Promoting IPM Implementation in Greenhouses: Banker Plants, Grower Education and an Assessment of Consumer Attitudes

PROJECT DESCRIPTION

A. Problem, Background and Justification

Historically, dairy farms have dominated the rural landscape in the Northeast, but this traditional farming sector is declining as production agriculture becomes more diversified. In contrast, the greenhouse industry is expanding, and has become a vital component of the Region's agricultural economy. In fact, revenues from greenhouse crops far exceed that of any other crop commodity in the Northeast, with annual sales in excess of $551 million in New England alone (NASS 2000, USDA-NEASS 2004). Public demand has driven this expansion, as people seek to beautify their homes and gardens with flowering plants.

Arthropod pests and diseases limit productivity and economic returns in greenhouse crops. Growers rely heavily on conventional pesticide-based strategies for their control. The compounds used pose a risk to applicators, consumers and the environment, and there are many negative aspects associated with extensive pesticide use (Broadbent & Pree 1997, Tatchell 1996, Harris 2000, Wesseling et al. 2001, Fenske 2002). Repeated pesticide applications can also adversely impact plant physiology and appearance (Spiers et al. 2004).

The goal of maintaining high levels of agricultural productivity and profitability while reducing pesticide use, though, presents a significant challenge. Research and outreach efforts must focus on increasing IPM implementation on all crops – strategies that emphasize cultural and biological controls as the main defense against pests but include the judicious use of pesticides. IPM reduces risks associated with pesticides, yet growers assert that they must use these materials to meet consumer demands for 100% pest-free plants. To be successful, control agents and IPM programs that are appropriate to local conditions must be developed. Generic IPM techniques developed for large, year-round facilities in southern states – where pests may be year-round rather than seasonal threats – are often not applicable to small, family-run greenhouse operations that are predominant in the Northeast. Furthermore, if not accompanied by appropriate extension and outreach activities, they will have little chance of adoption. Educational efforts must not only target growers, but also consumers. Consumers are a driving force in our market society; if, through education about the value of IPM-grown crops in terms of human health and environmental quality, consumer demand could be created, this would serve as a valuable incentive for growers to implement IPM.

Adoption of multiple management tactics – IPM – is essential to ensure that high-quality plants are produced, the greatest revenue generated, and the least amount of chemical insecticide used. Time, knowledge (or lack of), and ease of implementation appear to be the greatest barriers to the wider adoption of IPM techniques (GO IPM 2002, Skinner et al. 2003). This project will promote ways of reducing risks associated with pesticide use. The research component addresses issues related to the cost and quality of natural enemies as factors impeding their broader utilization, while outreach/extension activities promote grower education and document consumer knowledge and attitudes about IPM. The following objectives are proposed:

Project Objectives

1. **Evaluate the use of banker plants for production of predatory mites in spring bedding plants.**
2. **Assess the quality of natural enemy shipments received at different times of the year from Regional and National distributors.**
3. **Develop, organize, and conduct hands-on IPM training programs for greenhouse growers in ME, NH and VT.**
4. **Conduct follow-up surveys at garden centers in ME, NH and VT to determine changes in consumer attitudes and knowledge about IPM.**

Importance and Relevance to Growers and Other Stakeholders in the Northeast. The research objectives evaluate the use of banker plants for on-site production of predatory mites for the control of spider mites. Cost and availability are often cited as factors limiting growers' use of natural enemies. Banker plants offer great potential to provide a constant "feed" of such predators into a crop, reducing the need for multiple releases, and ensuring that a resident population is present should a pest outbreak occur. Few inputs are needed, once the natural enemy is established, to achieve long-term suppression. The cost of shipping natural enemies is often higher than the cost of the beneficials themselves; when multiple releases are required, shipping costs become a major expense. These can be minimized by using banker plants.

Costs can also be considerably reduced by using 'ground' shipping, which is one-third the price of 'overnight' shipping. However, this can take 1-2 days longer than standard overnight shipping. How will this affect the quality of the natural enemies received by the grower? We propose to assess the quality of predaceous mites used to control pests on spring bedding plants over the course of a growing season. Natural enemies will be ordered from three distributors and shipped via 'overnight' and 'ground' carrier. We will produce and distribute an informational pamphlet reporting results of our research, outlining methods growers can use to evaluate the viability of their shipments. This information will also be posted on our website for broader distribution. These are research priorities identified by the Regional Greenhouse and Ornamental IPM Commodity Working Group (GO IPM 2002).

In the extension component, we propose to directly address grower-identified needs by continuing to offer effective educational IPM workshops, drawing on the expertise of specialists in Europe and North America. Based on a recent survey by the Greenhouse and Ornamentals Commodity Working Group (GO IPM 2002), growers overwhelmingly stated that ***educational workshops*** were the best way for them to learn new production techniques. New plant varieties become available every year, and growers strive to respond to the constant demands of their clientele for access to these new products. Each new variety presents new production challenges and pest problems. To continue to grow and be profitable, both experienced and novice growers need support. As the Extension System throughout New England continues to be downsized, few people are left to provide leadership to address this need. Generally, specialists in fruit and vegetable crops and community IPM must do their best to cover several commodities, including greenhouse production. The only way to make up these gaps is to secure external funds to supplement ongoing programs. Growers in northern New England often lack the resources to attend national greenhouse meetings, and the opportunity to interact with specialists outside the

region. For this reason, it is critical that we bring national and world experts here. Growers who have attended our workshops have stated that the hands-on format used is the best way for them to learn the technical information and skills they need to implement IPM. Too often, educational meetings rely exclusively on lecture formats. This is a great way to reach a large number of people in a short amount of time, but they have little lasting impact on growers' pest management practices. To achieve true adoption, IPM techniques must be demonstrated, taking into consideration the individual conditions of each greenhouse operation. The workshops we host have been refined over the years to minimize lectures and maximize small group sessions. This format encourages learning and interaction between growers and specialists. The project proposed herein builds on this successful educational initiative we began 8 years ago. We have already secured funding to conduct a survey to monitor the outcome of our workshops in terms of changing grower practices; this will allow us to gain a better understanding of growers' needs and will enable development of more responsive and effective educational programs. Therefore, an impact assessment study is not included in the current proposal.

We have secured funds to assess the current level of consumer awareness about IPM. A survey will be given at garden centers in northern New England in May-July 2005. In association with this survey, educational materials will be distributed to participants to raise public appreciation of the value of IPM to them and the environment. We will share these results with growers at our workshops to encourage them to promote their use of IPM to their customers, and to continue to increase public awareness of its benefits. This survey will also serve as a foundation for future public awareness programs, and for growers to see IPM as a value-added component of their production systems. In the current proposal, we are seeking funds for a follow-up survey to see if outreach and education efforts have affected consumer attitudes about IPM. Over time, this will be critical to increase use of non-pesticidal pest management tactics. IPM will be advanced by changing the mind-set and behavior (pest management/purchasing) of both grower *and* consumer. By creating awareness among the public about the benefits of IPM, and increased demand for plants grown using these practices, this will in turn convince growers to implement more IPM practices.

Previous Work and Current Outlook

Spider Mites. The two-spotted spider mite, *Tetranychus urticae*, is a persistent problem in Northeastern greenhouses (Skinner et al. 2003). It damages plants by piercing and sucking the contents of cells. As damage increases the entire leaf may yellow and die. They also produce unsightly silken threads and webbing can encompass an entire plant when infestations are heavy. Because of their small size, these mites often go undetected until populations are high, requiring multiple applications of acaricides for control. Their broad host range, rapid reproductive rate and resistance to many standard pesticides, make this pest very difficult to manage (Dreistadt 2001, Elliott 2004a).

Two-spots can be managed biologically if populations are detected early. *Phytoseiulus persimilis*, a predatory mite, is very effective against this pest (Elliott 2004b). *Amblyseius fallacis*, another predatory mite, has a faster reproductive rate than *persimilis* at high (27-30° C) and low (18-22° C) temperatures; it can also survive in the absence of prey, feeding on pollen (Elliott 2004c). Pesticide-resistant strains are available.

Banker Plants. These are plants specifically selected to serve as a reservoir for low-level pest populations and their accompanying natural enemies. Banker plants are open rearing systems that produce natural enemies within the greenhouse. This system has several benefits. First, healthy natural enemies are continuously produced on-site (Goolsby & Ciomperlik 1999, Matteoni 2003, Murphy 2004). As there are few producers of natural enemies in the Northeast, growers sometimes have difficulties obtaining specific beneficials when they need them; these also have to be shipped from producer, to distributor (where they may be re-packaged), to grower, so their quality can be compromised. Second, over time, the natural enemy population on banker plants may become acclimatized to the local environment, and will perform more efficiently than those reared elsewhere. Lastly, if growers can establish a breeding population of natural enemies in their greenhouses, they will save money over the season.

There are disadvantages to the banker plant system, though. The major one is that, if not managed carefully, the resident pest population can spread to plants grown for sale (Dreistadt 2001). To ensure this does not occur, growers must inspect banker plants regularly and keep track of pest and predator populations. Secondly, banker plants, which must be spread throughout the greenhouse, also take up valuable growing space (Dreistadt 2001).

While effectively used in greenhouse and field-grown vegetables, their efficacy has not been widely assessed in greenhouse ornamentals. Tests in field-grown crops have yielded mixed results. When turnip was used as a banker plant for aphids and their parasitoids in European cauliflower fields, parasitism was high enough to protect the heads from aphid damage if the plants were started early in the season before hyperparasites impacted the parasitoids (Freuler et al. 2001). Banker plants were shown to be a reliable and economical method for field-delivery of *Eretmocerus* parasitoids in transplanted and direct-seeded cantaloupe or watermelon crops (Goolsby & Ciomperlik 1999). Several studies have been done to test their suitability for greenhouse-grown melons; banker plants provided an inexpensive and reliable means of controlling *Aphis gossypii*, though multiple releases of parasitoids were required (Conte et al. 2000). Using barley seedlings as banker plants, multiple natural enemies effectively controlled three major pests (aphids, mites and whiteflies) on watermelon (Goh HyunGwan & van Lenteren 1999). Banker plants were also tested for control of spider mites in landscape nursery crops; when established on the banker plant, beneficial mites dispersed up to 30 m down wind (Pratt & Croft 2000). Flowering caster bean plants were used to colonize the predatory mite *Amblyseius degenerans* for thrips control in a greenhouse crop of sweet peppers. After 4 weeks, the mites had dispersed up to 53 plants away from the banker plant, though migration across rows was limited (Ramakers et al. 1996). The economics of using banker plants in Canada was investigated for management of several different pest species in a variety of greenhouse-grown vegetable crops; biocontrol costs were reduced by 75% when banker plants, rather than regular inundative releases, were used (Matteoni 2003). This novel technology thus appears to have excellent, but as yet underutilized, potential for use in greenhouse ornamentals.

Quality Control. Producers of natural enemies must follow robust quality control programs to ensure that high quality individuals are continuously reared. This is essential to the biological performance of the natural enemies, and to the success of a biocontrol program. Quality control tests by commercial producers are done to ensure continued fitness, purity, sex-ratio, and fecundity of the mass-reared organisms (IOBC 2002, van Lenteren 2002). Biocontrol producers have actively developed a Code of Ethics to ensure that biological control products meet certain

standard quality requirements to ensure continued consumer confidence (Elliott & Glenister 2002). Upon receipt, growers, should perform a rudimentary assessment of quality, e.g., per-cent emergence (of parasitoids), or number of live individuals (predators) in the package. This is a critical component of, and immediately relevant to the success of, a biocontrol program. Using this 'grower criterion', we propose to assess the quality of shipments of three commercially-produced natural enemies used in spring bedding plants that are shipped via standard overnight vs a 'ground' carrier.

Extension Component

Educational Workshops. Extension specialists play a pivotal role in promoting greater adoption of IPM, yet expansion of the greenhouse industry has coincided with a downsizing in Extension, and there are very few programs left in the Region to provide the necessary support for this commodity. Recognizing the significant need for IPM education, researchers, growers, extension specialists and state agricultural personnel from Maine, New Hampshire and Vermont joined forces in 1995 to establish the Tri-state Greenhouse IPM Advisory Group, to provide practical support for the greenhouse industry in northern New England. This group bridges the gap between the theoretical aspects of research and the practical needs of greenhouse growers. Members assist in determining the needs and priorities of the greenhouse industry in our region, and developing and implementing research and education programs to address these priorities. With external funding support, the Tri-state IPM Group has organized workshops annually in the three states for the past 8 years, and based on the enthusiastic response from growers, this effort has been well received. The project we propose herein will build on these efforts.

A survey of Northeastern greenhouse growers conducted in 2003 revealed that the greatest hindrances to growers' adoption of IPM were a lack of knowledge in the use of biocontrols, and difficulties associated with the control of insects and mites (Skinner et al. 2003). Lack of skilled technical personnel was also listed as a major barrier to IPM implementation. Mites remain one of the most challenging pests for growers and there are tremendous opportunities to reduce pesticide sprays with effective use of natural enemies. We propose to conduct workshops that focus on these aspects of IPM, while continuing to provide growers with other relevant information. By linking this extension component with our research on banker plants, the transfer of information and technologies arising from our findings will be accelerated.

Why Conduct a Consumer Survey? There has been considerable promotion of organically-grown produce on a regional, national and international scale, but few programs similarly promote IPM-grown plants. Cornell University established a cooperative program in New York linking farmers growing vegetables according to standardized IPM guidelines with a major grocery chain that promotes the produce as a labeled "IPM product". However, this type of program is not widespread nor has it been used to market greenhouse-grown ornamentals.

Few studies have analyzed the marketability of IPM or consumer attitudes about the subject. A survey conducted in 1997 evaluated consumer preferences and their response to IPM-grown produce (Govindasamy et al. 1998). Though this study focused on vegetable production, many of the outcomes relate to the project we propose. Only 31.4% of the respondents indicated having ever heard of IPM before, yet 71% said they would purchase IPM labeled produce after learning what IPM meant. Almost 50% of the respondents said they would be willing to switch supermarkets to purchase IPM produce. In fact, survey participants were more willing to pay a

premium for IPM-grown produce than that which was grown organically. About 25% of the respondents indicated that they would be willing to pay 6-10% more for IPM-grown produce. This demonstrates that growers could benefit from publicity that promotes their use of IPM practices. These data apply specifically to fresh fruits and vegetables, and results from the survey we propose will provide critical information relevant to greenhouse grown-ornamentals.

Training programs and the follow-up consumer survey proposed help expand assess the knowledge base on IPM throughout the Region. Educational workshops and consumer education have been identified as priority needs by growers (GO-IPM 2002, Skinner et al. 2003), and this project clearly addresses priorities established by the Northeast IPM Center. Change is a gradual process, it takes many years to alter grower behavior. Considering that their livelihood depends on the income generated from sales of healthy plants, they cannot afford to drastically change management techniques until they are proven effective. Thus a long-term investment in research and extension activities specifically targeting this agricultural sector is essential to achieve the desired transition in grower practices and reductions in pesticide use.

B. Objectives

1. Evaluate banker plants for production of predatory mites in spring bedding plants.

Trials are currently underway at the Entomology Research Lab to compare conventional pesticide-based management vs IPM for production of bedding plants and ornamentals. The research proposed herein will complement this work. Three plant varieties will be evaluated for their suitability as banker plants to produce two predatory mites for suppression of spider mites in spring bedding plants. Predator mite and spider mite populations on the banker plants and adjacent crop plants will be monitored over time to determine the rate of population increase and dispersal throughout the greenhouse. In Massachusetts, a project is currently underway to assess the use of predatory mites in bedding plants to manage western flower thrips. The researcher reported that the trial set up in a commercial greenhouse was not successful because of the crop composition and pest population levels, which led him to move the work to a research greenhouse where conditions could be controlled (Van Driesche, U. Mass, 2003). To avoid these problems, we will conduct our research in experimental greenhouses (Yr 1 & 2) before moving to less predictable commercial settings (Yr 3) where growers cannot afford to lose their crop to pest management failure. These trials will also be used for demonstration purposes, and growers will be invited to view the banker plant system in action. Results from this project will be transferred to growers directly through workshops, extension publications, newsletter articles and electronic media.

2. Assess the quality of natural enemy shipments received at different times of the year from Regional and National distributors.

By evaluating the quality of the shipments received (numbers present and per-cent live) from different suppliers, via 2 methods of shipping, at different times of the growing season, we will generate information that is highly relevant to the use of biological control agents. First, it is essential that high-quality shipments are received by growers. Second, the high cost of shipping is often a dis-incentive to use natural enemies, especially when multiple releases are required over a growing season. Cheaper shipping options, providing there is no impact on the quality of the shipment, will considerably reduce the overall cost of a bio-based IPM program, and should

encourage greater use of beneficials in bedding plant production. This objective was developed in response to interactions with growers at the 2004 New England Greenhouse Conference (Brownbridge, pers. comm.).

3. Develop, organize and conduct hands-on IPM training programs for greenhouse growers in ME, NH and VT.

The Tri-State Greenhouse IPM Advisory Group will develop an educational program focusing on key insect pests and diseases for which chemical insecticides are commonly applied. To link with the research component of this project, banker plants for biological control of spider mite and other arthropod pests, will be featured in the workshops. However, to ensure a balanced program, segments dealing with other critical components of IPM, e.g., disease management and diagnosis, pH and soil management, calibration of sprayers, etc., will also be included. Growers who are members of the Tri-state Advisory Group will participate in the development of this program to ensure it addresses the needs of growers in their States and is delivered in a way that maximizes learning. Results from recent grower surveys and past workshop evaluations will also be reviewed to develop program content. Specialists will be invited from outside the region to participate, a move we feel will attract more growers. For example, at the 2004 workshops, Don Elliott (Applied Bionomics, BC, Canada) was a guest presenter, and in 2005 Rob Jacobson (IPM Consultant, Stockbridge Technology, UK) will take part. Growers with experience using biological control will be asked to assist in the presentations. We find that growers will often accept information more readily from their peers – *"if it works for them, it can work for me"* – than solely from researchers or extension personnel. Workshops will be limited to 40-50 participants per state to ensure that the hands-on format can be preserved, and dynamic small-group discussions are promoted.

4. Conduct follow-up surveys at garden centers in ME, NH and VT to determine changes in customer attitudes and knowledge about IPM.

Although IPM is a common term among agriculturalists, we recognize that relatively few members of the general public really know what it means. However, for retail growers the general public is their clientele, who must be satisfied with their merchandise to ensure repeat purchases. Therefore it is critical to gain an understanding of the criteria consumers use when they buy a plant. For example, is it more important that the plant appears pest-free, or that it was sprayed with less (or no) chemical pesticides? If it is the latter, consumer education must accompany our efforts to encourage growers to use IPM. Data from this survey will demonstrate the public's familiarity with IPM, and will enable researchers and marketing specialists to develop strategies and products that allow growers to better serve their customers. A shift in consumer attitudes will encourage the wider use of natural enemies and IPM by growers. We will complete a customer survey to discern current awareness of IPM in the spring and summer of 2005. In addition, a public education program will be launched by interested growers in the three states. This will include displaying an IPM poster in their retail areas, and distribution of a color brochure describing the principles and benefits of IPM. To track changes in consumer attitudes towards IPM-grown plants and their purchase, we are proposing a follow-up survey in yr 3 of the current project. This will provide us with a direct measure of the effectiveness of IPM promotional activities undertaken by the growers, and indirectly on the effectiveness of regional and national initiatives (e.g., through Regional IPM Centers). When carrying out these surveys, we are also afforded a teachable moment, and can maximize their educational impact.

C. Approach and Procedures

Research

Obj. 1. Evaluate banker plants for production of natural enemies in spring bedding plants.

Plant varieties. Two varieties of marigold (*Tagetes* spp., var. "Lemon gem" and "Discovery yellow") and bush bean (*Phaseolus vulgaris* L.) will be tested as banker plants in a greenhouse containing a variety of bedding and ornamental plants. The marigold species were selected to complement on-going research on their use as sentinel plants for early detection of thrips and spider mites. Based on recent observations, spider mite predators that were released in the greenhouse congregated on these marigolds, and soon afterwards the resident two-spotted spider mite population disappeared. These compact plants take up a minimum amount of space, yet can effectively serve as a reservoir for the natural enemy. Bush beans have been successfully used as banker plants for mite predators in greenhouse tomatoes (Matteoni 2003).

Greenhouse trials. Tests will be conducted in separate side-by-side greenhouses, each containing 4 benches (10 x 16 m), in conjunction with studies to compare IPM and conventional management practices in bedding plants. One greenhouse is managed according to accepted IPM principles, relying primarily on scouting, cultural and biological control. The other greenhouse follows more conventional management practices, with minimal scouting and heavy reliance on chemical insecticides. By incorporating the banker plants into this on-going study, we will gain insight into their suitability within two different pest management systems.

A variety of flowering and foliage plants will be produced in the greenhouses, representing common bedding and ornamental varieties grown in this region. Plants will be grown from seed, plugs and rooted cuttings. Varieties known to be susceptible to spider mites will be included. We anticipate being able to use natural infestations of spider mites as they are an annual problem; however, if a pest infestation does not occur, we will introduce plants carrying a low-level spider mite population. This would simulate a pest 'hot spot' that often occurs in a commercial greenhouse when new plant material is bought in. In the third year, we will test the utility of the banker plant system in two commercial greenhouses located within 10 mi of the Entomology Research Lab (see attached letters of support). Close proximity is essential for these initial stages of technology transfer/implementation to ensure ease of access and regular visits for monitoring and on-site management. Additional greenhouses can be included once the effectiveness of this approach has been demonstrated.

Banker plant placement and infestation. Banker plants will be spaced at about one plant per 2 running meters of crop bench, equivalent to three plants per bench in each greenhouse (12 plants per greenhouse). A completely randomized design will be used to select the plant type and bench location. Therefore each greenhouse will contain three of each plant type. Each trial will last for 5 mo (March-July), and will be replicated over two years. This goes beyond the normal bedding plant growing season, but will allow us to follow pest/predator population dynamics over an extended period, and will provide valuable information on the effectiveness of the different banker plants throughout.

Two weeks after banker plants are introduced into each crop, 5 persimilis (*P. persimilis*) and 5 fallacis (*A. fallacis*) will be released onto each plant – the recommended release rate per sq. meter (Elliott 2004b, 2004c). A second release may be made if, after 1 month, no predators are

recovered from the sample plants. This rate and frequency may be adjusted in Yr 2 depending on results of Yr 1 as an ideal release rate for banker plants in greenhouse ornamentals has not been established. Immediately prior to the first predator release, mite populations will be monitored on each plant by lightly tapping it 5 times over a white plastic tray, counting the number of mites on the tray using a headband Optivisor (3.5X). Spider mites are easily distinguished from their predators by the two greenish-black spots on their abdomen; they are also less mobile. The two predators are more difficult to differentiate, and if this proves to be the case, limited destructive sampling of flowers and leaves may be necessary, extracting the mites in alcohol for identification and counting. Predators and prey will be returned to the plants after inspection whenever possible.

Ornamental plants located at 0.5 m intervals to the east and west of each banker plant will be inspected in the same way to evaluate dispersal patterns of the predator and prey. The benches are too narrow to assess significant dispersal to the north and south. All other pest management activities that take place in the house, such as pesticide and fertilizer applications, will be recorded throughout the trial.

Grower participation. Growers will be intimately involved in the project, visiting research greenhouses in Yr 2 and participating in Yr 3. They will be compensated $1,000 for their time spent assisting in the trial. This incentive will encourage active cooperation; growers will be expected to provide scouting/monitoring data, and to assist in all aspects of the study in Yr 3. Included in the budget are costs for acaricides and pesticides. The basis of this project is not only to test a new pest management tactic in full collaboration with growers, but to use this tactic as one part of an IPM program that includes the judicious use of pesticides. The bottom line for a grower is to produce a saleable crop. If pest numbers dictate, intervention with an appropriate selective pesticide may be necessary. We have budgeted for this contingency, which will allow us to purchase and use selective materials that will have minimal impact on the beneficials. By working directly with the grower/owner of these small businesses, we will demonstrate the value of scouting/monitoring, which will reduce the frequency of pesticide applications, but will also use safer materials, reducing the health risks posed by any pesticide sprays that need to be made.

Statistical analysis. Data on the number of predators and prey per plant will be averaged within a banker plant type for each greenhouse, and analyzed using ANOVA to detect differences according to the production system, plant type, and time of year. Data on the number of predators and prey on adjacent crop plants will also be averaged according to distance from the banker plant and cardinal direction, and analyzed to determine the dispersal potential of the mites from the different banker plants.

Projected outcome and limitations. We expect to observe differences in establishment and reproductive rates of the two predator species. The optimal conditions for persimilis are 20-27° C and 60% rH; at these temperatures they reproduce faster than their prey. At warmer and cooler temperatures, the spider mite reproduces faster. In contrast, fallacis reproduces readily over a wider temperature range (9-32° C), and do best when the rH is >50%.

We anticipate differences in the suitability of the different banker plants for production of predatory mites. For example, while marigold flowers will be present, bush beans will not be in flower during the early months. This may restrict the establishment of predators when prey numbers are low; the ability of fallacis to survive on pollen in the absence of prey may promote

leave the vermiculite, falling into the Silwet solution as they attempt to escape the heat. After 4 h a lid will be placed over the entire separator to prevent evaporation of the solution, which will be topped-up as necessary. After 24 h, the mites will be filtered out of the Silwet and preserved in alcohol for later counting. The vermiculite will be sieved to remove dead mites, which will be similarly preserved. The percentage of live mites in each of the samples can then be calculated.

Methods will be slightly modified for *A. cucumeris* and the number of live mites only calculated for each shipment. These mites are normally sold as a mixture of bran, bran mites (food source in transit), and the predator. As the ratio of the two mite species can vary, and due to the difficulty in differentiating between the two species, dead mites and cast skins, an alternative extraction method must be used. In addition, *A. cucumeris* are less active than *P. persimilis* or *H. miles*, and will not readily move out of the bran. Five samples will be taken from the container, and placed directly in a 6 cm diam. x 2.5 cm high sieve (mesh width 333 μm, 42% open), spreading the carrier as evenly as possible. The sieve will be place 15 cm below a 150 W lamp for 5 mins to allow the sample to warm. This allows the small bran mites to move out of the sample first, and into a dish containing 0.04% Silwet placed under the sieve. This sample will be treated as a separate entity; examination will confirm the presence of bran mites vs. *A. cucumeris*, and the sample may be discarded in future evaluations. A fresh dish will be placed under the sieve for the second stage of this extraction. Full heat is needed to drive the predatory mites out of the sieve, so after the 'warming' period, the sieve will be raised to within 5 cm of the lamp for a further 15 min. *A. cucumeris* will fall into the dish and drown. They will be filtered out of the Silwet and preserved in alcohol for identification and counting.

Processing of samples. The number of mites in each sample will be counted under a dissecting microscope by inmates at the Northwest Correctional facility, St. Albans, VT. The Entomology Lab has an established entomology program at the Facility, and inmates have experience sorting and counting small insects, soil mites and Collembola.

Grower method for quality assessment. This will be tested for *P. persimilis* only in this project, but it could be adapted for other predatory mites in the future. The method will not be as precise as those described above, nor will it provide a 'total' count of live and dead mites. However, it will give growers with the information they need to predict the biocontrol potential, i.e., the no. live mites per shipment. It can be done quickly and simply without specialized equipment, empowering growers to do their own quality control testing.

Samples will be taken as described above, and placed one-by-one on a sheet of white paper under a warm bulb. The number of live predators running out of the material will be counted over 15 minutes (time may be revised depending upon results). The total number of live *P. persimilis* per container will be estimated using the mean of 5 samples. Numbers will be compared to those obtained using the Berlese method to assess the relative accuracy of this technique.

Statistical analysis. Mean numbers of live mites/sample will be compared between shipping methods and among suppliers for each month. Data will be subject to ANOVA, and multiple comparisons made to detect differences and compare among the variables tested (shipping method, time after receipt) to determine how these affect the viability of the selected natural enemies. Data will be compiled into an informational brochure to be distributed to growers attending our workshops and will be available for downloading via our web site.

Projected outcome and limitations. We anticipate differences in the health (quality) of the different predators depending on the time of year, time after receipt, and method of shipment. Such information is critically important to growers, and to the success of a biocontrol strategy. We will not determine the longevity, sex ratio or fecundity of the mites. Ideally, measurement of these parameters would be part of such a study, but limited resources mean this is beyond the scope of the current project. The information generated, however, will be an important first step in the process, and one that is in the hands of the growers. Also, such QC parameters should primarily be the domain of the companies to ensure shipment of high-quality natural enemies that perform according to the claims made by the producers. This is essential to customer satisfaction and repeat purchases. The information will save growers money and encourage them to utilize more beneficials in their IPM programs.

Extension

Obj. 3. Develop, organize and conduct hands-on IPM training programs in ME, NH and VT.

Workshops will be offered in each state in early January. Based on exit evaluations from previous workshops, this is the most convenient time for growers to meet, following the holiday season and preceding the spring growing season, ensuring that the information is provided to growers at a time when it is most needed and stands the greatest chance of being implemented.

Planning. To develop a suitable program, the Tri-State Greenhouse IPM Advisory Group will meet in early August. Evaluations from past workshops will be reviewed to determine the subjects that are of greatest relevance to previous attendees. To expand the scope of the program, specialists from Europe and/or Canada will be enlisted to participate in at least two of the three project years. In many respects greenhouse production is more advanced there in terms of using biologically-based IPM than in US, and thus we seek to draw on their expertise. Though specific international presenters cannot be identified at this time, some examples include, J. Bennison, Entomologist, ADAS Boxworth, Cambridge, UK; J.C. Van Lenteren, Research Station for Floriculture and Glasshouse Vegetables, The Netherlands; and G. Murphy, Ag Canada, Ontario, Canada. Specialists from the US will also be recruited to further strengthen the program. Workshops will be limited to 40-50 attendees per state per year, allowing us to use a hands-on format. Growers repeatedly stress the value of this format in terms of learning new techniques, and in the level of interaction promoted between growers and specialists.

Implementation. After the program has been developed, extensive organization will be required to promote and publicize the workshops. Announcements advertising the workshops will be sent out to >3,500 greenhouse professionals on our current mailing lists. These lists are updated regularly in cooperation with the State Departments of Agriculture, who maintain databases for certified pesticide applicators. It will also be advertised via regional greenhouse e-mail lists and websites, in grower newsletters, and at appropriate grower meetings within the region.

Educational handouts will be prepared to supplement the workshop sessions. This is a major task requiring several weeks of work to prepare, collate and copy, and to ensure it is presented in a user-friendly format. Organization will be coordinated at the Univ. of VT, which will be responsible for preparation and mailing of flyers and other advertising, registration, collation of registration packages, and travel and accommodation arrangements. Cooperators from ME and NH will be responsible for in-state facility arrangements. Each workshop will be evaluated

through exit questionnaires as in previous years. These provide valuable feedback and allow us to tailor the subject matter of future workshops to address growers' needs.

Obj. 4. Conduct follow-up surveys at garden centers in ME, NH and VT to determine changes in customer attitudes and knowledge about IPM.

Survey tools and sites. The questionnaire we will use in 2005 will be revised in collaboration with specialists from Dept. Community Development an Applied Economics, Univ. of VT. The survey, which will take no more than 5 minutes to complete, will be conducted at the same retail garden centers, nurseries and greenhouses in ME, NH and VT in yr 3 of the current project. As customer attitudes are likely to vary depending on the size of the community in which the business is located, surveys will be conducted at 5 sites within 20 miles of a major metropolitan center, and 5 sites located more than 20 miles from an urban area (10 sites per state).

Owners of the retail operations will again be contacted to obtain permission to survey their customers on their property. Surveys will be done on-site over weekends during May, June and July, the peak months for commercial sales of bedding plants in this region. At each site, 100 customers will be surveyed. Those completing a questionnaire will be given a coupon worth $2 towards their purchase in that business. The response rate is greatly improved when a monetary reward is given with the survey (R. Govindasamy, pers. comm.). This will also encourage the business owner to participate in the program. Data from the questionnaires will be summarized into percentages to determine changes in the public's perception and attitudes about IPM and whether this has influenced them to buy plants grown using IPM practices.

Projected outcome. We recognize that IPM is a term not currently known to most people. By providing growers with materials publicizing their use of IPM, and educational brochures to their customers during the survey in 2005, along with other education materials for distribution in the intervening years, we hope to raise awareness about its value and benefits. By doing so, this can influence the criteria people use when purchasing a plant. Continued public education will play a key role in creating demand for IPM-grown plants, and the survey we propose will serve as a tool to measure our progress in this regard.

Project Outcome and Products

- Manuscript reporting on the use of banker plants for spider mite management.
- Extension publication and trade magazine articles documenting the use of banker plants and results of our research.
- Extension publication on methods to assess the quality of shipments of natural enemies, and results of our research into shipment quality.
- Grower workshops on IPM in ME, NH and VT.
- Educational handouts for use at the workshops.
- Consumer survey to determine attitudes about IPM.
- Educational handout on IPM for the general public.
- Trade magazine report about consumer knowledge and attitudes about IPM.
- Increased opportunities to utlilze biological controls in ornamentals.
- Decreased pesticide use.

Duration and Timeline

Funds are requested for 3 years.
Projected start date: March 1, 2005
Projected end date: Feb 29, 2008

Timetable

Year 1 - March. 1, 2005 – Feb 28, 2006

- Conduct greenhouse studies to evaluate effectiveness of banker plants (Mar.-July).
- Assess quality of predatory mite shipments sent out via overnight vs 'ground' shipping (Mar.-July)
- Plan, organize and conduct IPM workshops in ME, NH and VT, incorporating information on consumer attitudes about IPM (Aug.-Jan.).

Year 2 - March 1, 2006 – Feb.28, 2007

- Continue greenhouse studies to evaluate effectiveness of banker plants (Mar.-July).
- Assess quality of predatory mite shipments (Mar-July)
- Prepare and submit article for grower magazine on use of banker plants in pest management (Sept.-Oct.).
- Compile results of natural enemy shipment assessments for an extension publication (Sept.-Dec.).
- Present research findings on banker plants at grower seminars and meetings (on-going).
- Coordinate IPM workshops in ME, NH and VT (Aug.-Jan.).

Year 3 - March 1, 2007 – Feb.29, 2008

- Test banker plants in two commercial greenhouses in VT (Mar.-June).
- Conduct consumer survey in ME, NH and VT (May-July).
- Prepare scientific manuscript on effectiveness of banker plants for on-site production of predatory mites and suppression of spider mites (July-Sept)
- Prepare and submit article for grower magazine on use of banker plants for suppression of spider mites in spring bedding plants (Sept.-Nov.).
- Prepare and distribute extension publication on banker plants (Sept.-Dec.).
- Prepare extension publication on use of predatory mite and ways of assessing shipment quality (Sept. – Nov.)
- Present research findings on banker plants at grower seminars and meetings (on-going).
- Coordinate IPM workshops in ME, NH and VT (Aug.-Jan.).

D. Cooperation and Institutional Units

Cooperators: **Colin Stewart**, Entomologist, UME Extension and **Cheryl Smith**, Plant Pathologist, UNH Extension, will serve as primary contact points for project activities in their states; letters of cooperation are included. *Colin Stewart* coordinates greenhouse IPM activities in Maine, overseeing scouting programs with commercial growers state-wide. For the past two years he has actively participated in the Greenhouse IPM workshops of the Tri-State IPM Group, and in related greenhouse IPM research/extension projects. *Cheryl Smith* has extensive experience with floriculture plant pathology in New England, and is frequently asked to speak on plant diseases

attacking greenhouse grown plants throughout the region. She is an active member of the planning committee of the New England Greenhouse Conference. All of the members of the Tri-State Greenhouse IPM Advisory Group will cooperate in this project by assisting in the development of the IPM workshops. A list of the current members may be found in the Appendices on the 2005 IPM Workshop flyer.

Institutional units:
Entomology Research Laboratory, Plant and Soil Science Department, Univ. of Vermont.
Advisory Committee: Tri-State Greenhouse IPM Advisory Group
Mr. Jeff Haddock, Grower-Owner, Gardenside Nursery, Shelburne, VT. Owner/operator of this greenhouse business, he has cooperated with us for the past 3 years on our thrips coldhardiness project. Research on banker plants will be done in a mixed-crop house in yr 3.
Mr. Ron Paquette, Paquette Full of Posies, Williston, VT. Owner/operator of this greenhouse operation, he has also cooperated with us on a thrips project. Will participate in the current project as a cooperator in yr 3, providing a research site for the banker plants.

Why Is This Project Worth Funding?

- ✓ It serves a significant agricultural commodity in VT and the US.
- ✓ It assesses a novel biological control approach to manage a major pest of ornamentals – two-spotted spider mite.
- ✓ It generates valuable data on the quality of natural enemy shipments that could significantly reduce costs associated with biological control.
- ✓ It provides valuable and effective educational IPM workshops for growers.
- ✓ It produces data on changes in consumer knowledge and attitudes about IPM and contributes to consumer education on the benefits of IPM.
- ✓ It will provide critical information that could improve markets for IPM-grown plants.
- ✓ It addresses grower-identified research and educational needs.
- ✓ It addresses goals identified by the Northeast Regional Commodity Working Group for Greenhouse and Nursery Ornamentals IPM (GO IPM).
- ✓ It strengthens regional collaboration between ME, NH and VT.
- ✓ It will help reduce use of chemical pesticides by greenhouse growers.

E. Implementation and Evaluation Plans

The fundamental premise of this research/extension proposal is to promote IPM implementation. The research component addresses issues relevant to the increased adoption of biological control, as a component of an IPM program for bedding plant production. The first research objective assesses the feasibility of using banker plants for on-site production of predaceous mites for suppression of spider mites. Banker plants are successfully used in greenhouse vegetables, but have not been widely tested in greenhouse ornamentals. Through research in experimental greenhouses, followed by testing at two commercial sites, a robust system will be developed that can be readily implemented by growers. Growers with more experience in the use of natural enemies are more likely to adopt these techniques at first, which is why we need to continue to educate growers in IPM and biological control, and pursue other fronts to enhance the uptake of these approaches. This will be partly achieved by using the experimental and commercial greenhouses where this research will be done as demonstration sites. In these, we will be able to show multiple growers how the system works, and how to use it in their greenhouses. In addition, we will incorporate our findings into the IPM workshops which are an integral part of this project, further promoting adoption of the technique.

We have already secured funding to evaluate grower's uptake of IPM practices that will be demonstrated in our workshop planned for Jan 2005. The evaluation will consist of a telephone survey done before, immediately after, and 6 mo. after the workshops. The questionnaire has been developed with members of the Dept. Community Development and Applied Economics at the Univ. of Vermont to ensure that the methodology used is sound. The survey can be adapted to measure the outcome of our demonstrations and workshops where the banker plant system will be displayed.

One of the impediments to greater use of beneficials, is the high cost of shipping. Our second research objective directly addresses ways in which these costs may be reduced, by simply using a less expensive shipping option. But, this must not compromise the quality of the natural enemies, as this will negatively impact the biocontrol program. The information we generate in this part of the study is directly relevant to the grower and the success of his/her biological control program, and thus has a high chance of implementation. Further, by reducing the costs associated with shipping, we are likely to increase the chances of growers using natural enemies in IPM. We also propose to develop a simple technique whereby growers can assess the viability of their natural enemy shipments themselves – quality control at the greenhouse level – which will be extremely valuable. As growers use more biological controls, pesticide use will be reduced, and the types of pesticides that are used will also change. This will decrease the risk of applicator exposure and environmental pollution. Furthermore, the types of pesticides we will advocate in our research and workshops are considered 'reduced-risk' in terms of their specificity for particular target pests, and low mammalian toxicity. Use of biological controls will also slow the development of resistance in the target pest complex. It is difficult to accurately measure the outcome of these initiatives, but surveys carried out at our IPM workshops, and the telephone survey outlined above, will be valuable tools in tracking changes in grower practices, and the type and volume of pesticides used.

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Goh HyunGwan & J.C. van Lenteren. 1999. Control of watermelon insect pests by the use of multiple natural enemies. Bull. OILB/SROP 22: 93-95.

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SAS Institute. 1992. SAS/STAT user's guide, Vol. 2, GLM-Varcomp, Ver. 6, 4th ed. SAS Institute, Cary, NC.

Skinner, M., S.D. Costa & M. Brownbridge. 2003. Priorities and needs for the Northeastern greenhouse and ornamentals industry: A survey of growers and other key personnel. Final report, Univ. of VT, Entomology Research Laboratory.

Spiers, J.D., F.T. Davies, C. He, A. Chau, K.M. Heinz & T.W. Starman. 2004. Effect of insecticides from five chemical classes on the growth and production of pot mums (*Dendranthema grandiflora* Tzelev var. Charm) pp. 168-172, *In* Proc. SNA Research Conference Vol 49.

Steiner, M.Y. 1993. Quality control requirements for pest biological control agents. Alberta Environmental Centre, Vegreville, AB. AECV93-R6. 112 pp.

The suitability and quality of the educational workshops will be evaluated with exit questionnaires that participants will be asked to complete. Similar questionnaires have been used for the past 5 years to evaluate workshops organized by the Tri-state Greenhouse IPM Group. These questionnaires have provided invaluable information on what growers want and has allowed us to tailor the subject matter of workshops to specifically address these stated needs. The questionnaires can be amended to include an evaluation of impact, so that we can measure the success of previous workshops in terms of growers' adoption of IPM practices.

The consumer survey is itself a way of monitoring the impact of educational efforts specifically targeting the general public. Planned for the third year of the project, it follows a baseline survey that will be carried out in 2005 through EPA funding. By comparing data sets from each survey, we will measure changes in consumer knowledge and attitudes about IPM, and how this has affected the criteria they use when purchasing a plant. Consumers can affect how their plants are grown, by the way in which they spend their dollars. IPM will be most effectively advanced by changing the mind-set and behavior (pest management/purchasing) of both grower *and* consumer. By raising public awareness about the benefits of IPM, and increasing demand for plants grown using these practices, this will in turn convince growers to implement more IPM practices. Nationwide, Extension has begun to recognize that consumers form the largest part of their stakeholder base. The consumer survey represents a way of bringing their voice to agricultural production in a novel and positive manner.

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III. Appendix

LOOK WHAT YOU'LL GET OUT OF WORKSHOP!

*How to **DIAGNOSE pH** problems and **CORRECT** them.*

*How to **MAKE** the most of **IPM** tactics.*

*The Pros & Cons of **BIO- vs CHEMICAL-BASED** IPM.*

*What **WORKS** for other growers for pest management.*

Bring your hot pest questions!

Workshops were planned with the tireless assistance of the Tri-state Greenhouse IPM Advisory Group:

Margaret Skinner, Michael Brownbridge
Bruce L. Parker & Thomas J. Doubleday
Univ. of Vermont

Alan Eaton & Cheryl Smith
Univ. of New Hampshire

Jon Turmel
VT Dept. of Agriculture

Scott Longfellow
Longfellow's Greenhouses, ME

Chris Schlegel
D. S. Cole Growers, NH

Jeff Huntington
Pleasant View Gardens, NH

Peter Konjoian
Konjoian's Grnhses, MA

Tom Durkis & Chris Rallis
NH Dept. of Agric. & Markets

Colin Stewart
Univ. of Maine

Support for these workshops was provided by:

Longfellow's Greenhouses
Applied Bionomics
Griffin Greenhouse Supply
IPM Laboratories, Inc.

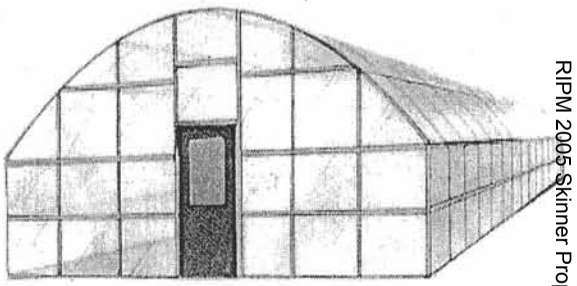
Agdia, Inc.
BioWorks, Inc.
Gemplers
Fischer Scientific

Univ. of VT Extension, IPM Prog.
National Foundation for IPM Education
Univ. of Maine, Coop. Extension, IPM Prog.
Univ. of New Hampshire Extension, IPM Prog.
VT Integrated Research & Ext. Competitive Awards
Univ. of Vermont Extension, Pesticide App.Train. Prog.
And other pending support.

Entomology Research Laboratory
661 Spear Street
Burlington, VT 05405-0105
Return Service Requested

Tri-state Greenhouse IPM Program

HANDS ON WORKSHOP!



RIPM 2005 Skinner Proposal

Putting the Pieces Together: How to Make IPM Work for YOU

January 5, 2005 Manchester, ME

January 6, 2005 Durham, NH

January 7, 2005 Burlington, VT

WELCOME!

The Tri-state Greenhouse IPM Program is a collaboration among growers and specialists from Maine, New Hampshire and Vermont. This year's workshops offer sessions on using multiple IPM tactics together cost-effectively to reduce pests and diseases, diagnosing pH problems and managing it, plus the latest news about emerging IPM issues.

These workshops are for greenhouse growers, extension specialists and professional pest managers. Growers of all levels of experience will learn something new.

In addition to the visiting speakers, there will be many of the "old" favorites: Michael Brownbridge, Tom Doubleday, Cheryl Smith and more.

Margaret Skinner, Univ. of VT
Entomology Research Laboratory
661 Spear Street
Burlington, VT 05405-0105
Tel: 802-656-5440

Alan T. Eaton, Univ. of NH
Dept. of Plant Biology,
252 Spaulding Hall
38 College Road
Durham, NH 03824-3544
Tel: 603-862-1734

Colin Stewart, Univ. of ME
Pest Management Office
491 College Avenue
Orono, ME 04473-1295
Tel: 207-581-2967

WE HOPE TO SEE YOU!

Share this brochure with your staff and colleagues.

PROGRAM

"Lectures are minimized, hands-on experiences maximized"

This year's SPECIAL GUESTS:

Rob Jacobson, IPM Consultant
Stockbridge Technology Ctr., United Kingdom

Paul Fisher, Associate Professor
University of New Hampshire, Durham, NH

8:00-8:30	Registration & Coffee
8:30-8:45	Welcome
8:45-10:00	**Putting the Pieces Together: IPM Case Study from Europe*** How to incorporate biological control with other IPM tools to keep pests below damaging levels.
10:00-10:30	Coffee Break
10:30-11:45	**pH Management, Part I: Diagnosing the Problems*** Hands-on session on identification of symptoms of pH-related problems.
11:45-12:45	Lunch
12:45-1:45	**Grower to Grower Discussions: Sharing Challenges and Solutions** Growers will share their experiences with IPM and what is working for them.
1:45-2:45	**pH Management, Part II: Getting it Right*** Learn the latest pH testing and management techniques.
2:45-3:45	**Conventional vs Biologically-based Management: Costs& Benefits/Pros & Cons*** Discussion of on-going practical research underway.
3:45-4:15	**What's Out, What's In, What's New, What are Growers Using?** Share the latest on chemical and biorational pesticides.

Give Out Door Prizes!

****

*Small-group concurrent hands-on sessions.
Live samples and microscopes will be available.

Up to 6 Pesticide Credits Awarded
6 Credits for VT Assoc. of Prof. Horticulturists

REGISTRATION FORM

Where and When:

January 5 - Longfellow's Greenhouses, Manchester, ME
January 6 - Univ. of NH, Durham, NH
January 7 - UVM Campus, Burlington, VT

Registration Fee: $50 (includes hand lens, snacks, lunch, IPM guide and more). If you need a parking permit **(for NH & VT sessions only)**, add $5. Make checks out to **UVM Entomology Research Lab.** Forms and checks should be received by **December 20, 2004**. Add $25 for the **2005/2006** *New England Greenhouse Floriculture Guide (It's a new edition this year!).*

Enrollment is limited. To ensure a place, register early. Pre-registration required.

✂ .....

Name: _____

Address: _____

_____

Tel: _____

Fax: _____

☐ I want a 2005/06 *NE Greenhouse Flor. Guide.*

Workshop Location (Check only 1):

☐ Manchester, ME ☐ Durham, NH ☐ Burlington,VT

☐ I need a parking permit for the workshop *($5, NH & VT only). Permits will also be available at the door.*

Persons from all 3 states are welcome to attend any of the locations. All registrants will receive notification of their place in the workshop and a map with directions.

Send registration and check to:

Margaret Skinner, Entomology Research Lab.
661 Spear Street, Burlington, VT 05405-0105

Questions? Call Margaret at 802-656-5440
Fax: 802-658-7710, email: mskinner@uvm.edu

Sorry, no refunds.

RIPM 2005 Skinner Proposal

IV. Key Personnel

Classification		% Time Allocation (SY, FTE, PY or TY)	Role & Responsibility (see narrative below)
AES PI:	Michael Brownbridge	0.80 SY	Coordinate research
UVM Ext PI:	Margaret Skinner	0.10 FTE	Conduct surveys and coordinate workshops
	Tom Doubleday	0.15 TY	Plant production and workshop organization
Technician:	Unassigned	0.15 TY	Assist with research and workshops

Roles and Responsibilities:

Margaret Skinner[1] will maintain primary responsibility for conducting the consumer survey and coordinating the IPM workshops in each of the three states. She will coordinate technology transfer of this research to growers through the Tri-state Greenhouse IPM Group and annual IPM workshops. This will include facilitating meetings of the Tri-state Greenhouse IPM Group, who will participate in planning and implementing these activities (Obj. 3 & 4). In addition, she will assist with data collection and preparation of the publication for the research objective.

Michael Brownbridge[1] will coordinate the research described in Obj. 1 and 2. In addition, as a member of the Tri-state Greenhouse IPM Group, he will assist with the Extension objectives and participate in the annual IPM workshops. He will review the consumer questionnaire, and interact with growers for the pre- and post-workshop evaluations.

Thomas Doubleday, Head Grower, Entomology Research Laboratory, VT has 18 years of experience managing the largest diversified greenhouse operation in Vermont, and has managed the experimental greenhouses at the Laboratory for 4 years. He will oversee all plant production activities and take part in all greenhouse related research, including data collection and entry. He will take a leadership role in the organization of the annual IPM workshops and will liaise with the grower cooperators in yrs 2 and 3.

[1] Curricula vitae and Current and Pending Research for these personnel appear in the Appendix.

Relevance Statement

1. Names and Institutions of PDs and Major Cooperators:

Project Directors:

i. Margaret Skinner, The Univ. of Vermont, Entomology Research Laboratory
ii. Michael Brownbridge, The Univ. of Vermont, Entomology Research Laboratory

Cooperators (in alphabetical order):

i. Jeffery Haddock, Grower/Owner, Gardenside Nurseries, Shelburne, VT
ii. Ron Paquette, Grower/Owner, Paquette Full of Posies, Williston, VT
iii. Cheryl Smith, Plant Pathologist, University of New Hampshire, Cooperative Extension
iv. Colin Stewart, Entomologist, University of Maine, Extension System

2. Title: Promoting IPM Implementation in Greenhouses: Banker Plants, Grower Education and an Assessment of Consumer Attitudes

3. Project Summary

This project will promote ways of reducing risks associated with the use of chemical insecticides by increasing opportunities to use biological control, and IPM education. First, we will assess the utility of banker plants for on-site production of predatory mites for control of spider mites on spring bedding plants. Banker plant systems provide a steady release of natural enemies into a crop, offering extended suppression of pests while reducing the cost and increasing the quality of the biocontrol agents. Second, many natural enemies are released innundatively into a crop, several times over a growing season. Shipping costs for these beneficials are considerable. We will determine whether cheaper shipping options, i.e., ground vs. overnight, impact the quality of the natural enemies received. We will also define a simple method to empower growers to perform their own quality control tests on mite shipments. Third, we will continue to develop and present innovative hands-on IPM workshops for growers in ME, NH and VT. Specialists from Europe and North America will participate, and results from our research will be incorporated into the program to aid technology transfer. Finally, we will perform a follow-up survey to measure changes in consumer attitudes and knowledge about IPM, and to see if our efforts to promote IPM have influenced the criteria people use when purchasing greenhouse-grown plants. This will follow a customer survey we will perform in 2005, which will be accompanied by the development and distribution of educational materials on IPM in the intervening years to raise public awareness and appreciation of the importance of IPM to them and the environment. Over time, consumer awareness will be critical to increase growers' use of non-pesticidal management tactics. If customers demand plants that with no (minimal) pesticide residues, growers will have to change their production practices. Together, these initiatives will promote a decreased reliance on toxic pesticides while creating an appreciation among growers' clientele about the benefits of IPM, and greater demand for plants grown using IPM practices.

4. Objectives

Research and extension components are combined in this project to promote greater IPM implementation in the northern New England region. Through the research we will assess banker plants as a novel system for using biological control in greenhouse-grown spring bedding plants and evaluate the cost and quality of natural enemy shipments. Through the extension component we will build on our existing regional collaboration to provide high quality educational workshops for growers that help to disseminate results from our research. In addition we will conduct a consumer survey to gain insight changes in their attitude after a 3-year public awareness effort done in cooperation with growers.

Research:

1. Evaluate the use of banker plants for production of predatory mites in spring bedding plants.
2. Assess the quality of natural enemy shipments received at different times of the year from Regional and National distributors.

Extension:

1. Develop, organize, and conduct hands-on IPM training programs for greenhouse growers in ME, NH and VT.
2. Conduct follow-up surveys at garden centers in ME, NH and VT to determine changes in consumer attitudes and knowledge about IPM.

5. Description of the Problem, Background and Justification

Historically, dairy farms have dominated the rural landscape in the Northeast, but this traditional farming sector is declining as production agriculture becomes more diversified. In contrast, the greenhouse industry is expanding, and has become a vital component of the Region's agricultural economy. In fact, revenues from greenhouse crops far exceed that of any other crop commodity in the Northeast, with annual sales in excess of $551 million in New England alone. Public demand has driven this expansion, as people seek to beautify their homes and gardens with flowering plants.

Arthropod pests and diseases limit productivity and economic returns in greenhouse crops. Growers rely heavily on conventional pesticide-based strategies for their control. The compounds used pose risks to applicators, consumers and the environment. Repeated pesticide applications can also adversely impact plant physiology and appearance.

The goal of maintaining high levels of agricultural productivity and profitability while reducing pesticide use, presents a significant challenge. Research and outreach efforts must focus on increasing IPM implementation on all crops – strategies that emphasize cultural and biological controls as the main defense against pests but include the judicious use of pesticides. IPM reduces risks associated with pesticides, yet growers assert that they must use these materials to meet consumer demands for 100% pest-free plants. To be successful, control agents and IPM programs that are appropriate to local conditions must be developed. Generic IPM techniques developed for large, year-round facilities in southern states – where pests may be year-round rather than seasonal threats – are often not applicable to small, family-run greenhouse

operations that are predominant in the Northeast. Furthermore, if not accompanied by appropriate extension and outreach activities, they will have little chance of adoption. Educational efforts must not only target growers, but also consumers. Consumers are a driving force in our market society; if, through education about the value of IPM-grown crops in terms of human health and environmental quality, consumer demand could be created, this would serve as a valuable incentive for growers to implement IPM.

Importance and Relevance to Growers and Other Stakeholders in the Northeast.

Adoption of multiple management tactics – IPM – is essential to ensure that high-quality plants are produced, the greatest revenue generated, and the least amount of chemical insecticide used. Time, knowledge (or lack of), and ease of implementation appear to be the greatest barriers to the wider adoption of IPM techniques (GO IPM 2002, Skinner et al. 2003). The research objectives evaluate the use of banker plants for on-site production of predatory mites for the control of spider mites. Cost and availability are often cited as factors limiting growers' use of natural enemies. Banker plants offer great potential to provide a constant "feed" of such predators into a crop, reducing the need for multiple releases, and ensuring that a resident population is present should a pest outbreak occur. Few inputs are needed, once the natural enemy is established, to achieve long-term suppression. The cost of shipping natural enemies is often higher than the cost of the beneficials themselves; when multiple releases are required, shipping costs become a major expense. These can be minimized by using banker plants.

Costs can also be considerably reduced by using 'ground' shipping, which is one-third the price of 'overnight' shipping. However, this can take 1-2 days longer than standard overnight shipping. How will this affect the quality of the natural enemies received by the grower? We propose to assess the quality of predaceous mites used to control pests on spring bedding plants over the course of a growing season. Natural enemies will be ordered from three distributors and shipped via 'overnight' and 'ground' carrier. We will produce and distribute an informational pamphlet reporting results of our research, outlining methods growers can use to evaluate the viability of their shipments. This information will also be posted on our website for broader distribution. These are research priorities identified by the Regional Greenhouse and Ornamental IPM Commodity Working Group (GO IPM 2002).

In the extension component, we propose to directly address grower-identified needs by continuing to offer effective educational IPM workshops, drawing on the expertise of specialists in Europe and North America. Based on a recent survey by the Greenhouse and Ornamentals Commodity Working Group (GO IPM 2002), growers overwhelmingly stated that ***educational workshops*** were the best way for them to learn new production techniques. New plant varieties become available every year, and growers strive to respond to the constant demands of their clientele for access to these new products. Each new variety presents new production challenges and pest problems. To continue to grow and be profitable, both experienced and novice growers need support. As the Extension System throughout New England continues to be downsized, few people are left to provide leadership to address this need. Generally, specialists in fruit and vegetable crops and community IPM must do their best to cover several commodities, including greenhouse production. The only way to make up these gaps is to secure external funds to supplement ongoing programs. Growers in northern New England often lack the resources to

attend national greenhouse meetings, and the opportunity to interact with specialists outside the region. For this reason, it is critical that we bring national and world experts here. Growers who have attended our workshops have stated that the hands-on format used is the best way for them to learn the technical information and skills they need to implement IPM. Too often, educational meetings rely exclusively on lecture formats. This is a great way to reach a large number of people in a short amount of time, but they have little lasting impact on growers' pest management practices. To achieve true adoption, IPM techniques must be demonstrated, taking into consideration the individual conditions of each greenhouse operation. The workshops we host have been refined over the years to minimize lectures and maximize small group sessions. This format encourages learning and interaction between growers and specialists. The project proposed herein builds on this successful educational initiative we began 8 years ago. We have already secured funding to conduct a survey to monitor the outcome of our workshops in terms of changing grower practices; this will allow us to gain a better understanding of growers' needs and will enable development of more responsive and effective educational programs. Therefore, an impact assessment study is not included in the current proposal.

In one-on-one discussions with growers, they repeatedly stated that they want IPM information presented in a straightforward, "how-to" format. GO IPM also clearly identified the need to develop clearer and more succinct guidelines to support IPM implementation as a high priority (see Appendices listing Extension and Research Priorities).

How will the project develop, promote and implement non-pesticidal tactics?

Greenhouse production is complex, and a multi-component approach to pest management is required. Growers can get overwhelmed by the choices they have to make and often resort to the easiest option—a chemical pesticide. To reduce reliance on pesticides and promote greater use of alternatives, a new approach is needed. Critical information must be synthesized to provide a practical, IPM-based decision support tool, whereby a sequential series of actions in response to pest incidence are defined. Using a decision tree approach, we will present a step-by-step IPM system that includes cultural controls, guidance on scouting and data interpretation, when and if to use biological controls, and which chemical pesticides to use if necessary, along with resistance-management strategies. Growers will be supported in their selection of pest management actions, and encouraged to make decisions based on sound IPM principles. This will empower them to take proactive rather than reactive steps to resolve pest problems.

In the Extension component of this project, hands-on workshops will be presented in all cooperating states (CT, MA, MD, ME, NH, NY, PA and VT) to demonstrate use of the decision tree systems and supporting practices. These will provide growers with the skills they need to put IPM into practice. An electronic version of the decision tree package will be placed on the NEPMC website, and other state and regional sites. Summaries of the individual IPM components for the pest complexes will also be prepared for inclusion on the NEPMC website.

What is the level of multi-state involvement?

This project builds on an 8-year collaborative relationship between Extension specialists, researchers and growers in ME, NH and VT, most of whom are members of GO IPM, the Greenhouse and Ornamentals IPM working group, established under the auspices of the NEPMC. GO IPM was formed to serve as a catalyst for collaborative research and extension

activities in the region, and this current project directly addresses needs identified for the region. Collaborators from 3 Northeastern states will be directly involved in the outreach/extension activities.

Does this project address a significant problem with environmental implications?

Yes. Throughout the Northeast, the greenhouse industry is one of the few agricultural sectors that has grown over the past 10 years. In many states, where the survival of small family farms is at risk, greenhouse production has become an important means of diversification and economic stability. While the total acreage under glass and plastic is relatively small compared to other major crops, more chemicals are used on greenhouse crops—on an ai/acre basis—than in any other agricultural sector. Through provision of specific guidelines that encourage the proactive use of IPM tactics, growers will become less reliant on chemical controls and the negative environmental impacts of this agricultural sector will be reduced.

What is the probability of the results of this project being implemented?

High. We have built many components into this project to ensure that the systems will be practical and effective. First, the head grower at the Entomology Research Lab was formerly a commercial grower, and has personal knowledge of the demands of the industry and constraints on IPM implementation. He provides an excellent reality check for all the research we do. Second, growers are involved in "field testing" the systems we develop, which will ensure that they are suitable. We find growers are often more inclined to believe another grower, and our cooperating growers will serve as excellent ambassadors for disseminating information and encouraging adoption. Lastly, the workshop programs will be designed to be interactive and hands-on. Based on our experience, and feedback from growers, this is the best way to get them to understand and then put into practice the techniques we present.

Does this project address either of the NE-IPM annual emphases?

Yes. Through this project, we will develop and test systems to effectively use biological control agents which is a form of environmental stewardship, and because we are developing practical approaches for their use the likelihood for implementation will be high (see previous section). Through our survey of customers we will determine the value of greater use of IPM in terms of plant salability.