NEWLEAF® COLORADO POTATO BEETLE-RESISTANT POTATOES: A FOUNDATION FOR SUSTAINABLE POTATO PEST MANAGEMENT

by
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NatureMark Potatoes

The classical breeding of resistant plant varieties, often through the incorporation of germplasm from non-crop species, has proven to be an effective way of reducing pesticide use and promoting sustainable agriculture. Host plant resistance is considered an ideal foundation for integrated pest management (IPM), and has been a key component of many IPM programs to date because of its compatibility with biological and cultural control tactics. Plant biotechnology expands the capability to introduce novel traits into plants, and speeds the development of crop varieties that are resistant to one or multiple pests. Biotechnology holds the potential to revolutionize agriculture by eliminating the need for pesticides and other chemical inputs. Reductions in pesticide use will facilitate the successful integration of cultural and biological control strategies in production systems which have historically relied primarily on broad spectrum chemical controls. Such a change offers far reaching benefits to individual farmers and society as a whole, including the reduction of point and non-point source pollution, accidental poisonings, fossil fuel consumption, and soil compaction.

In May of 1995, NewLeaf Russet Burbank potatoes became the first genetically modified, insect-resistant crop to receive full federal approval for commercialization. NewLeaf potatoes are genetically modified to produce the cryllla protein derived from Bacillus thuringiensis var. tenebrionis (B.t.t.), which is selectively active against the Colorado potato beetle (CPB). NewLeaf plants produce the B.t.t. protein at a high level throughout the season, providing complete control of all stages of the CPB without the addition of insecticide inputs. This effectively removes the CPB from the pest complex. Although the CPB is not the only insect pest requiring control in most potato producing regions, it is the target of insecticides on 95% of potato acres in North America and often dictates the timing and materials applied to the potato crop. In the absence of CPB, the options for management of other potato pests are increased. Individual insect pests can be managed selectively with controls that are timed specifically to damaging stages, or on the basis of appropriate action thresholds. In addition, entomophagous arthropods can become established in the cropping system, and can contribute to pest population regulation.

Prior to release of NewLeaf potatoes to commercial potato growers, extensive studies were conducted to determine the impact of engineered host plant resistance on potato pest management systems.

This Presentation is part of the Proceedings of the 1996 Washington State Potato Conference & Trade Show.

Specifically, multi-year/location studies were designed to explore the potential contribution of generalist predator populations in management programs utilizing engineered host plant resistance for CPB control. These studies demonstrated that arthropod natural enemies, in combination with NewLeaf potatoes, can provide a significant contribution to the management of aphids and other non-target pests.

In addition to research aimed at developing general pest control recommendations, a coordinated, collaborative research effort was undertaken to devise strategies to prevent or delay CPB resistance to the B.t.t. protein to ensure that NewLeaf potatoes remain an effective, environmentally benign, and sustainable tool for management of the CPB. Collectively, this effort culminated in the development of a comprehensive resistance management plan. A written document outlining the various strategies under consideration was submitted to the EPA in support of product registration in fall of 1994. The following are the primary elements of NatureMark's resistance management plan:

1) Agronomic and other pest management practices that promote multiple tactics for insect control, including cultural, biological, and chemical factors.

   NewLeaf potatoes should be incorporated into IPM programs as an integral, but not a stand-alone, measure. Growers should continue to utilize existing, accepted pest management practices that are designed to reduce pesticide inputs and delay resistance development. It is anticipated that non-chemical tactics for CPB management will increase the potential for biological control by allowing beneficial arthropod predators and parasites to increase in the agroecosystem. These natural enemies can also contribute to pest and resistance management of CPB and other potato insects.

2) Monitoring of CPB populations for susceptibility to the B.t.t. protein.

   The first step in resistance management is to establish an estimate of the target pest's baseline susceptibility for the purpose of long-term resistance monitoring. In 1992, NatureMark initiated a program for sampling and assaying susceptibility of diverse CPB populations to the B.t.t. protein. This program will continue in both the immediate and long-term.

3) High dose expression of the B.t.t. protein in potatoes to control CPB heterozygous for resistance alleles.

   Assuming that resistance to B.t.t. is the result of a single major gene that is inherited as a recessive or co-dominant trait, the "high-dose" hypothesis predicts that all homozygous susceptible and heterozygous resistance individuals will be killed. Therefore, only homozygous resistant beetles will have the ability to survive on NewLeaf plants. These homozygous resistant insects will be extremely rare and will most likely mate with susceptible insects, giving rise to heterozygous progeny. Expression of the B.t.t. protein in NewLeaf foliage is estimated to be approximately 20-50 fold higher than that needed to kill neonate larvae, representing a true high-dose approach to pest and resistance management.

4) Refugia as hosts for B.t.t. susceptible insects provided through non-CPB resistant potatoes.

There are several potential strategies under review for incorporating a refuge for B.t.t. susceptible CPB into the cropping system such as seed mixes, trap cropping, etc. In addition, not all potato varieties will contain the B.t.t. protein. A number of factors, including interplant CPB movement, mate and host finding behavior, and industry acceptance will dictate the choice and ultimate success of various refuge strategies.

5) Development of novel CPB control proteins with a distinct mode of action from the NewLeaf insect control protein.

Multiple gene and alternate gene strategies hold potential for substantially delaying or halting resistance development. Monsanto is actively searching for additional insect active proteins and other mechanisms for engineered host plant resistance to the Colorado potato beetle.

Resistance management and the appropriate use of pest control technology to ensure long-term efficacy requires commitment, coordination, and participation from manufacturers (industry), government (regulatory agencies), pest management advisors (Extension and independent consultants), and individual end-users (growers). NewLeaf potatoes and other products of biotechnology can form the cornerstone of environmentally sound, sustainable production systems.