INDUCTION AND FLOWERING PROCESSES: FLORIDA PERSPECTIVE

L. G. ALBRIGO
Citrus Research and Education Center
University of Florida
Lake Alfred, FL

While research has characterized flower bud induction from cool temperatures and water (drought) stress, very little characterization has occurred for intermediate climates where, at least in some years, both cool temperatures and water stress play a role in flower bud induction. Florida and nearby Caribbean Basin countries probably represent this intermediate situation. Several questions about flower bud induction should be answered in order for the grower to know what he can expect to happen, and what can be done to improve flowering, if needed, in a given year. How many hours of cool temperatures are required to have enough flower buds for an economic crop? Are all temperatures below a threshold, probably 24° C (75° F), equal in their ability to stimulate flower bud induction? How often are accumulated cool temperatures in Florida insufficient? In Florida, can low flower bud induction from moderate to low hours of cool temperatures in a given year be boosted by addition of water stress from withholding irrigation? Are there treatments that can be applied to enhance the stress induced flower bud induction that occurs from drought or cold? If so, at what time should these treatments be applied?

Two parallel experiments at Lake Alfred have been undertaken to determine the number of hours of cool temperatures required to get adequate flower bud formation. In addition, these experiments are intended to evaluate the relative effect of hours of different temperatures in 5° C (9° F) increments below 24° C in enhancing flower bud formation. One experiment included several groups of Hamlin trees in large pots. Every 15 days a group of trees were placed in a hot, growth forcing greenhouse after exposure to natural winter temperatures. As each winter progressed, groups of trees with increasing exposure to winter temperatures produced more flower buds with more flowers per inflorescence. In the second experiment, large limb units on a set of mature Valencia trees in the field were girdled and then separate sets of limbs were defoliated every 15 days until the winter was over. The flower buds and flowers were counted at bloom. Again flower buds and flowers increased until late in the winter. Preliminary evaluation of three years of data shows that maximum flowering occurred after 1500 to 2500 hours of temperatures below 24° C (75° F) or 800 to 1900 hours below 19° C (66° F) were accumulated. This occurred by 15 January in 1993-4 and 15 February in 1994-5. Presumably, in years when the spring flush is forced before these dates, less than full flowering can be expected. Full evaluation of relative temperature effects is underway.

In the past six-year period, there were at least two years in which insufficient cool temperatures occurred. In the past winter, 1996-97, only 1507 and 807 hours less than 24° C (75° F) and 19° C (66° F) had accumulated, respectively, by 28 December. A warm period of 13 days over 26.6° C (80° F) daily maximum temperature occurred. This forced a flush with limited flowers. The second cold period included a freeze that caused considerable mature leaf loss. On those trees with major leaf loss, little additional flowering has occurred. This is similar to the results that Furr and Armstrong (1956) and Ayalon and Monselise (1960) obtained in girdling and defoliating experiments when the defoliation occurred early. No additional flowering occurs after defoliation. Trees, with mature leaf retention, have good flowering this year with the 2132 and 1209 hours of accumulated cool temperatures below 24 and 19° C, respectively, from both cool periods. In some years when two cool periods occur and are well separated by a long period of warm temperature, two distinct blooms occur on the same trees (1990). The first bloom is usually terminal buds and the second is more from lateral buds that are presumably more difficult to induce and force to grow.

Studies done in Gainesville, Florida (Abbott, 1935) indicted that the start of differentiation of citrus flower buds on orange and grapefruit trees was from 12 to 29 January depending on the year. Mandarins began differentiation later by one or two weeks, probably accounting for their later bloom. Observations of bud break in central Florida and southern regions indicated that in some years differentiation must begin as early as the first week of January since bud break and flowering has been observed as early as 5 January and 10 February, respectively.

In relation to enhancing flowering, the work of Lovatt et al. (1988) with winter urea sprays on navel oranges to increase flowering and yields was a logical procedure to try under Florida conditions. Over a three-year period, 7 of 13 tests with winter urea at 50 lbs urea/acre were successful in increasing flowers and yields. Winter urea sprays have been observed to advance bloom date by 7 to 10 days over unsprayed controls. Further, phosphorous acid in the form of Nutriphite sprayed at 2.6 quarts/acre resulted in increased flowers and yields in 4/7 tests. Phosphorous acid in the form of Aliette increased yields in 1 of 3 tests. Unlike in California (Ali and Lovatt, 1992), the appropriate foliar treatment window in Florida is very narrow. Some induction is necessary from cold or water stress before the foliar treatments enhance flower bud induction. In the case of Florida's climate warm weather triggers bud break shortly thereafter. Once bud break begins little additional flower bud induction can be expected.

Another variable that may play a role in the intensity of flowering under Florida conditions is the relative carbohydrate accumulation, particularly in the early winter. Florida's temperatures and soil moisture allow for good photosynthetic rates during this period. Buds may be more easily induced to flower bud status under these conditions. Clearly carbohydrate depleted trees such as over-cropped mandarins do not bloom and early removal of leaves result in no flowers.

The overall effect of Florida's varied temperatures is responsible for changes in bloom date from year to year of more than two months. Earliest general bloom occur in early February and latest bloom occurs about 15 April. This does not include June blooms. In a regression study of winter and spring temperatures at Lake Alfred, FL to date of 'Valencia' bloom (Albrigo, unpublished), warmer temperatures in the early winter delay bloom (delay induction) while warmer temperatures in late winter (early spring) advance the date of bloom (speed up differentiation and flower bud development). The regression analysis for 12 years indicated that for each centigrade degree of increase of average temperature in December and January, bloom date was delayed by 1.82 days. For each degree of increase in February and March, bloom date was advanced by 2.65 days. Recent observations suggest that this analysis should be done on a monthly temperature basis since bloom dates in some years can be so early as to make March temperatures meaningless, i.e., 1997.

In summary, we can see that flower bud induction and flowering vary in intensity and date of occurrence in Florida. This is primarily due to 1) winter temperature differences that cause changes in when and how much flower bud induction occurs, and 2) early spring temperature differences that effect the rate of differentiation and flower bud development until flowering. It appears possible to increase the quantity of flowers by spraying with urea, phosphorus acid products and possibly other chemicals. Whether this process is nutritional, added stress or other mechanisms has not been adequately determined.

Literature Cited

Abbott, C. E. 1935. Blossom-bud differentiation in citrus trees. Amer. J. Bot. 22:476-485.

2. Ali, A. And C. J. Lovatt. 1992. Winter application of foliar urea. Citrograph 78(2):7-9.

3. Ayalon, S. And S. P. Monselise. 1960. Flower bud induction and differentiation in the Shamouti orange. Proc. Amer. Soc. Hort. Sci.75:216-221.

4. Furr, J. R. and W. W. Armstrong. 1956. Flower induction in Marsh grapefruit in the Coachella Valley, California. Proc. Amer. Soc. Hort. Sci. 67:176-182.

5. Lovatt, C. J., Y. Zheng and K. D. Hyke. 1988. Demonstration of a change in nitrogen metabolism influencing flower initiation in Citrus. Israeli J. Bot. 37(2/4):181-188.