Hybrid Hazelnut Evaluation Project on Prince Edward Island

Final Report, December, 2012

William M. Glen and Delmar Holmstrom

prepared for the P.E.I. Soil and Crop Improvement Association

Agriculture Research Fund Project

Introduction

This is the final report of the Hybrid Hazelnut project that was initiated in 2008. The original project was scheduled to end on March 31st 2011 but was extended to the end of March, 2013.

The project's objective was to evaluate hybrid hazelnut varieties under Prince Edward Island (P.E.I.) climatic conditions. Activities in 2011 and 2012 included expansion of the three existing sites with the addition of several new hazelnut varieties, monitoring of the existing varieties and further contact with hazelnut experts throughout the world.

Acknowledgments

The project was carried out with the commitment and dedication of the three owners of the sites on which the project was done. These three owners were:

Site 1	Kellys Cross	David Carragher
Site 2	Green Road	William Glen
Site 3	Milburn	Kim Boulter

Significant support was provided by Agriculture and Agri-Food Canada; Delmar Holmstrom, A.A.F.C. researcher was assisted by Christine Stewart and Dylan Andrews. The P.E.I. Soil and Crop Improvement Association provided support and partial funding for the project was received from the P.E.I. Research Fund.

Background

Hazelnuts (*Corylus* spp.), also called filberts, have many species found throughout the world. The most commercially valuable species, the European hazel (*C. avellana*), is found primarily in Turkey with significant production in Italy, Spain, France, and the United States (Josiah, 2009; Fulbright, 2003; Wikipedia, 2012). Canadian commercial production is restricted to British Columbia (Anon, 2012). In the rest of Canada hazelnuts are grown by hobby gardeners. The varieties grown are; the two native North American hazel species - American hazelnut (*C. americana*) and beaked hazelnut (*C. cornuta*)-, selected European (*C. avellana)* varieties or hybrids (crosses between the native species, the European hazel and Asian species).

Native species, although very adaptive to local climatic conditions, do not produce commercially viable crops as the nuts are generally small and have thick shells. European varieties have two serious limitations. First, they are generally not suited to the harsh winters

and late spring frosts found under Canadian conditions, as they come from a mild, temperate climate. Second, European varieties are not resistant (unlike the native North American species) to eastern filbert blight- a disease caused by the endemic fungus *Anisogramna anomala* - which is prevalent throughout North America east of the Rocky Mountains and is now found in Oregon and British Columbia (Kempler, 2009; Molnar et al, 2005).

In response to local demand for hazelnut plants, plant breeders since the 1920s, in the eastern and central United States, have crossed native and European hazels, attempting to combine the superior qualities of the European hazel with the disease resistance and cold hardiness of the American species (Dale, 2008). As a result, a number of varieties have been developed for the north eastern USA and southern Ontario regions (SONG, 2003). In addition, because the eastern filbert disease has appeared in Oregon hazel orchards, plant breeders at Oregon State University have also developed disease resistant varieties (Oregon Hazelnuts, 2012). Although these varieties were developed for warmer climate conditions than P.E.I., recent climate changes appear to show that the P.E.I. climate is becoming better suited for plants from warmer climates (Bootsma, 2010).

Hazelnuts are used in a number of products including chocolate confections; added to foods such as cereals, cookies, and breads; put into roasted nut mixes; and made into flavourings for products ranging from hazelnut oils, coffees, and syrups (Josiah, 2009). In recent years, Ferrero-Rocher, a major international candy manufacturer, has constructed a plant in southern Ontario for the production of Tic Tac, Nutella and Ferrero Rocher products. Their Ontario plant imports over 24,000 tonnes of hazelnuts (production from the equivalent of over 10,000 ha) from Turkey, Italy and Chile (Anon, 2005).

Producers in P.E.I. are looking for alternate crops for steeply sloping land that has been removed from annual row crop production. Crops suitable for these sensitive areas (potential high soil erosion) must also provide a potential economic benefit to producers and fit into the habitat conditions of the adjacent crops. Hazel trees have the potential to solve both objectives. Since hazel trees are perennial plants, tillage and soil erosion will be all but eliminated. If the trees survive and reach the productivity levels as found in other areas, they have the potential to return $5,000 per ha at maturity (Anon, 2012).

On P.E.I. several experiments/demonstrations on hazelnuts had been initiated in the past few years. In the spring of 2005, a trial was planted at Orwell to evaluate native beaked hazelnut (*C. cornuta*) and three varieties of hybrid dwarf hazelnuts - Winkler, Northern and

Grimo seedlings (obtained from Grimo Nut Nursery in Ontario). Results of the project are found on the P.E.I. Soil and Crop Improvement Association (PEISCIA) web site: http://www.peiscia.ca. In summary, the project showed that two of the seedling varieties, Winkler and Northern did grow well and produced nuts. Production levels were not high as the plants were less than five years old and no management methods were done to enhance yields. The third variety, Grimo seedlings showed considerable infection by eastern filbert blight.

In 2006, another project was established at Cornwall to evaluate the dwarf hybrid hazelnut varieties – Epsilon, Delta, Zeta and New York (Epsilon, Delta and Zeta varieties were developed in Oregon and considered immune to eastern filbert blight). Details of the experiment are found on PEISCIA web site: http://www.peiscia.ca. In summary, mortality was very high for the Zeta variety (over 95%), and the Delta variety (77%) and unacceptable for the Northern (43%) and Epsilon (36%) varieties. In addition, plant growth of surviving plants was slow and no nut production occurred to 2010. It was felt that the site was too exposed to winter winds for the hazelnut plants causing poor survival and growth. As a result, the project was terminated at the end of the 2009 season.

Because of the mixed results of the previous experiments, it was decided to initiate a new project on sites which were protected from the prevailing winds and to evaluate a wider selection of immune or blight resistant varieties. Starting in the fall of 2008, the first phase of this project was initiated. The project's objective was to evaluate a number of hazelnut varieties from north eastern USA, Oregon and southern Ontario. Varieties have been evaluated for survival and growth rate. Two sites in central P.E.I. were selected in the fall of 2008. The project was amended the winter of 2009/2010 and an additional site in western P.E.I. was added in the spring of 2010.

Sites

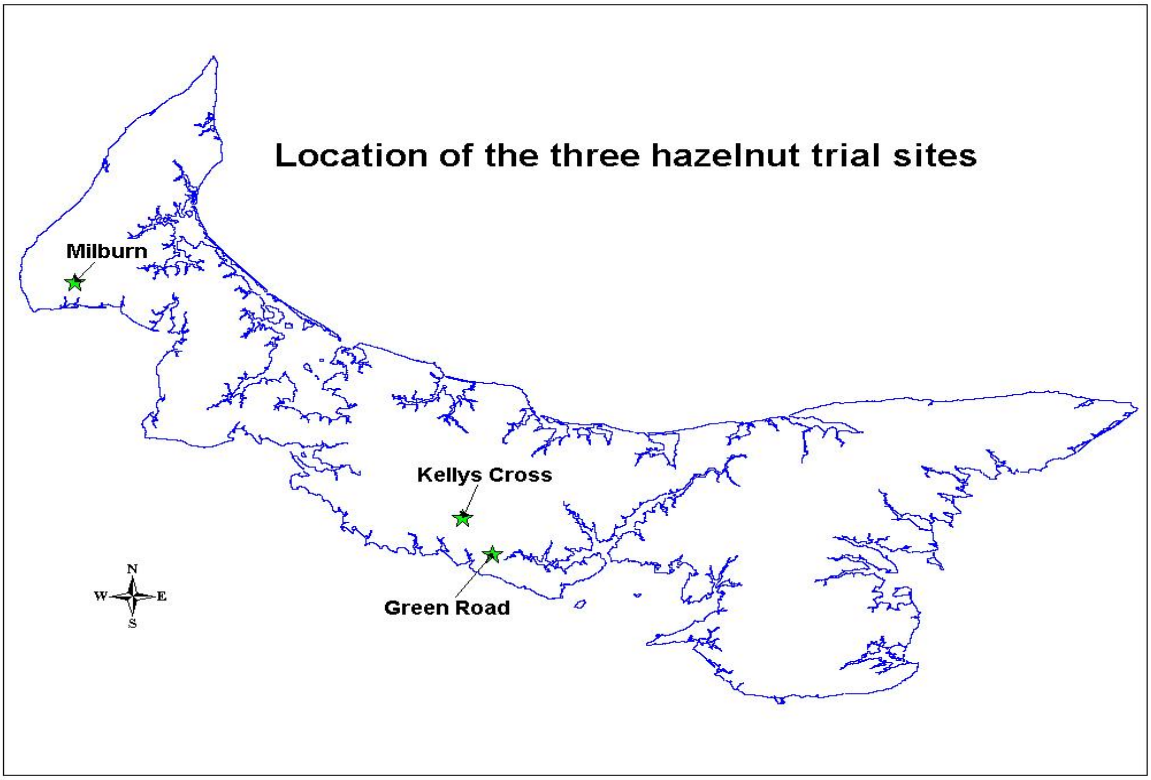
As previously noted this trial was established on three sites as shown in Figure 1. Each site had similar soils but varied considerably in aspect, slope and the amount of shelter.

Site 1 in Kellys Cross, Queens County had been in agriculture production with the previous crops having been grain and soybeans. The soil type was Alberry with a restriction of shallow to bedrock. The soil was a well drained sandy loam (MacDougall et al, 1988). The site was on a south facing aspect with a slope of approximately five to eight percent. The site was reasonably sheltered as it was surrounded by a white spruce hedge on the east, west and south.

Site 2 on the Green Road, Queens County was abandoned agricultural land which had only had the goldenrod cut the previous year. A small number of white spruce that had begun to colonize the site were removed prior to the hazelnuts being established. The soil type was Charlottetown with a restriction of shallow to bedrock (MacDougall et al, 1988). Like the Kellys Cross site, the soil was well drained sandy loam. The site had a north facing aspect and a slope of approximately 10 to 15 percent. The site is reasonably sheltered from the east, west and south but the higher part of the site is exposed to the north.

Site 3 in Milburn, Prince County had been converted from forest to agriculture about five years before the test was established. It was under a rotation of corn, grain, and alfalfa prior to the hazelnuts being planted in 2010. (Note the grower had planted a number of varieties in 2009 and these are included in this report.) The soil type was Charlottetown, a well drained sandy loam glacial till (MacDougall et al, 1988). The site was level and open to winds from the south and west.

Figure 1



Site preparation and plant establishment

The Kellys Cross site, Figure 2, was laid out in the fall of 2008 with rows six metres apart and in row spacing of four meters. The site design was a complete randomized block design with 6 plant varieties replicated four times (five plant plots). Sites were also added for up to five spare plants per variety and for an additional 40 plants that the grower wanted to test. The final layout consisted of eight rows with 25 plants in each row. Each planting site was sprayed with glyphosate at the rate of 300 ml per 10 litres the fall prior to planting (except for the fall of 2008 when some plants were planted on sites two weeks after spraying.)

Sites were excavated by hand (as was the case with all the sites) and in the fall of 2008 ten plants of the following 4 varieties – Epsilon, Gamma, Zeta and Grimo 186M – were planted. In the subsequent years other varieties were added, see Table 1.

In the spring of 2009, twelve plants of the above varieties were planted along with 22 plants of the Santium and Grimo 208P varieties. In addition, the grower planted twelve plants of Slate, thirteen plants of Geneva, five plants each of Yamhill, Jefferson, and Farris G17. In the spring of 2010, the following varieties were planted: Het 1, Het 3, Farris G17, Jefferson, Slate (12 plants) and Geneva (11 plants). In 2011 Car 3, Car12, Farris 88BS, Farris GTO, Grimo 208D varieties were planted. Twelve plants of Geneva, Grimo 186M and Farris G17 were also planted in order to compare year of planting effect on varieties. In 2012, the Yamhill variety was planted along with twelve plants of the Geneva, Farris G17 and Grimo 208P varieties.

The Green Road site, Figure 3, was staked and planting sites excavated in the fall of 2008 in preparation for planting the spring of 2009. The row spacing was six yards and the in row spacing was four yards. (Note the imperial measurement was used to match up with a previous planting adjacent to the site.) The site was a complete randomized design with each plant variety replicated four times (five plant plots). As was done at Kellys Cross the planting locations were sprayed with glyphosate the fall before planting. The herbicide rate used was 100 ml per 10 litres.

Figure 2, Kellys Cross site, August 2011

Figure 3, Green Road site, August 2010

The varieties planted in 2009 were: Epsilon, Slate, Geneva, Grimo 186M, Santinum and Grimo 208P. In the spring of 2010, three more varieties were planted: Het 1, Farris 88BS and Farris G17. In 2011, Jefferson, Grimo 208D, Het 3, Farris GTO, Car 3 and Car 12 were added. As was the case at Kellys Cross, twelve plants of Geneva, Grimo 186M and Farris G17 were also planted. In 2012 Yamhill and Farris GTO were added along with twelve plants of Geneva, Farris G17 and Grimo 208P planted to compare varieties year to year growth.

Table 1.
The planting year of Hazelnut varieties established at the three sites.
(the number in brackets indicates the number planted that year)

Variety	Sites		
	Kellys Cross	**Green Road**	**Milburn**
Car 3	2011 (22)	2011 (21)	
Car 12	2011 (22)	2011 (20)	
Epsilon	2008 (10), 2009 (12)	2009 (27)	2009 (5), 2010 (20)
Farris 88BS	2011 (20)	2010 (22)	2011 (5), 2012 (10)
Farris G17	2009 (5), 2010 (17), 2011 (12), 2012 (12)	2010 (22), 2011 (12), 2012 (12)	2010 (22)
Farris GTO	2011 (10)	2011 (10), 2012 (6)	2010 (22)
Gamma	2008 (10), 2009 (10)		
Geneva	2009 (12), 2010 (10), 2011 (12), 2012 (12)	2009 (21), 2011 (12), 2012 (12)	2009 (5), 2010
Grimo 186M	2008 (10), 2009 (12), 2011 (12)	2009 (14), 2011 (12)	2009 (5), 2010
Grimo 208D	2011 (22)	2011 (22)	2011 (22)
Grimo 208P	2009 (35), 2012 (12)	2009 (25), 2012 (12)	2009 (5), 2010 (20)
Het1	2010 (21)	2010 (21)	2010 (21)
Het3	2010 (22)	2011 (20)	2011 (20)
Jefferson	2009 (5), 2010 (17)	2011 (20), 2012 (2)	2011(5)
Santiam	2009 (25)	2009 (25)	2009 (5), 2010 (20)
Slate	2009 (11), 2010 (11)	2009 (24)	2009 (5), 2010 (20)
Yamhill	2009 (5), 2012 (02)	2012 (22)	
Zeta	2008 (10), 2009 (12)		

Note tree number vary due to the availability of the varieties.

All varieties were obtained from Grimo Nut Nursery in Ontario except for the Car 3 and Car 12 seedlings which were obtained from Rhora Nursery also in Ontario. The Epsilon, Gamma, Zeta, Jefferson, Santinum and Yamhill were developed in Oregon to combat the onset of eastern filbert blight in that major commercial hazelnut area of the USA. The other varieties

were developed in southern Ontario and the north eastern USA over the past several decades. Because native hazelnuts were immune to eastern filbert blight breeders were crossing native varieties with European varieties to develop varieties resistant to eastern filbert blight but that would have the nut characteristics and quality of the non filbert resistant European varieties. This work continues today hence new varieties will be forthcoming from Oregon, eastern USA and southern Ontario in the next few years.

In the spring of 2010 the Milburn site, Figure 4, was disced and cultivated prior to laying strips of plastic. The plastic was laid by a home made machine which is available from the P.E.I. Soil and Crop Association (contact Tyler Wright, tmwright@gov.pe.ca). Rows were placed 18 feet apart (except for the first three rows that were planted in 2009 which were 15 feet apart). At planting time, the planting sites were established by cutting the plastic ('X' pattern) every 12 feet and excavating a small hole. The site was established as a complete randomized design with each plant variety replicated four times (five plant plots). Nine varieties were planted in 2010: Santinum, Epsilon, Grimo 186M, Grimo 208P, Slate, Geneva, Farris G17, Farris GTO and Het 1. (Note the grower had planted 5 plants of Epsilon, Santium, Grimo 186M, Grimo 208P, Slate and Geneva varieties the spring of 2009.) In 2011, Grimo 208D and Het 3 were planted along with five plants of Jefferson and Farris 88BS. In 2012, ten plants of the Farris 88BS were planted as replacements for plants that had died in previous years.

Figure 4, Milburn site, June 2011

Soil Amendments

The planting holes on the Kellys Cross and Green Road sites had soil amendments added. For the first year this was done at the time of planting but the bone meal used was believed to have caused the excavation of the newly planted trees by wildlife. Subsequently planting holes were excavated and bone meal (200 grams), along with dolomitic lime (700-1,000 grams) were added the fall before planting. The Kellys Cross site from 2010 on also added a quantity of peat moss (4-5 litres/tree) to increase the soil organic matter. At the Green Road site, only bone meal was added in 2009 but from 2010 on, both lime and compost (4-5 liters/tree) were also used. The Milburn site had no additives (peat/compost, lime or bone meal) added to the planting holes as pH and organic matter levels as shown by the soil test analysis were considered optimal. Note chemical fertilizer should not be used either at time of planting or during the first year.

Weed control

The first season at Kellys Cross landscape fabric was used but it proved to be unsatisfactory (material disintegrated in the first season), so in subsequent years weed control has been accomplished using the herbicide glyphosate (Figure 2). The method has worked reasonably well although extreme care is required to avoid having the herbicide contact the tree stems. However, this method is moderately labour intensive and does not improve soil moisture retention. It also has to be done once or twice each year until the trees have reached a suitable height (probably age five years or more when the tree canopy shades the ground surface).

At the Green Road site, individual mats of Geotextile fabric or perforated plastic (approximately 1 m squares) were applied after planting. (Note in 2009 landscape fabric was used for a small number of trees and as was the case at Kellys Cross, it did not survive the season.) The material was secured to the ground using landscape staples (Figure 5). Although labour intensive to apply, this method controls weed growth, improves moisture retention by the soil and reduces the number of suckers. In addition, fertilizer application has not been impeded as the fabric and perforated plastic permit penetration into the soil of fertilizer spread around each plant.

As previously mentioned the Milburn site had the black plastic strips placed prior to planting (Figure 4). The material has proven to be very effective in controlling weeds and suckers. In addition, the strips have improved the water retention of the soil thereby reducing

soil moisture stress on the plants during periods of low rainfall. The only drawback to the plastic mulch is during fertilization. Either the fertilizer has to be applied by hand under the plastic or holes need to be punched through the plastic to permit point source application of fertilizer. Both methods have draw backs and are labour intensive. It is expected that as the trees grow this problem will disappear as fertilizer will then be applied on either side of the plastic mulch but still under the tree canopy.

All three sites had the grass in the rows and between the trees mowed a number of times per season.

Figure 5, Vegetation mats, Green Road, May 2012

Watering

During the growing seasons of 2010 and 2012 there was a lack of rainfall. During those dry periods the current year's plantings were watered weekly. This was done on the Kellys Cross and Green Road sites, fortunately the Milburn site did not suffer from this lack of rainfall. The amount of water added to each plant was between one and two litres. This activity was carried out in May and July 2010 and for the period May to August in 2012.

Other maintenance

Maintenance was carried out at all three sites including staking, pruning, and sucker removal (see Table 2.). Plant maintenance approximately followed the Oregon guidelines (http://www.oregonhazelnuts.org/growers-corner/grower-handbook/).
Staking of plants was substantially increased as a result of the damage that occurred the winter of 2010/2011. Some varieties, i.e. Geneva, and plants that were large at time of planting needed more staking than other varieties or smaller plants.

Table 2. Hazelnut Orchard field operation schedule

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Site Preparation				X	X					X	X	
Planting				X	X					X		
Pruning	X	X										X
Fertilizing					X	X						
Liming							X	X		X		
Plant Support					X	X	X	X	X	X	X	
Mowing					X	X	X	X	X	X		
Weed Control					X	X			X			
Sucker Control					X	X	X	X	X			
Sun Scald										X	X	
Rodent bait										X	X	
Leaf sampling								X				
Soil sampling					X					X		

Pruning activity has now increased in particular on plants over 2 years old in order to promote tree structure conducive to nut production as well as orchard activities including harvesting. The object of the pruning was to concentrate the growth on a single stem and to lift the crown to allow access. The ideal crown is cup shaped with the lower edge 90 cm off the ground (Anon, 2012a).

Fertilization starting the second year of the plant was carried out at all three sites in May with liming, where required, completed during the summer. Soil and tissue samples were

collected to determine fertilizer and lime requirements for the following year. Fertilizer type was determined using the Oregon recommendations - http://extension.oregonstate.edu/catalog/pdf/em/em8786-e.pdf - which were based on the tissue sample analysis (Olsen, 2001). The fertilizer amount was determined as per recommendation in "Nut Growing Ontario Style" which used tree diameters to determine fertilizer application rate (SONG, 1993).

Sun scald protection was applied to the trees as a result of visits to hazelnut orchards in Germany and documentation from Oregon (Glen, 2010; Olsen, 2002). The object was to reduce potential damage from the sun to the south side of the lower section of the main stem particularly in late winter. A solution of white latex paint diluted to about 40% paint 60% water was applied by brush to the south side of the stems (Figure 5). Whether this treatment is required has yet to be determined.

Figure 5, Sun scald protection

Rodent control was carried out using Radvani feeding stations (Radvani, 1974). These were filled with commercially available poisoned bait (Figure 6) and placed along the outer

edges of the hazelnut plantings next to possible rodent habitat. Hawk posts as observed in Germany were installed at the Green Road and Kellys Cross sites (Glen, 2010). The posts with a cross bar at the top were at least 12 feet in height and provide a perch for hawks with the hope they would assist in the control of rodents (see photo on the report cover).

Figure 6, Rodent bait stations

Monitoring each year consisted of measurements of tree height and tree stem diameter (between 2 and 4 cm above the ground surface). Extensive winter damage occurred at the Kellys Cross site with a lesser degree of damage at the Milburn site the winter of 2010/2011. Individual trees were assessed for branch and main stem breakage. In addition, at the Milburn site, mice damage occurred to some of the trees. Damaged trees have been left out of the data analysis. Although most trees are less than 2 years old, they were monitored for catkins and nut production.

Results and discussion

Data on root collar diameter (r.c.d.), plant height and mortality were collected shortly after planting and in the fall of each year. Air temperature data was collected hourly using data loggers located at the Kellys Cross and Green Road sites.

Survival

The overall survival of the plantings was 94.2%. The survival rates by site were; Kellys Cross 96.6%, Green Road 91.9% and Milburn 93.5%. The lower survival at the Green Road site was primarily caused by ants making nests underneath the vegetation mats and damaging the root collars of some trees. This was particularly evident during the dry summer of 2012.

There was a notable variation in survival between varieties (Table 3)

Table 3, Summary of Mortality by Variety

Variety	Year planted	Total planted	Number dead	Mortality %	Comments
Car3	2011	44	6	13.6	very small plants at planting
Car12	2011	43	6	14.0	very small plants at planting
Epsilon	2009-2010	73	17	**23.3**	
Farris 88BS	2010-2012	47	3	6.4	mortality caused by ants
Farris G17	2009-2012	114	4	3.5	
Farris GTO	2010-2012	42	3	7.1	
Gamma	2009	20	0	0.0	
Geneva	2009-2011	116	1	0.9	
Grimo 186M	2009-2011	117	5	4.3	
Grimo 208D	2011	62	3	4.8	
Grimo 208P	2009-2012	108	0	0.0	
Het1	2010	63	3	4.8	
Het3	2010-2011	60	4	6.7	
Jefferson	2009-2011	47	2	4.3	mortality caused by ants
Santiam	2009-2010	75	0	0.0	
Slate	2009-2010	71	5	7.0	
Yamhill	2009-2012	45	1	2.2	
Zeta	2009	22	4	**18.2**	

All trees including spares are included in the calculation of mortality except trees killed by mechanical damage or being dug up by wildlife.

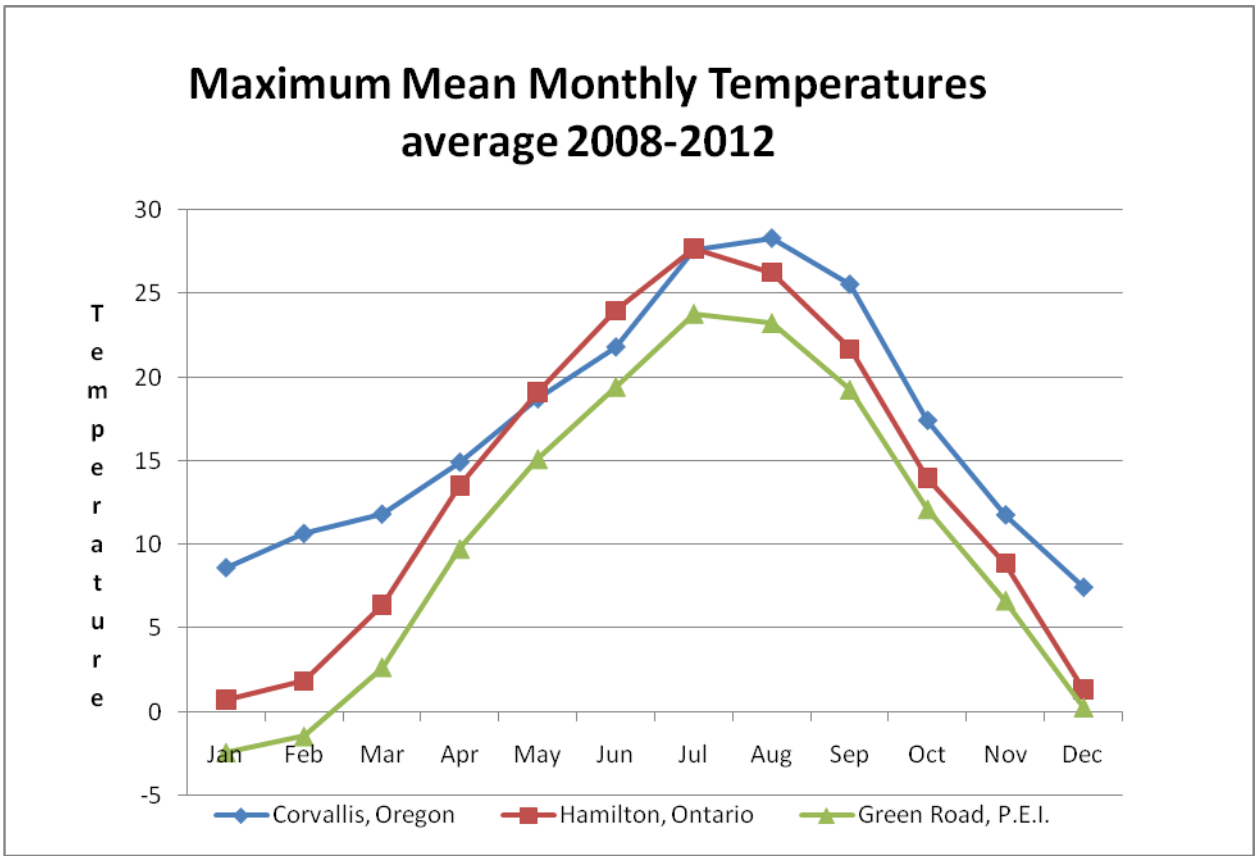
The survival of the Oregon varieties, Epsilon, Gamma, Jefferson, Santium, Yamhill and Zeta, varied considerably. The Zeta and Epsilon varieties did not appear hardy enough for the

P.E.I. climate. It was noted that the buds of Epsilon began to swell in the spring long before other varieties.

During March 2012, there was a very mild two day period when the temperature peaked at +22C. It appeared to have caused the Epsilon plants to break dormancy but the mild period was followed by a low of -9C the following week. The Epsilon had notable mortality before this weather event but the result was increased mortality and severe die back of the remaining plants. The Zeta variety had notable die back every year of the trial and the mortality was a reflection of this repeated die back.

Comparison of the mean monthly temperatures for Charlottetown versus those expected in Corvallis, Oregon and Hamilton, Ontario are shown in Figures 7 and 8. (Note Corvallis, Oregon is the location of the Oregon State University, who had developed some of the varieties under trial. Hamilton, Ontario is the closest Environment Canada weather station to the Grimo and Rhora Nurseries where the Ontario varieties were developed and plants obtained.)

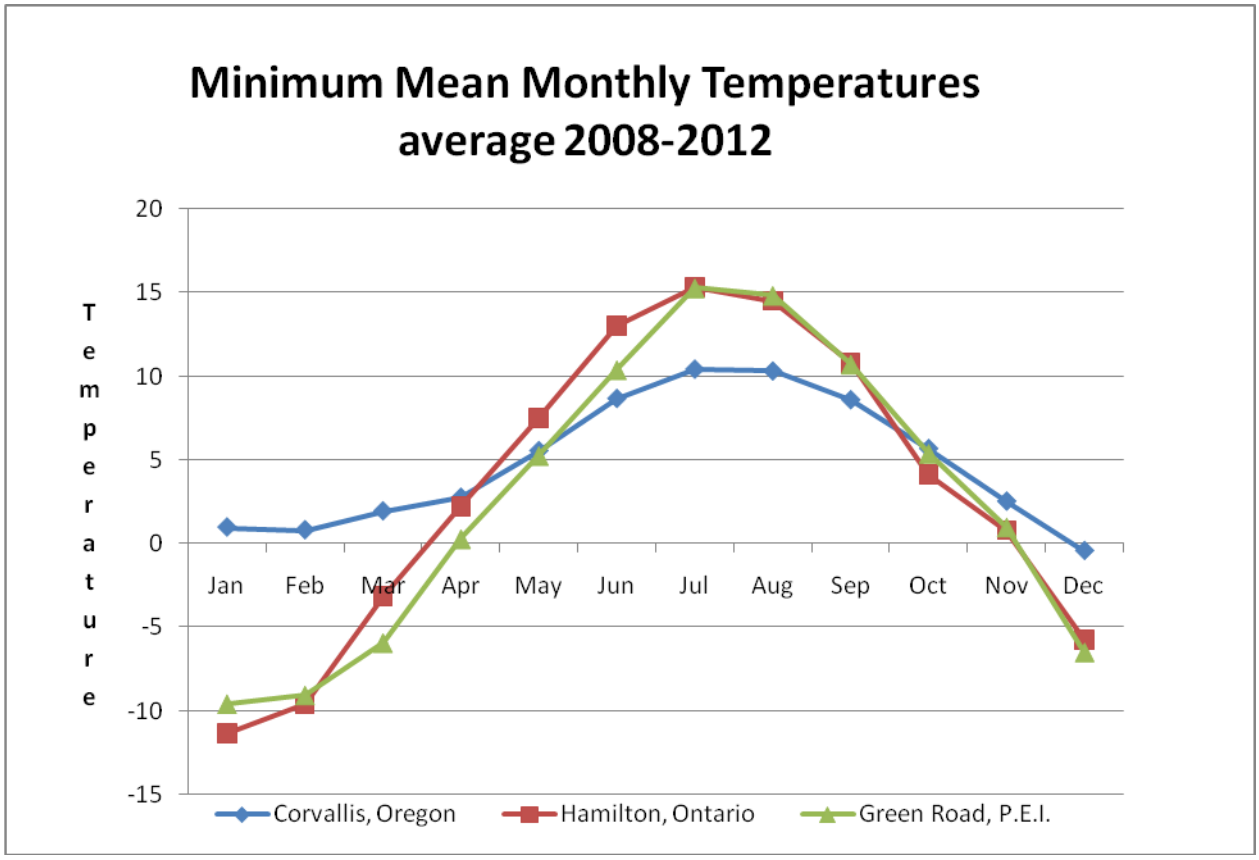
Figure 7, Mean Maximum Monthly Temperatures for Oregon, Ontario and P.E.I.



The maximum mean monthly temperatures for P.E.I are lower than the other two locations. Particularly during the winter months when compared to Oregon, P.E.I. has temperatures at least 10 degrees cooler. The difference during the summer was less, approximately five degrees.

The minimum mean monthly temperatures (Figure 8) show the same pattern of the winter months but the reverse is true for the summer where the P.E.I. and Ontario minimum means are five degrees warmer than Oregon.

Figure 8, Mean Minimum Monthly Temperatures for Oregon, Ontario and P.E.I.



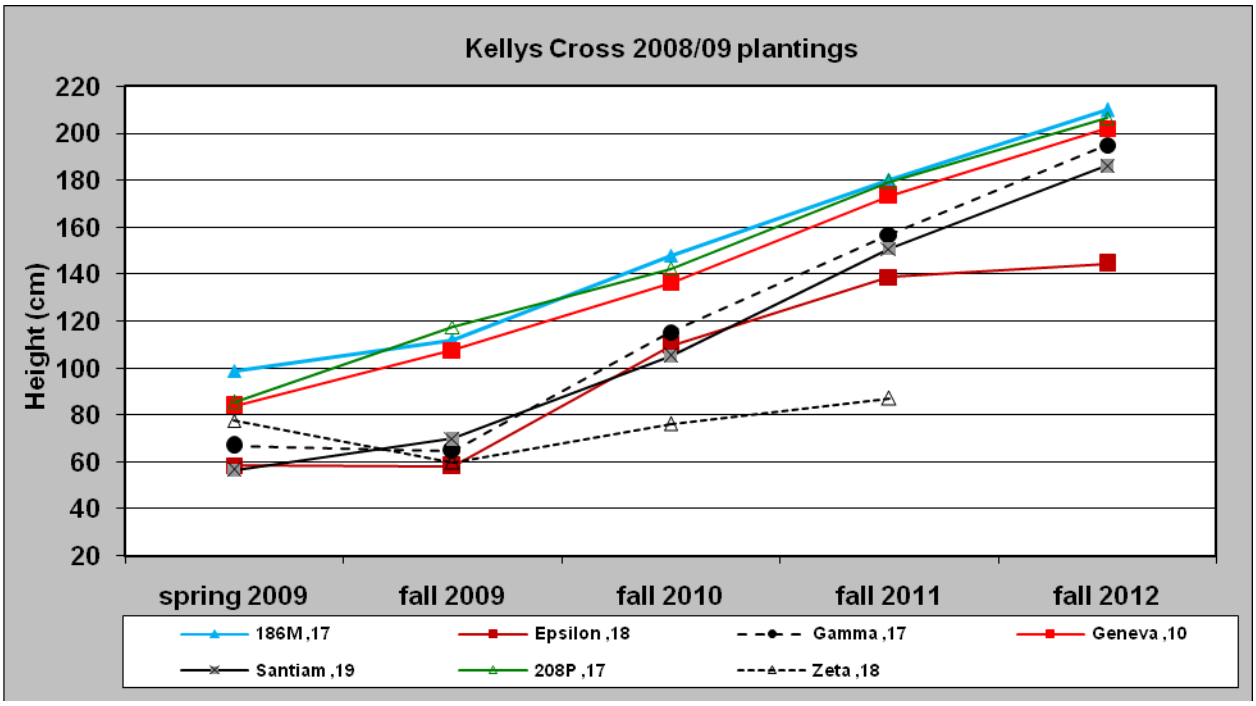
The other Oregon varieties; Gamma, Jefferson, Santium and Yamhill have not shown any indication of not being hardy enough for the P.E.I. climate.

The Car 3 and Car 12 seedlings were small (ranged from 30 to 40 cm) with very few roots when planted. The survival is believed to be a reflection of their small size and lack of roots. Since planting, the surviving plants have grown satisfactorily.

Height growth

Height growth of most of the varieties on each site generally was similar. Figure 9 shows the height growth of the 2008/09 plantings at Kellys Cross. Note the Zeta variety was removed in the fall of 2011 after having only just recovered to its original planting height. The Epsilon had put on very little in the way of height growth in 2012 due to the severe die back previously discussed. It will be noted that there was a range of heights at time of planting , but the growth rates were similar as indicated by the slope of the lines in the graph. Slate is the only other variety that had a lower growth rate. Note trees that suffered damage due to breakage caused by snow during the winter of 2010/11 are excluded from the height and r.c.d. averages. Figure 10 shows similar results for the Green Road site.

Figure 9, Height Growth rate of the 2008/9 plantings at Kellys Cross



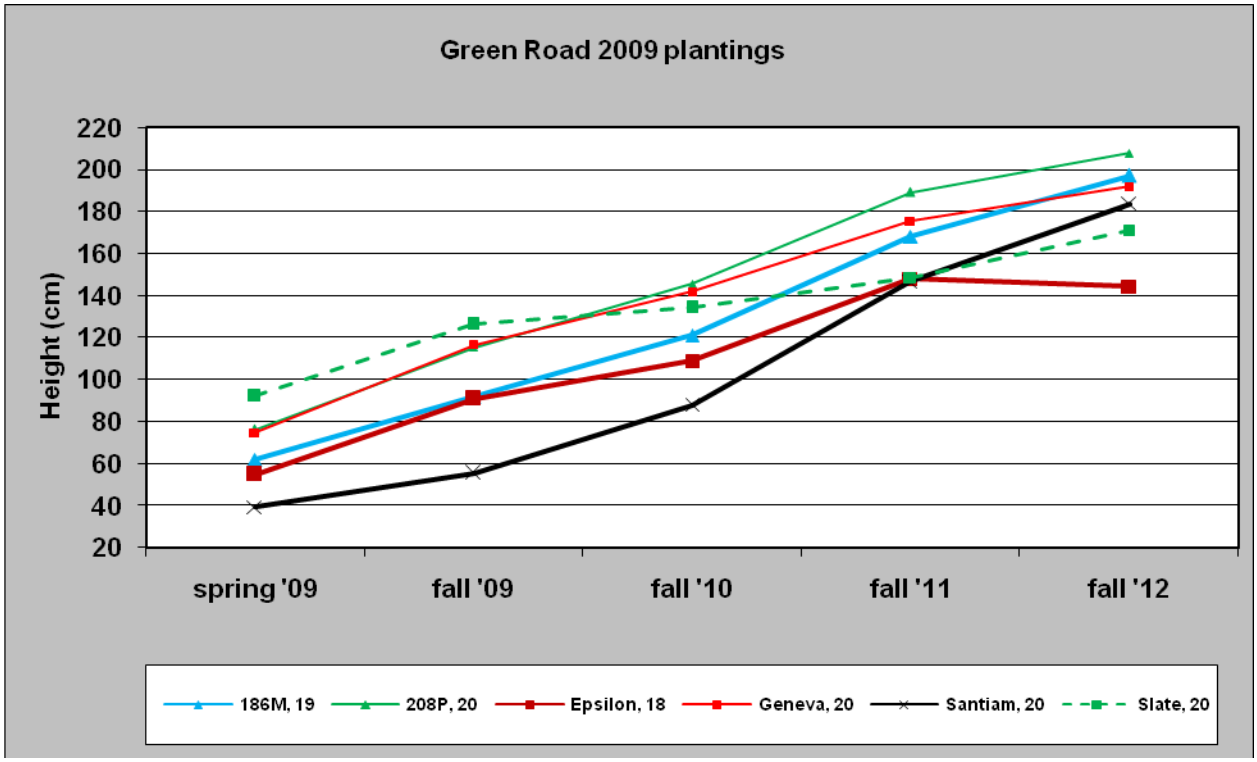
Notes for all Figures showing height and root collar diameter growth;

1-the number after the variety name indicates the number of plants used in the calculations.

2-plants that were damaged during the winter of 2010/11 are excluded.

3-the plants planted in the fall of 2008 at Kellys Cross are combined with those planted in the spring of 2009.

Figure 10, Height Growth rate of the 2009 plantings at Green Road



The comparison of the rate of height growth of a given variety on the three sites was less consistent. Figure 11 shows the height growth of Geneva planted on the three sites over a three year period. The variety was very consistent as shown by the slope of the lines. By comparison the Grimo 186M (Figure 12) showed much more variation between the sites. The Milburn site had a much poorer rate of growth. Appendix B includes the figures for all the varieties under test.

Root collar diameter (R.C.D.) was also measured as part of the trial. The measurement was taken 2-4 cm above ground. The results are plotted and shown in Appendix C. Due to the close relationship between height and diameter the comments made regarding height growth also apply to R.C.D.

Figure 11, Height Growth rate of Geneva

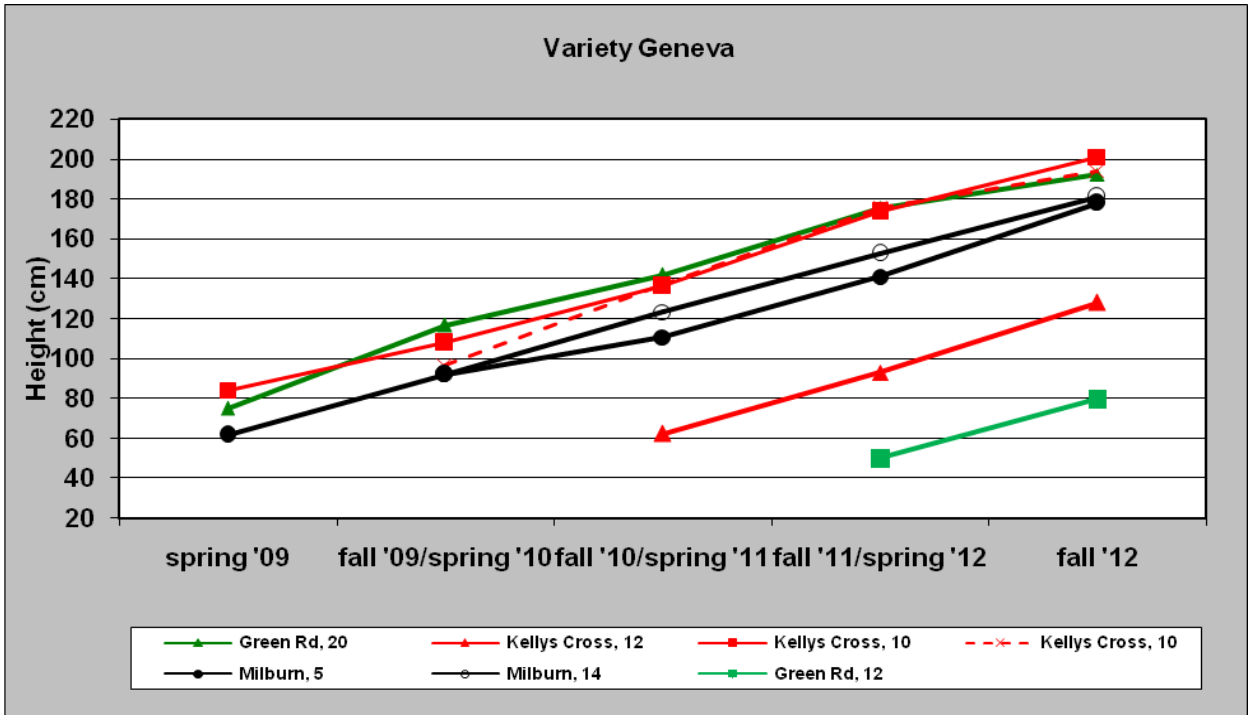
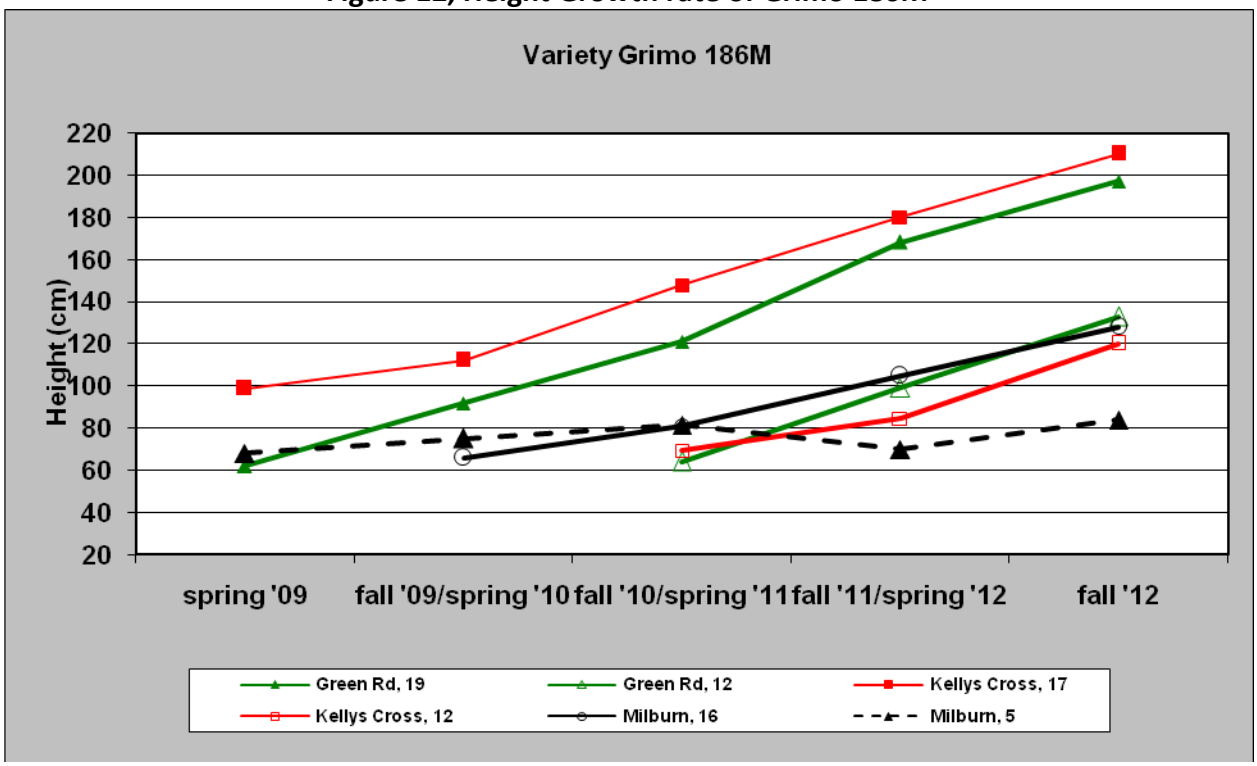


Figure 12, Height Growth rate of Grimo 186M



Problems encountered

The growing of hazelnuts to date has been relatively trouble free. Minor problems encountered have been branch and stem breakage due to heavy snow during the winter of 2010/11 particularly at the Kellys Cross site, mortality due to ants at the Green Road site and rodents at Milburn. Other problems encountered have been animals digging up plants when bone meal was used at planting, and plant die back when fertilizer was spread to close to the plant stem. Very slight damage was done to leaves by some unknown insects at all sites but the level was so low it did not appear to have had any effect.

The one exception has been the finding of blight on two varieties in 2012. Both varieties, Farris 88BS and Grimo 208D are reported to be blight resistant or immune. The plants that were found with blight had been planted in the spring of 2012 so had been exposed to the blight before arriving in P.E.I. as the blight takes a minimum of two years before the characteristic stem blisters appear (Figure 13). In total 15 Farris 88BS (out of a total of 42 plants) and two Grimo 208D plants (out of a total of 50 plants) were found to have blight.

Figure 13, Blight on Farris 88BS planted in 2012

Finding the blight on these varieties does pose the question, has the blight changed so that varieties that were believed to be resistant or immune are no longer? This question as yet does not have an answer but the implications are that close observation of the varieties in the trials should be done into the future to verify the immune/resistance status of individual varieties.

Conclusions

The results of this experiment show that most varieties planted as part of this trial are able to grow on P.E.I. under current climate conditions. There have been two exceptions, Zeta and Epsilon. However the other varieties from Oregon have grown at a similar rate to the varieties from Ontario and the north eastern United States.

The first planting was done as part of this trial in the fall of 2008 and the spring of 2009, so the oldest plants have only experienced four growing seasons. Each of these seasons has been different with respect to rainfall and temperature so they have covered much of the variability found during P.E.I. summers. Having said that, four seasons is a short period when one is looking at tree varieties. The varieties that were established early in this trial are now beginning to produce male and female reproductive structures. Catkins (male flowers) have been found on all varieties, except Zeta and nuts were observed on a number of the varieties (Table 4).

Table 4

Summary of age, catkin and nut production of varieties under test

Hazelnut varieties	# of growing seasons	has produced catkins on P.E.I.	has produced nuts on P.E.I.
Car 3, seedlings	2	Y	N
Car 12, seedlings	2	Y	N
Epsilon (OSU 669.073)	4	Y	N
Farris 88 BS	3	Y	Y
Farris G-17	4	Y	Y
Farris GTO	3	Y	N
Gamma (OSU 589.028)	4	Y	Y
Geneva (NY398)	4	Y	Y
Grimo 186M	4	Y	N
Grimo 208D	2	Y	N
Grimo 208P	4	Y	Y
Het 1	3	Y	Y
Het 3	3	Y	Y
Jefferson (OSU 703.007)	4	Y	N
Santium (OSU 509.064)	4	Y	Y
Slate (NY616)	4	Y	Y
Yamhill (OSU 542.102)	4	Y	Y
Zeta (OSU 670.095)	4	N	N

Where do we go from here?

This trial has given a very good baseline from which to examine a number of major issues that need to be addressed before the growing of hazelnuts in P.E.I. can be recommended.

The first is the question of pollen viability. Observations of the varieties under test showed that all except one produced catkins, but were the catkins hardy enough to produce viable pollen? Without a source of viable pollen no crop of nuts will be produced.

The process for examining pollen viability involves extracting the pollen from the catkins of one variety and placing it in a growth medium under controlled conditions. The pollen is then examined under a microscope every 12 hours and the number of pollen grains which have developed pollen tubes is counted and compared to the total number of pollen grains examined. It is suspected that not all the varieties in the trial will have viable pollen. If the variety is to be a crop variety, not a pollinator, the viability of its pollen is less important.

The second question is the timing of pollen release and female flower receptivity. Each variety has specific timing as to when it sheds pollen and has receptive female flowers. Observations by the authors suggest this can be spread over a four to six week period.

The third question is genetic compatibility. Hazelnut varieties will not pollinate themselves and have genetic markers, or alleles, which are expressed in the pollen and female flowers. If the pollen has the same allele as the flower then pollination does not occur (Mehlenbacher, 1997). Details are known for the Oregon varieties but this information is not available for the others. The only way compatibility can be checked is with controlled pollinations where the pollen from one clone is applied to the female flower of another while the female flower is kept in isolation from other pollen.

Since some of the varieties under test have produced a few nuts there is viable pollen, appropriate pollen release and flower timing, and genetically compatible varieties. The big question is - which varieties are involved in the successful pollination?

Once the compatible pollinators are identified, the question becomes which varieties will produce reasonable harvest in terms of volume and quality?

When the biological questions noted above have been answered, a second set of questions need to be addressed; how do you harvest the nuts, how do you prevent nut theft by rodents and birds, and the issues of handling the nuts in preparation for sale. A marketing study also may be required as the production hopefully increases. Small levels of production (less than two hectares) will probably be used for the local fresh market. Production over that

will need to have potential markets assessed. A number of locations around the world have found answers to these issues so potential solutions are available and hopefully suitable to P.E.I.

In summary, this trial has given the first critical answers regarding growing hazelnuts on P.E.I. so now the issues become much more focused as more knowledge is gained. It is the opinion of the authors that hazelnuts have shown that they do have promise on P.E.I. but further research is required to answer the remaining questions.

Slate nuts Green Road site, August 2012

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