GRIP4PSI RFP

Appendix

Comprehensive Plant Sciences Initiative Research Platform Descriptions

Platforms provide technologies and research challenges upon which transdisciplinary projects will be built to foster overarching interactions and integrated approaches to addressing grand challenges in agriculture.

1. Plant Improvement Platform

- **Crop Protection from Biotic Stress**—In agriculture, biotic stress is stress to plants caused by pests (the collective term for microbes, weeds, insects, and other organisms that have a negative impact on plant health and yield). Big issues in this area include:
  - Expanding basic knowledge of the genomics of pathogenic organisms, the mechanisms by which they cause plant diseases, and their ongoing molecular evolution;
  - Identification of crop traits associated with pest resistance and traits for tolerance of pesticides, herbicides, and other crop protection chemicals;
  - Development of biological or chemical fungicides, herbicides, and other pesticides for crop protection; and
  - Improvement of integrated pest management strategies.

- **Plant Adaptation to Abiotic Stress and Marginal Conditions**—Both in North Carolina and around the globe, enhancing plant yield in marginal environments is likely to have benefits along three principal pathways:
  - Identification of crops, crop cultivars, and plant traits associated with enhanced performance in various conditions of abiotic stress (*e.g.*, water, climate, soil fertility, salinity, occasional freeze pressures) providing opportunities for increasing agronomic yield on marginal lands;
  - Identification of traits associated with performance under stress conditions that may be incorporated into crop cultivars grown in high-productivity environments that may enable them to weather occasional unforeseen stress events, or provide for the development of new/improved crop cultivars using traits discovered for performance of crops on marginal land but that are also generally associated with resource use efficiency (*e.g.*, requiring lower levels of water resource inputs, fertilizer applications, etc.) to perform at high-yield levels; and
  - Development of tools and technologies for measuring stress conditions and quantitative effects on plant phenotype and gene expression.

- **Agri-Symbiotics (plant symbiotic interactions with non-plant organisms)**—This area focuses on advancing scientific understanding of the beneficial biological interactions between plants and other organisms (especially microbes, but also including fungi and invertebrates), and application

of knowledge of such symbioses to technologies for advancing agricultural yield. Big issues in this area include:

- Expanding basic knowledge of plant-microbe interactions and the impact on plant growth, metabolism, nutrition uptake, disease and pest resistance, resistance to abiotic stress, etc.; and
- Developing biological inputs for agriculture for the control of pests and diseases (biological control agents), providing an alternative to agricultural chemicals. The development and application of inoculants, probiotics, and other technologies to enhance the yield potential of crops.

While each of these fields stands alone as a research area of critical importance, the strongest potential for impact in addressing the complex problems facing agriculture lies at the convergence of technologies that span the various research fields, ranging from conventional plant breeding to gene editing to informatics. Targeted areas of convergence that could be addressed include the following:

- **Multiple/Cross-crop improvements:** Plant physiological or developmental processes affect important traits in complex systems where findings could be translated to multiple crops.
- **Integrated improvements of stress tolerance:** Plants perceive and respond to stress through multiple pathways and experience stressors—biotic and abiotic—concurrently. Manipulating drivers of stress tolerance, identifying molecular signals of stress, and designing strategies for intervention before negative plant responses requires understanding the mechanisms by which plants integrate signals from multiple stresses.
- **Biochemistry:** Identifying protein function underlying important traits in plants and microbes in agricultural systems will lead to new targets for plant breeding or gene editing.
- **Plant-microbial interactions:** Tools can be used to intercept signals for pathogen stress before negative plant responses as well as agri-symbiotic interactions with microbes in soil.
- **Integrative Application:** Crop improvement can occur only if growers implement the technology, use the products, or change management practices. North Carolina Cooperative Extension will bring important partners to the table who cross crop and disciplinary boundaries, drive beyond current industry priorities, and are application guided.

2. Data-Driven Agricultural Bioscience Platform

The Plant Data Sciences Platform was defined as the acquisition, processing, movement, and interpretation of data pertinent to crop production, from upstream basic research to downstream utilization by growers and consumers. It covers a systemic scale to include environmental, economic, phenotypic, molecular, and genetic data, spatial analytics and algorithmic development, computation, mobile geographic information systems (GIS), spatial data mining, and remote sensing. Major opportunities are seen for integrating and synthesizing plant data, as well as machine learning in areas such as:

- **Sensor Data for Precision Agriculture**
- **Genotype Modifications and their Translation to Phenotype and Environmental Responses in Crop Plants**

  Targets likely to be addressed might include the following:

- Data mining and algorithm development for heterogeneous data
- Sensor technology for basic research and field applications
- Heterogeneous data integration for improved breeding/genomic strategies
- Prototyping systems and translating results to crop production and utilization.

The Plant Improvement and Data-Driven Agricultural Bioscience platforms converge in areas of technologies aimed at integrating and synthesizing plant data, as well as machine learning that can be applied to plant systems. Targets at the intersection of the two platforms might include:

- **Application of Big Data over Multiple Scales**: Integration of population-wide variation across multiple experiments; integration of data from many factors that affect plants and their responses; integration of data from plant to field and beyond; integration of biological and physical data; capture of currently available data or data from existing experiments that would not be collected through improved experimental design.
- **Predictive modeling**: Identification of the best targets from large datasets; understanding key nodes in complex networks.
- **Sensor technologies**: Tools that would be co-developed with data sciences experts in order to obtain pertinent data for Plant Improvement Platform projects.

3. Resilient Agricultural Systems Platform

- **Goal:** To create a **resilient** food system that reduces food insecurity, improves diet-related health outcomes, protects the environment for future generations, and is profitable for producers.
- **Environmental Sustainability**: Agriculture should be conducted in a way that does not limit future generations from producing the food they need by degrading soil, water, biodiversity, or the people who produce the food.
- **Food Systems:** Challenges, including climate change, will impact access to and affordability of food and the ability of farmers to produce reliably at a profitable level.
- **Reducing Food Insecurity:** Tied not only to improving crop yields through biological and technological innovation, but also to improving access (availability, affordability, convenience, education) to healthy foods.

Targets likely to be addressed might include what is depicted in the Figure R&T-1. It is envisioned that these targets would bring together researchers with expertise in very diverse areas to form transdisciplinary project teams. Further, the figure is meant to illustrate the complexity of the many areas of opportunity under this platform, as well as the possibility for numerous and diverse collaborations among the individual areas.

Figure R&T-1: Targets Likely to be Addressed in a Resilient Agricultural Systems Platform.