all. As an example, *R. innominatus* has been identified by at least four N. American programmes as being an outstanding species to work with and yet it does not appear to have been evaluated in Europe. Instead of recreating the wheel, germplasm containing this *R. innominatus* background should be sent to Europe. European material with the Asiatic species *R. cockburnianus, R. crataegifolius* and *R. lasiostylus* in its background was sent to N. America from HRI 20 years ago. 'Kitsilano', which was derived from 'Comox' and an HRI *R. crataegifolius* selection, was the first cultivar to be released with *R.*

crataegifolius in its ancestry. Also HRI breeding lines derived from the N. American *R. spectabilis* have been returned to N. America.

Blackberry germplasm efforts are much less advanced, as a result of the following: (i) the smaller size and number of programs; (ii) most cultivars are relatively recently removed from their progenitor species; (iii) most cultivars have several species in their immediate background; and (iv) blackberries are generally much more pest and disease tolerant than red raspberry. Nonetheless, concerted efforts to intensively evaluate valuable species such as *R. ursinus* have been made and cultivars have been released with novel new germplasm background (e.g. 'Chesapeake' with *R. cuneifolius* background).

CHANGING TIMES

Production and Business Systems

Tunnel production, while not new in Europe, has dramatically increased around the world in the last few years. Today, much of the fruit produced in California for the N. American fresh market is being produced in tunnels. While many available cultivars are reasonably well adapted to this system, "tunnel cultivars" could be developed quickly if more seedlings were evaluated in tunnels. Most selection is done in the open field and relatively few selections have been assessed for tunnel production prior to release.

Machine harvesting has shifted from a business option to an essential business practice for processed fruit, especially in countries where picking labor is expensive or simply unavailable. In general, most blackberries harvest fairly easily and it is raspberries that have a broad range of response to machines. In crops such as blueberry, some producers are striving to sell a fresh product that has not been touched by human hands. In this case there are certainly cost concerns but food safety is really driving this issue. We may need machine harvested raspberries and blackberries for the fresh market for the same reasons. While selections are evaluated for ease of removal by hand, shaking, or based on how much ripe fruit is on the ground, until a machine is run over a selection you cannot be sure whether it will pick well without excessive plant damage. This has pushed some breeding programmes to obtain machines and others to get their selections onto farms where they can be machine harvested earlier in the evaluation process.

Primocane raspberries have been a viable commercial option for over 25 years. They now form the foundation for much of the fresh market industry and lend themselves to cultural manipulation that can lead to nearly year round production. Primocane fruiting blackberries are nearing commercialization. Within the past 10 years decent sources of this trait out of 'Hillquist' and *Rubus* species have been incorporated into advanced selections that are in their final testing. Primocane fruiting blackberries could revolutionize the fresh market blackberry industry to an even greater extent than the trait did for the raspberry industry. Most blackberry cultivars are not winter hardy enough for northern climates but primocane fruiting blackberry production will be possible.

Is the interest in nutraceuticals a fad or trend? The market for blueberries has increased dramatically due to studies that showed them to have high levels of antioxidants. The blueberry industry has been able to turn this good science into large increases in sales especially in receptive markets such as Japan. The good news is that red raspberries have more of these antioxidant or "nutraceutical" compounds (i.e. anthocyanins, phenolics, ellagic acid) as measured by ORAC or FRAP than blueberry, that blackberries have more than either and that black raspberries are highest of all (Moyer et al., 2002). The bad news is that blueberries were the first to be marketed in this way and are now firmly fixed in the consumers' mind. If it gets to be a case of extracting compounds and putting them in a pill, berries are likely to lose as commodities such as purple carrots can be produced much cheaper than berries. The question for breeders then becomes, how much, if any, effort to put into breeding for higher anti-oxidant levels. We already have much higher levels than most fruit crops and selection for this trait currently involves time-consuming evaluations. Many wild *Rubus* species have been used in Chinese medicine for centuries but we do not know how they work. There are other health-promoting compounds, such as ellagic acid, present at

high levels in raspberries and, if the early results are confirmed, there is great potential to encourage and increase raspberry consumption on nutritional grounds.

Globalization has increased the pressure to obtain the highest price for horticultural products. This has driven caneberry production to greenhouses, tunnels and the far reaches of the world in search of year round production that can be shipped fresh anywhere that favourable market conditions exist. This requires cultivars that can be manipulated to produce outside of their traditional environments and they must produce fruit that can handle the rigours of shipping and still be appealing to the customer. Breeders and horticulturists are doing a great job on the production end of the business but several breeders are concerned with the short term solution to handling long term shipping problems. The current trend is to select for fruit that can be picked easily at a very light colored, unripe stage. While this gets a great looking fruit to a distant, profitable market, it does sacrifice flavor. It would be a pity if we followed the strawberry industry and produced beautiful but bland berries. The consumer can only buy what is on the shelf and the whole industry must convince the buyers that flavor is just as important as appearance.

New Production Areas

The billion-person market in China offers attractive opportunities for many agricultural and horticultural sectors, but the caneberry industry must remain aware of what happened recently to the U.S. apple industry. The now huge Chinese apple industry sent vast quantities of inexpensively priced juice concentrate on to the market leading to a collapse of the historical pricing structure of apples and leading to the demise of a large part of the Pacific Northwest apple industry. China and other countries with very low labor costs and a low average standard of living want to produce crops that can bring in hard currency. Fruit crops with their limited land and high labor needs fit their needs very well. Until the native people in these countries begin to demand these products, most will be exported at a price that will be difficult for the developed countries to match. China has planted raspberries and blackberries that will soon be entering the processed market. This will impact breeding in several ways. We will be forced to produce cultivars that are even more efficient as quickly as possible. These distant producers will have a disadvantage in the fresh market for quite some time but the processing market in all countries will be under pressure. Finally, for those of us funded by industry, if the industry is competing poorly they will be less able to fund breeding, or any research, at current levels.

The Privatization of Breeding and the Rise of Importance of Patenting

Private companies with their own breeders and proprietary cultivars or public breeders with some part of their programme privatized are no longer an anomaly and no longer regional. They are driven, focused and effective as they apply their skills far from home. The obvious advantage of having cultivars that are tailored to the company’s production environments and markets drives some of these efforts. The privatization of portions of public programmes is driven by desperation to keep the programmes alive. The management of these public programmes demands that they be largely self-supporting. In order to do this, they must either patent cultivars that return tremendous royalties (probably untenable) or enter into agreements with private producers who want their own cultivars without going to the expense of setting up their own breeding programme. The swing towards privatization of public programmes may swing back as one survey respondent noted that “Privatization has proved too costly and has given us textbook examples of "market failure" to the detriment of our real customers - growers and the consuming public.”

Patenting has reduced levels of germplasm exchange. Patents, breeder's rights, and licenses, while not new, are now the standard for anyone who is not associated with the U.S. Department of Agriculture. While we seem to be coming out of a maelstrom as we all become more comfortable with the process and its implications, there are still many concerns as to what the long term effect of the restrictions inherent in patenting will have on germplasm exchange and broad testing of materials. These issues lead to several unfortunate outcomes including the decrease in germplasm exchange, decrease in information exchange,

and the further erosion of support for regional public programmes. Germplasm exchange, a highly successful cooperation between breeders that has helped the raspberry and blackberry industries of many countries, has been and will be decreased. The long-term effects of this will be significant. The effect of producers hiring a public breeder can be more insidious. Usually the producers who can afford these breeders are the same ones who can most effectively help with on-farm testing and lobbying for government support of the regional programmes. While competition is probably good in some ways for these regional programmes, if their support withers, the smaller growers within the regional industry will be disadvantaged.

Program Funding

As has been touched on repeatedly, the changing world politics, changing view/role of government, changing markets, and patenting all are impacting the funding of breeding programmes. As markets become tighter and profits smaller, it is increasingly difficult for growers to continue to fund long term breeding efforts at their current levels. Administrators think patents will bring large amounts of money into a programme and use this as justification to decrease funding to programmes. On the other hand, breeders must face the fact that few cultivars generate the amount of return that the administrators envision. Nonetheless we are an optimistic bunch and adapt to change by coming up with better, more efficient, and more focused breeding efforts to meet the needs of our growers.

CONCLUSION

After decades of relative stability and public funded breeding programmes serving their regional industries with locally adapted cultivars, there has been a period of great change in *Rubus* production worldwide and these changes are likely to continue. Some of the emerging production areas have no associated breeding programmes while some of the existing programmes are serving industries that are currently contracting. Only programmes with good resources will be able to exploit the new market for raspberry and blackberry cultivars, and this will strengthen these programmes still further.

While we are still largely using conventional approaches, good science, and a keen eye, the world of *Rubus* breeding continues to change rapidly before our eyes. We have met the needs of our varied industries in the past and will do so admirably into the future.

Literature Cited

Moyer, R., Hummer, K., Finn, C., Frei, B. and Wrolstad, R. 2002. Anthocyanins, phenolics and antioxidant capacity in diverse small fruits: *Vaccinium*, *Rubus* and *Ribes.* J. Agric. Food Chem. (in press).

Tables

Table 1. *Rubus* breeding programs worldwide.

Country	Location
Australia	Inst. Horticultural Develop., Knoxfield, Victoria
Bulgaria	Kostinbrod
Canada	
British Columbia	Agriculture and Agri-Food Canada, Agassiz
Nova Scotia	Agriculture and Agri-Foods Canada, Kentville
Ontario	University of Guelph, Guelph
Chile	Hortifrut, Santiago
China	Beijing Institute of Pomology & Forestry, Beijing
Germany	Freising-Weihenstephan
Hungary	Fertod
Italy	Ancona
Latvia	Dobele
Norway	Njos
New Zealand	HortResearch, Inc., Motueka
Poland	Brzezna
Romania	Maracineni-Pitesti
Russia	VIR, St. Petersburg
Serbia	Cacak
Sweden	Balsgard, Kristianstad
Turkey	Antalya
United Kingdom	
England	Medway Fruits, Maidstone
England	HRI-East Malling
Scotland	SCRI, Dundee
USA	
Arkansas	Univ. of Arkansas, Fayetteville
California	Driscoll's Assoc., Watsonville
California	Plant Sciences Inst., Watsonville
Maryland-New Jersey	Univ. of Maryland, Rutgers Univ., Virginia Tech,
Virginia-Wisconsin	Univ. of Wisconsin Cooperative Program
Maryland	USDA-ARS Beltsville
Minnesota	Univ. of Minnesota, St. Paul
North Carolina	N.C. State University, Raleigh
Oregon	USDA-ARS, Corvallis
Washington	Wash. State Univ., Puyallup
Washington	Multiple private programs

Table 2. Raspberry, blackberry/hybridberry cultivars released since 1980.

Location of releasing program	Cultivar
Red raspberry	
Australia	Alkoopina, Bogong, Dinkum, Glen Yarra
Bulgaria	Raliza, Samodiva, Ljlin, Essenna Poslata
Canada	
British Columbia	Chilliwack, Comox, Kitsilano, Malahat, Qualicum, Tulameen
Manitoba	Double Delight, Red River, Souris
Nova Scotia	Nova
Ontario	OAC Regal, OAC Regency
Quebec	Perron's Red
Czech Republic	Granat
Denmark	Zenith
Finland	Jatsi, Jenkka, Ville
France	Favorite, Galante, Meco, Princess, Wawi
Germany	Rusilva (Rrabant), Resa (Lucana), Rubaca (Naniane), Weirula
Hungary	Fertodi aranyfurt, Fert. Carmen, Fert. ketszertermo, Fert. zamatos
Mexico	Gina
New Zealand	Clutha, Rakaia, Selwyn, Waiau, Waimea
The Netherlands	Marve
Norway	Balder, Vene
Poland	Beskid, Nawojka, Polana, Polka, Pokusa, Poranno Rosa
Romania	Citria, Ruvi, Star
Serbia	Podgorina
Sweden	Ariadne, Boheme, Carmen
Switzerland	Elida, Framita, Himbo Star, Himbo Top
UK	
England	Autumn Bliss, Autumn Britten, Autumn Cascade, Autumn Cygnet, Autumn Byrd, Gaia, Joan J., Joan Squire, Julia, Malling Joy, Malling Augusta, Terri-Louise
Scotland	Glen Moy, Glen Prosen, Glen Garry, Glen Lyon, Glen Ample, Glen Magna, Glen Rosa, Glen Shee
USA	
California	AnnaMaria, Gloria, Godiva, Hollins, Holyoke, Isabel, Joe Mello, Lawrence, Tola, Wilhelm
Minnesota	Nordic, Redwing
NJ/Md/Virg/Wisc	Anne, Caroline, Claudia, Emily, Esther, Josephine, Lauren
New York	Encore, Prelude, Ruby (Watson), Titan
Oregon	Amity, Chinook, Coho, Lewis, Summit
Washington	Centennial
Black raspberry	
USA-Maryland	Earlysweet, Haut,
UK-SCRI	Glencoe

Purple raspberry	
USA-New York	Royalty
Blackberry/hybridberry	
Australia	Murrindindi, Silvan
Hungary	Fertodi botermo
New Zealand	Kaiteri, Karaka Black, Lincoln Logan, Mahana, Mapua, McNicol's Choice, Ranui, Riwaka's Choice, Riwaka Tahi, Taranaki**,** Tasman, Waimate
Poland	Orkan, Gazda
Serbia	Cacanska Bestrna
Sweden	Douglas (different from Douglass patented by B. Douglass)
UK	
England	Adrienne, Helen, Malling Sunberry
Scotland	Loch Ness, Tayberry, Tummelberry
Canada-Quebec	Per Can, Perron's Black
USA	
Arkansas	Apache, Arapaho, Chickasaw, Choctaw, Kiowa, Navaho, Shawnee
California	Pecos, Sonoma, Zorro
Illinois	Everthornless, Illini Hardy
Indiana	Doyle's Thornless
Maryland	Chester Thornless, Hull Thornless, Triple Crown, Chesapeake
Oregon	Black Butte, Douglass, Kotata, Siskiyou, Waldo
West Virginia	Cox's Miracle Berry