NCERA-101 Station Report 2008

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1. **New Facilities and Equipment.**

The University of Maryland completed construction of their new Biosciences building (http://chemlife.umd.edu/biosciencebuilding/), which opened on September 18, 2007. A new controlled environment facility was incorporated as part of 68,000 square feet of flexible laboratory space. The 33 faculty-led research groups housed in the building are working on the forefront of research in three critical areas: neuroscience, genomics/proteomics and pathogenesis. The building is equipped with two Biosafety Level-3 labs, which enable researchers to safely work with pathogens, the microorganisms that cause disease. Other resources include a 475-seat lecture hall and eight conference rooms for teaching and professional meetings. Each of the four levels in the building is dedicated to a different area of research: plant molecular and cell biology on the ground floor; neuroscience on the first floor; genomics on the second floor; and host-pathogen interactions on the third floor. The controlled environment facility contains Eight Percival Model AR-100L and four Percival Model AR-36L chambers. Both of these types of Percival units have the latest "Advanced Intellus Touch-Screen" Controllers. In addition, two Percival Model AR-66L chambers were moved from the previous facility belonging to Cell Biology and Molecular Genetics. These two units were purchased in 2006 and have the more generic "Standard Intellus" Controller. Three of the AR 36 Conviron growth chambers will also be moved into this new facility.

In addition to the Biosciences building, the following facilities have been added or modified in the research greenhouse and growth chamber facilities. The water efficiency in outdoor beds has been added to the greenhouse in order to provide a sufficient water flow and pressure for outdoor nutrient analysis research. The current flow was severely restricted by the fact the water was supplied at the end of the loop that provided irrigation to all of the zones in each of the ranges. We installed an independent line that originated from the fertigation system to allow both a sufficient water supply as well as the potential to automate the fertilizer mix to the outdoor ground beds. We have also have finally increased the drip irrigation usage within the greenhouse by fixing all of the leaks in the fertigation system to all of the ranges and learning how to program the system to supply irrigation to each zone in all four ranges of the greenhouse. Finally, we ran tests on the power consumption in both the greenhouse and the growth chambers in the Plant Science building in order to establish the capacity of the emergency power generators to supply power during an outage. Many, but not all, of the greenhouse operations are currently connected to the emergency generator but despite the finding that there was sufficient power from the current generator to connect all of the systems, the cost do so was found to be prohibitive. However, during a scheduled power outage, it was found that all of the

critical systems functioned normally. When the growth chambers and controlled environment rooms were installed in the Plant Sciences building in 1996 they were not added to the emergency power generator. The cost to add all of these systems to the existing generator was found to be much less expensive and so they will all be added.

2. **Unique Plant Responses**

Collaboration with Top Orchids. Dr. Kai-Hsien Chen, CEO of Top Orchids, is a graduate of the Botany Department at the University of Maryland and a faculty member in the Department of Horticulture at the National Taiwan University. He has established a collaboration between Ox Orchids in Taiwan and Top Orchids in Maryland in collaboration with the College of Agriculture and Natural Resources. They are renting 4,500 sq. ft. of space in the research greenhouse in order to establish a greenhouse orchid industry in the State of Maryland.

3. **Accomplishment Summaries**

The following are research projects being carried out either in the greenhouse or in controlled environment chambers at the University of Maryland:

Research in Plant Sciences and Landscape Architecture (PSLA):

a. José Costa is a small grain breeder who has been using both the greenhouse and the EGC growth chambers for research and breeding projects focused on the main small grains of economic importance in Maryland, wheat and barley.

b. Gary Coleman is a woody plant molecular biologist. He has used the greenhouse and both the EGC Macrocosm rooms in the greenhouse and the Conviron growth chambers in the Plant Science building to identify genes that are either induced or repressed during short-day photoperiod induced terminal bud formation and dormancy in Populus (P. trichocarpa x P. deltoides). Genes differentially expressed during short-day induced terminal bud formation and dormancy will be identified by differential display analysis of bud mRNA. cDNAs corresponding to differentially expressed genes will be cloned and sequenced.

c. Pete Dernoeden is a turfgrass pathologist whose Applied research efforts have been directed towards weed and disease control, and the development of integrated pest management strategies in turf. Basic research efforts have concentrated on the etiology of turfgrass diseases; the influence of fertility and other cultural practices on disease severity and weed encroachment; the non-target effects of fungicides; fungicide effectiveness as influenced by application timing, spray volume and rainfall; and weed biology. Most of this research has been carried out in the research greenhouse.

d. Scott Glenn is a weed scientist working on the biology and control of perennial weeds that infest agronomic crops. He is working in the research greenhouse to

develop economically and environmentally sound programs to manage these weeds.

e. William Kenworthy is Chair of PSLA and is a soybean breeder whose research projects in the greenhouse aim to develop improved varieties and germplasm, to develop lines with resistance to cyst nematodes, as well as having enhanced nutritional value, and to conduct supportive research in soybean variety evaluation, soybean production systems, and physiological aspects of crop productivity.

f. John Lea-Cox is a nutrient management specialist who makes extensive use of the greenhouse facilities to integrate various components of the nutrient management puzzle. The N and P leaching experiments will provide two years of continuous data using two commonly produced species, Blue Holl 'China Girl' and Azalea cv. 'Karen' under both sprinkler and drip irrigation. The irrigation studies will focus on determining accurate water contents in soilless substrates using a new technology, time-domain reflectometry. This research will also examine how the physical and chemical properties of soilless substrates affect the water-holding and thus the nutrient retention capacity of each substrate.

g. Joe Sullivan is a physiological ecologist who is using the greenhouse to determine the role that UV-B radiation plays in the growth and development of plants. The research centers on eastern tree species but crops, such as soybean, that are used as model systems are also included in his studies.

h. Harry Swartz is a small fruit breeder who is the most extensive user of greenhouse space for his strawberry, raspberry and blackberry breeding program that emphasizes utilization of primitive germplasm, biotechnology and tissue culture techniques to create superior cultivars primarily for improved fruit quality and nutrient value.

Research in the Department of Entomology

a. Galen Dively uses both the research greenhouse and a number of growth chambers and controlled environment rooms in both the greenhouse Macrocosm rooms and in Plant Sciences. His long-term research goal is to develop alternative management strategies for reducing environmental and resistance risks of novel insecticides and transgenic insecticidal crop technologies. Currently, he has projects that focus on the comparative risk assessment of transgenic insecticidal crops and conventional insecticides on nontarget invertebrates, conservation biological control of riparian grass buffers and cover crops, and evaluation of organic controls. He also has several projects that address information gaps in the biology and management of new pest species. In addition, his laboratory provides insect rearing and bioassay facilities for the monitoring and detection of resistance development.

b. Bill Lamp also makes extensive use of the research greenhouse and controlled environment rooms in Plant Sciences to address a critical concern of farmers: the significant reduction in alfalfa stand life caused by pests. Although alfalfa can persist in stands for many years, ecological and physiological factors act in concert with the pest community (e.g., weeds, pathogens, arthropods, nematodes) to shorten the life of stands. The resulting lack of persistence significantly reduces profit and, in locations and periods of severe stress, effectively prevents profitable cultivation of alfalfa.
c. Robert Denno is an insect ecologist who utilizes the greenhouse to investigate areas of ecological endeavor that include: (1) population dynamics with a focus on top-down (natural enemies) versus bottom-up (host plant heterogeneity) control of herbivorous insect populations, (2) predator subsidies and the spatial dynamics of predator-prey interactions (NSF funded), (3) plant-mediated predator-prey interactions, (4) high-order interactions among predators (intraguild predation and interference) and their consequences for herbivore suppression, trophic cascades, and biological control, (5) the ecological stoichiometry of multi-trophic interactions (6) biodiversity at higher trophic levels and its relationship to ecosystem functioning, (7) plant stress (drought and salt) and its role in the outbreak dynamics of herbivorous insects, (8) plant-mediated interspecific competition (direct and delayed) and induced resistance as important organizing forces in phytophagous insect communities and their applied consequences for pest management (USDA funded), and (9) the ecological causes and population-genetic consequences of dispersal in the context of life history evolution.

Research in Cell Biology and Molecular Genetics

Research conducted in the Arabidopsis Chambers in the new Biosciences Building

a. **Caren Chang** The ability to respond to a vast array of external and internal cues such as light, gravity, and hormones is vital to the growth, development, and survival of plants. The mechanisms by which plants perceive these signals and convert the information into physiological changes are only beginning to be understood. We are focusing on signal transduction of the plant hormone ethylene (C2H4), a simple gas that has profound effects on plant growth and development. Our research utilizes a combination of molecular biology, genetics and cell biology in order to understand the molecular mechanisms of ethylene signaling. Our model system is the small flowering plant *Arabidopsis thaliana*, which is well-suited for molecular genetic approaches.
b. **June Kwak**'s research goal is to genetically dissect abscisic acid and calcium signal transduction mechanisms in *Arabidopsis*, using interdisciplinary techniques. We are investigating molecular components of guard cell signal transduction cascade and their regulation mechanisms to achieve a detailed understanding of the network of signal transduction events that regulate stomatal movements.
c. **Zhongchi Liu** is interested in understanding how transcriptional regulation plays a key role in determining growth and development of both animals and plants.

Precise spatial and temporal regulation of regulatory genes or effecter genes can determine if a cell will grow or die, or if a cell will develop into a stamen or a carpel, or if a disease resistance gene can be turned on or off. Therefore, understanding the molecular mechanisms underlying the spatial and temporal-specific transcription of target genes has the utmost importance and far-reaching implications.

d. **Steve Mount** Research in the Mount lab is devoted to understanding how multicellular organisms accomplish the correct processing of RNA from protein-coding genes. This involves identifying the elements of primary sequence information that determine where (and whether or not) splicing will occur, determining which components of the splicing machinery play especially salient roles in recognizing those signals, and determining how those factors act.

e. **Heven Sze** Membrane transport is essential for almost all cellular processes, and disruption often results in disease or death. New information, emerging from the study of completed genomes, has revealed a surprising degree of conservation of structure of many important membrane transporter families. Yet we do not know the substrates and mode of action of most membrane transporters, their regulation, and their impact on cellular and organ function. Model systems have several advantages. The genomes have been sequenced, and they can be genetically manipulated, thus simplifying the study of those transporters that are conserved among organisms. We are using plants and yeast to identify key transporters and to understand how organisms sense and respond to changes in nutrients and toxic compounds in the cell or in the environment.

4. **Impact Statements**

a. **José Costa** has developed molecular markers in wheat, conducted genome mapping in barley, characterized an early flowering mutant in barley, and studied the utilization by small grains of nitrogen and phosphorus in agricultural soils. These approaches have been used to: (1) develop soft red winter wheat cultivars adapted to the mid-Atlantic region with increased resistance to Fusarium scab as well as resistance to other major diseases using marker-assisted selection. (2) to investigate the genetics of natural antioxidants and other bioactive compounds in wheat. And (3) to screen and breed hulless barley for fuel ethanol production (http://www.psla.umd.edu/extension/crops/wheat/2005AgroEcoFinal.pdf).

b. **Gary Coleman** has examined the quality and properties of wood in Poplar that are influenced by the relative abundance of the different cells types that comprise wood. Factors such as the composition of the cell wall, the arrangement and orientation of the cell wall, water content and relative abundance of cell types are just a few of the inherent factors that contribute to the overall structure of wood. Recently he has identified and characterized a connection between the genes that regulate the transition to flowering and those that control the onset of dormancy.

c. **Pete Dernoeden** has discovered and helped describe a new pathogen and disease of creeping bentgrass. Through morphological and molecular methods the fungus was described as Ophiosphaerella agrostis and the disease was named bentgrass dead spot. Graduate research advisory efforts have involved disease forecast modeling; weed seed germination degree day modeling; exploring a molecular technique (RAPD-PCR) for identifying turfgrass root pathogens; epidemiology and biology of Rhizoctonia solani; taxonomy of Pythium spp. inciting root dysfunction; developing fermentation and delivery technologies for evaluating biological disease control agents; and the study of soil microbial interactions with disease and other properties of the turfgrass ecosystem.

d. **Scott Glenn**'s herbicide programs were found to be most effective in controlling perennial weeds that included tank mixtures of sulfonylurea herbicides with dicamba in corn and glyphosate applications in glyphosate-tolerant corn and soybeans. Research anticipating inevitable weed shifts to glyphosate-tolerant weeds following annual applications of glyphosate to genetically altered crops. This study compares long-term weed control in continuous glyphosate-tolerate crops to the rotation of herbicide programs. This research is designed to help predict unwanted weed shifts and to prevent these weed shifts from inflicting serious economic damage to farmers.

e. **William Kenworthy**. The Maryland Cooperative Extension (MCE) teamed with the Chesapeake Field Institute (CFI), a 501(c)(3) organization chartered in the year 2000 to address the loss of profitability in traditional agricultural markets throughout farms. By working with local agribusiness, government officials, and community leaders, MCE and CFI have developed a plan that will result in farmers gaining knowledge and skills that will move them toward greater sustainability. The long term objective of this project is to enable farmers to engage in the production of alternative crops through which value-added enhancements are to be achieved.

f. J**ohn Lea-Cox**. Nutrient management has become a high priority issue for Agriculture with the passing of the Water Quality Act of 1998 by the Maryland State Legislature. Since the EPA now intends to enforce provisions of the Clean Water Act, this issue will now become a National issue. The nursery and greenhouse industry is coming under scrutiny since they are usually highly intensive agricultural operations. Many controlled nutrient leaching studies have been published over the years using various ornamental species. However, most have been limited to greenhouse studies that are hard to extrapolate to different climatic areas, and if they have attempted to develop nutrient budgets, they have often focused only on Nitrogen leaching.

g. **Harry Swartz** has established a unique approach to his extension activities. In order to maximize the impact of his breeding program worldwide, he has formed a private company called Five Aces Breeding that produces patents and royalties to the University of Maryland at no cost to the Extension Service. It allows him

to establish joint agreements around the world for the distribution advanced cultivars that are in production in England, Spain, Chile, Mexico and California. His entire research is carried out at the University and paid for by the profits generated by his company.

h. **Bill Lamp** has studied stresses imposed by such factors as unfavorable growing conditions, interference by weeds, and injury by pathogens, nematodes, and arthropod pests significantly shorten stand life. At times single factors such as a key pest species may threaten productive stand life, but more typically loss of stands results from stresses imposed by several factors. Similarly, specific crop management practices affect not only the crop directly, but the interaction between pest populations and crop. Also, the nature of these effects must be studied from a regional, or even national, perspective for a clear understanding. Thus, the complex issue of alfalfa persistence requires the input of a multidisciplinary and multistate team. As a result, this project will focus on an integrated and interdisciplinary approach to crop and pest management for improving stand longevity.

i. **Robert Denno**'s most recent research emphasis concerns how the flow of resources (nutrients) and organisms (predators and other invaders) influence food-web structure and community dynamics. Collectively, these research initiatives have important implications for pest suppression in agricultural habitats via predator refuges, for biological control at large, for the preservation of stable food-web dynamics across natural landscapes, and for restoration ecology.

j. **Caren Chang** has identified five related ethylene receptor genes in two subfamilies: ETR1 and ERS1 (subfamily 1) and ETR2 , EIN4 and ERS2 (subfamily 2). All encode homologs of the two-component histidine protein kinase family widely known in prokaryotes. Two-component histidine kinases perceive environmental stimuli and regulate responses through specialized phosphotransfer reactions. ETR1 was the first example of a two-component homolog among higher eukaryotes. Acting downstream of the receptors is a Raf-like serine/threonine protein kinase, CTR1, thought to act in a mitogen-activated protein (MAP) kinase cascade as in animals. Interestingly, the known signaling pathways leading to the activation of Raf in animals start with transmembrane tyrosine kinase receptors, whereas the ethylene response pathway in plants seem to regulate a Raf protein kinase in a new way, namely by a two-component-like receptors, which are primarily found in prokaryotes.

k. **June Kwak** has found that Guard cells located in the leaf epidermis that form stomatal pores are responsible for optimization of plant growth by optimizing CO2 uptake while controlling water loss under many environmental conditions and by integrating environmental and endogenous signals including water status, hormonal stimuli, CO2 levels, light and temperature. Plants lose over 95% of their water via transpiration through stomatal pores. The plant hormone abscisic acid (ABA) transduces environmental signals to protect plants from desiccation during drought periods by closing stomatal pores.

l. **Zhongchi Liu's** lab has been focused on understanding how several transcriptional repressors, LEUNIG (LUG), SEUSS (SEU), and BELLRINGER

(BLR), act to regulate diverse biological processes using Arabidopsis thaliana as our model system. Most of our work has been centered on dissecting the transcriptional repression of AGAMOUS (AG), a key regulator of floral organ identity and floral meristem determinacy. We have now expanded our work to include the study of how these transcriptional repressors act in other developmental or physiological processes including plant's stress responses. Another area of our research centers on cell division regulation. We have identified and characterized a new class of mutants defined by the tso1 and tso2 mutants. These mutants develop abnormal floral organ and leaf morphology and exhibit meristem bifurcation and fasciation. For more specific information, please click on the Research page.

m. **Steve Mount** Our *Arabidopsis* research is focused on the identification of sequences within exons that may act to enhance splicing (such sequences are known as exonic splicing enhancers, or ESEs). ESEs are best characterized in animal systems, and research on plant pre-mRNA splicing has emphasized the role of AU-rich or U-rich sequences within introns, there are compelling reasons to believe that ESEs also play an important role in plant splicing. In particular, SR proteins, the mediators of ESE activity in animals, are highly conserved. This research is funded by a grant from the NSF under the 2010 program in collaboration with co-PIs Caren Chang at Maryland and Steven Salzberg at TIGR.

n. **Heven Sze** The essential functions of Ca2+ depend on the spatial and temporal distribution of this ion within each cell. The dynamic changes of this ion within the cytosol and internal stores suggest that Ca channels and pumps are diverse and tightly regulated. Of multiple Ca-ATPases in Arabidopsis, only a few have been characterized. Major goals are to (1) identify and characterize Ca pumps after functional expression of plant genes in yeast mutants; (2) understand how expression and activity of transporters are regulated, and (3) understand the in vivo functions in plants. T-DNA disrupted mutants of pumps are being identified, thus allowing us to test for the first time whether growth, signaling responses, and male fertility are impaired. Proton pumps occupy a prominent position among all transporters in plants and yeast. Without the primary motive force to energize coupled carriers or ion channels, all other transport, and thus life, would cease. In spite of this, it is not understood how proton pumps are integrated into the signal transduction networks that govern growth and adaptation. A major proton pump (vacuolar H+-ATPase) acidifies the vacuole and endomembrane compartments, and provides the driving force for transport of many ions and metabolites across the vacuolar membrane. Many novel H+-coupled cation transporters were uncovered in plant genomes, though their functions are largely unknown. A working model is that H+ pumps and cation/H exchangers affect development, reproduction and tolerance to stress through their effect on endomembrane trafficking. One goal is to understand these functions at the biochemical and cellular level using a combination of biochemical, cellular, molecular, genetic and genomic tools.

5. **Published Written Works**
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