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Kent Kobayashi, Post-Doctorate, Horticulture Department, Oregon State University, Corvallis, OR 97331.

# COMPUTER MODELING AND SIMULATION OF PLANT DEVELOPMENT

**Models of plant development can be valuable planning tools for growers and researchers** by adding to our understanding of plant growth and by predicting environmental effects on plant growth. Terms such as **model, model building**, and **simulation** are being seen more frequently in the literature as interest increases in the **modeling of plant development**.

A model is a simplified representation of part of the real world system**. It shows the relationships among the different objects** in the system **and how certain factors affect these objects.** Often mathematical equations are used to express or define these relationships.

These relationships are tested to see how closely they agree with experimental data. If the agreements are poor, different relationships may need to be hypothesized.

If interested in seeing how a system (for example plants in a field) will be affected by changes in certain factors, a person often cannot conduct the necessary studies on real plants because of the costs or time involved. **One alternative is to run simulations by changing different conditions in his model** (Crovello, 1981). For example, a person may ask, "What would my profits be at the end of five years if I were to harvest my crop every six months instead of every four months?" Simulations on a model can produce this information without a person changing the actual harvest dates.

**Computer models for predicting the timing of specific developmental stages and quantifying development in deciduous woody plants have been developed** (Kobayashi, 1981; Renquist, et al., 1978). These stages include vegetative maturity, deep rest, end of rest, and spring bud break.

Renquist developed a computer model which uses temperature and daylength for predicting the date of vegetative maturity (Renquist, et al., 1978). Results of growth chamber studies were used to derive the model. Simulations were run on the model to determine the effective day and night temperature ranges for vegetative maturity development. A prediction accuracy within four days by the model indicated that a more precise determination of the critical daylength was needed.

**Studies have shown that the effect of temperature on plant development changes with the developmental stage of the plant** (Irving and Lanphear, 1967; Kobayashi, 1981). Vegetative maturity development in certain species is triggered by short daylengths and is optimal under warm temperatures (Renquist, et al., 1978). Following vegetative maturity (onset of winter dormancy), rest deepens in response to low temperatures (Kobayashi, 1981). After deep rest, low temperatures similarly break rest. When the chilling requirement has been met (end of rest), plants develop under warm temperatures.

Computer models were developed from these results and predicted the dates of deep rest, end of rest, and spring bud break of field-grown plants within two to three days and in addition, predicted daily plant development (Kobayashi, 1981). **It is emphasized that these models are only a beginning in the modeling of daily winter dormancy development and are applicable only to the terminal vegetative buds of red-osier dogwood.** Further studies are required to examine other factors affecting plant development (for example, plant age, solar radiation, wind, and rainfall, Lombard and Richardson, 1979) and to expand the use of models to other deciduous trees and ornamental crops (Kobayashi, 1981).

Because temperature effects on cold acclimation and deacclimation are dependent upon the developmental stage of plants (Irving and Lanphear, 1967; Kobayashi, 1981), an attempt was made to quantify plant development (Kobayashi, 1981). Once natural defoliation occurs it is difficult to visually determine the stage of winter dormancy. By quantifying development, the developmental stage at which a plant's response to temperature changes (hardening or dehardening response) can be determined. Results of growth chamber studies were used to develop hardiness models (Kobayashi, 1981). These models, using temperature and developmental stage, predicted hardiness levels within an average of five degrees centigrade. Again, these early models are applicable only to one species, and additional research is needed to develop similar models for other species.

**Computer modeling and simulation of plant development can help growers in the management of their crops.** In the future, decisions on the timing of practices such as harvesting, defoliation, irrigation, fertilization, and frost protection and decisions on post-production handling may be influenced by models which predict the developmental stage and environmental requirements of the plants**. With the increasing use of computers by growers, the impact and benefits of modeling are only beginning.**

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