

PROJECT SUMMARY

Title: Identification Of Factors Associated With Onion Bacterial Diseases To Facilitate The Development Of An Integrated Pest Management Program

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This is a 2-year multi-state research proposal requesting \$179,788 for research from P.L. 89-106. During the past 5 to 10 years, bacterial bulb decay has assumed much greater importance in the Northeast region. In PA and NY, annual losses range from 5 to 40%. However, disease losses are variable, both among and within fields; in many cases, the full extent of disease losses is not evident until harvest or thereafter. This proposal seeks to determine the factors that are correlated with more extensive losses from bacterial diseases. We hypothesize that the presence of inoculum of several important bacterial pathogens in soil, transplants and possibly weeds and thrips is strongly correlated to disease incidence and severity. In addition, we hypothesize that high levels of nitrogen fertilization, thrips-induced injury and wind-induced injury contribute to the incidence and severity of bacterial diseases. Our approach is to conduct intensive small plot surveys of factors related to the presence of inoculum in commercial fields and to determine the extent of bacterial disease development in those fields during the growing season, at harvest and following harvest. In addition, replicated on-farm research trials will be carried out to assess the relationship between nitrogen levels, thrips-induced injury and wind-induced injury and resulting bacterial decay in onions. Currently, small-scale diversified fresh market onion growers as well as large-scale onion producers lack effective tools with which to manage bacterial diseases in onions. The goal of this proposal are to identify important relationships and utilize such knowledge to develop IPM-based recommendations to reduce the likelihood of severe losses from bacteria pathogenic to onions.

Project Narrative:

(i) a. Problem

Onion growers in the northeastern United States are constantly challenged by yield losses due to bacterial bulb decay, which greatly compromise the quantity and quality of this crop. If bacterial diseases cannot be managed, growers in the Northeast region will not be able to grow onions profitably and thus production of a lucrative specialty crop could be greatly compromised.

Since the initiation of the Pennsylvania Simply Sweet Onion Program (<http://www.harvestvalleyfarms.com/passonion.html>) in 2002, the state's only trademarked crop, the market for both program onions and non-program sweet onions in PA has grown tremendously. In 2008, the estimated value of sweet Spanish onions grown on 200 A by 100 growers in PA was \$1.5 million dollars, which has increased to an estimated 300 A with a value of \$2.5 million in 2010 (M. Orzolek, personal communication). In PA, onion are typically grown in mineral soil on black plastic mulch in beds that are 3 ft wide with drip irrigation, exclusively with transplanted onions produced in TX, AZ or locally. Fields typically range from 0.5A to 2A in size and are predominately grown by 'plain sect' farmers. New York is the largest producer of onions in the Northeast accounting for 97% of the region's production. The state produces approximately 10,000 acres; the annual average value is \$45.5 million dollars. Approximately 80% of the onions are grown on muck soils and about 85% of the acreage is direct seeded; most of the remainder is grown from transplants produced in AZ. Muck or organic soil is defined as containing 20% to 80% or more of organic matter.

During the past 5 to 10 years, bacterial bulb decay of onions has increased in PA and NY with annual losses up to 40% or more on some farms as a result of reduced onion quantity and quality. In 2008 alone, 34 growers lost a total of \$140,000 to bacterial diseases in PA (J. Stoltzfus, personal communication to B.K. Gugino). In 2010, one grower family in NY reported that they will be reducing onion acreage from 175 A to 100 A due to annual losses of 20 to 35% from bacterial bulb decay (S.V. Beer and C.A. Hoepting, personal communication).

Because bacterial bulb decay often affects only a single internal scale while the outer scales remain firm, such infected bulbs are virtually impossible to detect. Such onions are shipped and consequently rejected, which often results in entire loads being dumped, despite only a small percentage of bulbs being infected. Unfortunately, these losses are occurring just as the "Buy Fresh, Buy Local" movement is gaining popularity across the Northeast. The movement has resulted in both consumers and wholesale retailers searching for local vegetables year round. In fact, one vegetable broker in PA indicated that he could sell three times his current volume of local onions being produced (Bill Saussaman, personal communication to B.K. Gugino). Despite the favorable market, bacterial diseases deter growers from increasing or investing in onion production. A large NY grower who produces 1450A of onions on muck soil, stated that if bacterial diseases could be managed effectively, the value of his crop would be increased by millions of dollars annually.

Onions are plagued by a number of bacterial pathogens that cause both bulb and leaf decay. With funding from the PA Vegetable Growers Association (PVGA) and the PA Vegetable

Research and Marketing Program (PVMRP), a survey was conducted in PA in 2009 and 2010 to identify the bacterial pathogens associated with symptoms observed in the field. Bacterial pathogens isolated from symptomatic onion bulb and/or leaf tissue include: the soft rot pathogens, *Pectobacterium carotovorum* and *Pseudomonas marginalis*; the center rot pathogens, *Pantoea ananatis* and *P. agglomerans*; and the bacterial leaf pathogens, *Xanthomonas axonopodis* and *Pseudomonas viridiflava* (Mansfield et al., 2010a). In NY, sour skin caused by *Burkholderia cepacia*, is the most important bacterial disease that caused bulb decay, especially in storage. However, *Pantoea ananatis* was documented as a problem in onion fields and storages, and the Beer lab has preliminary data indicating that several other pathogenic bacteria are responsible for losses to growers and packers in NY. These and other bacterial species have also been associated with onion bulb rots in Georgia (<http://www.ipmcenters.org/cropprofiles/docs/GAonions.pdf>), Washington (<http://www.ipmcenters.org/cropprofiles/docs/waonions.html>) and Colorado (<http://www.ipmcenters.org/cropprofiles/docs/coonions.pdf>).

Some bacterial rots, for example center rot, caused by *Pantoea ananatis* may first appear as leaf blights on the youngest center leaves of the plant and result in yellowing or bleaching and wilting of these leaves. The infection progresses down the leaves and neck, and eventually into the bulb. Affected bulb scales become soft and water-soaked and are yellow-brown in appearance (Carr et al., 2009). In PA, growers often harvest two or three weeks before maturity and sacrifice bulb size in an attempt to prevent leaf-borne bacteria from moving into the bulb and causing rots and storage losses. In some years, for example in PA in 2010, symptoms were not always apparent in the field until at harvest. This demonstrates the importance of developing an integrated season-long management program that is not based on the observation of symptoms in the field.

Attempts have been made by growers to manage bacterial diseases in onions with copper bactericides and other chemicals, such as Oxidate[®] (BioSafe Systems, LLC, Hartford, CT). However, the efficacy of such spray programs in reducing bulb decay is unclear, and despite applications during the growing season, the growers still sustain unacceptable levels of bulb decay.

(i) b. **Background**

Addresses specific needs identified by growers and stakeholders in the NE region. Onion growers in PA and NY have urged their respective Land-Grant institutions to address bacterial disease problems of onion. This is demonstrated by grower support letters (see Appendix) and by previous grower association funding from PVGA and PVRMP and the NY Onion Research and Development Program (ORDP) supporting research projects on bacterial diseases of onions. This proposal addresses three high priority cross-commodity research needs established by the NY Vegetable IPM Program (2007), including i) cultural practices for yield and quality enhancement, ii) adoption of new marketing opportunities/new crops/new products when they arise, and iii) non-chemical pest management.

On a regional level, this proposal focuses on developing and implementing IPM practices for onion bacterial diseases that were collectively deemed a priority pest by the Northeast Vegetable IPM Working Group in November 2009 (<http://www.northeastipm.org/priorities/Priorities-VegetableIPMWG-2009.pdf>). In addition, several of the general needs issues will be undertaken

including: i) expanded adoption of IPM by addressing the unique needs of all types of vegetable growers including small or isolated operations and organic growers, in addition to highly diversified farms, and ii) to conduct research on the promotion of plant health and suppress insect, disease and weed problems through cultural and biological practices, iii) demonstrate the efficacy of research outcomes through on-farm trials and iv) develop recommendations and disseminate this information in usable forms for farmers. In other regions, onion diseases were also deemed a research priority as indicated by California Garlic and Onion Research Advisory Board in 2007-2008 (<http://www.northeastipm.org/priorities/Priorities-USDA2007CAGarlicOnion.pdf>).

Issues that will be addressed by this project include the National IPM goals: i) to improve the economic benefits of adopting IPM practices and to reduce potential risks to human health and the environment caused by the pests themselves or by the use of pest management practices, and ii) to improve cost benefit analysis when adopting IPM practices, because if new IPM programs do not appear to be as beneficial as practices already in place, they are unlikely to be adopted.

Review of completed or on-going work. In order to develop an integrated pest management program, it is important to understand the factors associated with increased incidence and severity of onion bacterial diseases in commercial production fields especially when disease losses are variable, both among and within fields; in many cases, the full extent of diseases losses is not evident until harvest or thereafter. One key factor is identifying potential sources of inoculum so management efforts can be directed at excluding or reducing initial inoculum sources from the system. Aside from *Burkholderia cepacia* in NY, it presently is not clear which, if any, of the bacterial pathogens that affect onion routinely overwinter in onion-growing fields. Overwintering studies have been conducted for some of the pathogens in other generally warmer regions like GA, but the climates in PA and NY are quite different, thus the data from other areas are not likely to be applicable to our region. In NY, in a preliminary study in 2010, pathogenic *Burkholderia cepacia* was found in each of 16 muck **soil** samples collected prior to spring planting, while *Pantoea ananatis* and *Enterobacter cloacae* were found in only one of the soil samples (Beer *et al.* unpublished data). A similar survey of soil-borne pathogenic bacteria in PA has not yet been conducted.

Exclusion has long been considered one of the primary tools for managing bacterial pathogens in vegetable production systems whether by heat treatment of seed, sanitation practices or improved weed management. It is not clear if **planting materials**, seed and transplants, routinely serve to introduce inoculum of bacterial pathogens into PA and NY each season. Prior to planting in PA, a preliminary survey of epiphytic bacterial species isolated from both locally grown and imported onion transplants from TX and AZ found, *Pectobacterium caratovorum*, *Pseudomonas marginalis*, *Pantoea agglomerans* and *Pantoea ananatis*, the four bacterial species most frequently isolated from symptomatic onion tissue, were also most frequently isolated from young transplants. However, in NY, in a preliminary study in 2010, no pathogenic strains of bacteria were detected in six samples of transplants that were imported from Arizona or in 14 onion seed lots. Gitaitis *et al.* (1998; 2002) found *Pantoea ananatis* and *Pseudomonas viridiflava*, the causal agents of center rot and Pseudomonas leaf streak respectively, surviving asymptotically on several common **weeds** in GA. Additionally, *P. ananatis* was also found associated with crop plants including soybean, cowpea and Bermuda

grass (Gitaitis et al., 2002). Weeds or alternate host crops have not been surveyed for presence of bacteria that are pathogenic to onion in either PA or NY. Improved understanding of the relationship between bacterial bulb decay and epiphytic populations of bacteria in soil, on transplants, seed and weeds will direct research towards effective management strategies that affect identified issues. For example, if transplants are found to be an important source of bacterial pathogens, then research would be conducted to determine the most effective means of achieving pathogen-free transplants. Feasible management practices for the factors associated with bacterial diseases identified in this project will be developed and incorporated into an integrated pest management program.

Onion thrips (*Thrips tabaci*) are the most common insect pest in onion fields in the Northeast region and worldwide. Consequently, the damage caused during feeding may provide an avenue for ingress of bacterial pathogens into the plant. In PA, in a small-plot trial, bacterial bulb decay at harvest was higher when onions were grown on white plastic mulch compared to black plastic. Onions grown on the white plastic had twice the average number of thrips per leaf (6.2 thrips/leaf) than those grown on black plastic (3.1 thrips/leaf) (B.K. Gugino, unpublished data). In NY, preliminary data have shown that onions protected from onion thrips with effective insecticides throughout the growing season suffered only half as much bacterial bulb decay as onions that were not protected from onion thrips (C. Hsu et al., unpublished data). In 2003, Gitaitis et al. demonstrated that tobacco thrips can harbor and transmit *Pantoea ananatis*, and consequently, disease management recommendations for center rot were expanded to include more targeted thrips management. However, it is not currently known if onion thrips are also capable of harboring and/or transmitting any of the associated bacterial rot pathogens in PA and NY. If in this study, onion thrips are found to be an important factor in the development of bacterial disease in onions, than onion thrips management strategies will be developed and incorporated into an IPM program. This could especially be important for small-scale onion growers who grow onions on plastic, because these growers have not emphasized management of thrips in the past.

Observations from grower fields and preliminary on-farm research trials in PA and NY suggest that excessive **nitrogen fertility** is correlated with greater losses from bacterial diseases. Similar relationships have been reported for bacterial organisms in other vegetable crops, such as broccoli (Huber et al., 1974; Koike et al., 2007). Gent and Schwartz (2005) found a similar association between nitrogen levels and the incidence and severity of *Xanthomonas* leaf blight in Colorado. Although there has been a significant amount of research regarding nitrogen and plant disease over the years (Huber et al., 1974), its impact on onion bacterial disease development remains unclear. Preliminary data from NY showed that onions grown with the addition of only 2.0 lb/A of nitrogen had 0.7% bacterial rot at harvest. When the recommended rate of nitrogen (125 lb/A) was applied, bacterial rot at harvest was 10.8% of the bulbs, which was 94% higher than the 2.0 lb/A rate. When nitrogen was reduced to 62 and 94 lb/A, the incidence of bacterial decay at harvest was significantly reduced to 4.9% (less than half) and 7.3% (one third less) without any significant differences in yield (C. Hsu and B. Nault, unpublished data). Additional studies are needed to confirm the relationship between nitrogen and bacterial bulb decay, because preliminary evidence suggests that growers might achieve reduced losses from bacterial disease by reducing nitrogen fertilizer inputs.

In PA, manure is commonly used as a source of nutrients in onion production. Onions grown in fields with judicious amounts of manure application appear to have higher incidence of bacterial bulb decay at harvest which may partially account for the variable losses observed between fields. In 2010, in a field trial conducted in a manured field, there was a significant block effect where the block located at the bottom of a slope had 83% incidence of bacterial bulb rot at harvest, while the block located at the top of the slope had only 17% (Hoepting et al., unpublished data). Presumably, nitrogen leached to the bottom of the slope where it favored the development of bacterial disease. Further study of the relationship between manure use and bacterial diseases of onion is warranted. The results may affect future recommendations regarding the use of manure in onion production in an IPM-based program.

The environmental impacts of excessive nitrogen fertility on ground water pollution have been well documented. For example, in a water monitoring project conducted by the Orleans County SWCD and SUNY Brockport in spring of 2009, the Elba muck land, which is a major onion producing area in NY, had elevated levels of soluble nitrate (3 to 28 mg/L) and total nitrate (as high as 37 mg N/L). As a point of reference, the EPA maximum contaminant level of nitrate-N for drinking water is 10 mg/L. In fact, in 30 years of analyzing water samples, the scientists at SUNY Brockport had never encountered nitrate levels as high as detected on the Elba muck land. Such high nitrogen concentrations in the water strongly suggest that excessive amounts of N are being applied to the crops. Gaining a better understanding of the relationship between soil nitrogen, bacterial diseases and optimal yield will lead to reduced nitrogen inputs in onion production, increased profitability and reduced water pollution.

Work is currently underway to evaluate and demonstrate the impact of plant spacing and mulch type on the incidence of bacterial diseases in PA and NY supported in part by funding from PVGA, PVMRP and NE-IPM Partnership Program. In all three of our trials, there was a general trend that as plant spacing decreased and planting density increased, incidence of bacterial bulb decay at harvest decreased. In work supported by other funds in NY, including a recently awarded Specialty Crops Block Grant to co-PI Beer, procedures to induce the development of sour skin and center rot in a reproducible manner is planned for the 2011 growing season. Once disease-producing techniques are developed, they can be used in small-plot studies to efficiently evaluate any variable against incidence of bacterial disease, such as rate of nitrogen or manure, thrips-induced injury, varietal tolerance/susceptibility, efficacy of bactericides, etc. In fact, a trial is planned to evaluate natural products and biochemical pesticides that are consistent with IPM philosophies. Similar projects are also planned by co-PI Gugino in PA. Management recommendations derived from such research will be incorporated with the recommendations derived from this proposed project into a comprehensive IPM program for management of bacterial disease in onions for growers of any scale.

(i) c. **Justification**

Who stands to benefit. All onion growers in the Northeast region stand to benefit from this project. Smaller scale growers sell primarily sweet onions, through local produce auctions and direct markets. These lucrative markets pay \$1/lb or more for jumbo and colossal sized bulbs. Reducing losses from bacterial diseases will directly and immediately impact farm profitability. As we succeed in developing an IPM approach to manage bacterial bulb decay that relies heavily on cultural practices, current growers will sustain or increase their acreage and more small-scale

diversified vegetable growers will start growing onions, thus building the fresh market onion industry in the Northeast. Reduced incidence of bacterial diseases, especially when it is undetectable in the bulb, will greatly decrease loads being rejected and the dumping of healthy onions along with the rotten ones for large-scale muck onion growers. The results of this research would also be applicable for states such as New Jersey who are looking to build local production to support a processing industry that traditionally ships onions from the Pacific Northwest (Tom Orton, personal communication). The general public will benefit from having affordable locally-grown onions of superior quality available to the year round.

Applicability to other regions. Although small-scale intensive onion production occurs primarily in the Northeastern U.S., identification of important factors that relate to bacterial rot incidence and severity in larger-scale onion production in NY will be directly applicable to similar large-scale production occurring in Georgia, Colorado, Washington and other states where bacterial diseases can be a perennial problem.

Relevance to additional NER-IPM priorities. Fulfilling the objectives of this project will address a number of NE-IPM priorities, in addition to those already mentioned. Measurements of nitrogen uptake and its association with bacterial onion decay and yield will help determine the optimal rate of N application, which reduces the risk of runoff into precarious watersheds. When growers adopt our integrated approach to managing bacterial rots, they will not have to rely on several applications of copper bactericides, which were compromising their health and the environment. To-date, a comprehensive study relating cultural controls and sources of inoculum with the incidence and severity of bacterial rot diseases has never been attempted. The results of our proposed project in combination with the results of our other on-going research and demonstration projects will lead to the development of a comprehensive IPM program to manage bacterial decay in onions grown on any scale in the Northeast region in the near future. The adoption of this IPM program is expected to be high, because it will involve simple and economically feasible adjustments to their current practices, such as lower rates of nitrogen or manure.

(ii) Objectives and Anticipated Impacts

Currently, small-scale diversified fresh market onion growers as well as large-scale onion producers do not have adequate means of managing bacterial diseases in their onion crops. The overall goal of this project is to gain a better understanding of the factors contributing to bacterial diseases in commercial production fields, and thus facilitate more targeted management practices as part of an integrated pest management program.

1. Identify factors associated with bacterial disease incidence in commercial onion fields in order to facilitate the development of an integrated pest management program for onion bacterial diseases in the Northeast region.

We hypothesize that infested transplants, weeds, soil, and thrips are sources of bacterial inoculum in commercial fields. Furthermore, we hypothesize that injury from thrips, wind whipping and high levels of soil nitrogen contribute to bacterial disease incidence and severity. These factors were selected for evaluation based on preliminary evidence of their association with the incidence and severity of onion bacterial diseases in PA and/or NY. Using **intensive small plot surveys of commercial fields** as well as several

replicated on-farm component research trials we will determine the relationship of these factors (independent variables) to onion bacterial disease incidence and severity (dependent variable) and test our hypotheses. This information will be used to augment current management practices as well as further facilitate the development of targeted research-based integrated pest management plans.

(iii) **Approach, Procedures and Timeline**

A. Intensive small plot surveys of commercial fields

To identify factors related to bacterial disease incidence in commercial onion fields, an intensive field survey will be conducted in 25 to 30 fields in PA and the same number in NY in each of two years for a total of 50 to 60 fields per year and 100 to 120 fields over the course of the project. In each field, three plots approximately 1 bed wide (4 to 6 rows/bed) by 30 ft long (240 onions/plot or more for direct seeded plots) will be flagged and GPS coordinates recorded. Plots will be managed by the grower using his/her standard practices.

Field and plot selection. Commercial fields will be selected to reflect a range of historical problems with bacterial rot from none/minimal to extensive losses. Variability between fields will be needed to relate the described independent variables to the dependent variable (bacterial disease incidence and severity). In PA, the focus will be fields grown from cv. ‘Candy’ transplants on plastic mulch. In NY, primarily muck land fields direct-seeded with the cvs. ‘Red Bull’, ‘Mercury’, ‘Red Wing’ and ‘Red Zepelen’ will be studied however several transplants fields may be included as well. These reflect the dominant production systems in each state. The three plots within each field will be located to capture maximum potential variability within the field (e.g. in PA top and bottom of slope, wooded border, etc.; in NY, the edges and middles of the fields).

Data will be collected from each plot or field as described below:

Bacteria associated with onion transplants. In fields being planted with onion transplants in PA and NY, approximately 10 to 50 transplants will be collected at random from either the transplant beds or imported transplant bundles (1 or 2 plants/bundle of approx. 30 plants) that correspond to our field locations (1 sample/field). PIs do not anticipate any differences between plots within a field because fields are typically planted with transplants from the same source. Epiphytic populations will be recovered and concentrated in a phosphate buffer wash and dilution plated in duplicate onto appropriate microbiological media. Bacterial isolates will be identified using a combination of culturing and molecular techniques (see bacteria isolate identification). The same transplants will then be surface-disinfested and homogenized in a blender and dilution plated same as for the surface washes. The bacterial strains will be tested for pathogenicity (see pathogenicity testing). If transplants prove to be an important source of inoculum, procedures to monitor transplants for the presence of the pathogens could be implemented and procedures to surface-disinfest or treat them prior to planting might be developed.

Bacteria associated with weeds. To determine if naturally occurring common weed species in onion fields are potential overwintering reservoirs of onion bacterial pathogen inoculum, representative weeds will be collected at the field level from NY and PA (60 samples total).

Weed samples will be collected in spring and summer 2011 and 2012 to reflect the species most likely to be sources during the current growing season and then again in late winter/early spring of the following year from the field edge of those same fields to determine their potential to overwinter on perennial weed hosts. Where possible, the same weed species will be collected however, the PIs recognize that differences in crop rotations and production practices will influence the weed species present. Samples will be processed according to the protocol by Gitaitis et al. (2002), plated on the King's B agar and identified as using microbiological and molecular techniques (see bacteria isolate identification). A representative selection of recovered bacterial isolates will be tested for pathogenicity (see pathogenicity testing). We will bear in mind that once symptoms are present in onions, it is unclear whether bacterial pathogen recovered from weeds might have been derived from the diseased onions (the Chicken-Egg dilemma!)

Assessment of soil-borne bacteria. At planting, a sub-sample from the soil collected for nitrogen analysis will be dilution plated on King's B and tryptic soy broth agar to isolate the soil-borne bacterial pathogens associated with onion bacterial rots. The bacteria will be identified using a combination of culturing and molecular techniques (see bacteria isolate identification). A representative selection of recovered bacterial strains will be tested for pathogenicity to onion (see pathogenicity testing). Knowledge of whether or not these particular bacterial pathogens associated with onion bulb rots are already present (or absent) in the soil at planting, as is the case with *Burkholderia* spp. in NY, will help determine whether the soil is a potential source of inoculum in commercial fields. If so, then this can further aid in the development of crop rotations or strategies to reduce soil splashing.

Bacteria isolate identification. For further microbiological identification, bacterial colonies plated on King's B will be transferred to nutrient agar and/or PA20, which is selective for *Pantoea* spp. (Goszczyńska et al., 2006) or will be identified using a multiplex PCR technique developed using primers based on the single copy gyrase B gene designed to detect *Pectobacterium carotovora*, *Pseudomonas marginalis*, *Pantoea ananatis*, *P. agglomerans*, *Xanthomonas axonopodis*, *Pseudomonas viridiflava*, *Burkholderia cepacia* and *B. gladioli* (Mansfield et al., 2010a). The Gugino lab is in the process of incorporating primers for *Enterobacter cloacae* (Schroeder et al., 2010) into the developed protocol. The Beer lab will use a similar series of developed microbiological and molecular protocols to identify important onion bacterial pathogens in NY.

Visual disease assessment. In early to mid-July (mid-season) and again at harvest, two randomly selected sets of ten adjacent plants will be visually assessed in each plot for the presence of foliar bacterial disease symptoms (incidence) and rated for disease severity (% leaf showing symptoms) using the Horsfall-Barrett rating scale (0 = healthy to 12 = 100% plant tissue showing symptoms). Data will be converted to percent disease severity using ELANCO Conversion Tables (ELANCO Products Co., Indianapolis, IN) prior to data analysis.

Onion thrips assessment. Onion thrips counts will be recorded twice during the growing season in late June/early July in PA and in mid-July and mid-August in NY to reflect different climatic conditions and growing seasons. Total number of leaves and total number of thrips per

plant will be counted on 10 randomly selected plants per plot and number of thrips per leaf calculated. Thrips feeding damage will be rated based on the percent of leaf surface damaged.

In NY, as soon as thrips are detected on onion foliage, (and 2 or 3 times thereafter), samples of at least 50 thrips will be collected by vacuum harvester and divided into 10-thrips lots for processing. Each lot will be assessed for the presence of bacterial pathogens of onion on their external surfaces and in internal tissues by plating washes and macerates on appropriate media. In PA, in a sub-set of six fields, three with and three without a history of onion bacterial diseases, we will begin **onion thrips vectoring studies** using live field-collected thrips collected in early to mid-July in conjunction with bulbing using a vacuum harvester. Individual selected thrips (10 to 15 per plot) will be surface-disinfested in 10% (v/v) of 6.25% sodium hypochlorite solution for 30 sec and then in 70% ethanol for 30 sec. Each thrips will be rinsed in sterile PBST and placed in individual 1.5 ml microcentrifuge tubes along with a surface-disinfested onion leaf section following modified protocols established by Gitaitis et al. (2003) and Wells et al. (2002). Following 24 hrs of feeding, both the leaf section and the thrips will be individually crushed in PBST buffer and dilution plated on King's B agar. Bacterial isolates will be identified using a combination of culturing and molecular techniques (see bacteria isolate identification). Representative bacterial isolates will be tested for pathogenicity (see pathogenicity testing).

Soil and plant nitrogen content. Soil and/or plant nitrogen content will be measured at three critical points during the growing season, at planting, bulbing and harvest. One composite soil sample per plot will be collected to the 8-inch depth using a soil probe. Inorganic nitrogen will be measured at planting and bulbing using a standard KCl extraction (Keeney et al., 1982; Mulvaney, R.L. 1996) to measure the nitrogen that is readily available for plant growth. Potentially mineralizable nitrogen (PMN) will be measured at planting and bulbing using an anaerobic incubation (Hart et al., 1994) to capture the organic nitrogen fraction released during mineralization. Total N in the leaf tissue will be measured at bulbing and in the bulb tissue at harvest as a measure of plant up-take. Soil samples collected in PA will be analyzed in collaboration with Jason Kaye (Penn State Department of Crop and Soil Sciences – see Appendix for letter of collaboration) and with the Penn State Department of Crop and Soil Sciences Soil Research Cluster Lab (<http://cropsoil.psu.edu/facilities/src1>) using the similar methods as the Cornell Nutrient Analysis Lab for the NY samples. As stated in the review of completed and on-going work, preliminary on-farm research trials in PA and NY suggest that excessive nitrogen fertility is correlated with higher losses from bacterial diseases. A better understanding of this relationship is needed because as suggested by the preliminary data growers could possibly achieve reduced losses from bacterial disease in part by reducing nitrogen fertility inputs.

Yield assessment. At harvest, approximately 15 ft of row will be harvested from the inner two rows of each plot and yield, grade (> 4.0 in. colossal, 3.0 - 4.0 in. jumbo, 2.25 - 3.0 in. medium), and incidence of bulb rot quantified by visual assessment. A sub-sample of 75 to 100 onion bulbs will be dried, placed in storage and graded after 4 months to reflect typical production practices. Bacterial pathogens will be isolated and identified from select samples (see bacteria isolate identification).

Field management history. During the course of the growing season, data regarding soil type, crop rotation history, fertilizer/manure application history, etc. for each field will be

collected from the growers. Data regarding current season production practices will be collected at the end of the season.

Pathogenicity testing. Bacterial isolates will be tested for pathogenicity by inoculating either onion sets or leaves using a syringe inoculation technique. Onion sets will surface-disinfested, cut in half using sterile technique and one half inoculated near the shoulder with 100 μ l of 10^6 cfu/ml concentration of bacterial suspension using a hypodermic needle and syringe. The two halves will be incubated in a sterile petri-plate with sterile filter paper and sterile distilled water. After 7 days, bulbs will be observed for the development of symptoms. Healthy leaves from onion sets will be inoculated with a 50 μ l of 10^6 suspension of the bacterial isolate using a hypodermic needle and syringe. A second leaf will be inoculated with sterile distilled water as a control. Plants will be maintained in a greenhouse or growth chamber. Inoculation points will be marked using a marker and plants will be observed for the development of symptoms after 7 to 14 days. All tests will be run in duplicate.

Microclimate data. Hobo Onset temperature sensor loggers will be used to monitor soil (at the 2-in. depth) and crop canopy temperatures in one plot selected to represent each surveyed field. Growers will be asked to keep track of significant rain events using simple rain gauges (>0.1 in. accumulation).

Data analysis. Data collected from the extensive small plot survey will be analyzed using an analysis of covariance (ANCOVA) in PROC MIXED in SAS v. 9.2 (SAS Institute, Cary, IN) to test whether the independent variables measured (covariates) had an effect on bacterial rot incidence and severity (dependent variable) as well as yield. Farm would be considered a qualitative or class variable in the model. Data from muck and mineral soils will be analyzed separately. This survey will be repeated in year 2 in a unique set of fields.

B. Replicated component research trials

A series of replicated on-farm small-plot trials will be conducted to compliment the small-plot intensive surveys to fine-tune our understanding of the relationships between bacterial disease and nitrogen fertility, thrips and wind-induced injury.

1. Nitrogen rate trial

To determine the effect of nitrogen rate on the incidence and severity of onion bacterial diseases co-PI Hoepting will overlay a series of treatments on a pre-existing trial being conducted in NY by B. Nault and C. Hsu (Associate Professor and Research Associate, Cornell University; see Appendix for letter of collaboration) to evaluate the interaction of nitrogen fertility and thrips populations with funding from the USDA-NIFA Pest Management Alternatives Program. This trial will consist of five treatments including the Cornell recommended rate of nitrogen, 125lbs/A, and 0%, 50%, 75% and 150% of the recommended rate. The trial will be arranged as a randomized complete block design with 5 to 6 replications and will be established on the Elba muck in a commercial field with a history of bacterial disease. Treatment replicates will consist of plots one bed wide (5 ft with 4 to 6 rows/bed) by 40 ft long. The grower will not fertilize the plot, and individual nitrogen additions will be spread by hand and raked in. Each plot will be surrounded by a 10 ft unfertilized buffer. Each plot will be divided into 2 X 20 ft sections, one sprayed and one unsprayed with spinetoram insecticide

(Radiant[®] SC, Dow AgroSciences) for onion thrips, the most effective product commercially available.

Inorganic and PMN nitrogen will be quantified (see soil and plant nitrogen section) after planting and during bulbing (mid-July). Similarly, tissue analysis for total N content will be determined in leaves during bulbing and in the bulb at harvest. Onion thrips will be counted by treatment in sprayed and unsprayed plots in mid-July and mid-August, and percent damage rated on a scale of 0 to 100% when lodging begins. Three sub-samples of 20 plants per treatment-replicate will be inoculated with *Burkholderia cepacia*, *Pantoea* spp. and *Enterobacter cloacae* or left uninoculated (control). Bacterial suspensions containing 5×10^7 colony-forming-units per ml will be prepared in 5 mM potassium phosphate buffer, pH 6.5. Using a hand-pumped and carried garden sprayer, inoculum will be applied until run-off one time. Forty feet of row will be harvested and incidence of bacterial bulb decay at harvest quantified and marketable yield determined. A sub-sample of 75 to 100 bulbs will be stored in a commercial onion storage facility and evaluated for further bacterial bulb decay after 4 months in storage as previously described in the yield assessment section. Data collected that represents a continuous variable within each year (e.g. bulb weight, nitrogen content, percent disease incidence, etc.) will be analyzed using an ANOVA and means separated using Fisher's least significant difference test (LSD) (SAS 9.2, SAS Institute, Cary, NC). All rating data (e.g. thrips damage) and count data within each year will be analyzed using non-parametric ordinal data analysis. This trial or a similar version will be repeated in Year 2 depending on collaborators B. Nault and C. Hsu.

2. Thrips induced injury trial

To determine the effect of thrips injury on the development of bacterial diseases, bacterial inoculation treatments will be overlaid on plots differentially managed for thrips in a commercial field. The three relative levels of thrips damage will be achieved using different insecticide regimes to reduce thrips populations in consultation with Dr. Brian Nault, Associate Professor of Entomology at Cornell University. Plots will be inoculated with *Burkholderia cepacia*, *Pantoea ananatis* or neither (control). Each plot will be one bed wide (consisting of 4 to 6 rows) x 20 ft long with 3 ft breaks between plots within the bed. The experiment will be a 3x3 factorial with 4 replicates in a completely randomized design for a total of 9 treatments and 36 plots. Bacterial suspensions of *B. cepacia* and *P. ananatis* containing 5×10^7 colony-forming-units per ml will be prepared in 5 mM potassium phosphate buffer, pH 6.5. Using a hand-pumped and carried garden sprayer, inoculum will be applied until run-off one time when thrips damage (in the high damage plots) is considered at a seasonable high (around mid-June). The inoculum will be applied late in the day to preclude immediate drying.

Thrips counts will be made on 10 randomly selected plants in the inner two rows of the bed within 2 days of bacterial inoculation and number of thrips per leaf calculated. Thrips damage to the plots will be rated at the same time. Plots will be evaluated for bacterial disease incidence and severity 1 week after inoculation and again at harvest. Marketable yield will be measured on 15 ft of row per plot and a sub-sample of 100 bulbs will be harvested, dried down and stored in a commercial onion storage facility and evaluated for further bacterial bulb decay after 4 months (as described in the yield assessment). All continuous variable data will be analyzed by ANOVA using the GLM procedure of SAS v. 9.2 (SAS Institute, Cary, NC). If interaction is significant, means will be compared with the slice option in the lsmeans statement, otherwise main effect

means will be compared with the F-test from the ANOVA. All count data will be analyzed using comparable non-parametric data analysis. This trial will be repeated in Year 2.

3. Wind induced injury trial

To determine the effect of injury caused by wind, a hand-carried, gasoline engine-powered leaf blower will be used to simulate wind injury in the foliage of onions growing in a commercial field in NY. Preliminary spraying of growing onions in the field at different distances, directions and angles of spraying, air speeds and volumes will be done to determine appropriate settings to induce injury of the foliage. The degree of injury will be judged by dipping samples of treated plants in water and visually assessing the amount of leaf surface that is water soaked following a 30-second dip. A protocol that results in moderate water-soaking will be selected. To establish the three relative levels of injury, plots will be treated once, twice, or not treated with the leaf blower using the developed protocol. Within 2 hours of the simulated wind injury treatments, the plots will be inoculated with suspensions of *Burkholderia cepacia*, *Pantoea ananatis* or neither (uninoculated control). Bacterial suspensions will be prepared and applied as described for the thrips injury trial (above). Each plot will be one bed wide (consisting of 4 to 6 rows) x 20 ft long with 5 ft breaks between plots within the bed. The experiment will be a 3x3 factorial with 4 replicates in a completely randomized design for a total of 9 treatments and 36 plots. Insecticides will be applied on a 7-day schedule starting in mid-June to harvest to management thrips across the entire trial.

Plots will be evaluated for bacterial disease incidence and severity 1 week after inoculation and again just before harvest. A sub-sample of 100 bulbs from each plot will be stored in a commercial onion storage facility and evaluated for further bacterial bulb decay after 4 months. All continuous variable data will be analyzed by ANOVA using the GLM procedure of SAS v. 9.2 (SAS Institute, Cary, NC). If interaction is significant, means will be compared with the slice option in the lsmeans statement, otherwise main effect means will be compared with the F-test from the ANOVA. All count data will be analyzed using comparable non-parametric data analysis. This trial will be repeated in Year 2.

Project Timetable (Unless otherwise noted, the timeline will be the same for Year 1 and Year 2)

Month	Task and Objective	Completed by
April	Establish survey field plots, collect soil samples and sample transplants in NY and PA (<i>Obj. 1A</i>)	PA: Gugino NY: Hoepting
	Establish nitrogen rate trial in NY (<i>Obj. 1B1</i>)	NY: Hoepting
	Establish thrips and wind-induced injury trials in NY (<i>Obj. 1B2 & 3</i>)	NY: Beer, Hoepting
May 2011 only	Develop wind-induced injury protocol (<i>Obj. 1B3</i>)	NY: Beer, Hoepting
Jun to Jul	Apply wind induced injury treatments to the plots (<i>Obj. 1B3</i>)	NY: Beer

May to Aug	In-season data collection in survey plots in PA and NY (<i>Obj. 1A</i>) and replicated research trials (<i>Obj. 1B 1, 2, & 3</i>) See Appendix for more detailed monthly sampling timeline for (<i>Obj. 1A</i>).	PA: Gugino NY: Hoepting, Beer
Jul to Aug	Harvest field trials and in PA and NY (<i>Obj. 1A</i>)	PA: Gugino NY: Hoepting,
Nov/Feb	Storage evaluation of onions in PA (Nov) and NY (Feb) (<i>Obj. 1A</i>)	PA: Gugino NY: Hoepting, Beer
Aug to March	Data analysis and report writing (all trials)	PA: Gugino NY: Hoepting, Beer

(iv) Evaluation Plans

On-site data collection and statistical analysis: The focus on on-farm data collection to address a complex disease problem is a real strength of this proposal. The large data set generated over the course of the two-year project will enable us to statistically identify as well as better understand the relationships between the factors most closely associated with bacterial disease incidence and severity for the two most prominent onion production systems in the Northeast region. We will seek to identify similarities and differences between the production systems. Also, based on analyzing the data for Year 1, we may modify the sampling protocol for Year 2.

Augmentation of current management practices: Based on these results, the PIs anticipate being able to fine-tune recommendations with regard to important sources of bacterial pathogens, nitrogen, thrips and weed management recommendations as well as facilitate further research trials to develop more targeted research-based management plans. For example, if transplants are identified as an important source of bacterial pathogens, then additional targeted research would be directed towards determining the most effective method to achieve pathogen-free transplants. Another example would be if high nitrogen fertility is identified as an important factor, then additional research would be targeted towards determining the most effective rate of nitrogen that reduces bacterial disease without compromising yield.

Implementation/adoption of the use of improved management practices for management of onion bacterial diseases: The extension responsibilities of the PIs will facilitate the rapid dissemination of project results to onion producers and interested stakeholders via one-on-one interactions, twilight, local and regional meetings and newsletters articles. Also, the extensive on-farm research itself will increase grower awareness about onion bacterial diseases and the need to manage them in using an integrated strategy.

Long-term impact: The ultimate goal of this project is to develop knowledge-based, sustainable and cost-effective management strategies for bacterial diseases of onion in the Northeast and in other relevant production regions. In the long-term, the project's success will be the realization of (1) reduced economic losses from bacterial diseases; (2) reduced reliance on copper-based bactericide inputs (already recognized as ineffective) through integration of cultural management practices including optimization of nitrogen inputs for maintaining yields, minimizing thrips-induced injury and protecting plantings against wind-induced injury.

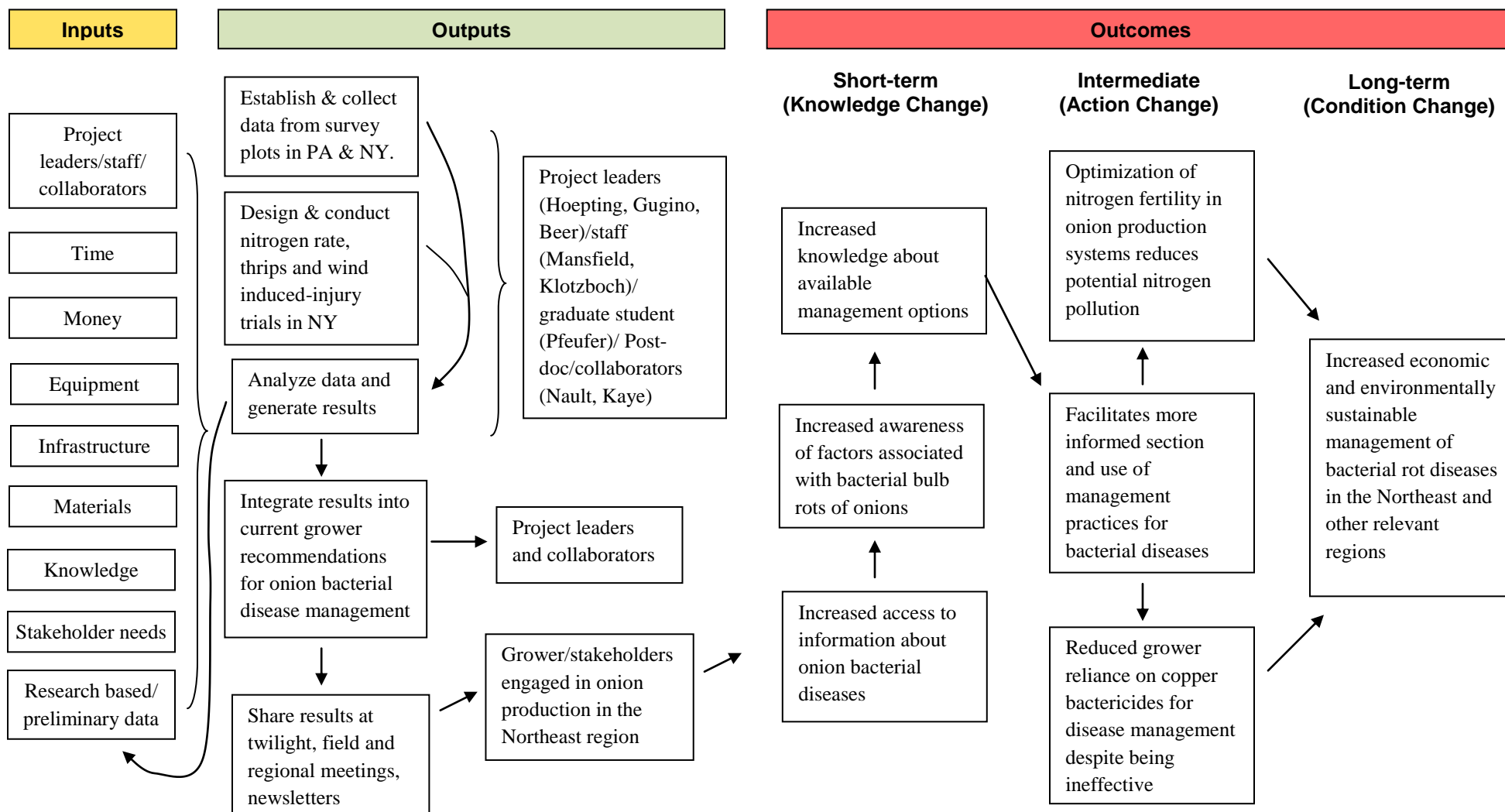
(v) Key Personnel and Project Roles

Beth K. Gugino is an Assistant Professor at Penn State with statewide research and extension responsibilities for vegetable pathology. Her experience and background is the development integrated management strategies for vegetable diseases and has extensive experience with soil microbiology and soil health. She has conducted numerous on-farm trials in collaboration with growers and county extension educators. She has been working to address bacterial diseases of onion since she began at Penn State in June 2008. As project director, she will coordinate all aspects of the project, conduct the field trials in PA and assist in NY when needed, write project reports and present results at grower meetings. **Michele A. Mansfield**, research technician, has extensive experience with the morphological and molecular identification of bacteria isolated from onion and will assist in field trials. **Emily E. Pfeufer**, Ph.D. candidate in Plant Pathology at Penn State, will provide leadership for the field survey objective in PA.

Christine A. Hoepting is a Vegetable Specialist with the Cornell University Cooperative Extension Vegetable Program (CCE-VP) in New York; her primary program responsibilities are related to onions. **Kathryn Klotzbach** is a Technician for the CCE-VP. Both have extensive experience conducting on-farm research and demonstration projects with onions. They have completed several successful NE SARE Partnership projects with onions including “Cultural practices to improve fresh market quality and profitability”. They are currently working on an IPM Partnership grant, “Cultural practices to manage bacterial diseases in the small-scale intensive production of fresh market onions”. In her role as a Specialist, Hoepting presents and distributes her research results and recommendations locally, statewide, regionally and internationally via field demonstrations, newsletter articles, research reports, the Cornell Vegetable Program website, and oral presentations at industry, grower and research meetings and conferences.

Steven V. Beer is a Professor of Plant Pathology and Plant-Microbe Biology at Cornell University. His present research and teaching responsibilities involve bacterial pathogens of fruit and vegetables. During his career, aspects of fire blight and its pathogen, *Erwinia amylovora* including epidemiology, control, genetics and mechanisms of pathogenesis were the main foci of his attention. In 2007, Beer’s program began to address bacterial disease problems of onions. This partial redirection of effort was in response to increasing problems experienced by New York onion growers. Present emphasis is on characterizing the bacteria that are responsible for losses and determining their epidemiology to facilitate the development of effective measures for reducing disease incidence and severity. The Beer Lab includes **Ms. Jean M. Bonasera**, a career Research Support Specialist, who has particular expertise in molecular biology, and a current Visiting Scientist and Post-doctoral Associate, **Dr. Ali. M. Zaid**, who has particular expertise in bacterial plant pathology and microbiological techniques for identification of plant pathogenic bacteria. It is anticipated that a post-doctoral scientist will be appointed, in part, to assist in carrying out the responsibilities of the Beer Lab inherent in this proposal. The Beer Lab will be primarily responsible for identification of bacterial pathogens and the carrying out of experiments designed to evaluate the importance of thrips- and wind- based injury to the incidence and severity of center rot and sour skin of onions grown on NY muck land.

Situation: During the past five to ten years, bacterial bulb decay of onions has assumed much greater importance in NY and PA with annual losses up to 40% or more on some farms as a result of reduced onion quantity and quality. We seek to identify and determine the relationship between factors such as infested transplants, weeds, soil and thrips and bacterial decay of onions. Furthermore, we seek to determine the relationship between soil nitrogen content, thrips injury and wind injury and how these factors contribute to bacterial disease severity on commercial farms. Our studies will enable growers to augment current management practices and facilitate the development of targeted research-based integrated pest management plans.



Assumptions

1. Growers are aware that they have problems with bacterial diseases.
2. Identifying the relationship between factors associated with increased bacterial disease incidence and severity will lead to improved management strategies
3. The developed management practices are economical and non-target effects of these practices are positive.

External Factors

1. Constraints of the current production system limit ability to adjust factors associated with bacterial diseases (i.e. nitrogen fertility, crop rotations, thrips management, etc.)
2. Variability in the weather and disease pressure in a given year.

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(a) Names and institutions of PDs and funded cooperators: Beth K. Gugino, The Pennsylvania State University; Christine A. Hoepting, Cornell Cooperative Extension; Steven V. Beer, Cornell University

(b) Project Title: Identification of factors associated with onion bacterial diseases to facilitate the development of an integrated pest management program.

(c) Project Type: Research

(d) Project Summary: This is a 2-year multi-state research proposal requesting \$179,788 for research from P.L. 89-106. During the past 5 to 10 years, bacterial bulb decay has assumed much greater importance in the Northeast region. In PA and NY, annual losses range from 5 to 40%. However, disease losses are variable, both among and within fields; in many cases, the full extent of disease losses is not evident until harvest or thereafter. This proposal seeks to determine the factors that are correlated with more extensive losses from bacterial diseases. We hypothesize that the presence of inoculum of several important bacterial pathogens in soil, transplants and possibly weeds and thrips is strongly correlated to disease incidence and severity. In addition, we hypothesize that high levels of nitrogen fertilization, thrips-induced injury and wind-induced injury contribute to the incidence and severity of bacterial diseases. Our approach is to conduct intensive small plot surveys of factors related to the presence of inoculum in commercial fields and to determine the extent of bacterial disease development in those fields during the growing season, at harvest and following harvest. In addition, replicated on-farm research trials will be carried out to assess the relationship between nitrogen levels, thrips-induced injury and wind-induced injury and resulting bacterial decay in onions. Currently, small-scale diversified fresh market onion growers as well as large-scale onion producers lack effective tools with which to manage bacterial diseases in onions. The goal of this proposal are to identify important relationships and utilize such knowledge to develop IPM-based recommendations to reduce the likelihood of severe losses from bacteria pathogenic to onions.

(e) Problem Description, Background and Justification: Onions are plagued by a number of bacterial pathogens that cause bulb rots. These diseases are complex and can be exacerbated by factors related to pathogen biology, epidemiology and production practices. Therefore, losses due to disease are highly variable both between and within fields and in some cases, not realized until after harvest. To-date, growers have been unsuccessful at managing the diseases despite multiple applications of copper-based bactericides. Assuming that we succeed in managing bacterial diseases through an IPM approach that relies heavily on cultural practices, growers will sustain or increase their acreage and more small-scale diversified vegetable growers will start growing onions, thus building the fresh market onion industry in the Northeast.

This proposed project specifically relates to the NE-RIPM priorities in the following ways:

- 1. Will reduce risks to the environment.** Overuse of copper-based bactericides to manage bacterial diseases and optimization of nitrogen application to maintain yields without increasing bacterial disease incidence and severity will reduce associated environmental risks.
- 2. Will reduce risks to human health.** There are on-going concerns associated with the use of copper-based bactericides for bacterial disease management. The ‘signal word’ for copper-based

bactericides is ‘danger’, which is assigned when a pesticide is highly hazardous if it can enter the body through: swallowing, inhalation or exposure to skin or eyes.

3. Has stakeholder support and the priority is cited. Onion growers in PA and NY have urged their respective Land-Grant institutions to address onion bacterial disease problems. This was demonstrated by funding from grower associations like the PA Vegetable Growers Association and the PA Vegetable Marketing and Research Program and the NY Onion Research and Development Program. This proposal also directly addresses three high priority cross-commodity research needs established by the NY Vegetable IPM Program (2007), including i) cultural practices for yield and quality enhancement, ii) adoption of new marketing opportunities/new crops/new products when they arise, and iii) non-chemical pest management. On a regional level, this proposal focuses on developing and implementing IPM practices for onion bacterial diseases that were collectively deemed a priority pest by the Northeast Vegetable IPM Working Group in November 2009 (<http://www.northeastipm.org/priorities/Priorities-VegetableIPMWG-2009.pdf>).

4. Focuses on a pest, crop, or setting found in at least five states or cropping regions.

Although small-scale intensive onion production occurs primarily in the Northeastern U.S., identification of important factors that relate to bacterial rot incidence and severity in larger-scale onion production in NY will be directly applicable to similar large-scale production occurring in Georgia, Colorado, Texas, Washington and other states where bacterial diseases are often perennial problems.

5. Will fill a niche (no such tactics or approaches exist). Bacterial diseases are complex and can be exacerbated by factors related to their biology, epidemiology and production practices. Attempts made by growers to manage bacterial diseases in onions with copper-based bactericides and other chemicals often fail. The identification of the relationship between factors most closely associated with onion bacterial diseases on commercial farms will facilitate the development of IPM programs that rely mostly on cultural practices, which currently do not exist.

6. Involves multiple states in an active partnership. This project will directly involve PA and NY in an active partnership however, the results will be relevant to all states in the Northeast region in which growers experience similar problems with onion bacterial diseases.

7. Will advance IPM implementation in several years. Within two years the results of this project will be used to augment current management practices and will facilitate the development of more cultural strategies in the subsequent two years as additional management practices are developed that address the factors most strongly associated with bacterial disease in commercial fields.

8. Is interdisciplinary. This project involves cooperation among two plant pathologists (one specializing in bacteriology) and an Onion Specialist; all have extensive experience conducting applied research that directly addresses grower-identified research priorities. Additionally, collaborations have been established with an entomologist, a soil scientist and a statistician to aid in addressing thrips, nitrogen fertility and data analysis issues.

9. Reduces dependence on chemical pesticides. The use of integrated cultural practices will reduce or eliminate the use of copper-based bactericides for managing onion bacterial diseases.

10. Has significant economic implications. Reducing losses from bacterial diseases will directly and immediately impact farm profitability. Both large and small-scale diversified vegetable growers in the Northeast stand to benefit from this project. Through this project, as we succeed in managing bacterial diseases through an IPM approach that relies heavily on cultural practices, current growers, both conventional and organic, will likely increase their acreage and

more small-scale diversified vegetable growers will likely start growing onions, thus building the fresh market onion industry in the Northeast.

11. Explains, justifies, and will serve an “underserved audience.” All vegetables including onions in the Northeast are considered minor crops. Many growers of these crops are fresh market diversified vegetable growers and organic vegetable growers who farm small acreage. Additionally, many are ‘plain sect’ growers, who are considered an underserved audience.

12. Addresses an emerging pest, crop, or problem. During the past 5 to 10 years, the incidence of bacterial bulb decay of onions has increased in NY and PA with annual losses of up to 40% or more.

13. Is likely to be adopted by the target audience. The significant losses associated with bacterial diseases will likely drive the adoption of management changes. Improved management strategies will be easily implemented, because they will only require growers to optimize current practices such as nitrogen fertility rates and source/treatment of transplants which will also facilitate adoption.

14. Advances an IPM practice that is more cost-effective than the status quo. During the past 5 to 10 years, bacterial bulb decay of onions has increased in NY and PA. During that same time, no new and effective management techniques were developed to combat the problem. In this project, we will get a better understanding of the factors associated with bacterial diseases in onions and thus facilitate targeted management strategies as part of an IPM program which will most likely involve reduced inputs, such as nitrogen fertilizer and bactericides while minimizing losses currently being sustained by both large-scale and small-scale growers.

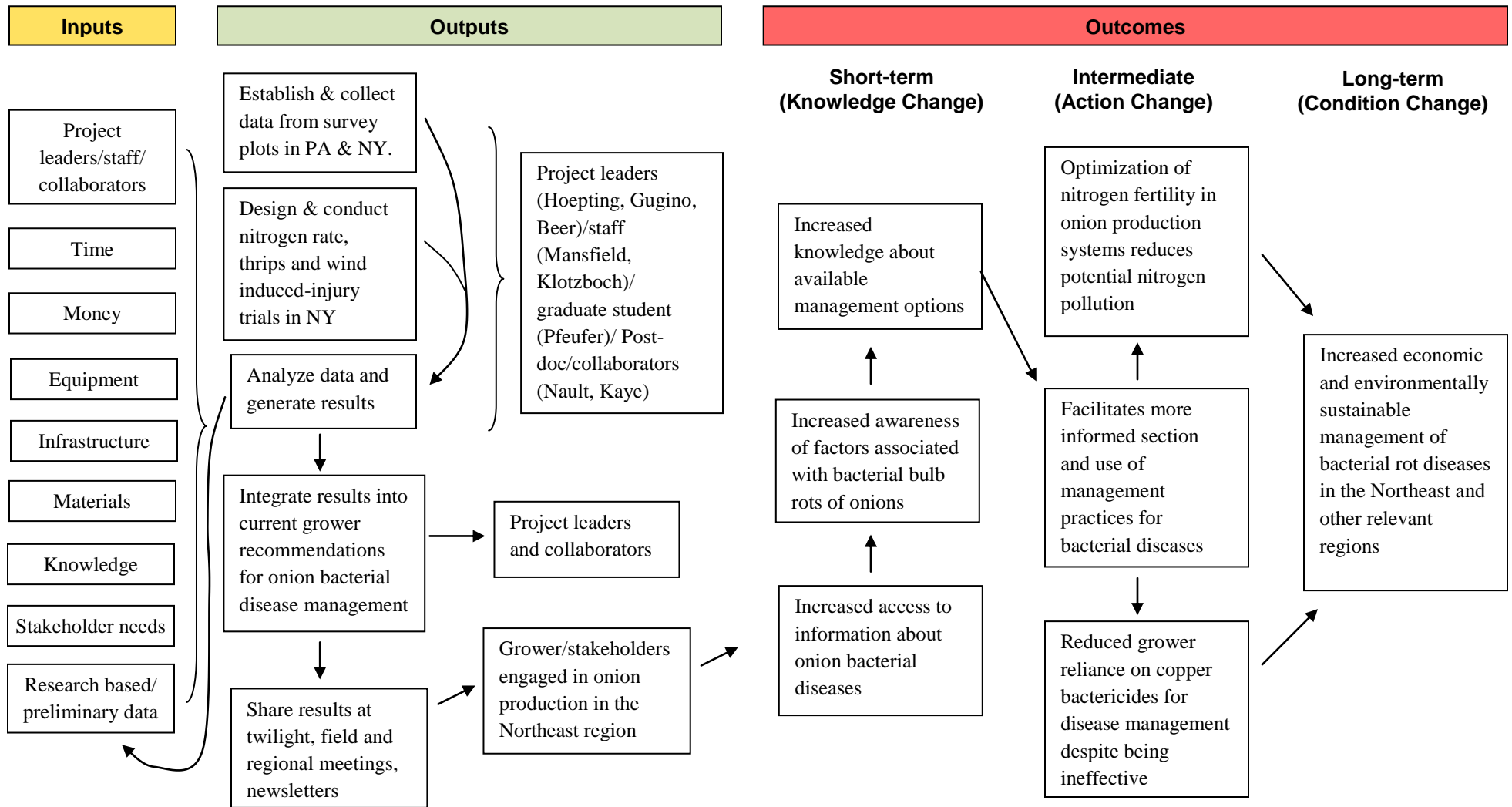
(f) Objectives and Anticipated Impacts

Currently, small-scale diversified fresh market onion growers as well as large-scale onion producers do not have adequate means of managing bacterial diseases in their onion crops. The overall goal of this project is to gain a better understanding of the factors contributing to bacterial diseases in commercial production fields, and thus facilitate more targeted management practices as part of an integrated pest management program.

1. Identify factors associated with bacterial disease incidence in commercial onion fields in order to facilitate the development of an integrated pest management program for onion bacterial diseases in the Northeast region.

We hypothesize that infested soil, transplants, weeds, and thrips are sources of bacterial inoculum in commercial fields. Furthermore, we hypothesize that injury from thrips and wind whipping and high levels of soil nitrogen contribute to bacterial disease incidence and severity. These factors were selected for evaluation based on preliminary evidence of their association with the incidence and severity of onion bacterial diseases in PA and/or NY. Using **intensive small plot surveys of commercial fields** as well as several **replicated on-farm component research trials** we will determine the relationship of these factors to onion bacterial disease incidence and severity and test our hypotheses. The results of this research will directly impact growers through the augmentation of current management practices as well as further facilitate the development of targeted research-based integrated pest management plans that will ultimately improve onion quality and profitability. The general public will benefit from having affordable locally-grown onions of superior quality available year round as well as benefit from reduced water pollution associated excess nitrogen runoff.

Situation: During the past 5-10 years, bacterial bulb decay of onions has assumed much greater importance in NY and PA with annual losses up to 40% or more on some farms as a result of reduced onion quantity and quality. We seek to identify and determine the relationship between factors such as infested transplants, weeds, soil and thrips and bacterial decay of onions. Furthermore, we seek to determine the relationship between soil nitrogen content, thrips injury and wind injury and how these factors contribute to bacterial disease severity on commercial farms. Our studies will enable growers to augment current management practices and facilitate the development of targeted research-based integrated pest management plans.



Assumptions

1. Growers are aware that they have problems with bacterial diseases.
2. Identifying the relationship between factors associated with increased bacterial disease incidence and severity will lead to improved management strategies
3. The developed management practices are economical and non-target effects of these practices are positive.

External Factors

1. Constraints of the current production system limit ability to adjust factors associated with bacterial diseases (i.e. nitrogen fertility, crop rotations, thrips management, etc.)
2. Variability in the weather and disease pressure in a given year.