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Setting A Yield Goal for Hazelnut Breeding in the Upper Midwest

Hazelnut Improvement Program

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Introduction

Bush-type hazelnuts have potential as a multi-use crop in the Upper Midwest providing both economic opportunities for growers and improved ecosystem services from the agricultural landscape. Private breeders in Minnesota and Wisconsin have been selling hybrid seedlings derived from interspecific crosses between European (*C. avellana*), Beaked (*C. cornuta*) and American hazelnut (*C. americana*). Survey work has identified more than 130 early-adopter growers with more than 66,000 genetically-unique plants. The current population of plants have demonstrated a wide range of yields, with an average yield that is unlikely to support a viable industry (Fischbach et al, 2011). However, it is possible some of the plants have the genetic potential to support a commercially-viable hazelnut industry in the Midwest. To find these plants, researchers with the Upper Midwest Hazelnut Development Initiative (UMHDI) have been working with the growers to screen on-farm plantings for high-performing plants for further evaluation in replicated germplasm trials.

Photo 1. Setting a yield goal for hazelnut breeding in the Upper Midwest will help determine whether yields from existing hybrid plants, such as shown here, are adequate for an economically viable industry.

As with all crops, germplasm improvement is a continuous process. To establish a new crop and concordant industry, the initial plant material must be a least sufficient to support economically-viable production. This Research Bulletin attempts to set a yield goal for ongoing plant improvement efforts in the Upper Midwest based on enterprise budgeting for the emerging industry. In other words, what is the minimum average annual in-shell yield sufficient to support commercially viable hazelnut production in the Upper Midwest? Furthermore, based on completed yield assessments, are there individual plants that have expressed the genetic capacity to meet this yield goal, such that mass selection efforts alone could provide viable cultivars?

Enterprise Budgeting

A fifteen year enterprise budget was developed to quantify cost-of-production on a per acre basis. Actual costs will vary considerably from farm-to-farm. In addition, there remain unanswered questions as to best management practices for hazelnut production such as pruning and fertilization. However, existing hazelnut systems are very similar to blueberry models with free-standing multi-stem shrubs in sod culture. For this budget, the following assumptions were made:

1. Plantings are arranged with a 15’ row spacing and 6’ plant spacing for a total plant density of 484 plants/acre. The plants will fully fill their space by year 7. Plants cost $4 each. On lower fertility sites or with poor management, it may be necessary to increase plant density to compensate for slower growth.

2. Site preparation is done in the summer prior to planting with a burn-down herbicide application, followed by ripping and a finishing disk. Doing this work in strips can reduce tillage needs, but for this analysis the

entire field is ripped and disked.

3. The micropropagated plants are planted in the fall after September 15. Drip irrigation is installed and roughly 0.7 cubic feet of wood chip mulch is applied around each plant. Although plants currently available to growers are seedlings, it is likely the industry will move to micropropagules. Ongoing research is investigating the best time for planting these micropropagules.
4. A cover crop is seeded immediately after planting in the row middles. If strip site preparation is done to leave existing vegetation intact within the row middles this step could be avoided.
5. In the spring the year after planting a pre-emergent herbicide is applied. During each growing season, grass weeds within the rows are controlled with selective grass herbicides and perennial broadleaf weeds are controlled with shielded applications of glyphosate using a backpack sprayer.
6. Row-middles are mowed as necessary to control vegetation. Cropping the row-middles is also an option, but not included in this budget.
7. Water is applied as necessary through the drip irrigation system consisting of a y-filter, 3/4" polytube header line and 1/2" feeder lines with two emitters per plant. A household well is used to supply the water. No costs for the well, pump, or electricity are included in this budget.
8. Nitrogen is applied annually with strip-applied coated-urea at 15 lbs/ac in years 1-3, 30 lbs/ac in years 4 -6, and 60 lbs/ac annually starting in year 7. Potassium and phosphorus are adequate and no additional nutrients are applied. All new plantings should be soil tested prior to planting and potassium and phosphorus adjusted as necessary.
9. There is a 5% mortality rate in the year of planting and the plants are replaced in year 2.
10. Another .7 cubic feet of wood mulch is applied in the third growing season.
11. All equipment use is compensated on an hourly basis to cover all ownership and maintenance of the equipment.
12. The plants begin yielding in the 4th year and reach full production in year 7. Fourth, fifth, and sixth year nut yields are 25, 50, and 75% of the mature plant yields, respectively.
13. Fifty percent (50%) of all plants produce nuts in year 4, 75% in year 5, and in year 6 and each year after, 90% of the plants have nuts each year.
14. There is alternate year bearing starting in year 7 with every even year having average yields 20% less than in odd years.
15. The plants are harvested by hand and it takes 3 minutes per plant in year 4, 4 minutes per plant in years 5 and 6, and 5 minutes per plant starting in year 7. Mechanical harvest will likely be possible in the future with improvement in harvest technology and plant form.
16. Renewal pruning begins in year 8 with a goal of removing 1 or 2 of the oldest canes per plant per year. It takes 3 minutes per plant. Research on renewal pruning is just beginning and no formal recommendations have yet been developed.
17. Drying is done in wooden pallet crates with periodic turning of the nut clusters to promote rapid drying. Husking is done at a cost of $1/lb. The cost of the crates and labor for drying is included in the $1/lb husking cost.
18. General manual labor for planting, application of wood chips, renewal pruning, and harvest is hired at $12/hr (wage, taxes, insurance).
19. Custom tillage and field spraying (tractor, implement, operator) is hired at $100/hr.
20. Herbicide application is custom hired at $35/hr to cover the cost of operator, personal protective equipment, and sprayer depreciation. Row-middle mowing is custom hired at $35/hr to cover the cost of operator, mower fuel and maintenance, and mower depreciation.
21. No insecticides are applied, however, it is likely Japanese beetle, big bud mite, and nut weevils will require control via an integrated pest management strategy. EFB is managed with plant resistance.
22. The project is self-financed with no interest costs.
23. The final product sold in this model is in-shell nuts. There may be revenue opportunities from husk material, but no revenue is shown in this analysis.

Appendix 1 shows the input costs over a 15-year period for one acre of hazelnuts given the assumptions above.

Determining a Yield Goal

To determine a yield goal it is first necessary to identify a target economic return. In this analysis, returns for a blueberry planting or corn/soybean rotation are used. A commercial blueberry operation can be expected to provide a cumulative net return to management at year 15 of $20,000 with break even at year 7

(Julian et al, 2011). This is equivalent to an annual return to management of $1333/acre. A conventional corn and soybean rotation can be expected to provide an annual return to management of $187/acre (Johanns et al, 2012). If this return to management is compounded annually at 3%, at 15 years the cumulative return to management would be $3478/acre or $231.86/yr. This would include breaking even at year 12. The blueberry model will be referred to as the "High Return" model and corn/soy model as "Low Return" model.

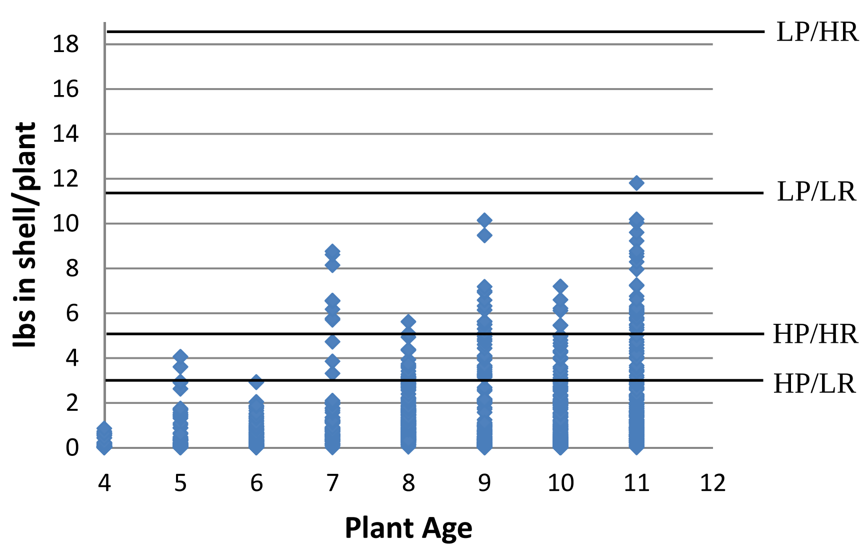

Figure 1. Minimum yield thresholds (horizontal lines) necessary for each of the four target economic scenarios in comparison to actual per plant yields from four sites in the Upper Midwest.. LP=Low Price ($1.50/lb); HP=High Price ($3.00/lb); LR=Low Return (corn/soy model); HR=High Return (blueberry model)

Determining a yield goal also requires identification of target prices for in-shell nuts. In this analysis, $1.50/lb will be used as the in-shell wholesale price based on USDA-ERS data ("Low Price"). It is likely a hazelnut industry in the Upper Midwest will organize grower-owned processing enterprises to add value to harvested nuts in order to pay growers more. For this analysis, $3.00/lb will be used for the grower processing price and termed: "High Price".

Using the costs-of-production shown in Appendix 1, the plant yields necessary to achieve the target returns for each of the two prices were calculated. To provide returns comparable to a corn/soy rotation ($3478/ac cumulative net income at year 15), minimum in-shell nut yields must be 3 lbs/plant at $3/lb and 11.25 lbs/plant at $1.50/lb. To provide returns comparable to blueberries ($20,000/ac cumulative net income at year 15), minimum in-shell nut yields must be 5 lbs/plant at $3.00/lb and 18.75 lbs/plant at $1.50/lb.

Assessing the Potential of Hybrid Hazelnuts

Current hazelnut breeding efforts of the UMHDI are focused on identification of select individuals from on-farm populations of inter-specific hybrids and from wild populations of American hazelnut (*Corylus americana*). Although selections have been made from the wild populations, the plants are currently being propagated for evaluation in field trials. As such, yield performance data won't be available for a number of years. However, there is considerable data available as to the performance of hybrid plants.

Dr. Lois Braun from the University of Minnesota has been measuring individual hybrid plant yields at four plantings in Minnesota and Wisconsin since 2004. Figure 1 shows the individual plant yields sorted by plant age at the time of yield measurement. In-shell yield was calculated by multiplying the kernel yield by three, assuming kernel yield is 1/3 total in-shell yield by weight. Yields are not adjusted by plant size. The figure contains 1098 individual yield measurements from 390 unique plants across the four sites. Figure 1 shows that within the current hybrid populations individual plants have produced yields above the target economic thresholds for both the Low and High Return scenarios if prices for in-shell nuts are $3.00/lb or more. Only one plant produced a yield sufficient for either target return with an in-shell price of $1.50/lb. This suggests that selections from these populations at least have the capacity to produce yields sufficient for a viable hazelnut industry in the Upper Midwest.

The yield capacity of a plant, however, is only one of the characteristics necessary for a viable cultivar. Consistent yields from year-to-year, and consistent yields across locations are equally important, as well as disease resistance and high kernel quality. Figure 2 shows the ten highest individual plant yields at each of the four sites sorted by plant age. The figure suggests that environment strongly influences yield, such that only 1 of the 4 sites had plant yields in excess of the HP/HR threshold. Thus, in some locations existing hybrid genetics may not support viable hazelnut production. That said, it is unclear what the limiting factors (e.g. weed control, soil fertility, deer browse) are at Sites 1, 2 and 4. Overcoming these limitations through agronomic practices may improve the yields and economic viability.

To better understand the yield potential of the hybrid genetics, the top plants from each of the plantings have been propagated and are currently being evaluated in replicated germplasm trials at five locations. The trials were established in 2010 and performance data will be collected from each plant for at least 4 years.

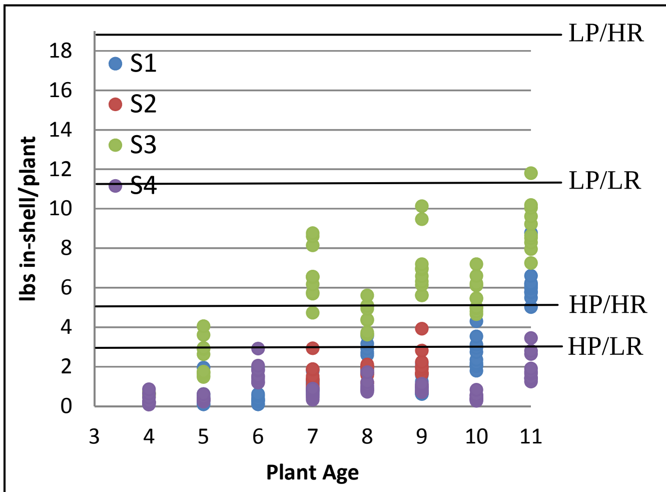

Figure 2. Minimum yield thresholds (horizontal lines) necessary for each of the four target economic scenarios in comparison to the ten highest individual plant yields sorted by plant age at each of four sites in the Upper Midwest. LP=Low Price ($1.50/lb); HP=High Price ($3.00/lb); LR=Low Return (corn/soy model); HR=High Return (blueberry model)

Conclusion

Hazelnut production in the Upper Midwest using bush-type plants has considerable economic potential, but will certainly require improved germplasm and, likely, business models that can pay growers $3.00/lb or more for in-shell nuts. When grown on higher fertility sites, the existing hybrid germplasm has demonstrated the potential to provide adequate yields. The next step is to identify individual plants that can sustain such yields from year-to-year and across a range of locations and that have durable resistance to eastern filbert blight. On lower quality sites, where current genetics may be economically marginal, proper management will be crucial to maximize yields. The germplasm trials underway in Minnesota and Wisconsin will provide a much more robust understanding of the suitability of the existing hybrid germplasm currently being grown by producers in the Upper Midwest.

Literature Cited

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Appendix 1. Enterprise Budgets for Bush-Type Hazelnuts in the Upper Midwest for Four Production Scenarios (Years 1-15)

Table 1. High Price/Low Return* Enterprise Budget - 3 lbs/plant

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Revenue	$ -	$ -	$ -	$ -	$1,088	$1,631	$2,936	$3,915	$3,132	$3,915	$3,132	$3,915	$3,132	$3,915	$3,132	$3,915
Expenses																
Land - Rented ($/ac/yr)	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80
Plants	$ -	$ 1,936	$ 97	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Drip Irrigation	$ -	$ 615	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Fertilizer	$ 30	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15
Herbicide	$ -	$ 115	$ -	$ 76	$ -	$ -	$ -	$ 76	$ -	$ -	$ -	$ 76	$ -	$ -	$ -	$ -
Wood chip mulch	$ -	$ 338	$ -	$ 338	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Tillage	$ 300															
Weed control	$ 150	$ 210	$ 210	$ 210	$ 210	$ 210	$ 210	$ 210	$ 210	$ 210	$ 210	$ 210	$ 210	$ 210	$ 210	$ 210
Cover crop seeding	$ 100															
Mowing		$ 280	$ 280	$ 280	$ 280	$ 280	$ 280	$ 280	$ 280	$ 280	$ 280	$ 280	$ 280	$ 280	$ 280	$ 280
General labor	$ -	$ 576	$ 264	$ 192	$ 48	$ 48	$ 48	$ 48	$ 348	$ 348	$ 348	$ 348	$ 348	$ 348	$ 348	$ 348
Harvest Labor				$ -	$ 145	$ 290	$ 348	$ 435	$ 435	$ 435	$ 435	$ 435	$ 435	$ 435	$ 435	$ 435
Drying and Husking				$ -	$ 181	$ 544	$ 979	$ 979	$1,044	$1,305	$1,044	$1,305	$1,044	$1,305	$1,044	$1,305
Total Expenses	$ 660	$ 4,165	$ 946	$ 1,191	$ 959	$1,467	$1,960	$2,123	$2,412	$2,673	$2,412	$2,749	$2,412	$2,673	$2,412	$2,673
Net Income	$ (660)	$(4,165)	$ (946)	$(1,191)	$ 128	$ 165	$ 977	$1,792	$ 720	$1,242	$ 720	$1,166	$ 720	$1,242	$ 720	$1,242

* High Price = $3.00/lb for in-shell nuts, Low Return = $3,872 per acre cumulative net income at year 15

Table 2. High Price/High Return* Enterprise Budget - 5 lbs/plant

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Revenue	$ -	$ -	$ -	$ -	$1,813	$2,719	$4,894	$6,525	$5,220	$6,525	$5,220	$6,525	$5,220	$6,525	$5,220	$6,525
Expenses																
Land - Rented ($/ac/yr)	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80
Plants	$ -	$ 1,936	$ 97	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Drip Irrigation	$ -	$ 615	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Fertilizer	$ 30	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15
Herbicide	$ -	$ 115	$ -	$ 76	$ -	$ -	$ -	$ 76	$ -	$ -	$ -	$ 76	$ -	$ -	$ -	$ -
Wood chip mulch	$ -	$ 338	$ -	$ 338	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Tillage	$ 300															
Weed control	$ 150	$ 210	$ 210	$ 210	$ 210	$ 210	$ 210	$ 210	$ 210	$ 210	$ 210	$ 210	$ 210	$ 210	$ 210	$ 210
Cover crop seeding	$ 100															
Mowing		$ 280	$ 280	$ 280	$ 280	$ 280	$ 280	$ 280	$ 280	$ 280	$ 280	$ 280	$ 280	$ 280	$ 280	$ 280
General labor	$ -	$ 576	$ 264	$ 192	$ 48	$ 48	$ 48	$ 48	$ 348	$ 348	$ 348	$ 348	$ 348	$ 348	$ 348	$ 348
Harvest Labor				$ -	$ 145	$ 290	$ 348	$ 435	$ 435	$ 435	$ 435	$ 435	$ 435	$ 435	$ 435	$ 435
Drying and Husking				$ -	$ 302	$ 906	$1,631	$1,631	$1,740	$2,175	$1,740	$2,175	$1,740	$2,175	$1,740	$2,175
Total Expenses	$ 660	$ 4,165	$ 946	$ 1,191	$1,080	$1,829	$2,612	$2,775	$3,108	$3,543	$3,108	$3,619	$3,108	$3,543	$3,108	$3,543
Net Income	$ (660)	$(4,165)	$ (946)	$(1,191)	$ 732	$ 890	$2,282	$3,750	$2,112	$2,982	$2,112	$2,906	$2,112	$2,982	$2,112	$2,982

* High Price = $3.00/lb for in-shell nuts, High Return = $20,991 per acre cumulative net income at year 15

Table 3. Low Price/Low Return* Enterprise Budget - 11.25 lbs/plant

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Total Revenue	$ -	$ -	$ -	$ -	$2,039	$3,059	$5,505	$7,341	$5,873	$7,341	$5,873	$7,341	$5,873	$7,341	$5,873	$7,341
Expenses																
Land - Rented ($/ac/yr)	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80
Plants	$ -	$ 1,936	$ 97	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Drip Irrigation	$ -	$ 615	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Fertilizer	$ 30	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15
Herbicide	$ -	$ 115	$ -	$ 76	$ -	$ -	$ -	$ 76	$ -	$ -	$ -	$ 76	$ -	$ -	$ -	$ -
Wood chip mulch	$ -	$ 338	$ -	$ 338	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Tillage	$ 300															
Weed control	$ 150	$ 210	$ 210	$ 210	$ 210	$ 210	$ 210	$ 210	$ 210	$ 210	$ 210	$ 210	$ 210	$ 210	$ 210	$ 210
Cover crop seeding	$ 100															
Mowing		$ 280	$ 280	$ 280	$ 280	$ 280	$ 280	$ 280	$ 280	$ 280	$ 280	$ 280	$ 280	$ 280	$ 280	$ 280
General labor	$ -	$ 576	$ 264	$ 192	$ 48	$ 48	$ 48	$ 48	$ 348	$ 348	$ 348	$ 348	$ 348	$ 348	$ 348	$ 348
Harvest Labor				$ -	$ 145	$ 290	$ 348	$ 435	$ 435	$ 435	$ 435	$ 435	$ 435	$ 435	$ 435	$ 435
Drying and Husking				$ -	$ 680	$2,039	$3,670	$3,670	$3,915	$4,894	$3,915	$4,894	$3,915	$4,894	$3,915	$4,894
Total Expenses	$ 660	$ 4,165	$ 946	$ 1,191	$1,458	$2,962	$4,651	$4,814	$5,283	$6,262	$5,283	$6,338	$5,283	$6,262	$5,283	$6,262
Net Income	$ (660)	$(4,165)	$ (946)	$(1,191)	$ 581	$ 97	$ 854	$2,526	$ 590	$1,079	$ 590	$1,003	$ 590	$1,079	$ 590	$1,079

* Low Price = $1.50/lb for in-shell nuts, Low Return = $3,694 per acre cumulative net income at year 15

Table 4. Low Price/High Return* Enterprise Budget - 18.75 lbs/plant

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Total Revenue	$ -	$ -	$ -	$ -	$3,398	$5,098	$9,176	$ 12,234	$9,788	$ 12,234	$9,788	$ 12,234	$9,788	$ 12,234	$9,788	$ 12,234
Expenses																
Land - Rented ($/ac/yr)	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80
Plants	$ -	$ 1,936	$ 97	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Drip Irrigation	$ -	$ 615	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Fertilizer	$ 30	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15
Herbicide	$ -	$ 115	$ -	$ 76	$ -	$ -	$ -	$ 76	$ -	$ -	$ -	$ 76	$ -	$ -	$ -	$ -
Wood chip mulch	$ -	$ 338	$ -	$ 338	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Tillage	$ 300															
Weed control	$ 150	$ 210	$ 210	$ 210	$ 210	$ 210	$ 210	$ 210	$ 210	$ 210	$ 210	$ 210	$ 210	$ 210	$ 210	$ 210
Cover crop seeding	$ 100															
Mowing		$ 280	$ 280	$ 280	$ 280	$ 280	$ 280	$ 280	$ 280	$ 280	$ 280	$ 280	$ 280	$ 280	$ 280	$ 280
General labor	$ -	$ 576	$ 264	$ 192	$ 48	$ 48	$ 48	$ 48	$ 348	$ 348	$ 348	$ 348	$ 348	$ 348	$ 348	$ 348
Harvest Labor				$ -	$ 145	$ 290	$ 348	$ 435	$ 435	$ 435	$ 435	$ 435	$ 435	$ 435	$ 435	$ 435
Drying and Husking				$ -	$1,133	$3,398	$6,117	$ 6,117	$6,525	$ 8,156	$6,525	$ 8,156	$6,525	$ 8,156	$6,525	$ 8,156
Total Expenses	$ 660	$ 4,165	$ 946	$ 1,191	$1,911	$4,321	$7,098	$ 7,261	$7,893	$ 9,524	$7,893	$ 9,600	$7,893	$ 9,524	$7,893	$ 9,524
Net Income	$ (660)	$(4,165)	$ (946)	$(1,191)	$1,488	$ 776	$2,078	$ 4,973	$1,895	$ 2,710	$1,895	$ 2,634	$1,895	$ 2,710	$1,895	$ 2,710

* Low Price = $1.50/lb for in-shell nuts, High Return = $20,695 per acre cumulative net income at year 15