Almond Fruit Phenology Model

Project No.: **09-HORT10-Gradziel**

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Objectives:

A. Recover as complete a data set as possible from Dr. Kester's almond bloom and fruit phenology studies. Complete the development of a fruit/embryo growth or phenology model for the variety Nonpareil in a form useful to Farm Advisors and other almond researchers and as a possible extension publication.
B. Test the proposed model for its value as an early predictor of developmental times for full bloom, seed development and in particular, hull-split for *Nonpareil*
C. Evaluate seed development data from the 1980s and more current research to assess the role of incomplete seed fill as a determinant in final variety yield potential.

Interpretive Summary:

Almond production in California is an exceptionally complex undertaking in the best of times, and has become increasingly difficult due to the rapid changes in agrochemical, water and insect pollinator availability, and climate change. Modeling the potential consequences of these changes allows some insight concerning the ramifications of different cultural practices and provides a rational foundation for the development of effective recommendations. An ambitious effort is currently underway for a comprehensive modeling of almond crop production under the primary direction of Bruce Lampinen and Ted DeJong, which utilizes recent technological advances to allow the gathering of immense amounts of field data and its subsequent analysis through advanced computer programs.

An equally ambitious attempt at modeling almond fruit development or 'phenology' was undertaken in the early 1980s by Dr. Dale Kester and cooperating Farm Advisors including Joe Connell, Mario Viveros, and Mark Freeman and while extensive and detailed data was collected for the variety *Nonpareil*, final analysis and information extension was never completed. In our present efforts to complete this analysis, most

of the data has had to be transferred manually or through statistical summaries, since the original data collection was undertaken before standard computer spreadsheet programs were established. Early results plotting sample means of *Nonpareil* kernel mass over the course of the growing season in one of the San Joaquin Valley test plots is shown in **Figure 1**. The results show a standard S- (or sigmoidal) curve indicating early logarithmic growth that eventually slows, then levels off at crop maturity. Plotting the same data based on accumulated degree-days shows a similar pattern but a surprisingly (for all plots analyzed so far) poorer fit to the S-curve predictor or model. A close fit to the specific sigmoidal curve or model employed is important since it is the basis for predicting final kernel size in future crops (based on early kernel development and accumulated days or heat units).

The ultimate objective of this early research was the capacity to predict the time of hull-split initiation for facilitating Navel Orangeworm control. While this approach (using 1980’s data) provides a relatively good prediction of kernel development, it has so far failed to accurately predict hull-split initiation, apparently because regional differences in cultural practices, particularly fertilization and irrigation varied considerably among test sites. Approximately half of the data from Sacramento and San Joaquin Valley test sites has been analyzed to date, with the probability of developing an accurate model for predicting hull-split dates diminishing as additional data (and so levels of variability) are incorporated.

The apparent failure of this type of preliminary model is, in fact, one of its benefits since when the model fails in predicting real-world responses; it directs us to specific limitations in our knowledge. In this way models have the capacity to evolve; the model inherently identifies information-deficiencies required for its effectiveness, leading to sequential improvements in its accuracy until it achieves ‘expert-systems’ status where predictions can be trusted. A more accurate model of almond orchard and tree productivity, such as that currently being developed by Lampinen and DeJong, would have valuable benefits (for example, predicting the optimal balance between fertilizer and/or water use and crop yield). Since these more complex models depend on large amounts of detailed data, the availability the 1980’s data results would also be of value. In addition, comparison of production trends based on current field data with comparable trends from the 1980’s can help gauge the extent of improvements in critical cultural practices, including fertilization, irrigation and orchard design over this time period.

Figure 1. *Nonpareil* kernel mass over the course of the growing season in one San Joaquin Valley test plot.