Transgenic Fungus-resistant Barley

A Document-based Case Study in Transgenic Crops

Laurie McGhee, Colfax-Mingo Schools
Ron Schuck, Ames Schools
Summer 2014
INTRODUCTION

This activity has been designed to engage you in thinking and analyzing a realistic situation. Your beliefs and life experiences are very important, however for this task your analysis needs to be based solely on the facts presented in the following documents.

You are responsible for reading and analyzing each of the attached documents. Record the strengths and weaknesses of the documents on the Document Analysis sheet provided. Once you have read and filled out the chart for each of the documents you will write an email where you share explain your decision. Again, you must use evidence from the documents to support your decision.

SCENARIO

You own 60 percent of your family farm with your two siblings. You currently grow barley used in animal feed as your major crop. Within the past 10 years you have seen an increase in barley powdery mildew, a fungal disease, infection in your crops. You have increased the amount of fungicide used per acre of barley, but have seen little benefits. Your seed company, Superseeds Incorporated, wants to raise the price of all barley seeds in order to continue funding a research project. The scientists of this project are in the process of going through the trials to get a new line of barley seeds approved by the Food and Drug Administration (FDA). This new hybrid barley plant was developed at State University and is resistant to barley powdery mildew. All of the tests thus far have been successful and the seed should be ready for market in five years. To keep you as a customer, Superseeds Inc. is willing to give you a significant discount on this fungus resistant seed if you stay with the company and pay the extra money for your current seed. You must decide if you should stay with Superseeds Inc. and pay extra, or switch to another seed company to buy seed at the current cheaper price.

QUESTION-PRODUCT

Should you pay extra for your barley seed for the next five years to support the research project and get a future discount on seed, or should you switch seed companies to pay less now, but lose out on the future discount?

You will write your siblings an email addressing which seed company you will be purchasing seed from and supporting your decision.
Researchers at State University have developed barley varieties with resistance to powdery mildew, a fungus that causes disease that can reduce crop yields by as much as 40 percent. Roger Fuest, a geneticist and professor at State University who led the research, says the most economical and environmentally safe method for controlling powdery mildew is by growing resistant barley.

Powdery mildew infections appear as fluffy white growths on the surface of the plant leaf. Infection leads to yellowing and eventual death of the entire leaf. “Whenever a plant encounters a pathogen, there is a massive reprogramming of the plant’s survival mechanisms,” says Fuest. “Barley is a type of cereal grain and the fourth largest crop grown in the world. We’ve discovered genes in a distant relative of barley that regulate the defense of the plant against barley powdery mildew. We were then able to insert the genes into barley seeds using transgenesis.”

After completing a year’s worth of tests on barley in the greenhouse where the resistance was verified, the lab sold the hybrid seed to Superseeds Incorporated, a local seed company here in the Midwest. “The seed company will go through the ten years of field tests required by the Food and Drug Administration, FDA, to be ready for sale to farmers,” explained Fuest. “We simply don’t have the facilities or monies available to take on that size of a project here at the university.”

Fuest went on to explain the broader impacts this kind of research has on other types of crops. “Wheat is a very close relative to barley and can also be infected by a type of powdery mildew. Additionally, squashes, beans, strawberries, grapes, roses, and apple and oak trees can also get these types of fungal infections. We are hoping to expand our research and learn more about the genes behind these defenses.”

When asked if he was going to move on to other plant diseases, Fuest laughed. “This is a great step in the right direction, but fungal diseases can mutate very easily, so it’s important to continue the research.”
Dear Valued Superseed Customer,

As you know, barley crops have been experiencing decreasing yields in spite of increased fungicide application to fight “powdery mildew.” In farming, reliable predictions of input costs provide the farmer with solid information to plan for a profitable future. That is why we at Superseed, Inc. are excited to offer you an opportunity to invest in our new “Fungus Fighter Barley.” Having shown great promise in our preliminary field tests we have been completing for five years, we expect to provide the new “Fungus Fighter Barley” in fall of 2019, following the results of additional field tests.

New seed varieties are likely to cost 33% more than the present “Standard Barley” seed. We ask for your help investing in the future by paying an additional 10% per year for “Standard Barley” from 2014 through 2018. If you help with this investment you will receive a 20% discounted price on the new “Fungus Fighter Barley” in 2019 and that discount will be provided to you as long as you remain our customer. If you choose to pay the regular price for “Standard Barley” for the next 5 years, you will not be eligible for the 20% discount on “Fungus Fighter Barley” when it is available.

<table>
<thead>
<tr>
<th>Item</th>
<th>Standard Barley (no 10% investment increase)</th>
<th>Fungus Fighter Barley No Discount</th>
<th>Standard Barley (with 10% investment increase)</th>
<th>Fungus Fighter Barley with 20% Discount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed price per acre ($)</td>
<td>27.50</td>
<td>50.00</td>
<td>30.25</td>
<td>40.00</td>
</tr>
<tr>
<td>Fuel price per acre ($)</td>
<td>6.00</td>
<td>2.75</td>
<td>6.00</td>
<td>2.75</td>
</tr>
<tr>
<td>Fungicide Price per acre ($)</td>
<td>6.00</td>
<td>2.00</td>
<td>6.00</td>
<td>2.00</td>
</tr>
<tr>
<td>Yield per acre (bushels)</td>
<td>80</td>
<td>90</td>
<td>80</td>
<td>90</td>
</tr>
<tr>
<td>Price per bushel ($)</td>
<td>2.21</td>
<td>2.21</td>
<td>2.21</td>
<td>2.21</td>
</tr>
<tr>
<td>Yearly profit per acre ($)</td>
<td>137.30</td>
<td>144.15</td>
<td>134.55</td>
<td>154.15</td>
</tr>
</tbody>
</table>

**Based on Projected prices and materials 2014-2018**

**Based on Projected price and materials 2019-2023**

**Based on Projected price and materials 2014 - 2018**

**Based on Projected price and materials 2019-2023**
2014

Superseed, Inc Technology/Stewardship Contract

Grower Full Legal Name: ______________________________

Mailing Address: __________________________ City: __________ State: _____ Zip: _________

Phone: __________________________

This contract between the grower named above and Superseed, Inc is binding on both parties.

Grower shall receive Fungus Fighter Barley Seed from the Superseed Company at a 20% discount from the regular $50.00 per acre price ($40.00). Standard Barley will be provided by Superseed from Fall 2014 to Fall 2018 and grower will pay an additional 10% research and development fee. Starting in Fall 2019 and continuing as long as this grower buys Fungus Fighter Barley from Superseed, Inc., a 20% discount will apply to this growers’ purchase of that seed.

Grower agrees to the following terms:

- Purchase Barley seed exclusively from Superseed, Inc. from Fall 2014 thru Fall 2023.
- No seed saving allowed
- Budget and planting records available to Superseed inspectors upon request.
- Planting according to Superseed Company “Best Practices.”

Superseed Company is free from liability for:

- Crop Loss above the seed purchase price 2020 through 2024.
- Damage claims from neighboring farmers for any reason.

Grower Signature: ______________________________

Date: _______________________

Form Number

131197531
High efficiency transgenic barley resistant to powdery mildew

Roger Fuest¹,a, Ehren Werner¹, Elsa Ballini²
¹Department of Plant Pathology, State University
²Lebniz Institute of Plant Genetics and Crops, Germany

a Corresponding author

Summary

BACKGROUND
Powdery mildew, caused by Blumeria graminis f. sp. hordei, is one of the most serious barley diseases. Bulbous barley, Hordeum bulbosum, a distant relative of domesticated barley, harbors many important genes for resistance to various diseases, including powdery mildew. The overall objective of the current study was to explore the genetic basis of powdery mildew resistance in bulbous barley as a source for improving cultivated barley, Hordeum vulgare L.

METHODS
DNA was extracted from the bulbous barley followed by cloning of the target gene using PCR. The gene was then slightly modified for optimal uptake in the standard barley. The modified gene was inserted into standard barley plant tissue and grown to maturity. The new transgenic seed was collected and tested.

RESULTS
Tests were completed and the presence of the transgene in the hybrid barley was verified. The transgenic barley is three times more resistant to powdery mildew infection with no fungicide use than the standard cultivated barley with no fungicide use. When combined with a single fungicide application at the onset of infection, the transgenic barley is two times more resistant to infection compared with the standard cultivated barley under the same conditions.

CONCLUSIONS
The transgenic barley will have higher yields than using standard cultivated barley because of the increased resistance to powdery mildew. This could have great implications to other fungal diseases including powdery mildew of wheat, a very close relative to barley. It should be noted the transgenic resistance prevents the powdery mildew present from reproducing.
High efficiency transgenic barley resistant to powdery mildew

RESULTS

Standard Barley: Level of Infection

Trangenic Powdery Mildew Resistant Barley: Level of Infection
Letter: Seed Companies Put Risk on Farmer’s Backs

Well I guess now I’ve heard just about everything. My seed company has offered me a great opportunity. They want to give me a chance to spend more money on my barley seed now so I “MIGHT” get better yields 5 years from now. All I have to do is sign their contract that all but promises higher yield and better fungus control. Oh yeah, did I forget to mention the small print. They can’t guarantee increased yield and better control. If I invest now by paying a higher price, I might get these benefits 5 years from now. Anymore you can’t count on a straight story. My seed company also gets access to my financial records. Talk about “signing my life away!!”

I thought the part of capitalism that was special is you can make a big profit if you are willing to risk “your own money” on it. Superseed, Inc. wants me to throw the risk on my shoulders as if I don’t already have enough risk on my farm. I’ve survived the farm crisis of the late 80’s and have increased chemical use with less control. I’ll survive this too but I am telling Superseed to “take a hike!!” You should too. It’s time to take back the farm.

Pete Moss, Shoe City, IA
Unparalleled standards in innovation

LBNI has traditionally led the way in the search for new active ingredients to combat fungal diseases in cultivated plants. Over the years, our products have consistently set new standards.

For example, with epoxiconazole, we set the industry standard for the azole class of fungicides, a standard that remains unmatched to this day.

LBNI was at the forefront of innovation when Oweline fungicides were first introduced, developing the first active ingredient in this class – a truly innovative milestone in the history of fungicides.

Our strong focus on research will continue. More active ingredients will be developed to support customers in controlling diseases. For example, our recently announced Intellum® is the first active ingredient in a brand-new chemical class and will soon broaden our product portfolio for specialty crop growers.

Reliable resistance management

Resistance development – associated with the prolonged use of fungicides – is a well-known risk. To maintain long-term effectiveness, growers need to use active ingredients responsibly at all times. Use of resistant seed strains can be useful in addition to fungicide use against infection, but because of the high mutation rates, cannot be used alone.

Guidelines for effective resistance management

- Apply the active ingredient in combination with one or more fungicides of a different type or alternatively.
- Restrict the number of treatments applied per season, and apply only when necessary.
- Use manufacturer’s recommended dose.
- Avoid use as a pesticide.
Management of barley powdery mildew in 2014 – fungicide resistance

Since 2012, some Western Australia barley growers have noticed a decline in control from Oweline fungicides and subsequently Barley powdery mildew populations resistant to line-based products have been identified across the wheatbelt. New research indicates barley varieties commonly used in Western Australia have an increased risk of susceptibility to powdery mildew and that careful fungicide management is needed this season.

Barley powdery mildew fungicide caution needed

The research done by the Australian Centre for Fungal Diseases (ACFD) found that the mildew fungus in Western Australia is highly variable (very different) for many resistance genes. Some barley varieties have various resistance genes that have been fairly effective. But the ACFD warns that the mildew is mutating to survive and have become resistant. The data shows the mildew is also becoming resistant to the fungicides currently used in much the same way, but in a shorter amount of time. Dr. Richard Oliver, director of the ACFD says the powdery mildew’s mutations reduce the effectiveness of these fungicides. He recommends farmers monitor their barley crops closely for changes in the mildew response in the coming seasons.
Oweline 999 – Fungicide

For control of Barley Powdery Mildew

Active Ingredient: 1 methyl, 4 di-ethyl, decanozole..............................41%
Inert Ingredients.................................................................59%
Total .......................................................... 100 %

EPA Reg. No. 314-159

Stop – Read the label before use
KEEP OUT OF REACH OF CHILDREN

CAUTION

For MEDICAL Emergencies call 24 Hours a Day 1-800-662-6049.
Have the product container or label with you when calling a poison control center.
NOTE TO PHYSICIAN: No specific antidote. Treat symptomatically.

| If SWALLOWED                     | • Immediately call a poison control center.  
|                                  | • Have a person sip a glass of water if able  
|                                  | • Do not induce vomiting.                     |
| IF INHALED                       | • Move person to fresh air.                   
|                                  | • If person is not breathing call 911 and    
|                                  | • Call a poison control center.               |
| IF ON SKIN OR CLOTHING           | • Take off contaminated clothing.             
|                                  | • Rinse skin immediately with plenty of      
|                                  | • Call a poison control center.               |
| IF ON EYES                       | • Hold eye open and rinse gently with         
|                                  | • Remove contact lenses, if present, after    
|                                  | • Continue rinsing                            |
## Document Analysis

<table>
<thead>
<tr>
<th>Document</th>
<th>Strengths</th>
<th>Weaknesses</th>
<th>Major Points</th>
<th>Critical Thinking Skills</th>
<th>Stance</th>
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<tbody>
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Transgenic Fungus Resistant Barley

Laurie McGhee: lmcghee@mail.colfax-mingo.k12.ia.us
Ron Schuck: ronald.schuck@ames.k12.ia.us

<table>
<thead>
<tr>
<th>Intended Audience</th>
<th></th>
<th>Check all that apply...</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>☐ 9th grade</td>
<td>☐ general audience</td>
</tr>
<tr>
<td></td>
<td>X 10th grade</td>
<td>☐ advanced audience</td>
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<tr>
<td></td>
<td>X 11th grade</td>
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<tr>
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<td>X 12th grade</td>
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<table>
<thead>
<tr>
<th>Time Required</th>
<th>This document based case study (DBCS) should take 3, 45-minute class periods</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Day 1: Introduce the scenario and analyze a document together as a class</td>
</tr>
<tr>
<td></td>
<td>Day 2: Students analyze documents and complete document analysis sheet.</td>
</tr>
<tr>
<td></td>
<td>Day 3: Students write e-mail to farm partners (siblings)</td>
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<tr>
<td></td>
<td>This case depends on the students' experience with DBCS. It may take longer if this is their first experience, or it may take less time if they already have experience with DBCS's.</td>
</tr>
</tbody>
</table>

| Introduction/Background | This DBCS is intended for use after a unit about DNA structure and function and after the iTag OWB Wolfe Barley Module. Basic knowledge of fungi life cycle and plant resistance mechanisms are helpful. A basic knowledge of scientific capability to transform cell to confer new trait expression will also be helpful. |

| Objectives of the Case | Research in plant genetics and crops is important and necessary. Impacts this research has on everyone lives will include intended and unintended benefits and consequences. Informed and scientifically literate citizens need to understand multiple factors that go into implementing new technologies. Among these factors are time, money, economics, sociology, environmental, and politics. Higher order thinking skills will be needed to interpret information from many sources and then produce a coherent e-mail about a decision to contractually commit to a new Barley variety or not. Critical thinking skills addressed in this DBCS include: recognizing bias in documents, determining limitations of documents, determining that evidence in one situation may not apply in another, analyzing data from multiple sources and in multiple forms, generalizing and summarizing sources from more than one source, making logical inferences from presented information, evaluating experimental design, and comparing and contrasting information. |

<table>
<thead>
<tr>
<th>Major Issues – Identify the major issues in the case that the students should analyze. Indicate which issues you think will (should) come up and what information you expect students to extract from each document.</th>
<th>Bias</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vested interest</td>
</tr>
<tr>
<td></td>
<td>Economics and budgeting</td>
</tr>
<tr>
<td></td>
<td>Environmental tradeoffs with any technology chosen</td>
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<tr>
<td></td>
<td>Fungicide use and resistance to fungicides</td>
</tr>
<tr>
<td></td>
<td>Plant resistance to fungal disease and biotechnical solutions</td>
</tr>
<tr>
<td></td>
<td>Safety and Pesticide Labels</td>
</tr>
<tr>
<td></td>
<td>Marketing and agribusiness</td>
</tr>
<tr>
<td></td>
<td>Science basic research and implementation of new technologies from that basic research.</td>
</tr>
</tbody>
</table>
**Classroom Management**

Tells the reader just how the case should be used in a classroom situation. The explanation must be presented in detail. What to do first, second, and last? How long do certain activities take? Indicate any pre-class assignments and follow-up assignments that might be used after a discussion of the case is finished. Include study questions and questions you will be asking in the classroom throughout the case. Provide closure for students – how do you wrap up this activity up?

<table>
<thead>
<tr>
<th>Day 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Divide students into groups of 2 or 3.</td>
</tr>
<tr>
<td>2. Hand out Introduction, Scenario, and Question/Product sheet to students. Read through and go over as a class.</td>
</tr>
<tr>
<td>3. Hand out Document Analysis sheet. Students will complete these together in their groups, but the teacher may want each student filling out their own sheet.</td>
</tr>
<tr>
<td>4. Go over Document A as a class, the teacher should model how to analyze the document. Fill out the Document Analysis sheet for Document A together.</td>
</tr>
<tr>
<td>5. Have students go over Document B in their groups and fill out the Document Analysis sheet for Document B.</td>
</tr>
<tr>
<td>6. As a class, discuss Document B analysis.</td>
</tr>
</tbody>
</table>

**Day 2**

- 8. Review the scenario, goals, and product to be produced as a class.
- 9. Students will then analyze the rest of the documents using the Document Analysis sheet.
- 10. Teacher should visit with the different groups to ensure they are all on the right path. (Formative Assessment)

**Day 3**

- 11. Students will be given time to finish their analysis of the documents.
- 12. Students will individually write an email explaining their decision, citing specific documents as evidence for their reasoning using their Document Analysis sheet. (Summative Assessment)

**References & Resources**

Include a list of references to follow up particular lines of thought or included in your documents. May also include online resources & associated URLs.

- **Barley Document Stamp:**
  Courtesy of Wise Lab, Iowa State University

- **Barley Powdery Mildew Picture:**

- **Projected 2014 Crop Budgets North West North Dakota**

- **Does planting GMO seed boost farmers' profits? Leopold Center for Sustainable Agriculture:**

- **BASF Fungicide Page:**

- **Field Row Picture:**
  [http://1hdwallpapers.com/rows_wallpapers.html](http://1hdwallpapers.com/rows_wallpapers.html)

- **Western Australia Department of Agriculture & Food:**

- **Australia Grains Research & Development Corporation:**

- **Australia Map:**

- **Pesticide Product Labeling System. United States Environmental Protection Agency**
Assessment of product – Identify the product that students will produce as a result of this DBCS. Do you evaluate class discussions? Do you have students complete peer evaluations? What are students expected to complete? Do you have a rubric to evaluate the final product? Include as many tools for this element as possible.

Students will complete a document analysis sheet as they analyze documents. Students will use the analysis sheet to write an email to a farm partner (sibling) explaining their choice of either paying a higher price for the promise of a new Barley variety that resists fungus infection or paying a lower price from a new seed company that is marketing a Standard Barley variety susceptible to fungus infection.

- Participation in class discussions will be evaluated using a rubric
- Student ideas will be formatively assessed during discussions
- The e-mail will be evaluated with a writing rubric specifically referring to the documents in this case.
## Document Library:
### A Summary of Skills and Relevant Content

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
</table>
|   | ▪ Powdery mildew disease can reduce crop yields.  
  ▪ Research lab of scientists have made transgenic resistant seed  
  ▪ Evaluate the quality of a document’s author/source  
  ▪ Determine reliability, credibility, & limitations of a document | ▪ Cost of staying with seed company and getting future discount is a better profit in future  
  ▪ Analyze data from graphs, tables, charts, & diagrams  
  ▪ Determine reliability, credibility, & limitations of a document  
  ▪ Determine relevance of information presented | ▪ If staying with seed company, there is a higher cost now with potential for discount  
  ▪ Liabilities and risks involved  
  ▪ Ask questions as a result of having limited information  
  ▪ Determine relevance of information presented |
| D | ▪ Explains how transgenic barley was made  
  ▪ Data supports it has better immunity against barley powdery mildew  
  ▪ Evaluate the quality of a document’s author/source  
  ▪ Evaluate experimental design  
  ▪ Make logical inferences from information presented explicitly in the text of a document | ▪ Transgenic barley reduces infection of powdery mildew significantly  
  ▪ Analyze data from graphs, tables, charts, and diagrams  
  ▪ Ask questions as a result of having limited information  
  ▪ Examine evidence collected from an experiment | ▪ Some people have strong opinions about contracts with seed companies  
  ▪ Tolerate ambiguity  
  ▪ Evaluate quality of a document’s author/source  
  ▪ Determine the relevance of information presented |
| G | ▪ New fungicides are made often and work well  
  ▪ Fungal diseases can become resistant to fungicide  
  ▪ Recognize bias in documents  
  ▪ Determine reliability, credibility, and limitations of a document  
  ▪ Make logical inferences from information presented explicitly in the text of a document | ▪ Powdery mildew resistance to fungicide is occurring  
  ▪ Analyze data from graphs, tables, charts, and diagrams  
  ▪ Determine that the evidence from one situation may not apply in a different setting  
  ▪ Make logical inferences from information presented explicitly in the text of a document | ▪ Fungicides are dangerous to humans  
  ▪ Tolerate ambiguity  
  ▪ Ask questions as a result of having limited information  
  ▪ Make logical inferences from information presented explicitly in the text of a document  
  ▪ Determine the relevance of information presented |
# PERFORMANCE TASK SCORING GUIDELINES

<table>
<thead>
<tr>
<th>SCORING GUIDELINES</th>
<th>EMERGING (0-2)</th>
<th>DEVELOPING (3-4)</th>
<th>MASTERY (5-6)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Fails to see flaws and bias in Documents.</td>
<td>• Recognizes and cites flaws and bias in at least 5 of the 9 Documents.</td>
<td>• Recognizes and explains the flaws and bias in all Documents.</td>
</tr>
<tr>
<td></td>
<td>• Fails to recognize and explain the quality and sources of Documents.</td>
<td>• Recognizes and explains the quality of some sources, but doesn’t recognize specifically the importance of Documents D and E.</td>
<td>• Recognizes and explains the quality of sources. Specifically citing Documents D and E as peer reviewed scientific sources.</td>
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<td></td>
<td>• Does not acknowledge explicitly the validity of the experimental design in Documents D and E.</td>
<td>• Does not acknowledge explicitly the validity of the experimental design of Documents D and E.</td>
<td>• Recognizes valid experimental design of Documents D and E.</td>
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<td></td>
<td>• Is unable to support their decision in an email in a logical and coherent manner.</td>
<td>• Integrates information from at least 5 documents in a logical and coherent email explaining their reasoning for their decision.</td>
<td>• Integrates major points of all documents in a logical and coherent email explaining their reasoning for their decision.</td>
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<tr>
<td></td>
<td></td>
<td>• Points out some of the counterarguments to their decision.</td>
<td>• Points out the counterarguments to their decision.</td>
</tr>
<tr>
<td>Document</td>
<td>Strengths</td>
<td>Weaknesses</td>
<td>Major Points</td>
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</table>
| A        | News story about the development of a transgenic barley seed variety that is resistant to powdery mildew in a research lab. | News story may not convey the whole story of a research paper. Published by the university where the lab is located – could be biased. Only did tests in the lab, not field. | • Transgenic barley was created and shows resistance to powdery mildew  
• Powdery mildew disease can reduce crop yields. | • Evaluate the quality of a document’s author/source  
• Determine reliability, credibility, & limitations of a document | For the new seed, stay with company. |
| B        | Indicates that the new Fungus Fighter barley variety will yield greater profit and with less use of the fungicide in the future. | Written by Superseed, Inc. – could be biased. Farm will have to sacrifice some profit for 5 years by paying more before seeing advantages of new seed. Projected costs, not certain. | • Discount on new transgenic barley when comes to market in 5 years.  
• Pay more for regular seed for next 5 years.  
• Projected profit is more, less fungicide use. | • Analyze data from graphs, tables, charts, & diagrams  
• Determine reliability, credibility, & limitations of a document  
• Determine relevance of information presented | For the new seed, stay with company. |
| C        | Guarantees a better price for Fungus Fighter barley for continuing customers over those farmers unwilling to pay the short-term price increase of the Standard barley seed. | Farmer has responsibilities under contract and assumes most to all of the risk. | • Higher cost now is stay with company with potential for discount in future.  
• Liabilities and risks involved. | • Ask questions as a result of having limited information  
• Determine relevance of information presented | For the new seed. (stay with company) |
| D        | Source is a peer-reviewed scientific journal. The transgenic barley resists the *Blumeria graminis* f. sp. *Hordei*, fungus that causes powdery mildew. | What works in a lab may not work in the field. | • Explains how transgenic barley was made.  
• Transgenic barley shows immunity against barley powdery mildew.  
• Implications for other plant diseases. | • Evaluate the quality of a document’s author/source  
• Evaluate experimental design  
• Make logical inferences from information presented explicitly in the text of a document | For the new seed. (stay with company) |
| E        | Graph indicated significantly less fungal infection in the transgenic barley variety and is from the same peer-reviewed science journal article in Document D. | Only 1 application of fungicide. Doesn’t say what fungicide was used. Only followed 7 days after infection. | • Data shows the transgenic barley had less infection than the standard barley. | • Analyze data from graphs, tables, charts, and diagrams  
• Ask questions as a result of having limited information  
• Examine evidence collected from an experiment. | For the new seed. (stay with company) |
<table>
<thead>
<tr>
<th>Document</th>
<th>Strengths</th>
<th>Weaknesses</th>
<th>Major Points</th>
<th>Critical Thinking Skills</th>
<th>Stance</th>
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</thead>
</table>
| F        | Points out some downsides to the new Fungus Fighter barley seed in that the farmer shoulders the risk and the farmer needs to allow business financial documents to be seen by Superseed, Inc. on request. | A person’s opinion. | • Some people have strong opinions.  
• Contractual responsibilities may be more than what the company says. | • Tolerate ambiguity  
• Evaluate quality of a document’s author/source  
• Determine the relevance of information presented | Neutral on seed.  
Against staying with company. |
| G        | Provides an alternative to the new resistant seed in continuing the fungicide research and development of new fungicides to deal with the resistance. Does recommend use of resistant varieties and may be seen as a pro new Fungus Fighter seed argument. | Company is biased. They make a profit by farmers using fungicides they produce. | • New fungicides are developed often.  
• Fungal diseases can become resistant to fungicide and new barley seeds, both are needed | • Recognize bias in documents  
• Determine reliability, credibility, and limitations of a document  
• Make logical inferences from information presented explicitly in the text of a document | Against new seed.  
(do not stay with company) |
| H        | An authority is pointing out the issue of powdery mildew fungus becoming resistant to current fungicides. | From Australia, may not apply in Midwest. | • Powdery mildew resistance to fungicide is occurring. | • Analyze data from graphs, tables, charts, and diagrams  
• Determine that the evidence from one situation may not apply in a different setting  
• Make logical inferences from information presented explicitly in the text of a document | Neutral on seed, but could be needed.  
(stay with company) |
| I        | A pesticide label from a fungicide used on powdery mildew. Fungicides can be dangerous and potential reduction of fungicide use by using the Fungus Fighter barley may have environmental benefits. | Very specific to only one type of fungicide. Many things have warning labels, but aren’t that dangerous. | • Fungicides can be dangerous to humans.  
• Could be dangerous to environment. | • Tolerate ambiguity  
• Ask questions as a result of having limited information  
• Make logical inferences from information presented explicitly in the text of a document  
• Determine the relevance of information presented | Neutral |