ASP-021 NSFGA Improving the Production and Storage of High Quality Apple Cultivars

Activity 10 – Anti-ethylene products on Honeycrisp™ and Ambrosia™ apples: 2020 & 2021 Harvest Results Update

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November 2021

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Introduction

The objectives for Activity 10 are two-fold: 1. To determine if anti-ethylene products will extend or broaden the period of optimal fruit harvest maturity; 2. To evaluate the impact of anti-ethylene products on fruit quality following long-term storage. The successful harvest of 2021 marked the second straight year of the Canadian Agricultural Partnership (CAP) project ASP-021 without interruptions due to extreme weather events or pandemic response measures, and with a full complement of sites and treatments for Activity 10 (Figure 1). In this update, we provide an analysis of fruit quality at harvest for the past two years (Objective 1). A final report will be generated after the fruit harvested in 2021 are removed from storage in June of 2022. The year 2021 marks the final year of field trials for Activity 10.

Figure 1. Photograph of one of the Ambrosia treatment sites, i.e. one of 24 cultivar / treatment sites used for Activity 10 in 2021 (left). Examining Honeycrisp stored under controlled atmosphere (CA) conditions in cold storage after the 2021 harvests. In total, 24 CA chambers containing 96 bushels of fruit were placed in storage in fall 2021; they will be assessed in May and June 2022 for Activity 10 (right).

Trial set-up

Cultivars: Ambrosia™ and Honeycrisp™

Statistical design: two-factor ANOVA. Factor 1 - Anti-ethylene products: ReTain® (a ½ rate applied 2 weeks before harvest 1), Harvista™ (applied 1 week before harvest 1), untreated control; Factor 2 - Harvest**:** 2 harvests at 10-day intervals for each cultivar.

Year-to-year harvest differences: Honeycrisp harvest 1 took place on September 27 in 2021 compared to October 7 in 2020 (i.e. 10 days earlier); Ambrosia harvest 1 took place on October 12 in 2021 compared to October 13 in 2021 (i.e. 1 day earlier).

Fruit quality parameters measured: colour (%), delta absorbance (DA) meter (i.e. chlorophyll) (I_{AD}), mass (g), internal ethylene (C_2H_4) content (%) (IEC), firmness (lbs), soluble solids (SS) (˚Brix), titratable acidity (mg malic acid/100 mL of juice) (TA) and starch (Cornell Starch-Iodine) (1 – 8).

Controlled atmosphere (CA) storage: standard CA: 2.5 kPa O_2 and 2 kPa CO_2. SmartFresh™ (SF) (applied after harvest) and delayed cooling (DC) (7 days @ 20 °C for Honeycrisp fruit only) were also included as variables.

Storage temperature: 3.5 °C (Honeycrisp), 1 °C (Ambrosia) *One Ambrosia treatment involved storage at a warmer temperature of 3.5 °C.

Storage duration: 8 months

Weather: 2020 vs. 2021

The 2020 and 2021 growing seasons were 3% and 5% above the 10-year average, respectively, in terms of the total amount of heat received, measured using base 5 °C growing degree days (GDD). The difference between years was not appreciable. Both years were similar in that they had a warm, dry month of June (Table 1); the 10-year averages for June are 337 GDD and 95 mm of rain. Heat in the 30 days after bloom, a phenological stage where fruit undergo rapid cell division, is positively correlated with higher fruit cell numbers and the *potential* for greater fruit size at harvest. The greatest contrast between the two years was found in the precipitation levels in the latter part of the growing season. More specifically, 43%, 72% and 39% more precipitation was received in 2021 relative to 2020 in July, August and September, the primary months when apple fruit undergo cell expansion in Nova Scotia. The 2020 growing season could be described as moderately dry, with approximately 8% less precipitation than the 10-year average in June through September, while 2021 could be described as a wet year, with 27% more precipitation than the 10-year average over the same months. Finally, a handful of significant rainfall events can sometimes distort the impact of higher precipitation levels. Once the ground is saturated, excess water is lost as runoff and is not absorbed by the apple trees. However, 2021 was also notable in that there was a greater number of precipitation events than in 2020 in every month of the growing season (Table 1); for the most part, these events occurred at even intervals, with no more than a few days separating precipitation events.

Table 1. Base 5 °C growing degree days (GDD) (single sine method), precipitation (mm) and precipitation events (days with precipitation ≥ 1 mm) for June, July, August and September, the primary growing season for apple fruit in Nova Scotia, in 2020 and 2021. All weather data came from the Environment Canada weather station located at the KRDC.

	June		**July**		**August**		**September**	
	2020	**2021**	**2020**	**2021**	**2020**	**2021**	**2020**	**2021**
GDD (base 5 °C)	378	419	478	438	480	486	323	355
Precip. (mm)	49	37	115	164	71	122	122	169
Precip. events	10	11	11	15	9	11	7	14

Results

- Treatment differences: Harvista and ReTain both showed *some* ability to delay fruit maturity relative to the control in Ambrosia and Honeycrisp apples over the 2020 and 2021 harvest seasons. For the Ambrosia fruit, the results were subtle. Harvista fruit had the highest acid and starch levels (i.e. lower starch index levels) followed by the ReTain and control fruit. None of the other parameters showed significant differences between treatments (Table 2). The treatment differences were more clear-cut when the Honeycrisp data were examined. For Honeycrisp, treated fruit had higher I_{AD} (i.e. chlorophyll) and starch levels (i.e. lower starch index levels) and lower ethylene levels, but none of the other parameters showed significant differences between treatments (Table 3). While the control fruit had the highest average colour rating between treatments for both cultivars, these differences were subtle and not significant (Tables 2 & 3).

- Harvest differences: Typically, fruit harvested at a later date should have greater colour, mass, ethylene, SS and lower I_{AD} (i.e. chlorophyll), firmness, TA and starch levels than fruit harvested at an earlier date. In our two years of data, harvest 2 Ambrosia fruit showed greater colour and lower I_{AD}, firmness, TA and starch relative to harvest 1 fruit (Table 2). Harvest 2 Honeycrisp fruit showed greater colour and lower I_{AD} and firmness relative to harvest 1 fruit (Table 3). The parameters not mentioned for both cultivars were not significantly different between harvests.

- Year differences: Growing conditions between years led to differences in the fruit. Both 2020 and 2021 were warmer than average, especially in the 30 days after bloom, generating optimum harvest windows that were earlier than normal. Arguably, fruit maturity in 2021 was ahead of 2020; the earlier Activity 10 harvest dates in 2021 relative to 2020 reflect this pattern. It is important to note that all fruit quality parameters do not move in step; growing conditions can have a differing effect on different quality parameters. For Ambrosia, the 2021 fruit were larger with higher I_{AD} levels and lower sugar, acid, firmness and starch levels relative to 2020 fruit (Table 2). Similarly, 2021 Honeycrisp fruit were also larger with lower sugar and firmness levels relative to 2020 fruit (Table 3). It is speculated that the higher precipitation levels in 2021 relative to 2020 (Table 1) possibly caused this year's fruit to bulk up with water and decreased dry matter content (DMC): i.e. low DMC → lower levels of sugar, starch, protein, cell wall material and low firmness. Low dry matter content *could* have implications on the long-term storability of 2021 fruit. However, as dry matter content was not measured directly as part of this study, this remains speculation and time will tell how these fruit hold up in storage relative to 2020.

- Disorders: Bitter Pit was an issue in 2021 and was the primary disorder observed at harvest in Honeycrisp fruit. Watercore was the primary disorder in Ambrosia in 2021. Across all Ambrosia treatments, incidence levels were slightly above 50% with some sites having levels as high as 80%. There was no apparent treatment effect on watercore incidence. Most instances of watercore were mild, with some exceptions. Time will tell whether this issue will sort itself out in storage.

Acknowledgements

This work was made possible through the contributions of several individuals, in particular, the late Dr. John DeLong, who spearheaded the effort. Conny Bishop, John's long-time postharvest technician, played a critical role in advancing this activity. Peter Harrison, who retired for a second time after seeing us through the successful 2020 harvest. Dale Hebb provided support in maintaining the KRDC controlled atmosphere system in 2021. Jeff Franklin provided weather data. Katherine Benedict and Kristen Cue provided technical support on a casual basis. As the overall project lead, Dr. Suzie Blatt provided project administration support. Finally, this work would not have been possible without the collaboration of the Nova Scotia Fruit Growers' Association (NSFGA), Scotian Gold Cooperative Limited, Van Meekeren Farms Ltd, and the growers who applied the spray products and allowed the use of their sites and fruit. A big thank you to all who contributed.

APPENDIX – Ambrosia and Honeycrisp data

2020 & 2021 Ambrosia harvest fruit quality table

Table 2. Ambrosia fruit quality parameter averages across Treatment, Harvest and Year: fruit colour (%), mass (g), chlorophyll (I_{AD}), internal ethylene (C_2H_4) content (IEC) (%), firmness (lbs), soluble solids (SS), titratable acidity (TA) (mg malic acid/100 mL of juice) and starch (Cornell Starch-Iodine) (1 – 8). Significance across the factors for each fruit parameter is denoted as follows: $p < 0.001$ (***), $p < 0.01$ (**), $p < 0.05$ (*), $p < 0.1$ (.), not significant (NS). A Tukey multiple means comparison was performed across treatments when the Treatment factor was < 0.05; averages with similar letter groupings for a given harvest are not significantly different.

	colour	mass	I_{AD}	IEC	firm	SS	TA	starch
Treatment								
Control	75	195	0.21	0.6	18.1	12.8	352^{b}	6.0^{a}
Harvista	73	195	0.24	0.6	18.1	12.7	387^{a}	5.4^{b}
ReTain	73	201	0.23	0.6	17.6	12.7	360^{ab}	5.9^{a}
Harvest								
Harvest 1	71^{b}	193	0.27^{a}	0.5	18.2^{a}	12.6	381^{a}	4.8^{b}
Harvest 2	76^{a}	201	0.18^{b}	0.7	17.6^{b}	12.9	350^{b}	6.8^{a}
Year								
2020	72	178^{b}	0.20^{b}	0.6	19.5^{a}	13.6^{a}	383^{a}	4.3^{b}
2021	75	215^{a}	0.25^{a}	0.6	16.5^{b}	11.9^{b}	349^{b}	7.2^{a}
significance								
Treatment	NS	NS	NS	NS	NS	NS	*	*
Grower	***	***	***	*	***	***	.	**
Harvest	*	*	***	.	**	*	**	***
Year	NS	***	*	NS	***	***	**	***
Treatment:Harvest	NS	NS	NS	NS	NS	NS	NS	NS
Treatment:Year	NS	NS	*	*	*	*	NS	NS
Harvest:Year	NS	NS	NS	.	NS	*	NS	*

2020 & 2021 Honeycrisp harvest fruit quality table

Table 3. Honeycrisp fruit quality parameter averages across Treatment, Harvest and Year: fruit colour (%), mass (g), chlorophyll (I_{AD}), internal ethylene (C_2H_4) content (IEC) (%), firmness (lbs), soluble solids (SS), titratable acidity (TA) (mg malic acid / 100 ml of juice) and starch (Cornell Starch-Iodine) (1 – 8). Significance across the factors for each fruit parameter is denoted as follows: $p < 0.001$ (***), $p < 0.01$ (**), $p < 0.05$ (*), $p < 0.1$ (.), not significant (NS). A Tukey multiple means comparison was performed across treatments when the Treatment factor was < 0.05; averages with similar letter groupings for a given harvest are not significantly different.

	colour	mass	I_{AD}	IEC	firm	SS	TA	starch
Treatment								
Control	77	265	0.32^{b}	4.5^{a}	14.6	11.9	558	7.6^{a}
Harvista	74	274	0.44^{a}	1.7^{b}	14.4	11.7	567	6.7^{b}
ReTain	76	281	0.40^{a}	1.0^{b}	14.9	11.9	581	6.8^{ab}
Harvest								
Harvest 1	72^{b}	269	0.46^{a}	2.2	15.1^{a}	11.8	587	6.8
Harvest 2	79^{a}	278	0.31^{b}	1.7	14.2^{b}	11.9	551	7.3
Year								
2020	81^{a}	264^{b}	0.37	1.8	15.0^{a}	12.3^{a}	587	6.9
2021	70^{b}	284^{a}	0.40	2.1	14.3^{b}	11.4^{b}	551	7.1
Significance								
Treatment	NS	NS	***	**	NS	NS	NS	*
Grower	**	***	***	NS	NS	***	NS	*
Harvest	***	NS	***	NS	***	NS	*	.
Year	***	*	NS	NS	**	***	*	NS
Treatment:Harvest	NS	NS	NS	NS	NS	NS	NS	NS
Treatment:Year	NS	NS	NS	NS	NS	.	.	NS
Harvest:Year	NS	NS	NS	**	NS	NS	**	*