



Sensory Evaluation and Quantitative Genetics of Fruit Texture Traits in Populations Derived from 'Honeycrisp' Apple (*Malus pumila* Mill.)

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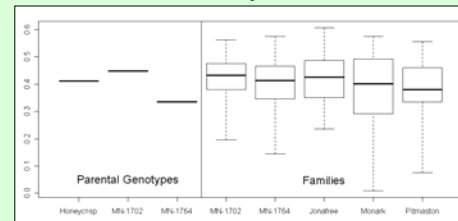
Abstract: Large tree size, long juvenile phase, high levels of heterozygosity, and vulnerability to inbreeding depression have inspired considerable interest in the applicability of marker-aided selection in apple. The apple cultivar 'Honeycrisp,' introduced by the University of Minnesota, is widely recognized for its crisp fruit. Towards development of markers associated with crispness, we initiated estimation of heritability for fruit texture.

Accurate estimation of heritability requires accurate phenotypic measurement across multiple years. Fruits from five populations, each with 'Honeycrisp' as a common parent, were evaluated for fruit texture in 2005 and 2006. Multiple harvest dates spanned several weeks in each year, allowing application of uniform harvest criteria. Data from sensory evaluation panels were collected weekly and used a labeled magnitude scale. Apples were distributed among panelists using a randomized incomplete block design. Individual panelist effects were accounted for by means of mixed-effects modeling. Subsequent analysis revealed phenotypic differences among populations and among trees within populations, as would be expected for polygenic traits in a highly heterozygous species. Unexpectedly, modest maternal effects were also evident for at least one of three texture traits evaluated. Results were consistent between years.

University of Minnesota Apple Breeding Program Plant Material:

- Thousands of genetically unique seedling trees.
- Typically, five to ten years required for consistent fruit bearing.
- Five large, mature 'Honeycrisp'-derived F₁ families selected.
 - Large numbers of fruit-bearing trees (63-129 per family).
 - Observed variability with respect to fruit crispness.
- Three of the five families contained reciprocal crosses.
- 2905 apples sampled from 470 trees
- Highly unbalanced design.
 - Varying numbers of trees per cross.
 - Some trees bearing fruit only one of the two years.

2006 Tree Crispness Values



Data Analysis:

- Nested mixed-effects model.
- Panelists treated as random effects (mean effect of zero, with panelist-specific variances).
- All other terms treated as fixed effects.
- Variance partitioning approximated, assuming a balanced experimental design.
- Additive variance terms estimated from variance components.

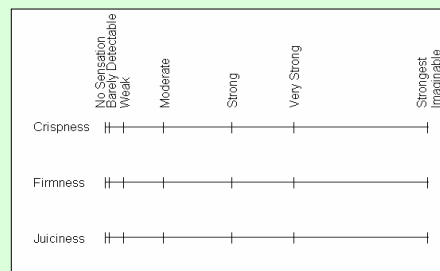
Data collection:

- Fruit were harvested weekly in 2005 and 2006.
- Trees sampled once per year at uniform starch-iodine levels.
- A minimum of four apples collected per tree.
- Apples evaluated within one week of harvest.
- Sensory evaluation panels convened weekly throughout the harvest period.
- One quarter systematically removed from each apple.
- Samples evaluated using a Labeled Magnitude Scale (see right).
- Apples randomized across panelists according to an incomplete block design.

Texture Traits Evaluated

Trait	What?	When?
Crispness	Sudden fracture with characteristic sound	Biting with incisors
Firmness	High resistance to deformation by applied force	Chewing with molars
Juiciness	Sensation of progressive increase of fluids	Chewing with molars

Labeled Magnitude Scale



Analyses of Variance

Factors	Crispness p-Values	Firmness p-Values	Juiciness p-Values
Year	0.830	0.119	0.010
Family	<0.001	<0.001	<0.001
Family/Cross	<0.001	<0.001	0.843
Family/Cross/Tree	<0.001	<0.001	<0.001
Family x Year	<0.001	<0.001	0.172
Family/Cross x Year	0.454	0.018	0.765
Family/Cross/Tree x Year	0.948	0.993	1.000

Conclusions:

- Phenotypic traits differed between families and between trees within families
- Interannual variation occurs at the family and reciprocal cross levels
- Phenotypic traits were consistent within trees across years
- Modest effects were detected at the reciprocal cross level for crispness and firmness
- Preliminary variance partitioning yielded near zero estimates of additive variance. Re-analysis using statistical software designed to incorporate the unbalanced design will be pursued

Selected Literature:

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