Introduction

Soil fertility is a critical determinant of agricultural productivity in Oregon and around the world. To maintain crop productivity, virtually all agricultural production depends on the regular application of some type of fertilizer to the soil. Research by the OSU College of Agricultural Sciences is aimed at maintaining farmers' ability to use commercial fertilizers at levels necessary to optimize output while also minimizing environmental risks. At least ten percent of the Oregon economy could be affected by the results of this research.

Nitrogen in most commercial fertilizers is quite volatile and leachable, making it easily lost to the air or water if it is not quickly incorporated into the soil (through cultivation, irrigation, or both) and used by crops. Farmers face a difficult question: “How can I maximize production by using fertilizers and at the same time minimize the number of applications of fertilizer and control my management costs and, thereby, remain competitive?"

One answer to this question involves applying high quantities of fertilizer, but less frequently. Although such an approach increases the cost of fertilizer, that additional cost can be more than offset because management costs are reduced. When this approach is utilized, however, there is increased risk of nitrogen loss and contamination of air and watersheds. Environmental impacts such as the algae blooms in the Gulf of Mexico “dead zone” extending out from the Mississippi River Delta are attributable to losses of nitrogen-based fertilizers from crops in the Mississippi watershed. In the Pacific Northwest, smog and elevated nitrogen levels in the Columbia River gorge are caused in part by fertilizers.

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1 Gwil Evans edited this report and provided many useful ideas that increased the report’s clarity. Numerous scientists gave freely of their time for interviews and offered helpful suggestions. In particular, Don Horneck, Extension Agronomist and Associate Professor of Agronomy at the Hermiston Agricultural Research and Extension Center, was an important contributor.
Although regulation and monitoring have increased in the United States, the European Union (EU) has adopted far stricter controls. Farmers in the United States express concern that greater restrictions on fertilizer use in the future may significantly limit the levels of agricultural output they can achieve. For example, if nitrogen regulations paralleling those in the EU were implemented in the United States, agricultural output could be reduced by approximately 25 percent. (The relationship between nitrogen applied and crop yield is not linear. For example, a 50 percent reduction in nitrogen would have approximately a 25 percent impact on crop yields in the Columbia Basin.²)

Controlled-release fertilizer offers an alternative answer to the farmer’s question about strategies for fertilizer use. Using controlled-release fertilizer, a farmer can apply just the amount of fertilizer the plant needs, knowing the fertilizer will be released as necessary, and with confidence that little of the fertilizer will be lost to the environment. OSU agricultural scientists are studying ways to make these controlled-release fertilizers more effective with a number of different crops.

This summary provides:
(1) **Background** both about the fertilizer industry and about Oregon State University’s research in support of controlled-release fertilizer;
(2) An **overview of the markets** to which most of the research discoveries contribute;
(3) An **economic estimate** of the current and potential value of the research to the agricultural industry and the rest of the Oregon economy;
(4) **Examples of benefits beyond the market** that are provided by the research; and
(5) A few **options to consider** that could enhance the economic effects of the controlled-release fertilizer research.

**Background**

Fertilizers from animals, plant wastes, and nitrogen-fixing crops have been utilized for thousands of years. The first mixed chemical fertilizers were sold commercially in the United States in 1849.³ After the Second World War, manufacturing plants that had been supplying nitrogen as a component necessary for bombs and other explosives converted to peacetime production and provided a ready supply of ammonia-based (nitrogen) fertilizers.⁴

The U.S. food supply is highly dependent on fertilizers. Disruptions in the supply of fertilizers or their use could at some point jeopardize U.S. food security. “Because natural gas is such an important feedstock for producing ammonia, low-cost natural gas

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² Discussion with Don Horneck, Nov. 5, 2010.
⁴ Wessels Living History Farm. Postwar Fertilizer Explodes: Farming in the 1940’s.York, Nebraska. [http://www.livinghistoryfarm.org/farminginthe40s/crops_04.html](http://www.livinghistoryfarm.org/farminginthe40s/crops_04.html)
provides a powerful economic advantage for ammonia production.” The cost of natural gas in the United States is comparatively quite high, however, and the proportion of the U.S. nitrogen fertilizer supply that is imported increased from 35 percent in 1997 to more than 70 percent in 2007. More efficient use of nitrogen fertilizers can keep Oregon agriculture competitive, reduce the environmental effects of fertilizer leaching into air and watersheds, and improve food security.

Scientists at the OSU Hermiston Agricultural Research and Extension Center (HAREC) began a study five years ago to determine the effectiveness of different types of controlled-release fertilizers on crops like wheat, grass seed, and potatoes. They have succeeded in testing two types of proprietary controlled-release fertilizers that have shown promising results: 1) a polymer-coated pellet and 2) a pellet that has a urease inhibitor that chemically slows the release of nitrogen to the atmosphere and soil. The urease-inhibitor fertilizer prevented nitrogen losses of 70 percent in wheat trials and 30 percent in grass seed trials during the 2010 season. Avoiding these losses means less fertilizer is applied while still allowing farmers to maximize production, reducing the number of applications of fertilizer, while also reducing concerns about losses of nitrogen to the air and water.

**Overview of the markets**

Fertilizer, especially nitrogen, is essential to agricultural production and profitability in Oregon. It is difficult to avoid speculating as to the number of crops and the share of their production that could be dependent on the successful outcomes of this research. We chose a conservative approach. While the research could affect every conventionally produced crop in Oregon, we discuss here just two crops—wheat and grass seed—on which scientists have successfully tested and shown measurable results in reducing both operating (or business) costs and environmental costs.

In 2009, **wheat** was the fourth largest Oregon commodity in sales at $260,152,000. The per-bushel price in 2009 averaged $5.39, a relatively low annual average price. In 2010, wheat probably was probably third in the state’s total sales (after cattle and dairy products). The combined 2009 sales of Oregon **annual and perennial rye grass seed** was $122,848,151, making it the eighth highest value crop in Oregon for 2009.

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6 Ibid.
**Economic estimate**

There are two types of economic effects that could result from the OSU research on controlled-release fertilizer and a third modest effect that comes directly from the research spending:

**Economic effect A: Maintaining crop output**

*The value of crop production and related economic effects in the Oregon economy that can be maintained if the use of nitrogen-based fertilizers is reduced to due regulatory constraints.*

If controlled-release fertilizers can be developed that satisfy regulatory requirements and improve the efficiency of fertilizer application, the loss of 25 percent of wheat and grass seed production that may be caused by increased regulatory controls can be avoided. These results would retain output of about $65 million in wheat sales and more than $30 million in rye grass seed sales.

**Economic effect B: Decreasing costs and increased profitability**

*Decreased costs of production and, for a period of time, increased profitability.*

Because controlled-release fertilizer may be applied less frequently and because nitrogen is released only when needed (with much lower environmental losses), there is a significant reduction both in producers’ costs to apply the fertilizer and in total cost of fertilizer purchased. Using OSU enterprise budgets\(^8\) we can estimate the benefits of this more efficient use of fertilizer: Net revenue to the producer could increase by $10 per acre of wheat and $20 per acre of rye grass. When these per-acre increases are multiplied times the acreage that could be affected, the total effects for wheat could be more than $4.5 million and for rye grass could be more than $2.25 million.

Use of controlled-release fertilizer thus will increase net revenue to the producer. In turn, how the producer spends those dollars would result in a higher local spending multiplier than do the producer’s current fertilizer expenditures that typically go to out-of-state or out-of-country firms.

Eventually, we would expect the controlled-release technology to be widely adopted by the competitors of Oregon’s farmers and, therefore, in a perfectly competitive market, the price would decline and significantly reduce the income or induced effects. Still, that will probably take a decade and will help the industry bridge the gap between a more

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\(^8\) OSU faculty members and agricultural producers work together to develop and update enterprise budgets for the different types of crop and livestock operations in Oregon - [http://arec.oregonstate.edu/oaeb/](http://arec.oregonstate.edu/oaeb/). An enterprise budget describes the type of crop or livestock being produced, size of the operation, and management practices. It suggests a reasonable level of output and price that may be realized to calculate gross revenue. It provides the typical inputs (e.g. land, labor, supplies and equipment) necessary to produce the crop or raise the livestock and estimates the costs of those inputs. Finally, the estimated costs are subtracted from the projected revenue to determine the net revenue or profit.
restricted environment for the use of inorganic fertilizers and alternatives to inorganic fertilizers like the intercropping techniques that are also being studied by OSU scientists. At a minimum, adoption and use of controlled-release fertilizer will keep Oregon farmers competitive and possibly help them realize a decade of increased profits.

**Economic effect C: Expenditures from research grants and contracts**

*Expenditures from outside Oregon to fund research on controlled-release fertilizers.*

A smaller though important economic effect is based on the recognition OSU scientists have received with this research and the research funding that is awarded from outside the state and spent primarily within the state. This is the third type of economic effect and includes $70,000 for salaries, supplies, and equipment.

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**Results from input-output modeling: Understanding the tables**

Measuring the responding effects of these three types of effects can be done using an input-output model (IMPLAN) and "shocking" the model with the production, income, and research spending effects that are affected by OSU’s fertilizer research program. Results of the input-output modeling are shown in the following three tables.

- Table 1 displays the **production effects** (expected to persist over time).
- Table 2 shows **income and research expenditure effects** (expected to be more variable).
- Table 3 shows **total long-term and short-term effects**.

Each table includes **direct effects** or the first-round spending when the crops are sold (Effect A, above) or the research is conducted (Effect C, above); **indirect effects** or spending with suppliers; and **induced effects** (including the Effect B, above, or those income effects for the producers who have higher profit margins) which are caused by workers and business owners at all levels of related production spending their incomes within their communities.

In each table, the direct, indirect, and induced effects are further expressed in four ways:
- Output – sales or gross revenues,
- Employment – both full and part-time jobs,
- Labor income, and
- Total value added to the product which includes the labor income, proprietor income, property income – leases and rentals, and indirect business taxes.
Table 1. Long-term economic effects of the Controlled-Release of Fertilizers Program at the OSU Hermiston Agricultural Research and Extension Center

<table>
<thead>
<tr>
<th>Type of Economic Effect</th>
<th>Output</th>
<th>Employment Full &amp; Part-time</th>
<th>Labor Income</th>
<th>Total Value Added</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct</td>
<td>95,750,038</td>
<td>1,305</td>
<td>6,300,675</td>
<td>43,112,471</td>
</tr>
<tr>
<td>Indirect</td>
<td>32,434,558</td>
<td>300</td>
<td>10,829,592</td>
<td>18,183,919</td>
</tr>
<tr>
<td>Induced</td>
<td>15,008,053</td>
<td>124</td>
<td>4,753,143</td>
<td>8,605,123</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$143,192,649</strong></td>
<td><strong>1,729</strong></td>
<td><strong>$21,883,410</strong></td>
<td><strong>$69,901,513</strong></td>
</tr>
</tbody>
</table>

Table 2. Additional short-term economic effects of the Controlled-Release of Fertilizers Program at the OSU Hermiston Agricultural Research and Extension Center

<table>
<thead>
<tr>
<th>Type of Economic Effect</th>
<th>Output</th>
<th>Employment Full &amp; Part-time</th>
<th>Labor Income</th>
<th>Total Value Added</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Effect</td>
<td>30,000</td>
<td>0</td>
<td>5,318</td>
<td>13,063</td>
</tr>
<tr>
<td>Indirect Effect</td>
<td>14,503</td>
<td>0</td>
<td>4,589</td>
<td>7,564</td>
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<tr>
<td>Induced Effect</td>
<td>7,502,271</td>
<td>61</td>
<td>2,378,334</td>
<td>4,297,092</td>
</tr>
<tr>
<td><strong>Total Effect</strong></td>
<td><strong>$7,546,774</strong></td>
<td><strong>61</strong></td>
<td><strong>$2,388,241</strong></td>
<td><strong>$4,317,719</strong></td>
</tr>
</tbody>
</table>

Table 3. Total long-term and short-term economic effects of the Controlled-Release of Fertilizers Program at the OSU Hermiston Agricultural Research and Extension Center

<table>
<thead>
<tr>
<th>Type of Economic Effect</th>
<th>Output</th>
<th>Employment Full &amp; Part-time</th>
<th>Labor Income</th>
<th>Total Value Added</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Effect</td>
<td>95,780,038</td>
<td>1,305</td>
<td>6,305,993</td>
<td>43,125,534</td>
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<tr>
<td>Indirect Effect</td>
<td>32,449,061</td>
<td>300</td>
<td>10,834,181</td>
<td>18,191,483</td>
</tr>
<tr>
<td>Induced Effect</td>
<td>22,510,323</td>
<td>185</td>
<td>7,131,477</td>
<td>12,902,216</td>
</tr>
<tr>
<td><strong>Total Effect</strong></td>
<td><strong>$150,739,422</strong></td>
<td><strong>1,790</strong></td>
<td><strong>$24,271,651</strong></td>
<td><strong>$74,219,233</strong></td>
</tr>
</tbody>
</table>
Examples of benefits beyond the market

While this research seeks to avoid production losses if limitations were imposed on the use of nitrogen, environmental impacts are not secondary in pursuing these studies. After all, serious environmental concerns related to air and water pollution can occur from excess application of nitrogen.

One potential benefit we have not attempted to quantify in this analysis is a possibility that, through the successful outcomes of this research, more water can be made available for residential and industrial uses in areas where water use is currently constrained by a Critical Ground Water designation. If nitrate leaching into the aquifer and surface water in the Lower Columbia Basin can be stopped—and eventually reversed—through use of this new technology, there is the possibility that regulatory restrictions on water use could be relaxed, thus helping sustain growth of a region highly important to the Oregon economy.

While the much publicized vulnerability of the nation’s energy supply and the high proportion of imported oil both have been used to justify intense and expensive efforts towards energy independence, food security may be a much more serious concern and justification. Reaching beyond the Lower Columbia Basin and even beyond Oregon, this research directly addresses a need for more efficient use of nitrogen, most of which is derived from natural gas. Alternative demands for natural gas in the United States means most nitrogen-based fertilizers are now imported, thus possibly making our ability to produce food even more vulnerable than our ability to move people and goods.

Options to consider

The public importance of this research to the Lower Columbia Basin’s regional growth, Oregon’s economy, and the U.S. food supply has not been recognized with a stable flow of resources for the research. At this point the research effort is privately funded at a relatively low level in pursuit of private returns or benefits. If the public benefits of the research were to be supported with three relatively low-cost expenditures, the pace of research in terms of the number of crops tested could be doubled from two per year to four.

Three immediate needs are:

• An additional graduate student at an estimated cost of $40,000;
• New laboratory located at the Hermiston Center (costing approximately $350,000) devoted to this work, enabling expansion of this work beyond its current lab, which is an upgraded shed; and
• Equipment to measure ammonia loss, direct path measurement devices, and ultrasonic anemometers with a cost of $250,000.
For additional information please direct questions to:

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Economic  Bruce.Sorte@oregonstate.edu  or 541.231.6566

Reference websites
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