FINAL REPORT

EVALUATION OF ALTERNATIVE STRATEGIES FOR SMALL FRUIT PRODUCTION

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ABSTRACT

Agricultural scientists, extension agents, professional growers and agricultural industry members researched critical aspects of strawberry and raspberry production in the Northeastern United States from June 1989-December 1994. This ambitious project studied many critical phases of strawberry production, with less emphasis on red raspberry production. This includes but is not limited to non-chemical techniques of soil sterilization and/or increased fertility, integrated pest management techniques for weed, insect and disease control, screening of strawberry and raspberry germplasm for disease and insect susceptibility and productivity, characterization of a new systems for strawberry and red raspberry production, and the identification and evaluation of biological agents for the control of major pests. Some highlights of the project follow:

- Information extension was a strong component of this project, with investigators developing a well-received newsletter, and delivering in excess of 150 presentations to grower, agent, and professional audiences, 26 field days and over 100 publications (refereed, non-refereed, extension and trade journals).
- In a widely distributed survey, growers indicated a strong interest in experimenting with new technologies. Growers also indicated a willingness to adopt new technologies, and importantly indicated a willingness to adopt even when profits would be reduced by as much as $200.00 per acre. They were, however, unwilling to commit more management time to new practices.
- A parasite of tarnished plant bug, *Peristenus digoneutis* was recovered from a S. Deerfield release site. This is the first recover in the nation by any state cooperating with this ARS project. It confirms the establishment of the parasite at that location.
- Killed sod groundcover management techniques in strawberry provided a viable alternative to herbicides.
- Cultivar susceptibility and bed type (raised vs. flat) were the most influential factors determining whether raspberry plantings were debilitated by *Phytophthora* root rot. Straw mulch was also detrimental for long term survival.

- The current practice of floricane removal immediately after harvest is resulting in more cane cold injury on cold sensitive cultivars.
- Rowcovers increase marketable yield, reduced the number of tarnished plant bug nymphs and reduced feeding injury on strawberries .
- High nitrogen levels were associated with *Botrytis cinerea* on strawberry during flowering.

OBJECTIVES

I. To devise and test sustainable production systems for strawberries and raspberries

II. To analyze economic potential of selected sustainable practices

III. To evaluate grower clientele attitudes toward changing production practices

IV. To provide information to growers and scientists

SPECIFIC PROJECT RESULTS
FINDINGS, RECOMMENDATIONS AND ECONOMICS

Raspberries

The conventional system

Raspberries are most often planted into flat beds, and herbicides are applied to control weed growth. The system of production most often employed is to plant tissue cultured or dormant canes of raspberries 24-30 inches apart, and allow the plants to fill in "hedgerows" with canes which are produced from the roots (red raspberries) or crowns (black raspberries). Summer-bearing raspberries produce fruit on the previous year's primocanes (floricanes), while primocane bearing types produce on the current year's growth. For summer bearing types, we currently recommend prompt removal of spent floricanes. All types of raspberries are dormant pruned to some extent. Primary problems associated with raspberry production are a lack of labor for harvest, disease infestations (primarily gray mold and for red raspberries, Phytophthora root rot), and insect pests. In heavy soils, Ridomil (metalaxyl) is used to prevent Phytophthora disease. In established plantings, herbicide is used in the plant row, and the space between rows is often cultivated to control weeds.

Modifications of the conventional system

1. Use of resistant cultivars to reduce damage from Phytophthora

Rationale: In sites with heavy soils and Phytophthora, the use of resistant cultivars may enable raspberry production where otherwise production might not be feasible.

Results: In comparison to the industry standard Titan, the cultivar Newburgh had significantly fewer diseased canes at the end of the first growing season (5 vs. 46%), more healthy canes per plot at the end of the second growing season (121 vs. 12 per 3m of row), and much higher yields (3785 vs. 278 grams of fruit per 3m plot).

2. Use of resistant cultivars for other pest problems

Rationale: Raspberries are susceptible to a host of pests which are routinely controlled by chemical pesticides. The inherent susceptibilities/resistances of currently grown cultivars is unknown.

Gathering this information will enable growers to target more resistant cultivars, particularly if they choose to grow with minimal pesticide programs.

Results: Due to high levels of disease infection, it was necessary to apply fungicides routinely in the second year of the experiment, however insecticides were only applied as needed.

Red raspberries. When all pesticides were withheld in the first year, red raspberries were more attractive to Japanese beetles than black raspberries. Newburgh had low susceptibility to fungal diseases, but high infestations of soldier beetle, potato leaf hopper and Japanese beetle. Newburgh was high yielding with good size. Amos (449AB) had good size, and adequate yield (in one year comparable to Newburgh) and it didn't have the insect problems that Newburgh did. Sentry and Boyne red raspberry plants were the most susceptible to anthracnose cane infection. Winter injury was most severe on Willamette and Sentry.

Black Raspberries. All of the black raspberries tested were extremely susceptible to anthracnose, with up to 63 lesions per 5 canes on New Logan, and Jewel and Haut showing some resistance at 16.5 and 8.5 lesions/5 canes, respectively. Early Black was the most susceptible to winter injury, and Allen the least. Sweet Lowden's Purple was the most winter hardy, however berry quality was unacceptable.

3. Use of trellis systems to increase productivity, reduce disease infestations, and mechanize fresh market raspberry production in the northeastern United States.

Rationale: Trellis systems have been shown to increase productivity of Titan red and Royalty purple raspberries. Trellising raspberries also offers the possibility of fresh market mechanical harvest (reducing labor costs), as well as exposing the canopy to sunlight and improving air circulation among the leaves. These latter two items should result in reduced leaf wetting time, hence lower disease incidence. The 'T' (or Lincoln Canopy) system appears to be particularly well suited to all of the above advantages, and has been little tested on raspberries worldwide.

Results: After 5 years of studying trellising systems for raspberries, with particular attention to the 'T' Trellis, we have concluded that system offers the benefit of increasing fruit accessibility and yield. However, due to the lack of an effective fresh market harvester as well as the lack of availability of a suitable sprayer, the system will not have broad applications as originally intended. It should also be noted that sprayer technology is currently enjoying new growth, and this dearth may be soon fulfilled.

The 'T' trellis has been employed to a modest extent among Northeast growers, and is particularly successful for PYO black raspberry growers, where the increase in both yield and fruit accessibility makes the extra cost worthwhile. Physiological studies on the system have yielded useful information, and not least importantly, plants trained to 'T' trellises consistently had less cold injury than those trained to 'V' or hedgerow systems.

4. Use of mulches to control weeds during the establishment year

Rationale: Herbicide use and cultivation during the first two months after planting have a negative effect on raspberry plant growth. The use of mulches might provide weed control, while alleviating the negative effect of alternative practices on roots.

Results: Heritage plants in plots mulched with straw during the establishment year produced greater cane numbers and yields in the second year compared to plots treated with herbicides or weeded by hand (51 vs. 27 and 29 canes/m^2; 11.1 vs. 6.18 and 7.23 kg/4.5 m plot).

5. Use of raised beds to reduce Phytophthora incidence

Rationale: Phytophthora requires standing water for zoospores to infect roots. If the soil matric potential is increased, infection might be reduced.

Results: At the end of the planting year, the percent of diseased canes was 50% less in raised bed plots. With raised beds, cane numbers were over 50% greater (85 vs. 49 per 3m plot), average cane length was greater (106 vs. 77 cm), and cane diameters were larger (8.8 vs. 6.8 mm). Yields in 1993 were 3X higher on raised beds (3 vs. 1 kg per 3m plot). All differences were statistically significant.

6. Use of straw mulch to facilitate cane growth in heavy Phytophthora-infested soils

Rationale: Straw mulch promotes good cane growth in the establishment year compared to no mulch or herbicide use; therefore, this enhanced growth might offset detrimental effects of Phytophthora.

Results: Straw mulch resulted in more canes, but a much higher incidence of diseased canes in a previously infested site (51% vs. 19%). Cane diameter was also reduced in the presence of straw mulch (6.9 vs. 8.9 mm for controls).

7. Use of alternative ground covers in established raspberry plantings

Rationale: Clean cultivation over many years may have negative effects on soil structure and raspberry plant growth. Permanent and seasonal covers might reduce weed competition while improving soil physical properties.

In an established planting on heavy soil, straw-mulched plots exhibited significant Phytophthora disease compared to plots with alternative groundcovers, including clover, perennial ryegrass-fescue, spring oats, clean cultivation, or mowed natural sod. With the exception of the straw mulch, after three years, no significant differences in yield, cane density or cane height have been observed among groundcover treatments.

8. Use of *Trichoderma* to inoculate soil to prevent *Phytophthora* infection

Rationale: Certain species and races of *Trichoderma*, a naturally occurring soil fungus, produce an antibiotic that is inhibitory to *Phytophthora fragariae* var. rubi. By inoculating soil with this beneficial organism, some reduction in disease incidence might occur.

Results: At the end of the second growing season, *Trichoderma*-inoculated plots had significantly more canes per 3m plot (78 vs. 60), although total yields were not significantly different.

9. Use of bio-rational pesticides

Rationale: If bio-rational pesticides are effective in controlling pests, they will offer another option to northeastern raspberry producers, and will allow individuals who prefer producing "organic fruit" alternatives to fruit rots and insect infestations. Pyrrolnitrin, a biologically derived fungicide, is of particular interest, since it has been shown to be effective and have fairly low mammalian toxicity.

Results: Safer Soap (2% solution) was ineffective at controlling aphids on black raspberry, with only Malathion 25W (8 lbs/a) and Guthion 35W (1.5 lb/a) showing reductions in aphid counts.

Pyrrolnitrin was sometimes effective (better than the non-treated control, but not as effective as the chemical control with either Captan/Benlate or Rovral) in controlling gray mold in the field and postharvest, however it was not consistent. This inconsistency was probably due to the chemical's sensitivity to light and rain-washing. Ciba-Geigy is currently working on a formulation of pyrrolnitrin which will resist these problems.

10. Use of root pruning for vigor management

Rationale: Raspberry vigor can be managed by trellising, or by removing some of the growth. One means of reducing growth without reducing node number (which represents the potential for inflorescence and fruit production) is to remove a portion of the roots. The expected result is to reduce cane height (and lodging and the need for support), without sacrificing production.

Results: Root pruning offered no advantage for Titan (summer bearing) raspberry at any of the timings used (spring dormant, leaf expansion, or bloom). While root pruning decreased cane height, making plants more manageable, it also reduced yield enough for us to consider it an unacceptable means of vigor control.

11. Use of floricane removal timing to reduce cold injury and improve productivity

Rationale: The removal of spent floricanes immediately after harvest has been promoted, since it allows for better air circulation in the canopy, and removes a source of disease inoculum. However, anecdotal evidence has suggested that removal this early in the season may result in more winter injury.

Results: Timing of floricane removal on Titan red raspberry had a significant effect on the level of winter injury on the canes, with the percent of live canes significantly less on plants with floricanes removed immediately after harvest as is currently recommended. In 1993 (the second year of the study), removal of canes in August resulted in less yield than removal during any date following August (starting in October).

12. Study of phenology of raspberries as a tool for pesticide scheduling

Rationale: An understanding of the relationship between plant development and time can assist growers in deciding when to apply certain pesticides.

Results: Over the three years, it was found that, generally, black raspberries varied little in their dates of first bloom, 50% bloom, 50% green, first ripe, or days from first bloom to first ripe within a given year. However, red raspberries varied considerably, and there were year*cultivar interactions in days from first bloom to first ripe fruit, indicating that for red raspberries, phenology alone will be insufficient for timing pesticide applications.

Recommendations for raspberries:

If one must plant on heavy soils, select resistant cultivars and plant on raised beds. If growing with low rates of, or no pesticides, use less suceptible cultivars, but monitor diseases carefully, because plantings can die as a result of disease infestation very quickly, particularly in wet seasons. Safer soap has proven ineffective against aphids in raspberries. Inoculation of beds with the appropriate strain of Trichoderma may provide some benefits. Mulch these beds with straw for the first year only, but remove it before the first winter. In subsequent years, avoid mulches which promote excessive soil moisture and *Phytophthora* infection. In the future, it may be possible to use Trichoderma-inoculated groundcovers in raspberry plantings to provide a large, continuous source of toxin against *Phytophthora.*

The 'T' trellis system may be employed to increase fruit accessibility. These systems are particularly useful for black raspberries. As more specialized efficient sprayers are developed, this system may have increased usefulness. Floricane removal of cold-tender cultivars should be delayed until October, unless disease pressure is particularly high, and/or fungicides are not employed.

Economic considerations:

Resistant varieties cost no more than susceptible varieties, although some of the susceptible varieties are capable of producing larger fruit or higher yields in the absence of disease - resulting in greater sales. Making raised beds requires specialized equipment and additional energy resources, but can eliminate the need for prophylactic fungicide applications for Phytophthora root rot, costing about $120 per acre annually.

The cost of straw mulch varies, but its use in the first year can offset the cost of an herbicide application, and can result in significantly increased yields in subsequent years. The greatest benefit generated from using a mulching weed suppressant system is the potential impact on early production. The increase in early production equates to a higher net present value per acre; $168/acre (PYO) and $1,271/acre (grower harvested). As with other alternative systems, the grower harvest operation is much more sensitive to changes in production. *Trichoderma* inoculum or inoculated groundcovers are not yet commercially available.

Economic analysis showed that a 4-8% increase in production would offset the cost of the trellising. For the PYO raspberry grower with a more "upscale" clientele, the trellis system may offer a useful means of increasing fruit accessibility, as well as the aesthetics of the planting. Because of the cost of the mechanical harvester, 80% harvest efficiency would be required on 120 acres in order to justify the expense. Because we were only able to reach 40% harvest efficiency, the machine was deemed uneconomical.[1] The cost of owning and operating a land plane for making raised beds for either raspberries or strawberries has been calculated to be about $90. per acre.

The monetary savings incurred for not having to apply a particular pesticide have been calculated to be between about $25 (for an inexpensive pesticide such as Surflan) to about $100 (for a more expensive pesticide such as Rovral) per acre, assuming that the cost of application is the same. Because the investment and the value of the raspberry crop is so high, conventional growers somewhat justifiably prefer to err on the side of caution, and apply a pesticide. However, for growers who have other reasons for preferring to eliminate pesticides, our conclusions are that using resistant cultivars, planting on raised beds, and using straw mulch only in the planting year offer viable alternatives to the conventional system, and may be the only choice for growers on heavier soils.

Strawberries

The conventional system

Strawberry varieties are selected on the basis of phenological maturity and productivity. They are planted into a well-cultivated site. Plants are not fruited in the planting year, but allowed to runner, forming matted rows by the end of the first growing season. These beds are renovated annually to

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[1] This particular machine, however, was seen at our raspberry plots, and as a result, evaluated for blueberry mechanical harvest, for which it is enjoying enormous success! The patent for the shaker mechanism has been purchased by a commercial harvester manufacturer.

maintain the perennial planting, and a given strawberry planting fruited for 3-5 years. Weeds are controlled with herbicides throughout the establishment and fruiting years. Straw mulch is used for winter protection and weed control in spring. Nitrogen is often applied in the spring to accelerate plant growth prior to fruiting. Often the same site is used for consecutive plantings. Fumigation is often used between plantings, though not routinely. The most pressing problems facing the strawberry industry are control of weeds (only a few herbicides are labeled for use on strawberries), *Botrytis* fruit infections (gray mold), black root rot, tarnished plant bug and strawberry clipper. Red stele, another root rot, has historically been a problem, but is now usually controlled with resistant cultivars and improved soil internal drainage.

Modifications of the conventional system

1. Using a rotation between strawberry crops as an alternative to fumigation

Rationale: Fumigation is extremely expensive and chemically-intensive. Certain cover crops might perform the same function as a fumigant at a lower cost. One possible rotation after harvest is hairy vetch, marigold, and perennial rye.

Results: A preplant cover crop of marigold reduced weed biomass in the subsequent year by 70%. When used in a rotation with hairy vetch and rye, annual grass biomass two months after planting strawberries was 47 vs. 133 and 150 g/m^2 for fumigated plots and plots continuously in strawberries for the past 6 years, respectively. Perennial broadleaf weed and nutsedge biomasses were less with fumigation, however. The rotation seemed to promote nutsedge tuber germination. The rotation provided a high level of annual grass and broadleaf weed control, but this benefit was offset by the increase in nutsedge numbers. In a separate experiment, cover crop rotations of buckwheat (summer) and winter rye (winter), or Sudex™ (Sudangrass X Sorghum hybrid) and winter rye planted in the year prior to planting strawberries suppressed weed growth in the strawberry planting compared to soil fumigation with Vorlex (methyl isothiocyanate) and non-treated controls. Strawberry plant growth was also enhanced compared to soil fumigation and control plots where buckwheat and winter rye or Sudex™ and winter rye were grown in the previous year.

2. Use of pre-plant soil solarization to manage soil-borne disease and weed pests

Rationale: Solarization is the solar heating of soil using an unventilated clear plastic covering. In this technique, soil is covered for several weeks when the solar radiation potential is high. Because many weeds and plant pathogens cannot survive at very high temperatures, soil solarization can provide an alternative to fumigation if there is enough sunlight to generate high soil temperatures.

Results: Soil solarization with clear polyethylene plastic succeeded in elevating temperatures significantly (45°C at 10 cm, 50°C at 2.5 cm), even under late summer conditions in the Northeast. However, solarization only suppressed weeds (g/m^2) significantly in one of two experiments. Strawberry plant growth was not effected by soil solarization compared to soil fumigation or the untreated control. It is likely that soil solarization is not reliable enough to under Northeastern conditions to reliably suppress weeds or pathogens.

3. Use of cultivars resistant to black rot

Rationale: Differential cultivar sensitivity to black root rot has long been reported by growers. However, little work has been done on strawberry cultivar tolerance and susceptibility to black root rot under controlled conditions.

Results: Jewel has some natural resistance to *Rhizoctonia*, one of the fungal pathogens often associated with black root rot. Lester is consistently susceptible, and Earliglow and Honeoye are intermediate in susceptibility.

4. Use of cultivars resistant to tarnished plant bug

Rationale: Tarnished plant bug is a serious pest of strawberries in the northeastern United States. The adult and nymph stages of this insect feed on the flowers and developing fruit of strawberries, causing a distinctive seedy-end malformation which renders the fruit unmarketable. The identification of cultivars which are less attractive to the insect would offer a non-chemical means of tarnished plant bug control.

Results: In our first evaluation of twenty different strawberry cultivars, significant differences between cultivars in amount of fruit lost to tarnished plant bug injury were observed. The least susceptible cultivars, including Honeoye and Sparkle, sustained damage levels of seven to fifteen percent, while the most susceptible cultivars such as Mic Mac and Kent, had fruit losses of approximately thirty percent. Based on the pedigrees of the cultivars tested, it appears that susceptibility to tarnished plant bug injury may in some part be an inherited characteristic, suggesting that breeding efforts for resistance may have potential as an alternative management strategy.

While insecticide sprays reduced injury for all the cultivars tested, the effect of sprays was much greater for cultivars previously observed to be highly susceptible to injury. Cultivars with the least susceptibility, most notably Honeoye, had only slight yield improvements from insecticide sprays, suggesting that planting such cultivars may allow farmers to reduce the amount of insecticides typically applied to strawberries to control tarnished plant bug.

While we planned to test large plots of resistant and suceptible cultivars in 1994, the tarnished plant bug numbers were too low to evaluate. Two new cultivars, Cavendish and Oka, produced very high marketable yields with low amounts of tarnished plant bug injury and relatively little difference between sprayed and unsprayed plots. This suggests that these cultivars may have potential as being relatively resistant to injury.

5. Using corn gluten meal as an alternative to herbicides in the planting year

Rationale: Corn gluten meal is a corn byproduct that has been reported to have herbicidal properties. It also contains a significant amount of nitrogen.

Results: In a relatively dry year, corn gluten meal (CGM) provided a significant amount of weed control compared to control plots for about six weeks after application. At 4,200 lb/A of CGM, weed control was equivalent to that provided by napropamide herbicide. After 6 weeks, weed control dissipated. Yields were equivalent in plots treated with CGM and those receiving 2 lb/A napropamide plus an equivalent amount of nitrogen fertilizer, while both had higher yields than the untreated control plot and plots receiving only herbicide (1010, 1199, 669, and 551 g/2m plot, respectively). In a wet year, corn gluten meal did not provide any weed control.

6. Planting into a killed sod to provide weed control

Rationale: Rather than bring weed seeds to the surface, planting into a killed rye sod in spring might reduce weed growth, especially if supplemented with straw mulch. At high plant densities, runner rooting is not a concern.

Results: In a matted row system, planting strawberries into a wide band in a killed sod provided a significant reduction in weed growth compared to planting into a fully cultivated bed (1021 vs. 3354 g/m^2). The standard herbicide program provided better weed control (744 g/m^2), but did not result in an increase in strawberry yield the following year (11.1 vs. 10.7 kg/6m plot for killed sod and herbicide, respectively).

In a high density ribbon row system, the rye-straw method provided significantly greater control several months after planting (309 g/m^2) than the conventional herbicide (814 g/m^2) and control treatments (882 g/m^2). In the subsequent year, both herbicide-treated and rye-straw plots had significantly higher yields than control plots (1.9, 1.9 and 1.6 kg/4m plot, respectively). Yields from all treatments were low (overall mean: 4,600 lb/A), however, apparently due to restricted root growth in uncultivated soil.

7. Use of rowcovers to exclude tarnished plant bug and strawberry bud weevil

Rationale: Synthetic rowcovers have been used on strawberries for nearly ten years to promote early ripening and to increase yields. Rowcovers also offer a possible alternative to insecticides for excluding tarnished plant bug and strawberry bud weevil from strawberry plantings.

Results: When rowcovers were applied over strawberry plants in the fall, yield of Redchief strawberries was significantly increased, and, in the first year of the study, tarnished plant bug injury was significantly reduced when compared to unsprayed, uncovered plants. However, in the second year of the study, rowcovers did not clearly reduce insect injury. The second season of this study was notable for its unusually cool, wet spring, which greatly reduced tarnished plant bug populations and delayed their activity, and therefore may have suppressed the potential effects of the rowcovers.

It appears that rowcovers may offer some protection from this pest, and with proper timing, may allow for the reduction or elimination of insecticide sprays typically applied to manage it. However, it is also clear that the effects of rowcovers are highly dependent upon weather conditions. Effects appear to be more highly expressed and beneficial when prevalent spring conditions are sunny as opposed to cloudy.

Injury levels from strawberry bud weevil were similar between covered and uncovered plots, and in some cases, the injury appeared to increase when plots were covered. This may indicate that strawberry bud weevil is overwintering in the plots, and thus is neither excluded by rowcovers nor prevented from feeding by the advancement in flowering time caused by the covers.

8. Use of an exotic parasite to control tarnished plant bug.

Rationale: Growers in Massachusetts often have populations of TPB in their strawberry fields that cause significant economic damage to the fruit. One to three applications of an insecticide per season have the same kinds of costs to the grower and the environment as miticides have. Once the parasite is established, it is permanent and there are no direct costs to growers (unlike the repetitive inundative releases of the predatory mite,

Amblyseius fallacis). The potential benefits are many, including savings in pesticide inputs, savings in many spp. of beneficial insects, and savings in resistance management.

Results: The parasite was successfully established at the primary release site in S. Deerfield, MA; a first for any state outside the original release sites in NJ and PA. This work is difficult because most of the first generation and all of the second generation parasites go into diapause and cannot be reared-out of the TPB hosts until the following spring. The parasite was also recovered from 2 other non-release sites approx. 30 miles from S. Deerfield. Background parasitism (by other species) at non-release sites was 42% in 1993 as compared to 76% parasitism at the S. Deerfield release site.

9. Use of predatory mites to control two-spotted spider mite

Rationale: The use of miticides is expensive, chemically intensive, and destructive to beneficial organisms. Predatory mites could be raised and released to enhance the naturally occurring parasite/predator complexes. Once releases have begun and miticides have been eliminated or greatly reduced, longer term benefits of conservation of these biological communities would be realized. The longevity of the miticide would also be greatly increased.

Results: We have been releasing and observing the native predator mite, *Amblyseius fallacis*, in strawberry fields in Massachusetts for 7 years in conjunction with our Strawberry IPM Program. Almost all strawberry growers in Massachusetts have adopted this practice. With careful timing, one release of 10,000/acre, suffices for a growing season. This compares favorably with the conventional system which employs a minimum of 2 applications of a miticide, such as Vendex or Kelthane. The most effective miticide, Plictran, is no longer available. An added benefit for growers is that they can use the release as their standard practice and fall back on a chemical application during an occasional emergency. The resistance of their populations to a material such as Kelthane will be much lower.

10. Effect of spring nitrogen status on postharvest gray mold development

Rationale: Nitrogen status can affect vegetative growth, enhancing the microenvironment for gray mold development. Nitrogen might also affect fruit firmness, allowing secondary infections to develop.

Results: In each of 3 years with Honeoye and Allstar, the incidence of gray mold increased with increasing spring nitrogen. This effect was observed with as little as 30 lb/A applied in spring. Microclimatic data revealed a correlation between canopy relative humidity during flowering and incidence of disease, and both are correlated with nitrogen status. Furthermore, fruit firmness decreased with increasing levels of spring nitrogen, but the trend was not statistically significant.

11. Development of biological controls for gray mold

Rationale: A reduction in the effectiveness of several key fungicides, due to the development of resistant strains of pathogen, has diminished our ability to control strawberry diseases. Naturally occurring antagonists offer a non-pesticide means of controlling fungal pests, however very little research has been conducted to isolate these antagonists from strawberry cropping systems.

Results: Pyrrolnitrin, a compound derived from *Pseudamonas cepacia*, was effective in controlling strawberry rots, hence extending shelflife, when used as a postharvest dip. Screening for microorganisms among those naturally found on the surface of a strawberry has yielded three potential antagonists: *Pseudonomas corrugata, Acremonium breve* and a yeast, all of which limited

infection of wounded fruit to less than 35%. In a newly developed bioassay using petals to screen for microorganisms with anti-fungal activity, two isolates, SF 204 and SF 247 limited the browning of petals to 10%.

Through comprehensive isolation and screening procedures, a promising anti-fungal agent was discovered (antagonist 247). It was as effective as standard synthetic fungicides in controlling gray mold, and its survival in the "uncontrolled" environment of the field was excellent. Additional testing is required to determine the consistency of performance and the efficacy of this particular biocontrol agent in different environmental conditions. No biocontrol products are presently registered for controlling gray mold.

12. Other alternative strategies for gray mold control

Rationale: The interruption of the sporulation cycle using compost, as well as flaming, mowing or raking overwintering inoculum offer potential for reducing levels of gray mold infection, since the fungus overwinters in duff in the strawberry field. These methods, though labor-intensive, are appealing because they are technically simple, relatively low-input, and logical.

Results: There were no significant differences between compost-covered and "check" beds' gray mold infection levels, perhaps due to a low field inoculum level. The compost-covered beds had fewer weeds. In our trials in 1990-92, flaming, mowing or raking did not reduce gray mold in the field. In fact, our data suggested that fall flaming and mowing resulted in higher gray mold levels.

13. Studies on black root rot development

Rationale: Many strawberry growers have experienced blackening of roots, although the exact cause of this condition is unknown. *Rhizoctonia* and *Pythium* fungi, and *Pratylenchus penetrans* nematodes have been implicated. These pathogens can occur in sites where disease symptoms do not develop, suggesting that environmental factors trigger susceptibility in strawberry plants. A grower survey of 54 sites and 113 variables at each site, and 4 cultivar trials at different locations were conducted.

Results: Black root rot continues to be an elusive disease which is extremely difficult to study because it is virtually impossible to duplicate in controlled settings. Existing biocontrol agents, including *Streptomyces, trichodermas* and *pseudomonas* were tested, and were inconsistent at best.

Variables correlated with black root rot disease in the field included soil compaction, fine soil texture, absence of raised beds, high rates of terbacil use, advanced age of planting, use of metalaxyl, and years of strawberry culture on the same site. Another study found that symptoms from black root rot were exacerbated by 2,4-D application. Cultivar response to black root rot soils were not consistent. Furthermore, we isolated different pathogenic fungi on strawberry roots when grown in the same infested soil, but at different temperatures. We have concluded that black root rot disease has multiple causes, and is stress related. *Pythium* and *Rhizoctonia* are major components of the disease, and nematodes, soil compaction, anoxic soil conditions, and herbicides are common stressors. Attempts at screening for broad resistance may not succeed because of multiple causes and stresses in field situations.

In a separate study, soil from strawberry plantings was evaluated for microbes which had the natural ability to suppress cultures of black root rot causal agents (species of the fungus *Rhizoctonia*). In a series of *in vitro* assays using a "beet-seed-baiting" technique, soils dug from strawberry fields which were sterilized showed consistently higher infection rates (40 % on average) than non-sterilized soils. Additional studies showed that soils from strawberry root zones had 35% more *Rhizoctonia* suppressiveness than soils dug from fallow non-strawberry sites.

When both soil types were sterilized, there were no significant differences in infection rates, while both had higher infection rates than non-sterile soil. Pathogenicity/pH tests showed that the fungal strains were most virulent at pH 5.5- 6.0. A build-up of specific *Rhizoctonia* competitors/antagonists in perennial strawberry plantings is possible and could be amended with microbe-rich composts or laboratory-grown cultures.

14. Using interplanted cover crops to displace problem weeds

Rationale: Rather than apply an herbicide after strawberry harvest, interseeding a cover crop might displace weeds and provide benefits such as nematode suppression and improved soil physical properties. Such an interrow cover should not be competitive for light, nutrients or water and not contribute to the seed bank.

Results: Sudangrass was a better interseeded cover crop than fescue or marigold. Controlling the height of the sudangrass by mowing, rather than chemical suppression, provided a high level of weed control. For example, weed biomass was 488 g/m^2 in untreated plots, but only 245 g/m^2 in sudangrass plots and 155 g/m^2 in herbicide-treated plots in the spring after interseeding. Mowing was found to be a better method of sudangrass suppression than chemical suppression. When straw mulch was applied in autumn to interseeded-mowed sudangrass plots, weed control the following spring was better than conventional herbicide-treated plots (54 vs. 206 g/m^2 of weed biomass) and both were better than untreated plots (220 g/m^2). Yields were less in sudangrass plots than herbicide-treated plots (11,700 vs. 13,400 lb/A equivalent), but this difference was not significant.

Recommendations for strawberries

Strawberries should be planted in sites that have not been planted to strawberries for many years. If the site has previously been in strawberries, a cover crop rotation is recommended. Heavy, compacted soils should be avoided. Raised beds have many advantages for disease management, and should be considered.

Weed management is a challenge during the establishment year. Corn gluten meal and planting into killed sods are possible alternatives to herbicide applications, however the latter is associated with decreased yields. Interseeded cover crops could substitute for postharvest herbicides in established plantings if managed properly, although effects on insects and diseases are still unknown. Sinbar herbicide should be used sparingly, especially on heavy soils, because its use has been associated with *Pythium* infection.

Predatory mites cost approximately $30-40 per 10,000 depending on volume. Material costs alone for Kelthane are $15/A per application, making predatory mites a viable alternative to miticides. Rowcovers may offer some protection from tarnished plant bug and with proper timing, may allow for the reduction or elimination of insecticide sprays typically applied to manage it. However, it is also clear that the effects of rowcovers are highly dependent upon weather conditions. Effects appear to be more highly expressed and beneficial when prevalent spring conditions are sunny as opposed to cloudy.

Spring nitrogen applications above 30 lbs/A should be avoided because N use has been associated with increased incidence of postharvest gray mold. Biological and biologically derived controls for gray mold are under development and show promise for the future.

Economic considerations:

Extending rotations and using cover crops are expenses that a grower would incur if he/she were to adopt our recommendations, but their use is far less expensive than fumigating with methyl bromide and chloropicrin, or absorbing the loss of a planting to black root rot or weeds. Economic analysis shows that if growers cover crop instead of fumigate with methyl bromide/chloropicrin, they can afford to rotate 1/6th (grower harvested) or 1/4th (PYO) of their acreage out of strawberries to a cover cropping scheme of hairy vetch, marigold and rye, assuming the same yields as fumigated sites.

Interseeded cover crops, such as the sudan grass described above, offer an alternative to herbicides and hand weeding. The net cost savings from adopting this practice is $119/acre, however yield is reduced by approximately 15%. Therefore, to maintain profitability at the same levels of the conventional system, growers would need to increase the price of strawberries by 0.03/pound to recover the yield loss. This may be possible in some situations, particularly is a premium can be obtained for "low input" fruit.

Making raised beds requires specialized equipment and additional energy resources, but can reduce the risk associated with black root rot. The cost of owning and operating a land plane for making raised beds for either raspberries or strawberries has been calculated to be about $90. per acre.

Corn gluten meal is not yet labeled for use as a strawberry herbicide, so we cannot consider the economics of its use at this time, other than to speculate that it is likely to be more expensive than herbicide use because of the large quantities required for weed control. Also, there is likely to be an environmental cost associated with the high nitrogen levels in the CGM.

Costs of chemical alternatives to biological control of the tarnished plant bug range from $35 to $110, depending on the particular insecticide employed. The costs of rearing and releasing the exotic parasite, *Peristenus digoneutis,* are difficult to estimate, however the potential for it being a one time cost would allow for a considerable initial investment.

The cost of straw mulch and interseeding cover crops may offset the cost of an herbicide application, but the risk of failure is greater when cover crops are used for weed management. Furthermore, greater management skills are required, as is a commitment to no herbicide use to ensure cover crop seed germination. Also, yields may be reduced using interseeded cover crops as substitutes for herbicides. At least over the short term, the conventional herbicide approach to weed management is economical and less risky, but the long term economics may favor the alternatives.

Grower Adoption of Alternative Practices

A mailing list of small fruit growers in the U.S. and a written survey instrument was developed to a) ascertain information describing the current state of the small fruit production subsector, b) evaluate attitudes of small fruit producers with respect to the environmental impacts of their production practices, and c) evaluate the extent of small fruit producer interest in and willingness to adopt specific practices and technologies evaluated and developed within this project.

Results of this survey of strawberry and raspberry growers were reported in two publications (see Addendum I). Use of chemical inputs in small fruit production was found to be extensive with most growers using chemicals to control insects, weeds, and diseases. In each case, applications included at least 3 chemical sprays per year and in some cases up to six sprays per year. Timing of chemical applications are predominately determined by monitoring, though spraying on a regular schedule is still practiced by a substantial percentage of growers. Chemical control of pests was

perceived by growers as generally effective, with most growers reporting losses of less than 10% after chemical control.

Growers surveyed indicated a general awareness of the environmental effects of their farming activities. In the past, growers indicated that their adoption of environmentally beneficial technologies has been high even though most of the growers did not indicate that a substantial increase in prices received would result in their producing chemical-free produce. Growers indicated a strong interest in experimenting with, and a general openness to new technologies which could reduce chemical use, though the level of interest varied with the type of technology. Growers indicated a willingness to adopt new technologies, and importantly indicated a willingness to adopt them even when profits would be reduced by as much as $200.00 per acre.

The central hypothesis and motivation taken in this research was that straightforward profit/loss analysis does not provide an appropriate or adequate explanation of the adoption of environmentally beneficial agricultural practices (EBAPs). Results dramatically confirmed the importance of non economic factors in the determination of the interest in adoption indicated by the respondents. Statistical modeling confirmed that producer attitudes toward the environment and general altruism were also important factors in explaining the probability of adoption.

DISSEMINATION OF FINDINGS

We have annually compiled a list of speaking engagements and publications generated by the principal investigators involved in this project. These lists are located in addendum I. Unique to this project has been the LISA Small Fruits Newsletter. Response from growers and other professionals to this newsletter has been extremely positive (page 5, Addendum).

In addition to the newsletter, a remarkable number of papers, articles, presentations, field days and extension publications have incorporated information from the results of research funded by this grant. The specifics are listed below:

Presentations
132 to growers and agents
30 to professional audiences
26 field days
3 undergraduate classes
16 on farm demonstrations/IPM collaborators

Publications
75 academic publications or proceedings (15 refereed publications)
16 trade journal articles
3 newsletters which were continuously contributed to
3 news releases
7 fact sheets
11 Production Guides

Potential Contributions and Practical Applications

Contributions and applications are outlined above. Because of the large number of projects, environments and results, the specific contributions and applications vary with the project. This includes practices that offer the potential for pesticide reduction.

Farmer Adoption and Direct Impact

As a result of the studies in this project, production manuals in the Northeast have been altered, and production practices changed. Specifically, growers in New England now routinely use predatory mites for two-spotted mite control in strawberries, new meristem-tip cultured plantings of raspberries are mulched with clean straw to control weeds and increase growth, raspberries are grown on raised beds to discourage root rot, trellis systems are being adopted (albeit at a modest level) for improved yield and accessibility of raspberry fruit, a system has been developed to grow strawberries without herbicides (though it's too early to evaluate adoption), and cultivar susceptibilities and resistances are published and can be considered when planting strawberries and raspberries. Scouting for insect pests in strawberry and raspberry plantings, and minimizing fungicide sprays using phenological information on strawberry has become routine, due not only to our projects, but others in the United States. Comments on the LISA project via our newsletter are listed on page 5 in the Addendum.

Producer Involvement

Over the 6 years of this study, we estimate the following number of growers have attended each of the following:

~2000 Conferences

~780 Field Days

*Note: These numbers are based on the number of events which we have spoken at, and the number of field days times an average number of growers, divided by a probable repetition of individuals over the years of the project.

Areas Needing Additional Study

- Tarnished plant bug predator
- Large plot testing of cultivar resistance/susceptibilities to tarnished plant bug
- Groundcover management/crop ecology studies, integrating environmental, insect and pathogen related parameters.
- Development of more efficient sprayers for specific production systems
- Studies on the interaction of disease infection and plant stress
- Further development and evaluation of natural antagonists to disease organisms
- Ecological studies on rhizosphere biology and the interactions of microbes with one another and plant roots

Photographs will be mailed under separate cover by 10 December 1994.

Information dissemination: 1989

Academic publications and published proceedings:

Wilcox, W. F. and M. P. Pritts. 1989. Evaluation of leaf spot severity on 39 raspberry cultivars, 1988. Biological and Cultural Tests for Control of Plant Diseases 4:8.

Travis, E. Rajotte, J. Rytter, B. Goulart, and G. Rebarchak. 1989. Cultivar susceptibility to anthracnose, botrytis and brown berry. Proc. 65th Cumberland Shennandoah Fruit Worker's Conference (In Press).

Travis, J., E. Rajotte, J. Rytter, and G. Rebarchak. Evaluation of fungicides and insecticides for phytotoxicity on black raspberry. 1989. Proc. 65th Cumberland Shennandoah Fruit Worker's Conference (In Press).

Goulart, D. L., F. Takeda, W. Janisiewicz and K. B. Evensen. 1989. Extending black raspberry shelf life using modified atmospheres and fungicides. Proc. 65th Cumberland Shennandoah Fruit Worker's Conference (In Press).

The following have been submitted to Insecticide/Acaricide Tests, a publication of the American Entomological Society.

Rajotte, E. G., J. W. Travis, J. Rytter, and G. Rebarchak. 1990. Evaluation of insecticides for controlling fruit damage on raspberry caused by beetles, tarnished plant bug and slugs.

Rajotte, E. G., J. W. Travis, J. Rytter and G. Rebarchak. 1990. Evaluation of insecticides for control of aphids on raspberry.

Rajotte, E. G., J. W. Travis, J. Rytter and G. Rebarchak. 1990. Evaluation of insecticides for Japanese Beetle and Soldier Beetle control on raspberry.

Rajotte, E. G., J. W. Travis, J. Rytter and G. Rebarchak. 1990. Postharvest evaluation of berry damage caused by beetles, tarnished plant bug and slugs on raspberry cultivars.

Rajotte, E. G., J. W. Travis, J. Rytter and G. Rebarchak. 1990. Evaluation of insecticides for control of potato leafhopper on raspberry.

Rajotte, E. G., J. W. Travis, J. Rytter and G. Rebarchak. 1990. Susceptibility to three insect pests by various raspberry cultivars.

Rajotte, E. G., J. W. Travis, J. Rytter and G. Rebarchak. 1990. Susceptibility to Japanese Beetle damage by various raspberry cultivars.

Travis, J., Rajotte, J. Rytter and G. Rebarchak. 1990. The phytotoxicity of fungicides and insecticides on black raspberry. Fungicide and Nematicide reports

Travis, J., E. Rajotte, J. Rytter and G. Rebarchak. 1990. Evaluation of rate of botrytis development on raspberry fruit of various cultivars. Fungicide and Nematicide reports

Travis, J., E. Rajotte, J. Rytter and G. Rebarchak. 1990. The phytotoxicity of fungicides and insecticides on black raspberry. Fungicide and Nematicide reports

Travis, J., E. Rajotte, J. Rytter and G. Rebarchak. 1990. Evaluation of fungicides for control of fruit anthracnose and brown berry on black raspberry. Fungicide and Nematicide reports

Travis, J., E. Rajotte, J. Rytter and G. Rebarchak. 1990. Raspberry cultivar susceptibility to anthracnose leaf infection and brown berry. Fungicide and Nematicide reports

Travis, J., E. Rajotte, J. Rytter and C. Rebarchak. 1990. Evaluation of fungicides for control of fruit anthracnose and brown berry on black raspberry. Fungicide and Nematicide reports

Extension publications:

Pritts, M. P., Agnello, A., W. Wilcox and G. Schaefers. 1990. Cornell Pest Management Recommendations for Small Fruit Crops. Cornell Coop. Ext. Pub.

Goulart, B. 1990. Fruit Production in the Home Garden. Penn. State Univ. Press.

Grower Presentations:

Between January 1990 and March 1990, many grower presentations have been made which have transmitted information pertinent to the results of LISA projects. For example, Pennsylvania has reported to 8 different grower groups. New York has also reported to 8 different groups. Presentations on LISA funded projects have also been made at the North American Strawberry Growers Annual Meeting, the Third North American Strawberry Conference, the Northeast Regional American Society for Horticultural Science Annual Meeting, and the North American Bramble Growers Annual Meeting.

Field days:

New York hosted 3 consecutive field days in which more than 150 individuals observed the results of ongoing LISA projects.

Classes:

Students from several classes at Cornell University observed the results of ongoing LISA projects.

Computers:

The raspberry expert system under development at Penn State University now contains a module for cultivar selection, tissue analysis, and soil analysis. Pest control modules will be added if funding is continued.

Newsletters:

Information generated from LISA projects has already been included in small fruit newsletters in Pennsylvania and New York. New York's small fruit newsletter reaches growers in 43 states.

On-farm demonstrations:

In Massachusetts, integrated pest management (IPM) practices were instituted on 10% of the strawberry acreage in that state. Data were then collected on standard vs. IPM fields for the last 3 years. In terms of dosage equivalents of pesticide used, there was a 40% reduction over 1987 levels and a $55 per acre reduction in pesticide costs. Table 10 (1990 progress report) demonstrates the reduction in pesticide use that occurred without significant effects on fruit quality. Data showing the same trends exist for New York State.

Row cover studies, root rot studies, and strawberry cultivar evaluations in New York were all conducted on grower farms. Fourteen growers participated in the predacious mite study and 3 others in gray mold management studies in Massachusetts.

Information dissemination: 1990

1. Extension Fact Sheets, Manuals, and Newsletters:

Marchant, D. J., ed. 1990. LISA Small Fruit Newsletter. vol. 1. Summary of LISA funded research in small fruits.

Schloemann, S. G., and D. R. Cooley, eds., 1990. 1990 New England Small Fruit Recommendations. Contains IPM and Low Input Information. Mass. Cooperative Extension Publication.

Schloemann, S. G., and D. R. Cooley. 1990. Strawberry IPM Manual for Massachusetts. In press.

Cooley, D. R., and S. G. Schloemann. 1990. Gray mold of strawberry. Dept. of Plant Pathology, Univ. of Mas. AG-657

Kovach, J., W. Wilcox, A. Agnello and M. Pritts. 1990. Strawberry scouting procedures. NYS College of Agric. and Life Sciences, Cornell Univ., Ithaca.

Pritts, M. P., W. F. Wilcox, A. Agnello, and G. Schaefers. 1990 Cornell Recommendations for Small Fruit Production, NYS College of Agric. and life Sciences, Cornell Univ., Ithaca.

2. Invited Talks/Tours for Growers and Extension Agents

Annual meeting of the North American Strawberry Growers Association Board of Directors co-hosted by the Strawberry IPM program and Nourse Farms, Inc. providing a tour of research facilities including field plots and laboratory/greenhouse facilities

Maine Cooperative Extension Farm Field Day, 1990, Monmouth, ME. "Integrated Pest Management for Strawberries."

Pennsylvania Fruit Growers Annual Meeting, 1990, Hershey, PA. "Integrated Pest Management for Strawberries." Pennsylvania Fruit News, 70 (5): 24-28.

Massachusetts Small Fruit Growers Association Winter meeting, 1990 Marlboro, MA. "Low input techniques for strawberry insect and disease management."

Massachusetts Small Fruit Growers Association Summer meeting, 1990, Northboro, MA. "IPM methods in strawberries: insects and diseases" and "Fumigation: Techniques and possible alternatives".

South Deerfield Research Farm Summer Field Day, 1990. "Low input techniques for strawberry insect disease management."

Farmers in Transition Conference, 1990, Waterloo, NY. "Alternative strategies in small fruit production."

Pest Management Conference, 1990, Ithaca, NY. "The use of interplanted cover crops in pest management strategies of strawberry."

Regional Fruit Extension Training School, Charles Town, WV "Using IPM techniques for weed management in strawberries."

Grower meetings held in Pennsylvania in 1990 where information relevant to LISA objectives was presented:

1 February 1990: Tri-State Fruit Meeting, Hershey, PA
30 Jan - 1 Feb: North American Bramble Growers Association Meeting
13 February 1990: Lackawanna Co.
14 February 1990: Berks Co. 27 February 1990: Synder Co.
6 March 1990: Bedford Co.
8 March 1990: Western PA regional meeting
9 March 1990: Erie Co.
15 March 1990: Jefferson Co.
1, 2 May, 1990: Southeastern Pennsylvania Twilight meetings
24 May, 1990: Syder Co. Twilight meeting
19, 20 June: Western Pennsylvania Twilight meetings

3. Papers/Reports Presented at Professional Meetings

Cooley, D. R. and S. G. Schloemann. 1990. Integrated pest management program for strawberries. Phytopathology 79: 118.

Cooley, D. R., W. J. Manning, D. J. Marchant and S. G. Schloemann. 1990. Differential field-tolerance among strawberry cultivars to binucleate Rhizoctonia. Northeast Division Meetings of Am. Phytopath. Society.

Trinka, D. and M. Pritts. 1990. Establishment studies with 'Heritage' raspberry. Annual meeting of the Amer. Soc. Hort. Science., Tucson, AZ.

Report on LISA projects to the Northcentral Regional Small Fruit and Viticulture Committee (NCR-22), Beltsville, MD.

Report on LISA projects to the Northeast Regional Bramble Production and Marketing Committee (NEC-64).

4. Presentations/field demonstrations for students

Stockbridge School of Agriculture (class lecture) 53 University of Massachusetts: (class lectures) Entomology class, Small Fruit Culture class, and IPM Education and Certification program short course.

Cornell University: (tour of LISA field plots) Sustainable Agriculture class, Small Fruit Production class, Introduction to Pomology class, Introduction to Horticulture class

5. Scientific reports for publication

Goulart, B. L. and M. J. Kelly. 1990. Trellis system for black raspberries. Proc. Multistate Inservice. Inwood, West Virginia.

Goulart, B. L., F. Takeda, W. Janisiewicz, and K. B. Evensen. 1989. Extending black raspberry shelf life using modified atmospheres and fungicides. Proc 65th Cumberland Shennandoah Fruit Worker's Conference.

Pritts, M. P. 1990. The use of interplanted cover crops in pest management strategies of strawberry. 52nd Annual New York State Pest management Conference Proceedings, Ithaca, NY.

Pritts, M. P. 1990. Using IPM in weed management for strawberries. Proc. Multistate Inservice. Inwood, West Virginia.

Rajotte, E. G., J. W. Travis, J. Rytter, and G. Rebarchak. 1990. Evaluation of insecticides for control of aphids on raspberry. Insecticide/Acaricide Tests 15:60.

Rajotte, E. G., J. W. Travis, J. Rytter, and G. Rebarchak. 1990. Evaluation of insecticides for control of potato leafhopper on raspberry. Insecticide/Acarcide Tests 15:58.

Rajotte, E. G., J. W. Travis, J. Rytter, and G. Rebarchak. 1990. Evaluation of insecticides for controlling fruit damage on raspberry caused by beetles, tarnished plant bug and slugs, 1989. Insecticide/Acarcide Tests 15:59.

Rajotte, E. G., J. W. Travis, J. Rytter, and G. Rebarchak. 1990. Evaluation of insecticides for Japanese Beetle and Soldier Beetle control on raspberry, 1989. Insecticide/Acaricide Tests 15:58.

Travis, E, Rajotte, J. Rytter, B. Goulart, and G. Rebarchak. 1989. Cultivar susceptibility to anthranose, botrytis and brown berry. Proc. 65th Cumberland Shennandoah Fruit Worker's conference. 54

Travis, J. W., E. Rajotte, J. Rytter, and G. Rebarchak. 1990. Raspberry cultivar susceptibility to anthracnose leaf infection and brown berry, 2989. Biological and Cultural Tests for Control of Plant Diseases, Vol. 5, p. 6.

Travis, J. W., E. Rajotte, J. Rytter, and G. Rebarchak. 1990. Phytotoxicity of fungicides and insecticides on black raspberry, 1989. Fungicide and Nematicide Tests 45:62.

Travis, J. W., E. Rajotte, J. Rytter, and G. Rebarchak. 1989. Evaluation of fungicides and insecticides for phytotoxicity on black raspberry. Proc 65th Cumberland Shennandoah Fruit Worker's conference.

6. Trade journal articles

Pritts, M. P. Strawberry diseases. Amer. Agriculturist, Oct. 1990.
Pritts, M. P. Strawberry insects. Amer. Agriculturist, Dec. 1990.

Information dissemination: 1991

1. LISA Small Fruits Newsletter

Three issues of the LISA Small Fruits Newsletter have been compiled and distributed. The newsletter has consisted mainly of articles relating to the ongoing research of the project cooperators, as well contributions from non-cooperators addressing strawberry and raspberry production. Copies of Volume 2 (1) and Volume 2(2) are attached in addendum 2.

The first two issues were sent to names compiled from small fruit mailing lists from ME, MA, NH, NY, PA, and VT, and were mailed to approximately 1000 people. Response forms were included, so that subsequent issues could be sent to truly interested readers. The Fall 91 newsletter has been sent to the approximately 450 respondents.

Responses by state:

ME -	102
PA -	65
MA -	61
VT -	40
NY -	36
NH -	29
WV -	15
VA -	18
Other States -	72
Canada -	10
Total -	448

Per issue cost for a 12 page newsletter is presently $.88 per copy including mailing. Thus the direct cost of the newsletter is $440 per issue. This is based on 500 copies of a 12 page newsletter. As requests for the newsletter continue, the total cost will rise due to increased number of copies printed.

Response to the Newsletter has been extremely positive. The following are samples of comments.

Growers' Responses

"Outstanding ! Well diversified. Touches on critical aspects of the small fruit farm. Keep it up. The more information the better." Bill Giriechi, Country Garden, Schenectady, NY.

"Your newsletter is very practical for the commercial grower, and I find it very helpful." Roger Pell, Pell Farm, Somers, CT.

"LISA Small Fruits Newsletter is very interesting. The procedures used, observations made and success or failures reported can be very helpful to all of us who are trying to do a better job." Amos H. Funk, Grower, Millersville, PA.

"Looks like an exciting start. I hope gov't funding is not reduced or eliminated!" Donald Finch, Finch Farm, Reading, PA.

"Informative...good start!" Arthur Tingue, Winterberry Farms, Chester, NJ.

"This is the kind of information that farmers need. We need to learn how to work w/biology instead of ignoring it. Keep up the good work!" D.M. Fulles, Belvedere Plantation, Fredricksburg, VA.

"Excellent so far!! Keep it in Laymans Language." Stanley Pratt, Porcupine Ridge Tree Farm, Augusta, ME.

"Excellent work, please keep it going!" Ken Bupp, Penn Vermont Fruit Farm, Bedminster, PA.

"A fine Newsletter. Am looking forward to the results of the strawberry groundcover experiments." Lanson Dean, What-A-View Farm, Vernon, ME.

"Good Info. Hope the program is extended beyond 2 yrs." John Burns, Pungo Blueberry Etc., Virginia Beach, VA.

"The information is greatly appreciated. Thank you." Frank V. Knapp, Buttermilk Farms, Millbrook, NY.

"Excellent, just the info we've been looking for." Thomas Halkett, Brightwind Farm, Cherryfield, ME.

"The LISA program for small fruits is certainly to be applauded, and is going in the right direction." Kevin Laing, Orchard Hill Farm, St. Thomas, Ontario.

"Good Approach." E. Hatch, Hatch's Patch, Greenfield, MA.

"I enjoyed your very informative and interesting articles. Please keep it coming. I shall look forward to the next issue." Marvin Graves, Graves Farm, Lancaster, MA.

"Very pleased to see Newsletter, as there exists a large gap between the need for sustainable methods and effort being expended to develop them." Tom Germaine, Woodland Farm, PEI.

"Perhaps reminders about things farmers did automatically years ago that have fallen in disuse, may be helpful to some of us." Frank Braun, Rte. 97 Strawberries, Warren, ME.

"Wonderful beginning!" Scott Proft, Someday Farm, E. Dorset, VT.

"It is encouraging-yea, even exciting- to see the land-grants producing work of this kind." Ward Sinclair, Flickerville Mt. Farm & Groundhog Patch, Warfordsburg, PA.

"Your newsletter contains a wealth of information. Nothing is available in this state to even compare with your material." W.I. Yerby, Yerby Berry Patch, Brodnax, VA.

"I like it. Plans are to put in strawberries, blueberries and raspberries this spring, and I'll plan on using as much LISA information as possible from the beginning." Gary West, Tracy Farm, Watkins Glen, NY.

Professionals' Responses:

"Your publication is a good example of the vast middle ground between chemical-intensive and "organic" farming. Our constituents are always interested in such things, and look forward to passing on future publications onto the general public." Paul Gregory, Maine Board of Pesticides Control, Augusta, ME.

"Berry production in the Northeast is very similar to the Midwest, so I look to your leadership as being very helpful." Kevin Edberg, MN Dept. of Agriculture - Mktg. Div., St. Paul, MN.

"I look forward with great anticipation to reading more on your LISA findings in strawberries. Keep up the good work." Phil Ahrens, Ahrens Nursery & Plant Labs, Huntingtonburg, IN.

"A First-Class Publication!" Wm. Cline, Hort Crops Res. Sta., Castle Hayne, NC.

"Very good publication, information in many cases is hard to come by." Aden Francis, Rhone-Poulene Ag Co., Eaglesburg, MI.

"Great Newsletter! I manage the Insect Identification Lab and this has just the information that growers ask for." Eric Day, VPI, Blacksburg, VA.

"I have pilfered IPM information from MA, PA and VA with almost religious zeal. I appreciate the chance to have small fruit information brought together in such an easy to use format." Dan Horton, Extension Entomologist, Athens, GA.

2. On Farm IPM use

As reported in previous reports, experiments were established and continued at grower sites. Growers were included in evaluating cover crop rotations for the control of black root rot rather than soil fumigation, the use of bio-control agents for the control of gray mold on strawberries, and the use of the predator mite *Amblyseius fallacis* for the control of two-spotted spider mite in strawberries. These efforts are coupled with the efforts of the strawberry IPM program and are considered an integral part of that program. This program has succeeded in reducing pesticide inputs for cooperating growers by 30-40% for the last 5 years. This is as a result of weekly scouting and reporting to the growers on key pest status and recommendations for action when needed.

3. Presentations of results to growers, scientists and students

Below are listed publications, newsletters and presentations at which information gained through this study was extended to growers, extension personnel and other professionals working in small fruit crops.

4. Extension Manuals and Factsheets

Coordinator, B.L. Goulart. Authors: R. Crassweller, B. Goulart, C. Haeseler, E. Rajotte, L. Hull, M. Saunders, J. Travis, J. Rytter, J. Halbrendt, W. Hock, and A. Muza. 1991. Small Scale Fruit Production: a comprehensive guide for the backyard and amateur grower. The Pennsylvania State University, University Park, PA. 105 pp.

Coordinator: B.L. Goulart. Authors: M. Brittingham, B. Goulart, J. Harper, P. Heinemann, W. Hock, E. Rajotte, J. Rytter, and J. Travis. 1991. Small Fruit Production and Pest Management Guide, 1991-92. The Pennsylvania State University, University Park, PA 107 pp.

Kovach, J., W. Wilcox, A. Agnello and M. Pritts. 1990. Strawberry scouting procedures. NYS College of Agric. and Life Sciences. Cornell University, Ithaca.

Pritts, M.P., W. F. Wilcox, A. Agnello, and G. Schaelfers. 1991. Cornell Recommendations for Small Fruit Production, NYS College of Agriculture and Life Sciences, Cornell Univ., Ithaca.

5. Newsletters

Goulart, B.L. Fruit Times (Regularly contributing author)
Marchant, D.J. Ed. LISA Small Fruits Newsletter.
Pritts, M.P. Cornell Small Fruits Newsletter

6. Invited talks/tours for growers and extension agents

a. Winter meetings

Mid-Atlantic Regional Extension Fruit School, Middleway, WV. November 1990. (Cooley).
Mid-Atlantic Regional Extension Fruit School, Middleway, WV. November 1990. (Goulart).
Mid-Atlantic Regional Extension Fruit School, Middleway, WV. November 1990. (Pritts).
Pest Management Conference, Ithaca, NY. November 1990.
Maine Vegetable and Small Fruit Growers Association Annual Meeting. January 1991.
New Jersey Small Fruit Meeting. Atlantic City, New Jersey. January 1991. (Cooley).
New Jersey Small Fruit Meeting. Atlantic City, New Jersey. January 1991. (Goulart).
Pennsylvania Inservice Training: Raspberry Production, University Park, PA. January 1992.
Maine Plant Food Society Annual Meeting. February 1991.
New Hampshire Small Fruit Growers Annual Meeting. February 1991.
Ohio Fruit and Vegetable Growers Congress. Cleveland, Ohio. February, 1991.(Cooley).
Ohio Fruit and Vegetable Growers Congress. Cleveland, Ohio. February 1991.(Goulart).
Virginia Sustainable Agriculture Conference. Charlottesville, VA. February 1991.
Maine Cooperative Extension Sustainable Agriculture School. March 1991.
Strawberry School, Batavia, NY. March 1991.
Strawberry School, Syracuse, NY. March 1991.
Transitions Conference, Waterloo, NY. March 1990.
Vermont Small Fruit and Vegetable Growers Association, Rutland, VT. March 1991. (Handley).
Vermont Small Fruit and Vegetable Growers Association, Rutland, VT. March 1991. (Pritts).
Strawberry School, Albany, NY. April 1991.
Michigan Horticultural Society Annual Meetings, Grand Rapids, MI. December 1991.
New England Small fruit School, Sturbridge, MA. December 1991. (Cooley).
New England Small fruit School, Sturbridge, MA. December 1991. (Pritts).
New England Small fruit School, Sturbridge, MA. December 1991. (Schloemann).
Minnesota Fruit and Vegetable Growers Association, Minneapolis, MN. January 1992.
North American Strawberry Growers Association, Williamsburg, VA. February 1992. (Pritts).
TriState Horticulture Meetings, Hershey, PA. January 1992. (Goulart).
TriState Horticulture Meetings, Hershey, PA. January 1992. (Pritts).

b. Summer meetings and field tours

County extension meeting in Lancaster/York County, Pennsylvania. May 1991.
County extension meeting in Schuylkill County, Pennsylvania. June 1991.
County extension meeting in Westmoreland County, Pennsylvania. June 1991.
Pennsylvania Inservice Training: Strawberry Production, summer portion. University Park, PA. June 1991.
Field Day, South Deerfield, MA. June 1991.
Cornell Weed Days, Field Tour. Ithaca, NY. July 1991.
North American Fruit Explorers, Field Tour, Ithaca, NY. September 1991.
Ag Progress Days, The Pennsylvania State University. University Park, Pennsylvania. August 1991.
Natural Organic Farmers Association Annual Summer Meeting. Amherst, MA August 1991.

7. Papers/Reports presented at professional meetings

Cooley, D.R., S.G. Schloemann, M. Mazzola, and B.I. Schloemann, 1991. Development and implementation of Northeast Strawberry IPM. Fruit Notes 56(2):1-5.

Goulart, B. L. and M. J. Kelly. 1991. Three years of experience with trellised black raspberries. Pennsylvania Fruit News 71:107-111.
Goulart, B. L., K. B. Evensen, P. E. Hammer, W. Janisiewicz, and F. Takeda. 1991. Effect of temperature, modified atmosphere and pyrrolnitrin on black and red raspberry shelflife. (abs.) HortScience 26:702.
Marchant, D., D.R. Cooley, S.G. Schloemann, and W.L. Manning. 1991. Strawberry cultivar screen for tolerance to black root rots disease complex. Fruit Notes 56(1):20-21.
Pritts, M.P. 1990. Interplanted cover crops in pest management strategies for strawberries. Northeast Regional meeting of the American Society for Horticultural Science, Burlington, VT. January, 1990.
Pritts, M.P. 1991. Biological applications in fruit production. Department of Biology, Bucknell University.
Pritts, M.P. 1991. Use of cover crops in pest management strategies of strawberries. Eighth Annual Symposium of Ecological Agriculture. Ithaca, NY. March, 1991.
Trinka, D. and M. Pritts. 1990. Tissue-cultured raspberry plant establishment. (abs.) HortScience 25:1162.

8. Scientific papers for publication

Goulart, B. L., P. E. Hammer, K. B. Evensen, W. Janisiewicz, and F. Takeda. (1992). The influence of pyrrolnitrin and high CO_2 on raspberry shelf life at 0 or 18C. J. Amer. Soc. Hort. Sci. (in press).
Goulart, B. L. (1992). Productivity and vigor of sixteen raspberry cultivars in central Pennsylvania. Fruit Var. Jour. (in press).
Pritts, M.P. 1990. The use of interplanted cover crops in pest management strategies of strawberry. 52nd Annual New York State Pest Management Conference Proceedings. Ithaca, NY.

Information dissemination: 1992

1. LISA Small Fruits Newsletter

• Four issues of the LISA Small Fruits Newsletter have been compiled and distributed. The newsletter has consisted mainly of articles relating to the ongoing research of the project cooperators, as well as contributions from non-cooperators addressing strawberry and raspberry production. A copy of Volume 3 (1) is attached in addendum B.

The first two issues were sent to names compiled from small fruit mailing lists from ME, MA, NH, NY, PA, and VT, and were mailed to approximately 1000 people. Response forms were included, so that subsequent issues could be sent to truly interested readers. The Sept. 92 issue (V01.3 (1) has been sent to the approximately 604 respondents. Response to the Newsletter has been extremely positive from growers and professionals. For samples of growers' responses see section 19.

Professionals' Responses:

"Your publication is a good example of the vast middle ground between chemical-intensive and "organic" farming. Our constituents are always interested in such things, and look forward to passing on future publications onto the general public." Paul Gregory, Maine Board of Pesticides Control, Augusta, ME.

"Berry production in the Northeast is very similar to the Midwest, so I look to your leadership as being very helpful." Kevin Edberg, MN Dept. of Agriculture - Mktg. Div., St. Paul, MN.

"I look forward with great anticipation to reading more on your LISA findings in strawberries. Keep up the good work." Phil Ahrens, Ahrens Nursery & Plant Labs, Huntingtonburg, IN.

"A First-Class Publication!" Wm. Cline, Hort Crops Res. Sta., Castle Hayne, NC.

"Very good publication, information that in many cases is hard to come by." Aden Francis, Rhone-Poulene Ag Co., Eaglesburg, MI.

"Great Newsletter! I manage the Insect Identification Lab and this has just the information that growers ask for." Eric Day, VPI, Blacksburg, VA.

"I have pilfered IPM information from MA, PA and VA with almost religious zeal. I appreciate the chance to have small fruit information brought together in such as easy to use format." Dan Horton, Extension Entomologist, Athens, GA.

2. On Farm IPM Use

As reported in previous reports, experiments were established and continued at grower sites. Growers were included in evaluating cover crop rotations for the control of black root rot rather than soil fumigation, the use of bio-control agents for the control of gray mold on strawberries, and the use of the predator mite *Amblyseius fallacis* for the control of two-spotted spider mite in strawberries. These efforts are coupled with the efforts of the strawberry IPM program and are considered an integral part of that program. This program has succeeded in reducing pesticide inputs for cooperating growers by 30-40% for the last 5 years. This is as a result of weekly scouting and reporting to the growers on key pest status and recommendations for action when needed.

3. Extension Publications - Manuals, Factsheets and Proceedings

Cooley, D. R., A. R. Bonanno, S. G. Schloemann and W. R. Autio. A Guide to Alternative Pesticide Products and Practices for Small Fruit: How to Comply with Massachusetts Public Ware Supply Regulations. University of Massachusetts Cooperative Extension System, Amherst, MA. 1992. Leaflet AG-872.

Cooley, D. R. and S. G. Schloemann, "Development and implementation of Northeast strawberry IPM in 121st Annual Report of the Michigan State Horticultural Society, E. Lansing, MI, 1991, 89-99.

Goulart, B. L., Coordinator. Authors: R. B. Crassweller, B. L. Goulart, C. Haeseler, E. Rajotte, L. Hull, M. Saunders, J. Travis, J. Rytter, J. Halbrendt, W. Hock, and A. Muza. 1991. Small Scale Fruit Production: a comprehensive guide for the backyard and amateur grower. The Pennsylvania State University, University Park, PA. 105 pp.

Goulart, B. L., Coordinator. Authors: M. Brittingham, B. L. Goulart, J. Harper, P. Heinemann, W. Hock, E. Rajotte, J. Rytter, and J. Travis. 1991. Small Fruit Production and Pest Management Guide, 1991-92. The Pennsylvania State University, University Park, PA. 107 pp.

Pritts, M. P. 1991. "Crop rotation and the non-chemical control of nematodes." in Proc. New England Small Fruit and Veg. Conf. p. 31.

Pritts, M. P. 1992. "Use of row covers for strawberries and fall-bearing raspberries." in Proc. Minnesota Fruit and Vegetable Growers Assoc.

Pritts, M. P. 1992. "Cover crops and mulches for strawberries and raspberries." in Proc. Minnesota Fruit and Vegetable Growers Assoc.

Pritts, M. P. and M. J. Kelly. 1992. "Alternative weed management strategies for strawberries." in Proc. NYS Pest Management Conf. 55:35-42.

Schloemann, S. G. and D. R. Cooley. "Using predators for controlling two-spotted spider mites in strawberries: a view from Massachusetts." in Pennsylvania Fruit News: 1992 Proceedings of the State Horticultural Association of Pennsylvania. Hershey, PA, 1992, 53-55.

Schloemann, S. G., ed. New England Small Fruit Recommendations: Managing diseases and insects on small fruit. 1992-1993. Cooperative Extension System University of Massachusetts. 60 pp.

Wilcox, W. F., M. P. Pritts, R. C. Seem, J. R. Nevill and J. A. Burr. 1992. "Cultural and chemical control of gray mold on strawberries." in Proc. NYS Pest Management Conf. 55:42-43.

4. Newsletters

Goulart, B. L. Fruit Times (Regularly contributing author)
Pritts, M. P. Cornell Small Fruits Newsletter
Tuttle, A. F. (Ed.) Northeast LISA Small Fruits Newsletter. (All LISA cooperators contributing regularly)

5. Invited talks/tours for growers and extension agents

a. Winter meetings

1991-92

- Pennsylvania Farm Show, Sustainable agriculture booth, Harrisburg, PA. January, 1992 (Goulart)
- Northeast Organic Farmers Association Winter Meeting, Worcester, MA. January 1992. (Schloemann, Cooley)
- New Holland Vegetable Day, New Holland, PA. February 1992 (Goulart)
- Northeast LISA Farmer-to-Farmer Information Exchange: Strawberry Weekend. Rowe MA February 1992. (Schloemann, Tuttle)
- Raspberry pruning inservice, University Park, PA. April 1992. (Goulart)

1992-93

- Annual meeting of the State Horticultural Association of Pennsylvania, Hershey, PA. January 1993. (Goulart, Pritts, Handley, Wilcox)
- Connecticut Small Fruit and Vegetable Growers Winter Meeting. Old Wethersfield, CT. January 1993. (Schloemann)
- North American Bramble Growers Association (where, who?)
- North American Strawberry Growers Association (where, who?)

b. Summer meetings and field tours

1992

- Small Fruit Twilight Meetings, Milton, PA May, 1992. (Goulart)
- Greenhouse and lab talk on LISA research for a group of entomologists and agronomists from the University of El Salvador's "Project for Lake Ilapango." May, 1992. (Tuttle)
- Vermont Small Fruit Growers Twilight Meeting. June 1992. (Schloemann)

- Bramble Agent Inservice meeting: summer session. University Park, PA. June, 1992 (Goulart)
- State Horticultural Association of Pennsylvania Research Committee Tour, Rock Springs, PA. June 1992. (Goulart)
- Field tour of LISA research, S. Deerfield, MA to a group of El Salvadoran students, extension agents, and community leaders. June,1 992. (Tuttle)
- New York Small Fruit Twilight Meeting, Binghampton, NY July, 1992 (Pritts)
- Cornell Weed Days Field Tour, Ithaca, NY July, 1992. (Pritts)
- Pennsylvania Farmer's Association Tour, Rock Springs, PA. July 1992. (Goulart)
- 1992 Vegetable and Small Fruit Field Day, Rock Springs, PA. July 1992. (Goulart)
- Southeast PA twilight small fruit growers meeting, Morgantown, PA. July 1992. (Goulart)
- Northeast Organic Farmers Association Summer Meeting. August, 1992. (Schloemann)

6. Papers/Reports presented at professional meetings

Cooley, D. R. "Development and implementation of Northeast strawberry IPM." Michigan State Horticultural Society Annual Meeting, E. Lansing, MI. 1991.

Cooley, D. R. "Massachusetts IPM Program: Can IPM Work?" and "Control of Strawberry Black Root Rot."

Goulart, B. L. "An automated multi-purpose irrigation system for strawberry." North American Strawberry Growers Annual Meeting, Williamsburg, VA. February, 1992.

Goulart, B. L. "Organic matter in upland blueberries: Cover crops, Amendments and Mulches." TriState Horticulture Meetings, Hershey, PA. January 30, 1992.

Handley, D. T. "Management of tarnished plant bug on strawberries." New England Small Fruit and Vegetable Growers Conference. December 1991.

Handley, D. T. Biology and control of tarnished plant bug." New Jersey Annual Vegetable Meeting. January, 1992.

Handley, D. T. "Tarnished plant bug: biology and management." Maine Vegetable and Small Fruit Growers Annual Meeting. January, 1992.

Handley, D. T. "Sustainable small fruit production." University of Maine Cooperative Extension Sustainable Agriculture Series. March 1992.

Handley, D. T. "Sustainable small fruit culture." Maine-New Hampshire Sustainable Agriculture School. March 1992.

Pritts, M. P. "The role of micronutrients in small fruit." New England Small Fruit and Vegetable Convention. Sturbridge, MA. December 1991.

Pritts, M. P., "Crops rotation a nd non-chemical control of nematodes." New England Small Fruit and Vegetable Convention. Sturbridge, MA. December 1991

Pritts, M. P. "Cover crops and mulches for strawberries and raspberries." Minnesota Fruit and Vegetable Growers Assoc.. Minneapolis, MN. January 8, 1992.

Pritts, M. P. "Use of row covers for strawberries and raspberries." Minnesota Fruit and Vegetable Growers Assoc. Minneapolis, MN January 9, 1992.

Pritts, M. P. "Weed control in strawberries: New approaches." TriState Horticulture Meetings, Hershey, PA. January 30, 1992.

Pritts, M. P. "Weed control in strawberries: New approaches." North American Strawberry Growers Association Annual Meetings. Williamsburg, VA. February 12, 1992.

Pritts, M. P. "Alternative weed management strategies for strawberries." NYS Pest Management Conf. Ithaca, NY November 10, 1992.

Schloemann, S. G. and D. R. Cooley. "Using predators for controlling two-spotted spider mites in strawberries: a view for Massachusetts." TriState Horticulture Meetings, Hershey, PA. January 30, 1992.

7. Scientific papers for publication

Goulart, B. L. 1992. Productivity and vigor of sixteen raspberry cultivars in central Pennsylvania. Fruit Var. Jour. 46(3):132-137.

Goulart, B. L., P. E. Hammer, K. B. Evensen, W. Janisiewicz and F. Takeda. 1991. The influence of pyrrolnitrin and high CO_2 on raspberry shelf life at 0 or 18 C. J. Amer. Soc. Hort. Sci. 117(2):265-270.

Handley, D. T., J. F. Dill and J. E. Pollard. 1992. Cultivar selection may affect management of tarnished plant bug injury to strawberries. Submitted to Fruit Varieties Journal. June, 1992.

Handley, D. T. and J. E. Pollard. 1992. Tarnished plant bug behavior on cultivated strawberries. International Strawberry Symposium. September, 1992.

McCue, J. J., Handley, D. T. and J. E. Pollard. 1992. Effect of row covers and insecticide sprays on insect damage to strawberries. International Strawberry Symposium. September, 1992.

Pritts, M. P., M. J. Kelly and M. Eames-Sheavly. 1993. Modifications to renovation practices in strawberry. Adv. Strawberry Res. 11:28-31.

Takada, F. and W. Janisiewicz. 1992. Extending strawberry fruit shelf life with pyrrolnitrim. p. 174-176. in A. Dale and J. J. Luby, eds. The Strawberry Into The 21st Century. Timber Press Portland, Oregon. p. 228.

Trinka, D. L. and M. P. Pritts. 1992. Micropropagated raspberry plant establishment as influenced by weed control practice, row cover use and fertilizer placement. J. Amer. Soc. Hort. Sci. (in press).

8. Other publications

Handley, D. T. 1992. Tarnished Plant Bugs. National Gardening Magazine. 15(4):18-19.

9. News Releases

Trellis systems may help northeast raspberry industry. 2 March 1992 (Goulart)
Automated irrigation protects fruit and saves water. 5 March 1992 (Goulart)
Plant small fruit at home. 19 March 1992 (Goulart)

Information dissemination: 1993

1. Speaking Engagements

U. Mass (D.R. Cooley, S.G. Schloemann, and A.F. Tuttle)

Presentations: Title, sponsor and location	Date	No. in attendance
• IPM and Sustainable strawberry production. Lecture for undergraduate students at UMass. (Schloemann).	Nov. 1992	15
• Strawberry IPM for managing soil borne root diseases. Connecticut Small Fruit and Vegetable Growers Association. Windsor, CT. (Schloemann).	January 21, 1993	100
• Sustainable/ biointensive strawberry production. Sustainable Agriculture Research and Education (SARE) Strawberry Grower to Grower Information Exchange. Rowe, MA. (Cooley, Schloemann, and Tuttle).	March 9, 1993	10
• Strawberry IPM. Hampshire County Beekeepers Association. Amherst, MA. (Schloemann).	March, 26, 1993	25
• Strawberry IPM training workshop. Sharon, MA. and S. Deerfield MA. (Schloemann).	April 27, and May 4 1993	46
• Principles and practices of Strawberry IPM. Rhode Island Cooperative Extension Twilight meeting. Kingston, RI. (Schloemann)	May 14, 1993	20
• Biointensive pest management and sustainability in strawberry production. Training for Extension scientists from Guatemala . S. Deerfield, MA. (Tuttle)	May, 20. 1993	15
University of Massachusetts Coop. Ext. Strawberry IPM Project. Massachusetts Farm Bureau Agriculture Awareness Day. Nourse Farms, Whately, MA. (Schloemann).	June 12, 1993	150
• Ecological principles using strawberries as an example. Pelham grade school. Pelham, MA. (Tuttle).	Sept. 9 and 24, 1993	20 (each)
• Sustainable strawberry production in practise. Lecture and demonstration for UMass Sustainable Agriculture class. Amherst and South Deerfield, MA. (Tuttle).	Oct. 4, 1993	15

Penn State (B. Goulart)

Goulart, B.L. Overview of sustainable agriculture small fruit systems. Sustainable agriculture seminar series, Penn State. 1 December 1992.

Goulart, B.L. An automated multi-purpose irrigation system for strawberry. Proc. Annual North American Strawberry Growers Association meeting. Annual meeting of the North American Strawberry Growers Association. Williamsburg, VA. 10 February 1992.

Goulart, B.L. Development of sustainable small fruit systems. Pennsylvania Association of Sustainable Agriculture annual conference. 5 February 1993.

Goulart, B.L. Panel member on LISA projects in the Northeast. 6 Pennsylvania Association of Sustainable Agriculture annual conference. February 1993.

Cornell (M. Pritts)

DATE	GROUP/LOCATION	TITLE
11/20/92	Strawberry IPM School Hickory Corners, MI	Weed management
1/16/93	Ontario Berry Growers Niagara Falls, Ont.	1) Alternatives to herbicides in berries 2) Trends in berry production
1/28/93	TriState Hort Mtgs. Hershey, PA	1) Alternative weed control methods 2) Use of mulches in new raspberry plantings
2/23/93	Missouri Small Fruit School Springfield, MO	1) IPM - Future directions 2) Alternative weed management strategies in strawberries
11/10/92	NYS Pest Management Conf. Ithaca, NY	Alternatives weed management strategies for strawberries
1/19/93	Direct Marketing Conf. Kingston, NY	Site selection
1/20/93	Direct Marketing Conf. Kingston, NY	Weed control and nutrient mgmt.
3/1/93	Row cover Workshop Owego, NY	Row covers in small fruit crops
3/11/93	Regional Fruit School Syracuse, NY	1) Site selection 2) Weed control and nutrient management
3/12/93	Regional Fruit School Batavia, NY	1) Site selection 2) Weed control and nutrient management

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U. Maine (D. Handley)

Tarnished plant bug research in strawberries. State Horticultural Association of Pennsylvania. January 28, 1993. Hershey, PA.

Tarnished plant bug research in strawberries. New Hampshire Fruit Growers Association Summer Tour. July 15, 1993. Monmouth, ME.

Effect of cultivar and insecticide sprays on tarnished plant bug injury to strawberries. American Society for Horticultural Science Annual Meeting. July 27, 1993. Nashville, TN.
Strawberry varieties and tarnished plant bug research. New England Vegetable Growers Association. November 6, 1993. Portsmouth, NH.

2.Field demonstrations
Cornell (M. Pritts)

DATE	GROUP/LOCATION	TITLE
7/8/93	Northeast Weed Science Ithaca, NY	Cornell Weed Days
7/17/93	Coop. Ext. Field Day Ithaca, NY	Berry crop field day

3.Oral presentations to academics:
(M. Pritts)
Dept. of Fruit and Vegetable Science, Cornell University, 9/10/92 Title: Feeding the World: Two models of production agriculture
Dept. of Horticultural Sciences, NYAES, Geneva, NY, 11/4/92 Title: Feeding the World: Two models of production agriculture
Northeast Region, ASHS meeting, 1/8/93, Symposium on Sustainable Agriculture: "Alternative strategies for berry crop production." Clarks Summit, PA
Ag Canada, 1/12-13/93, Special Guest at Conference on "Raspberry Decline Syndrome" Simcoe, Ontario, CANADA
Expectativas de rentabilidad y innovaciones technologicas en frambuesas, 9/29-30/93, Linares, CHILE. Three lectures.
Dept. of Horticulture, Michigan State University, East Lansing, MI, 10/28/93. Title: Sustainable berry crop production: paradigm or paradox?

(D. Handley)
An examination of tarnished plant bug feeding injury on strawberry. Northeast Region American Society for Horticultural Science Annual Meeting. January 8. 1993. Clarks Summit, PA.

(B. Goulart)
Goulart, B.L. 1993. Welcome to reality: An overview of a LISA project in small fruit. HortScience 28(5):443-444.

4. Publications and fact sheets:

Cooley, D. R., S. G. Schloemann and A. F. Tuttle. 1993. Development and implementation of integrated pest management for strawberries in Massachusetts. *Adv. in Strawberry Research* 12: 1-11.

Cooley, D. R., A. F. Tuttle, and S. G. Schloemann. 1993. Integrated management of black root rot of strawberry; an update of variety tolerance research. *Northeast SARE Small Fruits Newsletter* 4(1).

Else, M. J., S. G. Schloemann. 1993. Weed IPM Fact Sheet: weed scouting for strawberry growers. *Cooperative Extension publication #L-696.*

Schloemann, S. G., D. R. Cooley and A. F. Tuttle. 1993. Integrated pest management for strawberries in Massachusetts. 1993. *Proceedings of the New England Small Fruit and Vegetable Growers Association.* (in press).

Goulart, B.L., M. Brittingham, J. Harper, P. Heinemann, W. Hock, E. Rajotte, J. Rytter and J. Travis. 1994. Small Fruit Production and Pest Management Guide, 1994-96. The Pennsylvania State University. (in press)

Schloemann, S.G. and D.R. Cooley, eds. 1993. Integrated Pest Management for Strawberries in the Northeastern United States: A Manual for Growers and Scouts. A Univ. of MA Cooperative Extension publication (in press).

5. Refereed publications

Goulart, B.L. 1992. Productivity and vigor of sixteen raspberry cultivars in central Pennsylvania. Fruit Var. Jour. 46(3):132-137.

Handley, D. T., and J. E. Pollard. 1993. A microscopic examination of tarnished plant bug (Heteroptera: Miridae) feeding damage to strawberry. J. Econ. Entomol. 86(2): 505-510.

Handley, D. T., and J. E. Pollard. 1993. Tarnished plant bug (*Lygus lineolaris*) behavior on cultivated strawberries. Acta Horticulturae (accepted for publication April 1993).

Handley, D. T., J. F. Dill and J. E. Pollard. 1993. Tarnished plant bug injury on six strawberry cultivars treated with differing numbers of insecticide sprays. Fruit Varieties Journal 47(3): 133-137.

McCue, J. J. and D. T. Handley. 1993. Effect on rowcovers and insecticide sprays oninsect damage to strawberries. Acta Horticulturae (accepted for publication April 1993).

6. Published abstracts

Handley, D. T. and J. E. Polalrd. 1993. Effect of cultivar and insecticide sprays on tarnished plant bug injury to strawberries. HortScience 28(5): 118 (abstract/oral presentation).

Handley, D. T. and J. E. Pollard. 1993. An examination of tarnished plant bug feeding injury on strawberry. HortScience 28(4): 259 (abstract/poster presentation).

7. Other Publications

Bradley, F. M., ed. *Bountiful Berries* in: *The Expert Book of Garden Hints*. Pages 231-235. Rodale Press, Emmaus PA.

Goulart, B.L. 1992. Pruning basics. American Agriculturist 3:18,20,40.

Goulart, B.L. 1992. Pruning for fruit quality. American Agriculturist 2:48-49.

Goulart, B.L. 1993. Postharvest practices for small fruit crops: A review and some new ideas. Proc. State Hort. Assoc. Pa.

Goulart, B.L. and M.J. Kelly. 1992. Three years of experience with trellised black raspberries. Pennsylvania Vegetable Growers News. 15(1b):7-9.

Goulart, B.L., D.R. Daum and K.Demchak. 1992. Spray distribution on red raspberry plantings: An evaluation on three growing systems. LISA Small fruits Newsletter. 3(1): 1-3.

Handley, D. T. 1992. Tarnished plant bugs. National Gardening 15(4): 18-19.

Handley, D. T. 1993. Tarnished plant bug research in strawberries. Pennsylvania Fruit News 73(4): 104-105.

Poncavage, J. *No matter where you live, you can grow super strawberries*. Pages 2-6. *Organic Gardening*. December 1993.

Pritts, M. P. 1993. Alternative weed management strategies in strawberries. Penn. Fruit News 73:136-138.

Pritts, M. P. 1993. Alternative weed management strategies in strawberries. Proc. Missouri Small Fruit Conference pp. 59-66.

Pritts, M. P. and M.J. Kelly. 1992. Alternative weed management strategies for strawberries. Proc. NYS Pest Management Conf. 55:35-42.

Pritts, M. P. Careful evaluation is critical. Amer. Fruit Grower, May, 1993.

Pritts, M. P. See no weevil. Amer. Agriculturist, September, 1993.

Pritts, M.P. 1993. Integrated pest management in small fruit crops - future directions. Proc. Missouri Small Fruit Conference pp. 1-11.

Trinka, D. L. and Pritts, M. P. 1993. Use of mulches to control weeds in newly planted raspberries. Penn. Fruit News 73:139-142.

Wilcox, W. F., M. P. Pritts, R. C. Seem, J. R. Nevill and J. A. Burr. 1992. Cultural and chemical control of gray mold on strawberries. Proc. NYS Pest Management Conf. 55:42-43.

Information dissemination: 1994

1. Speaking Engagements to Growers

University of Massachusetts.(D.R. Cooley, A.F. Tuttle, and S.G. Schloemann)

Title, sponsor, and location	Date	No. in attendance
• How math is used in IPM. Greenfield Community College children's math show *The Math Connection* on public access cable TV. Greenfield, MA. (Schloemann)	1/31/94	unknown
• IPM for Managing Strawberry Diseases. New England Vegetable and Berry Growers Association Winter Meeting. Waltham, MA. (Schloemann)	2/5/94	75
• Departmental Seminar, Plant Pathology Dept., Univ. of MA: "Strawberry IPM" (Cooley and Schloemann)	2/10/94	20
• Polish strawberry growers IPM course. A joint project with Institute for Training and Development (Amherst, MA) and Univ. of Mass. Cooperative Extension to develop and offer training to six representatives of a cooperative of small fruit growers from Lodz, Poland. (Schloemann and Cooley.	6/29, 6/30 7/5, 7/7	10
• Northeast SARE Steering Committee Field Tour. Presented research results at our strawberry plots in S. Deerfield, MA. (Tuttle, Schloemann, and Cooley).	7/28/94	approx. 100
• Invited presentation, Midwestern Fruit Workers Conference, Indianapolis, IN: "Strawberry IPM program development" (Cooley)	11/4/94	30

Penn State (B. Goulart)

1993

28 January Postharvest practices for small fruit crops. State Horticultural Association of Pennsylvania Annual Meeting. Hershey, Pennsylvania.

26 July Welcome to reality: An overview of a LISA project in small fruit. Presented in a colloquium at the National meeting of the American Society for Horticultural Science. Nashville, Tennessee.

1 September Ericoid mycorrhizas: An overview and recent research. Plant Physiology seminar, Penn State University, University Park, Pennsylvania.

September A nursery survey of ericoid mycorrhizas in blueberries; and An aspirated radiation shield for use with thermocouples in agricultural applications. Two posters presented at the Plant Physiology Research Forum. University Park, Pennsylvania.

8 December Are blackcaps back? Suggestions for black raspberry culture and cultivar management. Michigan State Horticultural Association Annual Meeting. Grand Rapids, Michigan.

8 December Postharvest handling of strawberries and raspberries: Maintaining quality from the field to the consumer. Michigan State Horticultural Association Annual Meeting. Grand Rapids, Michigan.

15 December Strawberry irrigation systems: A novel approach to an ancient problem. New England Vegetable and Small Fruit Meeting. Sturbridge, Massachusetts.

16 December Trellises for raspberry production: More yield, more management! New England Vegetable and Small Fruit Meeting. Sturbridge, Massachusetts.

1994
5 February Trellis systems for Raspberries: A report on five years of study on black and red raspberry. North American Bramble Growers Association Annual Meeting. Columbus, Ohio.

Cornell (M. Pritts)

DATE	GROUP/LOCATION	TITLE
2/5/94 Columbus, OH	Ohio Fruit Growers Conf.	New approaches to weed control
2/13/94 Assoc. Niagara Falls, ONT	Ontario Berry Growers	Raspberry culture
2/16/94 Growers Association Niagara Falls, ONT	North American Strawberry	New approaches to weed control
3/15/94 School Piketon, OH	Ohio Strawberry Fruit	1) Strawberry nutrition 2) Alternative strategies for weed control
3/16/94 Piketon, OH	Ohio Small Fruit School	Raspberry plant establishment
4/6/94 Small Fruit School Queensbury, NY	Northeastern NY	1) Variety update 2) Phytophthora root rot
11/9/94 Ithaca, NY	Production Ag Week	Sustainable Small Fruit Research
7/14/94 Ithaca, NY	Cornell Weed Days	Field tour

2. Oral presentations to academics:

U. Mass. (Cooley:) National IPM Meetings, Las Vegas, NV. 4/20/94. Title: An overview of the development of the Massachusetts strawberry IPM program.

Penn State (B. Goulart)
Goulart, B.L. 1994. Physiological responses of 'T', 'V' and hedgerow trained red and black raspberries (*Rubus idaeus* L. and *R. occidentalis* L.). Sixth International Symposium on Rubus and Ribes. Skierniewice, Poland.

Cornell (M. Pritts)
Dept. of Horticulture, Michigan State University, East Lansing, MI, 10-28-93. Title: Sustainable berry crop production: paradigm or paradox?

Dept. of Fruit and Vegetable Science, Cornell Univ., 9/1/94. Title: Sustainable berry crop production: paradigm or paradox?

3. Extension Publications and Fact Sheets

SARE Project: Northeast SARE Small Fruit Newsletter. 1 or 2 issues per year, approx. 20 pp. per issue, distributed to 780 subscribers, edited by Tuttle and Cooley.

Coli, W. M., Cooley, D. R., Clifton, N., Jenkins, J. and B. Szala. "A microcomputer database of Massachusetts pesticide use estimates for tree fruits, small fruits, cranberries and vegetables." Univ. of Mass. Coop. Ext. System. Report on Special Project #90-EPIA-1-8066. 1994. 56 pp.

Cooley, D. R. and S. G. Schloemann, editors. Integrated Pest Management for Strawberries in the Northeastern United States: A Manual for Scouts and Growers. Amherst, MA. University of Massachusetts Cooperative Extension System, 1994. 52 pp.

Cooley, D. R. and S. G. Schloemann, editors. Integrated Pest Management for Strawberries in the Northeastern United States: A Manual for Scouts and Growers. Amherst, MA: University of Massachusetts Cooperative Extension System Publication #C211, 1994. 52 pp.

Goulart, B. M. Brittingham, J. Harper, P. Heinemann, W. Hock. 1994. Small Fruit Production and Pest Management Guide, 1994-95. The Pennsylvania State University. 112 pp.

Pritts, M. P., W. F. Wilcox, A. Agnello, and G. Schaefers. (1994). Pest Management Recommendations for Small Fruit Crops, NYS College of Agric. and Life Sciences, Cornell Univ., Ithaca.

Pritts, M.P. 1994. Alternative weed management strategies for strawberries. Proc. Ohio Asparagus, Strawberry and Small Fruit School. pp. 80-82.

Pritts, M.P. 1994. Raspberry plant establishment and weed control. Proc. Ohio Asparagus, Strawberry and Small Fruit School. pp. 105-106.

Schloemann, S. G., ed. and Cooley, D. R. section editor. New England Small Fruit Recommendations: Managing diseases and insects on small fruit. 1993-1994. Cooperative Extension System, University of Massachusetts. 60 pp.

4. Refereed publications

Handley, D.T. and J.E. Pollard. 1993. Tarnished plant bug (*Lygus lineolaris*) behavior on cultivated strawberries. Acta Horticulturae 348:463-468.

Handley, D.T., J.F. Dill and j.E. Pollard. 1993. Tarnished plant bug injury on six strawberry cultivars treated with differing numbers of insecticide sprays. Fruit Varieties Journal 47(3): 133-137.

Handley, D.T. and j.E. Pollard. 1993. A microscopic examination of tarnished plant bug (Heteropter:Miridae) feeding damage to strawberry. J. Econ. Entomology. 86(2):505-510.

Wing, K. B., M.P. Pritts and W.F. Wilcox. 1994. Field resistance of 20 strawberry cultivars to black root rot. Fruit Varieties Journal, in press.

Wing, K. B., M.P. Pritts and W.F. Wilcox. 1995. Biotic, edaphic and cultural factors associated with strawberry black root rot in New York. HortScience, in press.

Weaver, Robert D. "Pesticide Use and Consumer Demand for Produce Quality: A Survey of Evidence". Chapter in forthcoming book *Economics of Food Safety*, Ed. Julie Caswell, Elsevier. 1995.

5. Published abstracts

Demchak, K., G.M. Heisler, B.L. Goulart and S.B. Gleason. 1993. An aspirated radiation shield for use with thermocouples in agricultural applications. Hortscience 28(5):536. (abstract/poster presentation)

Goulart, B.L. 1993. Welcome to reality: An overview of a LISA project in small fruit. Hortscience 28(5): 443-444. (abstract/oral presentation)

Wing, K. and M. Pritts. 1994. Etiology of strawberry black root rot. HortScience 29:458.

6. Non-Refereed Publications

Goulart, B.L. 1993. Are blackcaps back? Suggestions for black raspberry culture and cultivar selection. Proc. 1993 Michigan State Horticultural Society Meeting.

Goulart, B.L. 1993. Postharvest handling of strawberries and raspberries: Maintaining quality from the field to the consumer. Proc. 1993 Michigan State Horticultural Society Meeting.

Goulart, B.L. 1993. Postharvest practices for small fruit crops: A review and some new ideas. Pennsylvania Vegetable Growers News. 16(6):14-16.

Goulart, B.L. 1994. Physiological responses of 'T', 'V' and hedgerow trained red and black raspberries (*Rubus ideaus* L. and *R. occidentalis* L.) Acta Horticulturae: inpress.

Goulart, B.L. 1994. Raspberry trellises: Pitfalls and possibilities. Northland Berry News. March: 16-17.

Goulart, B.L. 1994. Raspberry trellises: Pitfalls and possibilities. Pomona 27(1):65-66.

Goulart, B.L. 1994. Trellis systems for raspberries: A report on five years of study on black and red raspberry. Proc. North American Bramble Growers Association. in press.

Goulart, B.L. 1994. Trellises for raspberry production: More yield, more management!. Proc. 1994 New England Vegetable and Small Fruit Meetings. Sturbridge, Massachusetts.

Handley, D.T. 1993. Strawberry production and IPM strategies for New England. Ann. Rep. State Hort. Soc. Mich. 123:128-131.

Handley, D.T. 1993. Tarnished plant bug research in strawberries. Pennsylvania Fruit News 73(4):104-105.

Handley, D.T. 1994. Tarnished plant bug and strawberries: biology, management and research. Strawberry IPM Update. Iowa State University.

Handley, D.T. 1994. Tarnished plant bug: the unsolved mystery. Ann. Rep. Maine State Pom. Soc. 1994 (in press).

McCue, J.J., D.T. Handley and J.E. Pollard. 1993. Effect of rowcovers and insecticide sprays on insect damage to strawberries. Acta Horticulturae 348: 500-503.

Pritts, M.P. and M.J. Kelly. 1993. Alternative weed control strategies for strawberries. Acta Horticulturae 348:321-327.

Weaver, R.D. and B.L. Goulart. 1993. Small fruit grower interest in alternatives to chemical controls. SARE Small Fruits Newsletter 4(1):2-9.

Weaver, R.D. and B.L. Goulart. 1993. Grower interest in adapting alternative technologies: Results from a nationwide Survey. Pennsylvania Fruit News 74(3).

Wing, K. B., M.P. Pritts and W.F. Wilcox. 1994. Strawberry black root rot: a review. Advances in Strawberry Research 13:13-19.