

sumers; mechanical and biological weed control; soil and water conservation practices; animal and green manures; and agricultural chemicals that do not pose significant threats to humans, animals, or the environment (O'Connell, 1991).

Key questions for researchers and farmers may include the following: What management factors affect sustainability? What crops can be grown using sustainable agriculture practices? How can inputs best be manipulated? Must farmers accept lower profits for doing the right thing? What new technologies and practices will assist farmers in moving toward sustainable farming?

This colloquium was convened to address what is happening in the United States to make horticulture more sustainable. The following papers are presented by university researchers and others who have been involved in sustainable programs and by national project directors who develop guidelines for sustainable university programs.

These papers provide an overview of SARE, a discussion of waste streams in greenhouse production, a description of a multi-state project that evaluates the feasibility (biologic and economic) of using sustainable agriculture practices for small fruit, a description of a computer model (PLANETOR) that allows farmers to evaluate alternative resource management strategies, and a discussion of sustainable landscaping.

We in the horticulture community have a difficult task to address environmental issues. The market is now global. Land prices in many states are now too expensive to practice labor-intensive farming. We face many restraints as we work for solutions. We need to find systems that are not only environmentally sustainable, but also economically viable for the producers.

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Welcome to Reality: An Overview of a Low-input Sustainable Agriculture (LISA) Project in Small Fruit

Barbara L. Goulart¹

ADDITIONAL INDEX WORDS. extension education, integrated pest management, raspberry trellising, small fruit pest complexes, raspberry, strawberry, cover crops, floating rowcovers

SUMMARY. An in-the-trenches researcher/coordinator viewpoint of a northeast regional LISA grant funded from 1989-93 is presented. The specifics of the logistics of coordinating a multi-state grant in a fledgling granting program is emphasized, as well as the evolution of the content and focus of the research directions for the grant Evaluation of Alternative Strategies for Small Fruit Production (Univ. of Vermont Agreement 92-08-01). This was a project in which five states in the northeastern United States proposed to cooperate on a multi-disciplinary project exploring the biological and economic feasibility of selected production practices for small fruit. These practices were selected because they showed potential for increasing net profit by reducing purchased inputs or maximizing yield. Information transfer, before, during, and after the studies was emphasized, using such diverse means as grower experimental plots, the participation of growers in integrated pest management programs, the development and publication of economic data relevant to the projects, the development of a LISA small fruit newsletter, as well as more traditional means of information dissemination such as grower meetings, and trade and scientific publications.

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In 1988, a group of small fruit researchers in the northeastern United States became aware of a relatively new and nontraditional source of funding. The LISA program was sponsored by the USDA and offered an opportunity for field-oriented researchers to implement programs that were multidisciplinary in nature at a level of support that would increase depth and breadth in research and extension endeavors. In a time of shrinking to nonexistent public formula support, this competitive program represented a chance to make a contribution, even if in a somewhat nontraditional manner. The purpose of this paper is not to detail all of the research accomplishments of this particular group. The accomplishments that were supported either partly or in full by the project are too lengthy to discuss in this forum and are contained in a variety of other sources, including a well-received newsletter, and more than 100 publications. A partial bibliography of these contributions is found at the end of this paper. Rather, the objective of this paper is to outline the evolution of the project, with emphasis on the researchers' view of the programs objectives and implementation. The project entitled "Evaluation of Alternative Strategies for Small Fruit Production" was supported by the Northeast Regional LISA program via the Univ. of Vermont as project LNE89-16.

Why small fruit?

The small fruit commodity was well-placed to compete for this type of funding, which emphasized interdisciplinary approaches and biological and economic sustainability. The reasons are outlined below.

- Because small fruit crops garner particularly high profits per unit land area, they are ideally suited for areas where land costs are high, e.g., at the rural-urban interface. However, the risks associated with pesticide use are also high in these areas. This high profit/unit land area also allows part-time growers, an increasingly large segment of the commercial small fruit producers, to produce a crop profitably, and thus maintain the rural nature of their property, a priority in many states.
- Small-fruit researchers are particularly well organized across the region and the country. This is due, in part, to the historical shortage of funding and faculty positions in small fruit crops. The small-fruit research and extension personnel across the country are particularly well informed regarding one another's programs, and they make extensive formal (regional committees) and informal (personal contact) efforts to collaborate and avoid redundancy. Thus, the framework for putting together a team was in place.
- The body of knowledge that exists regarding small-fruit crops is relatively limited. This is an advantage and a disadvantage. The advantage

lies in the fact that many ideas (particularly those related to integrated crop management) have not been tested on small-fruit crops. Simple questions can be addressed quite readily by directly transferring knowledge and tested concepts developed on more thoroughly researched crops to small-fruit crops. An example of this is the testing and use of predacious mites, a commonly used strategy in apple production that could be readily tested in strawberry production systems. However, because the base of knowledge is relatively small for strawberries, a great deal of information is needed about all disciplines and interactions related to strawberry production, so that development of ideas to the point where they're usable for producers requires more time.

Personnel

Fourteen researchers from five university or research institutions contributed to this project (Table 1). From this listing, it is clear that the author's role as coordinator was, of necessity, administrative in nature. Decisions about the direction and emphasis of the project were decided in annual meetings in a democratic manner. All participants have contributed in research and teaching (technology transfer) roles.

One of the criteria for funding within the LISA program was the mandated participation of growers. This was, and continues to be, an intrinsic component of the northeastern small-fruit project, and every state had some level of county extension personnel and/or grower participation. However, for this project, the level of this participation was left to the discretion of the individual researchers. This was imperative, since certain projects are more appropriate for grower involvement than others. It is grossly inappropriate to expect growers to take risks on fledgling projects that are under primary exploration by researchers. Researchers who work with growers carefully nurture and cherish these relationships, not only because they feel responsible to those individuals, but because competent grower cooperators are difficult to identify, and the destruction of these relationships by inappropriately risky projects should be avoided at all costs.

Research objectives: Evolution of a collaborative research and extension project

The project began with a broad set of research and extension objectives that evolved and developed as time passed, and data were analyzed and interpreted. This is not unusual; however, because of the breadth of this project, the number of people contributing to it, the level of energy they injected into it, and eventually the level of fiscal support that the LISA program granted, this evolution occurred more rapidly than with most projects.

A summary of the iterations of the project is outlined below.

The first iteration: 1989-90

The original research goals outlined in the first proposal were extremely broad, including three crops (strawberry, raspberry, and blueberry), as well as investigators in five different disciplines. The original funding request, although called modest for the proposed work by one reviewer, was reduced from \$163,000 to \$53,000. This reduction obviously required a reduction in the proposed work, as well as a great deal of paring down of the depth into which individual researchers could conduct the work. Blueberry research, graduate assistantships, and outlying grower plots were eliminated. The remaining primary objectives and their components are outlined below.

OBJECTIVE 1: To devise and test production and pest management practices that reduce the need for purchased inputs.

- Strawberry and raspberry cultivar screens. Very little knowledge is available on the relative levels of susceptibility of commonly used raspberry and strawberry cultivars to pests. By selectively or completely withholding pesticides, susceptibilities to various insect and disease pests could be evaluated.
- Nonherbicide groundcover management in strawberry. Weed control is considered a weak link in strawberry production because herbicides are unavailable or unregistered and because strawberries are weak competitors. Thus, evaluations of solar heating as a substitute for fumigation, and research on preplant and interplanted cover crops was deemed a high priority.
- Biorational pesticide test screen on raspberry. Copper, sulfur, lime-sulfur, and soaps have been used extensively in the past for fungal and insect pest control and offered potential as an alternative to synthetic chemical pesticides. While copper and sulfur compounds are all extremely phytotoxic on raspberries, the need to find alternative fungicides is even greater now, since captan is no longer labeled for brambles.
- Natural mite predators on strawberry and bramble crops. Predator mites have proven an effective tool on apple. However, there is considerable variability in their effectiveness from year to year on small-fruit crops.
- Rowcovers to exclude insect pests on strawberry. A good example of a high-input, rowcovers nonetheless offer potential as a physical barrier against two of the most devastating insects on strawberry: strawberry bud weevil and tarnished plant bug.
- Biological control of gray mold. Yeasts, bacteria and a bacterial derivative, pyrrolnitrin, were all reasonable candidates for gray mold control.

OBJECTIVE 2: To evaluate the economic feasibility of the practices above. Because this objec-

tive was stated from the conception of the project, biological researchers knew they had a responsibility to keep track of costs and communicate with the agricultural economist to develop a reasonable set of assumptions by which to make economic evaluations. The economic evaluation was not developed for every aspect of the project, and only those projects that were developed well enough for limited grower adoption were deemed appropriate.

OBJECTIVE 3: To transfer technology to industry. It was our perception that there was a need to emphasize the transfer of the technology obtained by research to the small-fruit industry. This was accomplished through a variety of traditional and less traditional mechanisms, including grower meetings, grower publications, demonstration plots, and grower cooperator research plots. The original proposal also planned to develop expert systems as a means of information management, but the reviewers specifically requested that LISA monies not be used for this purpose.

The second iteration: 1990–91

Most of the projects outlined above were continued for multiple years. However, as the group worked together and analyzed data, various strengths emerged, while certain lines of research were discontinued. Areas that obtained extremely positive results were the groundcover management work in newly planted raspberries and strawberries. Work on raspberry trellises was begun because it had shown promise for labor and pesticide reduction and yield efficiency increases.

However, cultivar evaluations for pest resistance were discontinued on raspberry, due (primarily) to the decimation of the planting as a result of withholding pesticides—a useful lesson for the researchers involved as well as the granting agency. Solarization work also was discontinued due to the inability of the originator of the idea to conduct the research on the funds allotted, as well as the dismal prospects of the practice in the relatively low-light areas of the northeastern United States.

While the first year's projects were a rather eclectic collection, in the second iteration, projects began to fall into categories, allowing for better organization of information. These categories included cropping efficiency (with nutrient management, light management, and pest management as subdivisions), feasibility studies (including the previous economic evaluations as well as the beginning of a new study on grower adoption of new practices), and technology transfer (to which a LISA Small Fruit Newsletter was added).

The third iteration: 1991–93

During the third funding year (which followed a site review), the project continued to develop into distinct systems, and it became clear that future iterations would involve examinations into the interactions among many aspects of crop ecology. This is probably a natural progression; studying impacts of specific practices, and then expanding the scope of the project to examine interacting issues. For example, the use of sudan grass for intercropping with strawberries led very

naturally to the need to understand how this practice would influence insect populations within a strawberry planting. How would soil organic matter be influenced? Another example is evident from the raspberry trellising research. The light management system of trellising raspberries resulted in increased yield per unit land area, but raised questions such as Are alterations in canopy microclimate influencing the physiology of the raspberry plant? How is spray deposition affected by canopy type? How is the root system affected, given that the soil under a 'T' trellis is shaded? These projects are beginnings, and allow us to start taking a longer view of the problems that we hope to solve.

Technical aspects of interacting with the LISA program

Although the work that was done either would not have been possible or implemented superficially if not for this funding opportunity, the program has several policies and criteria that have blocked many worthy research projects. These policies will hamper projects that are extremely necessary and important if they are not reconsidered.

THE MULTI-STATE REQUIREMENT. Generally, it was assumed that states did not cooperate, and this requirement would force cooperation. In fact (at least in the case of fruit crops), states already cooperate on many research and educational efforts. The requirement for more than one state on the grant forced many awkward and nonsensical

Table 1. Researchers contributing to LNE89-16, Evaluation of Alternative Strategies for Small Fruit Production.

University/researcher	Role/discipline, specific project areas
<i>Penn State University</i>	
Barbara Goulart	Project coordinator. Horticulture. Field and postharvest testing of pyrolnitrin, raspberry trellis studies, root pruning, resistance screen for raspberries.
Donald Daum	Agricultural engineering. Spray deposition on raspberry trellises.
Edwin Rajotte	Entomology. Evaluation of biorational pesticides, compilation of research information.
Robert Weaver	Agricultural economics. Characterization of growers: demographics and adoption of new practices
<i>Cornell University</i>	
Marvin Pritts	Horticulture. Raspberry nutrient management, strawberry genotype/disease interactions, strawberry black root rot cultivar screening, strawberry cover crops and groundcover studies, raspberry <i>Phytophthora</i> study, strawberry cultural practices for <i>Botrytis</i> control.
Wayne Wilcox	Plant pathology. Strawberry genotype/disease interactions, strawberry black root rot cultivar screening, strawberry cover crops, raspberry <i>Phytophthora</i> study, strawberry cultural practices for <i>Botrytis</i> control.
M.A. Castaldi	Agricultural economics. Comparison of costs for alternative practices/systems.
<i>University of Massachusetts</i>	
Daniel Cooley	Integrated pest management. Biological control of <i>Botrytis</i> , Black root rot control.
Sonia Schloemann	Integrated pest management. Spider mite predators, soil solarization, tarnished plant bug parasitism.
Arthur Tuttle	Newsletter compilation and distribution.
<i>University of Maine</i>	
David Handley	Horticulture. Strawberry genotype sensitivity to tarnished plant bug, rowcovers as insect exclusion barriers in strawberry.
<i>USDA–Appalachian Fruit Research Center (WVa.)</i>	
Fumiomi Takeda	Horticulture. Pyrolnitrin studies on strawberry, Strawberry fruit rot antagonists.
Wojciech Janisiewicz	Plant pathology. Pyrolnitrin studies, strawberry fruit rot antagonists.
Donald Peterson	Agricultural engineer. Mechanical harvesting for raspberry trellis systems.

liaisons and often discouraged application by researchers with creative ideas well within the realm of the LISA initiatives.

THE GROWER PARTICIPATION REQUIREMENT. This requirement is, in and of itself, not necessarily negative. However, the level of grower participation that is expected is not usually realistic. As mentioned earlier, it is not often appropriate to have growers house primary research. It is a liability for the grower, with a high probability of failure, and a liability to the researcher, since suitable growers are not necessarily in close proximity to the place where the researcher is located.

On a more fundamental level, however, the developers of the program seemed to lack an appreciation of the grower involvement in all research projects. It is assumed that growers don't routinely have input into research programs when, in fact, they often do. Agricultural researchers do not decide what to research in a vacuum—growers are key sources of information. On-farm research has existed since the dawn of the extension service. The architects of the LISA program also underestimated the extensive and effective nature of the existing communication network among researchers, county extension personnel, and growers: specifically, the cooperative extension service.

SINGLE-YEAR FUNDING. The search for environmentally sustainable, economically sound practices is not short-term in nature. With perennial crops, the need for multiple years of funding is even more necessary, since planting establishment is often necessary before primary research can begin. The LNE89-16 project was funded initially at 33% of the requested level for 1 year (5 years were requested). This made it necessary to cut out large portions of the research and to do the remaining research by using other budgets for support. The second year's funding request had to be submitted with first time requests, making funding less likely.

GROWER READY IN 5 YEARS OR LESS. While few will debate that technology transfer from research to industry is extremely important, there are many challenging and potentially extremely useful areas of research that are intermediate in nature. Specifically, these are research problems that will not likely be ready for grower implementation in the next 3 to 4 years, but that are also not fundamental enough for other competitive agencies such as the National Science Foundation or the National Research Initiative to fund. Examples of such research includes mycorrhizal interactions, sink-source relationships, and identification of sources of genes for such traits as disease or drought tolerance. These areas, which no longer receive significant public funding, offer huge potential for large payoffs for the industry in the 10 to 15 year period, rather than a shorter term. They are also relatively risky, hence unlikely to receive direct industry support. There is currently no source of funding for projects such as these.

INTEGRATION OF SOCIOLOGICAL ASPECTS. Not all projects that fall into the realm of the LISA program have sociologically researchable issues associated with them. This tends to force liaisons that are connected only loosely with the projects or are superficial in nature.

It should also be emphasized that the LISA program has evolved and improved with time. For example, the 1-year funding and large funding cuts to individual projects is no longer nearly as prevalent. It appears that the program administrators have realized the necessity of continuity in funding for at least a few years. However, it still stands that many of the projects that are most appropriate, i.e., emphasize the evaluation of reduced pesticide use, integrated systems of food and fiber production, are extremely long-term in nature, and even 4 to 5 years of funding is inadequate. This is particularly true for perennial cropping systems.

As the program has grown and changed, the name of the program also has been changed from LISA to Sustainable Agriculture Research and Education (SARE). The deemphasis on low input is significant, since it suggests that reducing agrichemicals doesn't necessarily reduce total inputs and frequently requires increases in what producers must invest in the crop, often in the form of time, labor, planning, etc. The emphasis on education in the new title is also noteworthy. While the notion of technology transfer has been a key element of the program since its inception, including the word education in the program name accurately reflects its level of importance in the considerations of the review teams. The SARE program offers a unique opportunity for research teams that are interdisciplinary and interactive with the industries they serve. The changes in program structure and specific objectives are movements in a more pragmatic direction and continue to offer hope for funding creative research that will question current dogma and approaches, while retaining scientific integrity. The need for the funding of more intermediate research projects, those that are likely to be riskier, or longer-term (such as nutrition studies, crop ecophysiology studies, etc.), remains a glaring need in the funding arena.

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Sustainable Agriculture Research and Education (SARE) Program

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United States agriculture has been highly productive during the past 50 years. The benefits of this increased productivity, however, have been reaped by the off-farm sectors of the agricultural system (Table 1) at the expense of the farmer (Smith, 1992).

There have been many other unexpected changes associated with United States agriculture during this period. These include a decreased number of farms, increased farm size, increased dependency on off-farm purchased inputs, decreased system diversity, decreased biodiversity, increased risk associated with environmental quality and human health, decreased reliance on rural communities, and decreased direct contact with suburban and urban communities. This has resulted in the evolution of a single dominant system of agriculture—the industrial agribusiness farm model.

About 85% of the food and fiber produced in the United States comes from about 15% (300,000) of two million farms. Most of these enterprises are operated under the structural components of the following model (Bird and Ikerd, 1993; Strange, 1988):

- Centralized management.
- Emphasis on specialization.
- Hired worker days exceed owner on-farm work days.
- Separation of management and labor.
- Technology used to minimize labor inputs. Limited education requirement for labor component.
- Heavy reliance on purchased inputs.
- Technology designed to minimize real-time in-field decisionmaking.
- Emphasis on standardized farming practice.

The industrial agribusiness model farms have type of enterprise, economic, environmental, and conservation goals. They have remained viable by increasing their size. During the pro-

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