RESEARCH : aims and accomplishements

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My research is transdisciplinary in nature as it encompasses a broad spectrum of subjects relating to the environmental, cultural, social, economic and political dimensions of agriculture. Therefore my research fits well within the mission of the ESPM department which encourages interdisciplinary research at the interface of society and the environment. My work aims at obtaining a wider understanding of the agricultural context by studying the relationships between agriculture, the global environment and social systems. I believe that it is through this deeper understanding of the ecology of agricultural systems that doors will open to new management options more in tune with the objectives of a truly sustainable agriculture. The thrust of my work has been the development of the science of agroecology, which is defined as the application of ecological concepts and principles to the design and management of sustainable agroecosystems, providing a framework to assess the complexity of agroecosystems but at the same time the tools to develop environmentally sound, socially just, culturally diverse and economically viable solutions to problems inherent to the industrial model of agriculture. This science has been nurtured by advances in modern agricultural science and also by elements of traditional farming knowledge. In a sense agroecology has become a bridge that promotes the dialogue of western science and traditional wisdom.

On the ecological side, my research revolves around three central questions:

a) What is the ecological role of biodiversity in the function and performance of agroecosystems? This work centers on the exploration of the use of plant biodiversity to enhance biological pest control in agroecosystems. We have been able to identify a number of plant diversification designs that can lead to reduction of pest populations in cruciferous crops and vineyards due to the fact that these designs enhance the abundance and diversity of natural enemies of insect pests. We have been able to identify specific plant mixes that provide important resource subsidies (alternative prey-hosts, pollen, nectar, shelter, etc) to natural enemies of pests in a range of cropping systems and have been able to refine such defines to fit within normao agronomic management of many crops. Our work with farmers has translated into practical applications and a number of farmers in Sonoma (Benziger, Ridge and Medlock Ames vineyards), Fetzer vineyards in Mendocino County and Sainstbury, Quintessa, Icon, Sinskey and Coturri vineyards collaborate with us in testing flowering summer cover crops (buckwheat, wild carrot and alyssum) as well as vegetational corridors as part of their transition towards a more agroecologically based management system . Given our field days, workshops and other extension activities this work now has extended to many other farmers in northern California, we expect to have 25 growers trying various cover crop designs in the 2009 growing season. The work has also reached the Casablanca Valley of central Chile where blueberry, grape and apple farmers have adopted our agroecological designs. Similarly, partly based on our research results from Gill Tract plots, broccoli growers in Salinas and Watsonville use strips of alyssum, phacelia and other plants to provide habitat and alternative food to predators and parasitoids to control aphids in their commercial crops.

b) Is the ability of crop plants to resist or tolerate insect pests and diseases tied to optimal physical, chemical and mainly biological properties of soils? Much of what we know today about the relationship between crop nutrition and pest incidence comes from studies that we have conducted comparing the effects of organic agricultural practices and modern conventional methods on specific pest populations. We have found that soil fertility practices can impact the physiological susceptibility of crop plants to insect pests by either affecting the resistance of individual plants to attack or by altering plant acceptability to certain herbivores. In our studies, organically fertilized broccoli or cabbage plants suffer leas aphid and flea beetle infestation levels than chemically fertilized ones. The reduction in aphid and flea beetle infestations in organically fertilized plots was attributed to lower levels of free nitrogen in the foliage of plants. This further supports the view that insect pest preference can be moderated by alterations to the type and amount of fertilizer used. The data also suggests that this difference is evidence for a form of biological buffering characteristically found more commonly in organically managed soils and our work now centers on trying to understand the mechanisms at work.

c) Are there ecological processes that can be bolstered to provide biological forms of weed suppression in cropping systems managed under minimum or no-tillage management regimes? As part of our FIPSE funded US-Brazil Consortium on Agroecology and Sustainable Rural Development (CASRD) I have initiated research collaboration with a number of researchers and students at the Universidade Federal de Santa Catarina in southern Brazil. Our work attempts at elucidating the ecological mechanisms that underlie the performance of no- tillage systems developed by family farmers, that do not depend on herbicides for weed control but rely instead on the use of cover crop mixtures (including various combinations of oats, rye, pigeon pea, vetch, raphanus, etc) which leave a thick residue mulch layer on which traditional grain crops (corn, beans, wheat,etc) are directly planted. These crops display very little weed interference during the growing season and thus achieve agronomically acceptable yield levels. So far, very little research has been conducted to understand the ecological underpinnings of these systems, in particular ecological interactions (allelopathy, insect seed predation, etc) that may be involved in weed suppression and that also determine optimal soil fertility, pest regulation and crop productivity in such systems. This work entails participatory forms of research involving 20 farmers, whose fields are used as case studies where we monitor key processes underlying the performance of such cropping systems. Elucidating the mechanisms at play will provide principles and guidelines to hundreds of farmers who want to transition towards organic conservation systems. We are in the process of analyzing 4 years of data and expect to submit a major paper summarizing our findings to a high impact scientific journal by the end of this year.

The more socio-cultural aspects of my work emerge from the realization that traditional crop management practices used by small farmers in the Third World represent a rich resource for ecologists interested in understanding the mechanisms at work in complex agroecosystems, such as the interactions between biodiversity and ecosystem function or the use of natural succession as design templates to develop complex agroecosystems.

Perhaps the greatest challenge to understanding how peasants maintain, preserve and manage biodiversity is to recognize that the complexity of their production systems is closely linked to the sophistication of the traditional knowledge of the peasants who manage them. It is for this reason that my research does not separate the study of agricultural biodiversity from the study of the cultures that nurture them.

It is through my work and that of a few others that agronomists and ecologists are starting to recognize the virtues of traditional agroecosystems, where sustainability is based on the complex ecological models. An examination of the ways these farmers use biodiversity can speed the emergence of the principles needed to develop more sustainable systems both in industrial and developing countries.

My work has shown that the traditional crop management practices used by many resource-poor farmers are a rich resource for researchers seeking to create novel agroecosystems that are adapted to the local circumstances facing poor farmers in marginal environments. Through collaboration with many universities, NGOs and farmers organizations, my work aims at assisting Latin American resource-poor farmers translate these principles into practical strategies to enhance production and resilience. This has required redirecting my research to be more problem solving and participatory, so that it is relevant to rural people. My research categorically demonstrates that small farmers located in marginal environments in Latin America can produce much of their needed food using local resources and agroecological approaches. Data emerging from my research show very positive outcomes even under adverse conditions. Potentials include: raising cereal yields from 50 to 200 percent, increasing stability of production through diversification, improving diets and income, contributing to local food security and family nutrition and conservation of the natural resource base and agrobiodiversity.

One central question that now drives my research interests is to explore wether there are ecological characteristics intrinsic to traditional farming systems that enhance their resiliency to extreme climatic variations? Coping with chronically variable yields of food crops is critical for the survival of small farmers especially in marginal environments where agro-climatic conditions are challenging. My goal is to understand how small farmers manage risk exposure in harsh environments such as the Mixteca region of Mexico where the only insurance mechanism available to these farmers is derived from the use of inventive self-reliance, experiential knowledge, and locally available resources In this part of the world peasants developed farming systems adapted to the local conditions which eanabled them to generate sustained yields meeting their subsistence needs, despite marginal land endowments , climatic variability and low use of external inputs . Part of this performance is linked to the high levels of agrobiodiversity exhibited by traditional agroecosystems and therefore my focus is to understand to what extent diversification serves as an important farm strategy for managing production risk in the midst of drought.

As part of these efforts to preserve traditional agrioculture, I have been collaborated with UN-FAO in the project Globally Important Ingenious Agricultural Heritage Systems (GIAHS). My main function has been to aid in the identification of agricultural heritage sites in the developing world, as well to develop a methodology for the dynamic conservation of GIAHS to be used by teams in selected sites. This work will lead to the dynamic conservation of agricultural areas that exhibit unique cultural, genetic and cultural traits and that therefore offer key ecological services to humankind.

My work is also concerned with the fact that due in part to a lack of ecological guidance, agricultural modernization efforts in the Third World promotes monocultures, new varieties, and agrochemical packages, all of which are perceived by some scientists, as critical to increasing yields, labor efficiency, and farm incomes. With my work I have repeatedly questioned the assumption that progress and the development of traditional agriculture inevitably requires the replacement of local crop varieties with improved ones, and that the economic and technological integration of traditional farming systems into the global system is a positive step that enables increased production, income and community well being. For too long I have witnessed how *s*trong pressures promote the conversion of subsistence agriculture to a cash agricultural economy; as this happens, the loss of biodiversity in many rural societies progresses at an alarming rate, traditional patterns are often disrupted, and landraces along with indigenous technical knowledge are progressively abandoned. Part of my work centers around the preoccupation that the disruption of traditional agroecosystems may be aggravated by the promotion of emerging biotechnologies that emphasize transgenic crops and increased agricultural uniformity.

I am conducting preliminary research to test whether the introduction of transgenic crops may pose environmental risks and replicate or further aggravate the effects of modern varieties on the genetic diversity of landraces and wild relatives in areas of crop origin and diversification and therefore negatively affect native agrobiodiversity and the cultural thread of peasant communities.