

# OFFICIAL

## COOPERATIVE REGIONAL RESEARCH PROJECT STATEMENT

**Project Number:** NE-184

**Title:** Development of New Potato Clones for Environmental and Economical Sustainability in the Northeast

**Duration:** March 1, 1997 to September 30, 2001

## TABLE OF CONTENTS

JUSTIFICATION	4
RELATED CURRENT AND PREVIOUS WORK	7
OBJECTIVES	13
PROCEDURES	13

### **Objective 1. Determine the heritability of traits of economic importance and improve the genetic base of potatoes.**

Procedure 1.a. Determine the heritability of internal heat necrosis in chipping lines and any relationship between high specific gravity and susceptibility to internal heat necrosis.

Procedure 1.b. Determine the inheritance of long-term cold storage processing ability in diploid potatoes and improve the genetic base for this trait.

Procedure 1.c. Improve the genetic base of yellow-flesh potatoes.

Procedure 1.d. Improve the genetic base of red-skinned potatoes.

Procedure 1.e. Improve the genetic base of resistance to the Colorado potato beetle.

Procedure 1.f. Improve the genetic base of resistance to late blight.

Procedure 1.g. Improve the genetic base of resistance to early blight.

Procedure 1.h. Improve the genetic base of resistance to scab.

Procedure 1.i. Improve the genetic base of resistance to golden nematode and map genes conferring resistance.

Procedure 1.j. Improve the genetic base of resistance to root lesion nematodes.

### **Objective 2. Evaluate pest resistant, early-maturing, long-dormant cultivars for fresh market and/or processing from cold storage.**

Plant Material.

Procedure 2.a. Evaluate developing clonal material for potential use in the refrigerated pre-peeled industry.

Procedure 2.b. Evaluate promising selections for resistance to *Rhizoctonia*.

Procedure 2.c. Evaluate promising selections for resistance to scab.

Procedure 2.d. Evaluate promising selections for resistance to late blight.

Procedure 2.e. Evaluate promising selections for early-maturity, quality, and long storage potential.

Procedure 2.f. Evaluate promising selections for cold storage processing.

Procedure 2.g. Evaluate promising selections for resistance to viruses.

Procedure 2.h. Evaluate promising selections for resistance to ring rot.

### **Objective 3. Identify and quantify significant climatic and cultural effects on the performance of potato selections.**

Procedure 3.a. Study the genetic mechanisms of potatoes for responding to environmental stresses and identify these major environmental stresses.

Procedure 3.b. Classify the Northeast region into broad and 'distinct' growing areas.

Procedure 3.c. Develop predictive models based on performance data and climatic information.

Procedure 3.d. Study the impact of genotype x environment interactions on a 'sustainable agriculture' cropping system.

<b>EXPECTED OUTCOMES</b>	20
<b>ORGANIZATION</b>	28
<b>SIGNATURES</b>	29
<b>ATTACHMENTS</b>	30
Project Leaders	
Resources	
Critical Review	
Bibliography of NE-107 Research	
<b>RESPONSE TO REVIEWERS</b>	48

## I. JUSTIFICATION

**Statement of the Problem.** Potato production in the Northeast spans a very diverse set of growing environments, pest complexes and produce markets. These factors require the development of cultivars which are either broadly adapted or suited for specific production and/or marketing niches. The commercial tetraploid potato, *Solanum tuberosum* Group *Tuberosum* (Tuberosum) lacks strong resistances to many diseases (such as late blight, early blight and scab) and pests (such as Colorado potato beetle and nematodes) that potato growers are likely to encounter during the normal growing season and is deficient in many quality characteristics that changing and emerging markets require. In order to sustain both the environment and economic profitability of potato production in the Northeast, new cultivars need to be developed, evaluated and released to the growing community. Three US potato breeding programs exist in the Northeast: two state and one federal. In addition, the Canadian potato breeding program in Agriculture and Agri-Food Canada also has a strong emphasis on breeding new cultivars for the northeast region. These four programs develop most of the new cultivars that are eventually adopted by northeastern growers. The development of these new cultivars takes place in three major steps. First, the breeding programs generate segregating populations and evaluate them for a few traits under consideration. This is done in close cooperation with one to three other university programs. Second, superior progeny from these segregating populations are identified for evaluation for additional economically important traits with the cooperation of a wider circle of university and industry cooperators representing over a dozen environmental sites. Third, a set of production recommendations for the grower prior to cultivar release are developed. Without these three steps, no new cultivar could be successfully introduced. The NE-107 Project was developed to encompass these three steps.

**Value of the Potato in the Northeast.** The potato is the leading vegetable crop in the Northeast region. Farm value receipts for the potato crop produced in the 14 northeastern states in 1993 was over \$264 million. The northeastern potato crop is marketed in one of four main ways: as certified seed, tablestock, for chipping or for french fry production. In Maine and New York, 35.3% and 6.4%, respectively, of the potato acreage was planted for certified seed in 1993. The tablestock market consists primarily of round, white-skinned potatoes suitable for boiling and mashing. There are 41 potato chip plants in the northeastern region which account for 29% of the total U.S. potato chip production. McCain Foods, an international company with processing plants in the Northeast, currently produces french fries from Shepody, a long, white-skinned cultivar, but they are constantly evaluating new long tuber types from the northeastern breeding programs for their suitability for the french fry industry. The Northeast potato industry is in the midst of or adjacent to the largest population concentration in the United States. Research aiding this industry will impact on markets and production associated with over half of the populations of the United States and Canada. Consumers in the area will benefit from efficient production of fresh tablestock, chipping stock, and other processing types of potatoes in the Northeast.

**Need for Better Potato Cultivars.** Potato growers in the northeastern United States and eastern Canada need better adapted, pest resistant cultivars to serve the large markets in the region. Maintaining the potato grower's profitability while achieving improvements in yield and/or quality, and reducing negative environmental impacts is a major goal of today's research. Potato production involves the use of many types of chemicals, such as fertilizers, insecticides,

nematicides, fungicides, herbicides, vine desiccants, sprout inhibitors, seed treatments and sterilization agents. Overall reduction in the use of chemicals in potato production is desirable. Growers will benefit from reduced input costs and the environment will benefit. One of the most effective ways of reducing chemical use in potato production is through the development of new cultivars which have improved pest resistances, efficient fertilizer use, acceptable quality from long-term storage, and proper vine types for timely maturation and the control of weeds.

**Need for New Tablestock Cultivars.** The traditional tablestock potato from the Northeast is round and white-skinned. Katahdin was the standard of this industry until recently, when Superior, Monona and Norwis gained in popularity. Growers now consider Katahdin a bit too late in maturity and too susceptible to scab. Superior, Monona, and Norwis lack good tuber appearance. There is a need to produce an attractive, high yielding, round, white-skinned cultivar to preserve this tablestock market. Disease resistance and freedom from skin blemishes is essential. The selected clone should have an intermediate specific gravity (dry matter) with freedom from sloughing after boiling.

**Need for New Chipping Cultivars.** Round, white-skinned chipping cultivars which are disease resistant, high in dry matter, low in sugar and free of internal defects are needed. There are two distinct marketing opportunities for chip potatoes in the Northeast region. Potato producers from the more southern areas of the northeastern region sell their potatoes for processing directly following harvest. Atlantic is currently grown in these areas for chipping, but is susceptible to internal heat necrosis. New cultivars must be free of internal heat necrosis and process into chips with acceptable chip color within seven days of harvest. Potato producers from the more northern areas of the northeastern region may sell their potatoes for processing directly following harvest, but most are sold for processing following storage throughout the fall and winter. Cultivars with the ability to chip from long-term cool storage are needed so that reliance on agricultural chemical sprout inhibitors can be reduced and product quality can be maintained or improved.

**Need for New Russet-Skinned Baking Cultivars.** Increased consumer demand for baking potatoes requires that growers shift more attention to production of fresh market russet-skinned cultivars. New cultivars are needed since the fresh market russet cultivars developed in western and midwestern states are poorly adapted to much of the Northeast. Recent releases from the USDA, such as BelRus and Coastal Russet, have provided important marketing opportunities for russeted potatoes; however, additional new cultivars are needed which are higher yielding and have improved disease resistance and quality attributes.

**Need for New Cultivars for the Refrigerated and Frozen Potato Industry.** French fries form the bulk of the frozen food potato industry. New cultivars are needed since the standard russet cultivar, Russet Burbank, is poorly adapted to much of the Northeast. These new cultivars need to combine high yield, uniform oblong to long tuber shape, high specific gravity and acceptable fry color under Northeast growing conditions. In addition, a market for pre-peeled, refrigerated products is emerging. No research has been published looking at the effect of storage time and temperature on the processing of specific cultivars into pre-peeled refrigerated products. As new cultivars are developed they need to be evaluated for the rate of enzymatic browning on the tuber cut surfaces. Research on the use of various physical and chemical treatments to retard browning also need to be evaluated.

**Need for New Cultivars for Specialty Markets.** Improved potato cultivars are needed to meet expanded demand in several key marketing categories. High value markets exist for specialty potatoes with purple skin, red skin, and/or yellow-flesh. Adapted cultivars with these characteristics could maintain profitability for many potato producers in the Northeast. Currently available red-skinned cultivars do not produce a red enough skin to satisfy the market under Northeast growing conditions, especially when marketed from storage.

**Disease and Insect Resistant Cultivars.** The development of genetic resistance to major pests is critical to ensuring efficient crop production and improving protection of the environment. Disease and insect resistant cultivars provide an economical and environmentally sound means of producing potatoes in regions where pervasive disease problems exist. Development of resistant cultivars which are high yielding and suitable for existing markets is preferable to continued reliance on foliar fungicides, insecticides, seed treatments, nematicides and soil fumigants. *Tuberosum* does not possess sufficient resistance to many important potato pests. Concerted efforts are needed to identify new genetic sources of resistance and incorporate them into productive *Tuberosum* clones. Major pests and diseases which hamper potato production in the northeastern region include *Leptinotarsa decemlineata* (Colorado potato beetle), *Phytophthora infestans* (the causal organism of late blight), *Alternaria solani* (the causal organism of early blight), *Streptomyces spp.* (the causal organisms of scab), *Rhizoctonia solani* (the causal organism of rhizoctonia canker and black scurf), *Globodera rostochiensis* (golden nematode) and *Pratelenchus spp.* (root lesion nematodes). Current Colorado potato beetle control strategies rely heavily on the use of insecticides; however, CPB rapidly develops resistance to most insecticides soon after their commercial introduction. Likewise, *Phytophthora infestans*, *Helminthosporium solani* (the causal organism of silver scurf) and *Fusarium sp.* (the causal organisms of dry rots) have recently developed resistance to the fungicides previously used to control them. The state of Maine became eligible for Federal disaster relief following the late blight epidemic of 1994. Development of pest resistant potato cultivars will be an important resource for commercial potato growers to enable them to sustain their economic viability and minimize environmental degradation. In addition to actively breeding for resistance to the most economically important diseases and insect pests of potatoes, it is necessary to screen developing germplasm for a number of other diseases which may occur quite sporadically, such as viruses, bacterial ring rot, pink rot, dry rot and silver scurf. Nevertheless, information on the disease reaction of a new cultivar to these other diseases is important because it reduces the risk of severe loss to sporadic disease, reduces inputs required for disease control, allows growers to avoid particularly susceptible cultivars in areas at particular risk and allows growers wider latitude in their management strategies. Where the primary control of disease is by inspection rather than resistance (such as viruses and bacterial ring rot), knowledgeable selection can prevent the release of tolerant cultivars which harbor inoculum without showing detectable symptoms.

**Nitrogen Efficient Cultivars.** Current potato cultivars require varying amounts of applied fertilizers for optimal yield. Growers often apply more fertilizer, primarily nitrogen, than is necessary. The genetic variation in response to nitrogen has not been fully exploited. The identification of selections that are nitrogen efficient will be helpful in utilizing our natural resources more wisely and will reduce the potential for nitrate contamination of groundwater.

**Early Maturing Cultivars.** Well-adapted potato cultivars which produce high yields and mature under the short-season conditions prevalent throughout much of the

Northeast would require fewer applications of vine desiccant than older, late-maturing cultivars such as Russet Burbank and Katahdin, and would require less inputs of insecticides and fungicides to control late season pests. The development of early-maturing cultivars would also be advantageous in southern NE-107 locations because these cultivars would escape excessively high summer temperatures which decrease yield and tuber quality.

**Regional Evaluation and Modeling Efforts.** The potato is indigenous to South America and is best adapted to cool temperate environments (Hawkes, 1978). However, due to its high yield potential and value as a highly nutritious food, it is now grown in many environments very different from its site of origin. In many of these production regions, potatoes are exposed to longer day length, higher day and/or night temperatures and numerous other stressful conditions (Tai, et al, 1994). Genotype by environment interactions must be evaluated to aid in breeding for new cultivars with improved adaptation to production sites and cultural practices (Hill, 1975; Souza et al, 1993; Zobel et al, 1988). Thus, the development of a new cultivar is not complete until it has been properly evaluated over a range of environmental conditions, a wide array of disease and pest pressures, and subjected to numerous production practices. The regional research approach through the NE-107 project is the most efficient method of providing breeders, researchers, extension agents, growers and other potato industry members the opportunity to develop and evaluate new cultivars. This approach lends itself to the study of cultural practices that will optimize production of new cultivars over a wide range of soil, environmental and agricultural conditions.

**Value of the Regional Approach.** It may take 10-12 years from the time a cross is initially made until a new cultivar is released from that cross. Breeders not only generate the crosses, in the early stages of evaluation they are responsible for maintaining and increasing clean seed for distribution to a limited number of cooperating scientists, obtaining information back from these scientists, and making final decisions as to which selections have enough merit to put into tissue culture and enter into certification programs. Before a selection is ever entered into certification programs for regional testing in projects such as NE-107, breeders have been working closely with pathologists, entomologists, physiologists and agronomists. Such cooperation frequently involves several institutions in the region. Evaluations for specific traits are conducted at those institutions where the expertise exists, not necessarily at those institutions where the breeding was done. One of the strengths of the NE-107 Project has been the size of the four breeding programs associated with it. These breeding programs are large enough to sustain a critical mass of germplasm for breeding purposes. Over the years, the breeders associated with these programs have developed a system of cooperation encompassing scientists at multiple state locations to evaluate the developing germplasm for numerous traits that are important to the regional industry. Each state cooperates in this regional testing in the area of their scientific expertise. Such a system minimizes duplication of efforts and maximizes results for the overall region.

## II. RELATED CURRENT AND PREVIOUS WORK

Active CRIS reports list 255 projects involving various phases of potato breeding, potato genetics and varietal development in the U.S. and Canada. The activities of most of these projects are known to the NE-107 cooperators either by professional contacts, through publications, or by attendance at the annual meetings of the Potato

Association of America.

The objectives and activities of related projects, such as NRSP-6 (introduction, preservation, distribution, and evaluation of *Solanum* species), NCR-84 (potato genetics), and WRCC-27 (potato variety development) have been considered and are not in conflict with this project. NE-107 interacts with these projects through exchange of promising germplasm and published bulletins. There is a need for good communication between regions to take advantage of widely adapted germplasm. Occasionally a selection from the Western or Northcentral region will perform fairly well in the Northeast. However, these are the exceptions. In order to obtain selections which are well adapted to the Northeast region those clones usually must be selected in the Northeast. This principle applies to other regions as well.

**Tablestock Cultivars.** Several selections from the potato breeding programs in the Northeast region have either been released or are in the later stages of evaluation for their potential for the round, white-skinned tablestock market. Mainestay (Maine Agricultural and Forest Experiment Station, 1995), Allegany (Plaisted et al, 1993), Portage (Reeves et al, 1995), Prestile (Reeves et al, 1994), and St. Johns (Reeves et al, 1996) have all been released as tablestock cultivars recently. Of these new cultivars, the most successful to date has been Mainestay, which ranked sixth in certified acreage in Maine in 1995. Portage, which was found to skin too easily at harvest, and Prestile, which developed problems with air cracking, have found no industry interest. St. Johns has resistance to corky ring spot and golden nematode. It is being introduced to several other countries by Hetteema, a Dutch potato company. AF 1470-17 is another medium-late maturing, high-yielding selection which has some commercial interest. It stores well and has a high proportion of marketable tubers. NY84 is a high yielding clone with bright skin and good scab resistance. There were 64 acres of foundation seed of NY84 produced in 1995. It is earlier than Genesee and has larger tuber size. E11-45 is also suitable for tablestock and produces good chip color. However, its low specific gravity will confine it to tablestock markets. All of these clones have been tested in the NE-107 project.

**Chipping Cultivars.** Atlantic is the highest dry matter chipping cultivar grown on a commercial scale in the NE-107 region and all high dry matter cultivars are genetically related to Atlantic (Haynes et al, 1995). However, Atlantic is very susceptible to internal heat necrosis. Since processors demand high dry matter potatoes, it is necessary to determine the feasibility of developing high dry matter potato populations without excessive internal heat necrosis. Presently unknown is the relationship between high dry matter content, as measured by specific gravity, and susceptibility to internal heat necrosis. High yields must be maintained, yet tetraploid potato selections appear to show an inverse relationship between yields and specific gravity (Haynes et al, 1989b). It may be possible to circumvent this inverse relationship by taking advantage of heterotic responses that occur in 4x-2x crosses involving unrelated parental materials. High specific gravity is heritable in the diploid *S. tuberosum* Group *phureja-stenotomum* (PHU-STN) population (Haynes et al, 1989a) and selection for horticultural characteristics in this population can be conducted without sacrificing specific gravity (Haynes and Haynes, 1990). Variation for high specific gravity in this PHU-STN population is divided roughly into three equal parts: additive genetic, nonadditive genetic and genotype x environment (Haynes et al, 1995). Most of the variation arising from additive and nonadditive genetic sources can be transferred to tetraploid progeny via 4x-2x crosses (Mendiburu et al, 1974).

Much of the Northeast potato crop is placed in storage and marketed during the fall



and winter months. Sprout growth and weight loss in potatoes are reduced by low temperature storage; however, such storage conditions result in sugar accumulation and unacceptable processing quality in currently available processing cultivars. Consequently, processing cultivars are currently treated with sprout inhibiting chemicals and stored under warm conditions. Growers often apply sprout inhibitors to maintain tuber quality in storage for those cultivars which sprout early and rapidly lose quality when not treated. Development of new cultivars with long dormancy during low temperature storage would reduce the need for sprout inhibitors and allow growers to maintain tuber quality without chemical use. Progress has been made in the development of cold temperature chipping cultivars in the Northeast, namely, MaineChip (Reeves et al, 1994), AC Novachip (DeJong et al, 1995), Suncrisp (USDA et al., 1993), Pike<sup>1</sup> and Andover<sup>1</sup>. However, new cultivars that will process after even longer periods and lower storage temperatures are needed. Thus, new genetic sources of long-term cold storage chipping ability must be exploited. Two diploid potato species reportedly have long-term cold storage chipping ability: *S. tuberosum* Group *phureja* and *S. raphanifolium* (Hanneman, 1993). Selection for clones which maintain processing quality during cool temperature storage is currently underway and is a viable approach towards reducing sprout inhibitor use by potato producers. Energy consumption associated with warm temperature storage of chipping potatoes would also be reduced.

**Russet-Skinned Cultivars.** One russet-skinned cultivar which has been extensively tested in the NE-107 project and shows promise for Northeast growing conditions is B9922-11. This clone can be marketed either for fresh market or for processing into french fries. Yield and percentage of tubers greater than 8 oz is significantly better than either BelRus or Coastal Russet, two russet-skinned cultivars previously developed for the Northeast region. It is resistant to common scab, *Verticillium* wilt and race RO<sub>1</sub> of the golden nematode. Management studies are currently underway to develop a set of grower recommendations for this clone. Once these studies are concluded, B9922-11 will likely be named and released as a new cultivar.

**Refrigerated Potato Products.** Although research has been performed on the rate of enzymatic browning of the cut surfaces of potato cultivars (Sapers et al, 1989) as well as on the use of various physical and chemical treatments to retard browning (Sapers and Miller, 1993; Sapers and Miller, 1995), no research has been published looking at the effect of storage time and temperature on the processing of specific cultivars into pre-peeled refrigerated products.

**Specialty Cultivars.** The consumer acceptance of and willingness to pay a premium price for the yellow-flesh cultivar 'Yukon Gold' has resulted in renewed emphasis in breeding programs for developing new yellow-flesh cultivars. Methods of sampling for yellow-flesh intensity have been identified to reduce labor costs associated with the measurements while preserving the statistical sensitivity of the tests (Haynes et al, 1994). In addition, the influence of genotype x environment interactions on yellow-flesh intensity of tetraploid clonal selections is very small, indicating that selecting for yellow-flesh intensity can be done in one location (Haynes et al, 1996). Yellow-flesh intensity is highly heritable in the diploid hybrid PHU-STN population, indicating that the development of very intense yellow-flesh in this population will be easy (K.G. Haynes, personal communication).

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<sup>1</sup> The release notices for these new cultivars are being prepared by R.L. Plaisted, Cornell Univ. and B.J. Christ, Penn State U.

Heavy tuber netting exists in most Tuberosum red-skinned selections for the Northeast which severely limits their marketability. Redsen, which is one cultivar which does not have this problem, has not gained commercial acceptance because it skins easily during harvest and suffers from seed piece decay problems. In addition, all red-skinned cultivars currently available are susceptible to silver scurf, which is a serious tuber surface blemish.

**Colorado potato beetle.** A population with resistance to the Colorado potato beetle has been developed utilizing *Solanum berthaultii* (Bonierbale et al, 1992; Bonierbale et al, 1994). The clone NYL235-4, which has good resistance to CPB along with acceptable tuber conformation, has been released as germplasm to other breeders working on resistance to the CPB (Plaisted et al, 1992). Superior CPB resistant selections continue to be backcrossed to Tuberosum to incorporate CPB resistance into a more horticulturally acceptable form.

**Late blight.** R-gene (race-specific) resistance, generally derived from *Solanum demissum* has been used for late blight control for nearly a century (Forbes et al, 1994). The pathogen population rapidly generates strains which overcome specific genes, and race-specific resistance has largely been abandoned. Genome mapping of R genes is progressing (El-Kharbotly et al, 1994; Leonard-Schippers et al, 1994; Meksem et al, 1995) but their practical use is unlikely unless many cloned genes are included in a pyramiding scheme. Three of the breeding programs associated with the NE-107 project have had long-term breeding efforts for resistance to late blight. In 1966, Cornell University initiated a project of developing a tetraploid *S. andigena* and *S. vernei* population for adaptation and late blight resistance (R.L. Plaisted, personal communication). Selections for these two traits continued until ten years ago, when it was discontinued due to lack of funding for blight resistance. A few of the surviving clones were included in the blight trial in 1995 and displayed good resistance. True seeds held in cold storage for these past ten years have been retrieved and planted. In the 1995 late blight trial, the clone Q237-25 displayed exceptional resistance, in addition to qualities acceptable to the chipping industry, resistance to potato virus Y and race RO<sub>1</sub> of the golden nematode. In 1976 the USDA program initiated a breeding effort for late blight resistance using plant introductions with *S. demissum* germplasm (Goth et al, 1994). This work has continued to the present date and two blight resistant selections from this population will shortly be released as germplasm to other breeders (K.G. Haynes, personal communication). In addition, initial screening of the hybrid diploid population PHU-STN, which has also undergone more than ten cycles of recurrent selection for adaptation, suggests that there is good resistance to late blight in this population as well (K.G. Haynes, personal communication). The nature of the resistances in these genetic materials is currently unknown. The Canadian potato breeding program has developed a population of well adapted Andigena clones with good resistance to late blight.

Because fungicides have been available for suppression of late blight, and because quantitative transfer of polygenic horizontal resistance is difficult, it has seldom been a prime objective when breeding cultivars for developed countries. With mounting concerns about the safety, expense, and ultimate reliability of fungicides in the face of increasingly virulent *Phytophthora* strains, horizontal resistance is now seen as the most appropriate long-term strategy for improvements in blight control.

**Early blight.** Currently, the fungicides available for *Alternaria* are not highly effective (Fry, 1994). Simulation models indicate that the replacement of a susceptible cultivar with one having moderate resistance to early blight would allow

a 50% reduction in the amount of fungicide required to suppress the disease. Most cultivars are quite susceptible. However, Castile (Halseth et al, 1991), one of the cultivars developed and tested through the NE-107 project has moderate levels of resistance to early blight, such that fewer fungicide sprays need be applied during the growing season (Stevenson, 1994). Higher levels of resistance are still necessary to further reduce fungicide application. Resistance to early blight in the PHU-STN population is highly heritable (Herriott et al, 19886; Ortiz et al, 1993). These diploids have been used in 4x-2x crosses with Tuberosum germplasm and the resultant progenies also had good levels of resistance to early blight (Herriott et al, 1990). Early blight resistant progenies from these 4x-2x crosses have been backcrossed to Tuberosum to improve tuber conformation.

**Common scab.** The physiological/anatomical basis for scab resistance and its inheritance is not well understood. Scab evaluation is normally done for advanced selections under field conditions. Rating techniques have recently been expanded to allow selections to be clustered on the basis of the type of scab lesion they develop and the amount of tuber surface area infected (Goth et al, 1993). Genetic variation in Tuberosum accounted for most of the observed variation for scab reaction as measured by either the type of lesion or the amount of surface area covered (K.G. Haynes, personal communication). Genotype x environment interactions in this later test were quite low, which may be due to the fact that all four environments were extremely conducive to the development of scab. Resistance to common scab which is available on the diploid level can be transmitted effectively to the tetraploid level via 4x-2x crosses (Murphy et al., 1995). A technique which would allow earlier, more uniform screening of breeding lines is desirable. One possibility is the use of the pathogen's toxin, thaxtomin, to screen minitubers (Loria, 1994).

**Bacterial Ring Rot.** Bacterial ring rot is caused by *Corynebacterium michiganense* subsp. *sepedonicus*. It is a disease which is currently controlled by inspection/regulation rather than by resistance or tolerance. Detection occurs during foliage inspections at seed farms prior to vine kill and, to a lesser extent, during subsequent tuber inspections. Adequate symptom expression is essential for detection, but field symptoms often vary in their degree and appearance with environmental conditions, disease severity, and cultivar (Gudmestad, 1994; Kurowski and Manzer, 1992; Westra et al, 1994). Very tolerant cultivars fail to show any symptoms despite high vascular titers of the bacterium (Manzer and Kurowski, 1992). Therefore, all developing breeding selections, especially those with a potential market in Canada, require symptom screening.

**Rhizoctonia.** Rhizoctonia disease, caused primarily by *Rhizoctonia solani* AG3, is one of the most serious diseases of potatoes because of its endemic and ubiquitous presence. Marketable yield losses of up to 30% are often cited, although losses of 10 - 15% are more common (Carling et al, 1989; Little et al, 1988). Resistance to this disease is not present in currently available cultivars.

**Golden nematode.** Several potato cultivars with resistance to the RO<sub>1</sub> race of the golden nematode (*Globodera rostochiensis*) were originally tested in the NE-107 Project and are available from foundation seed growers: Allegany (Plaisted et al, 1993), Castile (Halseth et al, 1991), Elba (Thurston et al, 1985), Hampton (Plaisted et al, 1985), Kanona (Plaisted et al, 1989), Steuben (Plaisted et al, 1991) and Genesee (Plaisted et al, 1993). Of these, Kanona, and Allegany have received the widest acceptance. In 1995, the fourth largest seed acreage in New York was planted to Kanona. Allegany was initially adopted by tablestock growers, but is gaining some acceptance by chipstock growers. Genesee was released in 1993 and may serve the

needs of part of the industry for a cultivar with bright white skin and attractive shape. In 1995 trials, Elba again displayed better late blight resistance than other named cultivars.

Recently, a new race (RO<sub>2</sub>) of golden nematode was reported in New York (Brodie, 1995; Brodie, 1996). Resistance to this new race of the golden nematode was found in an Andigena and *S. vernei* population. The RO<sub>2</sub> resistant clones from this population are important parental materials for developing cultivars resistant to this new race of golden nematode. Long, russet-skinned and red-skinned cultivars with resistance to this new race of the golden nematode are nonexistent.

The location of the resistance gene for race RO<sub>1</sub> has been mapped (Ballvora et al, 1995; Barone et al, 1990; Pineda et al, 1992). The location of the resistance gene for race RO<sub>2</sub> is being pursued at Cornell.

**Root lesion nematodes.** With the declining use of systemic insecticidal/nematicidal compounds root lesion nematodes have reemerged as a serious potato production problem. Not only do these nematodes cause production losses alone, their interaction with the *Verticillium* wilt fungus also increases the severity of potato early dying disease. A relatively high level of resistance to root lesion nematodes has been identified in an Andigena and *S. vernei* population (Brodie and Plaisted, 1993). Recent discovery of races of this nematode that can overcome this resistance has resulted in an added level of difficulty in breeding for resistance.

**Potato Viruses.** Potato viruses, a particular problem for seed producers, are presently controlled by certification, inspection, and vector reduction. Host resistance which reduces severity is beneficial unless it masks foliar symptoms. Consequently, very susceptible selections may be discarded, but marginal improvement in resistance is seldom a breeding objective. The potential for severe phloem (net) necrosis damage in tubers, caused by potato leaf roll virus (PLRV), is a serious defect. Within two-three years, genetically-engineered resistance to PLRV should be commercially available in Russet Burbank, and PVY resistance should be available in Shepody. Resistance to these viruses will likely be transformed into certain other cultivars as well. Whether a substantial number of cultivars will be protected in this way remains to be seen. Two genes controlling extreme resistance to PVX have been mapped on the potato genome (Ritter et al, 1991), and these might also be transformed into established cultivars.

**Regional Evaluation and Modelling Efforts.** Performance data obtained from collaborative trials in the NE-107 project have provided a rich and unique source of information to carry out research work on genotype x environment interactions of advanced selections for the Northeast. The project has developed two sets of "baseline" data: one consisting of six industry standards to be grown at all sites for each season; the other being "breeders choices" where each of the participating breeders indicates one to three selections that everyone should test at all sites for that year. This dataset provides the opportunity to compare performance of many new breeding selections in a short period of testing. Extension cooperators (ME) have developed two extensive potato databases for use with PC software. One dataset includes all NE-107 trial data for 1990-1994 in Excel and Lotus spreadsheet formats. The second is information (including disease resistance, maturity, yield, dry matter, tuber characteristics, plant spacing and fertilizer rates) on 775 potato varieties and clones in a Microsoft Access 2.0 program.

A problem associated with the data is that not all selections are evaluated in all trials. This represents the situation of "incomplete two-way tables" in statistical analysis (Ouyang et al, 1995, Patterson and Thompson, 1971). Recent developments

in statistical methodology provide a number of new and efficient procedures to examine such types of data. The analytic results give much insight on the interplay between genotype and environments. A preliminary report on marketable yield of round, white-skinned potatoes indicates the usefulness of a linear regression method to evaluate the performance and adaptability of selections (Tai et al, 1993). Further work using such sophisticated statistical methods as: AMMI (additive main effect and multiplicative interaction model)[Gauch, 1992]; BLUP (best linear unbiased predictor); and REML (residual maximum likelihood)[Genstat, 1993; Horgan, 1992] are underway.

### III. OBJECTIVES

Three objectives for the NE-107 Project are proposed. These objectives were selected based on the needs of the potato industry in the northeast region and the existing scientific expertise at the state and federal levels to address these needs. The marketing opportunities for the region are varied and these objectives address critical research that needs to be undertaken to maintain economic and environmental sustainability for the potato industry. These objectives are:

- (1) Determine the heritability of traits of economic importance and improve the genetic base of tetraploid potatoes.
- (2) Evaluate pest resistant, early-maturing, long-dormant varieties for fresh market and/or processing from cold storage.
- (3) Identify and quantify significant climatic and cultural effects on the performance of potato selections.

### IV. PROCEDURES

- (1) **Determine the heritability of traits of economic importance and improve the genetic base of potatoes.**

**Procedure 1.a. Determine the heritability of internal heat necrosis in chipping lines and any relationship between high specific gravity and susceptibility to internal heat necrosis.** Previous research (Henninger et al, 1994) has demonstrated that the incidence of internal heat necrosis is largely a function of genotype. The exact nature of the genetic effect(s) involved in the expression of resistance to internal heat necrosis have yet to be elucidated. Tetraploid populations segregating for incidence of internal heat necrosis and specific gravity have been developed by the USDA and will continue to undergo evaluation in New Jersey and Virginia. Data will be subjected to genetic analysis to determine: 1) the genetic mechanisms involved in resistance to internal heat necrosis and; 2) the possibility of a linkage between the incidence of internal heat necrosis and specific gravity. Heritability of internal necrosis in potato chipping lines will be determined using the experimental design proposed by Levings and Dudley (1964) for autotetraploid populations. To obtain unbiased estimates of narrow-sense heritability, three populations have been developed for testing: the parent clonal population, a population for regressing offspring on parents, and a population for a design II mating scheme. Genotype x environment correlations will be removed by proper replication and randomization over space and time. The genetic variance components from the offspring-parent regression are composed of additive and digenic variance. The genetic variance components from the full-sib and half-sib populations derived from the design II

mating scheme are composed of additive, digenic, trigenic, and quadrigenic variance, and additive and digenic variance, respectively. Thus, there will be five equations available for estimating four parameters. The adequacy of a model with no epistatic components of variance can be tested with one degree of freedom. Partial correlation coefficients between incidence of internal heat necrosis and specific gravity will be computed after location, year, replications and family effects have been removed. In addition, high specific gravity diploids from PHU-STN will be utilized in 4x-2x crosses with *Tuberosum* to develop new genetic sources of high specific gravity (USDA). These hybrids will also be evaluated for internal heat necrosis in New Jersey, Virginia and North Carolina, and the inheritance of high dry matter via 4x-2x crosses from this population will be determined.

COOPERATORS: M. R. Henninger (Rutgers, NJ), S. Sterrett (VA Tech, VA), K. G. Haynes (USDA, MD), C. Yencho (NCSU, NC).

**Procedure 1.b. Determine the inheritance of long-term cold storage processing ability in diploid potatoes and improve the genetic base for this trait.** Diploid potatoes from *S. raphanifolium* and PHU-STN will be screened for their ability to produce chips of acceptable color following long-term storage at 40F (USDA). Crosses between and within these two diploid populations will be made and segregating families evaluated for their ability to produce chips of acceptable color following long-term storage (USDA, NY, PA). The inheritance of cold-temperature chipping ability will be determined by mid-parent-offspring regression. Promising selections will be screened for the presence of 2n pollen to determine their suitability as parents in 4x-2x crosses (USDA). Both diploid and tetraploid selections with the ability to produce light colored chips or fries after prolonged cold storage will be intercrossed and their progeny evaluated for processing ability following prolonged cold storage. Promising selections will be entered into regional trials for further evaluation (USDA, ME, Canada).

COOPERATORS: K.G. Haynes (USDA, MD), A.F. Reeves (U ME, ME), H. DeJong (Canada), D.E. Halseth (Cornell, NY), B.J. Christ (Penn State, PA).

**Procedure 1.c. Improve the genetic base of yellow-flesh potatoes.** Total carotenoid content of yellow-flesh diploid potatoes from PHU-STN ranges from 5 - 10 times that found in tetraploid white-flesh potatoes and 1.5 - 4 times that found in yellow-flesh potatoes (K.G. Haynes, personal communication). Thus, the yellow-flesh diploids are a source of new germplasm for improving yellow-flesh intensity and carotenoid content in tetraploid potatoes. Yellow-fleshed diploid potatoes from a hybrid population of PHU-STN will be outcrossed to tetraploid yellow-flesh selections from *Solanum tuberosum*. These populations will be evaluated for yellow-flesh intensity, yield, tuber characteristics (specific gravity, internal heat necrosis, size, smoothness, dormancy, shape), processing and/or fresh market capabilities and nutritional quality at multiple state locations (USDA, NJ, NY, PA). The heritability of yellow-flesh intensity in the diploid population is very high (K.G. Haynes, personal communication), so in addition to furnishing parental material for immediate 4x-2x crosses it should be possible to easily improve the yellow-flesh intensity and carotenoid content of these diploids for future 4x-2x crossing. The inheritance of yellow-flesh intensity at the 4x-2x level will be studied utilizing the models previously defined by Haynes (1990). Genotypic stability (Kang, 1990) of selected 4x-2x progeny will be evaluated at multiple state locations to insure wide adaptability prior to release as a new cultivar. There is considerable interest in developing small "B" size yellow-flesh cultivars for specialty markets. Thus, in addition to furnishing germplasm for use in 4x-2x crosses, many of these diploids

will be evaluated for their potential in filling this new marketing niche. Promising diploids will be intercrossed and the general and specific combining ability of these diploids for traits such as yield, size, smoothness, maturity and freedom from internal defects will be determined. Promising selections will be evaluated at multiple state locations (NJ, NY, PA, ME, DE, Canada).

COOPERATORS: K.G. Haynes (USDA, MD), M. R. Henninger (Rutgers, NJ), J. B. Siczka (Cornell, NY), M. Orzolek (Penn State, PA), E. Kee (DE), H. DeJong (Canada).

**Procedure 1.d. Improve the Genetic Base of Red-skinned Potatoes.** Crosses between Tuberosum red-skinned cultivars and Tuberosum x PHU-STN red-skinned hybrids will be made, and segregating progeny evaluated for red-skin intensity, tuber conformation and appearance, and susceptibility to silver scurf (USDA, NY). In addition, these red-skinned PHU-STN hybrids will be intercrossed with the yellow-flesh PHU-STN hybrids to develop a population of red-skinned, yellow-flesh diploids with superior tuber conformation for specialty "B" markets and for use in future 4x-2x crosses. The tuber conformation of the yellow-flesh PHU-STN populations is already quite good.

COOPERATORS: K.G. Haynes (USDA, MD), D.E. Halseth (Cornell, NY), J.B. Siczka (Cornell, NY), H. DeJong (Canada), M. Orzolek (Penn State, PA).

**Procedure 1.e. Improve the Genetic Base of Resistance to the Colorado Potato Beetle.** Superior CPB resistant selections continue to be backcrossed to Tuberosum to incorporate CPB resistance into a tuber conformation that is more horticulturally acceptable. Progeny from these crosses are grown in CPB infested fields each year and the most resistant selections will then be utilized as parents in the next crossing cycle.

COOPERATORS: R.L. Plaisted (Cornell, NY), W. M. Tingey (Cornell, NY).

**Procedure 1.f. Improve the Genetic Base of Resistance to Late Blight.** Multiple genetic sources of resistance to late blight have been assembled by the USDA, Maine, New York, and Canadian potato breeding programs. Parental materials with both vertical and horizontal resistance to late blight are being used in these breeding programs. Segregating populations will be tested for their resistance to late blight (USDA, ME, NY and PA). The most promising late blight resistant selections will be entered into the international late blight trials at Toluca, Mexico. These late blight resistant selections will undergo further evaluation for either fresh or processing market potential.

COOPERATORS: K.G. Haynes (USDA, MD), K. Deahl (USDA, MD), R.W. Goth (USDA, MD), A.F. Reeves (U ME, ME), D.H. Lambert (U ME, ME), R.L. Plaisted (Cornell, NY), W. Fry (Cornell, NY), B.J. Christ (Penn State, PA), T.R. Tarn (Canada).

**Procedure 1.g. Improve the Genetic Base of Resistance to Early Blight.** Resistance to early blight, caused by *Alternaria solani*, has been identified in diploid potatoes and transferred into the tetraploid germplasm base via 4x-2x crosses. These 4x-2x crosses have been screened for resistance to early blight and four early blight resistant selections have been crossed to three advanced selections from the USDA potato breeding program and one cultivar. This segregating population will be evaluated for resistance to early blight, specific gravity and chipping potential (USDA, PA). General and specific combining abilities of these four early blight resistant selections will be determined. Selections with good levels of resistance to early blight will

undergo evaluation at multiple sites to determine their potential for either the fresh or processing markets.

COOPERATORS: K.G. Haynes (USDA, MD) and B.J. Christ (Penn State, PA).

**Procedure 1.h. Improve the Genetic Base of Resistance to Scab.** No potato chipping cultivar with scab resistance has been widely accepted by the processing industry, although Pike, a very scab resistant chipping cultivar tested through the NE-107 Project is being released by Cornell University and Penn State. A number of fresh market cultivars and advanced selections with scab resistance have been crossed to several chipping selections. Segregating populations will be evaluated for resistance to scab, specific gravity and fresh market or chipping potential (USDA, ME). Field resistance to scab will be correlated with thaxtomin response to assess the feasibility of using this laboratory screening procedure for screening populations early in the selection process (USDA, NY). The inheritance of scab resistance will be studied in diploid PHU-STN populations with varying levels of resistance to scab. These populations have already been generated and will be evaluated for scab resistance in the coming years (USDA, NY).

COOPERATORS: K.G. Haynes (USDA, MD), R.W. Goth (USDA, MD), A.F. Reeves (U ME, ME), R.L. Plaisted (Cornell, NY).

COLLABORATORS: N. Anderson (U Minn, MN), R. Loria (Cornell, NY).

**Procedure 1.i. Improve the Genetic Base of Resistance to Golden Nematode and Map the Genes Conferring Resistance.** Parental materials with resistance to either the RO<sub>1</sub> or RO<sub>2</sub> race of the golden nematode will be intercrossed to combine resistance to both races into potato clones that meet necessary marketing characteristics. Segregating populations will be evaluated for resistance to both races of the golden nematode and for superior horticultural characteristics. Mapping studies will continue to map the RO<sub>1</sub> and RO<sub>2</sub> genes conferring resistance to the golden nematode (NY).

COOPERATORS: R.L. Plaisted (Cornell, NY), B.B. Brodie (Cornell, NY).

**Procedure 1.j. Improve the Genetic Base of Resistance to Root Lesion Nematodes.** Crosses among parental materials with high levels of resistance to root lesion nematodes have been made to combine resistance to two different races of root lesion nematodes. Segregating populations will be evaluated for resistance to these different races of root lesion nematodes and adaptation. Backcrosses will be made between root lesion nematode resistant clones and Tuberosum to incorporate these resistances into adapted germplasm (NY).

COOPERATORS: R.L. Plaisted (Cornell, NY), B.B. Brodie (Cornell, NY).

**(2) Evaluate pest resistant, early-maturing, long-dormant cultivars for fresh market and/or processing from cold storage.**

**Plant Material.** Dr. G.A. Porter, Department of Plant, Soil and Environmental Sciences, University of Maine, will coordinate the introduction of new selections from the breeding programs associated with the NE-107 Project for regional testing. He will recommend seed increases sufficient to meet the needs of the project, distribute the seed and collect fees for the Maine Seed Potato Board (MSPB). Advanced selections from the breeding programs will be placed in tissue culture and maintained at the Porter Seed Farm in Masardis by the MSPB. Uniform plant



material will be generated for project cooperators by the MSPB. This common seed source is a vital component for valid research and modeling of environmental characteristics, since performance among potato seed sources varies widely according to the growing conditions and storage environments to which the seed stocks are exposed. The MSPB will generate and maintain foundation seed potatoes from disease-free stock furnished by each breeder. The MSPB will be responsible for the production of disease-free seed and will sell the seed to cooperators and others.

**Procedure 2.a. Evaluate Developing Clonal Material for Potential Use in the Refrigerated Pre-peeled Industry.** New cultivars will be evaluated at harvest and through nine months of storage relative to their performance in pre-peeled refrigerated products. Four to eight cultivars will be evaluated each year. At harvest the cultivars will be processed into whole boil and slices, treated with a commercially available extender, heat sealed in film with an  $O_2$  Tr of 300cc/100in<sup>2</sup>/24 hr, and stored at 4-5 C for 16 days. At the time of processing the polyphenol oxidase (PPO) activity (Hsu et al, 1984), free tyrosine (Sapers et al, 1993), and phenolic acid content will be determined for each cultivar. Phenolic acids will be extracted by the method of Ramamurthy et al (1992), and separated and quantified using high performance liquid chromatography. Following 1, 8, and 16 days of refrigerated storage whole boil tubers will be evaluated as a mashed product for color, flavor and texture. One hundred consumers who regularly consume mashed potatoes will be recruited to evaluate the samples. A seven point hedonic scale will be used for each attribute. Potato slices will be evaluated as french fries with sample preparation following standard industry protocols. Sample size will be three slices of each cultivar. A seven point hedonic scale will be used for flavor and texture while the USDA French Fry Color Chart will be used to evaluate color. Total aerobic, psychrophile and yeast counts will be performed on whole boil and french fry slices at each sampling period. Microbial and chemical data will be correlated with sensory results to determine the causes of potential quality loss. All of the above analyses will be performed on the cultivars following 1, 3, 6, and 9 months of storage at 5-6 C.

COOPERATOR: A. Bushway (U ME, ME).

**Procedure 2.b. Evaluate Promising Selections for Resistance to Rhizoctonia.** Screening for resistance to this disease focuses mainly on the infection phase, since resistance to infestation by sclerotia (black scurf) is controlled by many factors such as tuber maturity and the length of time tubers are left in the ground following senescence of the mother plant. Data will be collected on tuber malformations, presence of aerial tubers, yield losses, and distribution of tubers in the various size categories to determine response to infection in the field (Quebec). Genetic improvement of potato for resistance to rhizoctonia cannot proceed until sources of resistance to rhizoctonia are found.

COOPERATORS: G. Banville (Quebec), B. Otrysko (Quebec).

**Procedure 2.c. Evaluate Promising Selections for Resistance to Scab.** All selections undergoing evaluation for possible release as a new cultivar will be evaluated for their reaction to scab in replicated field trials (Canada). Cultivars with known reaction to scab will be included each year of the test as a basis for comparison.

COOPERATOR: A. Murphy (Canada).

**Procedure 2.d. Evaluate Promising Selections for Resistance to Late Blight.** All

selections undergoing evaluation for possible release as a new cultivar will be evaluated for their reaction to late blight in replicated field trials (ME, NY). Cultivars with known reaction to late blight will be included each year of the test as a basis for comparison.

COOPERATORS: D. H. Lambert (U ME, ME), W. Fry (Cornell, NY).

**Procedure 2.e. Evaluate Promising Selections for Early Maturity, Quality and Long Storage Potential.** All tablestock and specialty market selections undergoing evaluation for possible release as a new cultivar will be evaluated in replicated field trials in multiple locations (ME, NY, DE, PA, VA, NJ, OH, NC, Canada). Vine maturity notes recorded at each of these locations will be used to identify selections which mature early with minimal need for chemical desiccation. Total yield and marketable yield for different size categories will be determined at each site. Weight loss will be measured from potatoes grown in Maine to select clones which do not suffer significant shrinkage losses in storage (ME). Sprout length will be measured after 2-4 months of storage to select clones which do not require the use of plant growth regulators for sprout suppression (ME). Following harvest, tuber samples will be boiled, baked and microwaved to determine their suitability for fresh market (ME, Canada, PA). After cooking darkening, sloughing, taste and mealiness will be scored for all selections (ME, Canada, PA).

COOPERATORS: G. Porter (U ME, ME), E. Plissey (U ME, ME), D.E. Halseth (Cornell, NY), R.L. Plaisted (Cornell, NY) J.B. Siczka (Cornell, NY), M. Henninger (Rutgers, NJ), B.J. Christ (Penn State, PA), S. Sterrett (VA TECH, VA), R. Hassell (OH), E. Kee (DE), C. Yenke (NCSU,NC), H. DeJong (Canada).

**Procedure 2.f. Evaluate Promising Selections for Cold Storage Processing.** Total and marketable yield, size distribution and specific gravity will be determined for all selections evaluated at all locations that have an existing or potential market for stored potatoes (ME, NY, PA). Samples of cultivars and selections entered into the NE-107 project from the breeding programs will be stored at two temperatures. Weight loss will be measured to help select clones which do not require the use of plant growth regulators for sprout suppression (ME). Chip or fry color will be measured with an Agron instrument or with USDA Chip or Fry Color Charts following storage for 2-4 months at 4C (ME,NY,PA, USDA).

COOPERATORS: G. A. Porter (U ME, ME), D.E. Halseth (Cornell, NY), B.J. Christ (Penn State, PA), K.G. Haynes (USDA, MD), R.L. Plaisted (Cornell, NY).

**Procedure 2.g. Evaluate Promising Selections for Resistance to Viruses.** Advanced potato breeding selections in the NE-107 project will be planted in replicated field trials and mechanically inoculated with potato virus X and Y. Aphids which have fed on potato leaf roll infected plants will be used to inoculate advanced selections with the leaf roll virus. Visual symptoms of virus infection will be recorded as well as virus titres using ELISA. Following harvest tubers will be cut and scored for the presence and severity of net necrosis.

COOPERATOR: R. Storch (U ME, ME), A.F. Reeves (U ME, ME).

**Procedure 2. h. Evaluate Promising Selections for Resistance to Ring Rot.** Advanced potato breeding selections will be planted in replicated field trials in ring rot infested soil in Maine. Visual foliar symptoms will be recorded during the growing season. At harvest, tuber symptoms will be recorded.

COOPERATOR: D. H. Lambert (U ME, ME).

**(3) Identify and quantify significant climatic and cultural effects on the performance of potato selections.**

**3.a. Study the genetic mechanisms of potatoes for responding to environmental stresses and identify these major environmental stresses.** Clones with known stress tolerance or susceptibility can be used to develop an array of genotypes with a range of growth responses. Growing this array across the NE-107 trial sites will provide an opportunity to discern if different genetic mechanisms are providing the observed response and to correlate it to specific environmental parameters (all trial sites). Potato quality concerns such as internal heat necrosis, black spot and hollow heart, while not impacting yield, can make the crop totally unmarketable. Some important environmental factors may be mitigated by cultural practices such as irrigation, appropriate fertilization or timely harvest. Researchers (ME, NY) will conduct cultural practice experiments on new clones to determine optimal input levels.

COOPERATORS: D.E. Halseth (Cornell, NY), J.B. Sieczka (Cornell, NY), G.A. Porter (U ME, ME), A.F. Reeves (U ME, ME).

**3.b. Classify the Northeast region into broad and "distinct" growing areas.** Several statistical procedures (AMMI, BLUP, REML) will be used (Canada, NY) to identify growing sites with similar response patterns for specific groups of traits for various market niches (russets, round white table, chips and french fry). Characteristics with small genotype x environment interactions such as specific gravity (dry matter) would require less trial data to obtain precise production maps, whereas traits with highly sensitive responses to environmental stresses such as total yield or chip color would require much more testing to obtain satisfactory levels of precision. This would help provide a more rational and economic evaluation system for breeders, growers and industry personnel in different regions. Such a scheme would provide zones of adaptation, help to identify major environmental types in our trial system and lead to the possibility of reducing the number of testing sites (and/or replications).

COOPERATORS: D.E. Halseth (Cornell, NY), G.C.C.Tai (Canada).

**3.c. Develop predictive models based on performance data and climatic information.** Up-to-date statistical methods (Kang, 1990) will be used to reveal the underlying mechanism of genotype x environment interactions and determine performance stability and adaptability of cultivars and selections evaluated in the trial system. The results would lead to the development of predictive models for genotype performance. The data generated by the NE-107 project are derived from a well-organized research network, but do pose an interesting challenge for statistical analysis because they are in the form of an incomplete two-way table. The first attempt to subject such a massive incomplete two-way table to regional analysis was carried out according to a linear model (Tai et al, 1993). This data set will be analyzed with additional advanced statistical methods (AMMI, BLUP and REML) to obtain performance models with high precision.

Further research work will include the use of multivariate methods to characterize and evaluate the overall performance of promising entries in chosen regions according to specific economic objectives (Canada, NY). Crop growth models can be

constructed based on response patterns of genotypes to various environmental and cultural practice inputs (Baker, 1988; Crosa, 1990; Crosa et al, 1995). Such models, properly parameterized and calibrated, can serve as diagnostic and predictive tools to acquire a high level of performance in new cultivars and selections. This would help breeders in their selection making process, and help growers and processors to choose superior cultivars and identify appropriate management strategies for their crop. All locations will continue to test and screen new clones (as well as including a set of three standard cultivars grown by all cooperators) to expand this database, which is one of the largest of its kind in the world.

COOPERATORS: D.E. Halseth (Cornell, NY), G.C.C. Tai (Canada).

**3.d. Study the impact of genotype x environmental interactions on a "sustainable agriculture" cropping system.** Research is not conducted solely for obtaining a better understanding about the functioning of individual plants, but more importantly to gain an insight into how these processes interact and integrate, enabling one to better manage the system as a whole. Important environmental factors that should be tested against NE-107 germplasm are photoperiod, temperature, irradiance, and fertilization. Such factors should be parameterized for optimal and threshold concepts. To take the fullest advantage of advanced genotypes specific cultivar (or clonal) production profiles will need to be developed (ME, NJ, NY, PA). Such recommendations will include suggestions for optimal nitrogen fertilization, plant spacing, irrigation needs, length of growing season, degree growing days and storage temperatures.

COOPERATORS: G.A. Porter (U ME, ME), M.R. Henninger (Rutgers, NJ), J.B. Sieczka (Cornell, NY), D.E. Halseth (Cornell, NY), B.J. Christ (Penn State, PA), E. Plissey (U ME, ME), A.F. Reeves (U ME, ME)..

## V. EXPECTED OUTCOMES

The potato industry in the Northeast region is a multi-faceted industry covering fresh market round-whites, russets, red-skin, and/or yellow-flesh potatoes, and processing markets, primarily for chips, but with increasing emphasis on french fries and pre-peeled refrigerated products. The research program to be carried out under the revised NE-107 project is expected to benefit consumers of fresh market and processed potato products through the introduction of new potato cultivars with improved qualities for these various markets. It is expected to benefit producers through the introduction of new potato cultivars with improved disease and insect resistance combined with acceptable marketing qualities to reduce the economic inputs in terms of insecticides, fungicides, nematicides and chemical sprout inhibitors, which will minimize environmental degradation. With the testing and introduction of these new potato cultivars, this research is expected to result in an economically and environmentally sustainable potato production system for the Northeast region.

The development and evaluation of appropriate statistical methods for use in a large scale multi-site-year trial system not only provides effective means to select promising potato cultivars for the northeastern region, but also to identify critical environmental and cultural factors which influence productivity and performance of potatoes. Understanding the underlying causes of genotype x environmental interactions helps to select new cultivars which are more capable of standing up to major environmental stresses and thus reduces the need for intensive inputs and management practices. This is certainly in line with the concept of sustainable