Investigating the role and mechanism of the novel isoparaffin mixture Civitas™ on turfgrass growth, metabolism, and disease resistance.

Bill Kreuser

Advisor: Frank Rossi

During the past several decades there has been increased public and political pressure to reduce chemical pesticide applications to agronomic and horticultural crops. In New York for example, the Child Safe Playing Field Act prevents application of synthetic pesticides to school and day care grounds. Typically, legislation of this kind exempts OMRI certified organic products such as horticultural oils. The novel OMRI certified horticultural oil Civitas™ (Suncor Energy Inc., Calgary, AB) is a food-grade isoparaffin mixture which has been found to increase turfgrass disease resistance by priming genes in the jasmonic acid pathway. Laboratory and field studies found that Civitas slowed disease development and increased fungicide efficacy in turfgrass. As a result, fungicide applications could be reduced or eliminated without significant disease development and associated decline in turfgrass quality.

In addition to increased disease resistance, Civitas has been found to increase turfgrass clipping yield, fertilizer and pesticide uptake efficiency, and increase mowing quality. Brief discoloration occurs several hours after application which is masked with the addition of a ground green mineral pigment (Harmonizer™). Our goal is to understand the mechanism by which Civitas alters turfgrass disease resistance, growth rate, fertilizer use efficacy. Our current hypothesis is that Civitas disrupts the leaf cuticle which 1) increases cell elongation by increasing cell wall extensibility, 2) releases small cell wall fragments that membrane bound damaged receptors proteins can recognize and prime defense genes, and 3) aids in the absorption of foliar fertilizers and fungicides in a similar manner as a spray adjuvant.

To test this hypothesis several greenhouse and growth chamber experiments have been proposed and include:

- Use of RNA-sequencing to analyze the turfgrass leaf transcriptome over a time-course and determine which metabolic pathways affected by Civitas
- Measure leaf cell wall extensibility following Civitas application
- Examine treated leaf cells with scanning electron microscopy and assay net photosynthesis, electrolyte leakage, cuticle concentration, relative water content, root/shoot mass and length.
- Measure fertilizer and fungicide uptake with using radio-labeled materials following Civitas application
- Use model plant systems to discover the mechanism Civitas perception by plants through mutant screens

Changes in DNA methylation that occur in apple interspecific hybrids

Benjamin Orcheski
Chair: Susan Brown

The goal of my research is to better understand the process of interspecific hybridization in apple. Hybridization is essential for the movement of desirable traits from wild apple species into the domestic apple via traditional breeding. Unfortunately, generating useful hybrids is not as straight forward as simply making crosses. The melding of two very different genomes can cause massive changes in gene expression and genome organization. Currently, little is known about what changes will occur and how to predict them. Since these alterations in expression and organization can affect genes controlling desirable traits, it is of interest to study their underlying cause.

Much of what determines how a hybrid behaves can be explained by epigenetics. Epigenetic phenomena affect gene expression without affecting the underlying DNA sequence. They control gene expression by both the packaging of DNA and covalent by modifications to DNA known as methylation. Epigenetic phenomena are dynamic and change throughout the plant lifecycle and in response to many things like stress, environment, and hybridization.

For my research, I will characterize the changes in DNA methylation that occur in apple interspecific hybrids. This will be done by generating hybrids from several wild species with a single domestic apple parent. The pattern of DNA methylation will then be assessed in both the parents and the hybrids. I then hope to use this information to infer the relationship between the domestic apple and the wild species. Furthermore, I hope to correlate the pattern of DNA methylation changes with gene expression data between the parents and hybrids.

Phenology of plant invasions

Maria Smith
Chair: Taryn Bauerle

Phenology has long been recognized as an important component for determining the structure of plant communities. In recent decades, global climate change has been responsible for alterations in plant phenology, with particular influence on earlier timing of leaf-out and prolonged growing seasons. Phenological differences in native and invasive species may contribute towards invasive success by extending periods of resource acquisition, as a result, changing community compositions that lead to alterations in biogeochemical cycles and biotic interactions of impacted ecosystems. However, functional mechanisms for understanding the variation between and among species is still poorly understood. Currently, we are exploring trait-based differences related to timing of leaf emergence and duration in approximately 80 woody species, both native and invasive, to eastern North America. We are examining the relationship between stem vascular anatomy and patterns of leaf emergence in order to understand the proximate causes of leaf phenology.

Seed Encapsulation and effect on seed and seedling performance

Hiromi Tasaki
Chair: Alan Taylor

Seed encapsulation is a new technology developed by Alliance Seed Capsule (AST) in which raw or coated seed are encapsulated in hard gel-based capsule. Pronounced plant growth and root development was observed in plants grown from encapsulated seeds. However due to the early stages of this technology, little is known about the fundamental basis of this encapsulation technology. How the chemical constituents of the hard gel-based capsule affects seedling growth requires in-depth investigation. The objective of this project is to determine the factor(s) responsible for the increased plant growth.

Improving Early Tree growth and Yield of Tall Spindle Apple Plantings

Leo Dominguez
Chair: Terence Robinson

The tall spindle is a high-density apple planting system where highly branched (feathered) trees are planted at 0.9-1.2 m in row spacing and 3-3.6m between row spacing for densities ranging from 2,300-3,700 trees/ha. The economic success of the tall spindle depends on significant 2nd and 3rd year yield, due cost of the trees, land and other establishment costs that go along with it. In order to obtain significant early yields large caliper trees that are tall and have 10 to 15 well-positioned feathers along the axis are required. It also requires minimal pruning at planting and for the first 3 years after planting, also for some varieties the feathers need to be tied down below the horizontal at planting to reduce vigor and enhance early cropping. The tall spindle system is more profitable compared with the traditional systems if high early and sustained yields of excellent fruit quality are achieved.

The tall spindle system is proving to be one of the best and most popular options that growers have for replanting orchards. However some growers have the problems of poor tree growth the first season which limits second and third year yield. This is in part because feathered trees have a huge canopy with not enough roots to support it; since many roots are damage in the nursery and at planting. Additionally many new plantings are left without irrigation especially in northeastern climates and this can result in a pronounced stress in some years where rain is not consistent.

The objectives of this project are: (i) test different approaches and techniques that will result in a better understanding in the management of highly feathered trees in the Tall Spindle system; (ii) evaluate the use of different forms of Nitrogen and growth stimulating products to improve growth in the early life of the planting and clarify the relationship between growth and yield, and (iii) disseminate the results obtain from the studies to the whole apple industry.

Understanding the Role of Quorum Sensing in Plant Competition

Kevin Panke-Buisse
Chair: Jenny Kao-Kniffin

In recent years, root-associated (non-symbiotic) microorganisms have been shown to enhance a plant's competitive abilities. Some benefits of rhizobacteria and fungi include assisting a plant with nutrient acquisition, protection against pathogens, and secreting growth-enhancing compounds. It is important to understand how plants are able to cultivate a rhizosphere microbiome that enhances their collective fitness.

Quorum sensing is an important, not yet well understood property of bacteria that allows for communication between individual cells within and between species. At its simplest, quorum sensing is a signaling strategy that alerts bacteria to the population density in their immediate vicinity, however further study is revealing that bacterial signaling may be far more complex and broad than ever before thought. Complex signal communication has been hypothesized and supported by recent research including universal bacterial signaling and inter-kingdom, i.e. plant-bacterial, communication.

In many cases quorum sensing is an efficiency safeguard. Individuals produce a small, relatively biologically inexpensive molecule allowing it to diffuse freely from the cell. This molecule is generally an autoinducing molecule, which when present at high enough concentration can trigger the expression of a suite of genes. These genes are often environmentally relative compounds like exo-enzymes that can greatly increase an organism’s fitness in a high population density setting, but would act as a deleterious drain on resources at a lower population density. In essence, the density sensing function of the quorum sensing molecule is a low-cost fail-safe to ensure the efficacy of the high-cost compound production. A recently heavily studied quorum sensing system comes from a well known and studied rhizosphere genera, Rhizobia. Quorum sensing in the Rhizobia is multilevelled organizes the expression of genes involved in mating pore formation, nodulation initiation, and N fixation. These processes are only activated in the presence of significant population density that the signaling molecule reaches a high enough concentration to induce gene expression of the group behavior.

With the study and further discovery of plant growth promoting bacteria and pathogen biocontrol strains, the need for greater understanding of the underlying processes that produce these effects becomes more apparent.The rhizosphere is a perfect location for the study of these interactions, both between bacteria and between the plants that cultivate them. Plant roots and the soil surrounding them, known as the rhizosphere, is an ideal environment for microbial growth. The sugars, amino acids, and secondary metabolites released from the plant during growth and from sloughed-off dead cells provide a nutrient-rich oasis in the relatively nutrient poor bulk soil.

In my presentation, I describe a new screening method for rhizosphere soil quorum sensing molecules, specifically Acyl-Homoserine Lactones (AHLs), that I am presently developing. This is the first step in a research project to identify and characterize quorum sensing in the rhizosphere of various common weedy and invasive plants. I hypothesize that, in a nutrient-poor environment, highly successful weeds can cultivate a specific rhizosphere community that increases plant fitness in comparison to neighboring competitors.

Further steps in this project include testing of known AHL-active rhizospheres as well as screening many common weed species including ragweed, lamb's quarter, giant foxtail, and bull thistle rhizospheres for active AHL signaling on the part of the plant as well as the bacterial community.

Tissue Culture as a Method for Rapid, Clonal Propagation of White Oak Species.

Anne Johnson
Chair: Nina Bassuk

Summary: Oaks have an important role in landscape horticulture and urban forestry. There are numerous species native to a variety of habitats in North America and they have long been a tree familiar in American culture. They are long lived, have a robust growth habit and wide, spreading crowns. Oaks readily hybridize (within their respective groups) possessing a vast amount of genetic diversity and potential. Yet these valuable characteristics have been severely underutilized due to the difficulty of vegetative propagation. Grafting often results in delayed incompatibility and cuttings do not easily root. Hybrids and unique types of oaks are rarely introduced to growers.

There has been recent progress in vegetative propagation using container layering and cuttings, however multiplication is slow. Some research has also been done on micro-propagating oaks, but this option has not been fully explored. Therefore, the long-term objective of our research is to investigate the potential for developing a micropropagation method. Shorter term goals include overcoming some of the specific

issues related to the initial phases: such as determining the best explant source, explant orientation in the medium and inducing shoot elongation during the establishment phase.

Belowground Root Competition of Norway Spruce and European Beech under Drought

Alex Paya
Chair: Taryn Bauerle

The study of plant roots is inherently difficult due to the heretogeneous and opaque nature of soil matrices. To date, only a select number of studies have attempted to observe an undisturbed root system, which is crucial if we are to understand the selective placement and competitive strategies of plants. Our work focuses on imaging undisturbed root systems in three-dimensions. This novel imaging work will allow us quantify the selective placement and growth of belowground tissues without disturbance and without the confines of a two-dimensional viewing window. Previous research has yielded improvements in 3D image resolution as well as algorithms that help measure root volume, lateral root length, and number of lateral roots. However, past research has not attempted to image full root systems or even more than one individual plant. Using specialized growth medium coupled with X-ray computed tomography (CT scanning), we have begun imaging root morphology, as well as fine-scale spatial relationships between competing and non-competing root systems. The next step of our research is to simulate drought conditions and quantify changes in root growth, and thus competitive success. As this method continues to improve, so too will our understanding of the selective placement of roots in response to neighbor identity and changing resource conditions.