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Hazelnut Production Potential in the Upper Midwest: A Report on Hybrid Hazelnut Yields

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Introduction

Commercial hazelnut production in the United States is currently limited to the Pacific Northwest and is based on cultivars of European hazelnut (*Corylus avellana*). United States production is approximately 2% of world production (USDA FAS, 2004). Turkey is the world's largest hazelnut exporter with 74% of production (USDA FAS 2004). Turkey exports approximately $1.4 billion dollars worth of hazelnuts to over 100 countries (Hazelnut and Products Exporters' Association, 2010). A growing local-food economy, interest in low-input oil crops for biodiesel, and concerns about sustainability of annual row-crop agriculture is driving an interest in hazelnut production in the Upper Midwest. Existing cultivars of European hazelnut are not suitable for production in Midwestern States due to poor winter hardiness and lethal susceptibility to Eastern Filbert Blight, a fungal disease native to the region.

Photo 1. Hybrid hazelnuts in the Midwest are grown as a multi-stemmed bush. High-yielding genotypes have the potential to support a thriving Midwest hazelnut industry.

For that reason, private breeders have been working to develop suitable hazelnut genotypes for the Upper Midwest focusing on hybrid crosses between European hazelnut and the native American hazelnut (*Corylus americana*). By crossing European with American, the hope is to develop a hazelnut shrub with the nut size and yield of the European and the cold-hardiness and disease tolerance of the American. Since the 1990s these breeders have been selling seedlings from these crosses to early adopter growers throughout the Upper Midwest. Ongoing survey work has identified 129 growers growing 65,853 plants in Iowa, Minnesota, and Wisconsin. Little is known how the hybrid plants are performing across the range of environments.

Photo 2. Existing Midwest hazelnut plantings are planted with seedlings (rather than clones), resulting in significant variability in size, form, and yield among plants in any given planting.

Because the hybrid plants are seedlings, rather than clones, there is considerable variability in yield from plant to plant due to both environmental and genetic

variability among plants. Thus, within the common environment of a planting some plants will have the genetic capability to produce more kernel than other plants. Measuring yield of the highest producing plants is important for identifying superior plant material in a planting, but measuring a random subset of plants is essential to knowing the average yield of the entire planting. This average yield is what should be used in building enterprise budgets and making business decisions. Furthermore, hazelnuts are alternate bearing. Thus, significant yield variation from year to year should be expected. To give growers some estimate of what kind of production to expect from a planting of the hybrid hazelnuts currently available, we compiled known kernel yield data from plantings in Minnesota, Wisconsin, and Nebraska.

It is important to note this Bulletin reports hybrid hazelnut yield data that may not have been collected in the same way at each of the listed plantings. At some sites, such as at the Viola and Nebraska plantings, yield was measured from randomly selected plants. At other sites, such as Montevideo, yield was measured on only those plants visually determined to have the highest yields. Despite the differences in data collection, the data presented here does provide important information as to the yield of existing plantings of hybrid hazelnuts.

Methods

Hazelnut yield data is available from seven plantings in Minnesota and Wisconsin and the Arbor Day planting in Nebraska as shown in Table 1. The data collection methods are summarized for each planting:

Photo 3. Hazelnut yields data is available from eight plantings in the Midwest. Collecting the data is essential to understanding how the existing plant material is performing across a range of environments.

Montevideo, Rosemount, Staples, Fillmore: All nut clusters were harvested from a subset of plants most years from 2004 to 2009. For the Montevideo, Rosemount and Staples plantings, which were all planted in 2000, data collection started the first year of nut-bearing, whereas for the Fillmore planting, which was three years older, data collection started in the fourth year of nut-bearing. In 2004 and 2005, bushes were harvested regardless of whether they were high yielding or not, whereas from 2006 to 2009 only the highest yielding bushes were harvested. The clusters were oven-dried at 90^{o}F and the husks were removed. The in-shell nuts were weighed, then a ten-nut subsample for each plant was cracked to determine percent kernel. Total kernel yield for each plant was calculated by multiplying total in-shell nut yield by percent kernel of the subsample. The average kernel yield for each year was calculated for the total plants sampled and the top ten highest yielding plants.

Viola, LaFarge: In 2009, all nut clusters were harvested from 100 randomly selected mature plants. Exact plant age is unknown. The clusters were oven-dried at 90^{o}F and the husks removed. The in-shell nuts were weighed and a ten-nut subsample for each plant was cracked to determine percent kernel. Total kernel yield of each plant was calculated by multiplying total in-shell nut yield by percent kernel of the subsample. The average kernel yield for all plants sampled and of the ten highest yielding plants was calculated. In 2010, the same protocol was used to determine kernel yield from 40 plants in a single randomly selected row in each planting.

Nebraska: The planting of hybrid hazelnuts at the Arbor Day Foundation in Nebraska was sampled by Elizabeth Hammond and reported in her 2005 Masters thesis (Hammond, 2006). The planting has approximately 5200 plants. Two sets of plants were measured: one set to determine average yield, and another to determine the yield potential of the best plants. For the first set (average yield) Hammond harvested all nut clusters from 162 randomly selected plants along four transects within the planting in

2002 and 2003. For the second set (yield potential), she visually identified the 54 highest yielding plants in 2002, then harvested these same plants all three years. The nuts were dried, husked, and weighed to determine total in-shell yield for each plant. A subsample was cracked to determine kernel percent, which was multiplied by in-shell yield to determine kernel yield. The average kernel yield of the ten highest producing plants was calculated for each year. Kernel percent was not measured for nuts from the 162-plant transects. For this Bulletin, the kernel yields for these plants were assumed to be 35% and 38% for 2002 and 2003, respectively, based on the average kernel yields of the 54 select plants for the same years.

Results and Discussion

Hybrid Hazelnut Kernel Yields

Kernel yields for the hybrid hazelnut plants sampled for each year at the eight sites are shown in Table 1. The average per plant yields ranged from 0.03 lbs kernel per plant to 2.58 lbs kernel per plant. The average per plant yield for all sites and all years was 0.45 lbs kernel per plant. The Montevideo and Nebraska sites had the highest average yields of the eight sites and also showed characteristics of

Table 1. Average kernel yields of hybrid hazelnuts from eight plantings in the Midwest, USA.

						Average of All Sampled Plants		Average of top ten plants		ave planting kernel yield (lbs/ac)**
Planting	Year	Plant Age	type of sampling	actual spacing (plants/ac)	# of Plants Sampled	kernel yield (lbs/plant)	kernel yield (lbs/ac)*	kernel yield (lbs/plant)	kernel yield (lbs/ac)*	
Montevideo, MN	2004	4	random	581	19	0.11	64	0.17	99	64
	2005	5	random	581	39	0.31	180	0.81	470	180
	2007	7	best	581	13	1.95	1131	2.24	1299	1133
	2008	8	best	581	47	0.88	510	1.51	876	511
	2009	9	best	581	45	1.42	824	2.36	1369	825
Rosemount, MN	2005	5	random	1742	22	0.08	46	0.13	75	139
	2006	6	best	1742	71	0.06	35	0.22	128	105
	2007	7	best	871	14	0.30	174	0.31	180	261
	2008	8	best	871	45	0.35	203	0.71	412	305
	2009	9	best	871	59	0.10	58	0.30	174	87
Staples, MN	2004	4	random	581	39	0.03	17	0.10	58	17
	2005	5	random	581	51	0.04	23	0.12	70	23
	2006	6	best	581	67	0.22	128	0.56	325	128
	2007	7	best	581	11	0.21	122	0.23	133	122
	2008	8	best	581	29	0.21	122	0.33	191	122
	2009	9	best	581	55	0.12	70	0.30	174	70
Filmore, MN	2004	7	random	581	113	0.01	4	0.04	23	4
	2005	8	random	581	142	0.06	32	0.27	157	32
Channhassen, MN	2009	6	best	697	27	0.30	175	N/A	N/A	210
	2008	5	best	697	27	0.06	37	N/A	N/A	44
Viola, WI	2009	N/A	random	1161	100	0.05	28	0.24	139	56
	2010	N/A	random	1161	40	0.04	21	0.12	70	42
LaFarge, WI	2009	N/A	random		100	0.08	47	0.44	255	
	2010	N/A	random		40	0.09	52	0.19	110	
Nebraska City, NE	2002	7	random	580	162	0.19	112	N/A	N/A	112
	2002	7	best	580	54	0.82	477	1.83	1059	477
	2003	8	random	580	162	1.00	582	N/A	N/A	582
	2003	8	best	580	54	2.58	1497	5.36	3107	1497
	2004	9	best	580	54	1.35	785	3.28	1902	785
Average of All Planting Years						**0.45**	**261**	**0.89**	**514**	**294**

* The average per plant kernel yield extrapolated to a per acre basis assuming a 5' x 15' plant spacing (580 plants/ac)

** Average kernel yield of the planting using actual plant spacing and the average kernel yield of all sampled plants for each site year

alternate year bearing. The higher yields at the Montevideo site are likely due to the fertile loam soils and excellent weed control. The higher yields at the Nebraska site may be due to a longer growing season.

Photo 3. Hybrid hazelnuts grown in the Midwest USA have potential as an oil, fresh-eating, and processed food crop.

We extrapolated the per plant yields to per acre yields by multiplying the average per plant yield for each site-year by the actual plant density of the entire planting. As shown in Table 1, the average per acre yield across all plantings was 294 lbs kernel per acre per year. Because the plant density will affect extrapolated per acre yields, we multiplied the average per plant yield for each site-year by a common plant density of 580 plants/ac (5' x 15'). At that common extrapolated density, the average kernel yield across all site-years was 261 lbs/ac. For comparison, between 2000 and 2007, average yields from European hazelnut trees in Oregon ranged from 1340 to 3040 lbs of in-shell nuts per acre (USDA, 2008). Assuming 55% kernel by weight, these yields equate to 737 and 1672 lbs kernel per acre, respectively. It is important to note that the average yields shown for the sampled plants at the Montevideo, Rosemount, and Staples site may be an over-estimation of the actual average planting yield given that the sampled plants were chosen because they were the highest yielding from the total population.

Average extrapolated kernel yields of the hazelnut plantings shown in Table 1 (580 plants/ac) ranged from 4 to 1497 lbs per acre, which is considerably less than yields of European hazelnuts in Oregon. However, this is not unexpected given that hybrid plantings are currently populated with unselected material and the Oregon plants are populated with clonal material of improved cultivars. The extrapolated average yields of the ten highest yielding plants in each planting ranged from 23 to 3107 lbs kernel per acre with an average across all plantings of 514 lbs per acre, which indicates there is the genetic capacity within the hybrid plantings to produce yields competitive with the European production.

Total yield is not necessarily the best measure of the financial feasibility of Midwest grown hazelnuts or the best criteria for comparison to existing production from European cultivars. The hedgerow system envisioned for Midwestern-grown hazelnuts may have lower costs of production compared to tree-based orchard systems used for European hazelnuts. Furthermore, the smaller average kernel size of the Midwest-grown hazelnuts may be desirable for nut cluster-type value added products or trail mixes, providing a market niche. Regardless, the yield data for existing hybrid hazelnut plantings in the Midwest reaffirms the importance of developing higher and more consistent-yielding hazelnut germplasm.

Photo 4. With excellent early management, individual genoytpes of Midwestern grown hybrid hazelnuts have demonstrated per acre yields equal to managed plantings of European hazelnuts. Improving average yields, however, will require development of more uniform and improved plant material.

Conclusion

Additional work is needed to better understand the average yields of plantings of hybrid hazelnuts. In particular, a standard protocol is needed for the yield sampling. A random selection of plants in a planting

followed by multi-year yield measurements of the same plants is likely the best method. To control for plant size (and plant age) total kernel yield for a plant should be adjusted to kernel yield per square foot of plant surface area. This can be done by measuring the widest point of each plant and dividing the total kernel yield by the planar surface area at the widest point. A per acre yield can then be calculated by assuming that half of the surface area of an acre will be occupied by hazelnuts in a hedge-row system.

At the same time, it is crucial that hybrid plantings be screened for high yielding plants, and then those plants be propagated for further evaluation in replicated performance trials at multiple locations. The range in yields currently seen in hybrid plantings from year to year and site to site will make it difficult to build a viable Midwestern hazelnut industry. Germplasm improvement is vital to the growth of the industry and it is important that existing and potential growers realize that Midwestern hazelnut production is a work in progress. In the meantime, because the yield potential of the parental plant material being sold by the hazelnut nurseries is unknown and clones of that material is not available, the yield ranges reported here should be used by growers in guiding hazelnut enterprise decisions. The yields reported here also give plant breeders and growers a benchmark for comparing yields of clonal or full-sibling plantings of next generation genotypes.

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Upper Midwest Hazelnut Development Initiative

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

Minnesota Hazelnut Foundation

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