NY-1 and NY-2 are two new cultivars from the Cornell apple breeding program. They will receive “official” names in the near future. NY-1 is the result of a cross between ‘Honeycrisp’ and an advanced breeding selection that has quality similar to ‘Jonagold’ and NY-2 is a cross between ‘Braeburn’ and ‘Autumncrisp’. These selections have been planted extensively throughout New York, and are the first varieties to be “managed” through a partnership with Cornell and a newly formed grower cooperative, New York Apple Growers, LLC. (NYAG). This cooperative offered all NY growers the opportunity to join and contribute some funds to market development and marketing. Over 900 acres of the 2 varieties will be planted. Initial evaluation of these selections was undertaken at Geneva previously, but this is the first comprehensive maturity and storage evaluation. In 2011, we studied the responses of both cultivars in air and controlled atmosphere (CA) storage. In this article, we outline the effect of harvest date on fruit quality of each variety.

Materials and Methods

Fruit were obtained from NY-1 and NY-2 trees growing at the NY State Agricultural Experiment Station in Geneva. NY-1 fruit were harvested from 7th leaf trees grown on M.9 EMLA rootstock and planted at a density of 484 trees/acre (1195 trees/hectare). NY-2 fruit were harvested from 5th leaf trees grown on M.9 T337 clone rootstock and planted at a density of 968 trees/acre (2391 trees/hectare). Approximately 138 fruit of NY-1 from each of four trees, and 72 fruit of NY-2 from each of eight trees were harvested at weekly intervals from Sept. 12 through Oct. 10 and Sept. 26 through Oct. 24, respectively. These dates were chosen to extend before and after anticipated best harvest dates for each selection. Different fruit numbers for each selection reflected the number of fruit available from the orchard block.

Fruit were transported to the postharvest laboratory at Ithaca on the day of harvest. Upon arrival, four replicates of 10 fruit were used for assessment of harvest indices, and the remaining fruit placed into cold storage at 33°F. SmartFresh (1-methylcyclopropene; 1-MCP) treatment was applied for 24 hours to NY-2. Fruit were stored in air at 33°F under plastic sheeting to reduce water loss, and evaluated after 2 and 4 months, plus 1 and 7 days at 68°F.

The following measurements were taken at harvest and after storage, except for red color, which was assessed only at harvest.

**Red color:** The percentage coverage of red color was estimated subjectively for each fruit.

**Internal ethylene concentration (IEC):** Ethylene is a plant growth regulator that is involved in many aspects of fruit ripening, major ones being aroma production and softening. For some varieties it can be used as a physiological indicator of the ripening stage of the fruit.

**Starch pattern index (SI):** In this test, the fruit is stained with an iodine solution and the patterns reflect hydrolysis of starch compared with the Cornell Starch Chart. A low value reflects high starch levels, while a high SI value reflects low starch levels since the starch is converted to sugar.

**Flesh firmness:** The firmness is not a strong indicator of physiological maturity, but rather a quality indicator. It is affected by many factors that are independent of maturity such as season, nutritional status of the fruit or exposure to sunlight. However, it is a useful measure of internal condition and fruit storability.

**Soluble solids concentration (SSC):** The SSC is a measure of soluble solids, of which sugar is a major component. Typically, a high % SSC is associated with sweetness, but like the firmness test, is not an indicator of maturity because it is affected by many orchard factors.

**Titratable acidity (TA):** The TA is a measure of the acidity of the fruit, and reflects the amount of sodium hydroxide that is necessary to neutralize the acid (mainly malic) in the fruit.

**Greasiness:** The slipperiness of the skin surface to touch is assessed subjectively. In varieties that develop greasiness, the phenomenon is typically associated with mature fruit and longer storage periods. Greasiness was rated at 1 = slight, 2 = medium, and 3 = high severity.

After storage, fruit were also assessed for the presence of external and internal disorders.
In addition to the formal assessments, fruit of both NY-1 and NY-2 were presented to 30 members of the NYAG group in Ithaca in January 2012. Each grower was asked to rate slices of fruit on the basis of texture, flavor and overall acceptability on a scale, where 1 = unacceptable, 2 = fair, 3 = good, 4 = very good, and 5 = excellent.

Results

Harvest indices: Red color development of NY-1 and NY-2 reached 80% or more on Sept. 26 and Oct. 10, respectively (Figure 1A).

The IEC of NY-1 was low at the first two harvest dates and then increased steadily over time (Figure 1B). In contrast, the IEC of NY-2 remained low at all harvest dates tested (Figure 1B).

The starch index of NY-1 was 1.2 on Sept. 12, and increased at each harvest date, until it started to level off on Oct. 10 (Figure 1C). In NY-2, the index was 3.9 at the first harvest, increasing about 1 unit and 1.9 units over the second and third harvest, respectively, and then more slowly for the last two harvest dates (Figure 1C).

The firmness of both selections was high at the first harvest and declined gradually over time (Figure 1D). The TA and the SSC of each selection decreased (Figure 1E) and increased (Figure 1F), respectively, over the harvest period. NY-1 fruit had much higher SSC and lower TA values than NY-2. Greasiness remained low except for the last harvest date of each selection (Figure 1G). While a high percentage of greasiness was detected, the intensity of greasiness was light.

NY-1 storage quality: Although quality of the fruit was measured after 1 and 7 days of shelf life at 68°F, only the data from day 7 are shown here. Except for disorders, which were lower immediately after removal from storage than after 7 days, the differences in quality over the shelf life period were small.

The IEC of the fruit increased over the first 2 months of storage but did not change greatly over an additional 2 months (Figure 2A). The firmness of the fruit after 2 months was similar to that at the time of harvest, but decreased by month 4 in fruit harvested on Sept. 26 and beyond (Figure 2B). The TA of the fruit decreased during storage, even after only 2 months (Figure 2C). The SSC increased from lower concentrations at harvest to higher concentrations after only 2 months of storage when harvest date was earlier than Oct. 3, but there was little effect of additional storage time (Figure 2D). A high incidence of fruit shriveling occurred in fruit harvested on Sept. 12 (data not shown).

The incidence of greasiness was low at the Sept. 12 harvest date for both storage periods, but increased with later harvest time, though decreased at the last harvest date (Figure 3A). Greasiness did not continue to develop during storage, and was typically slight at most evaluations. Two internal disorders were observed - core browning and vascular browning – each of which followed similar patterns over harvest dates (Figures 3B and C). Neither disorder was detected at 2 months of storage, but increased in fruit harvested after Sept. 19 when stored for 4 months.

The results of informal tasting by NYAG members in January are shown in Figures 4A-C. The results show that the best texture (a combination of rating 3, 4 and 5, representing good, very good and excellent) was found for fruit harvested on Sept. 12 and 19. After that date, the proportion of fruit with only fair texture increased markedly. However, the percentage of fruit
that had unacceptable ratings (1) was almost absent. Flavor ratings for fruit harvested on Sept. 12 were the lowest, with almost 50% of the fruit rated fair and unacceptable. The best flavor ratings were found for fruit harvested in Sept. 19, with over 90% scoring in the good to excellent range. The high flavor scores decreased slightly to about 80% in subsequent harvest dates, though again unacceptable flavor was low overall. The overall ratings reinforced the results of the texture and flavor data, and suggested that the Sept. 19 harvest date was optimal.

NY-2 storage quality: Due to larger fruit numbers available for NY-2, we were also able to treat fruit with SmartFresh. As for NY-1, quality data for NY-2 are shown only for day 7 after storage; differences in quality over the 7 day shelf life period were small.

The IECs of untreated fruit increased during air storage, though to relatively low concentrations (Figure 5A). SmartFresh treatment prevented any increase of IECs during storage, showing a powerful treatment effect regardless of harvest date. Firmness of the fruit showed similar changes: untreated fruit softened on average 2.6 lb-f after 2 months and then a further 1.1 lb-f over the next 2 months (Figure 5B). SmartFresh treatment prevented softening of fruit at all harvest dates.

The acidity of the fruit decreased during storage, and SmartFresh had little effect except for late harvested fruit stored for 4 months (Figure 5C). The SSC was not consistently affected by storage time or SmartFresh treatment (Figure 5D).

Greasiness increased greatly with increasing storage periods (Figure 6A), but intensity was generally slight. SmartFresh treatment delayed the development of greasiness at earlier harvest dates. No other disorders were found in NY-2 fruit stored for 2 months. Superficial scald and core browning were evident in fruit stored for 4 months, especially in fruit from earlier harvest dates (Figure 6B, C). Interestingly, scald was almost completely eliminated by SmartFresh treatment, while incidence of core browning only occurred in treated fruit. Core browning is a low temperature disorder, and the exacerbation by SmartFresh treatment suggests that inhibition of ethylene production may increase sensitivity of fruit to low storage temperature disorders.

The results of informal tasting are shown in Figures 7A-F. The results for untreated fruit (Figure 7A) show that the best texture ratings (a combination of rating 3, 4 and 5, representing good, very good and excellent) were found at all harvest dates. About 10% of the fruit were rated only fair for texture until the Oct. 17 and Oct. 24 harvest dates, when a number of fruit developed unacceptable texture. A significant percentage of fruit had unacceptable flavor at all harvest dates (Figure 7B) but overall ratings suggest that texture had a major impact on overall acceptability (Figure 7C).

SmartFresh treatment of fruit, markedly improved ratings for texture, flavor and overall acceptability (Figures 7D-F) compared with non-treated fruit. SmartFresh treated fruit showed no clear indication of a harvest date optimum based on our ‘sensory’ data.

Conclusions
In summary, and recognizing that this experiment represents results from a single orchard, and for only one year, the data suggest that the optimum harvest date for NY-1 at Geneva was around Sept. 19. Fruit harvested on this date were firm with high acidity. However, color development of fruit harvested on Sept. 19...
was not uniform, suggesting that optimal harvest for NY-1 for extended storage quality may require spot picking. Fruit harvested the week before had poor color, high levels of shriveling, and poor flavor development. Fruit harvested on Sept. 26 had good color development and were generally high quality, although the proportion of fruit with high scores for texture and flavor started to decline, and the susceptibility of fruit to brown core increased.

NY-2 appears to have a wide range of acceptable harvest dates, perhaps associated with a low fruit ethylene production. Color development did not reach steady levels until Oct. 10, and this might be a limitation for harvest. The selection softens and loses acidity more rapidly than does NY-1. The effects of SmartFresh on quality of the fruit, especially firmness, and high ratings through informal sensory evaluations, were very beneficial. The development of core browning in SmartFresh treated fruit, which we assume is a result of increased sensitivity to low storage temperatures, suggests that a warmer temperature such as 36 to 38°F may be warranted.

This study suggests that both NY-1 and NY-2 are apples that will benefit from CA storage to maximize quality for the consumer. NY-1 stays as firm as harvest levels after 2 months plus shelf life, but then softens, while NY-2 softens progressively in storage. Research is ongoing to develop the best recommendations for long term CA storage in addition to continuing our maturity studies.

Figure 4. Grower evaluations of A. Texture, B. Flavor and C. Overall acceptability of NY1 on January 9, 2012. The figures show the percentage of fruit in each category (1 = unacceptable, 2 = fair, 3 = good, 4 = very good, and 5 = excellent) at each harvest date.

Figure 5. A. Internal ethylene concentration, B. Firmness, C. Acidity, and D. Soluble solids concentration (SSC) of NY-2 after 2 and 4 months air storage plus 7 day shelf life. The harvest data are shown for comparison as a dashed line.

Figure 6. Incidence of A. Greasiness and B. Superficial scald, and C. Core browning in NY-2 fruit after 2 and 4 months air storage plus 7 day shelf life.
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Figure 7. Grower evaluations of untreated NY-2 apples (A. Texture, B. Flavor and C. Overall acceptability), and SmartFresh (SF)-treated apples (D. Texture, E. Flavor and F. Overall acceptability) on January 9, 2012. The figures show the percentage of fruit in each category (1 = unacceptable, 2 = fair, 3 = good, 4 = very good, and 5 = excellent) at each harvest date. Note that there was no SmartFresh treatment of fruit on the first harvest date (Sept. 26).

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- Provide the following information to the Crop Growers representative:
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  - That person’s cell phone number
  - Crop damage status, such as low, moderate or severe damage
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