

INFLUENCE OF DATE OF HARVEST ON YIELDS OF 'HAMLIN' AND 'VALENCIA' ORANGES AND 'MARSH' GRAPEFRUIT

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Abstract. Holding crops of 'Hamlin' and 'Valencia' oranges until late in the season depressed yields the following year, both on the basis of boxes of fruit and kilograms of soluble solids per tree but yields of 'Marsh' grapefruit were not reduced. Yields of 'Hamlin' orange, an early maturing cultivar, were reduced in both years by heavy fruit drop coupled with the fact that its fruit did not increase in size throughout the harvest season, as did those of 'Valencia' and 'Marsh'.

Holding or storing fruit on the tree is advantageous in that it permits a more orderly marketing season. For example, about equal quantities of 'Marsh' grapefruit are marketed in Florida each month from October through May. Moreover, early maturing cultivars, such as 'Hamlin' sweet oranges, are held on the tree later than in the past in order to obtain better quality of juice for frozen orange concentrate. On the other hand, holding fruit on the tree late into the harvest season has markedly reduced yields on a volume basis the following year in several areas of the world. This problem has been studied most intensively in California where 'Valencia' sweet oranges (*Citrus sinensis* (L.) Osbeck) may not be harvested until October of the year following that in which they bloomed, a period of 17 months. Yields are greatly reduced the following year (4, 6, 7). Similar results have been reported for navel sweet oranges (5).

Fruit are not held on the tree in Florida as late as in California because they mature earlier and deteriorate more rapidly in Florida's climate. Even so, recent research showed storing 'Marsh' grapefruit (*C. paradisi* Macf.) on the tree reduced the following crop (11). Thus, further research was conducted in 1974-75 and 1975-76 to determine the influence of storing fruit of 'Hamlin' orange, 'Valencia' orange and 'Marsh' grapefruit on the tree on yields the following year.

Materials and Methods

Experiments were conducted with 22-year-old 'Marsh' grapefruit, 22-year-old 'Hamlin' orange and 12-year-old 'Valencia' orange trees, all on rough lemon (*C. jambhiri* Lush.) rootstock. Trees were grown on Astatula fine sand in Lake County under standard commercial programs of fertilization and pest control.

A randomized complete block design with single-tree plots was used. There were 28, 21 and 50 replications in the 'Marsh', 'Hamlin' and 'Valencia' experiments respectively. Dates of harvest, which constituted, treatments are given in Tables 1, 2 and 3 respectively.

Fifty randomly selected fruit were taken from around each tree from 1.5 to 2.0 m above ground level at the time

of harvest for size and quality data. Total soluble solids (TSS), total titratable acid (TTA) and percent of juice on a weight basis (% juice) were determined for each sample according to standard methods. Yield was measured both as number of field boxes and as kg of soluble solids (kg solids) per tree. Kg-solids per tree was calculated by the follow-

ing formula: $\text{kg-solids} = \left(\frac{\text{no. boxes}}{\text{tree}} \times \frac{\text{wt}}{\text{box}} \right) \times \% \text{ juice} \times \frac{\% \text{ TTS}}{100}$, using 90 lb (40.8 kg) and 85 lb (38.6 kg) as the

average weights of a box of oranges and grapefruit respectively.

Results and Discussion

'Hamlin' orange. Yields of 'Hamlin' on a volume (box) basis (Table 1) decreased in both years with each later date of harvest. Mean differences were not always statistically significant, but yields of trees harvested at any given date were always less than for any previous date the same season. Moreover, yields of trees harvested the latest date of a given season were always significantly lower than those for at least the 2 earliest dates of harvest. Differences between the first and last dates of harvest were 1.5 and 2.4 boxes for the 1974-75 and 1975-76 seasons respectively. These quantities are economically important.

The pattern of yields was different from those reported for 'Marsh' grapefruit (10) and 'Valencia' orange (2, 3, 9) where yields increased with each successively later date of harvest the first season. Decreases in yields of late-harvested 'Hamlin' in both years were apparently due in large part to fruit drop and because 'Hamlin' fruit do not continue to increase in size throughout the season (Table 1). No data were obtained on fruit drop but much larger quantities of fruits were observed under trees harvested at successively later dates. Fruit size increased slightly between Nov. and Dec. harvests but stayed the same for the last 3 dates in both seasons (Table 1). The influence of late harvest on yields the following year was not as pronounced as has been previously reported for late-maturing cultivars (2, 4, 6, 7). This

Table 1. Effect of date of harvest on yield, quality and fruit size of 'Hamlin' orange.

Harvest date	Yield/tree	Solids/tree*	Juice	TSS*	TTA*	Fruit diam
	(boxes) ²	(kg)	(% by wt)	(%)	(%)	(cm)
1974-75						
Nov. 24	12.1a ²	27.3a	58.8a	9.4b	0.78a	7.3b
Dec. 28	11.7a	23.9b	52.3b	9.6ab	0.75b	7.4a
Jan. 30	11.4ab	23.4b	51.3b	9.8a	0.64c	7.4a
Feb. 25	10.6b	22.2b	51.6b	9.9a	0.60d	7.4a
1975-76						
Nov. 18	11.8a	27.7a	54.7a	10.5d	0.89a	6.7b
Dec. 29	11.6a	28.6a	53.2a	11.4c	0.83b	6.8a
Jan. 20	10.6b	28.6a	55.5a	12.1b	0.80c	6.8a
Feb. 23	9.4c	26.5a	55.2a	12.8a	0.67d	6.8a

*Pounds solids/tree = kg-solids/tree x 2.2; TSS = total soluble solids; TTA = total titratable acidity; box = 40.8 kg (90 lb).

²Means in each column followed by the same letter do not differ statistically at the 0.01 level.

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is not surprising, because the latest harvest date for 'Hamlin' was prior to bloom and over a month earlier than the first 'Valencia' harvest. Even so, differences between yields of the earliest and latest harvested trees were greater for the second season than for the first, suggesting late harvesting of 'Hamlin' did depress yields slightly the following year.

A large part of the 'Hamlin' crop is sold for juice on the basis of pounds solids, reported here as kg-solids. Yields calculated this way gave a somewhat different pattern because of variations in percent juice and total soluble solids (TSS). It is generally assumed that TSS and percent juice will increase during the first part of the season and remain static or decline as fruit becomes senescent. TSS did increase during the first season (1974-75), but the percent juice decreased (Table 1). The increase in TSS was not enough to overcome the loss in boxes of fruit and decrease in juice content. The large reduction in kg-solids between the Nov. and Dec. harvests was statistically significant. There were no significant decreases in yield between successive dates after that but the greatest difference of (5.1 kg-solids) was between the earliest and latest dates of harvest.

Total soluble solids increased the second year (1975-76) as the season progressed while percent juice remained essentially the same. Yields were not statistically different even though there was a mean difference of 2.1 kg-solids per tree between the January and February harvests. It is possible, of course, that there could be seasons in which date of harvest would have a greater effect on kg-solids but it appears that differences would be less pronounced than for yields on a box basis.

The advantage of prolonging the harvest season must be balanced against lower yields resulting from late harvest and the possibility of losses from freezes, as was experienced in 1977.

'Valencia' orange. 'Valencia' orange, unlike 'Hamlin', increased in yield with successively later dates of harvest during the first season (Table 2). These increases were primarily due to increases in fruit diam (Table 2). Differences were not statistically different even though there was about a 10% mean difference between the first and the last dates of harvest. The stepwise increases, however, suggest the differences were real. Harvest dates the first year influenced the yields the second year in that the pattern of yields was reversed; i.e., trees harvested in April 1976 had significantly more fruit than those harvested in July 1976. This influence is well documented by research in other regions (2, 3, 7, 8, 9).

Table 2. Effect of date of harvest yield, quality and fruit size of 'Valencia' orange.

Date of harvest	Yield/ tree (boxes)*	Solids/ tree (kg)	Juice (% by wt)	TSS* (%)	TTA* (%)	Fruit diam (cm)
1975						
Apr. 17	2.9a ⁷	6.4a	48.2b	11.2b	1.00a	7.1c
May 15	2.9a	6.9a	48.6b	11.7a	0.98b	7.1c
June 12	3.1a	6.8a	49.1b	11.0b	0.75c	7.4b
July 18	3.2a	7.2a	52.9a	10.1c	0.63d	7.5a
1976						
Apr. 14	4.8a	10.8a	50.6a	10.9b	0.92a	7.2c
May 21	4.4ab	10.5a	51.3a	11.7a	0.78b	7.2c
June 18	4.3ab	8.7b	47.9b	10.2b	0.63c	7.6b
July 12	3.9b	7.6b	47.7b	9.9c	0.59d	7.7a

*Pounds solids/tree = kg-solids/tree x 2.2; TTS = total soluble solids; TTA = total titratable acidity; box = 40.8 kg (90 lb).

⁷Means in each column followed by the same letter do not differ statistically at the 0.01 level.

Patterns of yields calculated as kg-solids per tree, unlike those for 'Hamlin', were essentially the same on a box and kg-solids basis respectively. The pattern of TSS was the same both seasons but percent juice remained the same for the first 3 harvest dates and increased for the last date in 1975 (Table 2). Percent juice remained the same for the first 2 harvest dates but it was lower for the last 2 harvest dates in 1976. Differences in juice quality either offset each other or were too small to meaningfully change the pattern of yields calculated as kg-solids from that on a box basis. Quality of juice varies considerably from year to year and it is very likely that this pattern could be changed to a limited degree. The pronounced influence of date of harvest, however, on yield on a box basis suggests the former will be the controlling factor.

'Marsh' grapefruit. 'Marsh' grapefruit, like 'Hamlin' orange, attains legal maturity in the fall but like, 'Valencia', it may be retained on the tree until summer, during which time fruit continue to increase in size. Yields of 'Marsh' grapefruit increased with late dates of harvest during the first season (Table 3). Differences were not statistically significant, even though the mean difference in yield between Oct. and Apr. harvest dates was 1.4 boxes. The largest difference between 2 successive harvest dates was 0.9 box between October and December. Increases in yield with successively later harvest dates were due to increases in fruit size as the season progressed (Table 3). Agreement of these data with those of previous work in the same planting and with work in other regions suggests the differences were real despite lack of statistical significance. Yields during the second season were not decreased by holding fruit on the tree late in the first season (Table 3). The data do not agree with that of previous work (10) in the same planting; however, the 2 experiments were not entirely comparable.

Table 3. Effect of date of harvest on yield, quality and fruit size of 'Marsh' grapefruit.

Harvest date	Yield/ tree (boxes)*	Solids/ tree* (kg)	Juice (% by wt)	TSS* (%)	TTA* (%)	Fruit diam (cm)
1974-75						
Oct. 29	13.4a ⁷	21.1a	48.2	8.3a	0.95a	10.5b
Dec. 30	14.3a	20.6a	46.6ab	8.4a	0.92a	10.7b
Feb. 17	14.5a	20.9a	45.0b	7.9b	0.84b	10.9ab
Apr. 12	14.8a	19.6a	46.0ab	7.7c	0.66c	11.0a
1975-76						
Oct. 21	16.2a	24.3b	47.2b	8.2a	1.02a	9.4d
Dec. 30	16.7a	28.8a	51.8a	8.5a	0.93b	10.1c
Feb. 24	17.1a	28.2ab	51.4a	8.2a	0.85c	10.3b
Apr. 30	16.6a	23.8b	47.9b	7.9a	0.66d	10.5a

*Pounds solids/tree = kg solids/tree x 2.2; TSS = total soluble solids; TAA = total titratable acidity; box = 38.6 kg (85 lb).

⁷Means in each column followed by the same letter do not differ statistically at the 0.01 level.

Yields in the first season were all lower than those of the second season, indicating treatments of various dates of harvest in 1974-75 were applied during an "off" year. This would tend to reduce the effects of a late harvest on subsequent yields, as was previously reported (10). Moreover, fruit were harvested in December of the second year in the previous work, instead of leaving fruit on the tree until late in both seasons as was done in this experiment. Thus, fruit continued to increase in size, which compensated at least in part for the depressing effect of late harvest the previous year. Fruit drop did not influence yields of 'Marsh' as it did

'Hamlin'; however, previous work has shown that holding fruit on the tree later (May and June) than in this experiment did result in considerable fruit drop (1).

Yields as kg-solids were calculated even though grapefruit is not usually sold on this basis. The kg-solids tended to decrease as the season progressed instead of increasing as did yields on a box basis. This was due to decreases in both TSS and percent juice. Differences were small and not statistically significant. Kg-solids per tree increased to a maximum during Dec. and Feb. the second year, the yield for the latest harvest date (Apr.) being about the same as or slightly less than for the first harvest in Oct. These yields were, of course, reflections of the box yields, TSS and percent juice, with the lower TSS and percent juice causing kg-solids to drop more sharply for the Apr. harvest than did yields on a box basis.

Application of Results

The data presented herein should not be used on a quantitative basis. It is the pattern of responses and some idea of the magnitude of the differences that are important as information that might be manipulated by growers to their benefit.

The most meaningful results with 'Hamlin' were the large fruit drop in the late season and the small influence of date of harvest on the subsequent crop. There is no research on the use of 2,4-D to prevent late season fruit drop of this cultivar. If late season drop could be prevented, the yields of kg-solids per tree would be increased with late dates of harvest, or at least not reduced.

Effects of late harvest on yield of 'Valencia' the following year suggests that early harvest is best, but all of the fruit can not be harvested early. Effects of late harvest can be minimized by harvesting plantings with light crops late and those with heavy crops first because the size of the crop as

well as the date of harvest influences the subsequent crop. Similarly, it would be best to harvest light crops of 'Marsh' grapefruit late and heavy ones early or else partially harvest (spot pick) heavy crops as is often done anyway. Previous work (10) has shown that even partial early harvest (Nov.) will appreciably offset the harmful effects of late harvest.

Date of harvest must also take into account the seasonal demands and prices for fruit and the greater hazard of freeze when fruit is held late. Virtually all grapefruit on trees in this experiment were lost from freeze damage in 1977, the year after conclusion of the experiment.

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INJURY TO CITRUS FRUITS BY LEAFFOOTED AND CITRON PLANT BUGS¹

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Abstract. The leaffooted plant bug pierces the citrus fruit peel and sucks juice directly from the underlying vesicles. Feeding punctures between the oil glands can result in secondary infections by microorganisms that are difficult to detect without cutting the fruit. Citrus oil released at the site

of penetration during feeding appears to inhibit secondary infection but the released oil often leads to a surface necrotic spot. Feeding and subsequent juice vesicle drying and oxidation in grapefruit make the fruit unsuitable for sectionizing as the dried-out juice vesicles become extremely visible as reddish-brown spots after alkali peeling.

The citron bug, *Leptoglossus gonagra* (F.), and the leaf-footed plant bug, *L. phyllopus* (L.), have been recognized as minor pests of Florida citrus for many years (4, 12, 13, 14). In recent years, these species have built up consistently damaging populations in many groves. This has been particularly true in the Indian River district (2).

Thompson (12), Watson (13), and Griffith and Thompson (4) have described feeding injury by these insects as penetration of the peel and extraction of juice which results in dry spots in the juice vesicle area. Fruit with several punctures might drop off the tree before harvest (12). Punctured fruit often decayed after harvest (13).

Alternate hosts are thistle (14), citron, and watermelon for *L. gonagra* (4), and some leguminous cover crop plants serve as host plants for both species. This paper reports ad-

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