

**FINAL PROJECT REPORT**

**WTFRC Project Number:** AH-05-501

**Project Title:** Mechanisms of apple fruit growth under Washington conditions

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**Budget History:**

| <b>Item</b>          | <b>Year 1:</b> | <b>Year 2:</b> | <b>Year 3:</b> |
|----------------------|----------------|----------------|----------------|
| <b>Salaries</b>      |                | 3380           |                |
| <b>Benefits</b>      |                | 1159           |                |
| <b>Wages</b>         | 7494           | 9584           |                |
| <b>Benefits</b>      | 757            | 968            |                |
| <b>Equipment</b>     |                |                |                |
| <b>Supplies</b>      | 6750           | 8850           |                |
| <b>Travel</b>        |                |                |                |
|                      |                |                |                |
|                      |                |                |                |
| <b>Miscellaneous</b> |                |                |                |
| <b>Total</b>         | 15000          | 23941          |                |

## SIGNIFICANT FINDINGS

- Gala fruit grew at the same rate as those of red delicious, and were only smaller at harvest due to their earlier harvest date.
- Different patterns of cell division, in terms of the number of cells dividing, were found in the 2 years of this study. In 2005 cell division occurred over a protracted period, but was much shorter in 2006.
- In 2006, fruit size was more closely related to cell size than cell number.

## RESULTS AND DISCUSSION

Flower and fruit samples were collected from a Washington orchard during the 2005 and 2006 growing seasons. The treatments were cultivar (Gala and Red Delicious) and crop load (heavy crop load, no thinning, and light crop load achieved by thinning at bloom). Sample collection began soon after bloom and continued until harvest. On each sampling date, fruit were shipped immediately from Washington to Indiana where fruit size was measured followed by preparation of samples for flow cytometry and dissection.

During 2005, our thinning treatments were insufficient to affect fruit size (Fig. 1). In 2006 we imposed a more severe thinning treatment and achieved a fruit size response, both in terms of fruit diameter and fruit fresh weight (Fig. 2). It is interesting to note that in both years, the growth of Gala fruit was similar to that of Red Delicious, but the greater final size of Red Delicious fruit was due to their later harvest date.

The main components of fruit growth are cell number and cell size. Cell number increased rapidly until approximately 50 days after full bloom but from that point until the end of the growing season, there was little change in over cell numbers (Fig. 3). There was no difference between Gala and Red Delicious fruit in terms of cell number. Likewise, reducing crop load did not increase fruit size by increasing the number of cells in the fruit. When cell size was plotted against accumulated growing degree days, the pattern was very similar to that in Fig. 3 plotted against days after full bloom (data not presented).

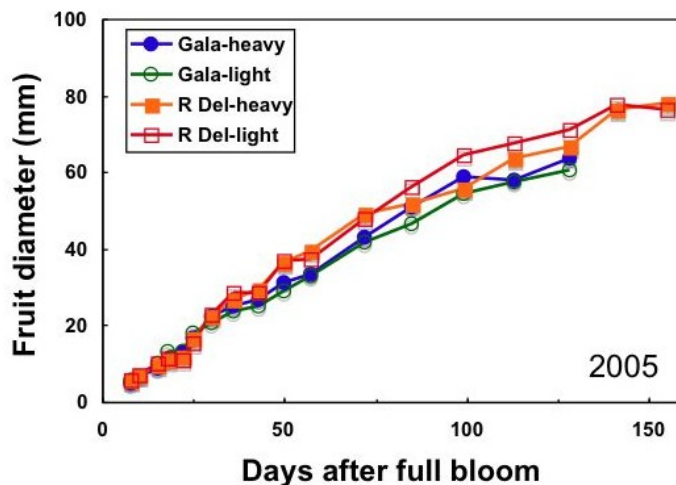


Fig. 1. Fruit diameter of Gala and Red Delicious fruit under different crop loads during the 2005 growing season.

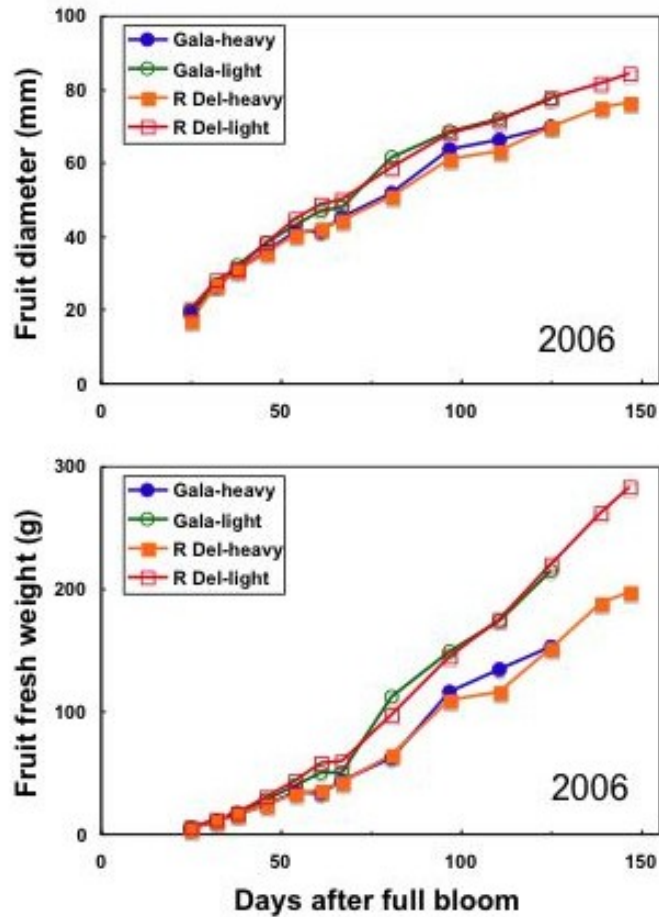


Fig. 2. Fruit diameter and final fresh weight of Gala and Red Delicious fruit under different crop loads during the 2006 growing season.

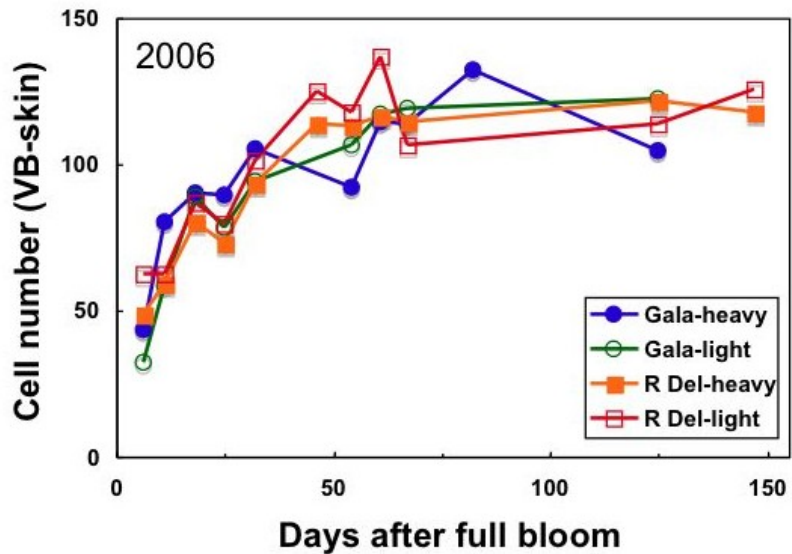


Fig. 3. Cell numbers in Gala and Red Delicious fruit under different crop loads during the 2006 growing season. Cell numbers were determined by counting a file of cells from the sepal vascular bundle to the epidermis.

An increase in the fruit cell number is brought about by cell division processes. One key component of this that has not been examined previously is the proportion of cells in the fruit actively dividing at any given point in time. Apple fruit contain a heterogenous population of cells, ie, they are not all doing the same thing at the same time. Using flow cytometry, we estimated the proportion of cells in a fruit that were actively dividing. As can be seen from Fig. 4, during the 2005 growing season, both Gala and Red Delicious reached a peak of about 15% of their cells dividing at one time. Both had a peak of cells dividing early in the season, but the proportion of Gala cells dividing declined soon after. Red Delicious on the other hand, had a second peak of cells dividing.

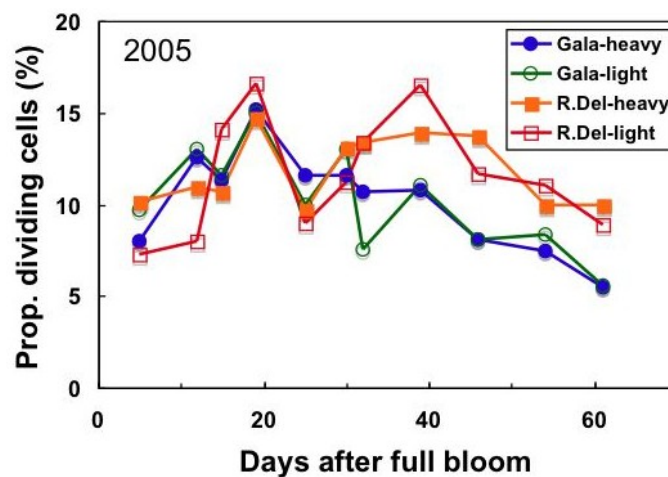


Fig. 4. The proportion of cells in Gala and Red Delicious fruit actively dividing during the 2005 growing season as estimated by flow cytometry.

In 2006 however, there was no difference between Gala and Red Delicious in terms of the proportion of cells dividing. In addition, crop load did not affect the proportion of cells dividing. As noted earlier (Fig. 3), neither cultivar nor crop load affected fruit cell number.

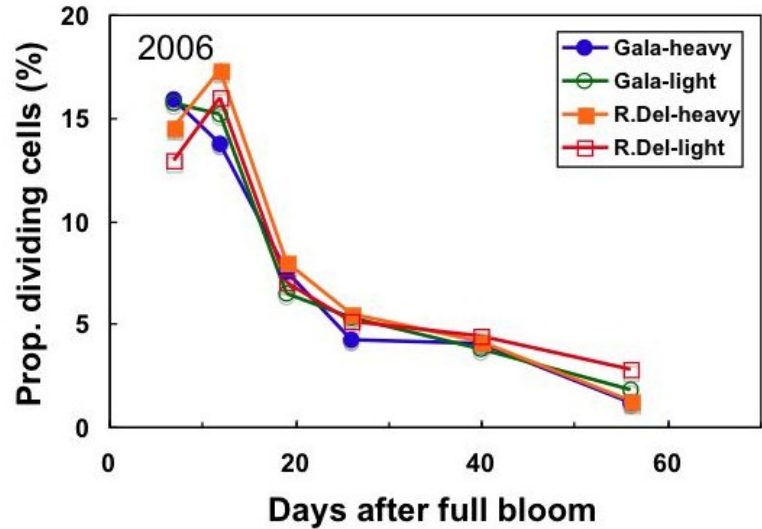


Fig. 5. The proportion of cells in Gala and Red Delicious fruit actively dividing during the 2006 growing season as estimated by flow cytometry.

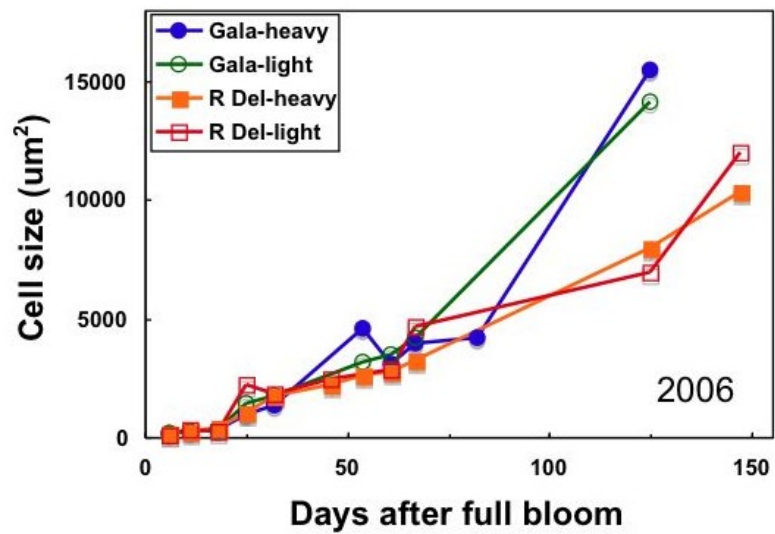


Fig. 6. Size of cortical cells in Gala and Red Delicious fruit under different crop loads during the 2006 growing season.

Crop load had no effect of fruit cortical cell size (Fig. 6). During the early part of the season, both Gala and Red Delicious had similarly sized cells. Cells in Red Delicious increased linearly over the season, whereas Gala cells appeared to increase dramatically at the end of the season. This result is puzzling but it should be borne in mind that it relies on one sample at the end of the season.

Fruit size throughout the season was much more closely related to cell size, rather than cell number (Figs. 7-8). Caution should be used in concluding that cell size is the only driver of fruit size, since this analysis includes data from early in the season through to harvest. Cell size is also a product of how rapidly cells are dividing.

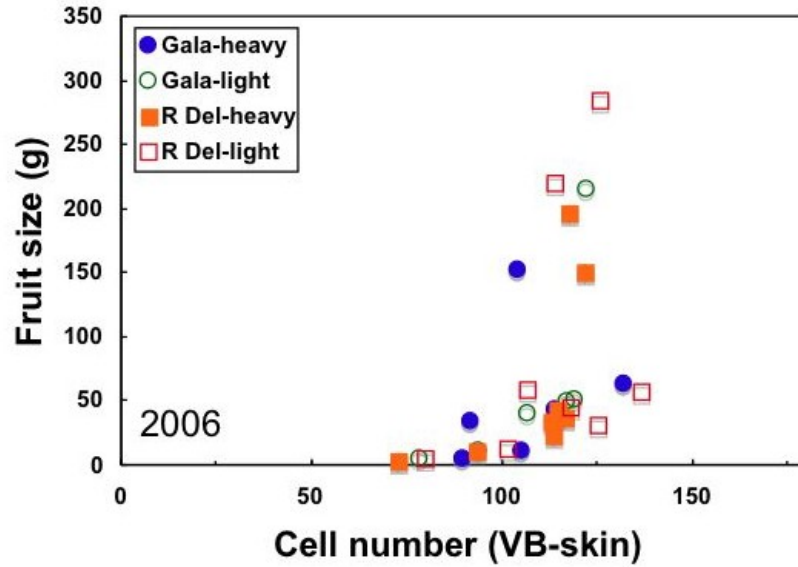


Fig. 7. The relationship between fruit size and cortical cell number in Gala and Red Delicious fruit under different crop loads during the 2006 growing season.

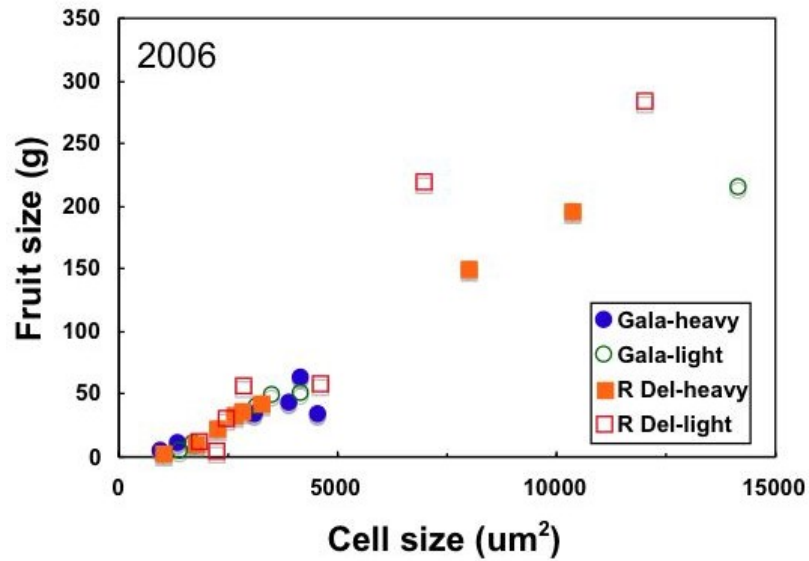


Fig. 8. The relationship between fruit size and cortical cell size in Gala and Red Delicious fruit under different crop loads during the 2006 growing season.