The Wisconsin Cranberry of the Future: A Basic Plant Breeding Approach

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For only about five years now, we have been pursuing a limited breeding program with the overall goal of genetically improving the cranberry for Wisconsin growers. This work resulted in large part from the initiative provided by the Gottschalk Family Endowment to UW-Madison. This endowment has not only provided the funding to support these efforts, but as importantly has built a stable support base so that a long-term effort like plant breeding could be reasonably pursued. This presentation will give an overview of this breeding effort and highlight some of the early findings and accomplishments. This effort is still at the early stages of development and refinement; thus there is ample opportunity for grower input into the goals and working relationships of the program. We hope you all will feel free to discuss your ideas with us.

Principles on which we are basing our breeding program.

For the fist year of the effort, we spent considerable time discussing ideas with growers and colleagues. From this initial discussion, it became clear that Wisconsin growers faced a number of problems that were not of general interest to other major growing areas in the U.S. In addition, there were a number of limitations on the scope of the program that had to be realized and incorporated. The result is a breeding program with the following characteristics and objectives:

- -Non-duplication of the efforts of other breeding programs
- -Focus on problems and potentials of the Wisconsin cranberry industry
- -Must operate under limited resources
    - -No State of Federal dollars would be available to support the effort
    - -No new personnel could be hired to work on the effort
    - -Unlike all other breeding programs, no cranberry research station would be available, thus the field work had to utilize grower sites exclusively
- -Both practical and basic biology objectives should be pursued:
    - -Major practical goals:
        - High yield
        - -Manageable plant:
            - -In sand or peat production sites
            - -In central or northern production areas
        - -Early and intense fruit color under Wisconsin conditions

-Cranberry biology goals
  - -What is the basis of high yield in Wisconsin?
  - -Shorten the time needed to breed cranberry so that progress could be rapid and costs minimized
  - -Techniques to select for the desired traits needed to be refined
  - -When would evaluations made under greenhouse conditions be useful?
  - -What field plot designs are be most cost effective?
  - -What particular genetic and heritable traits do various of cranberry cultivars offer when used as parents?
  - -Is there any value to increasing the ploidy level in cranberry?
  - -How far could cranberry be inbred? Is outbreeding essential to maintain vigor?
  - -How can transgenic cranberry plants be used as parents in a breeding program'?

Some of these goals have received more emphasis than others; these are highlighted in this report.

Shortening the breeding cycle for cranberry.

Utilizing both basic horticultural techniques and some aspects of plant biotechnology, we have developed a methodology that has shortened considerably the time it takes to produce a generation of new cranberry hybrids. This approach is outlined below:

Controlled flowering of potted plants
(Growth retarding treatments)
(Programmed chilling)
⇓
Greenhouse pollinations
⇓
Harvest of unripe fruit
⇓
Excision of seed and germination in sterile culture
⇓
Seedling micropropagation
⇓
Production of transplants
⇓
Field and greenhouse screening

This methodology has allowed us to produce hybrids in 1 to 2 years less time than would normally be required if the natural seasonal cycle of the cranberry was allowed to proceed. Not only has this allowed us to conduct the breeding program more rapidly, but because each generation of seedlings takes less total time to generate, costs are reduced.

Selection and evaluation techniques

What traits might be able to be screened in a preliminary way under greenhouse conditions, thus avoiding the cost and time of field evaluations of useless seedlings? Obviously, traits like manageability cannot be effectively evaluated under anything but field conditions. However, we have found that a trait like early and intense coloration of fruit may be effectively screened under greenhouse conditions. By comparing the relative development of fruit coloration of seedlings along with standard cultivars, differences in the biological tendency to develop early and intense fruit color can be detected. The worst seedlings can then be eliminated before field trials, thus saving considerably on time and costs.

Field plots are both expensive and time consuming. The major expense is maintenance of the plots. In planting a field trial of 100's of seedlings, it is essential that each seedling be kept physically separate from all the others for the 3 to 4 year trial period. Since cranberry is a vine, such physical separation involves periodic pruning of the vines encroaching on adjacent plots. In our experience, this is the single most limiting factor in determining how many plants can be evaluated under field conditions. Even with the very able assistance of the participating growers who have provided not only the site but often helped in the maintenance, properly managing small field trials of cranberries is a major undertaking.

Large individual plots of a seedling are easier to maintain than smaller plots because of a lower proportion of edge. However, large plots take more time to plant and occupy more of the grower's field space. Thus there is a compromise between plot size, maintenance requirement, and total amount of field space required. Presently, our scheme is as follows:

Micropropagated transplants
(Preliminary screening in the greenhouse)
⇓
Discovery field plots
(2'x2' to 4'x4')
(no replicates)
⇓
Performance field plots
(10' x 20')
(replicated)
⇓
Acre-sized plantings

Currently, we have four major field evaluation sites, three in the Cranmoor area and one in the northern production area. Hundreds of seedlings are being evaluated in the discovery plots and a number of early selections have advanced to the performance plots.

Early hybridizations and seedling responses

Our first set of hybridizations utilized a number of parental lines and were designed to both work-out all the methodologies needed to conduct a breeding program with cranberry and test the usefulness of these selections as parents:

-Desired character and parental line used:
- -Manageable plant, dependability: 'Stevens'
- -Fruit size, vigor: 'Pilgrim'
- -Early, intense color: Boone's 'Ben Lear' selections
- -Vigor: 'Norman LeMunyon'
- -Keeping Quality: 'Bergman'

Hundreds of seedlings resulting from crosses using these parents have been evaluated in discovery plots. The first year's harvest (1995) showed some intriguing results. Parents that were selfed produced seedlings that were distributed rather tightly in measured characteristics such as fruit coloration (Figure 1); that is, selfed crosses of a parent with dark colored fruit produced only seedlings with dark colored fruit. Hybrids between a dark colored parent ('Ben Lear 3') and a moderate colored parent ('Pilgrim') produced seedlings that showed a continuous array of coloration that ranged from low color to color somewhat higher than the highly colored parent (Figure 2). A similar continuum was seen with fruit size (Figure 3) one major component of yield. This data confirms our initial prediction that both of these traits are determined by a relatively large number of genes.

From these very early hybridizations, a number of seedling selections have been planted in performance plots. These early selections show both superior coloration and high vigor. In addition, some plants (e.g. 'Ben Lear #3') when used as parents have resulted in a higher percentage of poor performing seedlings than other parental lines (e.g. 'Ben Lear #8'). Such poor parental lines will not be used heavily in future breeding.

The results of this first work are encouraging enough to continue the evaluation of the seedlings. In addition, the information we have gained has allowed us to decide how to conduct more hybridizations which will emphasize the best performing plant materials.

Your input.

We are at a decisive stage in this program. Utilizing the resources currently available to us, we are maxed-out; that is, we cannot expand the program any further without more money and labor input. We do feel that the program is large enough to be able to make some important progress in accomplishing the breeding goals, however no new goals can be included without either more input or eliminating some of the current activity. Thus a number of questions arise that you should consider:

-Do you agree with the goals of this young breeding program'?
-Are there goals that you think are VERY important that need to be included?
-Is the program OK at its present size or would you like to see it move along faster?

In addition, we would be very interested in hearing about any special selections that you might have in the "back 40" that may have traits that would be useful in such a breeding effort. If so, we may be able to include some of these in our evaluation plots.

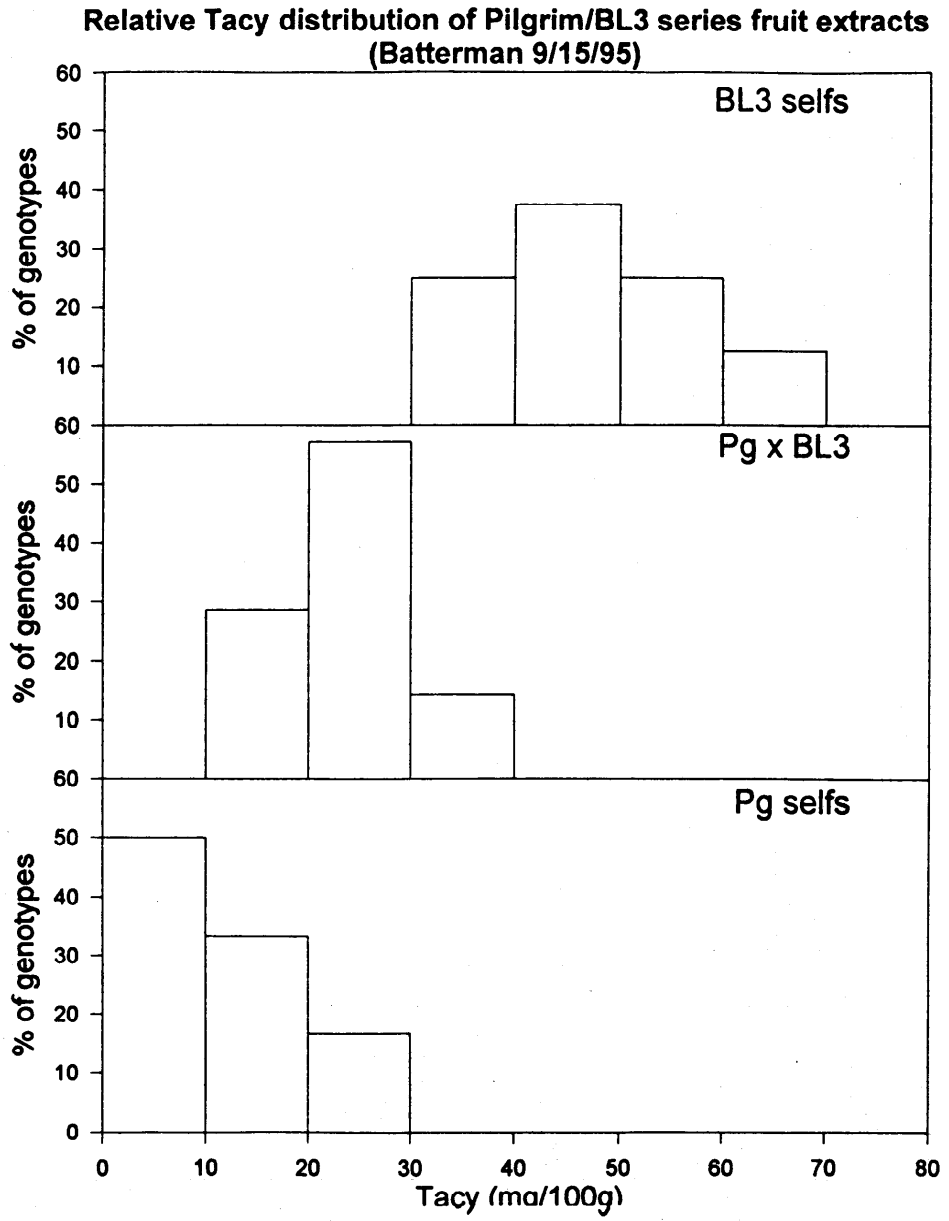

Figure **1.** The fruit pigment concentrations of seedlings from three different crosses: top, seedlings from selfed 'Ben Lear #3'; middle, seedlings from a cross of 'Pilgrim' and 'Ben Lear #3'; bottom, seedlings from selfed 'Pilgrim'. Seedlings grown in field plots and harvested 9/l5/95.

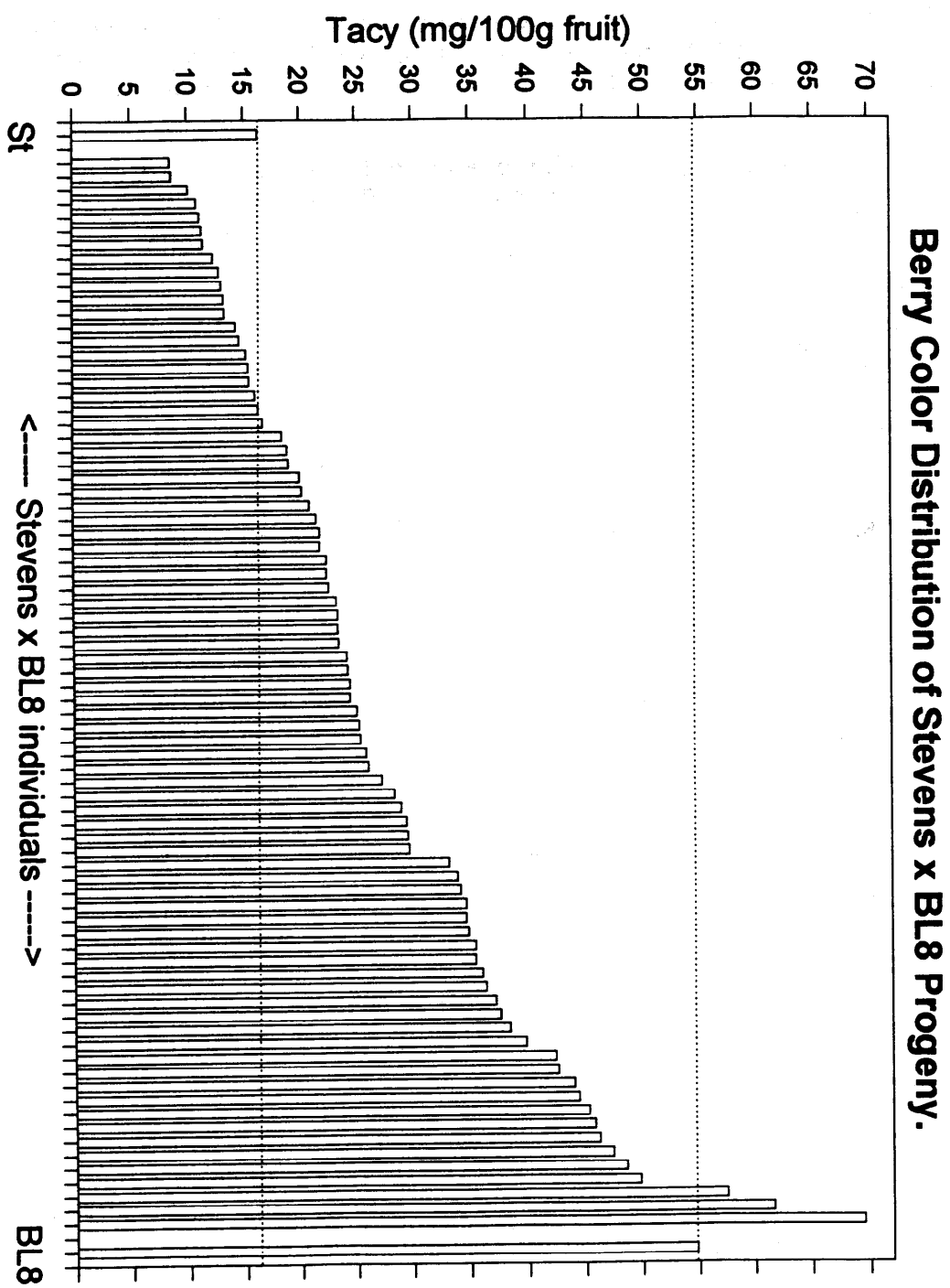

Figure 2. The distribution of berry color in seedlings and parents of a cross between 'Stevens' and 'Ben Lear #8'. Plants grown in the field and harvested in 1995.

Figure 3. The distribution of berry size in seedlings and parents of a cross between ‘Stevens’ and ‘Ben Lear #8’. Plants grown in the field and harvested in 1995.