# Cropload and Nutrition Affect Honeycrisp Apple Quality

**Terence Robinson and Sergio Lopez**
Department of Hort Sciences
NY State Ag. Exp. Station, Cornell University
Geneva, NY

This work was supported in part by the New York Apple Research and Development Program.

Figure 1. Honeycrisp apples with no storage disorders (top); soft scald (middle) and senescent breakdown (bottom).

Honeycrisp can be a very profitable variety for apple growers in the Northern states. Although yields/acre are often lower than McIntosh, crop value is often much higher. Results from our trial in the Champlain Valley with five orchard systems show the very high potential crop value over the first five years especially with the new high-density Tall Spindle system. However, Honeycrisp is prone to several storage disorders (e.g. bitter pit soft scald and senescent breakdown) (Figure 1) and storage rots, which make placing it in long-term storage extremely risky. If fruit quality after storage is poor or fruits develop storage disorders or rots then packouts can be very low and the potential grower return will be only a fraction of the potential. Compounding this problem is the highly biennial nature of Honeycrisp with trees cycling between low crop loads and high croploads. With either high or low crop loads fruit quality is not optimal before storage. There is an urgent need for methods to assess quality at harvest and to predict storage quality. We have previously reported on the effect of increasing crop load on tree growth, fruit size, fruit color, storage disorders and return bloom (Robinson and Watkins, 2003, Robinson et al., 2009). In this article we report on a study of soil and ground fertilization on Honeycrisp size, color, quality and storageability.

> "Honeycrisp can be a very profitable variety; however, if fruit quality is poor or fruits develop storage disorders or rots, then pack-outs can be very low and the potential grower return will be a fraction of the potential. Our studies have shown that cropload must be strictly managed since with either high or low crop loads fruit quality is not optimal and storage disorders are increased. Fertilization and irrigation also are related to f ruit quality and fruit mineral analysis should help segregate fruit, which can be stored with a low risk of storage disorders."

## Materials and Methods

Two field studies were planted in 2002 using Honeycrisp apple trees on M.9 rootstock. The first experiment compared soil applied nitrogen (0 and 100 kg N/ha), potassium (0 and 200 kgK2O/ha) and irrigation (none and trickle irrigation) in a factorial treatment scheme from 2002-2006. The second study compared foliar fertilizer treatments of N, B, Zn, Mg and Ca, and irrigation in a factorial treatment scheme from 2002-2006. From 2004-2006 four crop loads (0, 4, 8, 12 fruits/cm$^2$ TCA) were imposed on whole trees as a subplot treatment.

## Results

Nitrogen fertilization increased fruit size, yield, soluble solids and rot incidence but resulted in reduced red color, firmness and total value of the crop in two of the three years (Figure 2). Nitrogen fertilization also affected fruit mineral concentration. It increased fruit nitrogen content, N/Mg ratio and N/S ratio but it decreased fruit, P, P/S ratio and K/Mn ratio. In contrast, potassium fertilization increased shoot and tree growth, fruit size, red color and total crop value but reduced fruit dry matter concentration (Figure 2). Potassium fertilization also reduced soggy breakdown incidence. Potassium fertilization increased fruit K and Mg concentration, K/Mg ratio, K/Ca ratio, K/Mn ratio and decreased fruit B and Zn concentrations.

Irrigation increased shoot and tree growth, yield and fruit size but reduced fruit soluble solids and increased crop value in only one year. The combined effects of rainfall and irrigation were evaluated by calculating annual water balance and correlating tree and fruit responses to water balance over the three years. Fruit red color, size, incidence of soggy breakdown and incidence of soft scald were positively related to annual water balance while fruit firmness, soluble solids, bitter pit incidence and rot incidence were negatively related to water balance. Bitter pit incidence was most influenced by water balance during the early season near petal fall where water stress during that period resulted in a significant increase in bitter pit after storage (Figure 3). Increased fruit rot incidence was related to water stress during the late May and early June period (Figure 4).

Increasing crop load had a negative effect on shoot and tree growth, fruit size, firmness, color, soluble solids and dry matter concentration (Figure 5). Fruit size was reduced by increasing crop load in a curvilinear relationship. Fruit size was reduced rapidly as crop load increased from 0 to about 7 fruits/cm$^2$ of TCA. At a crop load of 7 fruits/cm$^2$ TCA, fruit size was about 175 g (100 count fruit size). Fruit size was 150 g at crop loads of 10 fruits/cm$^2$ or greater. Although a 150g Empire or Jonamac apple is still marketable, for Honeycrisp, which is sold as a premium apple, this size is not commercially acceptable. In contrast, at very low crop loads, fruit size often approached 300 g, which is considered excessively large by most marketers. In today's market a Honeycrisp fruit size between 200-220g is considered optimal. To obtain that fruit size in our studies would have required a crop load of 5-6 fruits/cm$^2$ of TCA.

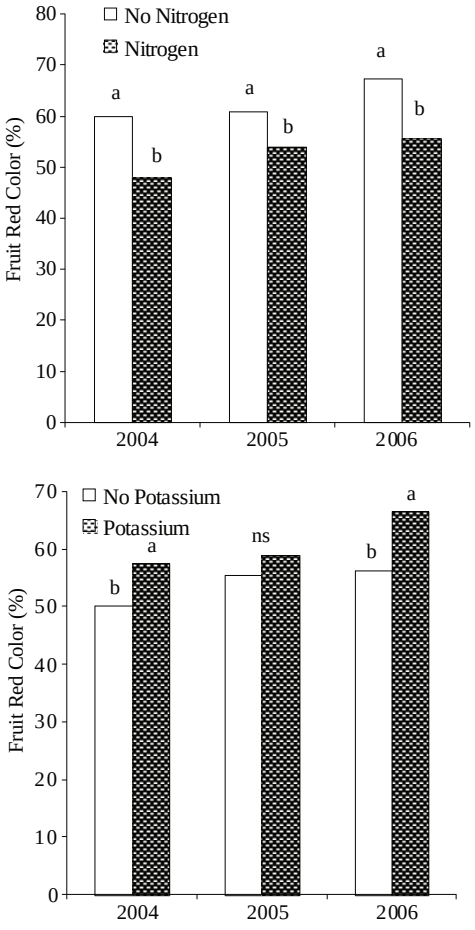


Figure 2. Effect of soil nitrogen fertilization (100 lb N/acre) (top) or soil potassium fertilization (200 lb K2O/acre) (bottom) on fruit red color of Honeycrisp/M.9 apples over the years 2004-2006.

In our studies, crop load had a large impact on fruit quality. Fruit soluble solids content was lower in fruit from heavy cropping trees than from light cropping trees. The suppressive effect of high crop loads on fruit soluble solids is probably due to a shortage of carbohydrate supply for the developing fruits on the heavy cropping trees. Fruit red color was poorer on heavy cropping trees than light cropping trees. This was the most striking visual evidence of the crop load effect on fruit ripening. At harvest we observed that fruit from trees, which had in excess of 10 fruits/cm$^2$ of TCA did not develop commercially acceptable fruit color. The curvilinear relationship between crop load and fruit red color showed that red color was reduced slowly as crop load was increased up to about 6 fruits/cm$^2$ TCA. However the curve became very steep at the higher crop loads. In addition, fruits from heavy cropping trees were softer, had lower acidity, and higher starch ratings. The poorer fruit color and reduced sweetness of the fruit, probably from heavy crop loads, indicates a lack of adequate resources to develop optimum quality. From a fruit quality perspective it would appear that crop loads around 5-6 fruits/cm$^2$ of TCA are optimum, resulting in good fruit color, soluble solids and medium acidity.

Crop load was related to the incidence of storage disorders and storage rots (Figure 6). Fruit from trees with higher crop loads were softer after storage, but had lower incidences of bitterpit, senescent breakdown, rot and superficial scald. However, fruit from trees with higher crop loads had greater soggy breakdown. Thus the poorer fruit firmness and quality from the high crop load trees resulted in lower susceptibility of fruit to storage disorders.

Crop value increased with increasing crop load up to 8-10 fruits/cm$^2$ TCA (Figure 7). Increasing cropload also affected fruit mineral concentrations. High cropload reduced fruit P, Mg, and K concentration, P/S ratio, K/Mg ratio, K/Ca ratio, K/Mn ratio and Mg/Ca ratio.

Foliar nutrient sprays have little effect on tree growth, yield or fruit quality. Ca sprays reduced bitter pit incidence in only one year.

Fruit mineral concentrations and ratios of nutrients were correlated with fruit responses. Fruit P concentration was positively related to incidence of bitter pit (Figure 8). Fruit P/S ratio was positively related to fruit red color (Figure 9). Fruit K concentration was positively related to fruit size (Figure 10). Fruit Ca content was not related to fruit firmness or bitter pit incidence. Fruit Ca/water ratio and fruit P concentration were positively related to fruit dry weight, whereas fruit Ca was negatively related to it. Fruit S content was positively related with blue mold incidence.

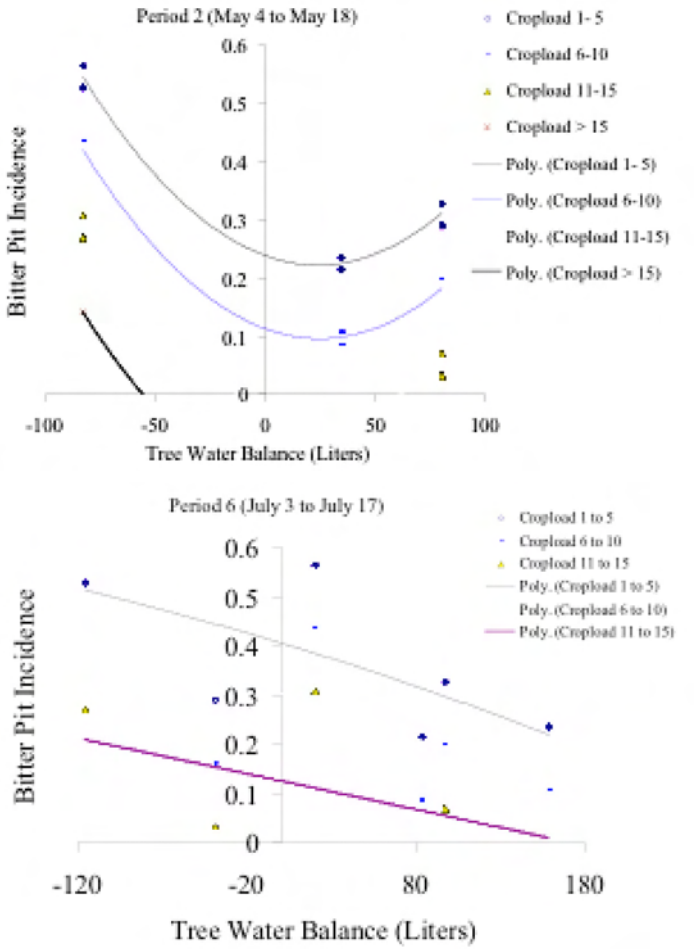


Figure 3. Effect of tree water balance in May (top) and in July (bottom) on incidence of bitter pit in Honeycrisp/M.9 apple at 3 croploads over the years 2004-2006.

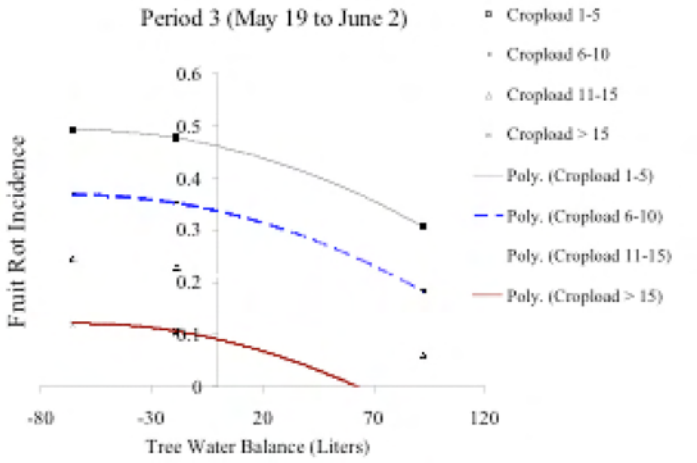


Figure 4. Effect of tree water balance on fruit rot incidence of Honeycrisp/M.9 apple at 3 croploads over the years 2004-2006.

## Discussion

Crop load had the greatest impact on Honeycrisp fruit size, color, soluble solids, storage disorders, storage rots and crop value. With either high or low crop loads Honeycrisp fruit quality was not optimal. Both crop load and nutrition affected Honeycrisp fruit quality. If crop load was too high fruit size was reduced, fruit quality was poor and crop value was reduced. If crop load is too low then yield is low, fruit size is too big, storage disorders are increased and crop value is reduced. It appears that the optimum crop load for optimum Honeycrisp fruit quality and crop value is 6-8 fruits/cm$^2$ of TCA.

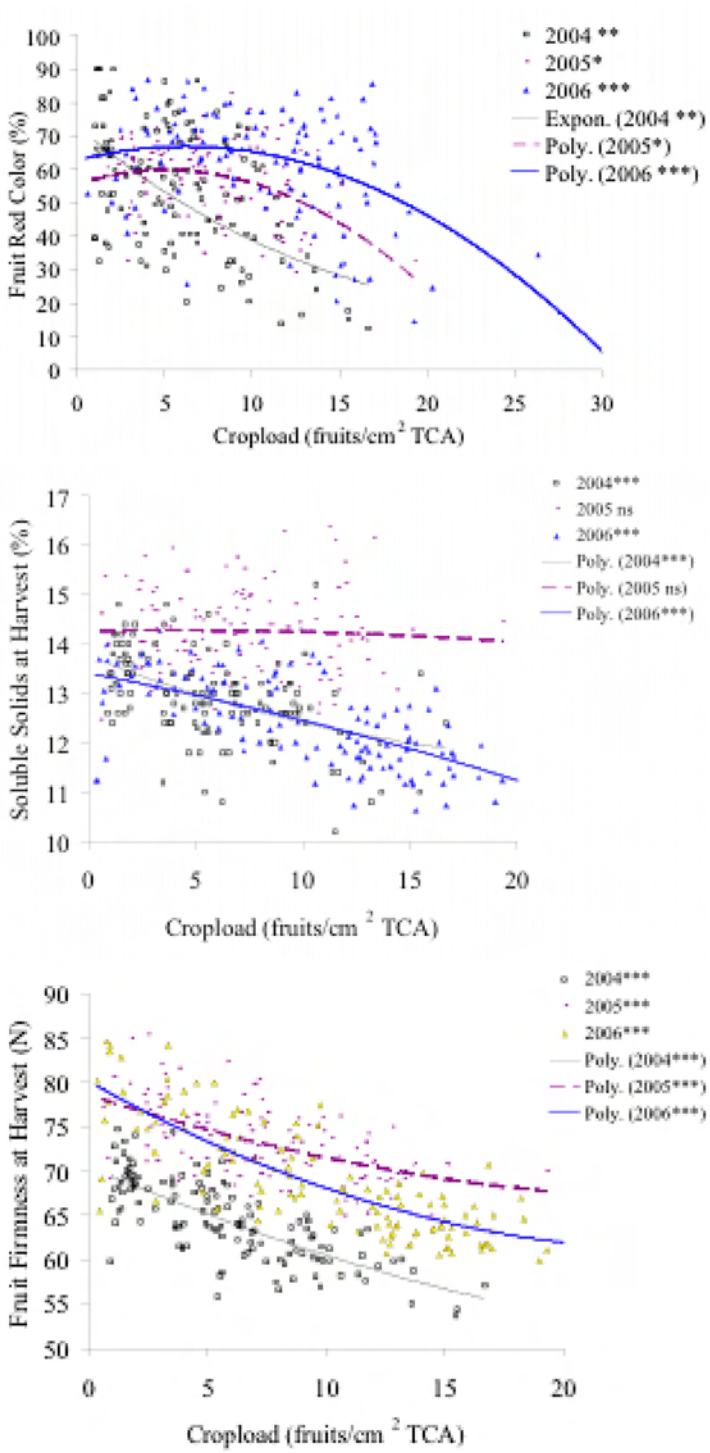


Figure 5. Effect of cropload on fruit red color (top), fruit soluble solids (middle) and fruit firmness (bottom) of Honeycrisp/M.9 apple over the years 2004-2006.

High nitrogen soil fertilization increased fruit size but reduced fruit color, storage quality and crop value while vegetative shoot growth was increased. In contrast potassium fertilization improved yield, fruit size, storage quality, and crop value while reducing the incidence of storage disorders and storage rots. However, Honeycrisp trees are weak growing and need some nitrogen fertilization to prevent runting out. Thus, we recommend a moderate level of nitrogen (20-50 lb N/acre) and a relatively high level of potassium (80-100 lb K20/acre).

Irrigation when combined with the total amount of rainfall was related to the incidence of bitter pit and fruit rot incidence. The early season (Mid May-Mid June) was related to increased incidence of bitter pit and fruit rot incidence. This was likely due to poor Ca uptake in the early season of years with a dry May and June. Thus, in dry years irrigation should be applied during the early season to ensure adequate Ca is absorbed by the plant and provided to the young fruitlets.

In our studies there was no relationship between fruit Ca concentration and fruit firmness, incidence of disorders or storage rots. We also could not show a benefit of fruit Ca sprays on fruit Ca levels or bitter pit incidence. Other foliar nutrient sprays (N, Mg, Zn, B) had little effect on yield, fruit quality, crop value, storage disorders or storage rots. However we did find a consistent relationship between fruit P concentration and incidence of disorders (primarily bitter pit). We also found a

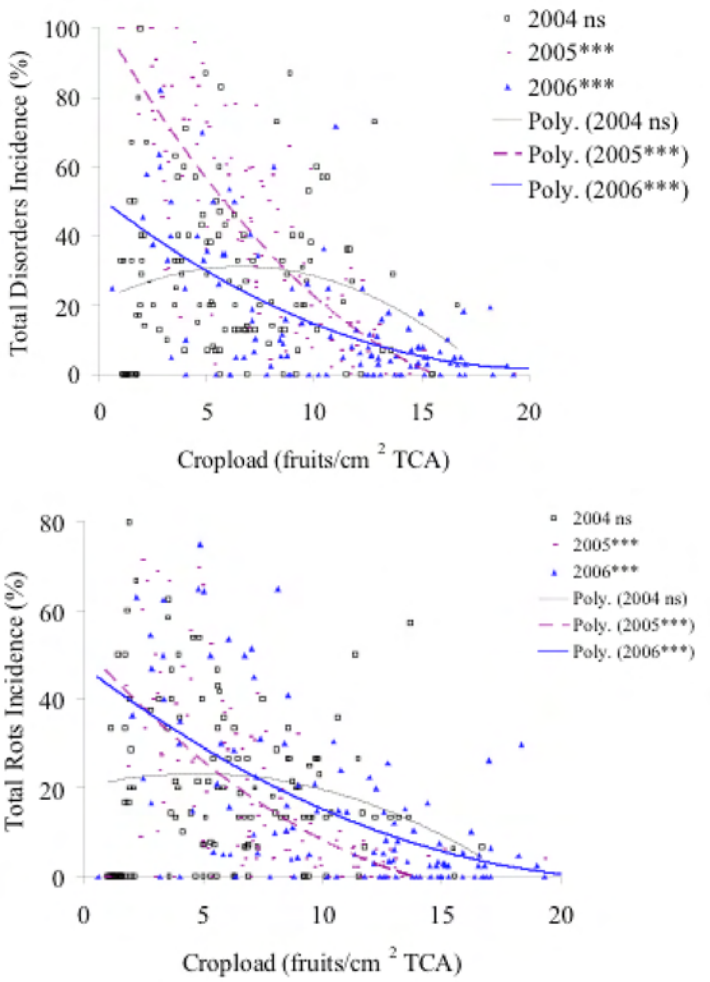


Figure 6. Effect of cropload on storage disorders (top) and fruit rots (bottom) of Honeycrisp/M.9 apple after a four-month regular air storage over the years 2004-2006.

consistent relationship between fruit P/S ratio and fruit red color. Perhaps fruit mineral analysis may prove beneficial to determine fruit storability. We suggest examining fruit P, S, Ca and P/S ratio, which is correlated to bitter pit and storage rot incidence. We propose to conduct a statewide survey of fruit mineral concentrations at the 25 mm fruit size and pre-harvest

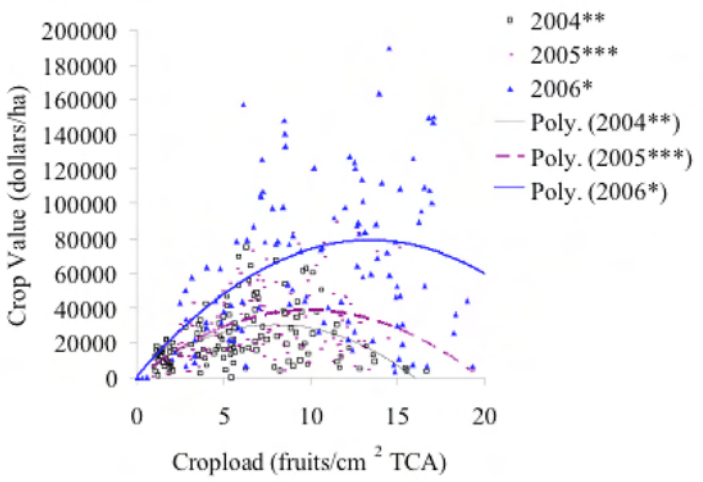


Figure 7. Effect of cropload on crop value of Honeycrisp/M.9 apple over the years 2004-2006.

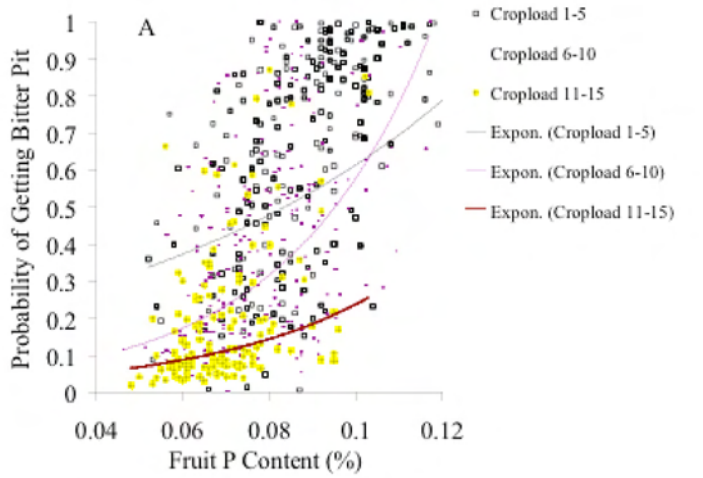


Figure 8. Effect of fruit phosphorus concentration on bitter pit incidence of Honeycrisp/M.9 apple in 2005 at 3 croploads.

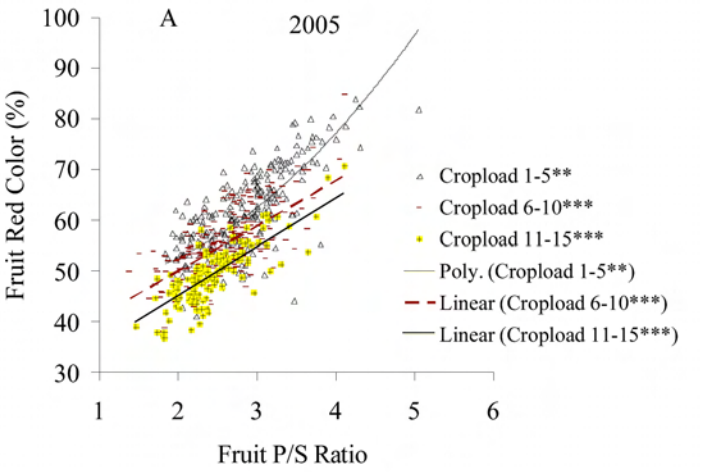


Figure 9. Effect of fruit phosphorus/sulfur ratio on fruit red of Honeycrisp/M.9 apple in 2005.

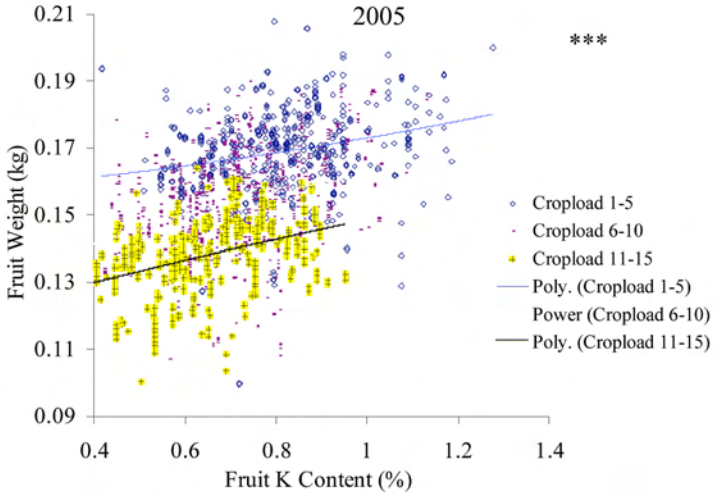


Figure 10. Effect of fruit potassium concentration on fruit size of Honeycrisp/M.9 apple in 2005.

and correlate differences in fruit mineral concentrations from different orchards with Honeycrisp storage quality in 2009 and 2010.

## Practical Suggestions for Managing Honeycrisp

Results from our field trials at Geneva suggest the following management strategies to optimize yield, fruit quality and crop value while minimizing storage disorders and rots.

1. Moderate Nitrogen fertilization (20-50 lb N/acre), although nitrogen helps push growth it results in poorer color, more rots and storage disorders.
2. High Potassium fertilization (100-200 lb $K_2O$/acre). This results in increased yield, fruit color, less storage disorders and rots and greater crop value.
3. Strict crop load management to optimize fruit quality, minimize storage disorders, manage biennial bearing and maximize crop value (6-8 fruits/cm$^2$ TCA on mature trees and 4-5 fruits/cm$^2$ TCA on young trees) (Robinson, 2008).
4. Early irrigation in dry years to reduce bitter pit and storage rots.
5. Fruit mineral analysis before harvest to determine fruit P, P/S ratio, K/Mg ratio and fruit Ca concentration to aid in segregating fruit for immediate sales and for storage.

## Literature Cited


Robinson, T.L, and C.B. Watkins. 2003. Crop load of Honeycrisp affects not only fruit size but also many quality attributes. *New York Fruit Quarterly* 11(3): 7-10.

Robinson, T.L. 2008. Crop load management of new high-density apple orchards. *NY Fruit Quarterly* 16(2): 3-7.

Robinson, T.L., S. Lopez, K. Iungerman, and G. Reginato. 2009. Crop load management for consistent production of Honeycrisp apples. *NY Fruit Quarterly* 17(1): 24-28.



**Terence Robinson** is a research and extension professor at Cornell's Geneva Experiment Station who leads Cornell's program in high-density orchard systems and plant growth regulators. **Sergio Lopez** was a graduate student from Puebla Mexico who recently completed his PhD degree with Dr. Robinson on Honeycrisp management.