# *The Rise and Fall of NewLeaf Potatoes*

MICHAEL THORNTON
*AMVAC Chemical Co.*
*Caldwell, ID*

From 1995 through 2001, genetically modified potatoes were sold in the United States and Canada under the brand name NewLeaf™. These potato varieties were relatively popular with growers because they replaced pest-control practices involving intensive use of pesticides with technology that was present in the potato seed. Market tests indicated that the concept of reduced pesticide use through biotechnology was also interesting to consumers. Despite being popular with growers and consumers, sales of NewLeaf™ potatoes plummeted after the 1999 growing season. I will outline some of the factors that made these potatoes popular, and then examine the issues that led to the rapid decline in sales and their eventual removal from the market. With that information as a background, I will attempt to evaluate the challenges and opportunities for biotechnology adoption in the potato industry in the future.

## THE NEED FOR BIOTECHNOLOGY IN THE POTATO INDUSTRY

Potato is one of the most widely grown vegetable crops, and is planted on approximately 1.3 million acres in the United States each year. Potato production is a high-cost, risky enterprise. Total cost of production exceeds $1,000/acre in most regions, and can be double or triple that in regions with high pest pressure. A high proportion of these production costs are associated with the use of pesticides (Figure 1).

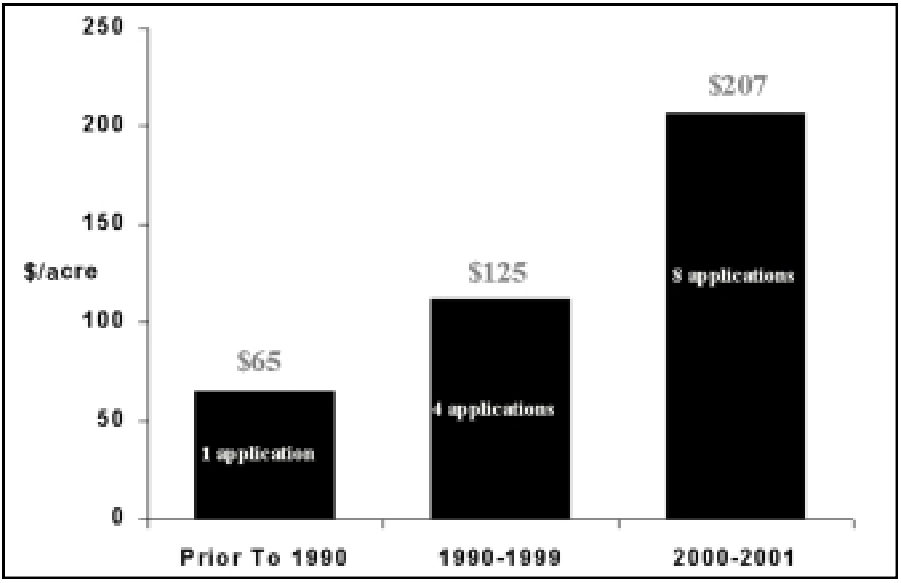


**Figure 1. The cost of pest control in various US potato-production regions (data collected from various sources).**

Potatoes are vulnerable to attack by many insect, disease, and weed pests. As a result, over 80% of the acreage is treated with herbicides, insecticides, and fungicides (Weise *et al.*, 1998). It has been estimated that reducing pesticide use by 50% would result in a 27% reduction in potato production, while a 100% reduction in pesticide use would reduce yields by approximately 57% (Knutson *et al.*, 1994).

An alternative to pesticide use would be to employ genetic resistance. Considerable effort has been made to find and incorporate sources of resistance to major pests through traditional breeding techniques. However, most of the widely grown varieties remain at least partially susceptible to a wide range of pests. Part of the difficulty in using traditional breeding to develop pest resistance is that potatoes have a very diverse genetic background, and crossing two varieties leads to a wide range of characteristics in the offspring. Therefore, it takes enormous space and time to identify new varieties that have both the pest resistance and the agronomic characteristics that will make them suitable for use on a commercial basis. It is not unusual for potato breeders to take more than 15 years between the initial cross and release of a new variety.

Biotechnology offers a way to incorporate genes for resistance to pests, without many of the complications associated with traditional breeding. Vayda and Belknap (1992) noted that the potato is an ideal candidate for molecular manipulation due to the ease with which it can be transformed. Initial efforts led to the introduction of insect-resistant potatoes that contained a gene encoding for the CryIIIA protein (Perlak *et al.*, 1993). Expression of this protein in the leaves provided protection from the Colorado potato beetle, one of the most damaging pests. This was followed just a few years later with the introduction of varieties with resistance both to the Colorado potato beetle and to the potato leafroll virus (Thomas *et al.*, 1997). Applications to control these two pests account for over 80% of insecticides used in potato production in the United States.

## Initial Market Reaction

The NewLeaf™ Russet Burbank potato was introduced with much fanfare in 1995. The industry had been anticipating it for several years, and had closely watched the research and regulatory trials (Knorr, 1994). The initial planting was only 1,500 acres, but quickly grew to 50,000 acres as seed stocks become available and more varieties were introduced (Figure 2).

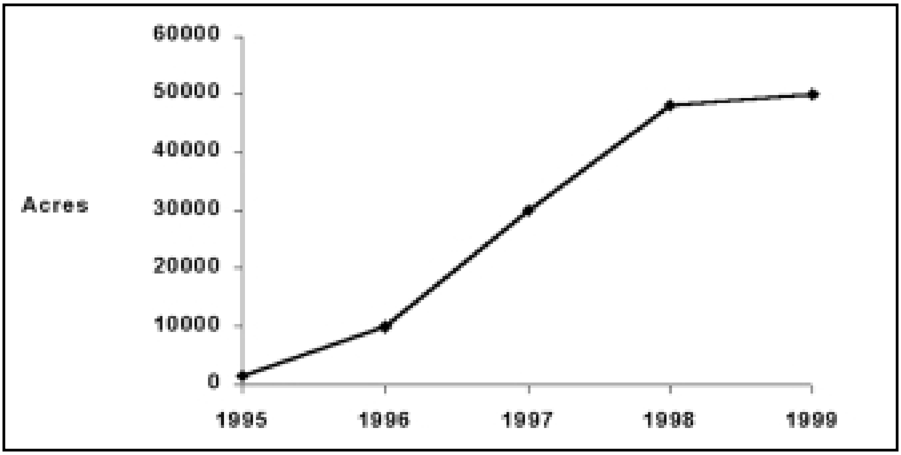


**Figure 2. Adoption rate of NewLeaf potatoes in the United States and Canada (unpublished NatureMark data).**

A couple of factors coincided with the introduction of NewLeaf™ potatoes that contributed to the market success. The first had to do with the difficulty the industry was having in controlling the Colorado potato beetle. This insect has a history of developing resistance to synthetic pesticides, which limits options for control and puts even more selection pressure on the remaining chemistries. The second factor was that generally mild winters in the major potato production regions during the early 1990s had led to high pest populations, especially of the green peach aphid. This aphid is the major vector of the potato leafroll virus, and because of these high populations the virus was

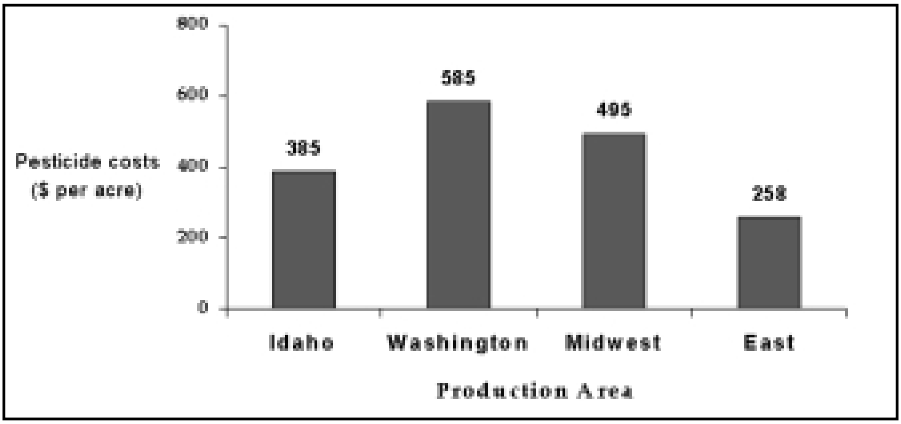


**Figure 3. Recommended insecticide spray programs and associated costs per acre for the PNW (G. Reed, Oregon State University, personal communication).**

becoming a widespread problem throughout the Pacific Northwest (PNW). As a result of these two situations, insecticide use and associated costs of insect control had increased rapidly (Figure 3).

Growers who planted insect- and virus-resistant NewLeaf™ potatoes were able to reduce insecticide costs significantly. A survey of twenty commercial farms in 1998 and 1999 found that, on average, the number of applications were reduced both in Idaho (short season) and in Washington (long season). Furthermore, tuber quality was improved due to elimination of defects associated with leafroll virus infection. A recent case study by the National Center for Food and Agricultural Policy (NCFAP) reported that insecticide use in the PNW states, Idaho, Oregon and Washington, could be reduced by 1.45 million pounds per year, with a net economic impact of over $58 million, if potatoes resistant to Colorado potato beetle and virus were planted on the 620,000 acres grown in those states (Gianessi *et al.*, 2002a).

Factors were working against the adoption of this technology within the industry. The technology agreement that all potato growers signed prior to planting these potatoes specified that a refuge of non-tranformed potatoes had to be left to reduce the potential for development of resistance to the CryIIIA protein. This resistance-management strategy was developed in a coordinated effort with leading entomologists (Hoy, 1999). Switching varieties during the planting operation was a complication that many potato growers were not used to. A second factor that worked against market adoption was the introduction of new class of insecticides (Imicloprid). These products, introduced at about the same time as NewLeaf™, offered an effective conventional pesticide alternative to producers struggling to control beetles that were becoming

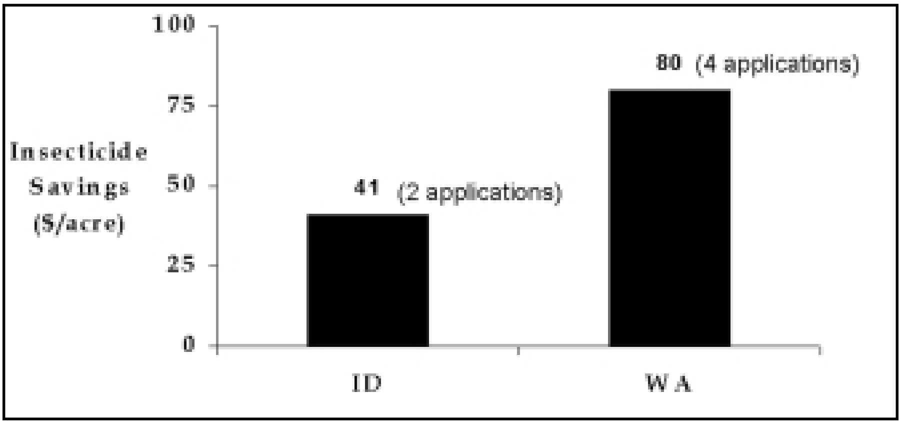


**Figure 4. Grower savings on insecticide costs and applications when planting NewLeaf™ potatoes with insect and virus resistance (averages for twenty locations, 1988 and 1989) (unpublished NatureMark customer survey).**

resistant to other insecticides. Despite these factors, the introduction of NewLeaf™ resulted in the fastest adoption of a new variety in the history of the United States potato industry.

## Factors Leading to the Close of Business

While it was clear that potato growers were gaining economic advantages from the use of this technology, entities higher in the marketing chain were trying to figure out how it would impact their business. About 60% of the potatoes produced are processed prior to entering the market, ending up in restaurants and other food-service outlets across the country. Potatoes were one of the few commodities that had been transformed through biotechnology and were readily identifiable as a food item on restaurant menus. When the public debate over the risks and benefits of biotechnology began to garner attention in the media, potato processors and retailers had to take a very hard look at how they were going to respond to any potential controversy. An initial attempt was made to segregate the genetically modified potatoes so that customers who requested non-GM products could be accommodated. However, the necessary testing protocols and segregation techniques were not well developed. As a result, processors found that the NewLeaf™ potato was not adding value to their business, and was, in fact, causing them to change practices in response to market demands. As market signals to growers from the primary buyers of their potatoes became less certain, many decided they could not afford the risk of planting NewLeaf™ potatoes. The acreage declined rapidly after the 1999 season. In 2001, Monsanto decided to close the potato division to focus on other opportunities for their biotechnology efforts (Figure 5).

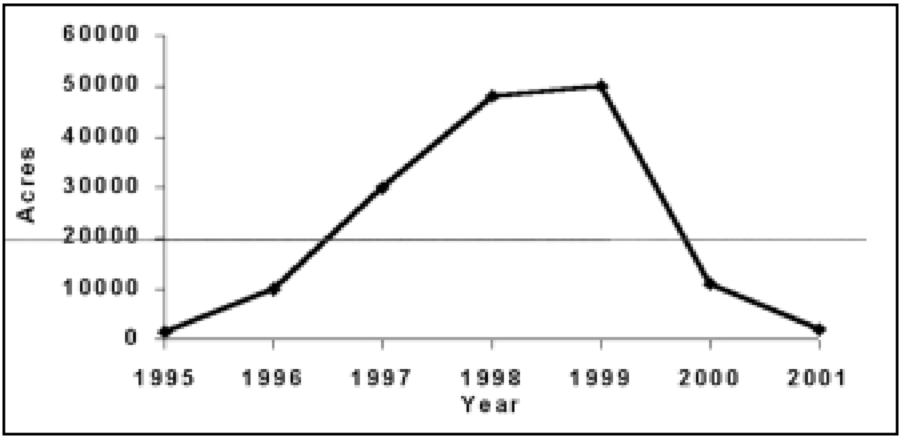


**Figure 5. Acreage of NewLeaf™ potatoes in the United States and Canada, 1995 through 2001 (NatureMark, internal data).**

Similar types of marketing situations were developing in the corn, canola, cotton, and soybean markets. A key question is, why did the potato business fail when this technology is still being used on millions of acres of other crops? I believe at least two factors contributed to the rapid demise of the NewLeaf™ potato business. The first factor was the relatively low acreage. Despite the rapid adoption and favorable response of growers to the technology, it represented a very low proportion of total production. By 1998, NewLeaf™ varieties accounted for less than 4% of all potatoes in the United States and Canada. The decision to close the business had very little impact on the supply of potato seed for the 2001 and 2002 growing seasons. Individual producers who had been relying on NewLeaf™ seed for a significant proportion of their planted acreage had to go out and find new seed sources, but this did not cause widespread market disruption. This is in contrast to other major crops, where the substantial portion of planted acreage in genetically modified varieties could cause significant market disruption if alternative seed sources had to be found.

A second factor relates to the expense of bringing the NewLeaf™ potatoes to market. Potatoes undergo the same regulatory process as other crops, costing millions of dollars to complete. These costs are recovered by charging technology fees when the seed is purchased. However, with a relatively small acreage base, companies are hard pressed to recover all development costs. A further complicating factor is that potatoes are very slow to propagate; it takes years to increase seed stocks to the point where substantial acreage can be planted.

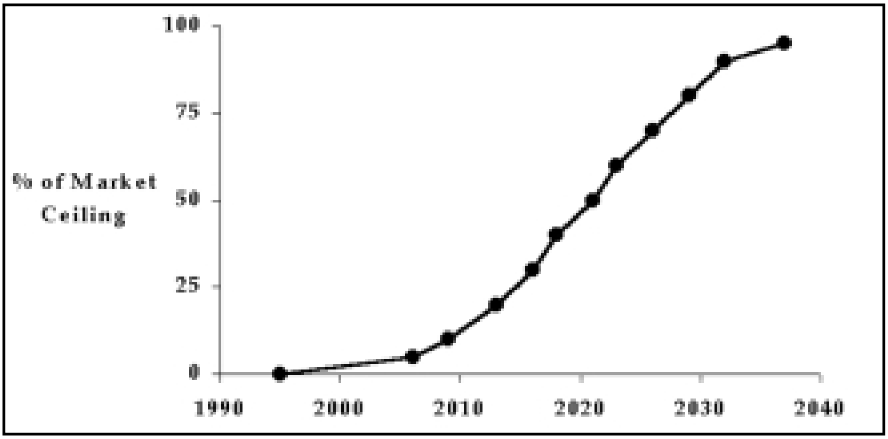


**Figure 6. Predicted adoption rate of genetically modified potatoes based on a model of similar technologies (adapted from Guenthner, 2002).**

## WHAT IS THE FUTURE FOR BIOTECHNOLOGY IN THE POTATO INDUSTRY?

The great opportunities and challenges that faced the potato industry in the period during which the NewLeaf™ potato was marketed remain to this day. The challenges of low acreage and high development costs will continue to make the potato a less attractive crop for private companies. Public institutions may be able to pick up some of this work, but the hurdle of regulatory approval will remain a key roadblock. Lack of segregation practices in the seed-potato and commercial crops will also make it difficult to deal with export issues in countries that have regulatory policies and timelines different from those in the United States. Most large food retailers and consumers still have not recognized direct benefits from the application of biotechnology in potatoes. Without these direct benefits, they may remain wary of this technology.

These challenges are balanced by some equally intriguing opportunities. Potatoes remain an excellent crop for improvement through biotechnology. Case studies by the NCFAP have reported the potential for fungus-resistant plants to reduce pesticide use by millions of pounds in the United States and Europe (Gianessi *et al.*, 2002b; 2003). Pest-resistant traits represent only the first wave of the application of this technology. Potatoes with increased solids, better storage characteristics, and improved nutritional content have been evaluated in field trials. Because potato products are consumed so widely, they also represent a valuable platform for introduction of health-related attributes, such as edible vaccines. The same characteristics of genetic diversity that make potatoes so difficult to improve by conventional breeding provide opportunities to identify and transfer many useful genes through biotechnology.

How will this struggle between the challenges and opportunities play out for the potato industry? I don't have a crystal ball to gaze into the future, but I can cite the work of one agricultural economist that looked at this question. Guenthner (2002) modeled the adoption rate of new technologies such as diet soda, microwave ovens, and processed potatoes. By looking at technologies that had safety and consumer-acceptance issues in common with genetically modified potatoes, he was able to come up with a formula that describes the three phases of market acceptance for these products. According to his model, genetically modified potatoes should go through the introductory phase by 2010, and reach a market peak some time after 2030 (Figure 6). As someone with a strong interest in future of the potato industry, I hope that he is right.

## REFERENCES


Gianessi L *et al.* (2002a) Plant biotechnology: Current and Potential Impact for Improving Pest Management in U.S. Agriculture—Insect/Viral Resistant Potato. Washington, DC: National Center for Food and Agricultural Policy.

Gianessi L *et al.* (2002b) Plant biotechnology: Current and Potential Impact for Improving Pest Management in U.S. Agriculture—Fungal Resistant Potato. Washington, DC: National Center for Food and Agricultural Policy.

Gianessi L *et al.* (2003) Plant biotechnology: Current and Potential Impact for Improving Pest Management in European Agriculture—Potato Case Study. Washington, DC: National Center for Food and Agricultural Policy.

Guenthner JF (2002) Consumer acceptance of genetically modified potatoes. American Journal of Potato Research 79 309–316.

Hoy CW (1999) Colorado potato beetle resistance management strategies for transgenic potatoes. American Journal of Potato Research 76 215–219.

Knorr AA (1994) Genetic engineered spuds are one step closer to market. Valley Potato Grower Magazine November 16–17.

Knutson RD *et al.* (1994) Yield and cost impacts of reduced pesticide use on fruits and vegetables. Choice Magazine January 15–18.

Perlak F *et al.* (1993) Genetically improved potatoes: protection from damage by Colorado potato beetles. Plant Molecular Biology 22 313–321.

Thomas PE *et al.* (1997) Reduced field spread of potato leafroll virus in potatoes transformed with the potato leafroll virus coat protein gene. Plant Disease 81 1447–1453.

Vayda ME Belknap WR (1992) The emergence of transgenic potatoes as commercial products and tools for basic science. Transgenic Research 1 149–163.

Wiese M *et al.* (1998) Use, target pests, and economic impact of pesticides applied to potatoes in the United States, USDA NAPIAP Report 2-CA-98. Washington, DC: USDA.

## Q&A

*Craig Winters (Campaign to Label Genetically Engineered Foods, Seattle, WA):* One thing that became a major issue in Europe was the firing of Árpád Pusztai. It hit the front page of all the European papers and generated some traction in the consumer and environmental movements that maybe there was some problem with genetically engineered potatoes. We were surprised that Monsanto didn't duplicate Dr. Pusztai's study to show it was faulty. Then, all of a sudden, the potatoes were removed from the marketplace that aroused suspicion that maybe there were problems with those potatoes. Did Monsanto try to duplicate Dr. Pusztai's studies?

*Thornton:* I'm not going to speak for Monsanto. I will say that, during the time I was with NatureMark, they did animal-feeding studies on the initial Bt potato showing there were no adverse effects. I don't know the specific animals they used. Somebody from Monsanto may wish to comment. They felt that they had such a body of evidence that this stuff was safe that they just didn't see a need to repeat that study. Again I don't want to put words in Monsanto's mouth so, if somebody wants to comment, they certainly can.

*Audience Member:* Those studies have been repeated. First of all I'd like to say that the work that is referred to by Árpád Pusztai did not involve NatureMark. He created a transgenic potato with a snowdrop lectin. He wanted to know whether by introducing a gene, in this case a lectin gene, would in some way interfere with the normal growth and development of the potato. His results suggested inhibitory effects. Other scientists looked at his methodology and found flaws in it, and subsequently repeated the studies, addressing those flaws, and found no problem. That research is available, and I don't think it had any impact on the story that we have just heard. The answer to your question is that the studies were repeated, but not by Monsanto.

*Thornton:* I agree with that comment. I don't think that particular story had a big influence on what happened in the potato industry here in the United States.

*Audience Member:* Is Monsanto maintaining the germplasm of the new wheat in the hope that the market will turn around?

*Thornton:* As I understand it, as of just a few months ago, yes they maintain a tissue culture bank of all the commercial varieties as well as all the copies of all the transformation events, and things like that. This technology is basically on the shelf, not in the trashcan.