
SBAR
SUSTAINABLE BIOECONOMY
FOR ARID REGIONS

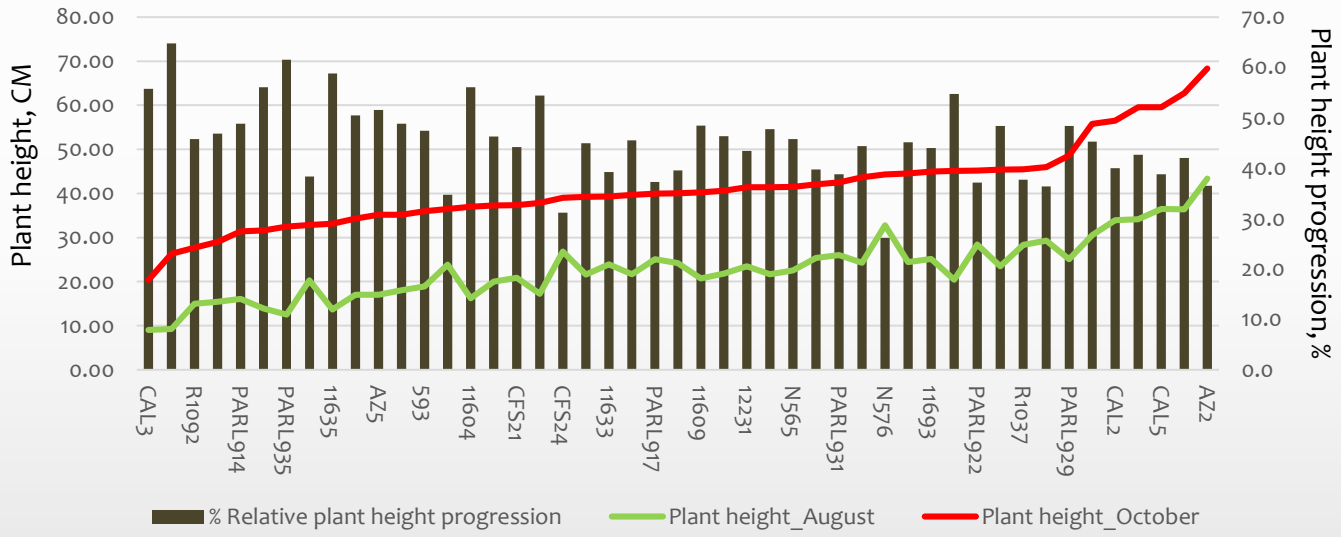
FEEDSTOCK DEVELOPMENT & PRODUCTION

Accomplishments:

July – December 2018

SBAR Q4 major accomplishments (Maricopa)

Hussein Abdel-Haleem, Greg Leake, Aaron Szczepanek, Adrianna Chambers, Amber Dearstyne



- There are significant phenotypic variations, e.g. plant height, within the USDA-guayule accessions, thus predictably more variations in other traits
- - The rate of growth is different among accessions, and independent from plant height, indicating different mechanisms could controlling plant height and growth rate

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Co-PI: Sangu Angadi

United States Department of Agriculture | National Institute of Food and Agriculture

Title: Pre-irrigation and critical growth stage based irrigation to improve water efficiency of guar

Accomplishments: First year field trial was harvested and samples are being processed.

- Pre-irrigation of guar significantly increased seed yield. This gives an opportunity to irrigate during cooler, off season, without competition from traditional cash crops.
- Skipping irrigation after flowering was better for guar seed yield than skipping irrigation vegetative stage.
- Among seed components, pods per plant was more sensitive to water stress.




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Feedstock Development at Bridgestone

Dierig, Cruz, Wang, Dittmar, Sullivan, Lynch, Prock

Key accomplishment: July to December 2018

- Identified USDA lines and individual plants with potential for biomass improvement using remote sensing and other phenotypic measurements.
- Determined the optimum planting temperature for 50 USDA lines using a thermogradient table.
- Completed the first of 2 years data to determined the best planting densities of the USDA line currently used by industry and another line bred for higher rubber content.
- Examined seasonal growth differences between 2 locations, irrigation types (drip and flood) and irrigation amounts at the ages of 4, 6, and 8 months so far.

USDA variety trial at Eloy with high throughput remote sensing tractor measuring plots

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Guar research accomplishments

Kulbhushan Grover, NMSU Las Cruces, NMJ

- Feedstock development
  - *Multiplication of guar germplasm*
    - Trial harvested and seed samples collected.
- Production technology
  - *Response of guar to moisture stress*
    - Trial harvested, field data collected, plant and seed samples collected.
- Scientific interactions
  - *Delivered presentations at national and regional scientific meetings and conferences.*
  - *Interacted with researchers for potential collaborations.*

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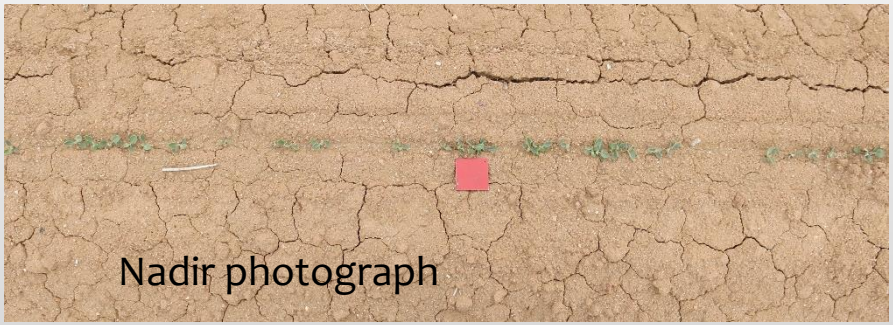
Guayule Herbicide Tolerance

Bill McCloskey

- Preemergence and pre-plant incorporated herbicide tolerance studies were conducted in Marana and Maricopa.
  - *Course-textured soils high in silt and/or sand*
  - *Included acetochlor, bensulide, ethalfluralin, metolachlor, pendimethalin & sulfentrazone*
  - *Stand Counts to measure seedling survival*
  - *Nadir photographs and leaf counts/plant at Maricopa to measure early seedling growth*



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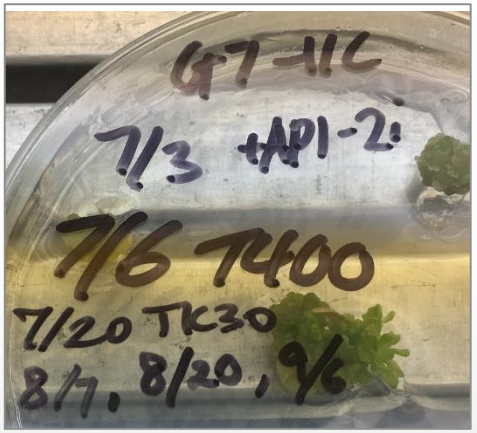
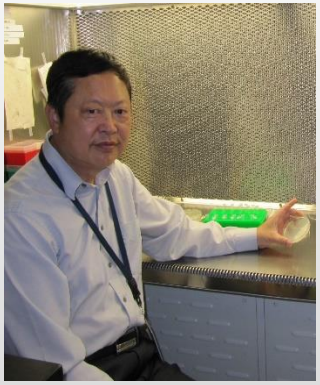
FEEDSTOCK DEVELOPMENT & PRODUCTION
USDA-ARS Rubber Lab– Colleen McMahan

OBJECTIVE 1: Improve biomass quantity and quality through genetics and traditional breeding

SUB Obj: 2) Downregulate flowering to improve yield - guayule

- Key Accomplishments July-December 2018
  - Transformation of guayule AZ-2 to downregulate *APETALA1* gene: 1020 calli growing in culture.
  - Transformation of guayule AZ-2 to downregulate *SEPATTALA3* gene: 1003 calli growing in culture.
  - Downregulation of *FLOWERING LOCUS T*, construct preparation in final stages, ECD Feb 2019.
  - New field study on rubber biosynthesis, soil microbes, and plant dormancy initiated (w/J. Neilson).








Team: Niu Dong, Sheyla Aucar, Trinh Huynh, Dante Placido, Chen Dong, Grisel Ponciano

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Soil Health Impacts on Sustainable Feedstock Production

Julie Neilson, Kyle Brown, Raina Maier

Baseline soil health analysis of MAC and Eloy fields: guayule irrigation trial

- 3 replicate samples analyzed from each field plot (54 samples/site)
- Soil chemistry (pH, EC,SAR, OrgMatter, K, P, Mn, Fe, Cu
  Spatial variability: lowest for pH (2%; MAC, 8.0; Eloy, 8.2)
  highest for P (38%, MAC, 7.58±2.87 mg/kg; 47% Eloy, 8.54±4.0 mg/kg)
- Soil Texture (*Eloy not complete*)
  MAC: Sandy Loam; Average clay, 15.9%±1.5% (9 % spatial variability)
- Soil biomass (Eloy 70% complete; MAC not done)
  Eloy: 42.5±13.4 ng DNA/g soil; 31% spatial variability

Winter Dormancy Experiment

- Objective: evaluate associations between rhizosphere microbiome and guayule rubber dynamics during winter dormancy (3 sample times)
- First sampling: Nov 13, 2018; time of projected increase in rubber transferase activity

Guayule rhizosphere soil

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Development of Guayule Growth models (Ogden, Pradyawong)

- **AquaCrop Model:** focuses on the effects of water irrigation on plant growth and products
  - *Input parameters: weather, management, soil profile and plant information*
  - *Reference: Horemans, J. et al. (2017). Can the agricultural AquaCrop model simulate water use and yield of a poplar short-rotation coppice?* GCB Bioenergy, (2017) 9, 1151–1164.
- **BioCro Model:** focuses on the effects of carbon dioxide level and temperature on plant growth and products
  - *Input parameters: Species-specific plant physiological traits, Soil physical properties, and Meteorological data*
  - *Reference: Wang D. et al. (2015). A physiological and biophysical model of coppice willow (Salix spp.) production yields for the contiguous USA in current and future climate scenarios. Plant, Cell and Environment (2015) 38, 1850–1865*

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Feedstock Development

Dennis T. Ray Lab (Ray, Teetor, Bennett, Coronado, Evancho, Ferini, Godfrey, Moreno, Morris, Schmalzel, Waltz, Willmon)

- Guayule:
  - *replanted density experiment*
  - *root rot screening ongoing*
  - *root growth: direct-seeded versus transplant*

Fig. 1: Guayule: root-rot scoring

Fig. 2: Guayule: direct-seeded roots at four months

- Guar:
  - *all accessions characterized and harvested*
  - *seed pods being threshed*

Fig. 3: Guar: non-branched, upright, good pod to biomass ratio

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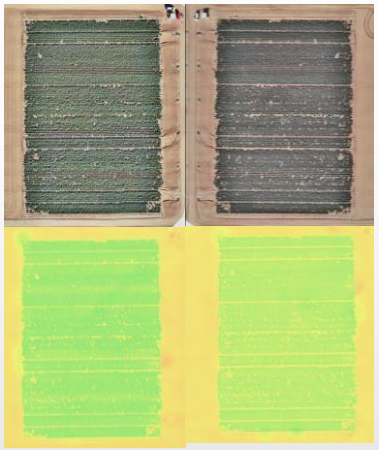
Irrigation experiments and models

Peter Waller and Diaa El-Shikha

- Eloi and Maricopa drip and flood experiments
  - *Collection of plant growth data once a month. Plant samples were collected every other month (Bridgestone crew)*
  - *Collection of soil moisture data (neutron probe). Irrigation model and moisture data were used for irrigation scheduling*
  - *Remote sensing data acquisition (Drone/Tractor-MAC only) Images were processed (stitched)*
  - *Crop coefficient curve was developed for the first year*
- WINDS model (Water, Irrigation, Nitrogen, Drainage, Salinity)
  - *Developing communications protocols with infield sensors*
  - *Processing drone data*
  - *Developing protocols to run model and database on server*

Dec 2018 Jan 2019



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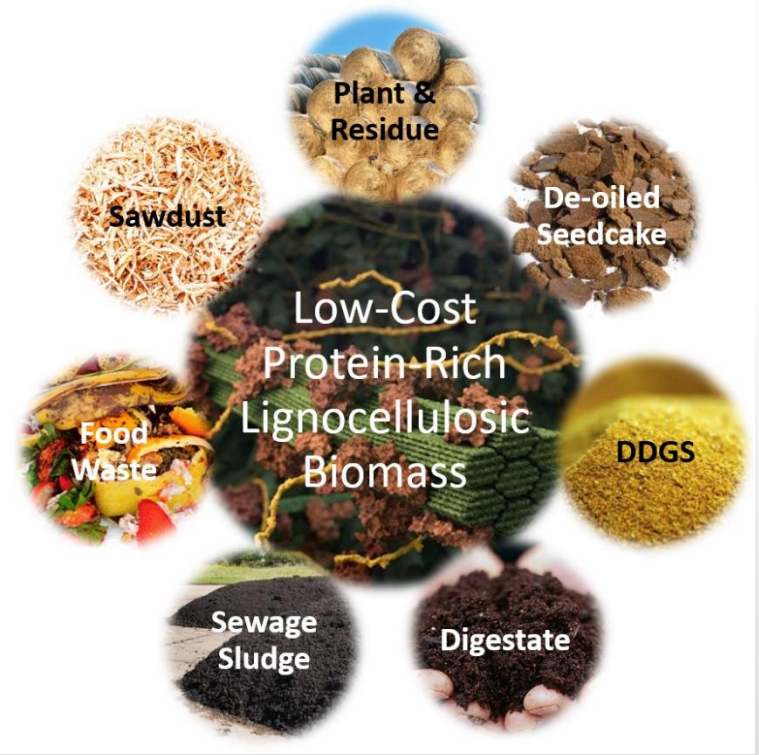
POST-HARVEST LOGISTICS & CO-PRODUCTS

Accomplishments:

July – December 2018

Co-Products from Bagasse and Resin (Brewer/Jena Groups)

- Measuring bagasse characteristics to add to guar variety trial and guayule biomass manuscripts
- Preparing two literature reviews: one on low-cost waste biomass routes to fuels and one on guayule resin extraction and separation
- Supporting lab analysis for guar gum and biomass, guayule metabolites and resin, and sustainability modeling data verification efforts
- Two graduate fellows working with middle school teachers on afterschool program and in-class SBAR-related activities



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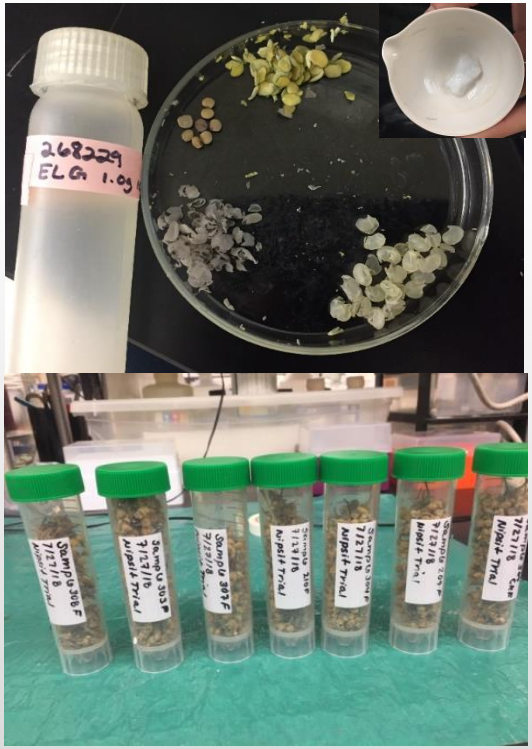
Guar & Guayule Analysis

Omar Holguin, Laura Rodriguez, David Dierig, Mark Cruz, Erin Gutierrez, Sa'Rae Montoya, Kaavya Polisetti

- Extraction protocol and purification protocol completed for galactomannan from Guar
- Completed Cold Tolerance Biomass Metabolomic Characterization of Guayule Leaf Samples
- Completed AZ Soil Sample Analysis
- Continued work on Nipsit Trial Guayule Leaf Sample Pesticide Analysis



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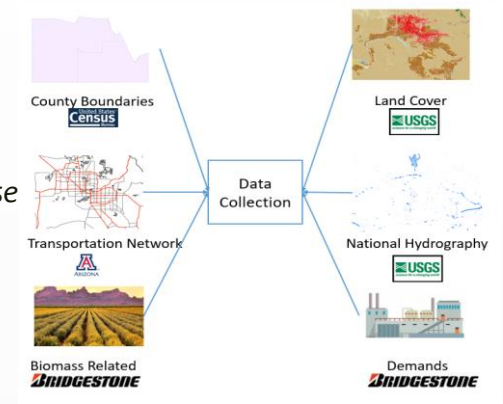
Optimization for Feedstock Logistics

Neng Fan and Ou Sun



- Data collection process
  - *Geographic information system (GIS) data are collected from online database*
  - *Cost factors are collected from published literature*
  - *Fields and yields related are collected from industry partner -- Bridgestone*
- The optimization model and algorithm are well developed
  - *The mathematical model is formulated as a two-stage stochastic programming model with consideration of planting plan uncertainty*
  - *Benders Decomposition is developed and applied to the optimization model*
  - *The testing code is written in C++ programming language and call the commercial solver CPLEX to solve the problem.*
- Case study is performed on two counties in Arizona
  - *154 farms with planting plan uncertainty are considered as supply*
  - *Sensitivity analysis on demand amount is studied*
- Deliverables
  - *One conference presentation in INFORMS annual meeting*
  - *One journal paper submitted to "Annals of Operations Research"*

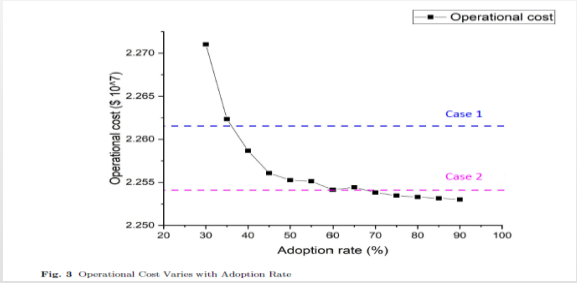


Fig. 3 Operational Cost Varies with Adoption Rate

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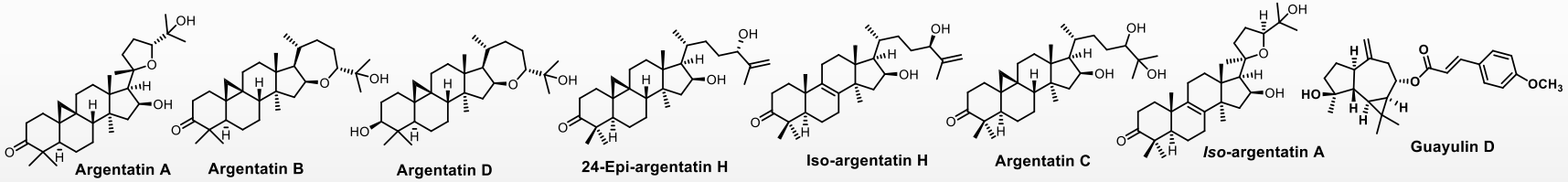
Isolation & Identification of Major & Biologically-Active Co-Products in Guayule

Gunatilaka, Molnar, Xu, Chandrashekar & Liu

- **Key Accomplishments (July – December 2018)**
  - *Isolation and identification of major metabolites of guayule resin*

    (10 metabolites were isolated and characterized, 8 are shown below)



  - *Optimization of isolation of polysaccharide co-products, including inulin, from guayule bagasse*
  - *Partial characterization of low molecular weight rubber fraction of Yulex GR rubber*
  - *Isolation and characterization of γ-eudesmol from guayule terpene solution*

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SYSTEM PERFORMANCE & SUSTAINABILITY

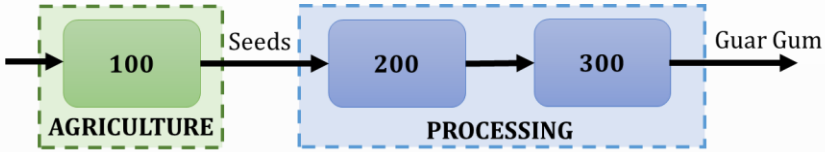
Accomplishments:

July – December 2018

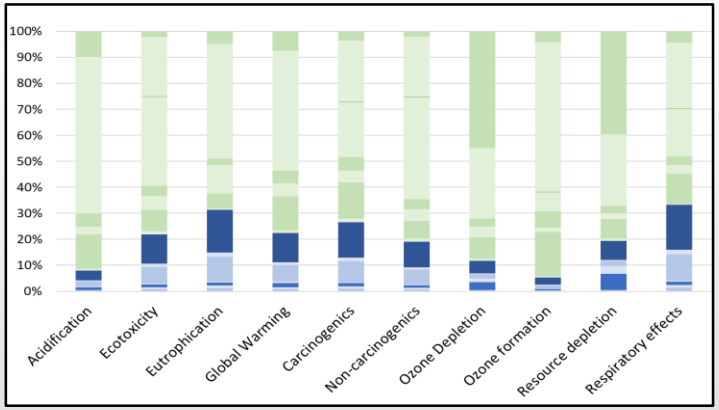
CSU Sustainability Team

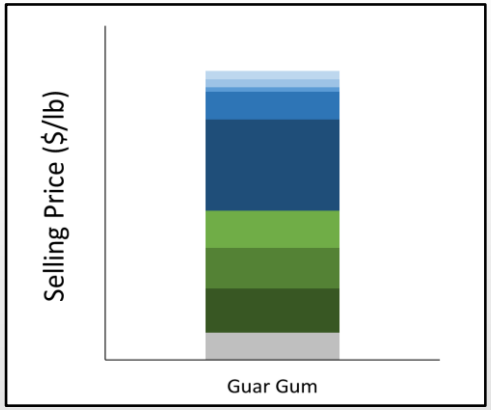
Jason Quinn, Evan Sproul, and Hailey Summers

- Model integration complete



- Combined life cycle and techno-economic results including agriculture (green) and processing (blue) can be generated





- Core modeling work to be refined with data from other teams

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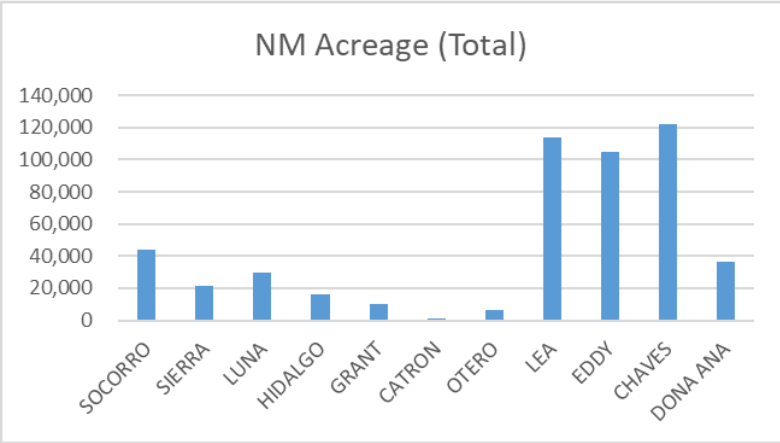
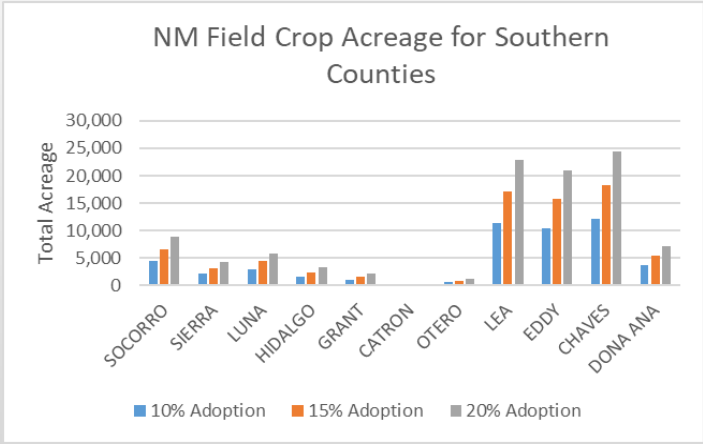
NMSU Sustainability Team

Paul H Gutierrez and Joram Robbs

- Farm Level Economics for Integrated Systems Model in collaboration with UA, CSU OSU and CSM.
- Potential Acreage for Crop Adoption in New Mexico.
- Guar Needs Assessment Survey – New Mexico Producers
- Publications in Progress: Impact of using Guar as a Rotation Crop on Cotton Production in the American Southwest - Ram Acharya, Robbs J., Grover K. and Gutierrez P. Guar and Guayule costs and returns fact sheet. Joram Robbs, Gutierrez P., Acharya R., and Grover K.





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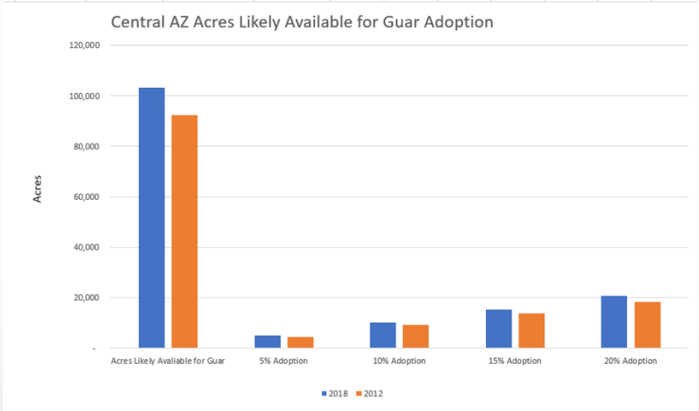
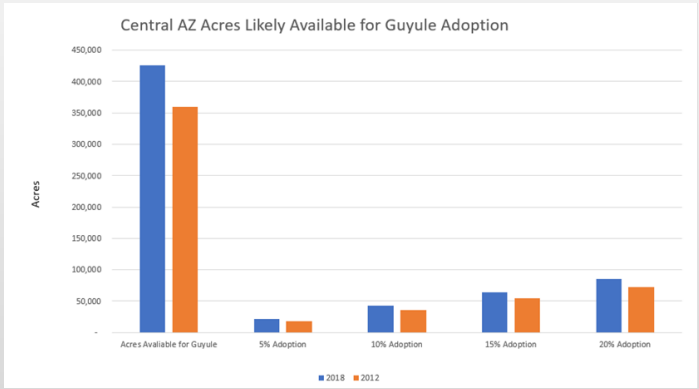
Cost of Production Studies and Whole Farm Analysis

Clark Seavert & Trent Teegerstrom

- Estimated potential acreage adoption for guar and guayule
- Added farm level economic data into the integration model
- Started development of the extension outreach materials
- Started negotiations between two tribal farms and Bridgestone





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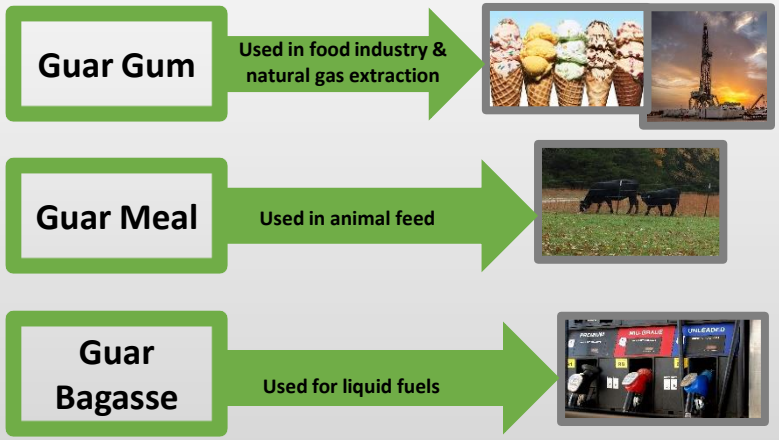
Colorado School of Mines

System Performance & Sustainability Team

Amy Landis, Pragnya Eranki, and VeeAnder Mealing

- Integrated modular model in collaboration with broader sustainability team completed
- Refining of team-wide integrated model in progress
- Initial literature review of social sustainability tools complete
- Abstract on social sustainability literature review accepted for oral presentation at On Sustainability conference in Vancouver, Canada



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EXTENSION & OUTREACH

Accomplishments:

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Co-PI: Sangu Angadi

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Arizona Grower Extension

Blase Evancho

- Blase Evancho was chosen to take over SBAR Extension & Outreach – Arizona Growers in October and should be fully integrated in the 1st quarter of 2019.
- Meetings held with 2 Native American farming communities to discuss their interest & knowledge of guayule production.

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SBAR Guar extension outreach

Kulbhushan Grover, NMSU, Las Cruces, NM

Presentation on SBAR and Guar Project at NM State 4-H Conference.

NMSU On-Farm Demonstration on Guar.

Field Day on Guar at NMSU Lyendecker.

Information dissemination on SBAR- NMSU.

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Idowu

NM Extension & Outreach

- Presented SBAR informational materials at the New Mexico Sustainable Agriculture Conference on December 12, 2018.
  - *100 people had opportunity to view SBAR displays and received project handouts/publications.*
- On-station guar trial at NMSU Los Lunas Agriculture Science Center was harvested.
  - *Samples are currently under processing.*
- A guayule cold tolerance study was initiates in Las Cruces at Leyendecker Plant Science Center
  - *Study is currently on-going in the field.*
- Needs assessment for Guar was launched in New Mexico
  - *Some completed surveys have been received and more surveys will be distributed in NM in January/February 2019*

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Arizona Cooperative Extension -

Channah Rock, Natalie Brassill, & Stevi Zozaya

- Completed stakeholder 'needs assessment'
- Arizona and New Mexico Regions
- Grower focus
- Terms, Ag practices, interest, questions/ concerns
- 150+ responses
- Recruited 4 SBAR Summer Interns

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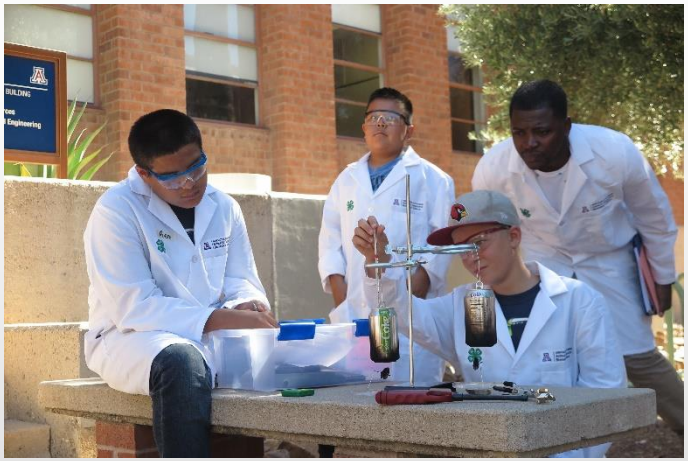
4-H UA: Gerardo Lopez, Daniela Cabrera, Cara Duncan
NMSU: Paul Gutierrez, Laura Rodriguez-Uribe

- The Evaluation of the SBAR 4-H Biofuel Summer Camp has been reviewed and feedback is guiding the planning for this year's summer camps in AZ and NM.
- Activities are being developed that help integrate the SBAR Research components: Feedstock Development & Production, Post-Harvest Logistics & Co-Products and System Performance & Sustainability into this years biofuel summer camps in AZ and NM.
- Collaboration efforts have been established with local Schools in AZ and NM for promoting the SBAR project and for recruiting.



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EDUCATION

Accomplishments:

July – December 2018

Education Team

Development of the SBAR Fellow Seminar: Fellows and Teachers in the Classroom

Team: Dr. Sara Chavarria, Dr. Corey Knox, Dr. Catie Brewer, Torran Anderson, Cara Duncan, Stephanie Sikora

- SBAR Fellows in 5 school districts: 4 in Tucson, 1 in Las Cruses
- SBAR Fellow Seminar launched in Fall 2018 (topics covered: curriculum design, working with middle school students and designing culturally relevant curriculum.)
- Curriculum support via classroom visits and Bridgestone trip.
- First iteration of fellow-developed lesson plans.
- Attended EEO meeting in NM (topics covered: recruiting SBAR grad students as future fellows, challenge of recruiting Native American teachers, planning 2019 Summer PD, community friendly website pages)

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SBAR Evaluation

- Follow up surveys developed and implemented
  - *feedback from teachers and fellows*
  - *summer PD experience and their confidence in developing and implementing SBAR lessons in classrooms*
- Fellows (4 of 6 responding, one fellow left the project)
  - *high level of confidence in communicating science*
  - *Comfort with a variety of audiences, developing lesson plans with their teacher partner, and implementing lesson plans in the classroom.*
  - *High level of understanding roles and responsibilities as an SBAR graduate fellow.*
- Teachers (3 of 6 responding, one teacher left the project due to medical emergency)
  - *Moderate level of confidence in communicating SBAR science and incorporating relevant content into their classroom lessons, with confidence being higher when working together with their graduate fellow partner.*
  - *Mixed level of understanding roles and responsibilities as an SBAR teacher.*
- Planning retreat in Las Cruces, NM December 5-7, 2018. Created preliminary evaluation plan for summer 2019 EEO activities and ongoing extension activities. New evaluation tools are under development, while others are being revised to better meet team needs.

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Organize MS and/or PhD education opportunities within the University of Arizona around the theme "Sustainable Bioeconomy"

- Curriculum design continued for the planned Sustainable Bioeconomy and Bioenergy (SBB) track (study concentration area) for the existing Professional Science Master's in Applied Biosciences (PSM-ABS) Graduate Interdisciplinary Program (GIDP) for MS students.
- Lists of existing classes offered at the UA were scrutinized for inclusion into the list of elective classes for the Science Module (15 credit hours total).
- Suitability of the previously compiled list of elective classes for the Professional Preparation Module (12 credit hours) is being investigated.
- Harmonization of the new track with the existing 5 other tracks of the PSM-ABS GIDP is important to maintain program consistency.

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