Northern New York Agricultural Development Program
2007-2008 Project Report

Improved Apple Orchard Management Systems and Rootstocks for NNY

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Introduction
The Northern New York (NNY) apple industry is large (5,000 acres and a farm gate value of $16 million) and is an important segment of Northern New York agriculture. The industry has knowledgeable and progressive growers, an extensive infrastructure, and proximity to markets. However, to remain competitive in the world apple market NNY apple growers need to continue to modernize their orchards to improve orchard production efficiency and fruit quality. Modern high-density orchard planting systems, will help improve efficiency, yield and fruit quality and will offer growers the opportunity to plant profitable new varieties. Replanting older orchards to new high-density orchards with popular new varieties will help the long-term viability of the Northern New York apple industry.

The goal of this project was to develop and extend to growers information on modern, competitive orchard systems that incorporate new high priced varieties, disease resistant rootstocks, high planting densities for early production and partial labor mechanization to reduce costs. Research results on high density orchards and new rootstocks conducted in other parts of NY state is not directly transferable to the colder climate of NNY. Thus this project evaluated new rootstocks and orchard systems in Clinton County utilizing on-farm orchard systems and rootstock experiments that the project leaders have already established in NNY. In addition new on-farm experiments were conducted in 2008 on improved chemical thinning and drop control strategies with Honeycrisp and McIntosh. The project involved the apple growers in NNY through field days, workshops and winter fruit grower meetings.

Materials and Methods
We had previously established 4 on-farm trials in Clinton County that were used in this research project.

1. Champlain Valley 2002 Orchard Systems Trial. This replicated field plot was established at Everett Fruit Farm in Peru, NY and it compares 5 orchard system (Central Leader on MM.111, Slender Pyramid on M.26 and G.30, Vertical Axis on M.9, B.9 and G.16, Solaxe on M.9, B.9 and G.16 and Tall Spindle on M.9, B.9 and G.16). The objective of the trial was to develop realistic performance and cost data for the colder part of NY state to provide growers with practical examples of different orchard system performance and economics. Densities range from 218 trees/acre to 1307 trees/acre. Varieties include McIntosh and Honeycrisp. The experimental design is a randomized complete block split plot with 3 replications and 30 trees per experimental unit.

We measured yield, fruit quality, light interception and labor input requirements for each of the various tree forms and planting densities. We will perform an economic analyses of the trial utilizing the actual packout and labor costs in 3 more years when the trial is 10 years old.

2) Everett Orchards 1999 Rootstock Trial: This replicated field plot compares 4 new rootstocks from Germany (Supporter series stocks) for survival, productivity and adaptability to the cold climate of NNY. The experimental design is a randomized complete block 8 replications and 1 tree per experimental unit. We measured yield, fruit size and survival for each of the rootstocks.

3) Chazy Orchards 2001 Semi-commercial Rootstock Trial. This replicated field plot compares 16 rootstocks (G.16, G.30, B.9, B.118, O.3, Vineland 1, Vineland 3, Supporter 4, Mark, M.9T337, M.9Nic29, M.9/MM.111, M.26, M.7, MM.106, and MM.111) for survival, productivity and adaptability to the cold climate of NNY with Honeycrisp and McIntosh as the scion varieties. The experimental design is a randomized complete block 8 replications and 10 trees per experimental unit. We measured yield, fruit size and survival for each of the rootstocks.

4) Forrence Orchards 2002 CG Rootstock Trial: This replicated field plot compares 17 new rootstocks from the Geneva apple rootstock breeding program and 8 Malling stocks from England, 2 clones of B.9 from Russia, Ott.3 from Canada, P.22 from Poland and Supporter 4 from Germany with Honeycrisp as the scion. This trial is a comparison of many of the new disease resistant rootstocks from Cornell which have substantial potential in NNY. The experimental design is a randomized complete block 10 replications and 1 tree per experimental unit. We measured yield, fruit size and survival for each of the rootstocks.

In addition, we established 3 one-year thinning, return-bloom management trials with Honeycrisp and a pre-harvest drop control trials with McIntosh apple in 2008.

1) Thinning of Honeycrisp (Chazy): In 2008 we conducted a 1 year replicated field study at Chazy orchards of timing and concentration of chemical thinners to managed cropload on the new highly priced apple variety, Honeycrisp. This variety is proving to be difficult to manage and improved thinning strategies are essential to the long-term success of this variety. This study evaluated single vs. multiple sprays of NAA, NAA/Sevin and BA/Sevin on thinning efficacy of Honeycrisp. The experimental design was a randomized complete block with 4 replications and 2 trees per experimental unit.

2) Thinning and Return Bloom of Honeycrisp (Chazy): This study was begun in 2007 where a multi-factor field study of timing of chemical thinner application was laid out to evaluate return bloom in 2008. The experiment had 15 treatments of various rates and combinations of NAA, Carbaryl, and Benzyl Adenine. The experimental design was a randomized complete block with 4 replications and 2 trees per experimental unit.

3) Control of pre-harvest drop with McIntosh (Chazy): We conducted a replicated field trial where we evaluated Harvista, ReTain, and NAA in 2008 to reduce pre-harvest drop of McIntosh. The trial was conducted at Chazy Orchards in cooperation with Tre Green. The objective was to determine the effect of Retain, or Retain combined with NAA, Harvista, or Harvista combined with NAA, on preharvest drop of McIntosh apples in the Champlain Valley.

The treatments were:

1. Untreated Control
2. Retain 333 g/acre @ 3 weeks before harvest (Aug. 22)
3. Retain 333 g/acre @ 2 weeks before harvest (Aug. 29)
4. Retain 333 g/acre @ 2 weeks before harvest (Aug.29) + NAA 20ppm @2 week before harvest (Aug.29)
5. Retain 166.4 g/acre @ 2 weeks before harvest (Aug.29) + NAA 20ppm @2 week before harvest (Aug.29)
6. NAA 20ppm @1 week before harvest (Sept. 7)
7. Harvista 120g ai/acre @ 1 week before harvest (Sept. 7)
8. Harvista 120g ai/acre @ 1 week before harvest (Sept. 7) + NAA 20ppm @1 week before harvest (Sept. 7)
9. Harvista 60g ai/acre @ 1 week before harvest (Sept. 7) + NAA 20ppm @1 week before harvest (Sept. 7)

Results

Orchard Systems Study (Table 1, Figures 1-8):

Our comparison of 5 orchard production systems has shown that the high density Tall Spindle system has been the most productive in the Champlain Valley. The Tall Spindle had the earliest production with a small crop in the second year. The M.9 trees had more yield than either B.9 or G.16. M.26, G.30 and MM.111 had no crop in the second year. In the third and fourth years there was a linear relationship of density and yield with the M.9 rootstock having greater yield than any of the other stocks. In the fifth year (2006) frost and poor pollination reduced crop significantly with McIntosh but not with Honeycrisp. However, Honeycrisp suffered from biennial bearing and had less than a full crop. B.9 rootstock was the most productive rootstock with Honeycrisp in 2006 but M.9 and G.16 were the most productive with McIntosh. In 2007 and 2008 there was a large crop with both varieties. The tall spindle system had the highest yield and with McIntosh/M.9 trees reached 1500 bushels/acre. With Honeycrisp the most productive combination was the Tall Spindle on G.16 rootstock which had a yield of 750 bushels/acre.

At the end of 7 years, there was a strong linear effect of tree planting density on cumulative yield (Table 1). As expected the trees the CL/M.111 trees had the lowest yield, followed by the Slender pyramid, Vertical Axis, SolAxe and Tall Spindle. Among rootstocks M.9 had the highest yield with McIntosh followed by B.9, G.16, G.30, M.26 and MM.111. With Honeycrisp, B.9 had the greatest yield followed by M.9, G.16, G.30, M.26 and MM.111.

Crop value was greatest with the tall spindle system in each year except 2006 when frost damage reduced crop value with the Tall Spindle more than any other system. Nevertheless, in 2007 and 2008 the tall spindle again had the greatest crop value. The Tall Spindle had the greatest cumulative crop value followed by the Vertical Axis and SolAxe which did not differ significantly, then the Slender Pyramid and lastly the Central Leader. The Tall Spindle exceeded the cumulative crop value of the Central Leader by 7.7 fold with McIntosh and 10 fold with Honeycrisp.

Honeycrisp had 2/3 the yield of McIntosh but 3.5 times the cumulative crop value as McIntosh due to higher fruit price. By the end of the 7th year the best Honeycrisp system had accumulated $53,000 in cumulative crop value compared to only $14,000 for McIntosh. This level of returns would essentially pay for the establishment cost of the Honeycrisp block by the end of the 5th year. It is likely to take 10 years with McIntosh.

This trial shows that much higher yields than previously achieved are possible with the Tall Spindle system at a relatively young orchard age. This dramatically changes the orchard profitability potential for new orchards in NNY State.

McIntosh Rootstock study (Table 2):

The plot has completed 10 years and had a large crop in 2008. Among dwarf rootstocks the smallest trees were on M.9T337 followed in order by, Supporter 2 Supporter 1, Supporter 3, and M.26EMLA. All of the stocks had 100% survival. The stocks with the greatest yield efficiency were M.9T337, Supporter 2, Supporter 3 and Supporter 1. This group had significantly higher yield efficiency than M.26EMLA. M.9T337 had the largest size followed by Supporter 2, M.26, Supporter 1 and Supporter 3. The later 2 rootstocks had significantly smaller fruit size then M.9. Of this group none of the new dwarfing stocks exceeded the performance of M.9. However, Supporter 2 was almost as good as M.9. Our trial did not show different winter hardiness. Only if Supporter 2 had greater winter hardiness would it be a superior rootstock to M.9.

Among semi-dwarfing rootstocks, trees on M.26EMLA were the smallest and trees on M.7EMLA and were the largest with Supporter 4 trees intermediate in size. The most efficient rootstock in the semi-dwarf plot was Supporter 4 followed by M.26 and lastly M.7. Root suckers were greatest with M.7 and lowest with M.26 and Supporter 4. This trial showed that Supporter 4 is a superior semi-dwarfing rootstock and much better than M.7. Our trial did not show different winter hardiness. However, if Supporter 4 is winter hardy it would it be a much superior rootstock to M.7.

Predicting Chemical Thinning study (Figures 9):

Carbohydrate Model Results for the Champlain Valley

We used a computer model and weather data from the weather station owned by Adam Sullivan of Sullivan Orchards in Clinton County to calculate in real time the carbohydrate status of trees in the Champlain Valley during the thinning period in late May and early June. This estimate of carbohydrate status was used to predict thinning response of apple trees in Clinton County. We presented the data in Figure 9 at the thinning meeting on Thursday May 29. After the thinning meeting there were 5 days with cloudy weather and a severe carbohydrate deficit. Saturday May 31 had a severe deficit due to very cloudy weather. Sunday and Monday June1-2 have had a mild carbohydrate deficit. From Tuesday June3-Sunday June 8 there was period of severe carbohydrate deficits due to high daytime temperatures, high night temperatures and somewhat overcast weather resulting in moderate to low sunlight levels. The carbohydrate status was very negative due to temperatures in the mid 80's.

We interpreted the 2008 data as follows:

1. The positive carbohydrate status on Wednesday May 28 was followed by a period of mild deficits and severe deficit days which resulted in a significant response for thinners applied that week.

2. The period from Tuesday June 3- Sunday June had a severe carbohydrate deficit with high daytime temperature and high night temperatures. The sustained period of night-time temperatures above 60°F resulted in excessive thinning if full rates of chemicals were used. The model suggested reduced rates for this period

We recommended that growers use caution in thinning in 2008 and to use lower rates to avoid over-thinning.

Return Bloom of Honeycrisp study (Figure 10):

In 2007 we applied 13 chemical thinning treatments to heavy blooming Honeycrisp trees at either petal fall or at 10mm fruit size. The treatments at petal fall did too little thinning except at the highest rate of 10ppm NAA + Carbaryl. Treatments at 10mm fruit size also did too little thinning. We did not apply the high rate of 10ppm + Carbaryl at the 10mm stage for fear of removing all of the fruitlets. The next spring (2008) none of the treatments resulted in any amount of return bloom except the high rate of NAA+Carbaryl applied at Petal Fall. This result combined with other work at Geneva, lead us to conclude that Honeycrisp requires very early thinning (during bloom or at petal fall) to have sufficient return bloom the next year. In this respect it is very similar to the variety Macoun which also must be thinned early with high doses of NAA+Carbaryl.

This information was not needed in the spring of 2008 since almost all Honeycrisp orchards had a light bloom following the heavy crop in 2007. However, we expect a heavy bloom in 2009 which will require growers to thin aggressively at petal fall to avoid another biennial bearing cycle in 2010. We are scheduled to make a presentation at the Hort Expo in Syracuse to discuss this important finding with NY Honeycrisp growers.

Control of pre-harvest drop study (Table 3, Figures 11-13):

In 2008, temperatures in August and September were close to normal. As a consequence fruit drop was low in the Champlain Valley until late in the harvest season.

At Chazy orchards in the Champlain valley pre-harvest fruit drop from untreated control trees remained low until winds from Hurricane Ike in late Sept. caused significant drop. In our plot drop exceeded 20% by Sep 21 and by the end of Sept had reached 60% drop. NAA applied on Sep 8 did not statistically reduce drop at any date although there was a small numeric decrease in drop from NAA. The full rate of Harvista applied on Sept 8 (1 week before harvest) provided excellent drop control in the Champlain Valley study. The addition of NAA to Harvista did not improve its effectiveness. The half rate of Harvista combined with NAA gave similar but slightly inferior drop control as the full rate of Harvista in the Champlain Valley study. Retain reduced fruit drop whether applied on Aug 25, (3 weeks before harvest) or Sep 2 (2 weeks before harvest) however the efficacy was much better when applied 2 weeks before harvest than 3 weeks before harvest. The addition of 20ppm NAA to the Retain sprays on Sep 2 did not statistically improve the performance of Retain but there was a small numeric improvement in drop control. When a reduced rate of Retain (166g/acre) was used with NAA the efficacy in reducing drop was reduced compared to the full rate of Retain applied on the same day; however the low rate of Retain plus NAA had similar efficacy to the full rate of Retain applied on Aug 22. It appears that in the Champlain valley if Retain is applied too early its effects wear off by the time massive drop begins in late September. The best Retain (Sept 2) or Retain+NAA treatment gave similar drop control as Harvista. However, Retain alone applied Aug 25 was less effective in controlling preharvest drop. The impact of the NAA in the spray mixtures on fruit quality after storage has not yet been determined.

The results of this study indicate that Harvista applied as a dilute spray with Silwett (0.25%) using commercial airblast spray machines can provide very effective drop control of McIntosh which is perhaps the most sensitive apple variety to pre-harvest drop. However, the 2008 season was not a heavy drop year with high heat before harvest. This study needs to be continued until we experience the high drop years to fully evaluate the potential of Harvista as a control measure to prevent pre-harvest drop.

The fruit quality effects of Harvista and Retain is currently being evaluated and a final report will be prepared in Mid January.

Education and Outreach Efforts

We conducted a vigorous extension and outreach program with this project. In March 2008 we conducted a winter pruning workshop in the orchard systems plot on Everett Fruit Farm to teach tree pruning and training for high density orchards. In May 2008 we conducted a chemical thinning workshop at Bob Harts fruit farm. In June 2008 we conducted a summer field day where the orchard systems and rootstock plots were featured. We published several articles in the NY Fruit Quarterly magazine which were sent to all tree fruit growers in the state. In Dec. 2008, we made 2 presentations to fruit growers in Quebec which were available to Champlain valley apple growers. We will make a presentation in Feb 2009 at the Statewide Hort Expo in Syracuse and later in Feb. 2009 at the Northern NY winter fruit schools on orchard modernization.

Publications in 2008 for growers from this project:

Fazio, G. and T. Robinson. 2008. Modification of nursery tree architecture by apple rootstocks – a breeding perspective. *NY Fruit Quarterly* 16(1): 13-16.

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

Robinson, T.L. and A.N. Lakso. 2008. Predicting and understanding chemical thinner response in real time. *Proceedings Great Lakes Fruit Workers Annual Meeting* 2008:15-18.

Robinson, T.L. and A.N. Lakso. 2009. Predicting and understanding chemical thinner response in real time. *Proc. of the 2009 Empire State Fruit and Veg. Expo.* p. 20-25.

Robinson, T.L. and A.N. Lakso. 2008. Predicting and understanding chemical thinner response in real time. *Journée Pomicole Provinciale* 2008:34-41.

Robinson, T.L. and S.A. Hoying. 2008. Successful high density apple orchards. *Journée Pomicole Provinciale* 2008:23-31.

Robinson, T.L. and S.A. Hoying. 2009. Fine points to consider when making planting system decisions. *Proc. of the 2009 Empire State Fruit and Veg. Expo.* p. 5-9.

Robinson, T.L. and S. Lopez. 2009. Cropload management for consistent Honeycrisp apples. *Proc. of the 2009 Empire State Fruit and Veg. Expo.* p. 16-20

Robinson, T., G. Fazio and S. Hoying. 2008. Intermediate stage evaluation of Cornell-Geneva and other promising rootstocks: Progress Report. *Compact Fruit Tree* 41:27-32.

Robinson. T.L., S.A. Hoying, A.M. DeMarree, K.I. Iungerman and M.J. Fargione. 2007. The evolution towards more competitive apple orchard systems in New York. *NY Fruit Quarterly* 15(1):3-7.

Table 1. Performance of McIntosh and Honeycrisp apple trees on 6 rootstocks trained to 5 orchard systems in the Champlain Valley.

Variety	System	Stock	Tree Density/ Acre	Cum Yield/ Acre	Av Fruit Size	Cum Crop Value/ acre
Honeycrisp	Central Leader	MM.111	218	221	227	4564
	Slender Pyramid	G.30	444	1383	239	29617
	Slender Pyramid	M.26	444	939	217	19625
	SolAxe	B.9	726	1633	230	36123
	SolAxe	G.16	726	1586	231	34733
	SolAxe	M.9	726	1495	221	32246
	Vertical Axis	B.9	726	1821	227	39508
	Vertical Axis	G.16	726	1584	217	32838
	Vertical Axis	M.9	726	1865	223	39398
	Tall Spindle	B.9	1307	2465	222	53107
	Tall Spindle	G.16	1307	1857	217	37371
	Tall Spindle	M.9	1307	2012	210	39720
McIntosh	Central Leader	MM.111	218	329	164	2140
	Slender Pyramid	G.30	444	1542	148	7005
	Slender Pyramid	M.26	444	972	151	4117
	SolAxe	B.9	726	1806	147	8645
	SolAxe	G.16	726	1855	142	7584
	SolAxe	M.9	726	2475	150	12418
	Vertical Axis	B.9	726	1851	145	7882
	Vertical Axis	G.16	726	1858	147	8105
	Vertical Axis	M.9	726	2804	145	11095
	Tall Spindle	B.9	1307	3190	143	13596
	Tall Spindle	G.16	1307	2690	141	11457
	Tall Spindle	M.9	1307	3841	143	14878
		LSD P≤0.05		**393**	**10**	**6686**

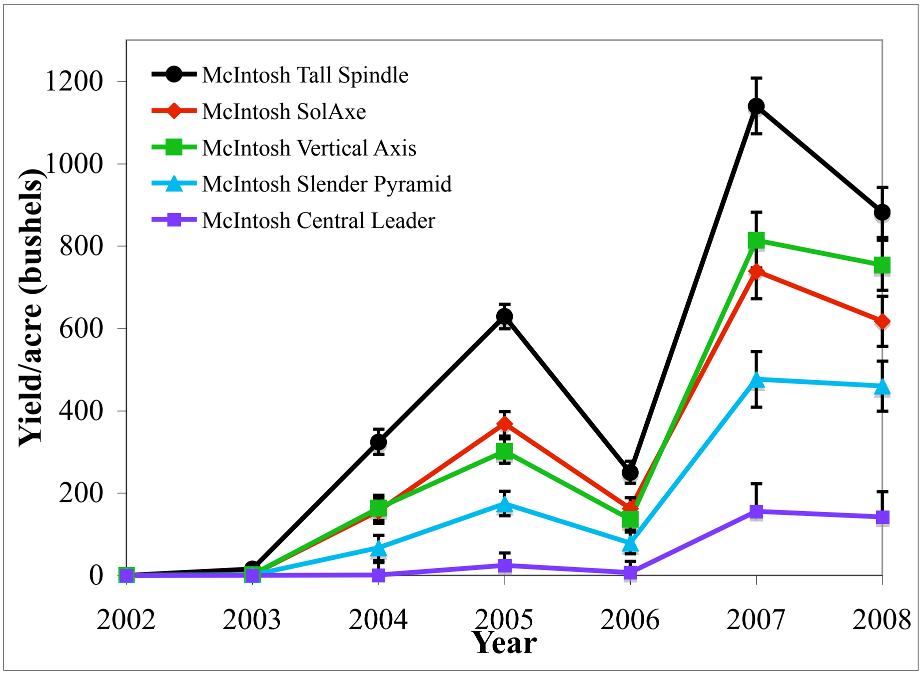

Figure 1. Annual yields of McIntosh apple trees trained to 5 orchards systems over the first 7 years in the Champlain Valley

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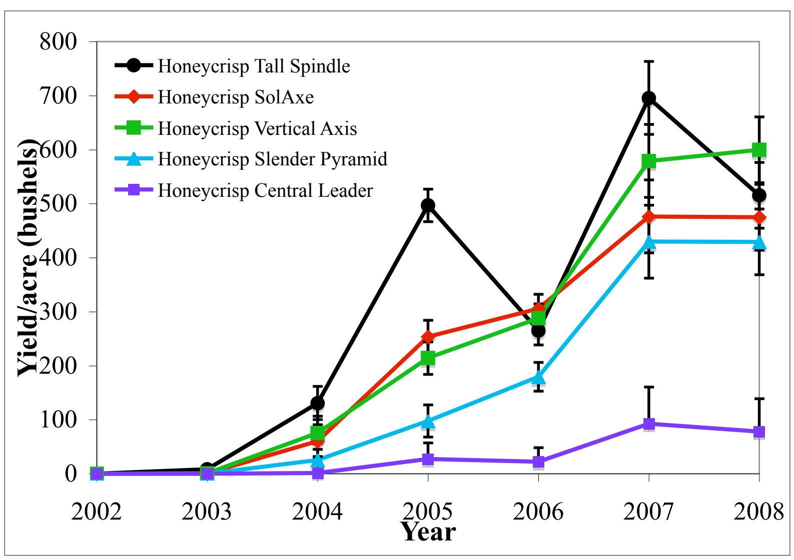

Figure 2. Annual yields of Honeycrisp apple trees trained to 5 orchards systems over the first 7 years in the Champlain Valley.

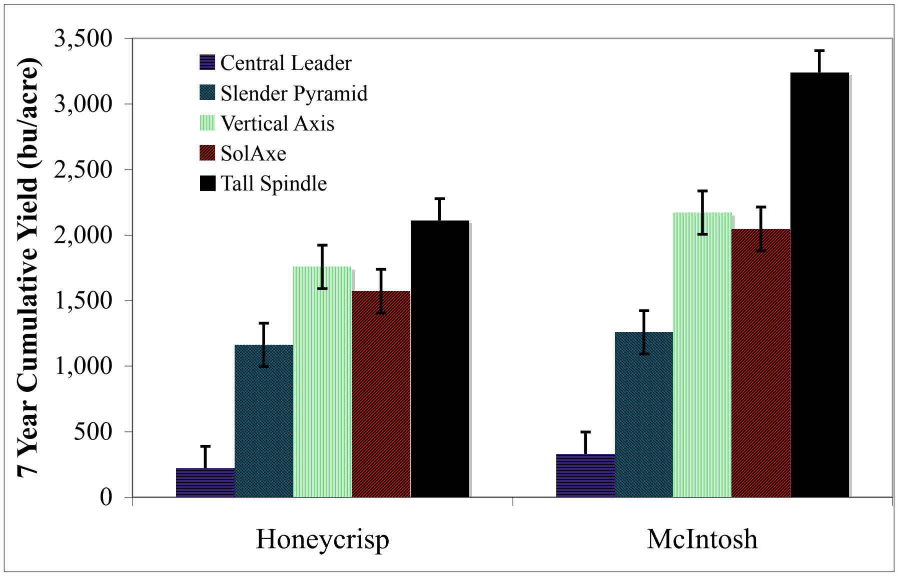

Figure 3. Cumulative yields of Honeycrisp and McIntosh apple trees trained to 5 orchards systems over the first 7 years in the Champlain Valley orchards.

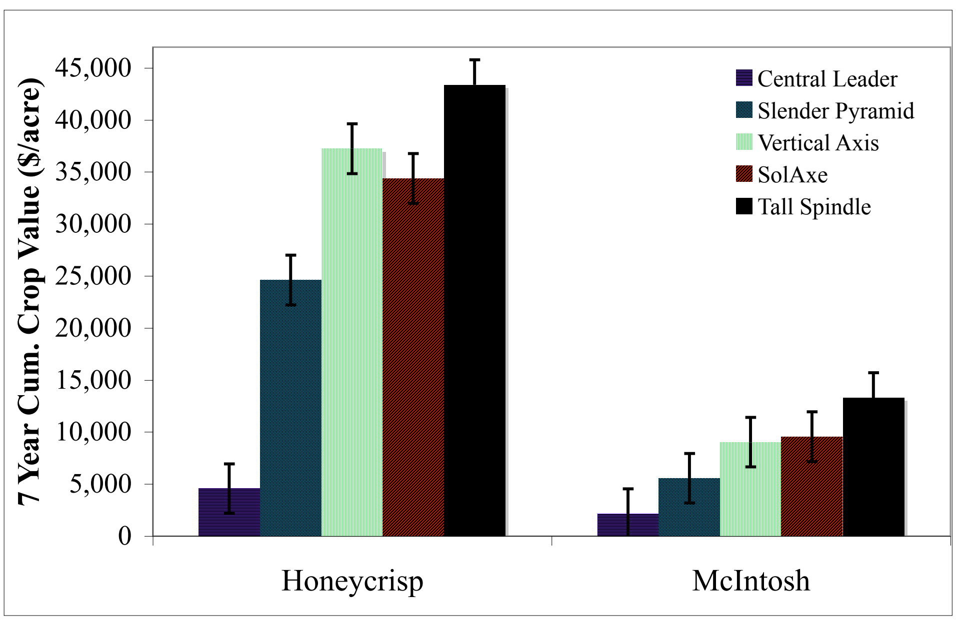

Figure 4. Cumulative crop value of Honeycrisp and McIntosh apple trees trained to 5 systems over the first 7 years in the Champlain Valley.

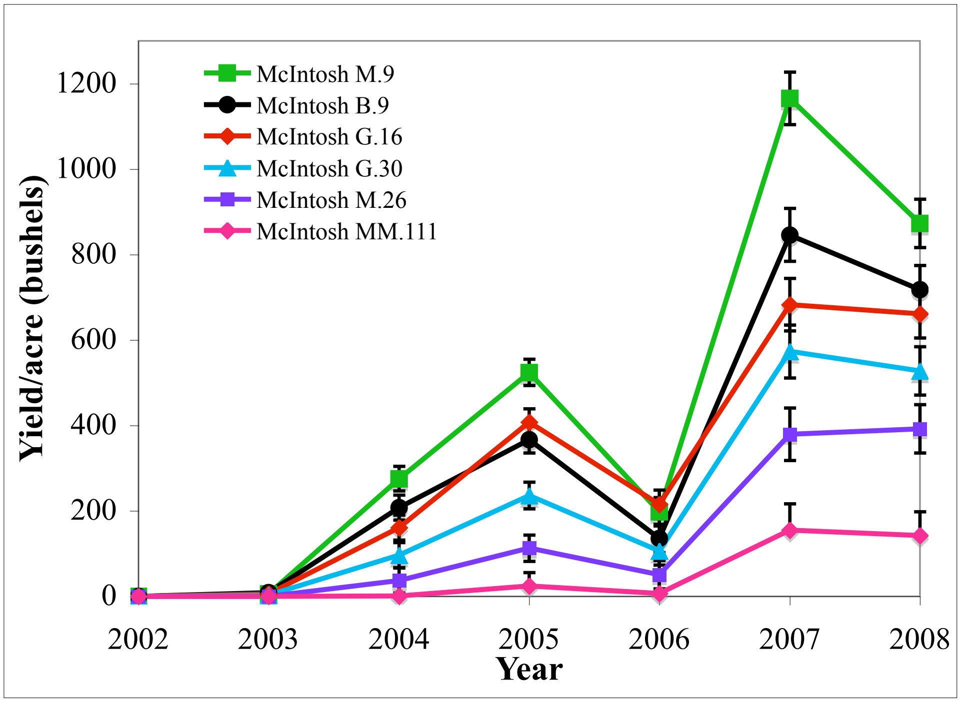

Figure 5. Annual yields of McIntosh apple trees grown on 6 rootstocks over the first 7 years in the Champlain Valley.

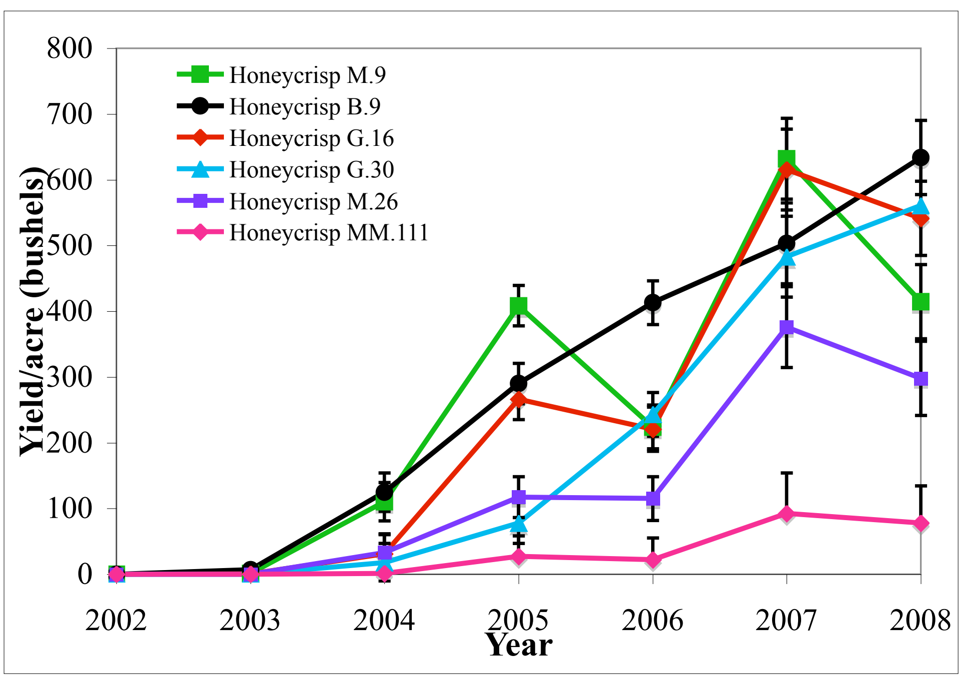

Figure 6. Annual yields of Honeycrisp apple trees grown on 6 rootstocks over the first 7 years in the Champlain Valley.

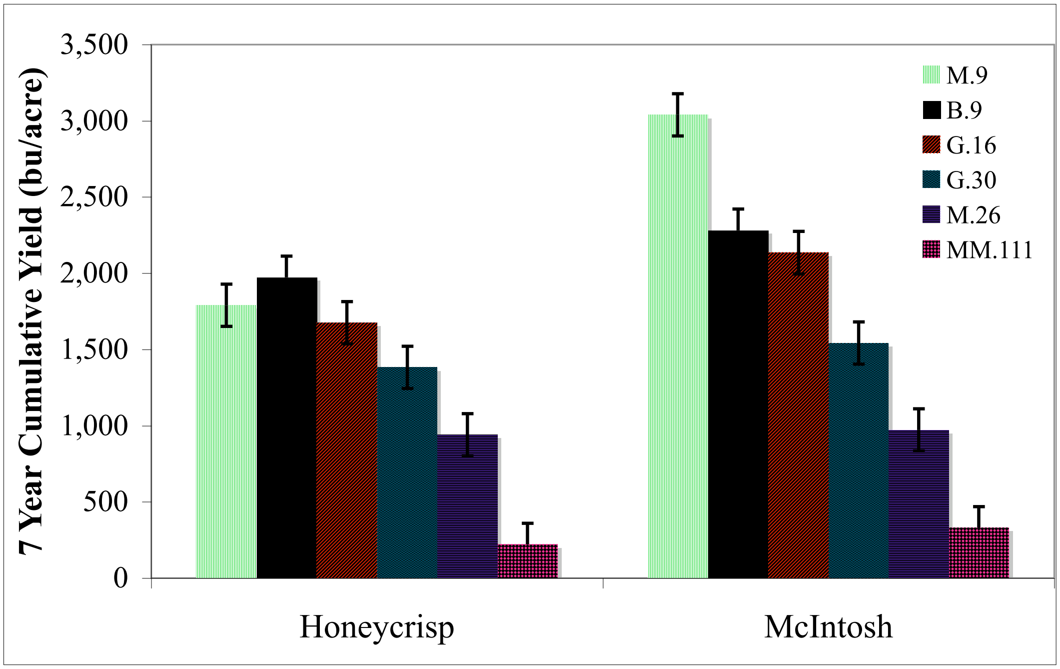

Figure 7. Cumulative yields of Honeycrisp and McIntosh apple trees grown on 6 rootstocks over the first 7 years in the Champlain Valley.

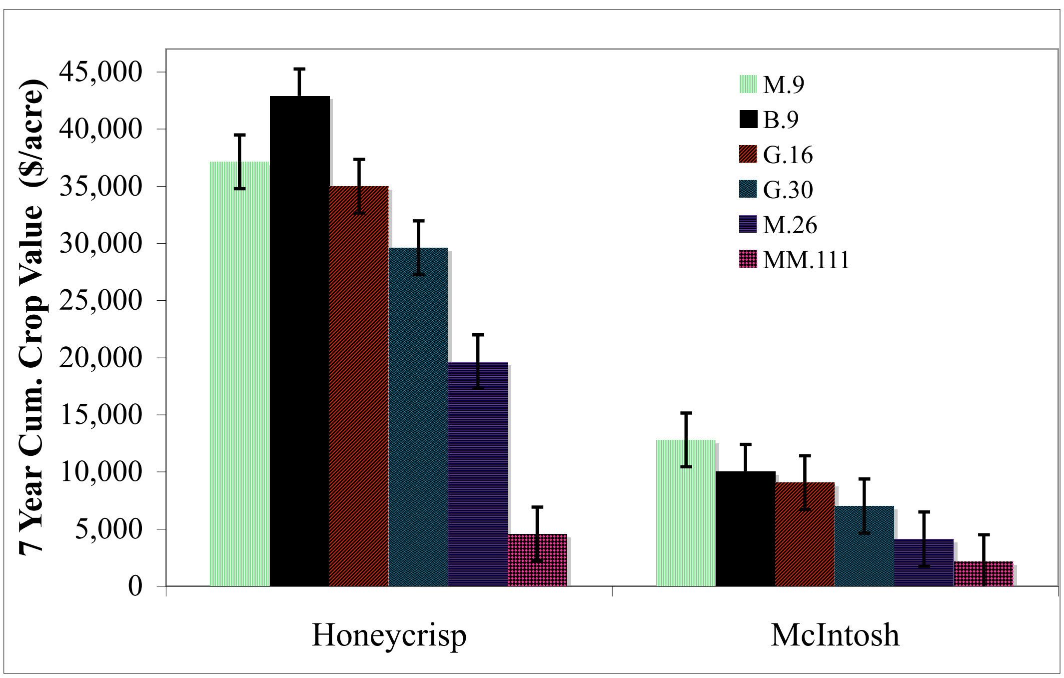

Figure 8. Cumulative crop value of Honeycrisp and McIntosh apple trees grown on 6 rootstocks over the first 7 years in the Champlain Valley

Table 2. Performance of Supporter Rootstocks in the 1999 NC-140 McIntosh Rootstock Trial

Plot	Stock*	TCSA Nov. 2007 (cm2)	Fruit No. 2008	Yield 2008 (kg)	Fruit Size 2008 (g)	Yield Eff. 2008 (kg/cm2 TCSA)	Cum. Fruit Number	Cum. Yield (g)	Cum. Yield Eff. (kg/cm^2 TCSA)	Av. Fruit Size (g)	Cum Number of Root Suckers	Tree Survival (%)
Dwarf	M.9T337	23.1 c	175 a	24.1 a	137.7	1.08	850	121	5.47	156.4	2.7	100
Dwarf	Sup2	28.9 bc	185 a	25.1 a	136.4	0.88	1055	144	5.05	150.4	0.5	100
Dwarf	Sup1	34.9 ab	214 a	28.9 a	136.7	0.85	1160	162	4.72	147.4	0	100
Dwarf	Sup3	34.9 ab	188 a	25.9 a	139.5	0.73	1200	159	4.54	140	0.8	100
Dwarf	M.26EMLA	42.9 a	185 a	27.5 a	148.8	0.67	817	117	2.81	148.6	0.3	100
	LSD $p \leq 0.05$	**8.7**	**56**	**7.5**	**7.8**	**0**	**223**	**29**	**1.0**	**8.60**	**2**	
Semidwarf	M.26EMLA	48.4 c	177 c	25.4	144.4	0.52	792	114	2.35	151.7	0	100
Semidwarf	Sup4	77.4 b	304 a	45.3	148.9	0.59	1248	205	2.66	171.7	1.3	100
Semidwarf	M.7	105.0 a	275 b	43.7	159.3	0.42	1065	180	1.73	171.7	17.7	100
	LSD $p \leq 0.05$	**14.4**	**73**	**9.7**	**12.7**	**0**	**381**	**52**	**0.9**	**12.70**	**8**	

*Rootstocks ranked by cross-sectional area.

Figure 9 unavailable

Figure 9. Carbohydrate balance and maximum and minimum temperatures at Peru, NY in the Champlain Valley during the chemical thinning period. The Gray box is the period when most commercial growers sprayed chemical thinners.

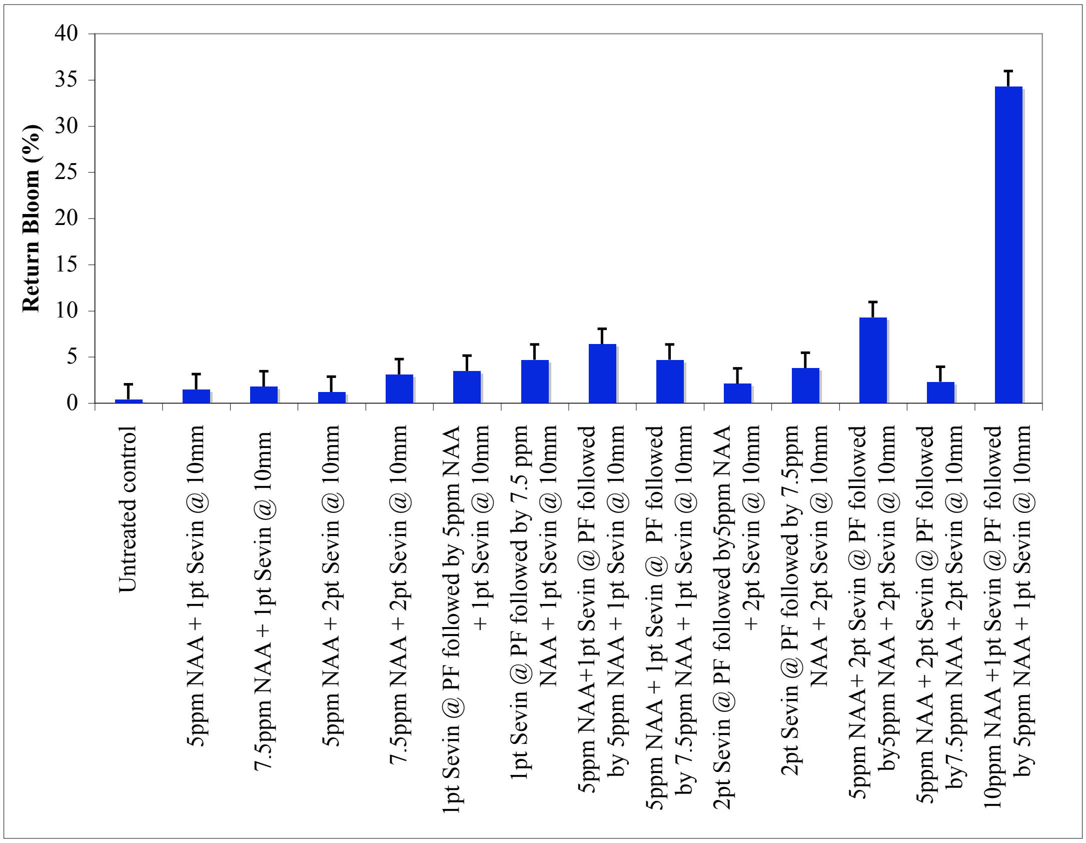

Figure 10 Return bloom in 2008 of Honeycrisp/M.9 trees at Chazy Orchards following various chemical thinning treatments in 2007.

Table 3. Effect of Retain, NAA and Harvista on preharvest fruit drop of McIntosh/M.26 apple trees (2008- Champlain Valley)

Treatment	Cumulative Drop 9/16/2008	Cumulative Drop 9/23/2008	Cumulative Drop 9/30/2008	Cumulative Drop 10/7/2008
Untreated Control	5.9	11.4	61.7	85.5
333g Retain/acre 8/25/08	5.3	6.9	25.3	43.0
333g Retain/acre 9/2/08	3.5	4.2	12.1	22.0
333g Retain/acre 9/2/08 +20ppm NAA 9/8/08	1.4	2.8	9.8	19.0
166g Retain/acre 9/2/08 +20ppm NAA 9/8/08	4.0	5.0	27.2	43.6
20ppm NAA 9/8/08	5.1	8.5	51.6	71.0
120g Harvista 9/8/08	4.6	5.6	8.25	16.2
120g Harvista+20ppm NAA 9/8/08	2.8	3.1	5.8	13.9
60g Harvista +20ppm NAA 9/8/08	3.4	4.2	14.3	22.9

LSD P≤0.05	2.6	3.9	14	16

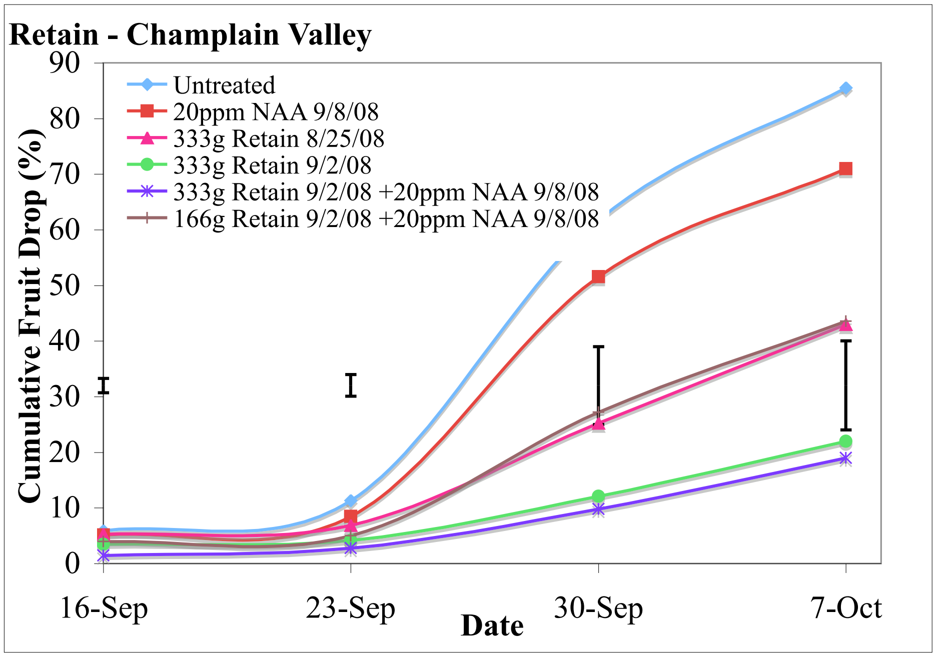

Figure 11. Effect of Retain, NAA and Retain+NAA on fruit drop of McIntosh/M.26 apple trees in the Champlain Valley, NY (2008).

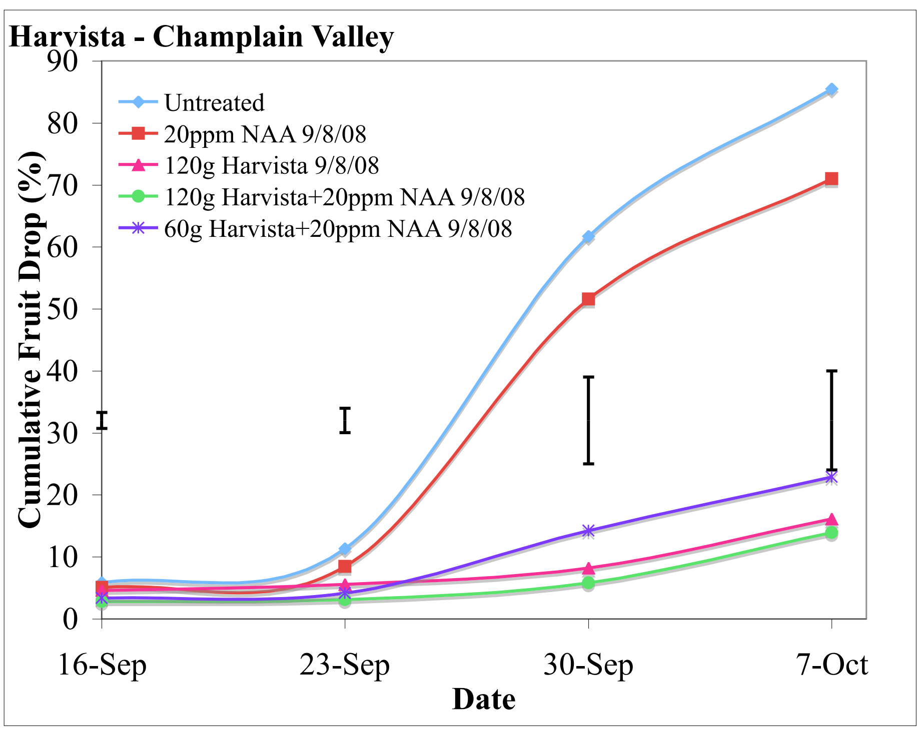

Figure 12. Effect of Harvista, NAA or Harvista+NAA on fruit drop of McIntosh/M.26 apple trees in Champlain Valley(2008).

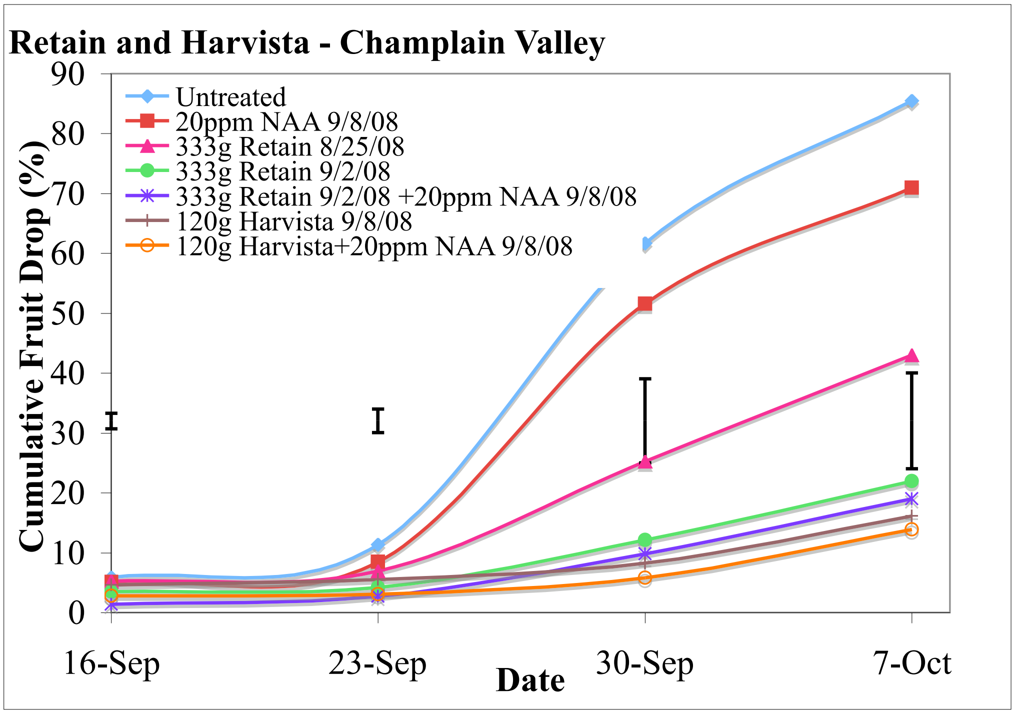

Figure 13. Effect of Retain, Harvista, NAA, Retain+NAA or Harvista+NAA on fruit drop of McIntosh/M.26 apple trees in Champlain Valley. (2008).