2019 Summary of Accomplishments
FEEDSTOCK DEVELOPMENT & PRODUCTION

Lead: Dennis T. Ray
Feedstock Development: Ray Lab

- Developed grading system for salt tolerance experiment (Fig. 1)

![Guayule salt tolerant grading scale](image)

Figure 1: Guayule salt tolerant grading scale: 1 = No effect; 2 = Yellow leaves (~10 – 25%), brown leaves (~10 – 25%); 3 = Yellow leaves (~10 – 25%), brown leaves (~25 – 50%); 4 = Yellow leaves (~10 – 25%), brown leaves (~50 – 75%); 5 = Mortality, complete or imminent (brown leaves >90%).

- Harvested guayule density trial (Fig. 2)

- Harvested guar 16-18 December (183-184 days after planting) (Figs. 3-4)

![Harvested guar](image)

![Harvested guayule density trial](image)

Fig. 3 (left): harvesting; Fig. 4 (right): threshing

Fig. 2: Guayule harvest 9 Oct.

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

Obj 1: Improve biomass quantity and quality through genetics and traditional breeding
Sub Obj: 2) Downregulate flowering to improve yield - guayule

Key Accomplishments Oct-Dec 2019

- As of January 2020 we have performed several thousand guayule transformations featuring 4 constructs, plus one 2-gene construct. All genes are transcription factors related to flowering which are downregulated by RNA interference:
  - APETALA1 AP1: Calli growing under selection pressure
  - SEPATTALA SEP3: Plant transformation confirmed by PCR for 6 events, moved to rooting media
  - FLOWERING LOCUS T FT2: Calli growing under selection pressure
  - LEAFY: Calli growing and forming leaves under selection pressure
  - pND6 – AP1 – SEP3 (pAS): initial calli obtained, transformations continuing.

Team: Niu Dong, Trinh Huynh, Mariano Resendiz, Dante Placido, Chen Dong, Grisel Ponciano

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Q4 major accomplishment (Maricopa)

Hussein Abdel-Haleem (co-PI), Lily Luo (Postdoc), Aaron Szczepanek and Tristan Dunton (Biological Science technicians), Harmony Glover, Avery Luna and Brandon Vera (students)

Variations in NDRE, a vegetation index, among guayule genotypes and weeks

- Remote sensing could be used to detect the phenotypic variations among guayules
- Improved germplasm tend to be greener (healthier) compare to wild

Rubber and resin % in one-year old plants guayule genotypes

- There are phenotypic variations within guayules for rubber and biomass
- Improved germplasm tend to be high in rubber with heavy biomass
- Negative correlation between biomass and rubber

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Feedstock Development at Bridgestone
Dierig, Cruz, Wang, Dittmer, Sullivan, Lynch, Prock

Key accomplishment: Quarter 4, 2019

- Analyzed data from harvest of 18 month-old plants of 2 varieties planted at 5 densities. Biomass was highest in AZ-2 overall. The plants spacings were 30, 18, 12, 6, 3-inch and biomass for AZ-2 was lowest at the 30” density. We found no difference in biomass production between the other densities. Rubber % was unaffected by densities.

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Guayule Herbicide Tolerance
Bill McCloskey

- Postemergence herbicide tolerance studies were completed at Maricopa and Eloy.
  - Measured guayule seedling tolerance to carfentrazone (Aim) at different growth stages.
  - Found that guayule is completely tolerant to the grass herbicides clethodim, fluazifop, and sethoxydim.
  - Determined that paraquat kills guayule seedlings.

Aim @ 2 fl. oz./A on 3.5 leaf guayule – 7 DAT

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Spatial and Temporal Variability in Soil Microbiome Associated with Guayule Dormancy

Lia Ossanna, Yongjian Chen, Julie Neilson
In collaboration with
McMahan Research group and Diaa El Shikha

Research Aim: characterize soil microbiome variability for 3 guayule growth stages

November: cold induced rubber biosynthesis

February: winter dormancy with active rubber biosynthesis

April: Spring active growth

- Soil microbiome varies with guayule growth stage: 25% of bacterial/archaeal community variability is explained by sampling time (20% for fungi)
- Spatial variability greatest in February (most active rubber production time): plants across field may experience different plant/microbe interactions
- Results will be combined with plant growth and rubber production data to evaluate correlations

Two locations sampled per plot at each time point

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Guayule and guar irrigation experiments

- The following presentations on guayule and guar irrigation were made at the AAIC conference in September 2019.

- Growing direct-seeded guayule with furrow and subsurface drip irrigation in Arizona

- Development of a remote crop condition sensing system utilizing Internet of Things
  - D. Hoare, M. Katterman, P. Waller

- Evaluating crop water status for guar using WINDS model

- Assessment of irrigation requirement for guayule using WINDS model

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Guar cultivars showed lots of variation in germination.

Cultivar differences were more prominent under lower temperatures.

Kinman was different and tolerated lower temperatures better compared to other cultivars.

It is possible to expand guar acreages to cooler locations, if we find cold tolerant cultivars.

<table>
<thead>
<tr>
<th>Cultivars</th>
<th>Temperature °F</th>
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<tbody>
<tr>
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<tr>
<td>Santa Cruz</td>
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</tbody>
</table>
Guar research – Kulbhushan Grover

■ Feedstock Development
  - Evaluated field performance of Guar genotypes.

■ Production technology
  - Evaluated response of guar to planting densities.

■ Scientific interactions
  - Delivered presentations at scientific meetings.

Guar nodules

Guar field, NMSU Fabian Garcia Plant Science Center, Las Cruces, NM.

Guar harvest, Las Cruces, NM.

Guar pods

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AquaCrop Modeling of Guayule
Patrick Lohr, Sarocha Pradyawong, Kim Ogden

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POST-HARVEST LOGISTICS & CO-PRODUCTS

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

- Preparing manuscripts on guayule bagasse/resin characteristics, conversion of low-cost protein- and lignin-rich biomass wastes into fuels, and guayule resin composition and applications
- Conducting guayule bagasse and algae co-hydrothermal liquefaction tests
- Initiating experiments into guayule resin applications as polymer tackifiers and urban insect repellents
- Supporting lab analysis for guar gum and biomass, guayule metabolites and resin, and sustainability modeling efforts
- Four graduate fellows working with middle school teachers on afterschool program and in-class SBAR-related activities

Heteroatom chemical compound class distribution for guayule resin observed using negative- and positive-ion atmospheric pressure photoionization Fourier-transform ion cyclotron resonance mass spectroscopy (APPI FT-ICR MS).

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Guayule metabolomics studies on freeze tolerance and identification of *Rhizobia* in nodules of guar plants grown in NM

- Sixty-eight guayule leaf and stem samples were harvested from Cold Germination, Freeze tolerant, and Survivor plants grown at the Leyendecker Plant Science Center NM.

- Five *Rhizobia* species were identified within the guar plants grown in Fabian Garcia: *Rhizobium azimense* 23C2, *Rhizobium* sp. AC93c, *Rhizobium* sp. T1Gsb2, *Rhizobium* sp. Cap_B1, and *Rhizobium pakistanense* BN-19.

- Three species of nodule associated bacteria identified: *Pseudomonas*, *Bordetella*, and *Agrobacterium*.

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SYSTEM PERFORMANCE & SUSTAINABILITY

Lead: Jason Quinn
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Farm-Level Economics:
Sita Khanal, Clark Seavert, Trent Teegerstrom & Paul Gutierrez

- Signed agreements between at least two Tribal Farms in AZ for Establishment of experimental plots on Tribal lands
- Budgets are included in the Sustainability Team’s integrated model
- Five enterprise budgets to be published on university websites.
- Whole-farm case studies are linked into a sensitivity model that can be adjusted as desired for breakeven analysis.

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Data collection process:
- Geographic information system (GIS) data from the USDA CropScape is collected for the most likely crops to switch to Guayule.
- Detailed farm information for the past 10 years is analyzed to identify additional potential facility locations (please refer to Fig. 1).
- Parameters for the irrigation water used per crop were determined based on the feedback from the Research Meeting Group presentation.

The multi-objective optimization model and algorithm are updated to consider:
- Multi-objective defined for economic, environmental, and social impacts with a weighted factor.

Decomposition-based coding and algorithm updates:
- The model is coded using the programming language C++, the solver CPLEX, and the UoA’s high performance computing (HPC).
- The decomposition code is updated to include labor per location and construction permits within the model.

Fig 1. Identified facility locations based on most likely crops to switch to Guayule – Maricopa and Pinal.

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Mines – Sustainability Team
Dr. Amy Landis, VeeAnder Mealing

- **Data Integration**
  - Developed guar and guayule field trial summary tables, displaying all field trials, associated PIs and their purpose in one location
  - Lead field data collection effort proposed approaches for utilizing data in integrated model

- **Social Sustainability**
  - Initial literature and matrix mapping of social sustainability tools relevant for emerging feedstocks is complete
  - Reviewed and summarized data from social sustainability break out session at SBAR retreat & developed framework using United Nations’ sustainable development goals

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EDUCATION

Lead: Sara Chavarria
Curriculum & Instruction: C. Knox, T. Anderson, C. Brewer, G. Fritz
Support & Evaluation: C. Duncan, S. Sikora, J. Fields
Oversite: K. Ogden, A. Rogstad
Education Team

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

- July 2019: Summer Train the Trainer at NMSU and Professional Development Week at UA
- Fall Seminar with SBAR Fellows working in their SBAR Teachers classroom focused on lesson plan development
- Classroom visits to SBAR teacher/fellow schools. Including a trip to Sells, AZ where two new SBAR teacher/fellow pairs are working on Tohono O'odham Nation.

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Evaluation of EEO, Jen Fields

- Implemented evaluation tools and protocols for summer EEO activities, including AZ 4-H summer camp and AZ/NM SBAR teacher/fellow PD
- Analyzed data from evaluation tools implemented with campers, teachers, and fellows including observations, surveys, concept mapping and focus group interviews. Received ongoing input from EEO staff via individual interviews and meetings.
- Provided summarized evaluation findings and data analysis spreadsheets to EEO groups so that they could review full evaluation data from each stakeholder group.
- Provided suggestions to EEO teams, based on evaluation findings, for program modifications moving forward into year 3 EEO activities
- Developed Year 2 annual evaluation report
EXTENSION & OUTREACH

Leads: John Idowu & Blase Evancho
Extension & Outreach
Arizona

- Weed management trials were presented at the Central Arizona Farmer Field Day to 43 growers and ag professionals.
- The needs assessment survey was deployed to Native American communities in Arizona, and we received input on 13,700 agriculture production acres.
- The SBAR Newsletter was completed and delivered to 319 subscribers to the “Crop Rotator” Central Arizona Extension Newsletter.

Dr. Bill McCloskey discusses guayule weed management trials.
Guar extension and outreach - Kulbhushan Grover

- Farmer field demonstrations on guar
  - Anthony, NM

- SBAR Train-the-Trainer workshop on guar
  - NMSU, Las Cruces, NM

- Future Farmers of America (FFA) Conference presentation on guar
  - NMSU, Las Cruces, NM

- NMSU Agric. College Open House - community event on guar products
  - NMSU, Las Cruces, NM

- Field tours of guar trials to students, growers and researchers.
  - NMSU, Las Cruces, NM

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SBAR – Grower Extension
John Idowu

- Guar and guayule information were presented at:
  - SBAR Train the Trainers Workshop, Las Cruces
  - Clovis Ag. Science Center Field Day
  - Tucumcari Ag. Science Center Field Day
  - Los Lunas Ag. Science Center Field Day
  - Program Review Event at NMSU

- Guar on-station trials were completed in Las Cruces, Los Lunas, Tucumcari and Clovis, NM.

- Farmers were able to see the guar demonstration trials during the field days at various locations.

- First SBAR Grower Extension Newsletter was released in December 2019.

- At least 550 people were reached with SBAR information in New Mexico.

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Collected feedback from SBAR ‘Project Puente’ 2019 mentors

Started the development of new ‘Project Puente’ mentor materials

Started the development of new ‘Project Puente’ intern materials

Begin recruitment of SBAR 2020 Summer Interns and Mentors
Evaluation of EEO, Jen Fields

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