Precision Management: How and Why We Should Irrigate

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Irrigation is essential to prevent water stress and small fruit size of apples in dry summers, even in humid climates like New York State. In 2015, we carried out five trials across NY. Non-irrigated trees in the Hudson Valley had much more water stress, which resulted in considerably less yield and smaller fruit sizes. Failure to properly irrigate our orchards, especially in dry years and those on light soils, can affect not only yield of the current season, but tree growth and return bloom, which in the long run will be an important loss per acre.

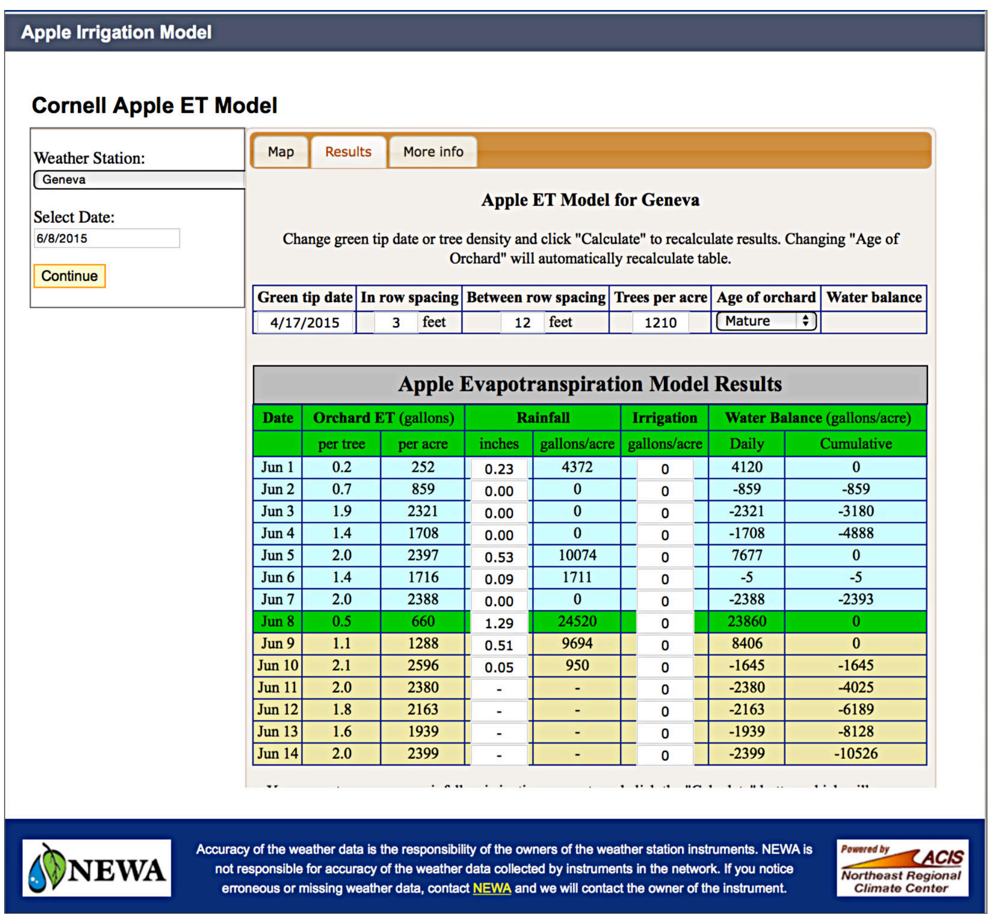
> **"With more precise water management, growers will be able to limit plant water stress and more consistently achieve the optimum economic fruit size and calcium content for each variety."**

The profit apple growers make per acre varies widely among growers and is affected by yield level, fruit size and fruit quality. The wrong fruit size or poor fruit quality greatly reduces the potential income per acre. Better management can achieve much higher returns per acre for a given variety of apple. For each variety and orchard, there is an optimum number of fruits per tree where yield, fruit size and fruit quality are optimized.

Growers attempt to achieve desired fruit size by properly reducing crop load with chemical thinners in the spring, but if the summer turns out to be dry, they will still not achieve the desired fruit size, and crop value will be severely compromised. To precisely manage fruit size requires precision in both chemical thinning and in irrigation. A second critical value of irrigation is to improve and maximize growth of newly planted or young apple trees. The economic success of high-density orchards depends on obtaining significant yields in the third, fourth and fifth years to repay the establishment costs.

Good water status is essential to maximize fruit size at any given crop load. Water stress at any time of the season reduces fruit growth rate, with a permanent loss in fruit size that is difficult to recover later. Water stress also limits uptake of calcium into the fruit and can result in more bitter pit. With more precise water management, growers will be able to limit plant water stress and more consistently achieve the optimum economic fruit size and calcium content for each variety.

Precision irrigation involves calculating the amount of water trees need for each day of the season based on temperature, sunlight level, wind speed and rainfall, using a web-based model (Dragoni and Lakso 2011) and then adding back to the soil the



Apple Irrigation Model

Cornell Apple ET Model

Weather Station: Geneva

Select Date: 6/8/2015

Continue

Map | Results | More info

Apple ET Model for Geneva

Change green tip date or tree density and click "Calculate" to recalculate results. Changing "Age of Orchard" will automatically recalculate table.

Green tip date	In row spacing	Between row spacing	Trees per acre	Age of orchard	Water balance
4/17/2015	3 feet	12 feet	1210	Mature	

Apple Evapotranspiration Model Results

Date	Orchard ET (gallons)		Rainfall		Irrigation	Water Balance (gallons/acre)	
	per tree	per acre	inches	gallons/acre	gallons/acre	Daily	Cumulative
Jun 1	0.2	252	0.23	4372	0	4120	0
Jun 2	0.7	859	0.00	0	0	-859	-859
Jun 3	1.9	2321	0.00	0	0	-2321	-3180
Jun 4	1.4	1708	0.00	0	0	-1708	-4888
Jun 5	2.0	2397	0.53	10074	0	7677	0
Jun 6	1.4	1716	0.09	1711	0	-5	-5
Jun 7	2.0	2388	0.00	0	0	-2388	-2393
Jun 8	0.5	660	1.29	24520	0	23860	0
Jun 9	1.1	1288	0.51	9694	0	8406	0
Jun 10	2.1	2596	0.05	950	0	-1645	-1645
Jun 11	2.0	2380	-	-	0	-2380	-4025
Jun 12	1.8	2163	-	-	0	-2163	-6189
Jun 13	1.6	1939	-	-	0	-1939	-8128
Jun 14	2.0	2399	-	-	0	-2399	-10526

NEWA

Accuracy of the weather data is the responsibility of the owners of the weather station instruments. NEWA is not responsible for accuracy of the weather data collected by instruments in the network. If you notice erroneous or missing weather data, contact NEWA and we will contact the owner of the instrument.

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Figure 1. Irrigation Model website with sample data from Geneva during the spring of 2015.

correct amount of water to minimize water stress and maximize fruit size. The model takes into account factors such as sunlight, temperature, humidity and the tree's responses to them to estimate how weather affects water use.

Cornell Apple Irrigation Model

The Apple Irrigation Model (http://newa.cornell.edu/index.php?page=apple-irrigation) on the NEWA website allows users to select a weather station close to their farm and then enter information on the spacing and age of the orchard (Figure 1). The model will then calculate and display the amount of water needed for that orchard for each of the last 7 days and for the upcoming 6 days, based on the weather over the last 7 days (from the weather station data) and from forecasted weather data expected over the upcoming 7 days (Figure 1). The calculated water volume needed by the orchard is displayed in gallons/acre. If the number is negative, the grower should add that amount of water to his orchard. If the number is positive, it means that rainfall exceeded transpiration and more water is available than needed, and no more water should be added. The website also allows a user to enter his own recorded rainfall, as rainfall varies considerably within short distances, and the weather station data may not represent the actual rainfall at the farm.

The Cornell model has the feature that rainfall is considered and subtracted from the water requirement of the trees. It also considers the effective rooting area of different age orchards to include only the portion of the rainfall that is available to the trees in the calculations of tree water requirement.

Precision Irrigation Management

This new model and website will allow more precise management of tree water status in both wet and dry years than was previously possible. Precisely managing soil water supply will require:

1. The grower or consultant to weekly log onto the NEWA website and determine the daily water requirement for his specific orchard (spacing and age) for the previous week and the upcoming week.
2. Irrigate the orchard to fully replace the estimated water requirement of the particular orchard via trickle irrigation.
3. To avoid oversaturating the soil when irrigation water is applied just before a large rainfall event or just after a large rainfall event, we suggest not applying the suggested irrigation amount for 1 day before a predicted large rainfall event (0.5 inches or more) or for 3 days after a large rainfall event.
4. The frequency of addition of the required water depends on soil type. With sandy soils, water should be added either daily or every 2 days. With silt or clay soils, the daily amount of water needed can be added up for several days and then added in one irrigation cycle.
5. In the early part of the season (early May to mid-June), we suggest that water be supplied once per week for both sandy and clay soils.
6. From mid-June until the end of August, we suggest that water be supplied twice per week in clay soils and every other day with sandy soils.

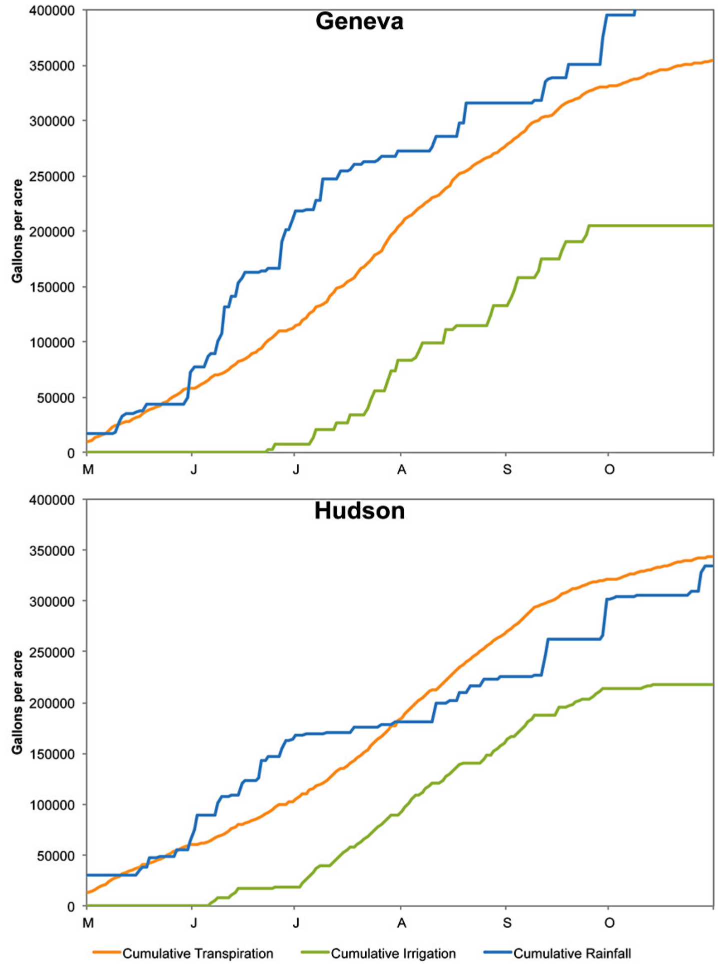

Figure 2. Cumulative tree transpiration, rainfall and irrigation from May through October in Geneva and the Hudson Valley, NY in 2015.

Results from 2015

In 2015, we conducted an irrigation management trial on four apple farms (one each in Ulster and Orleans, Wayne and Clinton Counties) and one at the Experiment Station in Geneva, using the Cornell Apple Irrigation Model. Geneva was an Empire/B9 orchard planted in 2011 at 1,156 trees/acre. Hudson (Ulster) was a Gala/M9 orchard, planted in 2011 at 1,117 trees per acre. In 2015, a Plumac/B9 orchard was planted in Orleans, at 1,980 trees/acre. Wayne was another Gala/B9 orchard planted in 2009 at 838 trees/acre. In the Champlain Valley (Clinton) a NY1/B9 orchard was planted in 2010 at 1,037 trees/acre.

At each site, we managed soil water level according to the irrigation model to minimize water stress while other trees were left unirrigated. We assessed tree growth and tree stress, plus crop yield, fruit size and fruit quality (flesh firmness and sugars) with irrigation and no irrigation. The difference between tree water requirement and rainfall is the water balance, with a negative number indicating the need for irrigation and a positive number indicating too much water. Daily effective rainfall was quite variable, but in general, 2015 was not an especially dry year, with frequent rains in June in Geneva that exceeded 5,000 gallons/day. In contrast, rainfall in Hudson was much less abundant, being mainly concentrated in June and a couple of weeks between August and September.

Accumulating the water balance values from bud break gives cumulative water supply and water demand. In 2015 in Geneva, the cumulative graph showed that water supply from rainfall was sufficient to meet water requirements of the tree for the whole season, whereas in the Hudson Valley, water requirement exceeded supply from rain from August through October, indicating the need to irrigate the trees during the whole summer (Figure 2). A delay in irrigation under these conditions makes it very difficult to "catch up" later in the season, when the cumulative water deficit becomes large. Heavy irrigation in a short period to catch up can lead to water and nutrient leaching.

The growth, function, productivity, and water use of trees are closely tied to tree water status. With the use of a pressure chamber (Figure 3), we can measure the suction force that is being exerted by the tree to obtain water. The more negative the value, the more tension the tree needs to exert, thus the more stressed it gets. We can consider that tree stress starts with values below about -1.6 MPa. No tree stress was observed in the Geneva, Wayne, Orleans and Champlain orchards, with slight differences between irrigated and non-irrigated trees (Figure 4). On the other hand, significant water stress was observed during all three summer measurements in Hudson for non-irrigated trees, with values lower than -1.6 MPa (Figure 4).

Regarding the number of harvested fruits, yield and fruit size, no differences were observed in Geneva and Wayne (Figure 5), where no tree stress was observed (Figure 4). Conversely, even though no differences were observed for the number of fruits that were set early, yield and fruit size in Hudson were significantly much smaller for those non-irrigated trees (Figure 5). Irrigated trees had an average of 1.5 kg more per tree, with bigger apples weighing about 140 g vs 110 g (irrigated vs. non irrigated, respectively) (Figure 5). This also explains why the concentration of soluble solids was higher for stressed trees (Figure 6), as less water content was present in the fruits.

Considering the results from the Hudson orchard in its 5th leaf, we can estimate a loss of 235 bu/ha (1,117 trees/acre) or 414 bu/ha in the case of a high-density orchard as in Orleans (1,980 trees/acre) (Table 1). In terms of crop value, the lack of irrigation showed a loss of $3,859– $6,809/ha, depending on tree density (Table 1). Usually, when the crop is light,

Figure 3. Pressure chamber used to assess tree water stress in the orchard.

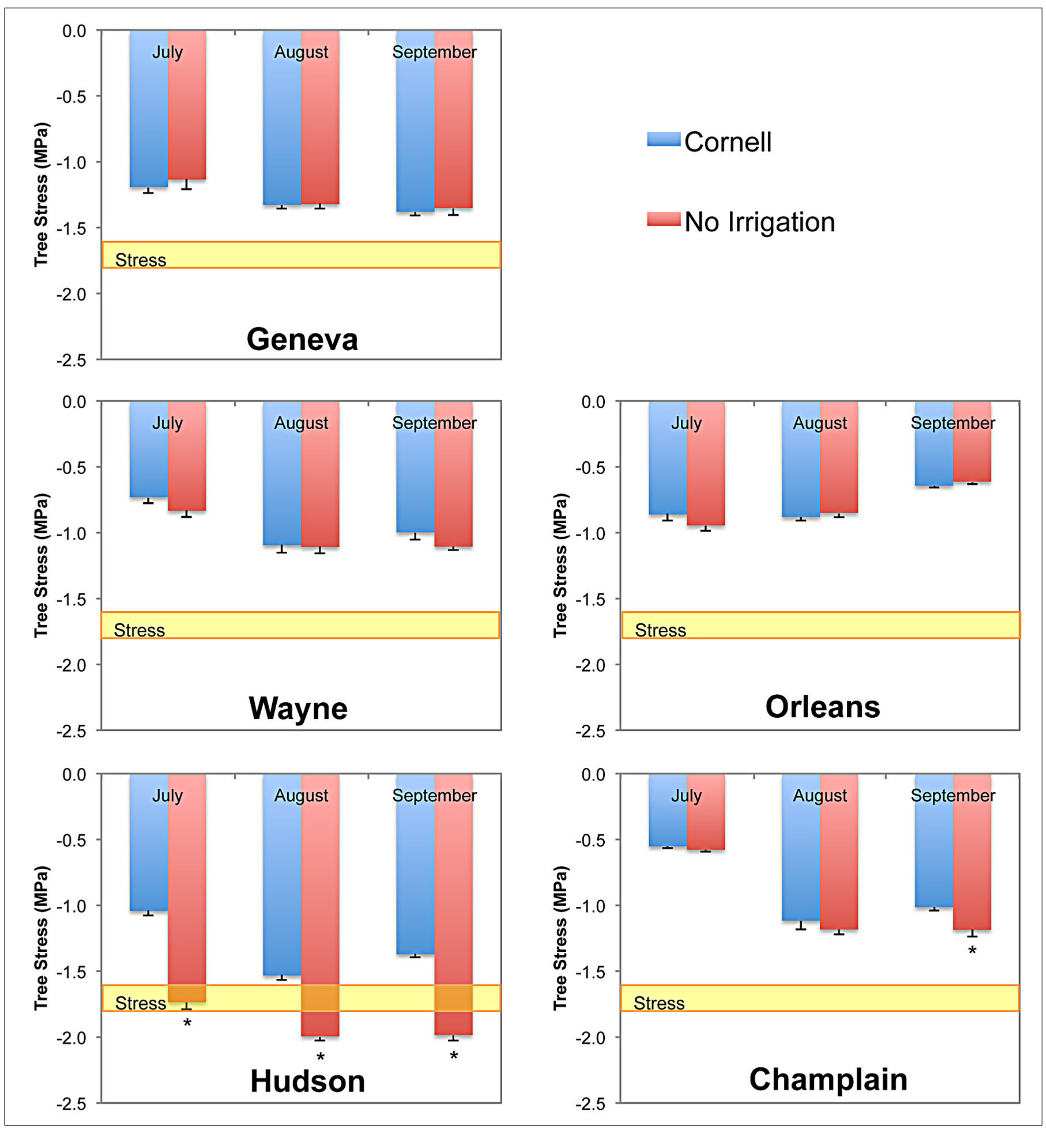

Figure 4. Tree stress during summer in Geneva, Wayne and Orleans Counties, and the Hudson and Champlain Valleys in 2015. Asterisks indicate significant differences.

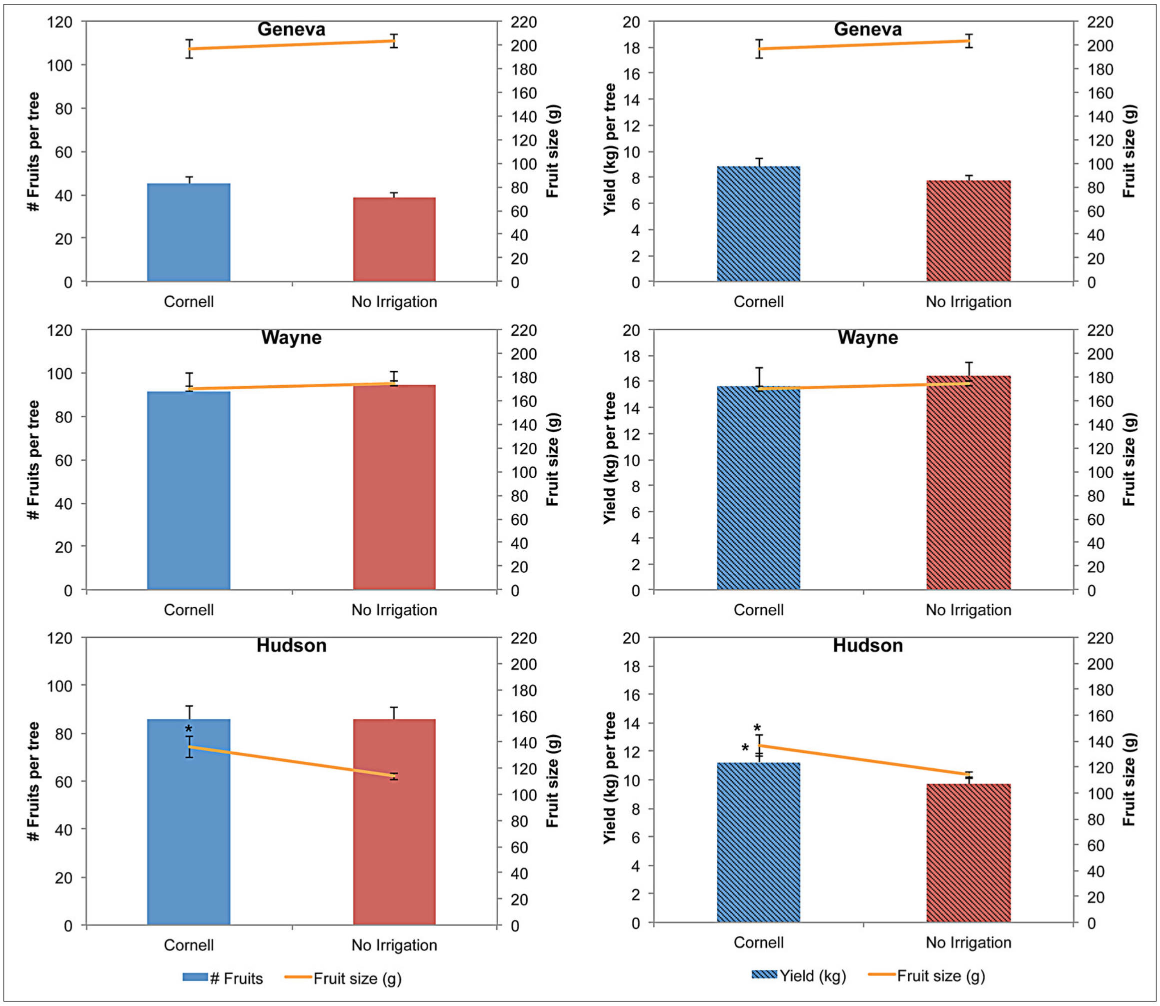

Figure 5. Number of fruits, fruit size, and yield in Geneva, Wayne and Hudson Valley orchards in 2015. Asterisks indicate significant differences.

there can be some stress with little effect, but when the crop is heavy, any stress has a stronger effect. Losses due to water stress could be even worse for fully productive orchards and late varieties with a longer growing season, such as Fuji. Further research is needed regarding how the stress observed in 2015 will affect return bloom and growth during the next season, and how a drier summer can affect yield and fruit size in other areas like northern and western New York.

Table 1. Yield and income per ha estimation for an irrigated vs non-irrigated orchard for different densities, according to results obtained in Hudson in 2015 (5th leaf). Apple price was estimated according to fruit size: 0.59 $/kg (140 g) and 0.54 $/kg (110 g).

Per ha	Irrigated	Non-irrigated	Difference
Yield	11.2 kg/tree	9.7 kg/tree	1.5 kg/tree
Yield (2,778 trees)	31,236 kg	26,982 kg	4,254 kg
Yield (4,902 trees)	55,118 kg	47,611 kg	7,507 kg
Yield (2,778 trees)	1,722 bu	1,487 bu	235 bu
Yield (4,902 trees)	3,038 bu	2,625 bu	414 bu
Income (2,778 trees)	18,429 $	14,570 $	3,859 $
Income (4,902 trees)	32,520 $	25,710 $	6,809 $

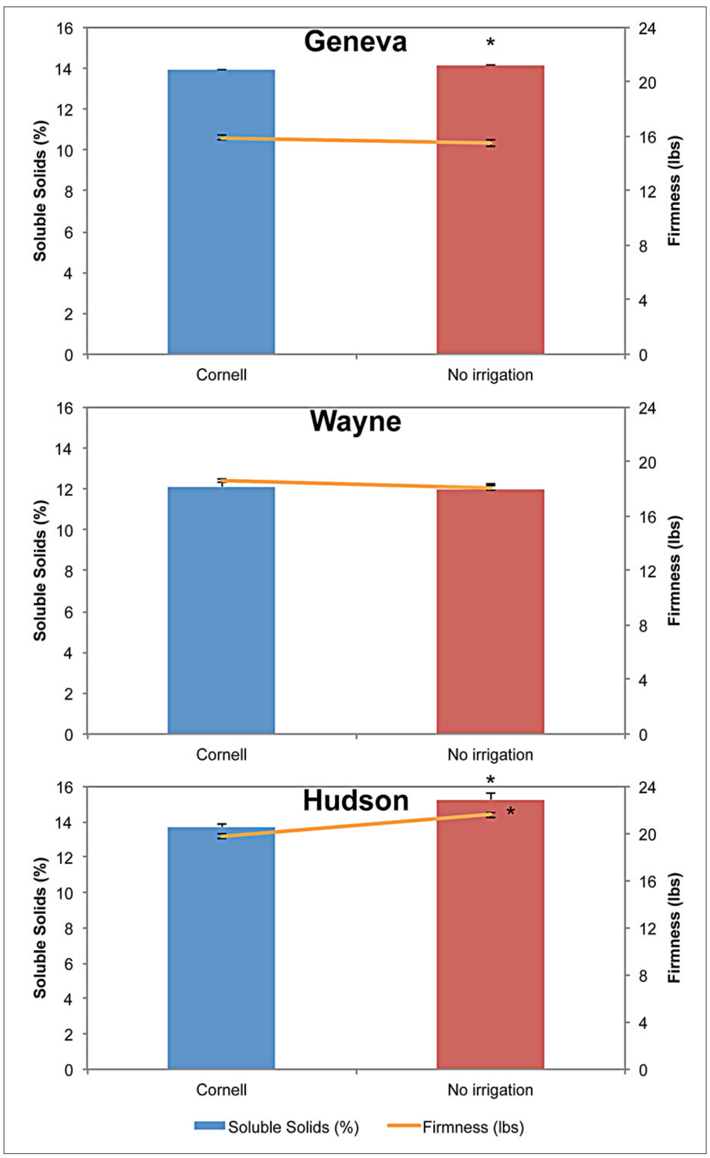

Figure 6. Soluble solids and firmness in Geneva, Wayne and Hudson Valley orchards in 2015. Asterisks indicate significant differences.

Summary

Good water status is essential to maximize fruit size at any given crop load. In our trials, it was seen that in some locations irrigation was not necessary, but at the Hudson location, irrigation led to better fruit size and economic value. With more precise water management, growers will be able to limit plant water stress and more consistently achieve the optimum economic fruit size and calcium content for each variety. With the use of the updated Apple Irrigation website, growers can easily improve the yield of their orchards weekly by applying the right amount of water.

Literature Cited

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