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Hybrid Hazelnut Production Trials
Year 6 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 from the WI DNR and with full sibling progeny from a controlled cross between two hybrid hazelnuts selected by Forest Agriculture Enterprises (Viola, WI). A full description of these plantings and establishment methods is provided by Fischbach and Tibbals (2016). 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. The plants first started producing in 2015 at age 5. This Bulletin reports on the 2016 performance at age 6. Thousands of these full-sibling hybrid seedlings have been planted by 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

In 2016, 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 and 5 being exceptional nut production (Table 1). There is typically very little nut predation in hazelnut plantings until the nuts start to ripen in late-August and early-September. By doing a visual nut production rating we are assured of having at least one measure of relative nut production without concern of nut loss. However, a visual rating of nut production is essentially an evaluation of cluster density and because kernel yield is what matters, an actual harvest of the nuts is necessary to quantify kernel yield. Harvest begins when most of the nuts on a plant have abscised and are loose in the husk.

At Bayfield, all plants rated 4 or 5 were individually harvested between September 3 and September 9. Eighteen randomly chosen 3-rated hybrid and 16 randomly chosen 2-rated hybrid plants were harvested in bulk and used to determine an average yield per 3-rated hybrid plant and average yield per 2-rated hybrid plant. The same process was used for 11 randomly chosen 3-rated American plants and 10 randomly-chosen 2-rated American plants. No nuts were harvested from plants rated 0 or 1. At Stoughton, all plants rated 4 or 5 were individually harvested on September 1. Sixteen (16) randomly chosen 3-rated hybrid and 24 randomly chosen 2-rated hybrid plants were harvested in bulk and used to determine an average yield per 3-rated hybrid plant and average yield per 2 -rated hybrid plant. The same process was used for 3, 3-rated and 5, 2-rated American plants. No nuts were harvested from plants rated 0 or 1. At Spooner, no plants were harvested as significant nut predation occurred due to a delay in harvesting. Deer browse was also an issue at Spooner in 2016, significantly reducing yields as the August nut ratings show in Table 1.

All harvested nuts were air-dried in plastic mesh onion bags in an unheated greenhouse until the husks were brittle. Husks were removed with a barrel husker and aspirator. 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 harvested 2s or 3s to calculate an average yield per 2-rated or 3-rated plant.

Results and Discussion

Nut Load Ratings

As expected, at all three sites, more plants in 2016 produced nuts than in 2015 (Table 1). There was considerable variability among the three sites in nut load ratings with Bayfield having a higher percentage of plants with nut production compared to the Spooner and Stoughton sites. Figure 1 shows the percentage of plants at each site with a nut load rating of 3 or higher. At the Bayfield site in 2016, more than 70% of American and close to 60% of hybrid plants had nut load ratings of 3 or higher, which is significantly more than the 30% and 38% for the American and hybrid plants, respectively, at the Stoughton site. This is surprising given the richer soils and longer growing season of the Stoughton site compared to the Bayfield site. However, there was considerable weed competition at the Stoughton site and almost no weed competition at Bayfield. Both the American and hybrid plants at Spooner had low nut load rating in 2015 and 2016 due to deer browse. An electric fence was installed in November of 2016 at the Spooner site to protect the plants going forward.

Yield

Total kernel yield in year 6 for the entire Bayfield planting was 39 lbs (Table 3). With 431 total plants on 0.88 acres this equates to a per acre yield of 44.5 lbs of kernel. On a per plant basis, American hazelnut yielded slightly more than the hybrid plants with 0.16 lbs kernel per plant compared to 0.07 lbs per plant. The total kernel yield at Stoughton was 42.8 lbs (Table 3). With 359 total plants on 0.74 acres this equates to a per acre yield of 57.8 lbs kernel. On a per plant basis, the hybrids at Stoughton yielded slightly more than the American plants with 0.13 lbs of kernel per plant compared to 0.09 lbs of kernel per plant. Why the American hazelnut plants are more productive at Bayfield than Stoughton is unknown. It is possible the hybrids are not as well adapted to the sandy soils and short growing season of Bayfield as the parents of the full-sib hybrids, both of which were selected based on performance near Viola, WI. Because the American hazelnuts were planted as 1-0 bareroot dormant seedlings in 2011 while the hybrids were planted as leaf-on potted seedlings, it is possible the American hazelnuts are simply ahead developmentally compared to the hybrid plants. However, the plants are nearly the same height and the American hazelnuts are only slightly wider (Table 4). Visually, it is nearly impossible at this point to differentiate the American plants from the hybrid plants based on size.

	Bayfield		Spooner		Stoughton	
August Visual Nut Load Rating	**2016**	**2015**	**2016**	**2015**	**2016**	**2015**
0 = no nuts	3.1%	7.3%	38.0%	47.2%	20.2%	40.0%
1 = a few nuts	2.1%	14.6%	35.2%	16.7%	23.8%	21.1%
2 = some nuts, usually on one branch	20.8%	16.7%	9.9%	16.7%	23.8%	9.5%
3 = nuts on multiple branches	51.0%	31.3%	14.1%	8.3%	20.2%	15.8%
4 = many nuts all over shrub	14.6%	17.7%	1.4%	8.3%	10.7%	11.6%
5 = exceptional yield, branches weighted down	8.3%	12.5%	1.4%	2.8%	1.2%	2.1%
Total number of plants	96	96	72	72	94	95

	Bayfield		Spooner		Stoughton	
August Visual Nut Load Rating	**2016**	**2015**	**2016**	**2015**	**2016**	**2015**
0 = no nuts	8.1%	21.8%	41.0%	67.4%	14.0%	35.0%
1 = a few nuts	8.4%	21.5%	22.4%	17.7%	19.2%	21.8%
2 = some nuts, usually on one branch	25.4%	20.6%	16.4%	9.7%	28.3%	19.9%
3 = nuts on multiple branches	43.0%	26.6%	13.7%	1.7%	24.2%	16.5%
4 = many nuts all over shrub	14.3%	6.6%	2.7%	2.9%	11.3%	6.0%
5 = exceptional yield, branches weighted down	0.9%	3.0%	3.8%	0.6%	3.0%	0.8%
Total number of plants	335	335	175	175	265	266

Table 1. Age 5 (2015) and age 6 (2016) August visual nut load ratings for american hazelnuts (top) and hybrid hazelnuts (bottom) at three locations.

One of the purposes of the trial plantings is to evaluate the performance of the full-sib hybrid hazelnuts and determine whether the offspring of the particular controlled cross are capable of supporting an economically viable planting. A great number of variables will determine economic viability, but an important component is per acre annual kernel yield. Per acre yield is a product of both average per plant production and plant density. The trial plantings were established with 6' plant spacing and 15' row spacing. This equates to 484 plants per acre. At age 6, the width of the hybrid plants averaged 3.8 ft at Bayfield and 4.7 ft at Stoughton (Table 4). As such, the planting is not yet fully occupied. At this planting density, per acre kernel yields for the hybrids were only 34 lbs at Bayfield and 63 lbs at Stoughton. If the plants had been established at a higher density, such as with a 3' plant and 15' row spacing (968 plants per acre) and per plant yields were the same, the per acre yields would be 68 lbs at Bayfield and 126 at Stoughton. For perspective, average per acre Oregon kernel yields at age 6 are projected at 600 lbs of in-shell (Miller et al, 2013), which equates to 276 lbs of kernel per acre, assuming the in-shell nuts are 46% kernel by weight.

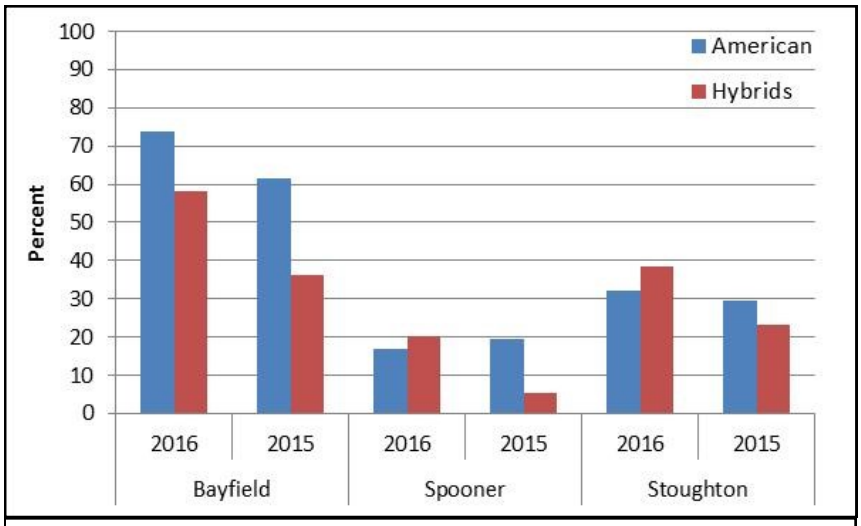

Figure 1. Percentage of plants with an August nut load rating of 3 or higher.

	Bayfield		Stoughton	
Nut Load Ratings	**C. americana**	**F1 Hybrid**	**C. americana**	**F1 Hybrid**
2 = some nuts, usually on one branch	1.8	2.8	1.8	7.9
3 = nuts on multiple branches	7.0	9.5	1.1	6.1
4 = many nuts all over shrub	3.3	11.2	3.9	16.2
5 = exceptional yield, branches weighted down	2.9	0.8	0.7	5.1
Total number of plants	96	335	84	265
Total bulk kernel yield (lbs)	**14.9**	**24.3**	**7.5**	**35.3**
Total Kernel yield (lbs/plant)	**0.16**	**0.07**	**0.09**	**0.13**

Table 3. Age 6 (2016) kernel yields for hybrid and American hazelnuts at two locations. Yields shown are the total combined yield for all plants with the same nut load rating.

	Bayfield		Stoughton	
	C. americana	**F1 Hybrid**	**C. americana**	**F1 Hybrid**
average lbs kernel/plant	0.16	0.07	0.09	0.13
average width (ft)	4.2	3.8	5.3	4.7
average height (ft)	3.7	3.8	5.6	5.5
lbs kernel per acre (6' x 15' spacing)	**77**	**34**	**44**	**63**
lbs kernel per acre (3' x 15' spacing)	**155**	**68**	**87**	**126**

Table 4. Extrapolated American and hybrid hazelnut yields at two planting densities.

It is currently unknown how yields from bush-type hazelnuts vary in response to planting density, but to maximize early per acre yields with these hybrids a higher planting density than the 484 plants/acre used in these trials will likely be necessary.

Seedling or Clonal Plantings?

Seedlings from controlled crosses are a tempting way to populate commercial plantings as propagation costs to produce the seedlings are low compared to clonal propagation. Hybrid and American hazelnuts are proving very difficult to vegetatively propagate, thus there is interest in using full-sib progeny from controlled crosses to establish commercial plantings. Generally, though, full-sibling populations for woody perennial plants are used primarily as a breeding population to find exceptional individual plants that can be clonally propagated to produce commercial plantings. Thus, the value of these trials may be in identifying individual plants that significantly out-perform all the others.

Table 5 shows the top 10 producing hybrid hazelnut plants at both Bayfield and Stoughton in 2016. The ranking is

based on yield density which is a calculated value of ounces of kernel per square foot of canopy coverage with canopy coverage being the cross sectional area of the plant at its widest diameter. The individual per plant kernel yields of the top 10 averaged 0.84 lbs at Stoughton and 0.36 lbs at Bayfield, which is significantly higher than the average of the plantings as a whole. Extrapolated yields at age 6 with a 6' x 15' density would be 406 lbs/acre at Stoughton and 174 lbs/ acre at Bayfield. There is genetic potential in the plantings to produce yields competitive with Oregon tree-based systems, particularly in areas with richer soils and a longer growing season than in Bayfield.

	Bayfield			Stoughton		
Plant	total in-shell wt (lbs)	total kernel wt (lbs)	oz kernel per sq ft	total in-shell wt (lbs)	total kernel wt (lbs)	oz kernel per sq ft
1	1.75	0.58	0.77	2.76	0.95	1.12
2	0.90	0.33	0.75	2.59	1.04	1.01
3	0.77	0.25	0.60	1.99	0.91	0.92
4	1.66	0.55	0.60	2.62	0.83	0.90
5	0.85	0.28	0.60	2.26	0.66	0.84
6	0.97	0.36	0.55	2.63	0.95	0.83
7	0.81	0.38	0.53	2.67	0.96	0.81
8	0.80	0.28	0.49	1.34	0.49	0.75
9	0.76	0.27	0.49	2.86	0.88	0.74
10	0.78	0.29	0.46	2.31	0.76	0.71
Average	**1.00**	**0.36**	**0.58**	**2.40**	**0.84**	**0.86**

Table 5. 2016 in-shell yields, kernel yields, and yield density of the top 10 performing hybrid plants at Bayfield and Stoughton. Yield density is the weight of kernels produced per square foot of canopy coverage measured as the cross sectional area of the plant's canopy at its widest diameter.

Figure 2 shows the kernels from the hybrid plants with the highest yield density at the two locations in comparison to kernels from the two parents (CR9 and GR8). Kernel size, shape, color, flavor, and fiber thickness vary. They are smaller than kernels from European hazelnut cultivars, but for processing markets size is of less importance than cost of production and quality. Figure 3 shows the kernels from the 4-ranked and 5-ranked hybrid plants with the highest individual kernel weights. There may be individual 2– or 3-rated plants in the plantings with larger kernels, but they didn't have high enough overall yields to warrant harvesting individually. There is variation among these plants with the largest individual kernels, but generally there is very little fiber and quality is high.

There is sufficiently high plant performance and adequate variability within this full-sibling population that with an additional bearing year in 2017, it will be possible to make selections of top performing plants. Because these top plants are single plant accessions it would be best to first evaluate them in replicated performance trials in multiple locations before establishing widespread clonal plantings.

Conclusion

It will take a few more production years to develop the enterprise budget and cash flow analysis necessary to fully evaluate the viability of this full-sib family and that viability will depend greatly on the context of the overall system. If the goal is to maintain hazelnut genetic diversity and utilize hazelnuts in a polycultural system with multiple and diverse revenue streams, these full sibling seedlings may prove adequate. That said, it would be worthwhile to evaluate the performance of this full sibling family in fertile soils in parts of the Upper Midwest (southern MN, southern WI, Iowa, Illinois) with a long growing season and with perfect weed control from day 1. If the goal is to build a regional hazelnut industry that is economically profitable, the most important use of these full-sibling plantings may be as a source of superior genotypes or for future plant breeding efforts.

For new plantings using these full-sibling seedlings it would be beneficial to use a 3 ft or 4 ft in-row spacing to increase early per acre yields, particularly on lower-quality sites, such as in Bayfield. However, eventually the

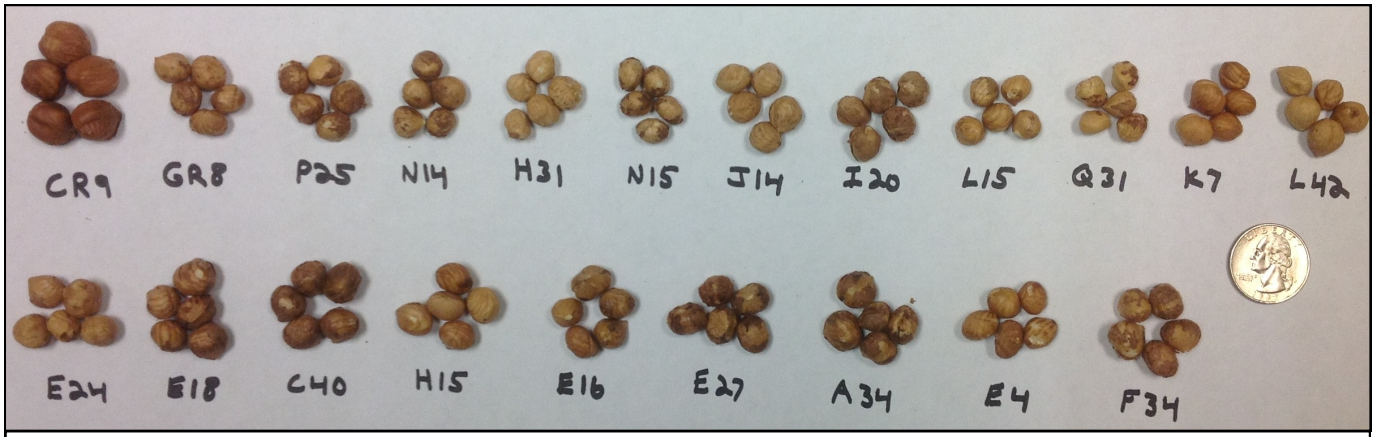

Figure 2. Kernels from the top hybrid plants at Bayfield (top) and Stoughton (bottom) compared to the two parent plants (CR9 and GR8). Top plants were selected based on yield density.

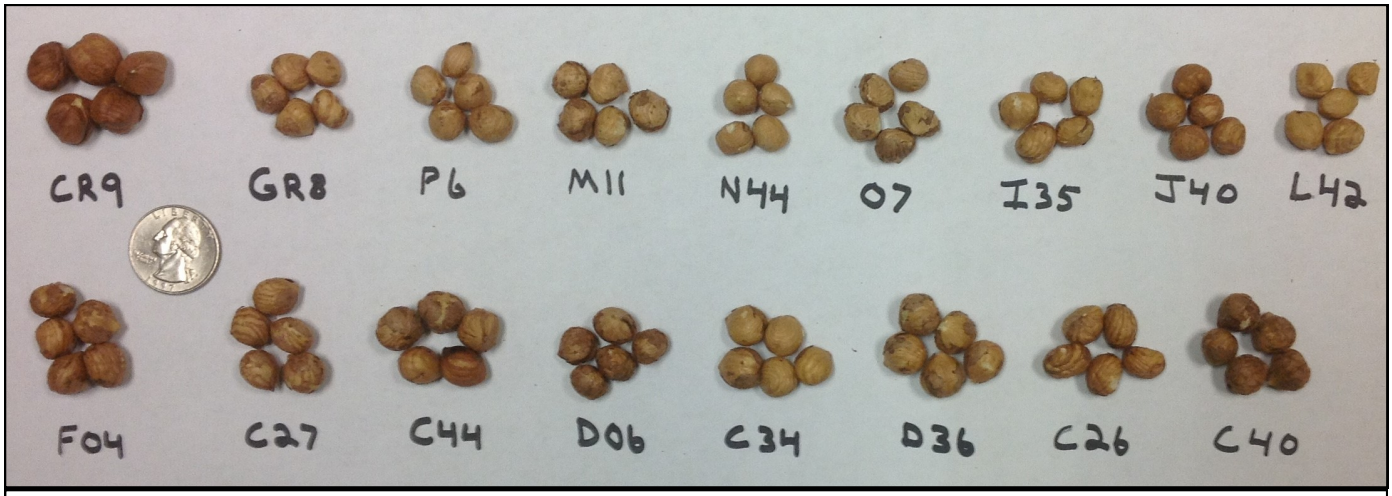

Figure 3. Kernels from the 4-ranked or 5-ranked hybrid plants at Bayfield (top) and Stoughton (bottom) with the highest individual kernel weights in 2016.

plants will fill their space and overlap with adjacent plants to create dense hedgerows. What long-term impact this will have on yields and what kind of pruning strategy will be required is currently unknown. Also, without a completed enterprise budget, the economic returns of a higher density planting with these full-siblings are unknown. In Oregon, though, the higher plant costs of double-density plantings has been shown worth the investment. (Miller, 2013). Though not preferred browse, the plants should be protected in areas with high deer populations. Also, good management of weeds and soil moisture is important as the average yield of the full-sibling material, at least through age 6, is not high enough to overcome poor agronomic management.

Literature Cited

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