Practical Implications of Early- and Mid-Summer Water Stress on Tree Growth, Cropping, and Physiology

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The sunnier weather we experienced in June 2022 should have been good for photosynthesis and resulted in greater production of carbohydrates to support fruit growth compared to other years, unless the hotter temperatures and lack of rainfall in late June/early July 2022 in portions of Eastern New York have induced water stress in the plant. This is the kind of situation where even with irrigation apples don't always size that well. We think it is because the high temps and high evaporative demands with the rather high hydraulic resistance of apple roots, we get some significant stresses even with wet soil. The following Figure 1, modified from Mark O'Connell and Ian Goodwin in Australia, shows that increased afternoon vapor pressure deficit (VPD) creates greater stress in the plant. In a study we did with fruit growth monitors we found the fruit started to expand about 2 pm each day but with afternoon VPD's of 3 kPa even with irrigation the trees still experience stress and fruit growth is reduced.

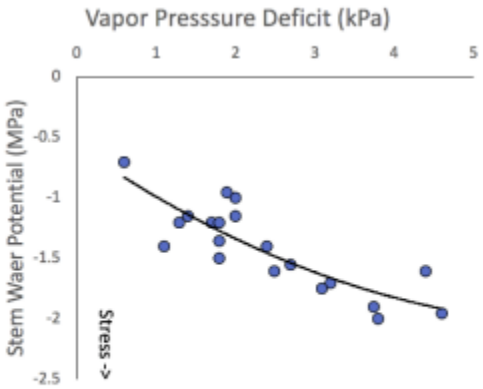


Figure 1. Relationship of increasing Vapor Pressure Deficit (increasingly drier and hotter air) on plant stem water potential (more negative values indicate more stress) in irrigated trees on sunny days. Modified from O'Connell and Goodwin, 2007.

This is the type of situation that we think overhead misting or overhead nets could help. Misting cools the tree to reduce transpiration, while nets reduce radiation and transpiration. We have not conducted this kind of physiology research in NY, but with the types of droughts and heat like 2016, early 2018, early 2020, and this year, it might be well worth trying in the future. We are currently conducting a project with the support of USDA-Specialty Crop Research Initiative (SCRI), and New York Farm Viability Institute (NYFVI) to use new apple micro-tensiometers and fruit growth gauges to monitor plant stress (stem water potential) and their relations to real-time fruit expansion to see if we can avoid reductions in fruit growth during stress periods. One practical approach to managing water stress is to use summer pruning or hedging to reduce tree leaf area during droughts. One of our former students (Kuo-Tan) found that fairly heavy summer pruning reduced tree transpiration and caused less water stress. We were surprised, thinking that the interior leaves would just increase their transpiration, but if they were in the shade for very long, they lose some gas exchange capacity, so they don't use as much water as the

young exposed leaves we removed. This does also reduce photosynthesis, but if water stress is a greater problem it may be worth it, assuming there is no loss by sunburn.

How Water Stress Affects Apple Trees

Whenever the water-use demands of a tree cannot be met due to dry soil or sunny, hot dry conditions, stress will develop.

Timing of Water Stress

Growth processes by cell division are more sensitive to water stress than processes such as cell expansion, storage and photosynthesis or transpiration. Consequently, water stress that develops in the spring and early summer can have dramatic effects on vegetative growth, fruit growth and fruit set because early-season shoot growth and early development of fruits are primarily by cell division processes. If the drought develops early in the season, there will be a reduction in vegetative growth, which will reduce leaf area and possibly canopy light interception. Crop load may be also be reduced by early stress that may affect fruit size potential and final set, leading to lighter crop load. These responses can change future water requirements later in the season.

Water stress that develops more typically in midsummer will have less effect on vegetative growth and less effect on fruit yield, as canopy development and fruit set are complete or nearly so by summer.

Effects of Water Stress on Vegetative Growth

Since adequate water is needed for cell turgor to drive expansion growth of apple leaves and stems, shoot growth is sensitive to water deficits. Detailed measurements of shoot growth rate in relation to plant water stress indicate that shoot expansion is almost linearly reduced by declining midday stem water potentials showing increasing stress (Figure 2). Although mature leaves can osmotically adjust to maintain turgor, apple shoot tips do not. Therefore, shoot-tip turgor and growth will decline directly with declining water potentials. Fruit and roots have been shown to adjust osmotically for turgor maintenance.

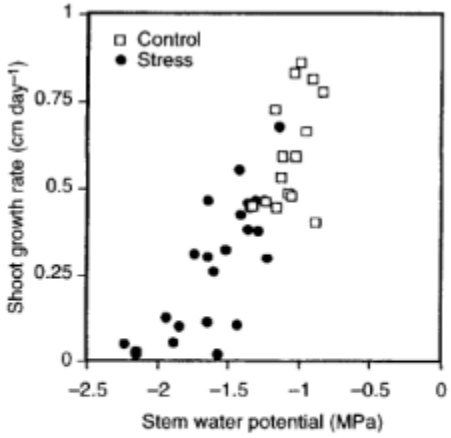


Figure 2. Relationship of extension-shoot growth rate to variations in midday stem water in apple trees as affected by drought stress (M. Al-Hazmi and A. Lakso, unpublished data). The more negative the potential the greater the stress.

Effects of Water Stress on Fruit Growth and Development

Water stress reduces several aspects of fruit growth. Fruit set in the first weeks after bloom appears to depend on maintenance of an adequate rate of fruit growth. Therefore, reductions in fruit growth during the early cell-division period can reduce both fruit set and the potential for good fruit size at harvest, although these early-season processes are often complete before severe stress develops. The effects of water stress on fruit development appear to be more severe if the stress occurs during the cell-division period (3-4 weeks after full bloom). Reductions in growth during cell division are manifested over the remainder of the season, even if water is abundant later (Figure 3). Some years ago, we conducted a study of early water stress on fruit growth of potted Empires. We stopped watering the trees in the cell division period for 10-12 days then re-watered all season. In 1994 the stress did not develop until after cell division, and we saw some initial size reduction, but it recovered by harvest. In 1995 the stress was earlier, and so it presumably reduced cell numbers and even with good water for the rest of the season the final size was reduced. We believe that this year we might see a range of situations like this with varying times of stress starting depending on soil reserves and rainfall.

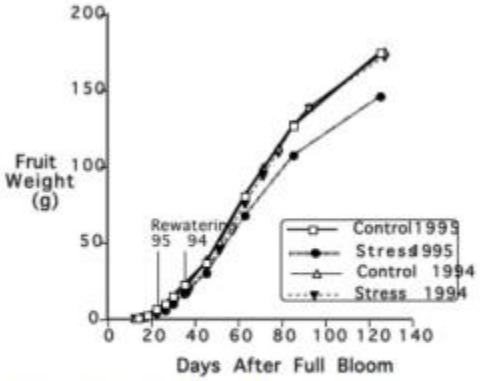


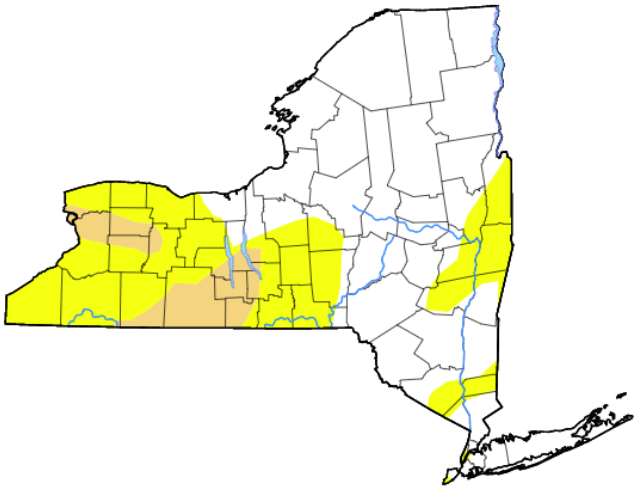
Figure 3. Apple fruit growth as affected by short-term water stress during cell division (1995) or after cell division (1994) on seasonal fruit development (M. Al-Hazmi and A. Lakso, unpublished data).

Summary

Generally, sunlight affects carbohydrate supply while temperature affects more the demand for that carbohydrate. The balance of carbohydrate supply to demand is important to fruit development and thinning as we have learned. The tree can be in balance with less sunlight if it is cool as both supply and demand are reduced. Conversely, the tree can also be in balance in sunny warm conditions as both supply and demand are increased assuming there is no drought. The worst situations are cloudy and hot weather and warm nights, as demands increase but the supply is not only reduced by lower light but also the heat can reduce photosynthesis even further. Hot, dry conditions where VPD is high can lead to significant water stress as discussed above. The drought complicates things. If the stresses that developed in the trees in the last 4-6 weeks were enough to reduce photosynthesis, then fruit growth rate was reduced. Monitoring fruit growth during droughts is a very useful tool in any case as it integrates a lot of such competing factors. Finally, it is essential to have irrigation for tall spindle plantings to ensure tree establishment and maximize fruit size at any given crop load. Water stress at any time of the season reduces fruit growth rate with permanent loss in fruit size, which is difficult to

recover later. Also, very dry soil conditions can reduce the availability of nitrogen, phosphorous, potassium, calcium, and boron to tree roots.

We hope some of the rains we are now getting will help to mitigate the negative effects of the 2022 drought on fruit size and yield. Good luck the rest of the 2022 season!



Map released: Thurs. July 21, 2022

Data valid: July 19, 2022 at 8 a.m. EDT

Intensity

- None
- D0 (Abnormally Dry)
- D1 (Moderate Drought)
- D2 (Severe Drought)
- D3 (Extreme Drought)
- D4 (Exceptional Drought)
- No Data

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