TEXAS A&M AGRILIFE RESEARCH | EXTENSION

TEXAS A&M UNIVERSITY

TEXAS A&M PLANT BREEDING BULLETIN

June 2014

Our Mission: **Educate and develop Plant Breeders worldwide**
Our Vision: **Alleviate hunger and poverty through genetic improvement of plants**

Four outstanding plant breeding students received Ph.D. degrees from Texas A&M University in May. Julie Rothe, Suheb Mohammed, Trevis Huggins, and Kolbyn Joy completed all requirements for their Ph.D. in Plant Breeding in Soil and Crop Sciences at Texas A&M University and graduated last month. Julie and Trevis will remain with us for a few months as a Post Docs in Dirk Hays' wheat stress physiology program; Suheb has taken a Post Doc position in cowpea genetics at the University of Virginia with Michael Timko; and Kolbyn joined Monsanto's research team in St. Louis. All four made meaningful contributions to our plant breeding research in the Department and all contributed to our teaching program by assisting in one or more undergraduate laboratories. Below are the abstracts from their dissertations. We hope the very best for these recent graduate students and expect to hear of great accomplishments during their careers.

Trevis Huggins

Dissertation Title: Understanding the Genetic Interactions that Regulate Heat and Drought Tolerance in Relation to Wax Deposition and Yield Stability in Wheat

Abstract

Wheat (*Triticum aestivum* L.) has been a major food crop for nearly 8000 years. Breeders continue to face an ongoing battle to produce stress tolerant cultivars to feed a rapidly increasing global population. The ability of cultivars to perform similarly in grain yield across diverse environments is an important trait that is critical to successfully matching food

supply food demands with decreasingly available arable lands. The work described in this dissertation focused on defining and understanding the genetic interactions of leaf epicuticular wax (EWL) and high temperature (HT) and drought tolerance (DT) and its association with yield stability, to aid breeders in stress tolerance selection. The effect of high temperature on epicuticular wax, yield attributes and yield stability were investigated in a recombinant inbred line population of 180 individuals from a Halberd x Len cross by physiological and molecular techniques.

Epicuticular wax offers advantages in protecting the plant from both biotic and abiotic stresses. Under HT conditions, EWL can reduce chlorophyll fluorescence by reflecting excess irradiation and also reduce stomatal conductance, helping to regulate the rate of transpiration. QTL for EWL with large effects were detected on five chromosomes (A & B genomes). QTL for yield stability and yield components stability indices with large effects were detected on seven different chromosomes (A & B genomes). High EWL may promote stable yields but its sensitivity to environmental conditions makes it challenging to definitively point to it as a source of improved stability. Although there were mixed relationships with yield performance and environments, the stability statistics for QTL provide strong evidence that genetic variation may be heritable and could have implications for breeding programs targeting a set of environments rather than a single environment.

Kolbyn Joy

Dissertation Title: Inheritance of cotton fiber length and strength

Abstract

The U.S. cotton industry has become predominantly an export market which requires a higher standard of fiber quality than does the domestic market. To remain competitive, U.S. cotton must meet the quality standards demanded by the consumers of raw cotton whether they are domestic or abroad. Diallel and generation means analyses (GMA) were conducted on fiber quality data of nine and five, respectively, parental genotypes to gain a better understanding of the genetic control of cotton fiber length and strength and to ascertain the value of the reported genotypes toward the improvement of fiber quality.

Parental genotypes included extra-long staple uplands (*Gossypium hirsutum,* L.), mutated uplands, high strength uplands, and interspecific hybrids.

General combining ability (GCA) and specific combining ability (SCA) were estimated according to Griffing's diallel Model I, Method 4 for lint percent, high volume instrumentation (HVI) upper half mean length (UHML), fiber bundle strength (Str), uniformity index, elongation, micronaire, advanced fiber information system (AFIS) upper quartile length on a weight basis, mean length on a number basis, short fiber content on a number basis, immature fiber content, maturity ratio, and standard fineness. Estimates of GCA were significant across environments for all traits. SCA effects were significant for most traits but accounted for a smaller proportion of the variability in comparison to GCA effects. TAM B182-33 ELS would be the parent of choice to simultaneously improve fiber length and Str,.

The GMA was conducted on the parental, F_1, F_2, and backcross generations. Low levels of transgressive segregation for both UHML and Str were observed for some populations. Broad sense heritability ranged from 0.00 to 0.67 for UHML and from 0.22 to 0.82 for Str. Additive gene action was significant for all but three parental combinations for UHML and for all parental combinations for Str. Generally, the significance and magnitude of additive genetic effects were more consistent among parental combinations and years than were non-additive genetic effects for both UHML and Str. Dominance and epistatic genetic effects often were of a greater magnitude than additive genetic effects but in an inconsistent manner, and in both positive and negative directions.

Suheb Mohammed

Dissertation Title: The Role of Leaf Epicuticular Wax in Improved Adaptation to Moisture Deficit Environments in Wheat

Abstract

Water deficiency is the primary reason for decreasing wheat (*Triticum aestivum*) yields globally, causing a nearly 50-90% yield reduction on at least 60 Mha of land in developing countries Previous studies have identified associations in genomic regions for

cooler canopies, heat susceptible index, and grain yield components in winter wheat. This project aims to define the role that leaf epicuticular wax (EW) plays as a drought adaptive trait in terms of yield stability. A spring wheat Len/Halberd recombinant inbred line population was used to test this question. The RIL population exhibits significant segregation for leaf EW, canopy temperature (CT), awns, and drought susceptible index (DSI) yet has been selected. An alpha lattice design with 180 recombinants and 2 replications was used with two distinct treatments (water deficit and control conditions) at each of 5 environments. The inheritance of leaf EW was low (15%) due to a high environmental influence. The RILs grown under water deficit produced significantly higher EW content (19 to 30%) when compared to control. The leaf EW load significantly correlated with plot yield (r=32%), DSI (r=-40%), and leaf CT (r=-32%) under water deficit conditions. In addition, EW and CT correlated with higher yield stability using DSI and across environments using Eberhart stability under water deficit. Novel and robust co-localized QTLs for the leaf EW, cooler canopies, DSI, and grain attributes were detected on 2B, 3B, 5A, 5B, 6B, 7A, and 7B. High LOD scores and co-localization of CT and DSI along with independent EW loci explaining 35%, 41%, and 31% phenotypic variation respectively were detected on chromosome 4A. Chromosome 3B was investigated with closed association of leaf EW and canopy temperature all across the chromosomal length. Chromosome 6B had significant SNPs associated with cooler canopies in Halberd (2.4ºC) compared to Len. The Halberd parent played a role in donating major alleles for moisture stress tolerance whereas, Len donates major yield allelic variants. Many novel and robust QTLs were identified to dissect the crop performance under moisture stress conditions. These identified genetic loci conducive potential tools in strategic breeding approaches.

Julie Rothe

Dissertation Title: Breeding for Tolerance of Cowpea to Low Phosphorus Soil Conditions through Physiological and Genetic Studies

Abstract

Cowpea (*Vigna unguiculata* (L.) Walp.) is a major food legume across Sub-Saharan West Africa where its leaves, pods and seeds are consumed as food and its residues are fed to livestock as protein rich fodder. However, soils of West Africa are poor in phosphorus (P), a soil macronutrient all crops need for growth. Fertilizer with P is not readily available and is too expensive for West African farmers. This research was therefore undertaken to identify cowpea lines that inherently grow well in P-deficient soils and use them to breed improved cowpea varieties that require less phosphorus fertilization. A hydroponic phenotypic screening method with silica sand was used to identify cowpea varieties that have tolerance to low soil P as measured by shoot dry biomass production. Both tolerant and susceptible varieties from the screen were further analyzed for root biomass, internal shoot P content, and internal root P content. Seed P, particularly the effect of cotyledon P, and total root production were investigated as physiological sources of tolerance. Tolerant cowpea varieties were crossed with susceptible varieties, and the resulting F_1, F_2 and BC_1 seeds were screened to determine the inheritance and genetic control of tolerance. A Recombinant Inbred Line (RIL) population of a tolerant by susceptible cross was mapped using SSR markers to identify linkage groups or QTL for tolerance to low soil P.

Phenotypic screening results identified four cowpea varieties to have P-deficiency tolerance (CB-46, IT97K-1069-6, IT98K-476-8, and TX2028-1-3-1) and two cowpea varieties (Big John and Golden Eye Cream) to have partial P-deficiency tolerance via high seed P content. All varieties experienced increases in root production under low P treatments relative to normal P treatments. Phenotyping of F_1, F_2, and BC_1 populations showed that low P tolerance is a heritable trait in cowpea with significant additive effects

and narrow-sense heritability. Estimates of gene number suggested the tolerance to be a single-gene trait. Mapping linkage groups or QTL for low P tolerance identified QTL in which three SSR markers – CLM0269, 221/222, and CLM0298 – were significantly associated with tolerance and are potential candidates for marker-assisted selection (MAS).

Continuing and Distance Education in Plant Breeding at Texas A&M

Continuing education course modules in plant breeding and genetics, and related disciplines are available from Texas A&M University to clientele interested in gaining new information in plant breeding or simply seeking refresher courses. This program is designed for individuals employed in private industry, CGIAR centers, government agencies, non-government organizations, and other agriculture professionals who need and desire additional knowledge and training in plant breeding but who are not interested in an additional academic degree. A professional certificate can be a part of this program. No campus visit is required. Course modules currently available are (https://scsdistance.tamu.edu/continuing-education-courses/):

Course Name	Number of Credits	Required for Certificate	Next Date Available (Dates Subject to change)
Basic Plant Breeding	3 Total Units Credits	Yes	June 2, 2014 – August 14, 2014
Introduction to Plant Breeding	1 Credit	Yes	June 2, 2014-August 14, 2014
Breeding Self Pollinated Crops	1 Credit	Yes	June 2 – August 14, 2014

Breeding Cross Pollinated Crops	1 Credit	Yes	June 2 – August 14, 2014
Advanced Plant Breeding	3 Total Credits	Yes	September 1- December 17, 2014
Advanced Genetic Principles of Plant Breeding	1 Credit	Yes	September 1- October 3, 2014
Selection: Theory and Practice	1 Credit	Yes	October 6 – November 7, 2014
Statistical Tools in Plant Breeding	1 Credit	Yes	November 10 – December 17, 2014
Experimental Designs in Agronomic Research	3 Credits	Yes	September 1 – December 17, 2014
Factorial Experimental Designs in Agronomic Research	1 Credit	Yes	September 1- October 3, 2014
Factorial and Unbalanced Designs in Agronomic Research	1 Credit	Yes	October 6 – November 7, 2014
Correlation, Regression, Covariance, and Biplot Analysis in Agronomic Research	1 Credit	Yes	November 10 – December 17, 2014

Quantitative Genetics and Plant Breeding	3 Credits	Elective	January 20-May 13, 2015
Module 1	1 Credit	Elective	January 20-February 20, 2015
Module 2	1 Credit	Elective	February 23-April 3, 2015
Module 3	1 Credit	Elective	April 6-May 13, 2015
Analysis of Complex Genomes	3 Credits	Elective	January 20-May 13, 2015
DNA Marker Technology and Genetic Mapping	1 Credit	Elective	January 20-February 20, 2015
Recombinant DNA and Cloning	1 Credit	Elective	February 23-April 3, 2015
Sequencing Genomes and Other Genomic Tools	1 Credit	Elective	April 6-May 13, 2015
Soil Fertility	3 Credits	Elective	September 1- December 17, 2014 *Purchase*
Genetics	3 Credits	Elective	September 1- December 17, 2014 (Please contact

			leann.hague@tamu.edu for purchase information)
Plant Disease Management	1 Credit	Elective	June 2 – August 12, 2015 (Please contact leann.hague@tamu.edu for purchase information)
Physiology of Plants	3 Credits	Elective	September 1- December 17, 2014
Introduction to Host Plant Resistance	1 Credit	Elective	January 20-February 20, 2015
Host Plant Resistance to Disease	1 Credit	Elective	February 23-April 3, 2015
Intellectual Property in the Plant Sciences	3 credits	Elective	January 20-May 13, 2015
Introduction to IP, International Treaties and Patents	1 credit	Elective	January 20-February 20, 2015
IP Documentation	1 credit	Elective	February 23-April 3, 2015
IP Transfer and Enforcement	1 credit	Elective	April 6-May 13, 2015

These and other Continuing Education courses in plant breeding and related disciplines will be available in the Fall 2015. For more information visit https://scsdistance.tamu.edu/

or contact LeAnn Hague, Distance Education Coordinator in Soil and Crop Sciences at leann.hague@tamu.edu or (979)845-6148.

Distance Plant Breeding M.S. and Ph.D. degree programs at Texas A&M.

Texas A&M University offers MS Thesis Option, MS non-thesis option, and PhD Plant Breeding degrees at distance. For details, visit https://scsdistance.tamu.edu/plant-breeding-distance-education/.

Meetings

National Association of Plant Breeders 2014 Annual Meeting in Minneapolis MN on August 5 – 8. Visit www.plantbreeding.org for details.

ASA/CSSA/SSSA International Annual Meeting in Long Beach, CA, November 2-5. Visit https://www.acsmeetings.org/ for details.

ASHS Annual Meeting in Orlando, FL, July 28-31. Visit http://www.ashs.org/?page=GeneralConference for details.

Please direct comments concerning this bulletin to Wayne Smith, cwsmith@tamu.edu or 979.845.3450.