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# Hybrid Hazelnut Production Trials
# Year 5 Yield and Performance

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**Introduction**

Early-adopter hazelnut growers in the Upper Midwest have been planting seedlings from open-pollinated crosses between American hazelnut (Corylus americana) and European hazelnut (Corylus avellana). Average yields from these early-adopter plantings are estimated at 250 lbs kernel per acre, which is not commercially viable (Fischbach et al, 2011). However, there is considerable genetic diversity within the seedling plantings and some individual genotypes have shown potential to produce economically viable yields. Our research team has been evaluating the top genotypes in replicated performance trials with the intent to release improved clonal material of the top genotypes to growers.

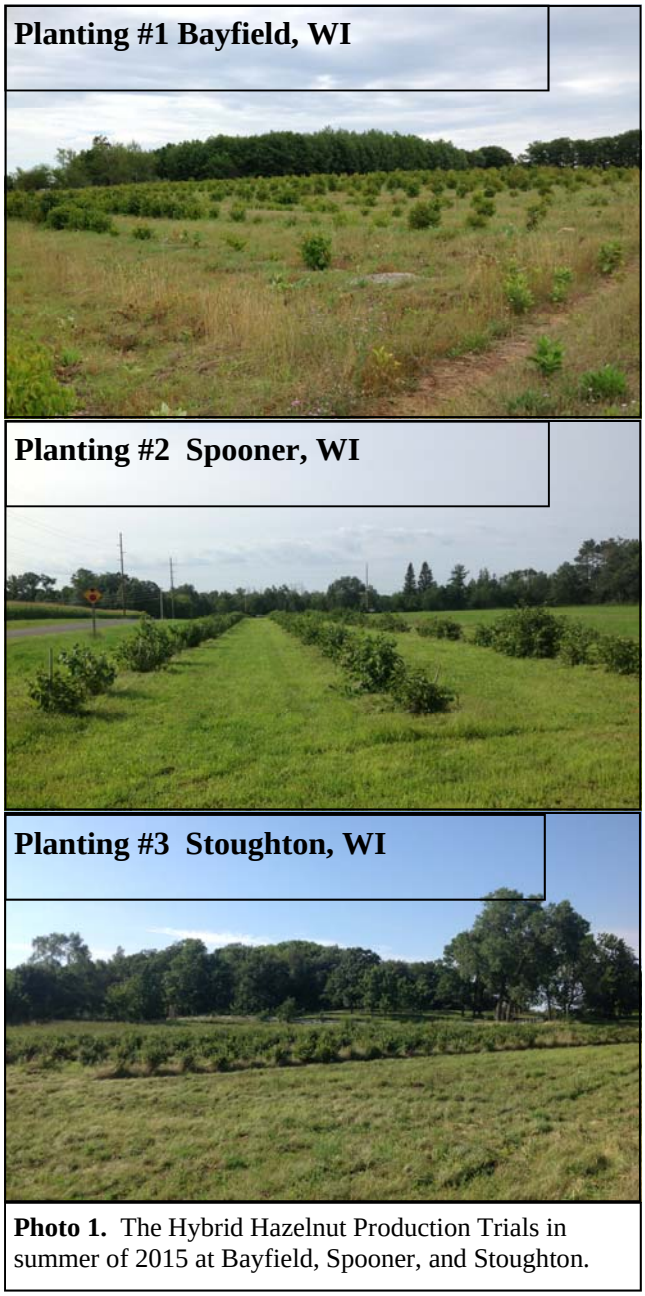


**Photo 1.** The Hybrid Hazelnut Production Trials in summer of 2015 at Bayfield, Spooner, and Stoughton.

Private breeders have been supplying hybrid hazelnut seedlings to growers for at least 20 years. Seed for this material is typically collected from the best plants, but because hazelnuts are wind-pollinated it is likely the male parent(s) for these seedlings is unknown. While growers wait for development of proven clonal material, there has been interest in using seed from controlled crosses to produce plant material as a means to maintain genetic diversity within plantings and to improve the average yields of hazelnut plantings. The viability of a full-sibling planting will depend on the performance and uniformity of the offspring of a given cross.

In 2011, in cooperation with Forest Agriculture Enterprises (Forest Ag), our team established four plantings in Wisconsin with full-sibling F1 seedlings from a controlled-cross block managed by Forest Ag. The parents for the controlled cross were selected by Forest Ag from their own mature planting, however neither parent had been evaluated in replicated performance trials. The purpose of the F1 plantings are to develop enterprise budgets, demonstrate hazelnut production practices, test agronomic practices such as the use of grow tubes (Fischbach and Tibbals, 2016), and evaluate the yield potential of F1 plantings from the Forest Ag controlled cross. Thousands of these same seedlings have been planted by private growers since these plantings were

established in 2011 and, thus, these plantings will provide valuable information as to what growers can expect as their plantings mature.

## Methods

The Wisconsin Hybrid Hazelnut Production Trials were established in the summer of 2011 at three locations in Wisconsin (Bayfield, Spooner, Stoughton) with full sibling off-spring from a controlled cross between two hybrids selected by Forest Agriculture Enterprises (Viola, WI). The plants were started from seed in a 4" 1-quart round pot in February 2011 in a greenhouse, transferred to a cold frame, and planted in June at all three locations. The seedlings were roughly 6" tall with 5-6 nodes at the time of transplanting (Photo 2).

| | Spooner | Bayfield | Stoughton |
|---|---|---|---|
| **Soil Type** | loamy sand - 368B | sand - 705C | silt loam - PnB |
| **2010 Crop** | alfalfa/orchardgrass | mixed hay | fallow |
| **2011 Site Preparation** | plow and disk | plow and disk | rototill andt 24'' subsoil |
| **Row middles** | seeded to forage grass two weeks before planting | clean tillage in 2011, grass after that | seeded to clover/grass mix after planting |
| **Mulch** | chopped grass | 4 inches of wood chips | wood chips |
| **Planting date (C. americana)** | May 19 | May 18 + 22 | May 21 |
| **Planting date (hybrids)** | June 24 and 27 | June 8 | July 10 |
| **Weed Control** | mow alleys, Poast/Round-Up within row, hand weeding | mow alleys, Poast/Round-Up within row, hand weeding | mowing, hand pulling, weed whip |
| **Tree Tubes** | 30" Vine-Gro | 30" Vine-Gro | 30" Vine-Gro |

**Table 1.** Site details for the three trial plantings.

Individual planting details are shown in Table 1. At the Bayfield location the plants were planted on June 8, 2011 and immediately mulched with 4" of woodchips in a two foot radius around the plant. A 30" Tubex Vinegro® tree tube with a 1" diameter bamboo stake was installed on each plant and left there until May of 2013 (Photo 3, top). Drip irrigation was installed and water has been supplied throughout the growing season since planting. At the Spooner location, the hybrid plants were planted on June 24, 2011 and immediately mulched with 5" of green-chop orchardgrass (Photo 3, middle). The same tree tubes were installed and weeds were controlled with hand-pulling and glyphosate applied as a spot treatment with a shielded sprayer as necessary. There has been no supplemental water. At the Stoughton location the plants were planted on July 10. Tree tubes, wood chip mulch, and drip irrigation were installed immediately after. Weeds have been controlled with mowing and weed whipping. At times weed pressure has been significant (Photo 3, bottom). At all three sites 1-0 bareroot dormant American hazelnut seedlings (*Corylus americana*) from the WI DNR were planted every fourth plant within each row in May of 2011 (Photo 3, top). Because the American hazelnut seedlings were planted when dormant, no tree tubes were used.

**Photo 2.** The 3 month old F1 hybrid seedlings (above) were transplanted from 4" pots and grown in a tree tube to protect the plants from wind, transplant shock and herbivory. The American hazelnut plants were bareroot dormant seedlings transplanted in May.

**Photo 3.** Heavy mulch and herbicides were used to control weeds at the Bayfield (top) and Spooner (middle) plantings. Mulch and periodic mowing were used at the Stoughton planting (bottom).

The Stoughton and Spooner plantings both experienced extreme drought conditions in 2013. Stoughton has had significant defoliation from Japanese beetles every year since 2013. Spooner has had some browse injury from deer. The Bayfield planting has very sandy soils with low fertility, but has not seen any herbivory or extreme drought since planting. All three sites experienced record cold temperatures during the winter of 2013/2014.

In 2014 and 2015, all plants at all three locations were visually rated for nut production on a scale of 0-5 with 0 being no nut production and 5 being exceptional nut production (Table 2). The nuts were first harvested in 2015 to determine kernel yields. At Bayfield, all plants rated 4 or 5 were individually harvested. Nuts from the 3-rated and 2-rated plants from four of the 10 rows were harvested in bulk and used to determine an average yield per 3-rated plant and average yield per 2-rated plant. No nuts were harvested from plants rated 1 or 0. At Spooner all plants rated 4 or 5 were individually harvested. Nuts from all 3-rated and 2-rated plants were harvested in bulk and used to determine an average yield per 3-rated plant and average yield per 2-rated plant. No nuts were harvested from plants rated 1 or 0. At Stoughton, all plants rated 4 or 5 were individually harvested. No nuts were harvested from plants rated 0, 1, 2, or 3.

All harvested nuts were air-dried until the husks were brittle with husks removed in a barrel husker. Total in-shell weight was measured for each plant or bulk sample. A 10 nut sub-sample from each plant or bulk sample was cracked and the kernels were weighed to determine a percent kernel. Per plant kernel yields were calculated by multiplying percent kernel by the total in-shell weight. For the bulk harvested 2s and 3s, the total kernel yield for the bulk harvest was divided by the number of 2s or 3s harvested to calculate an average yield per 2-rated or 3-rated plant. To control for plant size, total per plant kernel yields were converted to per plant kernel yields per square foot of canopy coverage by measuring the plant at its widest point and dividing the per plant kernel yield by the canopy coverage calculated as the surface area of a circle. In addition, total per plant kernel yields were extrapolated to per acre yields by multiplying the kernel yield per square foot of canopy coverage by 28,750 sq ft (2/3rds of an acre)

**Results**

Yield Ratings

At age 5 there was considerable variability among sites in the percentage of plants that had nut production beyond just a few nuts (2-5-rated plants). At Bayfield, 78% of American hazelnuts and 56% of hybrid hazelnuts produced nuts. At Stoughton, 39% of American hazelnuts and 43% of hybrid hazelnuts had nut production. Spooner had the lowest percentage of bearing plants with 36% of American hazelnuts and 15% of hybrid hazelnuts (Table 2).

The percentage of plants with high yield ratings (4-rated or 5-rated) varied across location and by plant type, as well, with nearly 30% of American hazelnuts at Bayfield rated 4 or 5, and only 3.5% of hybrid hazelnuts at Spooner rated 4 or 5 (Table 2).

Yield

Total year-5 kernel yield for both American and hybrid hazelnuts at all three sites was minimal. Total planting yields ranged from 1.7 lbs kernel for all the hybrid plants combined at Spooner to 6.0 lbs kernel for all the American hazelnut plants combined at Bayfield. Total kernel yield was not calculated at the Stoughton site as the 2-rated and 3-rated plants were not harvested. However, total yield from the 4 and 5-rated hybrid plants at Stoughton was 3.5 lbs of kernel On an extrapolated per acre basis, kernel yields ranged from 18.0 lbs per acre for American hazelnut at Bayfield to 4.4 lbs per acre for hybrid hazelnuts at Spooner.

**Discussion**

One key aspect of the economics of hazelnut production is precocity. Like other perennial crops there is

**Table 2.** Percentage of hybrid and American hazelnut plants with a 0, 1, 2, 3, 4, or 5 yield rating at age 5 (top). Total bulk kernel yields for all plants in a yield rating category at age 5 (bottom).

| Yield Rating^ | | | Stoughton | | Bayfield | | Spooner | |
|---|---|---|---|---|---|---|---|---|
| | | | C. americana* | F1 Hybrid** | C. americana* | F1 Hybrid** | C. americana* | F1 Hybrid** |
| 0 | No nuts | % of plants | 40.0% | 35.0% | 7.3% | 21.8% | 47.2% | 67.4% |
| 1 | A few nuts | % of plants | 21.1% | 21.8% | 14.6% | 21.5% | 16.7% | 17.7% |
| 2 | Some nuts, usually on one branch | % of plants | 9.5% | 19.9% | 16.7% | 20.6% | 16.7% | 9.7% |
| 3 | Nuts on multiple branches | % of plants | 15.8% | 16.5% | 31.3% | 26.6% | 8.3% | 1.7% |
| 4 | Many nuts all over shrub | % of plants | 11.6% | 6.0% | 17.7% | 6.6% | 8.3% | 2.9% |
| 5 | Exceptional yield, branches weighted down | % of plants | 2.1% | 0.8% | 12.5% | 3.0% | 2.8% | 0.6% |
| | | Total number of plants | 95 | 266 | 96 | 335 | 72 | 175 |

| Yield Rating^ | | | Stoughton | | Bayfield | | Spooner | |
|---|---|---|---|---|---|---|---|---|
| | | | C. americana* | F1 Hybrid** | C. americana* | F1 Hybrid** | C. americana* | F1 Hybrid** |
| 0 | No nuts | Kernel Yld (lbs) | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | A few nuts | Kernel Yld (lbs) | DNH | DNH | DNH | DNH | DNH | DNH |
| 2 | Some nuts, usually on one branch | Kernel Yld (lbs) | DNH | DNH | 0.2 | 0.5 | 0.2 | 0.5 |
| 3 | Nuts on multiple branches | Kernel Yld (lbs) | DNH | DNH | 0.6 | 2.6 | 0.3 | 0.2 |
| 4 | Many nuts all over shrub | Kernel Yld (lbs) | 2.6 | 2.9 | 1.4 | 1.5 | 0.8 | 0.7 |
| 5 | Exceptional yield, branches weighted down | Kernel Yld (lbs) | 0.4 | 0.6 | 1.7 | 1.4 | 0.6 | 0.3 |
| Total number of plants | | | 95 | 266 | 96 | 335 | 72 | 175 |
| Total bulk kernel yield (lbs) | | | **N/A** | **N/A** | **3.8** | **6.0** | **1.9** | **1.7** |
| Total kernel yield (lbs/acre) | | | **N/A** | **N/A** | **18.0** | **8.2** | **12.0** | **4.4** |

DNH = did not harvest

^Each plant was visually rated for yield prior to harvest, data shown are for plants categorized by yield rating

*1-0 bareroot dormant plants planted in May 2011

**3 month potted seedlings transplanted in June/July 2011

a lag time between planting and first harvest that requires a significant up front investment of cash and resources. With the low percentage of plants with significant nut production (4-rated and 5-rated plants) at age 5, these trials indicate the pre-production establishment phase for American hazelnut seedlings and seedlings from this particular hybrid cross is at least 5 years.

As with any crop, weather, weed control, and other environmental variables can have a big impact on production. Clearly Spooner suffered from drought and moderate deer browse. The Stoughton site is on fertile soils with a long growing season, but significant weed competition, drought, and Japanese beetle herbivory likely reduced yields. The Bayfield site, however, had no deer browse due to fencing, plenty of moisture due to drip irrigation, and little to no weed competition. The number of plants in production was higher at Bayfield, but total yield on a per acre basis was still only 17.9 lbs/acre for American and 8.2 lbs/acre for the hybrids.

The higher percentage of plants in production at age 5 for American hazelnut at all three sites was likely due to the plants being larger at planting and being planted while dormant in the spring. The American hazelnut plants were essentially beginning their second year when planted while the hybrid plants were only 6 month old. In addition, growers and researchers report that transplant shock for potted hazelnut seedlings planted leaf-out is significant and can even cause the plants to go dormant. Tree tubes were used on the hybrids to protect the seedlings from transplant shock and herbivory and clearly increased plant height and size in the first two years of growth, but by age 5 the tubes had little effect on plant size or year-5 nut yields (Fischbach and Tibbals, 2016).

One question the trials are attempting to answer is the degree of uniformity in the F1 hybrids. At all three sites, there is considerable variation with respect to nut production at age 5 even though plant size and form is remarkably uniform (data not shown). Most of the hybrid plants are not yet producing, but the small percentage that are may reflect genetic

**Table 3.** Average kernel size of American and hybrid hazelnut plants in 2015 at three locations.

| | Stoughton | Spooner | Bayfield |
|---|---|---|---|
| | ----------grams---------- | | |
| **C. americana** | 0.53 | 0.43 | 0.34 |
| **Hybrid** | 0.55 | 0.50 | 0.35 |
| **P-Value** | NS | NS | NS |

NS = no statistically significant difference

differences and the opportunity for improving plant performance through selection. Interestingly, the average yield for the 5-rated hybrid plants at each of the three sites was roughly 550 lbs kernel per acre, which is comparable to age 5 yields from top plants in the UMHDI Hazelnut Germplasm Trials, indicating the need to continue tracking performance of the 5-rated plants for possible evaluation in replicated performance trials.

**Table 4.** Average per plant kernel yields per square foot of canopy coverage.

| | Stoughton | Spooner | Bayfield |
|---|---|---|---|
| | ----------grams/sq ft---------- | | |
| **C. americana - 4** | 4.02a | 4.28a | 3.48a |
| **C. americana - 5** | 4.13a | 10.2b | 6.69b |
| **Hybrid - 4** | 3.34a | 5.42a | 3.94a |
| **Hybrid - 5** | 8.64b | 9.14b | 8.73b |
| **P-Value** | 0.0931 | 0.0049 | 0.0001 |

values with the same letter are not statistically different

Also of interest is the difference in performance between American hazelnut and hybrid hazelnuts. One reason for development of hybrid hazelnuts has been to combine the yield and nut size of European hazelnuts with the hardiness and disease resistance of American hazelnut. In this trial, the average weight of the kernel of 4 and 5-rated American hazelnuts was the same as the 4 and 5-rated hybrid plants at each of the three trial locations (Table 3).

The average per plant kernel yields of the 4-rated plants were similar between American and hybrid plants at each of the locations (Table 4). Interestingly, the average yields of the best American and hybrid plants (5-rated) was the same at Spooner and Bayfield, but at Stoughton the best hybrid plants had twice the average yields of the best American plants. The fact that the two parents of the hybrid cross were selected from a planting near Viola, WI, suggests the high-performing traits of the parents might only be expressed at locations similar to Viola. Despite early trends, it will be important to track the performance in future years before making conclusions as to the performance differences of the hybrid hazelnuts compared to the American hazelnuts in these trials. Likewise, it will be a few more years before conclusions can be made as to the commercial value of progeny from this particular hybrid cross.

## Literature Cited

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*The Upper Midwest Hazelnut Development Initiative is a collaboration of researchers in Wisconsin and Minnesota working with early-adopter hazelnut growers to develop an Upper Midwest hazelnut industry.*