PennState
College of Agricultural Sciences

PROPOSAL TRANSMITTAL

Date: 1/22/2018 **PSU Ref. No:** 199627

Title: Validation of the Model for Predicting Bitter Pit in 'Honeycrisp' Apples

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Proposed Project Period: 07/01/2018 - 06/30/2019 **Total Project Request:** $2,124

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Please reference PSU Ref. Number in all correspondence.

Extension Advisory proposal for 2018

State Horticultural Association of Pennsylvania

Title: Validation of the Model for Predicting Bitter Pit in 'Honeycrisp' Apples

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Duration of project: July 1, 2018 – June 30, 2019

Justification:

Some apple cultivars are prone to the development of bitter pit. This disorder, characterized by sunken blackish lesions over areas of brown corky flesh, generally manifests itself at the calyx end of the fruit following cold storage. Many cultivars are susceptible to bitter pit, but 'Honeycrisp' is especially susceptible. In general bitter pit has been associated with high levels of nitrogen (N), phosphorous (P), potassium (K) and magnesium (Mg) relative to the concentration of calcium (Ca) in the fruit flesh. Large fruit tend to be more susceptible than small fruit. Work in Massachusetts showed that there is a three-dimension distribution of Ca in the fruit (Weis et al., 1980). Flesh Ca concentrations were lowest just under the skin at the calyx end and increased towards the stem-end of the fruit and towards the core. Measuring nutrient concentrations in apple flesh is difficult because analytical methods designed for leaf tissue must be modified due to high sugar concentrations in fruit flesh. Rather than drying the samples, fruit flesh samples must be freeze-dried before grinding and freeze-dryers are unavailable to most apple growers. Tara Baugher and Chris Watkins recently showed that peel tissue from the calyx end of the apple can be dried like leaf tissue for analysis and concentrations of peel tissue were related to the incidence of bitter pit (personal communication). The Penn State Agricultural Services Laboratory has developed a modified procedure to analyze dried apple peels and they are working on a modification of the method that will allow them to analyze fresh apple peels.

We recently completed a study where bitter pit incidence of 'Honeycrisp' apples was recorded for individual trees in six orchards in Adams County for three years. Three weeks before harvest, peel tissue was sampled from 20 fruit per tree. At harvest a sample of fruit from each tree was placed in cold storage for 4 months and fruit were assessed for bitter pit after 7 days at room temperature. Data were used to develop a model to predict bitter pit (Baugher et al., 2017). In 2014 and 2015, the percentage of fruit with bitter pit ranged from 0 to22% and in 2016 the percentage of fruit developing bitter pit after cold storage ranged from 0 to 74%. Bitter pit was negatively related to peel Ca concentration and positively related to N, P, K, and Mg concentrations and average shoot length. The best model explained 68% of the variation in bitter pit and included only shoot length and the ratio of peel N/Ca. Other models that were nearly as good, but were more complex and contained more predictor variables were also published. Although the data set was used to validate the model with three different statistical techniques, we are still uncertain of its accuracy in commercial situations in other years. The most disturbing aspect is that no model developed with a single year's data accurately predicted bitter pit for the other two years of the study and the three models were quite different. However the model developed with all three years of data explained 68% of the variation in bitter pit. The objective of this study is to validate the model by sampling fruit from commercial orchards in 2018. If the model

predictions are adequate, we will be able to use peel analyses to make storage and marketing decisions for 'Honeycrisp' apples based on the likelihood of bitter pit development.

Procedures:

During the spring we will identify a total of 12 to 15 orchards in three counties (Adams, Bedford, and Centre) to participate in this study. We would like to identify blocks of 'Honeycrisp' trees with a history of bitter pit, ranging from negligible to severe. We will attempt to include blocks of trees on M.9, B .9 and possibly M.26 rootstock. Three weeks before anticipated harvest we will collect 4 fruit from each of six trees per block that are typical for that block and peel tissue will be removed from around the calyx end of each fruit. The peel tissue will be dried at 60°C (140°F) for three days and sent to the analytical lab for nutrient analysis. At harvest, two boxes of fruit (about 80 lbs) per orchard will be transported to Rock Springs and will be stored at 34°F for about 90 days. The fruit will be removed from cold storage and will be placed at 70°F for a week before evaluating each fruit for bitter pit symptoms.

The model developed in our previous study will be used to predict the percentage of fruit that we expect will develop bitter pit symptoms. Then these predicted values for bitter pit will be plotted against the observed values to assess the reliability of the model. These statistical methods are used in medical research to compare results from new technologies with results using accepted methods that are often more expensive or time-consuming (Altman, 1991; Bland and Altman, 1986; Laurent, 1998). These methods were used by Marini (2001) to compare two methods of sampling apple trees to estimate average fruit size with the true average fruit size.

Results from this study will be published in the Fruit Times Newsletter and if the model successfully predicts bitter pit, the information will be added to future editions of the Pennsylvania Tree Fruit Production Guide. If the model is validated we will also work with the Director of the Penn State Agricultural Analytical Services Lab to develop a form that will allow growers to submit apple peel tissue for analysis and interpretation so growers can make informed decisions concerning the storage potential of their 'Honeycrisp' fruit.

Literature Cited

Altman, D.G. 1991. Practical statistics for medical research. Chapman and Hall. New York.

Altman, D.G. and J.M. Bland. 1983. Measurement in medicine: The analysis of method comparison studies. The Statistician 32:307–317.

Baugher,T.A., R. Marini, J.R. Schupp and C.B. Watkins. 2017. Prediction of bitter pit in 'Honeycrisp' apples and best management implications. HortScience 52:1368-1374.

Laurent, R.T.S. 1998. Evaluating agreement with a gold standard in method comparison studies. Biometrics 54:537–545.

Marini, R.P. 2001. Estimating mean fruit weight and mean fruit value for apple trees:comparison of two sampling methods with the tree mean. J. Amer. Soc. Hort. Sci. 126:503-510.

Weis, S.A., M. Drake, W.J. Bramlage and J.H. Baker. 1980. A sensitive method for measuring changes in calcium concentration in 'McIntosh' apples demonstrated in determining effects of foliar calcium sprays. J. Amer. Soc. Hort. Sci. 105:346-349.

Budget:

Direct Costs		Total
Salary (Category 1)		998.00
Fringe*		416.00
Travel In State		350.00
Tissue Analysis	15 @ $24.00 each	360.00
Total Requested From Sponsor		2,124.00

**Fringe benefits are computed using the fixed rates of 41.60% applicable to Category I Salaries, 15.40% applicable to Category II Graduate Assistants, 7.90% applicable to Category III Salaries and Wages, 0.10% applicable to Category IV Student Wages, and 26.30% for Category V, Postdoctoral Scholars and Fellows, for fiscal year 2018 (July 1, 2017, through June 30, 2018). If this proposal is funded, the rates quoted above shall, at the time of funding, be subject to adjustment for any period subsequent to June 30, 2018, if superseding Government approved rates have been established. Fringe benefit rates are negotiated and approved by the Office of Naval Research, Penn State's cognizant federal agency.*