BREEDING AND GENETICALLY ENGINEERED ORGANISMS

-Issues relating to Cranberries-

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There are two topics that I will address in this paper:

1. Describe a selection from our breeding program that has advanced to the release stage.
2. Review the latest results with our genetic engineering of cranberry and the obstacles to its commercial use.

New cultivar release

As you recall from our previous presentations, the cranberry breeding program at UW-Madison is designed to be highly focussed on a few goals of potential importance to the Wisconsin industry:

1. Develop cultivars *for Wisconsin* that have high and reliable yield.
   - Consistent yields from season-to-season (not biennial bearing).
   - Yields equal to or higher than 'Stevens'.
2. Develop cultivars with early and intense fruit coloration.
3. Determine the genetically-controlled components of yield. This information will be useful in designing future breeding programs.
4. Develop breeding lines *for Wisconsin* that reliably transmit useful traits. Again, these lines will be invaluable in future breeding efforts.
   - One aspect of this work is to see if our genetically-engineered cranberries can faithfully transmit their engineered traits to progeny.

Work on all these goals has progressed well considering we are dealing with a perennial plant with a much longer life cycle than the easy-to-breed agronomic annual crops. After talking with many growers about their needs and ideas, one of our first efforts was to conduct a series of crosses between a 'Ben Lear'-type cranberry and 'Stevens'. More than 600 progeny seedlings were planted in a bed in the Cranmoor area and from this, a number of early selections were made based on early and intense fruit coloration. These selections were then planted in other test beds. We are pleased to announce that one selection has performed so consistently well that we are now ready to release it to the industry for their planting and evaluation. Briefly this cultivar has been tested in two regions in Wisconsin northern (Phillips) and central (Cranmoor and Biron) and has been observed in the field for more than 5 years. In comparison to other seedling selections and cultivars planted in the same bed or nearby beds, this selection always has had

superior fruit color compared to standard cultivars such as 'Stevens' (Figure 1), 'Pilgrim', and even 'Ben Lear'. In addition, the selection has had estimated yields equal to or greater than the standard 'Stevens' (although these estimates are preliminary as they are based on relatively small plantings).

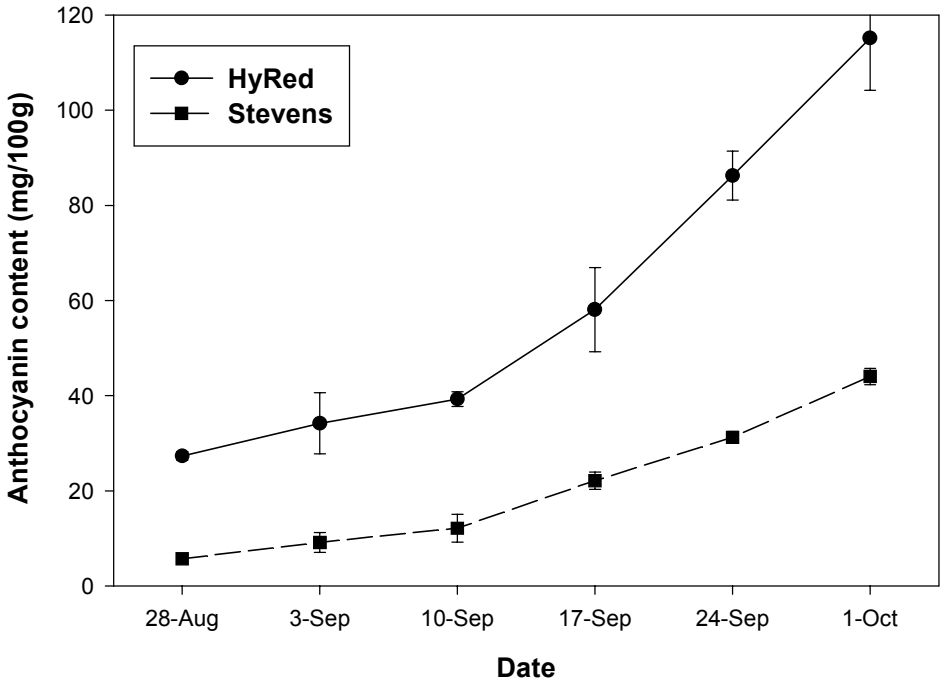

Figure 1. Seasonal fruit color analyses of a new hybrid selection, 'HyRed', compared to the standard cultivar 'Stevens'. Data from plots in the Cranmoor area during the 1997 growing season. Note both the early fruit coloration and very high color levels of 'HyRed'. Similar results were obtained in 1996.

The necessary path involved to finalize such a release consists of a number of steps:

1. Testing
   - Characteristics of this selection in tests:
     - Early maturing.
     - Mid-Sept harvest potential.
     - High color, TAcy greater than 60.
     - Consistently good yields (estimated).
   - The ultimate test will be in larger plantings in grower's fields.
2. We then write-up the data and-
   - Apply for a Plant Patent through WARF (Wisconsin Alumni Research Foundation).
   - Seek Department of Horticulture approval for the release.

3. We need to determine how best to distribute materials to cooperating growers:
    - Do we contract with a professional propagator(s)?
    - Should WCGA or the WCB be involved in managing the release?
    - In any case, we wish to give Wisconsin growers first priority to obtain the plant and then Ocean Spray growers (in any region) will have second priority. Once these demands are met, then any grower can obtain materials.

Probably the hardest step is finding an appropriate name for this selection. We prefer to have the name say something about the plant itself. The leading contender is the name 'HyRed'.

Genetically engineered cranberry

In past years, we reported on our success with applying modern genetic-engineering techniques to cranberry. One of these efforts involved inserting a gene that gives tolerance to the herbicide glufosinate, better known as Liberty herbicide. In mid-90s, we recovered transformed plants of 'Pilgrim' that expressed this tolerance, but at a level that was marginally useful for commercial purposes. We then went on to use this engineered 'Pilgrim' plant as a parent in breeding and recovered many seedlings that also showed tolerance. This work accomplished three purposes:

1. We now know that the inserted gene (originally from a soil bacterium) and its expression is stable in our Pilgrim' plant and thus can be relied upon in commercial settings.
2. This work also demonstrated that we can use regular crossing techniques, perfected earlier to create 'HyRed', to pass this herbicide tolerance trait to other hybrids and selections. Thus herbicide tolerance to glufosinate can now be a part of the parental lines that we are developing for future breeding. For example, we can now preserve the high fruit color and herbicide tolerance traits while selecting for improvement in other important traits.
3. Most startling, some of the progeny showed markedly increased levels of tolerance to glufosinate. One selection has tolerance levels 5-10 times that of originally engineered parent, a level that certainly is commercially useable.

So, why don't we release this engineered cranberry as a new selection? Unfortunately, there are some major obstacles that stand in the way of such an effort. One concern is environmental in character and asks, "Will the genes in this cranberry escape into the wild?" Of course, the answer is yes as we can see no way to absolutely prevent pollen or fruit from moving into areas surrounding plantings of this engineered cranberry. Thus the next question, and the most important environmental one, is, "What will be the ecological effects of the movement of glufosinate tolerance genes?" Cranberry in its native Wisconsin setting is not a dominant plant and occurs as a scattered and patchy component of the groundcover. Thus any changes in cranberry cannot lead to major disruption of the ecosystem in which it grows as a native. In addition, the trait of tolerance to glufosinate will have no relevance in the native areas; we know of no natural sources of this herbicide thus the gene will have no function in native areas. Thus the gene coding for

glufosinate tolerance will not give any selective advantage to those cranberries possessing it. Most likely the gene will be rapidly lost in future generations of wild cranberries. Our conclusion, then, is that the environmental question is not a major detriment to the commercial use of glufosinate-tolerant cranberries.

A second set of obstacles involves getting complete access to the technologies used to create the herbicide-tolerant cranberry. There are at least three different patents that apply to this glufosinate-tolerant cranberry. Although we can get the rights to some of them, efforts by us and others to obtain the right to commercially use the gene that directly codes for the herbicide tolerance have been unsuccessful. In addition, Liberty herbicide is not approved for use on cranberries (although it is approved for many other food crops) and this registration process would have to be pursued.

A more difficult impediment to the commercial use of glufosinate tolerance in cranberry production is consumer acceptance of food products containing this trait. For example, a recent (1999) survey of consumer attitudes in all the EEC countries showed that there was strong negative sentiment in regards to the use of biotechnology for foods. Many consumers strongly agreed with the statement that "biotechnology is not natural". Although the attitude of consumers in the U.S. is not nearly so negative towards biotechnology, that appears to be changing. Since cranberries are considered a "healthful" food that is "natural", do we want to risk a consumer backlash by commercially using cranberries that have employed genetic engineering in their breeding? To us, at least at present, the risk seems too high.

The EEC survey also noted that consumer attitudes toward the use of biotechnology for human health and medicine are relatively positive. One future scenario might be that as the public gets more comfortable with biotechnology as used for medicine, this comfort level will carry over into the use of biotechnology for food purposes. Thus in five years or so, select and beneficial uses such as reducing the use of chemicals in cranberry production areas may become more widely acceptable.

As always, time will tell.