Crop Sciences at Purdue University

A Report to the CSREES Review Team

February 4, 2009

Program Vision, Mission, and Goal

- Our shared **vision** is to have a Crop Science program with the capacity to address local, national and global concerns of crop genetic improvement and management, natural resource conservation, as well as management and protection of the environment.
- The research **mission** of the Crop Science group is to conduct and disseminate results of innovative and relevant research that addresses important biological and environmental problems in crop sciences to serve the future needs of agriculture and society.
- Our **goal** is to become the premier research and academic program in crop sciences by distinguishing ourselves in the education of undergraduate and graduate students and in the pursuit of excellence in crop research and accomplishments.

Background & Overview

- Program
  - Disciplinary
  - Multidisciplinary
  - Collaborative
  - Multitude of Scales
    - Cell biology
    - Genetics, genomics, breeding
    - Physiology, cropping systems
    - Earth Surface and terrestrial
    - Commodity range: Turf, Forages, Crops
    - Geographic scale: State, Nation, International

Background & Overview, Cont.

- Widely recognized research programs
- Great history of interdisciplinary research
- Rooted in 1862 tradition, but evolving
- Successful grant generation record
- International connection & recognition
- Historically strong ties with private seed industry
- Among the nation's best graduate programs
- A comprehensive learning experience
- A collegial working environment

Background & Overview, Cont.

Crop Science Programs at Purdue:

- Plant Breeding & Genetics
- Crop Physiology & Cropping Systems
- Turf Physiology & Management
- Climate & Remote Sensing

Plant Breeding and Genetics

FACULTY	RESEARCH AREA
Anderson, J.	Plant Genetics & Genomics (disease res.)
Doerge, R.	Bioinformatics, Statistics
Ejeta, G.	Plant Breeding & Genetics (sorghum)
Hudson, K.	Plant Genetics (soybeans)
Jackson, S.	Plant Genetics & Genomics
Ma, J.	Plant Genetics & Genomics
Ohm, H.	Plant Breeding & Genetics (small grain)
Rocheford, T.	Plant Breeding & Genetics (maize)
Scofield, S.	Plant Genetics & Genomics (disease res.)
Szymanski, D.	Plant Cell Biology
Tuinstra, M.	Plant Breeding & Genetics (maize)
Vierling, R.	Plant Genetics (soybeans)
Weil, C.	Plant Genetics & Genomics (maize)

Crop/Turf Physiology & Management

FACULTY	RESEARCH AREA
Bigelow, C.	Turfgrass Nutrition & Management
Brouder, S.	Crop Nutrition & Management
Camberato, J.	Crop Nutrition & Management
Housley, T.	Carbohydrate Partitioning
Jiang, Y.	Environmental Stress Physiology
Joern, B.	Nutrient Management & Planning
Johnson, K.	Forage Management & Nutrition
Nielsen, B.	Crop Management Systems & Education
Reicher, Z.	Turfgrass Management & Education
Volenec, J.	Crop Physiology & Biochemistry
Vyn, T.	Crop Physiology & Cropping Systems

Climate & Remote Sensing

FACULTY	RESEARCH AREA
Crawford, M.	Applications of Remote Sensing
Grant, R.	Applied Meteorology
Gurney, K.	Atmospheric Science & Ecology
Niyogi, D.	Climate Modeling & Analysis
Zhuang, Q.	Gases in the Atmosphere

Comments from the Last Review

Plant Breeding and Genetics

- Determine the appropriate balance between molecular genetics and modern germplasm development
- Assume greater leadership in the interdisciplinary programs to entice other plant scientists to work on systems/commodities of interest to the Department.
- Aggressively pursue a strategy for being major participants in the Life Sciences Initiative.
- Form cluster group(s) with a broad but niche-product focus - corn and soybeans.
- Develop high-throughput genotyping to facilitate plant improvement.
- Endorse curriculum changes to include genomics, physiology and biochemistry, and bioinformatics.

Comments from the Last Review

Crop Physiology and Cropping Systems

- Engage more faculty in teaching and have new hires teach whole plant physiology.
- Bridge the traditional disciplines in crop management, crop improvement, and molecular genetics. Will likely require additional expertise in whole-plant and/or canopy physiology.
- Expand collaborative ties with key faculty outside the Department and at other institutions to fill gaps in expertise.
- Establish research goals to coalesce interdisciplinary research groups (i.e. added value, improved stress tolerance, yield increase, increase nutrient use efficiency, and land reclamation).

Comments from the Last Review

Turf Sciences

- Current faculty resources (associated AP staff) are woefully inadequate.
- The courses dedicated to turf science are under-represented in the curriculum.
- The Team recommends that the Department actively seek avenues to integrate turf students into other Departmental activities.
- Determine if graduates could benefit from additional emphasis on communications, business and management courses in the option.
- The Team suggests adding a curriculum mandated internship at a golf course/turf-related facility and perhaps a second internship.

New faculty positions since the 2002 review

Discipline Area	Individual	Appointment
Turf	Cale Bigelow	Agronomy 100%
Turf & Whole Plant Physiology	Yiwei Jiang	Agronomy 100%
Soybean extension*	Vice-Shawn Conley	Agronomy 100%
Soybean Genomics/Genetics	Jianxin Ma	Agronomy 100%
Maize Genetics	Torbert Rocheford	Agronomy 100%
Crop Science	Lori Snyder	Agronomy 100%
Maize Breeding	Mitch Tuinstra	Agronomy 100%
Soybean Genetics/Genomics	Karen Hudson	USDA-ARS 100%**
Small Grain Functional Genomics	Steve Scofield	USDA-ARS 100%**

*Position currently vacant. Active search occurring.
**Adjunct Faculty

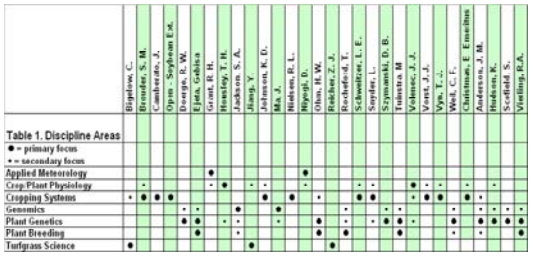
Major equipment and facilities obtained since the 2002 review

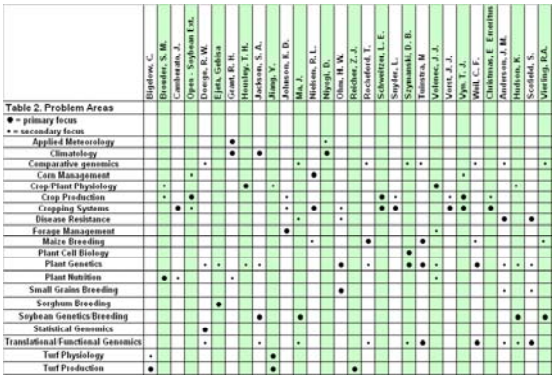
Equipment or facility	Year	Cost
454 Roche Sequencer*	2008	$500,000
ABI SOLID Sequencer*	2008	$500,000
Illumina Bead Station – Genotyping*	2008	$200,000
Seed and Tissue Handling Facility Renovation	2008/2009	$247,000
Irrigation at ACRE	2008	$215,000
Long term Cold Seed Storage	2009	$275,000
Precision maize planter with GPS		$180,000

*Equipment purchase by College of Agriculture and installed in Core Genomics Facility in Whistler Hall

Where Are We Now?

- A program with good breadth & depth
- A strong genetics and genomics cadre
- Plant breeding thrust recently rebuilt
- Crop physiology effort rebuilding
- Realignment via 'Grand Challenges' underway
- Commodity focus & balance reaching c' core
- Good publication and grant record
- Good national & international recognition





Program Outcomes & Impact Since 2002

- Plant Genetics, Genomics, and Breeding
  - Maize Breeding & Genetics strengthened
  - Resolve around Translational Genomics
  - Leadership in genome sequencing; TILLING
  - Functional Genomics, e.g VIGS
  - Better understanding of host-pathogen int.
  - Public release of wheat, oat, soybean, sorghum germplasm
  - Int Striga Mgmt (ISM) Technology validated in 3 African countries
  - Further strengthened ties with Seed Industry

Program Outcomes & Impact Since 2002

- Crop/Turf Physiology & Management
  - Turf program reinforced; 2 new hires
  - Sustain strong Industry support & service
  - Understanding of synthesis & degradation of protein and CHO reserves in roots
  - Efficiency of nutrient use and utilization
  - G x E effects in plant stress assoc. with crop management

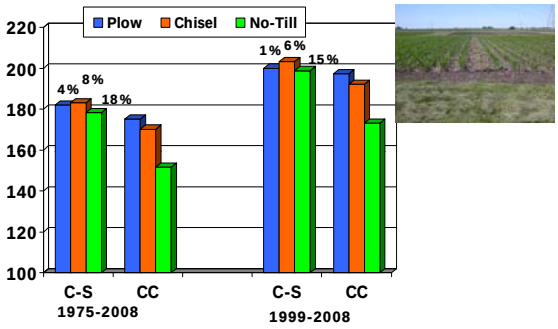
Program Outcomes & Impact Since 2002

- Climate & Remote Sensing
  - Greatly infused faculty strength
  - Better understanding of UV physiology
  - Better understanding of ET at Landscape
  - Models with Energy Budget, CO2, Gas
  - Advances in earth observation, airborne & space based sensors

Susceptible local landrace planted next to *Striga* resistant variety, P9401, at Fedis, Oct., 2006

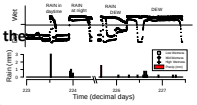
Susceptible variety — *Striga* resistant variety

Corn Yield Response to Tillage and Rotation, Silty Clay Loam, W. Lafayette, IN, 1975-2008.



Potential for Asian soybean rust infestation
RH Grant

- **Hypothesis: Given the frequency of dew during the summer, canopy wetness would not limit the spread of the SBR in Indiana.**
- **Two seasons of soybean canopy wetness measurements were made to evaluate wetness duration with depth.**
- **Results showed wetness at the bottom of the canopy where infection usually begins was most often due to rain events, not dew events. Thus occurrence of rain (with sufficient air temperature when the spores should be present is the best measure of spore infection. Dew events usually d not penetrate to the area of most likely infection.**
- **Impact: Prediction of infection likelihood is best done relative to rain event wetness and not dew event.**



Current Research in Plant Breeding & Genetics

- Mechanisms of cell growth and development
- Sequencing of genomes (soybeans)
- TILLING: maize, sorghum, switchgrass, and soybeans
- Biofortification: CHO, Protein, Vit, Minerals
- Signaling pathways, host-pathogen interactions
- Genomics: alternative approaches
- Translational Genomics: a new initiative
- Id./Valid./Util. of robust molecular markers
- Genetics of biotic/abiotic/nutr. traits in crops
- Breeding Methodologies; Germplasm development

Crop/Turf Physiology & Mgmt.

- Phys. mechanisms of stress tolerance
- Phys. mechanisms of plant growth & devpt.
- Partitioning of CHO, specific sugars
- Water, Nutrient Use Efficiency in plants
- Input Use Efficiency in crop management
- Crop mgmt systems: efficiency, site specific
- Integrated crop-livestock mgmt systems
- Sustainability of alt. crop mgmt systems

Climate and Remote Sensing

- Analysis of land surface processes; vegetation, and atmospheric interactions
- Analysis of biological effects b/t atmosphere and organisms
- Transport and deposition of gases in the biosphere
- Statistical pattern recognition of high dimensional data analysis
- GIS, Precision Farming
- Multi-resolution methods in image analysis
- Data diffusion techniques in image analysis

Where Do We Want to Be?

1. Advance Our Knowledge Base in the Crop Sciences
   - decipher genomes; gene functions; signal pathways; traction on translational genomics; molecular breeding; physiology of trait (biotic & abiotic) expression; GxE?
2. Develop Integrated Programs for Greater Impact
   - Gradual move from disciplinary to system approaches; form cluster groups; build public & private linkages; build experiences; pursue excellence; develop balance.

Where Do We Want to Be, cont.

3. Nimbleness to Address Emerging Societal Concerns
   - Current grand challenges; Will new ones emerge? How will we react?
4. Further Strengthen Educational Efforts
   - Education & research: mutual reliance in rationale and experience.
5. Strengthen International Foci Collectively
   - Ind. vs group; broaden linkages; broaden funding opportunities.

Disciplinary Studies

Research Thrusts: Next 5 years

Genetics, Genomics, & Breeding

- Leveraging genetic diversity in plants (**Jackson**)
  - Focused on crop plants, water use in legumes; in partnership with International Centers: CIAT, ICRISAT, GCP
- Functional Genomics of Wheat (**Scofield**)
  - Identify efficient tools for identification of gene function; Application of VIGS to different wheat diseases
- Mechanisms of Disease Resist. in Wheat (**Anderson**)
  - Identify plant & virus determinants in resistance; cereal virus epidemiology; robust marker systems for MAS

Research Thrusts: Next 5 years
Genetics, Genomics, & Breeding

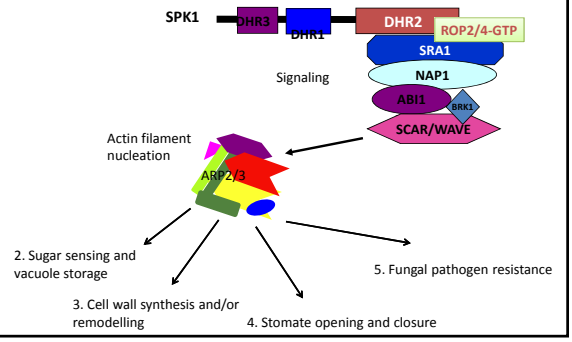
- Drought tolerance & root volume in wheat (**Ohm**)
  - QTL mapping, Doubled Haploids, Gene Introgression
- Drought tolerant trait develpt. in maize (**Tuinstra**)
  - Gene and allele mining in temp. & trop germplasm; In collaboration with industry; focus on stay green; also herbicide coating technology for Striga control
- Drought & Striga resistance in sorghum (**Ejeta**)
  - Validation of QTL generated to mainstream mol brdg.

Current Research Thrusts
Crop & Turf Physiology

- Impact of taproot VSP Levels on Alfalfa (**Volenec**)
  - Study effect on re-growth and winter survival
- Drought and flooding tolerance in turf (**Yiwei Jiang**)
  - Exploit natural variation; identify genes underlying traits
- Natural variation in warm season grasses (**Bigelow**)
  - Suitability to Indiana (Northern transition zone); Evaluate cultural practices on species persistence; input reduction

Integration of WAVE-ARP2/3 pathway with metabolic inputs and cellular outputs in model and crop species

1. Metabolic regulation of pathway activity and Its Cellular Function

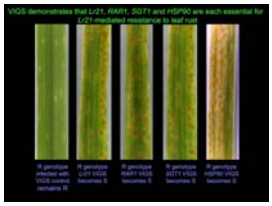


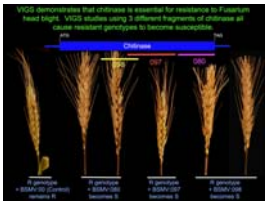
We are employing virus-induced gene silencing (VIGS) to identify the functions of genes in hexaploid wheat

VIGS utilizes an engineered viral constructs to transiently activate RNA-mediated gene silencing of chosen genes.

Silencing in VIGS is sequence-specific, therefore all copies of the chosen gene are simultaneously silenced. This is a critical advantage in hexaploid wheat where most genes are present in at least 6 copies.

Two examples of using VIGS to confirm the function of genes with essential roles in leaf rust and Fusarium head blight resistance





Impact of Transgenic Alteration of Taproot VSP Levels on Alfalfa Performance (Volenec et al.)

Hypothesis: Reducing/eliminating taproot VSP concentrations will slow regrowth after harvest and reduce winter survival.

- Levels of all 4 VSPs were significantly reduced in transgenic plants (T1-x) when compared to control plants (red boxes).
- Plants will be transplanted into the field and evaluated for growth and persistence.
- Impact on fungal resistance and starch hydrolysis will also be evaluated because these VSPs possess sequence homology with chitinase and β-amylase

Integrative Approaches

Grand Challenges & Integrative Science

1. Climate Change
2. Bio-energy
3. International Agriculture
4. Harnessing Plant Genetics
5. Chemicals in the Environment
6. Landscape Management

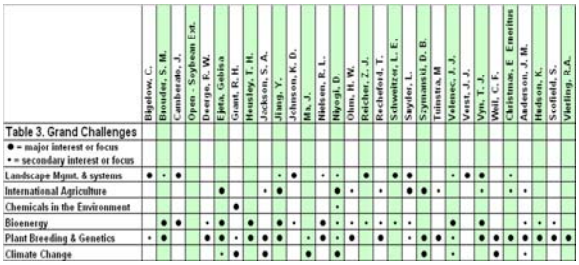


Table 3. Grand Challenges	Bigelow, C.	Brouder, S. M.	Cambardella, C.	Dyer, Soybean Est.	Doerge, T. W.	Ejeta, Gebisa	Grant, R. H.	Heuberger, T. H.	Jackson, S. A.	Jiang, Y.	Johnson, K. D.	Ma, J.	Nielsen, R. L.	Niyogi, D.	Ohm, H. W.	Reicher, Z. J.	Rechenthin, T.	Schwartzer, L. E.	Sayler, L.	Szymanski, D. B.	Tuinstra, M	Valenzuela, J. J.	Vorst, J. J.	Yin, T. J.	Wall, C. F.	Christou, E. Emeritus	Anderson, J. M.	Hudson, K.	Scofield, S.	Yierling, R.A.
● = major interest or focus																														
• = secondary interest or focus																														
Landscape Mgmt. & systems	●	•	●							•	●		•		•		●		●			•		●	●		•			
International Agriculture						●			•	●				●	•			•		●	●	•			•		•	•			
Chemicals in the Environment							●								•															
Bioenergy		●	●		•	●		●		●	•		●	•	•	•	•	•	•				●		●			•	•	•
Plant Breeding & Genetics	•	●			●	●	•	●	●	●		•	●	•	●		●		•	●	●	•			●	●	●	●	●	●
Climate Change						•	●		●			●		●						●			•		●		•				

How Will We Get There?

How Will We Get There?

1. Sustain a Productive Work Environment
   - Science, Mission, Service with resolve & commitment
   - Reasonable degree of latitude
   - Support and encouragement when needed
   - Improved facilities
2. Pursue Opportunities for Creative New Initiatives
   - Grand challenges identified
   - Champion integrative sciences
   - Form internal partnerships; assess strength, identify gaps
   - Other new initiatives

How Will We Get There, Cont.

3. Enhance Competitive Ability for Extramural Funding
   - Support for internal cluster groups to earn experience & recognition
   - Proactive decisions by Dept., College, and University leaders
4. Build and Strengthen National and International Linkages
   - Balance linkages with the Developed & Developing World
   - National and international research centers
   - Catalyze funding authorizations with our actions
   - Niche & competitive advantage
5. Strengthen Staff and Recruitment and Retention
   - Attract and keep the best

Challenges to Program Aspiration

- Competitive Funding Tightening
  - The Economy; Endowments; Private Sector; Foundations
- Finding ways to distinguish ourselves
- Establish niches & competitive advantage
- Agility & nimbleness of program; may need new investments
- New Initiatives with local seed grants: value & leverage
- New positions for c' core: 2 phys/ecology; 1 brdg positions
- Define & sustain a balanced program: can't do everything
- Balance: Disciplinary & Systems; Science & Service
- Sustain the resolve, generate pilots, produce results, & LEAD!