GROWTH REGULATORS AND FRUIT SET OF CITRUS

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Unlike apples or pecans, most citrus does not require cross pollination with a different, compatible variety to produce adequate crops. Some varieties undergo normal pollination, fertilization, and subsequent seed development. The process of fertilization and pollination is covered elsewhere in this short course. However, other varieties produce fruit without sexual fertilization, a process termed "parthenocarpy". These fruit are seedless. Citrus fruit can be further classified as strongly parthenocarpic, such as 'Marsh' grapefruit or 'Hamlin' orange, or weakly parthenocarpic, such as navel orange or mandarin-hybrids like 'Robinson', 'Orlando', 'Minneola' and 'Sunburst'. In the 1950s, Krezdorn and Robinson noted that 'Orlando' and 'Minneola' tangelos produced poorly unless cross pollination was provided with a compatible variety. Trees receiving cross pollination produced seedy fruit and had increased yields over trees that were not cross pollinated which produced seedless fruit. Around the same time Coggins et. al., in California also found that applications of gibberellic acid (GA) to weakly parthenocarpic varieties increased fruit set and yields without using cross pollination. Since then several studies have been conducted worldwide on the use of growth regulators to increase fruit set and yields of weakly parthenocarpic citrus varieties. The objective of this paper is to discuss the use of growth regulators for improving fruit set and yields of citrus with emphasis on varieties grown in Florida.

Navel Oranges

Studies from California in the 1960s and from Florida in the 1980s (Table 1) showed that navel oranges typically set and mature less than 1% of the total flowers on the tree during bloom. Consequently, yields of old-line navels traditionally are lower than those of other sweet oranges such as 'Hamlin'. During the late 1950s and early 1960s, Coggins et. al., from California and El-Zeftawi from Australia began applying GA to navel orange trees to improve set and increase yields. The theory was that the GA would substitute for the natural GA synthesized by the seeds. Spray application of GA in Australia increased fruit set, but results in California were variable. In one experiment fruit set and yields were increased over nontreated trees, while in another study there was no effect or yields were actually reduced. High concentrations of GA caused twig dieback and leaf drop and increased fruit splitting.

During the same time period, Krezdorn in Florida applied GA as a flower dip or whole tree spray to 'Dream' and 'Summerfield' navel oranges to improve set and yields. The flower dips increased fruit set but the whole tree sprays had no effect on set or yields. Krezdorn and Davies conducted follow-up studies in the late 1970s using whole tree sprays of GA generally applied until run-off with a hand sprayer at high volumes. They also tested captan and seaweed sprays for improving set and yields. None of these materials proved successful for increasing either fruit set or yields under Florida conditions.

Subsequently, Southwick and Davies tested the effect of GA and benzyladenine (BA), a cytokinin-type growth regulator, on fruit set of navels. They also applied calcium sprays in combination with GA during bloom because calcium is known to be associated with fruit abscission. GA and calcium sprays initially increased fruit set, but only until the "June drop" period, after which set was the same among treatments. Moreover, yield of navel oranges was not increased by either treatment. BA sprays did not increase fruit set. However, BA has proven effective for increasing fruit set of navel oranges in Spain. Therefore, there are no scientific studies in Florida supporting the use of growth regulators for improving fruit set and yield of navel oranges, although several unsubstantiated claims have been made.

Table Fruit set and drop of navel oranges in Florida (from Lima unpublished, 1982).

Fruit set period	Fruit drop/tree (no.)	Fruit set (%)
Initial fruit set	71,913	.3
June drop	8,41	
Summer drop	120	
Summer-fall drop	86	
Total fruit drop (final fruit set)	80,530	0.65
Mature fruit harvested	532	
Total flowers/tree	81,062	

Mandarins and Mandarin Hybrids

The situation with mandarin hybrids and some mandarins differs from that with navel oranges. Soost, working in California, observed that he could increase fruit set of 'Clementine' mandarin using GA sprays during bloom over that of non-GA treated trees. In Florida, Krezdorn applied GA to 'Orlando' tangelos during prebloom, full bloom, and postbloom (Table 2). He observed increased fruit set and more importantly, yields with application of 10 ppm GA (9.5 g a.i./acre). Fruit were seedless and larger than non-treated fruit. Current recommendations are to apply 10 to 30 oz. of GA (9.5-28 g a.i./acre) per acre at full bloom. However, the upper limit is considerably above recommended rates from other citrus regions and should be viewed with caution (El-Otmani and Coggins, personal communication). Typically GA is applied at 10 to 50 ppm usually at full to late bloom to mandarins in several areas including Morocco, Cuba, Spain, Argentina and Israel (El-Otmani and Coggins, personal communication). GA also increases fruit set for 'Nova' tangerine in South Africa. GA application has been very effective in increasing yields and particularly producing seedless fruit which are in demand in the European market. The assumption has also been made that GA would have the same effect on other mandarin-hybrids such as 'Sunburst', although this concept has not been throughly tested in Florida.

Table 2. Influence of gibberellic acid sprays at late bloom on average yield (boxes/tree) of several citrus varieties (adapted from Krezdorn and Cohen, 1962).

Variety	Unsprayed	GA (ppm)		
		10	25	50
Orlando	0.8	2.0	1.4	.5
Dream navel	0.3		0.4	0.4
Summerfield navel	3.7	---	3.5	3.7

Summary

Adequate fruit set and yields are typically not problems for most citrus species including round oranges and grapefruit. Nevertheless, some mandarins, mandarin (tangerine) hybrids and navel oranges have poor set and yields unless cross pollination is provided. Alternatively, growth regulators, especially GA, can be used to improve fruit set and yields of mandarin hybrids such as 'Orlando' tangelo and some mandarins. However, they are ineffective in improving fruit set for navel oranges under Florida conditions.

Selected References

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