Crop Load and Rootstock Interact to Affect Golden Delicious Tree Growth, Fruit Size, and Ripening: 2003 NC-140 Apple Rootstock Physiology Trial

Wesley R. Autio, James Krupa, and Jon M. Clements
Department of Plant, Soil, & Insect Sciences, University of Massachusetts

As part of the 2003 NC-140 Apple Rootstock Physiology Trial, a planting of Gibson Golden Delicious on three rootstocks was established at the University of Massachusetts Cold Spring Orchard Research & Education Center in 2003. Trees in this trial grew very poorly during their first two seasons. They grew well in 2005, 2006, and 2007, but fruit set was very low in 2006. In 2007, crop load was adjusted to between 3 and 14 fruit per cm^2 trunk cross-sectional area (TCA).

At the end of the 2007 growing season, TCA of trees on G.16 and M.26 EMLA were significantly greater than that of trees on M.9 NAKBT337 (Table 1). Rootstock did not affect root suckering (2003-07), yield per tree (2007 or cumulative), yield efficiency (2007 or cumulative), or crop load (since they were adjusted) (Table 1).

The purpose of this trial was to determine if crop load and rootstock interacted to affect tree physiology. Crop load and rootstock did not interact significantly to affect trunk growth (Figure 1). Incremental growth in 2007 declined with increasing crop load and was greatest for trees on M.26 EMLA. Trees on M.9 NAKBT337 and on G.16 were similar. When presented as a percent of TCA at the end of 2006, trunk growth was similar for trees on M.26 EMLA and M.9 NAKBT337 and lower for trees on G.16.

Fruit characteristics also were measured in 2007 (Figure 2). Fruit size was negatively related to crop load, declining from an average of approximately 220g at 3 fruit/cm^2 TCA to 140g at 14 fruit/cm^2 TCA. Crop load did not interact with rootstock, however. M.9 NAKBT337 resulted in the largest fruit and G.16 and M.26 EMLA resulted in smaller and similarly sized fruit.

Flesh firmness declined with time and was negatively affected by crop load (Figure 2). Rootstock effects on firmness were nonsignificant, but rootstock interacted with crop load. Specifically, the impact of crop load on fruit from trees on M.9 NAKBT337 was variable. Effects were was more consistently negative with trees on M.26 EMLA and on G.16. The general

Table 1. Trunk cross-sectional area, suckering, yield, yield efficiency, and average crop load in 2007 of Gibson Golden Delicious trees on three rootstocks in the Massachusetts planting of the 2003 NC-140 Apple Rootstock Physiology Trial. All values are least-squares means, adjusted for missing subclasses.[z]

Rootstock	Trunk cross-sectional area (cm^2)	Root suckers (no./tree, 2003-07)	Yield per tree (kg) 2007	Yield per tree (kg) Cumulative (2006-07)	Yield efficiency (kg/cm^2 TCA) 2007	Yield efficiency (kg/cm^2 TCA) Cumulative (2006-07)	Crop load (2007, no./cm^2 TCA)
G.16	15.9 a	0.0 a	19.4 a	25.1 a	1.25 a	1.60 a	7.8 a
M.26 EMLA	19.8 a	0.0 a	25.2 a	29.3 a	1.36 a	1.46 a	7.3 a
M.9 NAKBT337	11.3 b	0.4 a	17.1 a	21.7 a	1.54 a	1.95 a	8.5 a

trends noticed for firmness are particularly interesting, since fruit from trees with a greater crop load were smaller and ripen later, two conditions where increased firmness would be expected.

Soluble solids concentration was affected by rootstock, with M.9 NAKBT337 resulting in the highest concentration and M.26 EMLA resulting in the lowest (Figure 2). Crop load was negatively related to soluble solids concentration, but it also interacted significantly with rootstock. As with flesh firmness, the negative effect of increasing crop load was most consistent with fruit from trees on M.26 EMLA and on G.16. Soluble solids concentration of fruit from trees on M.9 NAKBT337 was negatively affected by increasing crop load, possibly to a lesser degree than the other rootstocks, but the effect also was more variable. The general results with soluble solids concentration followed what would be expected relative to effects of crop load and rootstock on ripening, with the ripest fruit having the greatest concentrations.

Starch contents also were affected by rootstock, with fruit from trees on G.16 and on M.26 EMLA having the lowest contents (highest index values) and those from trees on M.9 NAKBT337 having the highest content (lowest index values) (Figure 2). Crop load was negatively related to starch content (positively related to index values), and crop load did not interact significantly with rootstock. It is interesting to note that the lowest starch contents, normally associated with the ripest fruit, were measured at the highest crop loads. Clearly, competition for carbohydrates reduced starch concentration in fruit at the high crop loads. Likely, the low soluble solids concentrations also seen at high crop loads were as much related to low starch levels as delayed ripening.

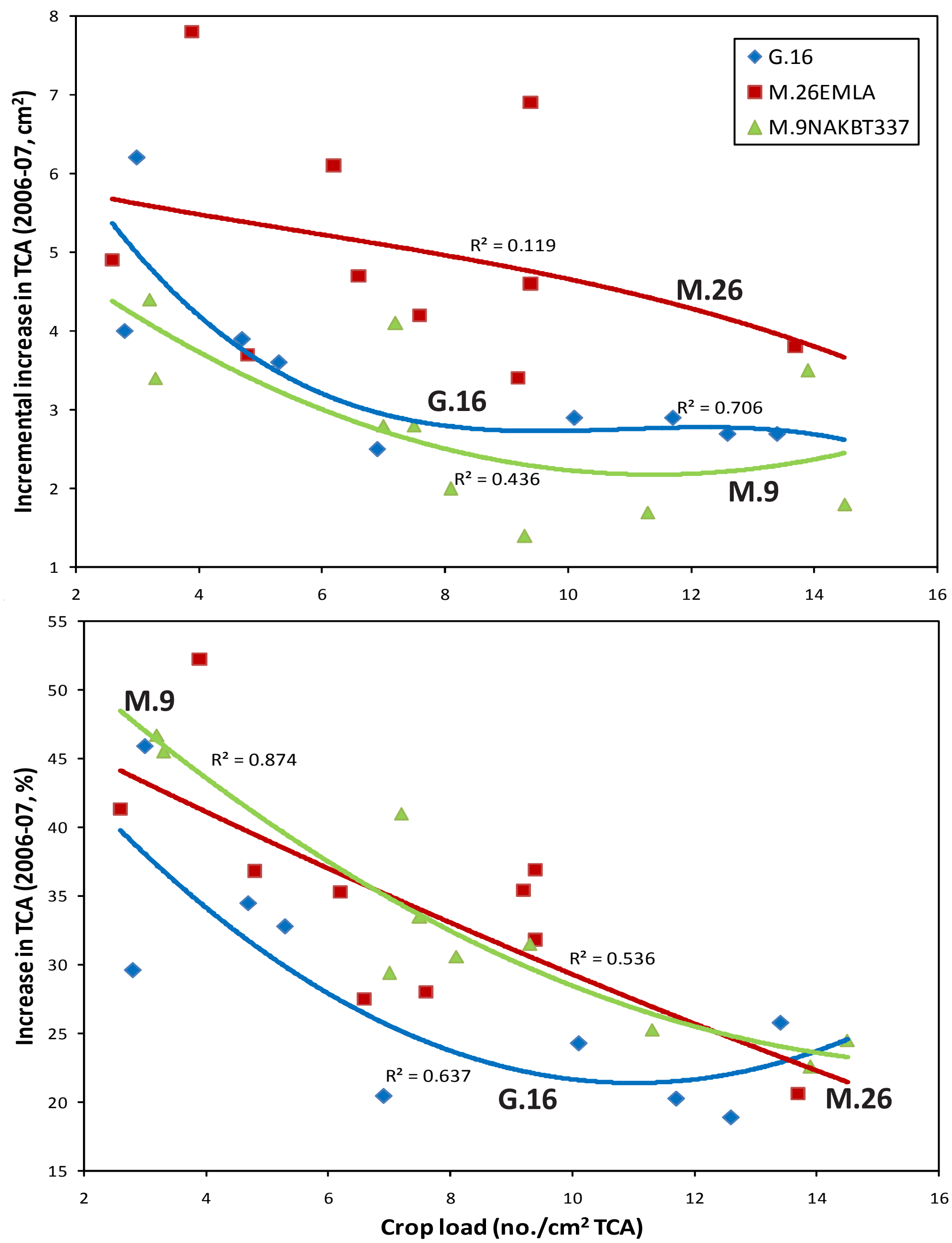

Figure 1. Effects of crop load and rootstock on trunk growth in 2007, expressed as the incremental and percentage increase in trunk cross-sectional area, of Gibson Golden Delicious trees in the 2003 Apple Rootstock Physiology Trial.

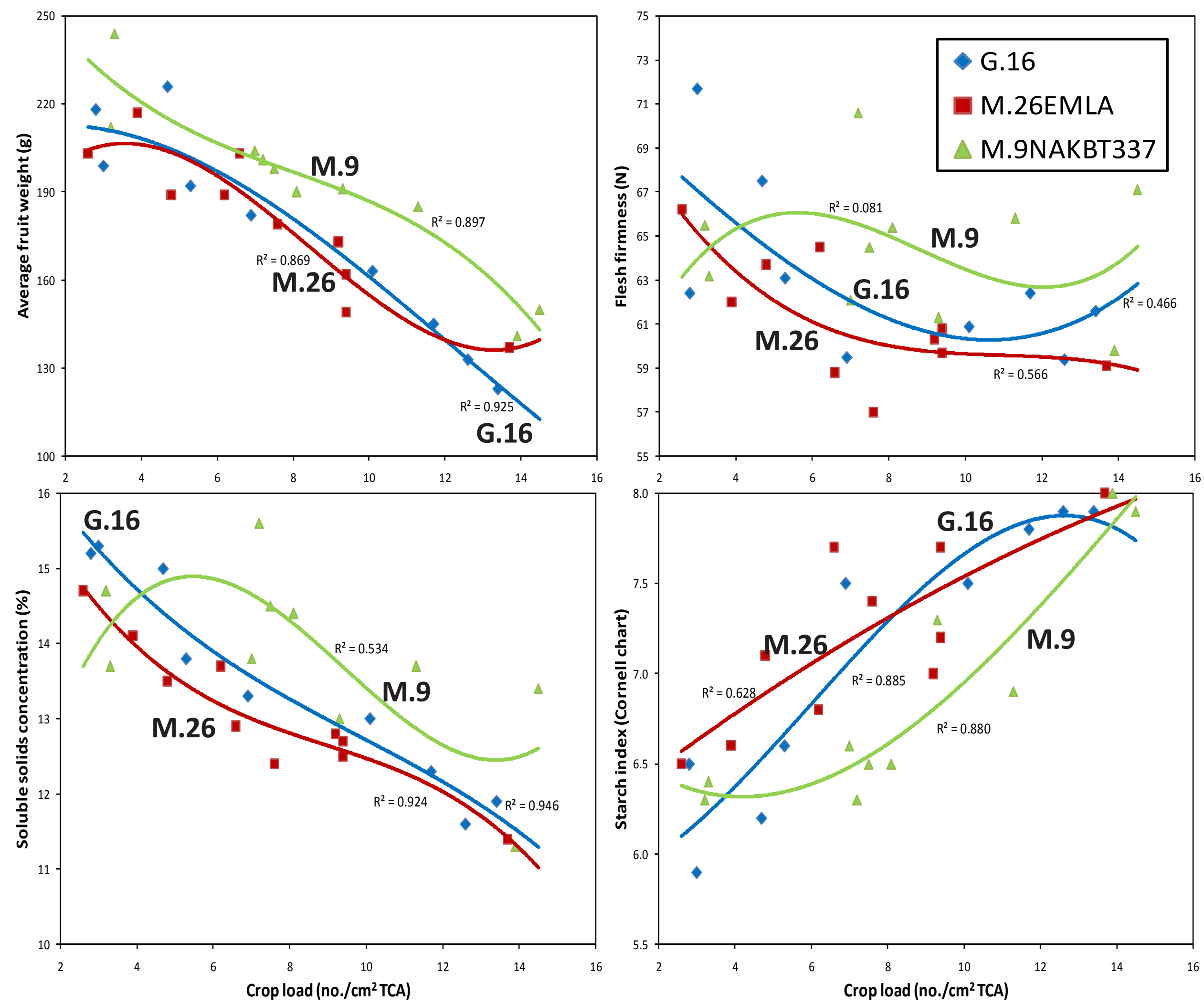

Figure 2. Effects of rootstock and crop load on size, flesh firmness, soluble solids concentration, and starch breakdown of fruit from Gibson Golden Delicious trees in the 2003 Apple Rootstock Physiology Trial.

Internal ethylene concentrations more accurately assess ripening than do flesh firmness, soluble solids concentration, or starch content, particularly in an experiment where treatments affect the latter measurements outside of their effects on ripening. Overall, ethylene concentrations were similar in the core cavity of fruit from trees on G.16 and M.9 NAKBT337 (Figure 3). The concentration was lower in fruit from trees on M.26, suggesting that these fruit were less ripe than those from trees on G.16 or M.9 NAKBT337. The negative effects of crop load on internal ethylene concentration were pronounced, confirming other work showing a negative relationship between crop load and ripening. Also, crop load and rootstock interacted significantly. The relationship between crop load and internal ethylene were consistent and dramatically negative for G.16 and M.26 EMLA. The relationship was more variable and less pronounced for M.9 NAKBT337. Using the date when fruit reached an average log ethylene of zero, the date of ripening can be compared. Crop load had a pronounced effect, delaying ripening by as much as 3 weeks from light set to heavy set. Crops load and rootstock did not interact significantly. On average, fruit from trees on M.9 NAKBT337 ripened 1.2 days before those from trees on G.16, and fruit from trees on M.26 EMLA ripening 3.8 days later than those on G.16.

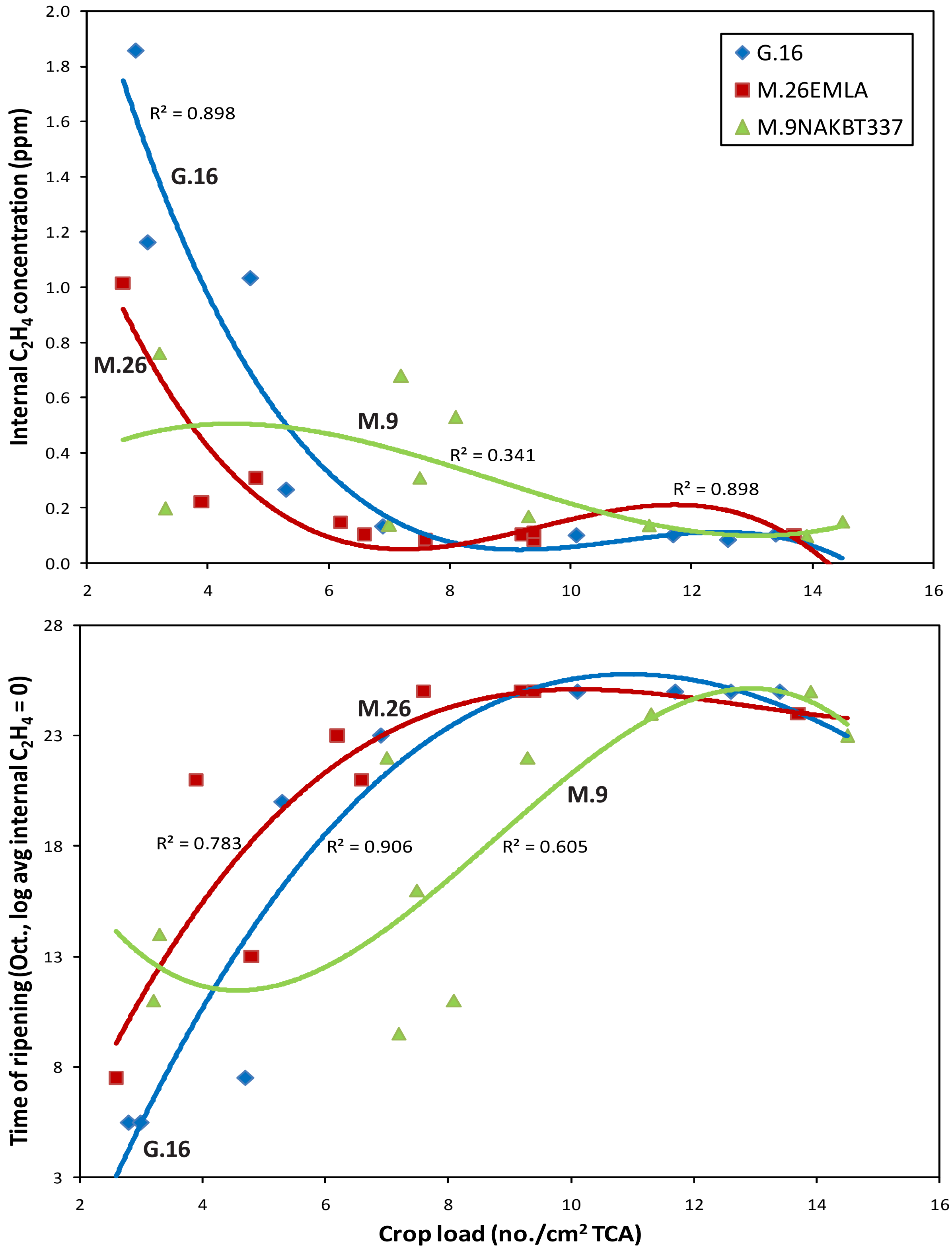

Figure 3. Effects of rootstock and crop load on the internal ethylene concentration and an estimate of the time of ripening of fruit from Gibson Golden Delicious trees in the 2003 Apple Rootstock Physiology Trial.