ARTICLES

The following three articles fall into a new and distinct category of contributions published in the Journal of Natural Resources and Life Sciences Education. They are called Case Study articles. Interest in providing problem-solving and decision-making experiences in education has sparked interest in the adaptation of decision cases for publication in this journal. Although decision cases have long been used in colleges of business, they have only recently been adapted to natural resources, life sciences, and agriculture. Guidelines have been developed to describe the format for publication of decision cases in the Journal of Natural Resources and Life Sciences Education. Prospective authors will find it helpful to see pages 2-3 in this issue for guidelines in manuscript preparation to ensure minimum editorial delay.

Mueller Farm: Lupin as an Alternative Crop for On-Farm Protein Production

S. R. Simmons,* D. Putnam, and D. Otterby

ABSTRACT

The decision whether to grow an alternative crop is often complex and of much contemporary relevance as producers seek to diversify and buffer their farming operations against increasing costs and volatile commodity prices. In recent years, white lupin (Lupinus albus L.) has been proposed as an alternative crop for on-farm production of dairy protein supplement in the North Central USA. This case considers a situation faced by a Central Minnesota dairy producer in 1991 as he decided whether to attempt to grow lupin as a protein supplement on his farm. The producer had previously made three attempts to produce lupin in 1988–1990. These attempts had been unsuccessful because of a combination of drought and weed problems. The case was developed as a format for stimulating in-depth consideration and discussion of factors involved in alternative crop adoption. The case hinges on two questions; whether lupin can be successfully grown on the farm and whether lupin can supply adequate protein for the farm’s high-producing dairy herd? The case also illustrates how human factors can be important in many production decisions through consideration of the producer’s determination and perseverance in the face of adversity. In deliberating the case decision, students need to integrate both agronomic and ruminant nutrition factors. The case has been class-tested twice with students rating it “good” to “very good” for its effectiveness at familiarizing them with issues and factors associated with alternative crop adoption.

Enhancing crop diversity within agricultural systems is of much current interest. At the level of the individual farm, a producer who desires to enhance diversity must assess the feasibility and advantages/disadvantages of adopting a specific alternative crop. This case was developed to provide students with insight into the crop adoption decision process.

THE CASE

In baseball, it’s three strikes and you’re “out.” Dairy farmer Jeff Mueller was beginning to feel like “Casey” after taking his third strike. For 3 yr he had attempted to produce lupins (Lupinus spp.) as a participant in a university-sponsored project evaluating the feasibility of growing and feeding white lupin (Lupinus albus L.) as an alternative protein supplement for dairy cattle (Bos taurus). By all accounts this experience was less than satisfactory.

Like most dairy farmers in the 1980s, Mueller felt the pressure of rising production costs. A significant portion of his production expenses went each year to purchasing protein supplements to add to his ration to sustain his herd’s high level of milk production. He was eager to find ways to reduce these costs and the prospects of producing a high-protein feed crop on his own farm that could replace all or part of his purchased supplement was very appealing. Such a crop should provide him with a “buffer” from the uncertainties of volatile protein supplement prices? Thus, when Mueller was asked by his county agent in 1988 to participate in an on-farm research trial designed to evaluate lupin as an alternative protein supplement for dairy, his response was enthusiastic.

Mueller had never before grown lupins, but he had heard of other farmers in his central Minnesota area who had, and some reported good success. For example, a Minneapolis Star and Tribune newspaper account (Petersson, 1987) described one dairy farmer who had grown

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1Teachers who intend to use this case for classroom or extension education purposes may request a copy of the full Case Teaching Note from the corresponding author.

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6.1 ha (15 acres) of lupin for the first time in 1987 and obtained a yield of 1850 kg/ha (68 bu/acre). This reportedly provided more than enough protein supplement to supply that farmer’s 60-cow herd. He claimed to have reduced his protein supplement expenses by two-thirds just by substituting lupin for the soybean [Glycine max (L.) Merr.] meal he had been purchasing. The article further noted that the lupin seed could be fed directly without processing and that the crop was easy to plant and harvest. “They’re easy to combine, super easy,” reported the farmer. He also remarked in the article that the crop’s tolerance to low temperatures meant that he could plant and harvest lupins earlier than soybeans. As a summary assessment the farmer stated, “You have to sell the soybean at whatever price they offer, and then buy back the meal for whatever cost they want to charge. We figured there had to be a better way.”

Such logic made sense to Mueller, and although he did not produce soybean on his farm, he did pay nearly $20,000 each year for soybean and other protein supplements. The prospect of growing lupin to eliminate or reduce this expense, as well as his dependence on external suppliers, was very attractive.

By participating in the university-sponsored project, Mueller knew he would have direct access to university specialists who could answer his questions and help him understand this new crop. The university also offered to provide no-cost lupin seed and inoculum to cooperators, which was no small factor since Mueller knew that lupin seed cost was high (Exhibit 1).

There was some uncertainty in 1988 regarding how many years the project might run, which meant that Mueller’s commitment was on a year-by-year basis. Thus, he knew that he could “opt out” of participating in the project in future years if things didn’t work out. “I can’t lose,” he thought.

What a difference 3 yr had made. By December 1990, most of Mueller’s earlier enthusiasm for lupin was gone. Severe drought in his first year (1988), coupled with serious lambquarters (Chenopodium album L.) and common ragweed (Ambrosia artemisiifolia L.) problems, had resulted in very little harvestable yield. As he agreed in 1989 to participate in the project for a second year, Mueller reasoned, “Surely the drought will let up and I’ll be all right.” But ragweed and lambquarters infestations in his field that year were even worse than in 1988, and when coupled with sporadic dry periods during the season, essentially no yield was obtained in 1989. On the heels of such discouraging results, Mueller was reluctant to participate in the trial again, but his desire to “see this thing through” plus extra financial support from the university for the 1990 growing season favored his participation. However, damage and reduced stand caused by a hail storm soon after emergence in May forced Mueller to disk under this 1990 lupin crop, again obtaining no seed yield.

After his 3-yr experience with lupin, Mueller was understandably discouraged. “I hear reports of farmers in my area having success with lupins, but that sure hasn’t been my experience. I can’t figure out why they can do it and I can’t. It just doesn’t seem worth the hassle. Maybe I should look into other options for reducing protein supplement costs such as enhancing the quality of forages produced on the farm or experimenting with growing and feeding roasted soybean.”

The Decision

Mueller’s 3-yr effort to produce and feed lupins had not been successful. He hadn’t grown enough seed to be able to adequately assess how his cows would perform with lupins in their ration. His interest in becoming more self-sufficient for protein on his farm was still strong and his nature was to “continue the fight.” “After all,” Mueller reasoned, “many of my problems with the lupins, such as the drought and hail, could have happened to any crop.” But with no new herbicides coming available for ragweed or lambquarters control, Mueller knew that production of weed-free lupins on his farm would be a real challenge in the future. He did not look forward to further disappointment and failure. The university project had ended and there was no more financial support forthcoming. From now on he was on his own.

The 1991 cropping season was approaching and Jeff knew that he had to decide soon whether to continue his efforts to produce and feed lupins on his farm. If he chose not to do so, he needed to assess his other options for reducing protein supplement expenses. If he did continue to grow lupin, he had to find a way to assure that the unsuccessful experiences of 1988 through 1990 were not likely to be repeated.

Background on the Farm

Jeff Mueller’s farm was located in central Minnesota west of Little Falls near the community of Swanville. He went into partnership with his father on the family Holstein dairy farm in 1979 following graduation from high school. At that time their herd was approximately 50 cows, but when Mueller’s brother also joined the partnership in 1986, the herd was expanded to 100 milking cows, a relatively large herd by Minnesota standards (Exhibit 2). Mueller, his father, and his brother each owned their land separately but they managed it as a single unit. Their combined owned acreage was 204 ha (505 acres) of which 144 ha (355 acres) was tillable. Mueller, himself, owned 38 ha (95 acres) of tillable land and 59 ha (145 acres) of woodland and meadow. The family also rented additional land area for production of corn (Zea mays L.) and hay.

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**Exhibit 1. Estimated production cash costs for lupin and soybean in central Minnesota (Putnam et al., 1989).**

<table>
<thead>
<tr>
<th>Expense</th>
<th>Lupin</th>
<th>Soybean</th>
</tr>
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<tbody>
<tr>
<td>Seed</td>
<td>91.40 (37.00)</td>
<td>22.20 (9.00)</td>
</tr>
<tr>
<td>Fertilizer</td>
<td>28.70 (11.60)</td>
<td>28.70 (11.60)</td>
</tr>
<tr>
<td>Herbicide</td>
<td>43.00 (17.40)</td>
<td>43.00 (17.40)</td>
</tr>
<tr>
<td>Fuel</td>
<td>23.70 (9.60)</td>
<td>23.70 (9.60)</td>
</tr>
<tr>
<td>Repairs and maintenance</td>
<td>41.00 (16.60)</td>
<td>41.00 (16.60)</td>
</tr>
<tr>
<td>Interest on cash expense</td>
<td>9.90 (4.00)</td>
<td>9.90 (4.00)</td>
</tr>
<tr>
<td>Total</td>
<td>237.70 (96.20)</td>
<td>168.50 (68.20)</td>
</tr>
</tbody>
</table>

† Expenses do not include fixed costs such as land, machinery, and taxes.
The terrain in the area of the Mueller family farm was gently rolling with occasional small peat bogs and depressions. The original vegetation was northern hardwood forest and oak (Quercus sp.) savannah. The tillable soils on the farm were predominately sandy loam (Typic Fragiaqualfs and Aerie Fragiaqualfs), and were poorly to well drained (Exhibit 3). They also were somewhat rocky, which hampered tillage, cultivation, and harvesting operations. Soil pH tended to be moderately acidic with low levels of exchangeable K and low to high levels of P.

Climatic conditions were very important for determining the cropping systems in the region. Soybean was seldom grown because of the relatively cool growing season temperatures, especially at night. For example, average July minimum temperatures in the country were less than 16 °C (60 °F) (Erickson et al., 1979). Average daily maximum temperatures in July were about 28 °C (about 82 °F). Growing season length was also somewhat short with a 12 May average date of last frost in the spring and a 26 September average first frost date in the fall. Such conditions were well-suited to a cool-season legume such as lupin. Annual precipitation on the Mueller farm averaged 660 mm (26 inches) with a summer precipitation (June–August) of 305 mm (12 inches). Although the total amounts of precipitation received in the area of the Mueller family farm were adequate for lupin, the sandy soils caused drought conditions to readily occur during dry periods, as in 1988. Some lupin producers in the area had successfully produced lupin under irrigation, but Mueller did not currently have the capacity to irrigate.

**Crop Management**

Alfalfa (Medicago sativa L.) and corn were the main crops typically grown in rotation on the Mueller family farm, with 4 to 5 yr of alfalfa alternated with 3 to 4 yr of continuous corn. Field pea (Pisum arvense L.), spring triticale (X Triticosecale Wittmack), or oat (Avena sativa L.) were used as companion crops for establishing the alfalfa. Alfalfa was also sometimes direct-seeded on level fields using a preplant-incorporated herbicide for weed control in the establishment year. Alfalfa was either chopped at bud stage for haylage or cut for hay. Corn was harvested both for grain and silage. Crop area on the farm in 1989-1990 (including rented land) was approximately 121 ha (300 acres) of corn, 40 ha (100 acres) of alfalfa, 12 ha (30 acres) of oat underseeded with alfalfa, 49 ha (120 acres) of grass hay, 49 ha (120 acres) of pasture, and the 2 ha (5 acre) lupin trial.

**Herd Management**

The Dairy Herd Improvement (DHI) rolling herd average milk production for the Mueller farm in December 1990 was 9437 kg (20 787 pounds) per cow. The herd average had increased steadily since 1987 (Exhibit 4) and was considerably higher than the state DHI average for Holsteins of about 7718 kg (17 000 pounds) (Exhibit 2). Mueller's production goal was to move the herd average to 10 896 kg (24 000 pounds) within the next few years. To reduce production costs, the Muellers began in 1989 to purchase protein supplements in bulk and to mix their own ration using the total mixed ration (TMR) concept. To reduce production costs, the Muellers began in 1989 to purchase protein supplements in bulk and to mix their own ration using the total mixed ration (TMR) concept. Even with bulk purchasing, however, protein supplement expenses in 1990 totaled approximately $20 000. A typi-
might be due, in part, to reduced intake and excessive suggested that lower milk production for lupin-fed cows quantities of essential amino acids. The results of the trial microbes would be incapable of synthesizing sufficient could be detrimental to high-producing cows since rumen was of importance because excessive protein degradation in the rumen, was substantially protein degradation in the rumen, was substantially degraded, whereas lupin protein was 80% degraded. This confirmed that lupin seed protein was more degradable in the rumen than soybean meal, possibly to an even greater extent than indicated in the earlier study. Although the later study was more positive regarding the prospect of using lupin in dairy diets, Mueller was still concerned about the impact of lupin on a high-producing herd like his. A factor in Mueller's decision was his lack of knowledge and experience with using lupin in his herd's ration. He had hoped to produce enough lupin seed in his 1988-1990 trials to experiment with feeding them, but the lack of production allowed no opportunity to do so. Recent university trials (Guillaume et al., 1987; May et al., 1991) had provided conflicting information regarding the use of lupin in rations of lactating dairy cows. In an earlier trial (Guillaume et al., 1987), a total of 45 Holstein cows had been fed diets consisting of 50% forage (corn silage, alfalfa silage) and 50% protein concentrate. In one diet, soybean meal supplied 34% of the total crude protein, whereas in the other ground lupin seed made up 38% of the protein. Cows fed lupins consumed significantly less dry matter, although the reasons for this reduced intake were not clear. Lupin-fed cows also tended to produce less milk, although the differences were not significant within the statistical precision of the experiment. In situ disappearance of N, an indicator of relative protein degradation in the rumen, was substantially higher for lupin than for soybean meal, especially during the first few hours (Exhibit 6). Overall crude protein from soybean meal was estimated in the study to be 71% degraded, whereas lupin protein was 80% degraded. This was of importance because excessive protein degradation could be detrimental to high-producing cows since rumen microbes would be incapable of synthesizing sufficient quantities of essential amino acids. The results of the trial suggested that lower milk production for lupin-fed cows might be due, in part, to reduced intake and excessive protein degradation. These researchers cautioned that further investigation was needed to confirm these results.

In the later trial (May et al., 1991) there was no evidence of reduced intake for cows fed diets in which up to 100% of the soybean meal had been replaced by ground lupin seed. In fact, diets with 75% lupin replacement gave substantially higher fat-corrected milk production than diets containing only soybean supplement. The researchers attributed this to the higher fat (energy) content of the lupin-containing diets. Further studies confirmed that lupin seed protein was more degradable in the rumen than soybean meal, possibly to an even greater extent than indicated in the earlier study. Although the later study was more positive regarding the prospect of using lupin in dairy diets, Mueller was still concerned about the impact of lupin on a high-producing herd like his.

**Summary**

Two issues played on Jeff Mueller's mind as he weighed the prospect of again growing lupins on his farm in 1991: (i) whether he could successfully produce lupin considering the constraints he faced, particularly with weed control; and (ii) whether lupin would make a suitable protein source for his herd considering its current production level and future goals. The Mueller family farm was one of the most highly regarded dairies in central Minnesota. Mueller had received in 1990 a Minnesota Department of Agriculture competitive grant to conduct on-farm testing of alternative cover crops for forage production, which was indicative of his innovative and resourceful approach to crop management. The installation of the total mixed ration system in 1989 was another indication of the progressive approach that the Muellers took in the management of their herd and in the reduction of production expenses. Steady improvement of herd productivity, coupled with his goal for continued enhancement of production, placed utmost importance on having access to high performance rations that included adequate quantities of quality protein. Mueller needed to decide whether to consider lupin as a viable crop for his farm's future.

**TEACHING NOTE**

**Case Objectives**

The overall objective for this case is to provide students with problem analysis and decision-making experience typical of that faced by farmers seeking to diversify their
operations and to reduce production expenses. The case provides insight into the process of alternative crop adoption. Upon completion of the case students will have:

1. Improved their capability to analyze a dairy operation with respect to its need for a protein supplement.
2. Improved their capability to consider the prospects, options, and risk factors for producing alternative crops.
3. Become familiar with principal production procedures and constraints for lupin, a representative new and uncommon crop.
4. Considered the integration of agronomic and animal production factors within a single decision focus.

Use of the Case

This case was originally developed during 1989 for use in 1990 in the interdisciplinary “capstone” course (AnPI 5060) in the animal and plant systems major at the University of Minnesota. The case was revised and updated in 1991 and again used in the course in that year. Almost all students in this course had prior coursework in agronomy/horticulture and soil science. Few had coursework in animal science. The case was assigned to groups of three or four students. To enhance authenticity, exhibit information was provided to the students, whenever possible, in the form of original sources. For example, Exhibit 4 was provided in the form of actual DHI herd summary sheets obtained from Mueller. Similarly, students were provided an actual copy of the article by Guillaume et al. (1987) for Exhibit 6. Groups were given a period of about 5 d to deliberate the case outside of class prior to making a presentation of their decision and supporting rationale in class. The entire class then participated in an instructor-guided discussion of the case, decision options, and issues. Faculty or staff representing animal science and plant/soil sciences participated in the general case discussion.

The earlier version of the case was evaluated in 1990 as part of the overall course using a 1–7 rating scale (1 = unsatisfactory, 2 = poor, 3 = fair, 4 = satisfactory, 5 = good, 6 = very good, and 7 = excellent). Its’ overall rating was “very good” based on a response from 10 students. Three students rated the case “excellent,” four rated it “very good,” one rated it “good,” and one “satisfactory.” In 1991, the revised case was evaluated by the students on a learner-outcome basis using the same rating scale as 1990. Eight students experienced the case and their evaluations are summarized in Table 1. The case was particularly effective for improving the students’ capabilities to integrate agronomic and animal production factors within a single decision focus. This is consistent with the primary purpose for developing this particular case and using it in the animal and plant systems major capstone course. The most common criticism of the case was that students felt they had incomplete or inadequate information on which to base a decision. Some students also expressed that the case seemed complex with many factors and options to consider. The case was specifically selected for development precisely because, as an alternative crop in Minnesota, lupin is poorly understood and researched. Similarly, the decision is complex and includes factors other than technical or scientific considerations. Nevertheless, crop managers must often base decisions on incomplete or inadequate information and human factors; thus, the case in its incompleteness and complexity represents an accurate documentation of reality. Some students also expressed concern that their personal background limitations in agronomy hindered their abilities to relate to the case. Because deliberation of the case was a group effort, the opportunity was provided to capitalize on the synergies of cooperative learning. Each group was deliberately constituted to maximize the diversity of the students, particularly in relation to course and agricultural backgrounds.

Issues in the Case

The case centered around two central questions:

1. Could Mueller successfully grow lupins on his farm?
2. Could Mueller effectively utilize lupins as a protein supplement for his dairy herd?

The desirability of reducing feed expenses was clear in 1990, but whether production and feeding of lupin would provide a meaningful reduction in those expenses was problematic. One difficulty was the unknown production capability for lupin on the Mueller farm. The failures of the 1988–1990 lupin crops resulted in no yield performance record being available for the farm.

A critical constraint for producing lupin on the Mueller farm was weed control. The outlook was not bright for overcoming this problem since no herbicides were labeled or likely to become labeled in the near future to control common ragweed and common lambsquarters in lupin.

Table 1. Student assessment of learner outcomes attainment for the Mueller Farm decision case in AnPI 5060 in 1991 (n = 8).

<table>
<thead>
<tr>
<th>Learner outcome</th>
<th>Unsatisfactory</th>
<th>Poor</th>
<th>Fair</th>
<th>Satisfactory</th>
<th>Good</th>
<th>Very good</th>
<th>Excellent</th>
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<tr>
<td>Improved capability to analyze dairy</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>1</td>
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<td>operation for protein need</td>
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<td>Improved capability to consider prospects</td>
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<td>0</td>
<td>2</td>
<td>3</td>
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<td>and options for producing alternative crops</td>
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<td>Increased familiarity with principal</td>
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<td>1</td>
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<td>production procedures and constraints for</td>
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<td>lupin</td>
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<td>Improved capability to integrate</td>
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<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>3</td>
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<td>agronomic and animal production factors</td>
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<td>within single decision focus</td>
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The option of planting in wider rows and cultivating could have been considered, but yield potential would be reduced and weeds within the row might still not be controlled. The possibility that Mueller might be tempted to use off-label herbicides in this situation prompted important ethical and legal considerations in the case. Developing capacity to irrigate was also considered, especially in light of the drought experience in 1988.

An important agronomic and economic issue in the case was the availability and cost of lupin seed. Mueller was provided complimentary seed during the years of his participation in the university project, but that option was no longer available after the 1990 season. Lupin seed costs were high, approximately $86 to $99/ha ($35-$40 per acre), and the number of seed suppliers was limited. Although the possibility existed for Mueller to produce his own seed each year, his past lack of success with weed control and the likelihood of seed-borne diseases made this option less attractive.

Although extension literature available at the time of the decision indicated that lupins could replace at least 65% of the meal supplements in dairy cow diets, the extent of this replacement for the Mueller herd was not known. Furthermore, research had raised questions as to whether lupin-fed cows might have lower intake or suffer from inadequate by-pass protein, which would have been particularly unsatisfactory for high producing herds. The high level of production of Mueller’s herd, coupled with his short-term goal of producing 10 896 kg (24 000 pounds) per cow, clouded the issue as to the extent to which lupin could replace protein supplements on his farm. The case provides a springboard for more indepth consideration of ruminant nutrition analytical techniques (in situ, in vitro) as well as discussions of the importance of protein degradability. The case is a good one for discussing difficulties encountered when making decisions where information is incomplete or contradictory.

The individual qualities of Mueller were also important issues influencing the case decision. His desire to be less dependent on external protein supplement suppliers and expenses was central to the case. His record of past innovation suggested that he was not one to back down from a challenge. The decision depended greatly on the strength of Mueller’s determination and desire to persevere through the difficulties that he would encounter in future efforts to produce and feed lupin on the farm. Whether Mueller would invest the time, effort and expense to develop the capability to produce lupin was a question.

ACKNOWLEDGMENT

Special appreciation is expressed to Mr. Jeff Mueller for his generous cooperation in providing information needed to develop this case. Appreciation is also expressed to Dr. Melvin Stanford, Mankato State University, and former assistant JoAnn Barbour for their constructive critique and assistance while researching and writing this case.

REFERENCES