Final Project Report to the NYS IPM Program, Agricultural IPM 2003-2004

1. Title:
Assessing Virus Resistance in New York Grown Potato Varieties and Breeding Lines: Disease Resistance as an Integral Part of Pest Management

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4. Type of Grant
Pest Resistant Crops

5. Project Locations
New York, Maine, and nationally

6. Abstract:
In 2002, two viruses that are part of an emerging potato disease complex (tuber necrosis) were first described in the US. Viruses can be difficult to score visually, compromising seed certification programs. The focus of this proposal is: i) the collection of *Potato Virus Y* (PVY) field isolates representative of those compromising potato production, and ii) testing commercial varieties and breeding lines to assess their resistance phenotypes. Plants from commercial production areas were analyzed to determine which of the common viruses are present, namely, *Potato Virus A* (PVA), *Potato Virus M* (PVM), *Potato Virus S* (PVS), *Potato Virus X* (PVX), PVY or *Potato Leafroll Virus* (PLRV). Of the 500 plants sampled, 386 contained PVY, most commonly with one or more other viruses. Twenty one of the commercial varieties can be inferred to be PVY susceptible. Five of the samples contained 'necrotic isolates' of PVY that induced a veinal necrosis when inoculated onto tobacco. Two of these necrotic PVY isolates were not recognized by the diagnostic monoclonal antibody used in Foundation Seed programs, and three of the isolates were recognized by the diagnostic monoclonal antibody, but did not give rise to a veinal necrosis. These results emphasize shortcomings in the accepted methods of disease management. We now have in hand representative field isolates of PVY. This will allow us to assess the resistance phenotype of potato breeding lines and commercial varieties.

7. Background and Justification:
With 23,300 acres harvested in 2001, New York's potato crop was valued at $58.8 million. One of the foundations of commercial potato production is the planting of pathogen-tested, certified seed (=tubers). The success of certified seed programs is the reason that some diseases are no longer limiting factors in potato production; this is especially true for diseases caused by viruses. The use of certified seed is a quintessential example of an integrated pest management strategy, controlling diseases while reducing risk and environmental impact. Certification relies on the visual assessment of the health of the crop during the growing season, inspection of the harvested tubers, and winter seed trials wherein samples of each lot are planted in Florida and rated for levels of disease. Viruses that only induce mild symptoms or are asymptomatic in foliage are particularly problematic and compromise the certification system.

Pest management in potato relies heavily on the contributions of plant breeding. High crop productivity, profitability, sustainability and environmental stewardship require integrated management strategies and any pests that compromise plant growth will affect yields. In potato production, viruses reduce plant growth and in some cases tuber quality. Virus infections also work synergistically and exacerbate the effects of other pests. This proposal focuses on components of an emerging disease complex impacting potato production in the US, namely, viral-induced tuber necrosis. The tuber necrotic viruses are a tremendous concern in seed certification programs and these viruses are significant barriers in international trade. Two of the viruses were only first reported in the US in 2002; they are emerging disease agents that need to be monitored for effective management.

Symptoms of tuber necrosis can result from infection by any one of three viruses: *Potato mop top virus* (PMTV), *Potato virus Y* (PVY) strain NTN, and *Tobacco rattle virus*. PMTV and PVY are the primary concern in the Northeastern US. The most effective means of controlling these viruses is through clean seed programs and seed certification, but visual diagnosis and detection can be problematic. Thus, information about distribution, virus strains, varietal responses and symptom expression, and host resistance is paramount.

PMTV was first reported in the US from Maine in 2002. Its distribution has not been established and its presence in seed potatoes needs to be monitored. PMTV is spread with potato seed (tubers), is transmitted by the same soil-borne pathogen that causes powdery scab, and can become established in the soil. In parts of Scandinavia, sensitive cultivars cannot be grown in infested soils. Necrotic strains of PVY (PVY-N) have been present in the US for decades, but their spread has been limited through the efforts of seed certification programs. In 2002, the appearance of PVY-NTN strains in the US was first described; NTN (=N tuber necrotic) strains are a subset of N strains and all can be identified using a tobacco bioassay. Since PVY moves with infected seed, it has become fairly widespread, although at present PVY-NTN strains are not common in the US. This is likely to change, as PVY is efficiently spread by aphids in the field. Insecticides generally do not control nonpersistently transmitted viruses such as PVY, but severe disease outbreaks have prompted seed growers to resort to mineral oil sprays. Furthermore, the aphid-transmitted leafroll virus can be controlled with insecticides and growers may not distinguish between the foliar symptoms caused by leafroll versus PVY.

Enhancing crop production by focusing on host resistance is an outstanding example of environmental stewardship and risk reduction. The primary objective of this project is to identify commercial varieties and breeding lines that are resistant to PVY, and those that are asymptomatic. Because varietal responses can be strain specific, virus strains representative of those in production in the Northeast will be collected and used in the screening process.

8. Objectives:

1) To test for the presence of necrotic strains of *Potato virus Y* in seed and commercial potato production areas and to collect strains of PVY representative of the pathogen diversity.

2) To determine the *Potato virus Y* resistance phenotype of potato varieties commercially grown in New York.

3) To determine the *Potato virus Y* resistance phenotype in breeding lines and potato varieties under development for release in New York.

9. Procedures:

1) Symptomatic and asymptomatic plants were sampled from production areas of NY state and tested by immunoassay (ELISA) for the presence of *Potato virus Y*. Tissue testing positive for PVY was archived as dried tissue stocks and mechanically inoculated onto tobacco; this is a bioassay to test for the induction of a veinal necrosis characteristic of N strains. The diversity of PVY strains was assessed using a set of potato varieties (differentials) and monoclonal antibodies. In order to increase the probability of virus detection in asymptomatic plants, leaf tissue from 10 plants were combined and processed as a unit (bulk sampling). Sampling of asymptomatic plants is important for several reasons: i) virus strains may induce

mild foliar symptoms (or be asymptomatic), but give rise to severe tuber symptoms, ii) symptoms may be viral strain and potato variety specific, iii) viruses may be asymptomatic alone, but devastating in mixed infections with other viruses (synergism), and iv) asymptomatic plants function as reservoirs of the virus (a 'typhoid Mary' in potatoes). A representative set of PVY strains from the collection will be used to assess the resistance phenotypes of potato varieties (below). This portion of the study is important, as it provides virus isolates representative of the pathogen population that commercial producers will encounter.

2) Strains of PVY were mechanically inoculated onto selected potato varieties and the resistance phenotype scored. This first year of study was restricted to greenhouse plants. Because host responses vary with environmental factors, a second year of work with field grown plants is planned, but not part of this proposal. Inoculated plants were scored for visual symptoms and systemic infection by the virus tested for by ELISA. PVY strains representative of the natural diversity in the Northeast will be employed in these experiments. This portion of the study is important for two reasons: i) the greenhouse studies will provide information for growers on varieties that are especially sensitive (or resistant) to PVY and that should be avoided (or recommended) in seasons following years when disease was prevalent and hence inoculum levels are expected to be high, and ii) symptomless carriers of the virus will be identified and recommendations can be made to growers to avoid these varieties in regions or years when PVY is a problem.

3) A wider diversity of the strains collected in section (1) will be used to challenge breeding lines that are used in the NY State breeding program at Cornell University. The objective is to determine the durability different resistance genes are that are being used to develop varieties that will be released for commercial production. The initial focus was on two varieties, 'Eva' (=NY112) and NY115. 'Eva' is known to have a form of 'extreme' resistance typical of the breeding program. It is desirable to know if there are strains present in the Northeast that will overcome this resistance. NY115 is only being grown commercially on a limited acreage, but it is a parent for many of the crosses presently being made in the breeding program. Thus, an assessment of resistance in NY115 and its progeny is warranted. This portion of the proposal is important because it provides information on varietal resistance during development and before the release of varieties. Of particular importance is the identification of symptomless carriers that cannot practically be assessed for virus levels by seed certification programs.

10. Results and Discussion:

The first year of this study has focused on sampling plants from commercial production areas and determining which of the common viruses are present, namely, *Potato Virus A* (PVA), *Potato Virus M* (PVM), *Potato Virus S* (PVS), *Potato Virus X* (PVX), *Potato Virus Y* (PVY) or *Potato Leafroll Virus* (PLRV) as determined by DAS-ELISA. Of the 500 plants sampled, 386 contained PVY (Table 1), though in many cases this virus was present with one or more other viruses (Table 2). The potato varieties from which these PVY isolates were recovered are listed in Table 3. Twenty one of the commercial varieties can be inferred to be PVY susceptible.

Of the 386 PVY positive samples, five contained 'necrotic isolates' that induced a veinal necrosis when inoculated onto tobacco (Table 4). Although all PVY isolates are easily detected with anti-PVY polyclonal antibodies, two of these necrotic isolates were not recognized by the diagnostic monoclonal antibody used in Foundation Seed programs. These isolates may represent escapes that are not effectively managed by the PVY management plan suggested by the USDA and practiced in many US seed producing states and Canada. Furthermore, three of the isolates were recognized by the diagnostic monoclonal antibody, but did not give rise to a veinal necrosis, thus emphasizing the shortcomings of the use of this diagnostic assay in virus management.

This study is ongoing. We now have in hand representative field isolates of PVY that will allow us to assess host resistance. Greenhouse assays will be conducted to determine the resistance phenotype of potato breeding lines and commercial varieties. Another applied aspect

of virus management is monitoring the transmission of virus from field-infected plants into tubers and then into successive field generations of potatoes. The latter will have profound impact on disease control and crop yields.

Table 1. Number of individual symptomatic and composite asymptomatic samples testing positive for *Potato Virus A* (PVA), *Potato Virus M* (PVM), *Potato Virus S* (PVS), *Potato Virus X* (PVX), *Potato Virus Y* (PVY) or *Potato Leafroll Virus* (PLRV) as determined by DAS-ELISA.

		Individual symptomatic samples[a]		Composite asymptomatic samples[b]
	Collection year	2002		2003
	No. plants sampled	205	300	1030
Virus	PVY	182	204	8
	PVS	173	182	60
	PVX	55	31	3
	PVM	36	0	0
	PVA	12	1	0
	PLRV	1	2	0
	none	4	76	41

[a] Virus symptoms included necrotic lesions, leaf mosaic, leaf mottling, rugosity, stunting, and/or discoloration.
[b] Composite samples consisted of 10 leaves each from 10 asymptomatic plants.