TEXAS A&M PLANT BREEDING BULLETIN

April 2018

TEXAS A&M UNIVERSITY--EDUCATING AND DEVELOPING PLANT BREEDERS WORLDWIDE TO ALLEVIATE HUNGER AND POVERTY THROUGH GENETIC IMPROVEMENT OF PLANTS

Robert (Rob) Arnold is one of our distance plant breeding students working on his Ph.D. under the direction of Dr. Seth Murray, corn breeder. Rob is unique among our students in that his primary focus is not genetic gain for agronomic yield, but on identifying and improving a unique set of quality traits from a breeding program. Rob wants to make better tasting whiskey without sacrificing alcohol yield, and he believes that developing/selecting unique corn hybrids specifically for flavor components is a path towards that goal. I recently read a draft of his research proposal and thought that you would find it as interesting as I did. Rob and Seth approved and the following was extracted from his complete research proposal. I hope that you enjoy learning about a bit about breeding corn for whiskey production.

Research Title: Genetic and Environmental Influences on Alcohol Yield and Flavor in Maize-Based Whiskey—Tools for Selection of Novel Maize Hybrids

The United States (U.S.) whiskey industry is dominated by whiskey styles that by law must contain maize (*Zea mays*) as the main fermentable substrate, or that by choice use maize as a substantial secondary ingredient. *Bourbon whiskey*, per the U.S. Code of Federal Regulations, must contain at least 51% maize in the grain bill (i.e., the recipe). However, most *bourbon whiskey* brands utilize 70-80% maize in their recipe. *Corn whiskey*, a much less popular yet still important style, must contain at least 80% maize in the grain bill. Even most *rye*

whiskeys will contain a high percentage of corn to complement the rye. Maize is clearly a vital ingredient in many of the U.S.'s most popular whiskies, and the Canadian whisky industry is quite similar in this aspect. In Scotland and Ireland, two of the largest regional producers in the whiskey industry, barley is favored. Consequently, raw barley is the dominant grain in the Irish style known as *single pot still whiskey*; and barley's downstream derivative barley malt is the dominant grain for Scotch and Irish *malt whiskeys*. However, maize still has a place in these industries, as it is used by some distillers for the creation of *Scotch grain whisky*, which on a volume basis is the biggest contributor in *Scotch blended whiskies.*

With maize being such an important ingredient in whiskey production, it is surprising that little has been done to investigate maize genotypes and their associated growing environments that are most suitable (i.e., high agronomic yield, high-quality flavor and high ethanol yield) for whiskey production (an extensive literature search revealed only five scientific journal articles and all were post since 2005). And further, to our knowledge, there are no studies that investigate suitableness in the context of flavor. Barley and wheat, on the other hand, mainly driven by research backed by the Scotch whisky industry, have both received much investigation into the suitability of different varieties and environments. Many of the barley and wheat studies focused on agronomic performance or potential ethanol production, but a few focused on flavor consequences.

Current protocol among nearly all major maize-associated distilleries is to utilize yellow dent maize. While they will specify a certain grade (at least #2 in the U.S.), and potentially even require the maize to come from a certain geographical area, they will not request a certain hybrid/cultivar. This is largely due to the fact that the logistics of the maize industry does not readily allow one hybrid to be separated and stored until requested. If one were to compare this disregard for cultivar consideration to the wine industry, it would be analogous to winemakers deciding to make a red wine, and instead of requesting or growing a certain red grape cultivar (e.g., merlot, syrah, pinot noir, etc.), they would only concern themselves with the color of the grape—red. Winemakers, of course, do concern themselves with the cultivar of grape, as the diversity of flavors within the red grape (and white grape) category is extensive, which is supported by the fact that many wines are categorized and labeled as cultivar-based. Those that are not are usually labeled by the region (e.g., Bordeaux), with an industry understanding that regulations usually require only certain cultivars to be grown in those regions (e.g., merlot, cabernet sauvignon, and cabernet franc for red grapes in Bordeaux).

Even if distilleries did wish to utilize specific commercial yellow dent maize hybrids, they would still have a relatively conserved level of diversity to choose from since all breeding efforts have been directed towards agronomic performance. One main hypothesis of this research proposal is that concurrent with this decline in agronomic diversity was a decrease in flavor diversity. Therefore, the hypothesis also suggests that the commercially available yellow dent cultivars contain reduced and homogenous flavors compared to the species as a whole. That said, heirloom corn recently has seen a resurgence in the whiskey industry, mainly by those craft distillers seeking new and interesting flavors. While the flavor potential in heirlooms is diverse and unique, these open pollenated varieties are characterized by inconsistent agronomic yields. Further, heirlooms usually exhibit higher levels of protein and oil and lower levels of starch as compared with modern hybrids. Consequently, the alcohol yields for heirlooms are lower than what is possible with modern hybrids. Ultimately, while flavor is an important trait for distillers to consider, alcohol yield—especially to the larger distilleries—is equally vital. While heirlooms may find a niche in the distilling industry, hybrids will maintain their dominant role.

Flavor is a complex trait, and a challenging phenotype to measure. Chemically speaking, it is the combination of primary and secondary metabolites that activate the taste and olfactory systems. While the environment plays a large role in regulating the production of these metabolites, such metabolic by-products can only be produced if either the genome codes for the needed genetic machinery or possibly lacks the genetic machinery to degrade it. If the genetic diversity of maize hybrids has narrowed due to breeding, then it's possible that the suite of metabolites responsible for flavor has also contracted. It generally is accepted that the majority of recently developed maize inbred lines utilized in American breeding programs are products of a small, stratified, and closed germplasm base. Using the wine industry once again as an example, it would be as if red grapes were over time all bred and selected solely for yield, eventually removing genetic diversity and flavors from the germplasm, resulting in a universally utilized red grape for wine production. There would be no merlot, syrah, or pinot noir varietal wines. Instead, we would just have a general category of red wine; with the only differentiating factor being the geographical location in which that red grape was grown.

It is the *basic science* goal of this research to identify how the genetics and the environment influence alcohol yield and flavor in maize-based whiskey. With this knowledge, the *applied science* goal would be to select for a genetically unique hybrid that is well adapted to the environment of Texas (such as those TAMU hybrids derived from tropical germplasm that originated in Mexico and Central America), that brings unique flavors (without sacrificing alcohol yield), and that will be used to replace the use of commercial hybrid maize at the Firestone & Robertson Distilling Co. (Ft. Worth, Texas). Further, the results may have implications beyond whiskey. While improved whiskey flavor is a definite goal, and we expect superior flavor in maize to translate to the whiskey, the identification of heighted flavor

hybrids may also by default mean the identification of heightened nutrient hybrids, as reports show that flavor often translates to nutrients. Given that the breeding industry is beginning to focus not just yield but also nutrient quality of crops, our research may reveal data that helps facilitate this movement.

Rob was born in Louisville, KY and attended the University of Tennessee where he received a BS in microbiology. Rob then moved to Dallas and enrolled in a Ph.D. program in Biochemistry at UT Southwestern Medical Center. However, he decided to leave early with an M.S. degree to help start the Firestone & Robertson Distilling Co. Rob noted that “Texas A&M's distance plant breeding PhD program not only provided me an avenue to complete a PhD, but it has trained me to think about and pursue grain growing and selection in a completely new and methodical way.”

Rob noted: “My hobbies are traveling with my wife, endurance racing, and craft beer. I also enjoy documentaries about the food industry, especially those that focus on pioneering chefs, as I believe many of their innovations can translate to the whiskey industry.”

We look forward to the completion of Rob’s Ph.D. dissertation research and his findings.

Meetings of Interest

National Association of Plant Breeders, NAPB will hold their annual meeting at the University of Guelph, Ontario, Canada August 7 – 10, 2018. More information will be available soon at https://www.plantbreeding.org.

American Society of Agronomy and the Crop Science Society of America's annual meeting will be in Baltimore, MD, November 4 – 7. More information at https://www.acsmeetings.org/.

Distance Plant Breeding at Texas A&M

Distance Plant Breeding at Texas A&M

Distance Plant Breeding Program and Continuing Education courses available for Summer & Fall 2018 (https://scsdistance.tamu.edu/available-courses)

Continuing Education

Available Courses

Summer Courses: May 21 – August 31, 2018

To fully participate in our continuing education courses, students should have:

- **High speed internet connection and updated browsers, including Internet Explorer and either Chrome of Firefox**
- **Common plug-ins (e.g. Adobe Reader, Flash Player, Virus Protection, Java, etc.)**
- **Speakers and Webcam with microphone**
- **Skype**
- **Ability to either scan or fax course documents to the instructor**

Summer 2018

Plant Breeding Fundamentals – Full Course (3 Units) – Cost $679.65
May 21 – August 31, 2018

Introduction to the field of plant breeding for students without a plant breeding background. Includes common plant breeding terminology and introduction of concepts. Genetic improvement of crops by hybridization and selection; special

breeding methods and techniques applicable to naturally self-pollinated, cross-pollinated and asexually reproduced plants.

Basic Plant Breeding - Full Course (3 Units) - Cost - $679.65
May 21 – August 31, 2018

Basic Plant Breeding can be taken as an entire course (all three units) or each unit can be taken individually. For participants in our Professional Certificate in Plant Breeding and Genetics, completion of all three units is required.

> ***Unit 1 - Introduction to Basic Plant Breeding   Cost - $226.55***
> ***May 21 – June 22, 2018***
> **Introduction to Basic Plant Breeding provides a review of plant reproduction, genetic variation, gene banks, germplasm preservation, gene segregation, the power of selection and its role in plant breeding, and an introduction to intellectual property and its role in the life of a plant breeder. This unit is designed to prepare the participant to explore the genetics and methodologies employed by plant breeders of self and cross pollinated crop species in units two and three of Basic Plant Breeding.**
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> ***Unit 2 - Breeding Self Pollinated Crops Cost - $226.55***
> ***June 25 – July 27, 2018***
> **The frequency of any specific heterozygous locus will be reduced by 50% for every generation of selfing, resulting in a mixture of homozygous lines within any natural population. Phenotypic selection within heterozygous generations will lead to homozygous or near homozygous germplasm lines or cultivars under self-pollination. This unit is designed to communicate plant breeding methodologies that take advantage of the genetic consequences of natural or forced self-pollination in agronomic crops. Topics will include: [1] the basics of segregation, [2] breeding methodologies, [3] the grain sorghum conversion program-an example of backcrossing in a different direction, [4] review of a commercial soybean cultivar development program, and [5] a review of the types of genetic releases from Texas A&M AgriLife Research.**
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> ***Unit 3 - Breeding Cross Pollinated Crops   Cost - $226.55***
> ***July 30 – August 31, 2018***
> **Topics covered include: quantitative genetics and plant breeding, effects of selection on Hardy Weinberg Equilibrium, mating designs with cross pollinated crops, breeding methods for cross pollinated crops, deviations from Mendelian ratios, genetic male sterility and hybrid seed production, seed certification and types of release.**

Recommended textbooks are “Breeding Field Crops” by J.M. Poehlman and D.A. Sleper, and “Principles of Cultivar Development” by W.F. Fehr. A final exam will allow the participant to assess their grasp of topics covered. Participants in the Plant

Breeding and Genetic Certificate Program must score 70% on the final exam for each unit.

This is a "self-paced" course and is available for viewing for a limited time. Time commitment is individual student driven. Few outside assignments are made. Students should view each lecture, review all previous lectures and be prepared to discuss any issues that are unclear. Each unit has a printable note set and most units have a set of review questions that can be used as a tool to check your comprehension and grasp of unit concepts. Feel free to contact the instructor, Dr. Wayne Smith, by e-mail (cwsmith@tamu.edu) or phone (979-845-3450) with any questions you have or if you need additional information.

Fall Courses: August 27 – December 14, 2018

Fall 2018

Plant Breeding Fundamentals – Full Course (3 Units) – Cost $679.65

August 27 - December 14, 2018

Introduction to the field of plant breeding for students without a plant breeding background. Includes common plant breeding terminology and introduction of concepts. Genetic improvement of crops by hybridization and selection; special breeding methods and techniques applicable to naturally self-pollinated, cross-pollinated and asexually reproduced plants.

Basic Plant Breeding - Full Course (3 Units) - Cost - $679.65

August 27 - December 14, 2018

Basic Plant Breeding can be taken as an entire course (all three units) or each unit can be taken individually. For participants in our Professional Certificate in Plant Breeding and Genetics, completion of all three units is required.

> ***Unit 1 - Introduction to Basic Plant Breeding Cost - $226.55***
> ***August 27 – September 28, 2018***
> **Introduction to Basic Plant Breeding provides a review of plant reproduction, genetic variation, gene banks, germplasm preservation, gene segregation, the power of selection and its role in plant breeding, and an introduction to intellectual property and its role in the life of a plant breeder. This unit is designed to prepare the participant to explore the genetics and methodologies employed by plant breeders of self and cross pollinated crop species in units two and three of Basic Plant Breeding.**
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> ***Unit 2 - Breeding Self Pollinated Crops Cost - $226.55***
> ***October 1 – November 2, 2018***

The frequency of any specific heterozygous locus will be reduced by 50% for every generation of selfing, resulting in a mixture of homozygous lines within any natural population. Phenotypic selection within heterozygous generations will lead to homozygous or near homozygous germplasm lines or cultivars under self-pollination. This unit is designed to communicate plant breeding methodologies that take advantage of the genetic consequences of natural or forced self-pollination in agronomic crops. Topics will include: [1] the basics of segregation, [2] breeding methodologies, [3] the grain sorghum conversion program-an example of backcrossing in a different direction, [4] review of a commercial soybean cultivar development program, and [5] a review of the types of genetic releases from Texas A&M AgriLife Research.

Unit 3 - Breeding Cross Pollinated Crops Cost - $226.55
November 5 – December 14, 2018
Topics covered include: quantitative genetics and plant breeding, effects of selection on Hardy Weinberg Equilibrium, mating designs with cross pollinated crops, breeding methods for cross pollinated crops, deviations from Mendelian ratios, genetic male sterility and hybrid seed production, seed certification and types of release.

Recommended textbooks are “Breeding Field Crops” by J.M. Poehlman and D.A. Sleper, and “Principles of Cultivar Development” by W.F. Fehr. A final exam will allow the participant to assess their grasp of topics covered. Participants in the Plant Breeding and Genetic Certificate Program must score 70% on the final exam for each unit.

This is a "self-paced" course and is available for viewing for a limited time. Time commitment is individual student driven. Few outside assignments are made. Students should view each lecture, review all previous lectures and be prepared to discuss any issues that are unclear. Each unit has a printable note set and most units have a set of review questions that can be used as a tool to check your comprehension and grasp of unit concepts. Feel free to contact the instructor, Dr. Wayne Smith, by e-mail (cwsmith@tamu.edu) or phone (979-845-3450) with any questions you have or if you need additional information.

Advanced Plant Breeding - Full Course (3 Units) - Cost - $679.65
August 27 - December 14, 2018

Expectations of genetic improvement for different plant breeding methods; relative efficiency for crops of different reproductive mechanisms; genetic variances, covariances and genotype-environment interaction components of variance used in planning selection procedures. Advanced Plant Breeding can be taken as an entire course (all three units) or each unit can be taken individually. For participants in our Professional Certificate in Plant Breeding and Genetics, completion of all three units is required.

Unit 1 - Advanced Genetic Principles in Plant Breeding
August 27 – September 28, 2018
Topics covered include: Hardy Weinberg, means and variances, covariances and heritability, mating designs, genetic diversity.
Cost - $226.55

Unit 2 - Selection: Theory and Practice in Advanced Plant Breeding
October 1 – November 2, 2018
Topics covered include: recurrent selection, inbred line selection and testcrossing, selection environments, indirect selection, multiple trait selection, QTL MAS, heterosis and hybrid prediction.
Cost - $226.55

Unit 3 - Statistical Tools in Advanced Plant Breeding
November 5 – December 14, 2018
Topics covered include: statistical concepts review, expected mean squares and combined analysis, GxE interactions and stability analysis, polyploidy.
Cost - $226.55

Experimental Designs in Agronomic Research - Full Course (3 Units) - Cost - $679.65

August 27 - December 14, 2018

Teaches fundamental principles and procedures of experimental designs in agricultural sciences. Emphasis includes factorial designs, predicting outputs, use of covariance, and balanced and unbalanced experimental designs as related to common agricultural research projects under field, greenhouse or growth chamber culture. Students will become familiarized with computer programming of common statistical software. Experimental Designs in Agronomic Research can be taken as an entire course (all three units) or each unit can be taken individually. For participants in our Professional Certificate in Plant Breeding and Genetics, completion of all three units is required.

Unit 1 - Factorial Experimental Designs in Agronomic Research
August 27 – September 28, 2018
Topics covered include: Fundamentals of agricultural research methodology and methodology, basic statistical concepts for testing of hypothesis, introduction to simple computer statistical software programs and applications, complete randomized design, randomized complete block design, and Latin square design.
Cost - $226.55

Unit 2 - Factorial and Unbalanced Designs in Agronomic Research
October 1 – November 2, 2018
Topics covered include: Split-plot and split-split plot designs, nested designs, variance analyses, interactions with years and locations, comparisons of

paired and grouped mean, estimation of missing values, the general linear model, and planned incomplete block design.
Cost - $226.55

Unit 3 - Correlation, Regression, Covariance, and Biplot Analysis in Agronomic Research
November 5 – December 14, 2018
Topics covered include: Correlation, regression, path coefficient analysis, covariance analysis, nearest neighbor analysis, augmented designs and moving means and analysis, database management, biplot analyses.
Cost - $226.55

This is a "self-paced" course and is available for viewing for a limited time. Time commitment is individual student driven. Students should view each lecture, review all previous lectures and be prepared to discuss any issues that are unclear. Each unit has a printable note set and voiced over PowerPoint video lectures.

Intellectual Properties in the Plant Sciences - Full Course (3 Units) - Cost - $679.65
August 27 - December 14, 2018
This course introduces the major foci of intellectual property (IP) impacting plant sciences, including: 1) traditional vs. emerging knowledge economies, 2) governing U.S. statutes and international treaties, 3) forms of IP protection, and 4) IP asset identification, valuation, capture, and deployment towards an understanding of best practices for the development of effective IP strategies and management of IP portfolios.

Unit I - Introduction to Intellectual Property, International Treaties and Patents Cost - $226.55
August 27 – September 28, 2018
Unit I of the Intellectual Properties in the Plant Sciences Course. Topics covered include: IP Culture and the Knowledge Economy, Traditional Knowledge vs. Biopiracy, Sui generis Systems, International Treaties, Overview of Patentability, Utility Patents, and Plant Variety Patents.

Unit II - Intellectual Property Documentation Cost - $226.55
October 1 – November 2, 2018
Unit II of the Intellectual Properties in the Plant Sciences Course. Topics covered include: Trademarks, Copyrights, & Trade Secrets; USPTO; Inventorship, Ownership, Compensation, IP Training; Confidential Information; IP Audit; IP Value; Competitive Intelligence; Cyberspace – IP and IT Cooperation.

Unit III - Intellectual Property Transfer and Enforcement Cost - $226.55
November 5 – December 14, 2018

Unit III of the Intellectual Properties in the Plant Sciences Course. Topics covered include: Intellectual Property Transfer and Enforcement, IP Case Studies, IP Portfolio, IP Strategy and Leveraging IP Value.

Other Academic and Continuing Education courses in plant breeding and related disciplines that will be available during other semesters include Host Plant Resistance; Crop Production; Selection Theory; Marker Assisted Selection; Genomic Analysis; Field Crop Diseases; Field Insects; Essential Nutrients in Crop Growth; and others. 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 Degrees in Plant Breeding

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

Visit https://scsdistance.tamu.edu/plant-breeding-distance-education/ for details.

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