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Hybrid Hazelnut Production Trials
Year 7 Yield and Performance

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Introduction

The Wisconsin Hybrid Hazelnut Production Trials were established in the summer of 2011 at three locations in Wisconsin (Bayfield, Spooner, Stoughton) with American hazelnut seedlings (*C. americana*) from the WI DNR and with full sibling progeny from a controlled cross between two hybrid hazelnuts selected by Forest Agriculture Enterprises (Viola, WI). The purpose of the plantings is to introduce hazelnuts to potential growers in Wisconsin, develop enterprise budgets for bush-type hazelnut production, and evaluate the performance of the plant material. A full description of the plantings and prior year results are reported by Fischbach and Tibbals (2016) and Fischbach and Zuiches (2017). This Bulletin reports on the 2017 performance at age 7.

Photo 1. WI Hazelnut Production Trial at the Spooner Agricultural Research Station in Spooner, WI

Methods

The plantings were established in 2011 with wild-type American hazelnut (*C. americana*) seedlings sourced from the WI DNR and full-sibling (F1) seedlings from a controlled cross between two select hybrid parents made by Forest Agriculture Enterprises. These same seedlings are currently being sold by Forest Agriculture Enterprises. The seed source of the *C. americana* plants is unknown. The plantings were established with 6ft in-row plant spacing and 15ft between-row spacing. Every fourth plant in a row is a C. *americana* seedling.

As in prior years, for 2017 all plants at all three locations were visually rated for nut production in mid-August on a scale of 0-5 with 0 being no nut production, 1 being at least one nut, 2 being some nuts mainly on one branch, 3 being nuts on multiple branches, 4 being nuts all over the shrub, and 5 being exceptional nut production. A visual rating of nut production is essentially a rating of cluster density, which is a good predicter of kernel yield (Demchik et al, 2014). Beginning when the nuts began to ripen in late-August, individual plants were harvested to determine kernel yield.

For all three locations (Bayfield, Stoughton, Spooner), all plants (*C.americana* and hybrid) rated 4 or 5 were individually harvested to determine the total yield of 4-rated and 5-rated plants. In addition, randomly chosen 3-rated and 2-rated plants for *C. americana* and the hybrids were harvested and used to determine an average yield per 3-rated plant and average yield per 2-rated plant. Total planting yields for the 3-rated and 2-rated plants were determined by multiplying the average 3-rated and 2-rated plant yields by the total number of 3-rated and 2-rated plants, respectively. No nuts were harvested from plants rated 0 or 1.

All harvested nuts were dried in plastic mesh onion bags in a forced-air dryer until the husks were brittle. Husks were removed with a barrel husker and aspirator. Total in-shell weight was measured for each plant and a 10 nut sub-sample from each plant 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.

Results and Discussion

<u>Nut Load Ratings</u>

Figure 1 shows the percentage of *C. americana* and hybrid plants at each of the three trial locations that produced nuts at age 5 (2015), age 6 (2016), and age 7 (2017). By age 6, more than 90% of both the *C. americana* and hybrid plants were producing at Bayfield, but it took an additional year at both the Spooner and Stoughton sites to reach 90%. At Spooner the extra year was likely due to deer browse during the establishment years. A fence was installed in the fall of 2016 and the plants responded well in 2017. The reason for the delay at Stoughton is a little less clear, but weed competition was more intense at the Stoughton location and the site is more fertile such that the plants may have stayed vegetative longer.

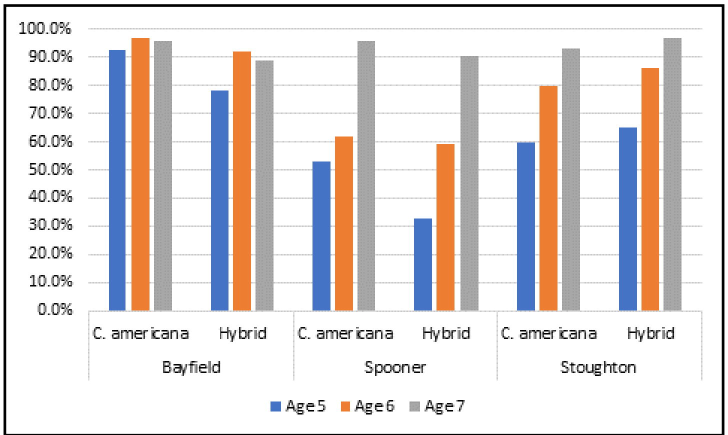

Figure 1. The percentage of *C. americana* and hybrid plants that produced nuts at age 5 (2015), age 6 (2016), and age 7 (2017) at each of the three trial locations.

Although nearly 90% of all the plants at all three locations produced nuts in 2017, not all plants produced the same volume of nuts. Figure 2 shows the percentage of plants at each location with a nut load rating of 3 or higher. As expected, as the plants age and more stems become reproductive there is more nut production. At Bayfield, roughly 65% of the *C. americana* plants have had 3-rated nut loads in each of the last three years, but the hybrids have been lower at roughly only 50%. The differences across years at the Spooner and Stoughton sites is striking with nut production up significantly in 2017. An important part of these trials is determining the economic viability of this particular F1 family and at age 7, only 50-60% of the plants at any given site are producing "good" yields. This could be a function of genetic variability or it could simply be the plants don't come into full production until age 7 or 8.

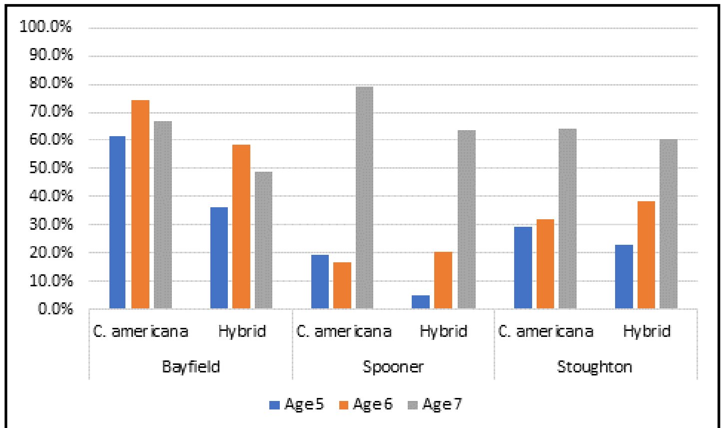

Figure 2. The percentage of *C. americana* and hybrid plants with a nut load rating of 3 or higher.

Plant Size

Table 1 shows the average height and width of the *C. americana* and hybrid plants at the three trials sites. Despite significant weed competition, the plants at Stoughton are responding to the more fertile soils and have filled the rows. The plants at Bayfield and Spooner are smaller with some space still remaining between the plants (Photo 1). Interestingly, within each location the *C. americana* and hybrid plants are basically the same size, though the *C. americana* tend to be slightly wider and shorter than the hybrids.

The hazelnut hedgerow production system proposed for the Upper Midwest includes mechanically harvesting the nuts directly from the shrubs. As such, managing plant size will be an important component of mechanical harvest. Plant size is a function of genetics, precocity (early nut production will slow vegetative growth), and location (soils and climate). At age 7, the plants are still of manageable size, but it will be interesting to see what happens to yield in the coming years as they grow into each other.

Kernel Yield and Quality

Table 1 shows the 2017 average per plant kernel yields at each of the three trial locations. Figure 3 shows the extrapolated per acre yields as calculated by multiplying the average per plant yields by the planting density (484 plants/acre). Both Stoughton and Spooner had significantly higher yields than Bayfield in 2017, but yields were still less than 150 lbs kernel/acre. For comparison, the average kernel yields of plantings at age 7 in Oregon are considerably higher at more than 300 lbs/acre (Miller et al, 2013). The reason for the low yields at Bayfield in 2017

	Bayfield		Stoughton		Spooner	
	C. americana	F1 Hybrid	C. americana	F1 Hybrid	C. americana	F1 Hybrid
average lbs kernel/plant	0.11	0.05	0.28	0.25	0.26	0.19
average width (ft)	4.9	4.2	6.3	6.0	5.0	4.9
average height (ft)	4.0	4.1	7.1	7.3	5.1	5.3

Table 1. Age 7 (2017) plant size and average per plant kernel yields for the C. americana and hybrid plants.

is not known, but may be due in part to an infestation of big bud mite that clearly damaged fruiting buds. There was no harvest in 2016 at Spooner due to a combination of deer browse and nut predation and there wasn't enough production in 2015 at Stoughton to warrant a full harvest.

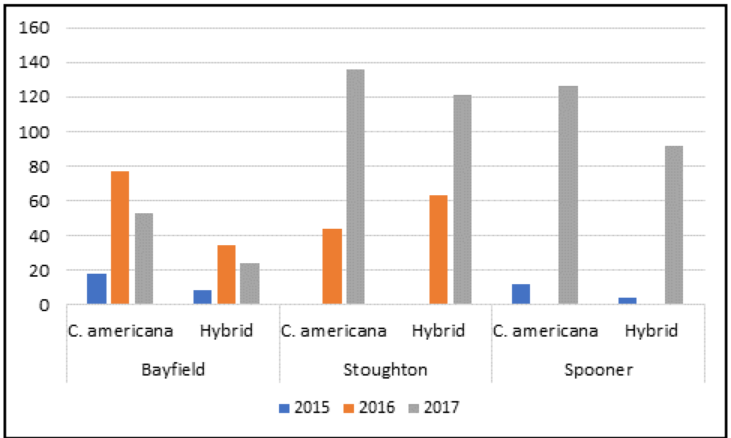

Figure 3. Extrapolated per acre yields (lbs kernel per acre) for the *C. americana* and hybrid plants in each of the last three years at each location.

At all three locations in 2017, *C. americana* tended to have higher per acre kernel yields than the hybrids. This is disconcerting as the *C. americana* are unselected wild-type hazelnuts grown from seed collected from the wild and the hybrids are from a controlled cross from two selected parents. It is hoped and expected the hybrids would perform better. The result is perhaps not surprising, however, as the *C. americana* seedlings are well adapted to the region and on average should all perform reasonably well. The hybrids on the other hand have *C. avellana* in the parentage, which is not native to our region, and as a result, a greater percentage of the offspring may not perform as well, reducing the average. Figure 2 shows this quite clearly as at all three locations a greater percentage of the *C. americana* plants had a nut load rating of 3 or higher in 2017 as compared to the hybrids.

	Bayfield	Stoughton	Spooner
C. americana	0.31	0.41	0.28
F1 Hybrid	0.36	0.51	0.33
P-Value	0.07	0.0001	0.002

Table 2. 2017 average kernel weight (grams) of *C. americana* and hybrid plants at three locations.

An equally important variable when comparing the hybrids to *C. americana* is kernel quality. One reason for producing the hybrids is to increase the kernel size of the *C. americana* by crossing it with *C. avellana*. As shown in Table 2, at all three locations the average kernel weight was larger for the hybrids compared to the *C. americana.* The average kernel size is still significantly smaller than even the smallest grades of *C. avellana*, but if selling whole kernels, the larger size of the hybrids may be important. The difference in kernel weight across location is also important as clearly the longer growing season and more fertile soils of the Stoughton site are producing larger kernels.

Seedling or Clonal Plantings?

Most perennial crop industries are based on a handful of high-performing cultivars due to their superior quality and performance. Examples include 'Honeycrisp' apples, 'Jefferson' hazelnuts, 'Patriot' blueberries, and 'Stevens' cranberries. In addition to superior product quality, plantings of a limited numbers of clonal varieties provides product uniformity, ease of management, and enhanced profitability. The big downside, though, with large-scale clonal plantings is possible catastrophic failure if pests or abiotic conditions overcome the pest resistance or adaptability of the cultivar.

Figure 3. The two main types of plants found in the F1 family being evaluated in these trials.

A "middle ground" option that has been proposed for the hazelnut industry in the Upper Midwest is to plant seedling off-spring, known as F1 families, from controlled crosses of two select parents. Such an approach would maintain more genetic diversity in a given planting, but the *average* performance of all the plants in the planting would have to be sufficient to support profitable production and the *range* in performance across the plants would also have to be manageable. For example, too much diversity in nut maturity may make mechanical harvest more challenging, too much diversity in nut shape and shell thickness may make processing more challenging, and too much diversity in kernel size or flavor may make marketing more challenging.

The maximum average annual yield for this F1 family observed thus far in these trials is 121 lbs kernel/acre. This average yield is likely to go up over time, but may not be sufficient to support profitable production with a reasonable break-even period. Furthermore, there is considerable diversity in nut production, nut maturity, nut size, and kernel characteristics within the family that pose considerable production challenges. The F1 family approach to populating hazelnut plantings in the Upper Midwest may have merit, particularly in systems in which hazelnuts are a secondary focus, such as riparian buffer plantings or silvopasture systems where hazelnuts are used for shade and a supplement to a ration. The F1 family approach would benefit from a more robust breeding program to identify the best parents for controlled crosses and by evaluation of a larger number of families.

	Kernel Yld (lbs/ac)		Ave Kernel Wt (g)	
	Hybrid	C. americana	Hybrid	C. americana
Stoughton	306	334	0.70	0.48
Spooner	210	235	0.42	0.34
Bayfield	77	106	0.40	0.40

Table 3. Extrapolated 2017 average kernel yield and average kernel weight of the top five hybrid and *C. americana* plants at each of three locations.

Another "middle-ground" approach is to establish clonal plantings using select cultivars, but include multiple cultivars. This would mitigate the genetic diversity and resiliency concerns while also providing the benefits of managing improved and proven cultivars. As such, perhaps the greater value of the F1 family being evaluated in these trials is identification and eventual propagation of the top-performing plants. Table 3 shows the average kernel yield and average kernel weight of the top five hybrid and top five *C. americana* plants so far identified at each location, based on three years of nut production data. Establishing plantings with clonal material from these top plants would results in much higher average yields. Equally important, though the kernel size is smaller than cultivars of *C. avellana,* the kernels are of high quality and would work in processing markets and for customers trained to eat smaller hazelnut kernels.

Figure 3 shows the two general plant forms in the F1 family evaluated in these trials. The top photo shows the most common type, which is very similar to *C. americana* with a wide form and involucres that fully enclose the nut. The higher producing plants of this type, such as shown in the top photo, have drooping branches in the fall, heavily laden with nuts. The bottom photo shows the less common type (roughly 8% of the plants) with a more *C. avellana* appearance with an upright form and involucres with exposed nuts. Cluster density is typically lower, but the nuts tend to be larger and with higher kernel percentages.

Conclusions

Seven years into the trials, the average yields from the F1 family being evaluated in these trials have not demonstrated a kernel yield advantage over wild type *C. americana.* However, the average kernel size of the hybrids is larger. Growers that have already established plantings of these hybrid seedlings should focus on good management to maximize yields including good early weed control, providing water, and minimizing deer browse. Though it hasn't been studied directly in these trials, nitrogen fertilization could also increase yields. The next step in these trials is to vegetatively propagate the top performing individual plants for evaluation in replicate at multiple sites.

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