FEEDSTOCK DEVELOPMENT & PRODUCTION

Dennis Ray, Peter Waller, Raina Maier (Julie Neilson), Diaa El-Shikha, Kim Ogden, David Dierig, Colleen McMahan, Hussein Abdel-Haleem, Duke Pauli, Bill McCloskey, Kulbhushan Grover, Sangu Angadi

Feedstock Development and Production

- **Objective 1: Improve biomass quantity and quality through genetics and traditional breeding.**
  - ***Objective 1a: Exploitation of Apomixis - Guayule***

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Feedstock Development and Production

- **Objective 2: Develop high-throughput phenotyping to support crop expansion using remote-sensing methods to create interactive databases/tools.**

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Biomass improvement and phenotyping:

- *Sampling, processing, protocols and rubber analysis for variety trials*
- *Drone and HTP tractor for biomass accumulation and other traits*
- *Ploidy determination*
- *Methodology for rate of apomixis*

14 Day	1	2	3	4	5	6	7	8	9	10
	11° C	14.5° C	18° C	21° C	23.5° C	26° C	28.5° C	31° C	34° C	36.5° C
593	55.2%	73.6%	69.6%	70.4%	70.4%	60.8%	58.4%	55.2%	53.6%	20.6%
11591	56.0%	57.0%	74.0%	61.0%	57.0%	54.0%	56.0%	65.0%	46.0%	41.0%
11604	43.0%	86.0%	89.0%	89.0%	86.0%	88.0%	85.0%	85.0%	78.0%	55.0%
11605	46.0%	67.0%	61.0%	64.0%	56.0%	52.0%	53.0%	54.0%	49.0%	30.0%
11635	31.0%	65.0%	56.0%	57.0%	60.0%	56.0%	50.0%	52.0%	39.0%	30.0%
AZ5	35.0%	56.0%	46.0%	60.0%	38.0%	64.0%	52.0%	55.0%	51.0%	45.0%
AZ6	67.0%	91.0%	91.0%	94.0%	95.0%	85.0%	91.0%	81.0%	80.0%	69.0%
CAL3	83.0%	75.0%	87.0%	84.0%	87.0%	85.0%	77.0%	76.0%	74.0%	58.0%
CFS 24	60.0%	76.0%	93.0%	76.0%	73.0%	82.0%	67.0%	63.0%	57.0%	55.0%
CFS21	26.4%	50.4%	52.8%	51.2%	56.0%	46.4%	43.2%	55.2%	39.2%	38.4%
HS06	49.0%	74.0%	72.0%	78.0%	79.0%	85.0%	73.0%	69.0%	75.0%	56.0%
N396	46.0%	45.0%	58.0%	50.0%	46.0%	38.0%	46.0%	59.0%	55.0%	34.0%
N565 II	33.0%	47.0%	44.0%	47.0%	43.0%	53.0%	35.0%	25.0%	37.0%	34.0%
N576	25.0%	38.0%	34.0%	30.0%	36.0%	42.0%	42.0%	34.0%	32.0%	21.0%
PARL 914	36.0%	67.0%	68.0%	65.0%	59.0%	62.0%	63.0%	61.0%	63.0%	45.0%
PARL 916	64.0%	62.0%	75.0%	79.0%	70.0%	67.0%	70.0%	74.0%	71.0%	47.0%
PARL 917	37.0%	42.0%	47.0%	38.0%	52.0%	45.0%	39.0%	42.0%	49.0%	32.0%
PARL 919	51.0%	79.0%	79.0%	74.0%	80.0%	77.0%	83.0%	78.0%	75.0%	68.0%
PARL 920	59.2%	58.4%	72.8%	55.2%	68.0%	58.4%	63.6%	64.8%	58.4%	56.8%
PARL 922	41.0%	65.0%	69.0%	79.0%	74.0%	66.0%	71.0%	68.0%	62.0%	46.0%
PARL 923	41.0%	72.0%	87.0%	74.0%	73.0%	80.0%	78.0%	74.0%	67.0%	58.0%
PARL 929	38.0%	43.0%	68.0%	74.0%	74.0%	65.0%	59.0%	63.0%	53.0%	34.0%
PARL 932	41.0%	75.0%	77.0%	73.0%	72.0%	76.0%	72.0%	63.0%	63.0%	54.0%
PARL 935	43.0%	38.0%	60.0%	62.0%	49.0%	60.0%	49.0%	51.0%	48.0%	35.0%
R1092	29.0%	62.0%	55.0%	61.0%	53.0%	52.0%	49.0%	48.0%	50.0%	38.0%
R1103	43.0%	55.0%	59.0%	53.0%	65.0%	54.0%	49.0%	58.0%	50.0%	40.0%
R1110	51.0%	63.0%	62.0%	62.0%	55.0%	53.0%	55.0%	57.0%	44.0%	42.0%

Production practices

- *Plant density study sampling*
- *Germination at different temperatures for optimal planting temperature*
- *Planting in New Mexico (colder region)*

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Needs from other project collaborators

- *Uniformity in sampling and timing of harvests*
- *Comparable HTP senesors and image analyses*
- *Collaboration with NMSU on planting and metabolomics for cold tolerance*
- *Planning and coordination on all joint experiments*

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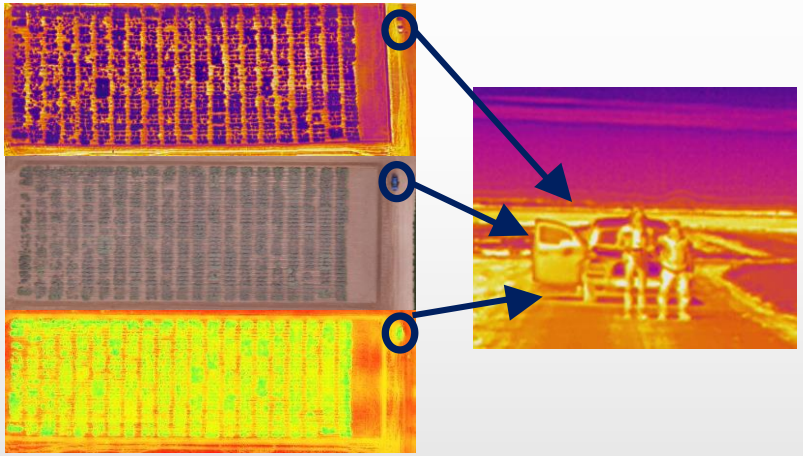
Objective: *Feedstock Development (Guayule)*
Sub Objec.: *Phenotypic characterization (Guayule)*

2019:
-Collect and analyze field/lab phenotypic data of one-year old guayules (plant height, biomass, flowering time, rubber and resin, and HTP-related traits)

Our all-times way

The new TECH way……



Needs and Take-home of 2019:
-ALTAS of guayule collection (one-year old)
Winners and losers, Round one!
-Precision phenotyping (ground, aerial HTP…. for many forms, shapes, aka. varieties)

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University of Arizona Feedstock Development

Objective 1: Improve biomass quantity and quality through genetics and traditional breeding.

Objective 1 a: Exploitation of Apomixis - Guayule

- **Evaluate germplasm**
  - *Yield components (field)*
  - *Leaf cuticular waxes (field/drought tolerance)*
  - *Root growth (green house/drought tolerance)*
- **Identify and characterize off-type plants**

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Biochemical Analysis

Analytical Support: Improved Profitability

- Biochemical composition analysis of guar & guayule co-products
- Analytical evaluation of the thermochemical conversion products
- Feedstock Development "omics"

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Year 2 Needs

- Guar
  - *Guar Seeds (field trials)*
  - *Guar Gum Quality Assessment*
  - *Feedstock development "omics"*
- Guayule
  - *Continued Co/By-Product Characterization*
  - *Feedstock development "omics"*
- Thermochemical Samples
  - *Characterization of conversion team products*

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Feedstock Development and Production

- **Objective 1: Improve biomass quantity and quality through genetics and traditional breeding.**
  - ***Objective 1b: Flowering to improve yield – guayule.***

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FEEDSTOCK DEVELOPMENT & PRODUCTION (FD&P)

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

SUB Obj: 2) Flowering to improve yield - Guayule

Next steps:

- ✓ Continue transformations in the laboratory…
  - … efficiency is low but we expect to get there!
- ✓ Prepare transformation constructs for additional candidate genes:
  - ..SEP3 underway, possible binary (AP1 + SEP3) next
- ✓ Measure gene expression from meristem and flower tissues from SBAR field trials
  - Support current strategy or revision if indicated.

We need:

- ✓ Feedback from field trials if/when differential flowering is observed.

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Guayule Growth Modeling

- Specific Goal: Predict growth rate of guayule
- Objective 1: Improve biomass quantity and quality through genetics and traditional breeding.
- Objective 2: Develop high-throughput phenotyping to support crop expansion using remote-sensing methods to create interactive databases/tools.
- Two scales
  - *Individual plants – size (height, number of stems, etc.) as a function of time and composition as a function of time (% rubber)*
  - *Field – use the drone data to model growth as a function of time.*

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Coordination with others

- Dennis for individual plants
- Colleen –relationship to flowering
- Bridgestone – rubber content
- Pete Waller team with the drone data
- Weather and Irrigation data
- Julie – soil data (N,P, etc)

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Feedstock Development and Production

- **Objective 3: Deploy superior genotypes of guayule and guar to regional growers.**

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Objective 3: Deploy superior genotypes of guayule and guar to regional growers.

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Guayule

- Evaluate 1-year yield component data
- Evaluate 42 lines for root rot tolerance
- Screen original five lines a second generation

Guar

- Initiate regional yield trials
- Decide upon planting scheme/protocol
- Data to be taken
- Any new lines to evaluate
- Evaluate next generation from crossing blocks (yield components, disease and insect resistance)

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Guar research objectives- Year 2

- Objective 1:

Feedstock development

  - *Evaluation of guar germplasm.*

- Objective 2:

Production technology

  - *Response of guar to various planting densities.*

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Feedstock Development and Production

- **Objective 4: Deploy agronomic production practices; identify agronomic information for salinity, herbicide, and nutrients to support production; provide irrigation apps using algorithms to growers.**

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Irrigation

- Next steps
  - *Continue irrigation experiments*
    - Develop crop coefficients for guayule and guar within irrigation experiments
    - Monitor and manage irrigation experiments
    - Collect plant samples in April
    - Integrate remote sensing in irrigation experiments
    - Correlate remote sensing with plant status
    - How it fits: develop BMPs for irrigation of guayule and guar
  - *Continue WINDS model development*
    - Implement WINDS at winds.arizona.edu
    - Integrate remote sensing measurements into WINDS
    - How it fits: provide a tool to manage irrigation in guayule and guar

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Irrigation

- Guar irrigation
- Guayule irrigation
- Remote sensing
- Sangu Angadi runs the guar irrigation experiments in New Mexico
- The Bridgestone team runs the guayule irrigation experiments in Eloi
- We are working to integrate efforts with Dr. Didan's image tools.

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Waller group
Fitting into the SBAR mission.

- Coordination of irrigation experiments
  - *Planning of irrigation treatments and layout*
  - *Hadiqa Maqsood to Clovis to develop crop coefficients*
  - *Matt Katterman collecting neutron probe measurements and plant analysis*
  - *Work with Diaa El-Shikha on project decisions*
- Develop irrigation tools
  - *Program python and MySQL version of WINDS model*
  - *Development of sensors to connect with WINDS model*
  - *Work with Kamel Didan to use Maricopa irrigation experiment images as case study for remote sensing data explorer platform.*

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Waller group
Next steps

- Diaa El Shikha manage irrigation experiments (post – doc)
- Put WINDS model online and link to remote sensing platform
  - *Waller (10 hr/wk), Murdoch-Hoare (10-15 hr/wk), additional undergraduate student assistant (10-15 hr/week), Didan and Barreto*
    - Link python code and new MySQL database to current winds.arizona.edu and online remote data explorer platform
    - Install sensors in all irrigation treatments and automate processing of IR, TDR, neutron probe, flowmeter, and drone image data
- Matt Katterman weekly trips to collect neutron probe, and plant growth and samples for chemical analysis (1/4 time research ass.)
- Development of crop coefficient for guar (Sangu Angadi experiment)
  - *Hadiqa Maqsood (Fulbright scholar) and summer worker (3 months, full time) assist with guar experiments*

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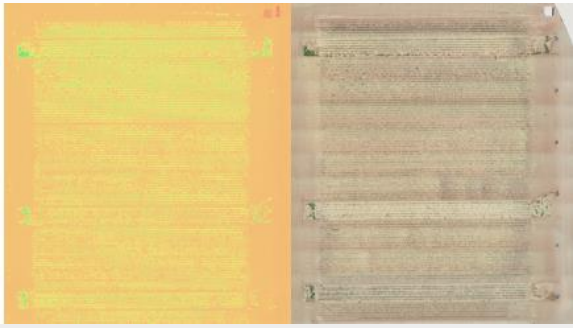
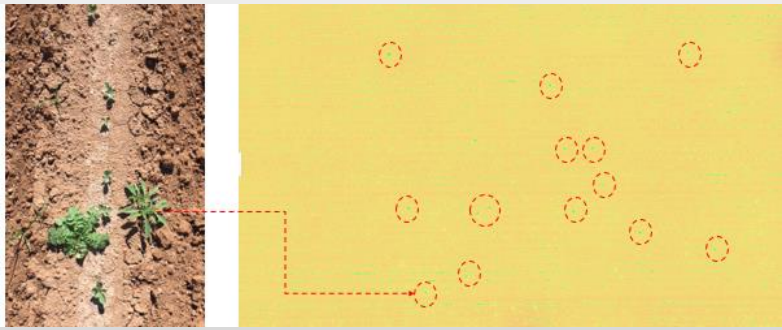
Irrigation Experiment

- Next steps
  - Calibrate the neutron probe for Eloy soil
  - Collect monthly plant data (height, width, % cover) at MAC and Eloy
  - Schedule the irrigation treatments at Eloy and MAC
  - Processing the weekly soil moisture data collected by Matt Katterman
  - Collecting RGB and multispectral and RGB images using the drone
  - Collecting and processing remote sensing data using the tractor (biweekly-monthly)





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Irrigation Experiment

- Next steps
  - Soil texture/WHC analysis at ALARC for the soil samples collected from MAC and Eloy
  - Correlate the remote sensing data (Multispectral/RGB) to plant growth parameters
  - Correct basal crop coefficient obtained from previous experiment based on the collected soil moisture data
  - Present the data of the first year at the 2019 annual meeting of the ASABE

Growth parameter	RGB Index	Correlation value	Did they work in early stages
Plant height	VI13, VI14, VI18	|0.60-0.77|	No
Plant width	VI18	|0.63-0.73|	No
Percent cover	VI18	|0.63-0.73|	No

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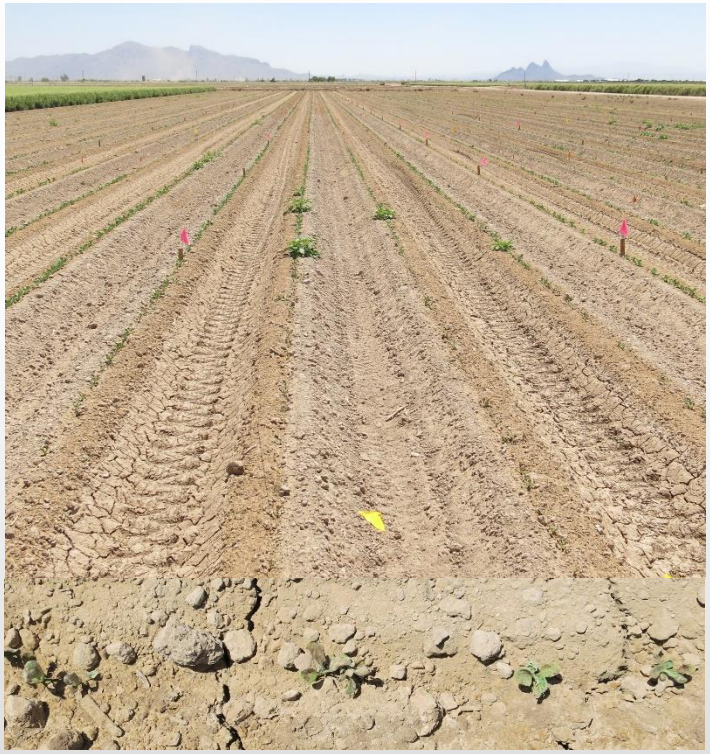
Managing Weeds in Guayule



Aim: 4 fl. oz./A @ 4 leaf growth stage

- Guayule response to postemergence herbicides
  - *Aim: surviving injury in spring & fall*
- Guayule response to preemergence herbicides
  - *Course textured soils*
  - *Fine textured soils*
  - *Tank-mixtures*
- Guayule defoliation

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Managing Weeds in Guayule

Agronomic Practices

- Establishment in course textured soils (60% sand, 20% silt, 20% clay)
  - *Crusting & salt management*
- Sprinkler irrigation
  - *Frequency & duration*
- Furrow irrigation
  - *Planting depth*
  - *Incorporating Herbicide*
- Insect control

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Research Plan for Eastern High Plains of New Mexico for 2019

- Improve water productivity of gaur using pre-irrigation and critical stage based irrigation approach
- Develop crop coefficients for guar for Evapotranspiration (ET) estimation (with Ms. Hadiqa Maqsood & Dr. Waller)
- Increase guar acreage by understanding soil temperature and germination relationship for existing cultivars
- Evaluate guar germplasm in Eastern High Plains of New Mexico (with Dr. Dennis Ray)

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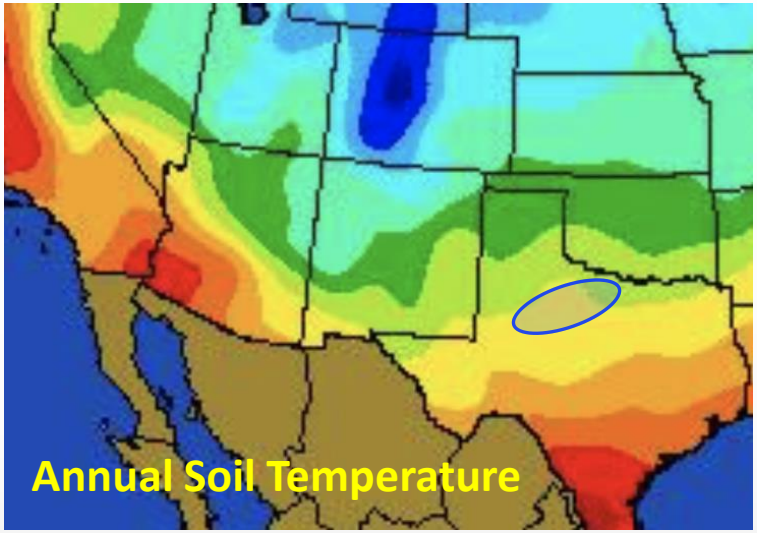
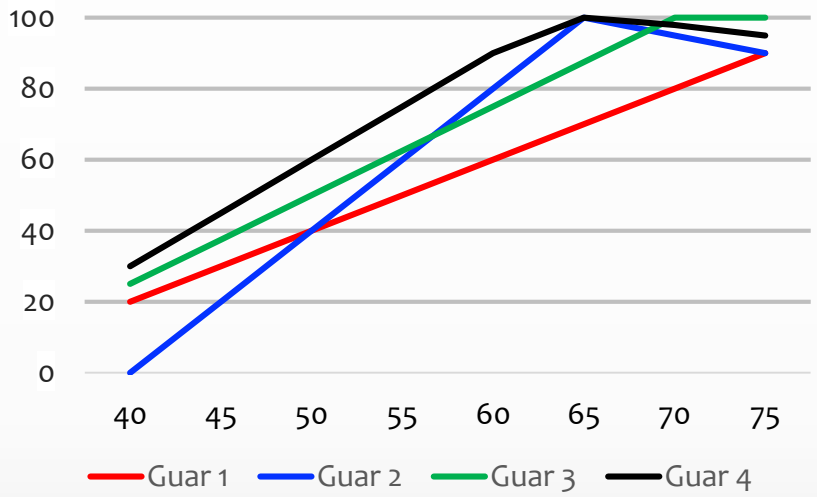
Soil Temperature vs. Guar Germination





- Plant guar depends on soil temperature
- Increasing guar acreage needs better understanding of soil temperature and germination relationships
- The relationships for current guar cultivars → Ideal planting dates, ideal cultivar for an agroclimate and extend guar area

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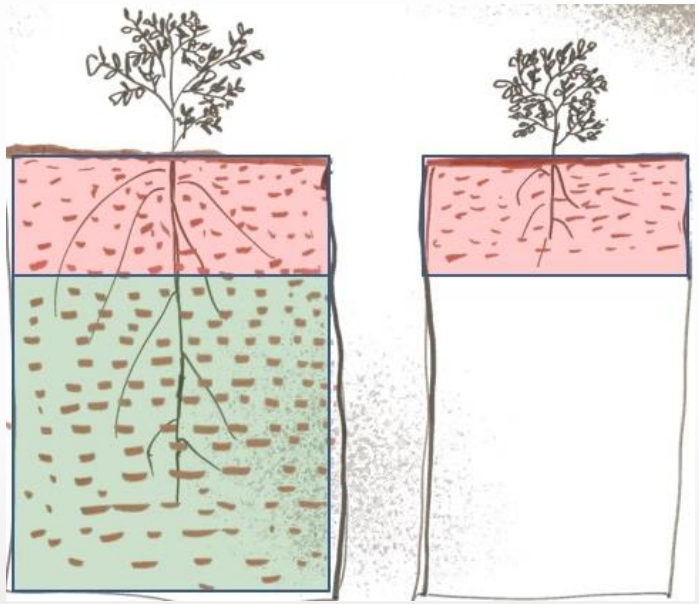
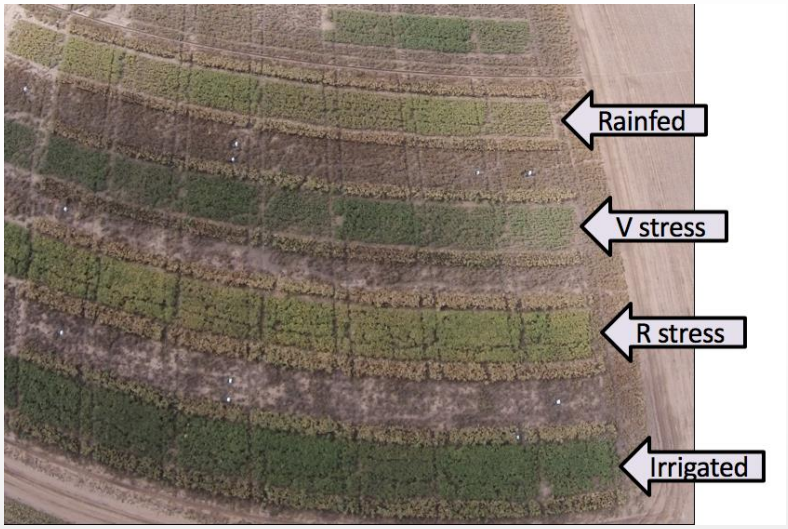
Pre-irrigation & Critical Stage Based irrigation





- Will assess how efficiently guar uses water available in the deeper soil profile
- Can we save water by skipping irrigation during non-critical growth stages
- Understand drought physiology of guar cultivars

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Feedstock Development and Production

- **Objective 5: Develop soil quality and health knowledge critical to environmental sustainability.**

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Sustainable Feedstock Production: Soil Health

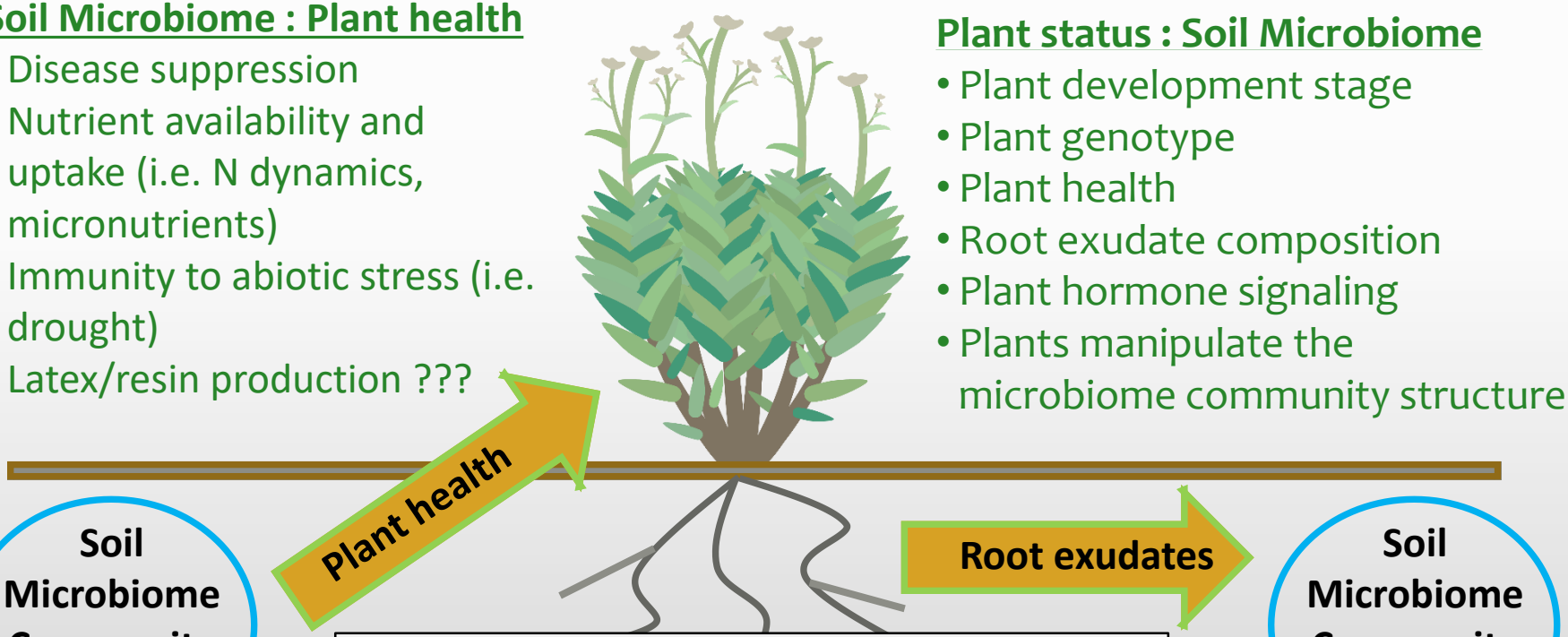
Raina Maier and Julie Neilson

Objective

Develop soil quality and health knowledge critical to environmental sustainability; initial focus on guayule.

Soil Microbiome : Plant health

- Disease suppression
- Nutrient availability and uptake (i.e. N dynamics, micronutrients)
- Immunity to abiotic stress (i.e. drought)
- Latex/resin production ???



Plant status : Soil Microbiome

- Plant development stage
- Plant genotype
- Plant health
- Root exudate composition
- Plant hormone signaling
- Plants manipulate the microbiome community structure

Year 1: Sampling to characterize baseline soil quality profile of MAC and Bridgestone fields

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Soil Health Focus for Year 2

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Year 2 Specific Objectives:

1. Generate baseline **soil health profile** for MAC and Bridgestone guayule fields at plant germination stage. Non-rhizosphere soils analyzed.
2. Coordinate **YR 2 sampling** at end of winter dormancy (March 2019).

Soil Health Profile (54 soil samples per field):

Chemistry: with NMSU (pH, EC, OrgM, NO_3-N, P, K, cations, SAR).

Physical: Soil texture (% clay)

Biological: Microbiome community structure

- Phylogenetic profile (bacterial and fungal community composition)
- Relative abundance of target PGP or pathogenic bacteria and fungi
- Fungal abundance
- Identification of target functional genes for quantification

YR 2 Sampling Coordination with Collaborators :

- ✓ Crop phenotyping: plant height, biomass estimates, plant architecture, flowering rate, rubber and resin production
- ✓ Document root rot incidence or other plant disease
- ✓ Continued collaboration with NMSU for soil chemical analysis

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POST-HARVEST LOGISTICS & CO-PRODUCTS

Neng Fan, Leslie Gunatilaka, Istvan Molnar, Omar Holguin, Catie Brewer, Umakanta Jena

Post-Harvest Logistics & Co-Products Year 2 Plan & Needs

- Fan Group (Transportation Models)
- Gunatilaka & Molnar Groups (Co-Product Chemistry)
- Holguin Group (Co-Product Chemistry)
- Brewer & Jena Groups (Bagasse Conversion)

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Optimization for Feedstock Logistics (Fan group @ UA)

- Continue the data collection for feedstock logistics (farm fields, road networks, water supply, existing facilities)
- Construct the optimization models for operations, such as flexible biomass harvest scheduling, operations of storage and process facilities considering uncertainty issues
- Integrate the economic benefits and environmental influences into the optimization models
- Develop efficient algorithms based on decomposition approaches to solve large-scale optimization models

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Optimization for Feedstock Logistics – Needs from Collaborators

- Data/information from other research groups:
  - *Continue the collaboration with Mr. Trent Teegerstrom and Dr. Paul Gutierrez on the economic costs and benefits of Guayule/Guar farm fields*
  - *Productivity and yield information of guayule/guar from the team on Feedstock Development and Production*
- Process and other data information from industrial partners

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Isolation & Identification of Major & Biologically-Active Co-Products in Guayule & Guar (Gunatilaka, Molnar, Xu, Chandrashekar & Liu)

Overall Goal of Project
Identification of co-products of economic importance from guayule & guar

SBAR Mission
To build a sustainable bio-economy for arid regions to improve quality of life in rural communities and Native Nations

Year 2 Research Objectives

- Identify major secondary metabolites of guar gum
- Isolate bioactivity-guided guayule and guar metabolites with potential applications in agriculture and medicine
- Chemically modify major metabolites to obtain potential value-added co-products

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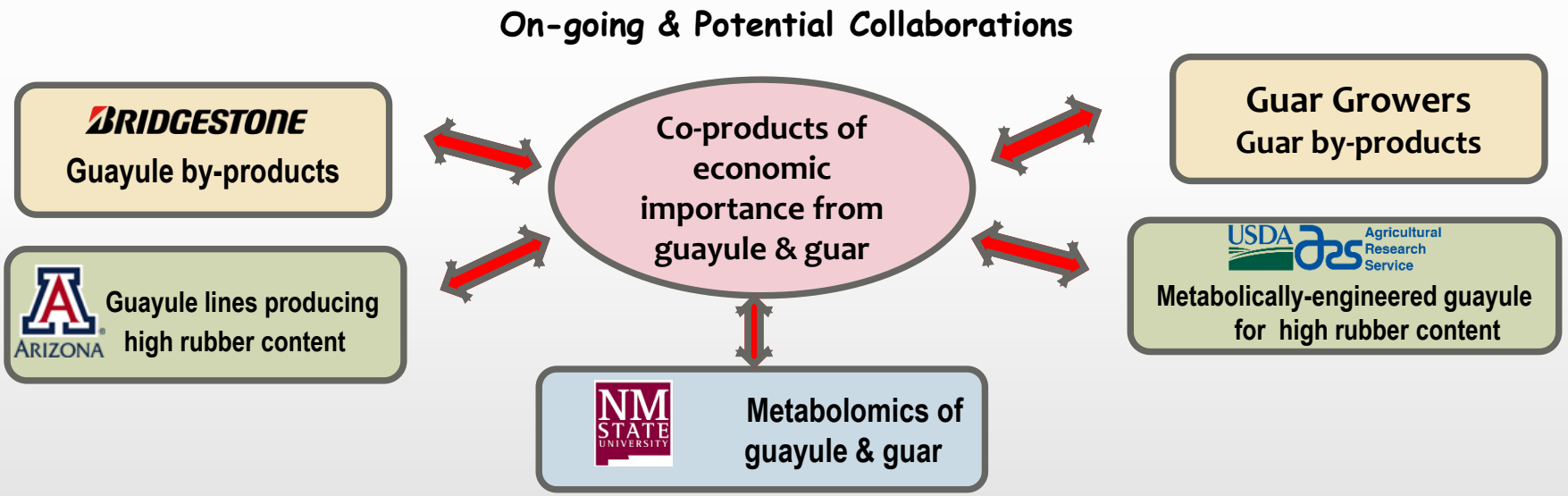
Isolation & Identification of Major & Biologically-Active Co-Products in Guayule & Guar-Needs from Collaborators



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Biochemical Analysis (Holguin group @ NMSU)

Analytical Support: Improved Profitability

- Biochemical composition analysis of guar & guayule co-products
- Analytical evaluation of the thermochemical conversion products
- Feedstock Development "omics"

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Biochemical Analysis—Needs from Collaborators

- Guar
  - *Guar seeds (field trials)*
  - *Guar gum quality assessment*
  - *Feedstock development "omics"*
- Guayule
  - *Continued co/by-product characterization*
  - *Feedstock development "omics"*
- Thermochemical Samples
  - *Characterization of conversion team products*

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Co-Products from Bagasse & Resin (Brewer & Jena groups @ NMSU)

- Provide bagasse characterization to support guayule and guar variety and agronomy trials
- Produce manuscripts on lignocellulosic biomass conversion methods, guayule and guar bagasse evaluation for feedstock
- Research guayule resin separation methods as resin characterization results are available
- Find or measure data needed for guayule and guar processing models, specifically for lignocellulosic pretreatment and hydrothermal liquefaction

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Co-Products from Bagasse & Resin–Needs from Collaborators

- Samples of bagasse to understand variability with different varieties and growth conditions
- Information about samples
- Requests for characterization and/or processing data
- Field trips to guayule and guar processing facilities to train new researchers
- Assistance and training with analytical methods
- Results from process models to advise on method down-selection

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SYSTEM PERFORMANCE & SUSTAINABILITY

Trent Teegerstrom, Clark Seavert, Paul Gutierrez,
Jason Quinn, Amy Landis

SBAR

Teegerstrom & Seavert

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

Whole Farm Economic Analysis and Producer Decision Scenarios

- Identify appropriate methods for whole farm analysis
- Secure reliable data on Guar and Guayule yield, production cost and prices for the development of a robust Enterprise budgets in AZ
- Update yield, production cost and prices for alfalfa hay, cotton, corn, wheat and grain sorghum for the development of a robust Enterprise budgets in AZ
- Establish whole farm economic analysis scenarios for AZ and NM farms
- Work with NM Economic team for NM budgets of all crops noted above
- Created the base economic analysis for exploring the impacts and sensitivities that influence Guar and Guayule production and economic profitability in AZ.
- Completed the costs and returns of establishing and producing Guayule for Arizona
- Completed AgProfit budgets for alfalfa hay, cotton, corn, wheat and grain sorghum in AZ
- Use NM team budgets of integration into the base economic analysis for exploring the impacts and sensitivities that influence Guar and Guayule production and economic profitability in NM

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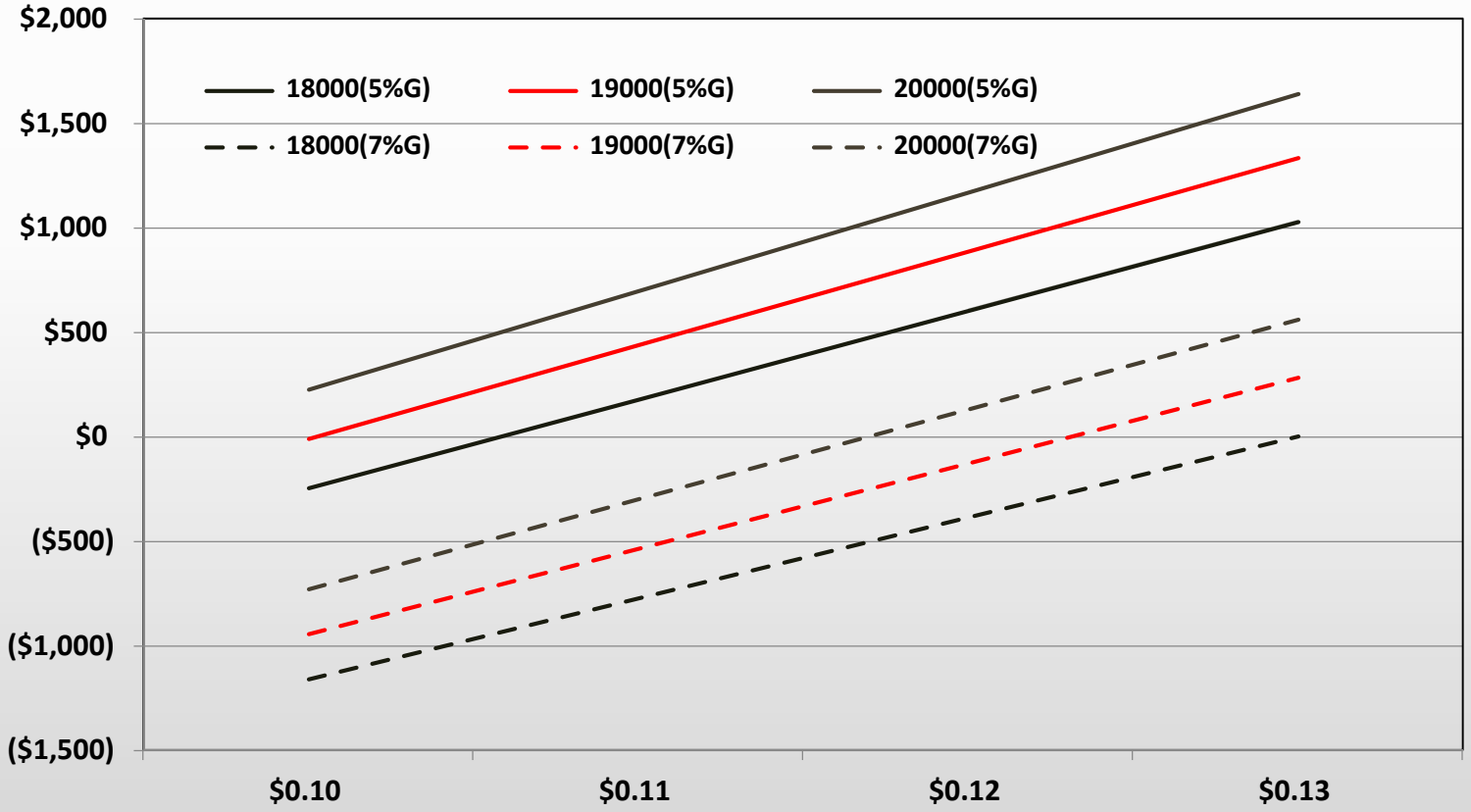
Sensitivity Analysis of Growing Guayule vs. Cotton, Wheat and Alfalfa Rotation, Seven Year Analysis (7% & 5% Discount Rate for Guayule vs. Alternative Rotation)



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Power Units and Equipment Total Hours When 25% Guayule Production Replaces Cotton, Wheat and Alfalfa Hay, 7-Year Rotation.

Power Units & Equipment	Base Operation Total Hours	25% Guayule Total Hours	**Difference Total Hours**
175 HP 4WD Tractor	3,475	2,977	**(498)**
125 HP 2WD Tractor (2)	9,448	6,688	**(2,760)**
V-Ripper	-	121	**121**
Offset Disk, 18'	1,123	897	**(226)**
Drag, 18'	1,838	1,379	**(460)**
Shank Chisel	793	679	**(113)**
Moldboard Plow	933	599	**(333)**
Landplane	-	61	**61**
Float, 20'	307	153	**(153)**
4-Row Lister	433	402	**(31)**
Bed Shaper	-	36	**36**
8-Row Planter	194	180	**(14)**
8-Row Cultivator	606	480	**(127)**
Drill	280	210	**(70)**
Cotton Stripper, 2-Row	522	261	**(261)**
Cotton Trailer, 8 Bale	840	420	**(420)**
Shredder, 2 Row	243	121	**(121)**
Swather (2)	3,080	2,310	**(770)**
Baler (2)	4,813	3,609	**(1,203)**
Bale Wagon (2)	4,813	3,609	**(1,203)**
Fert. Broadcast	-	29	**29**
Fert. Sidedress	-	55	**55**
Boom Sprayer, 30'	-	25	**25**
Saddle Tank Sprayer	-	55	**55**

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Future Research/Work

- Finalize Guayule Budget
- Explore interventions for Guar profitability at the farm level
  - *Price Hedging*
  - *Value Added*
- Economic Impact Analysis of Guayule/Guar production on Rural Economies
- Publication on Farm level Economic Impact Analysis
- Preliminary Regional Impact Analysis of Guar/Guayule production (Farm Income + Industry Sales)

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Research Needs

- Connect with Clark/Trent for Production Sales or Value (Gross Revenue)
  - *Guayule and Guar by County, NM & AZ*

- Connect with Jason for estimates on industry value of producing Guayule and Guar based on the TEA

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SBAR

Quinn

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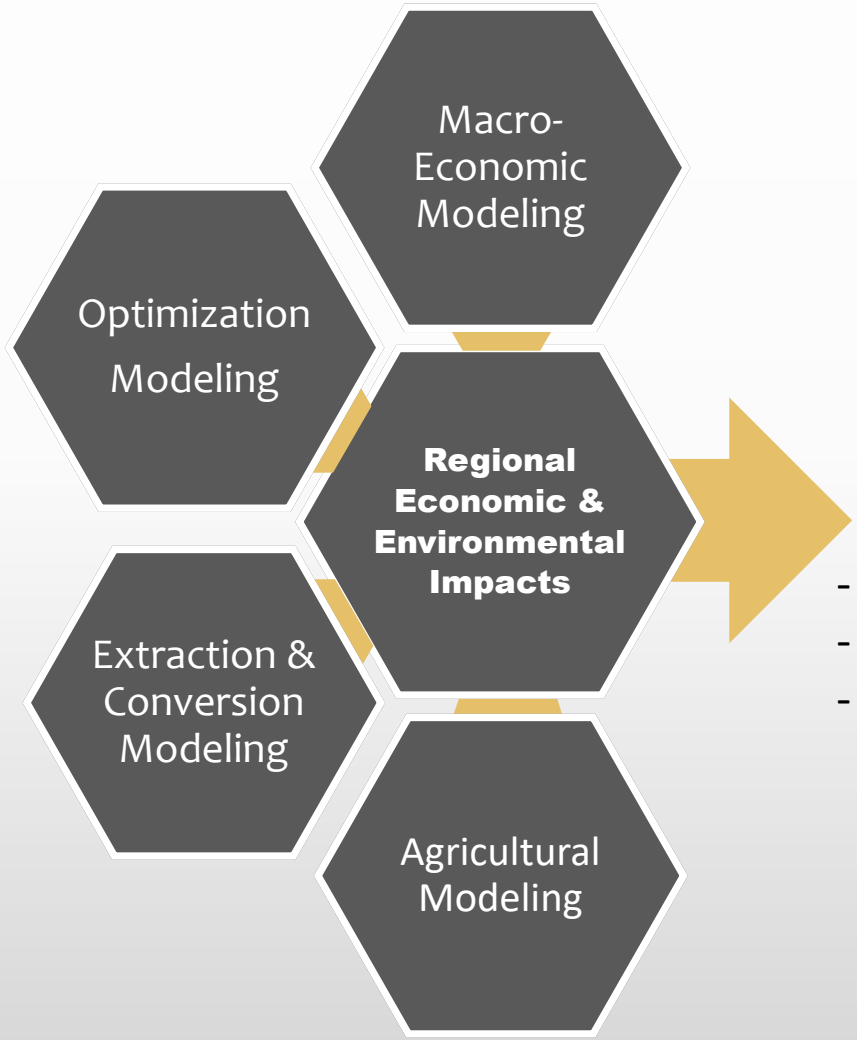
Colorado State University



- Sensitivity analysis
- Feedback to agricultural groups
- Feed forward to extension/education

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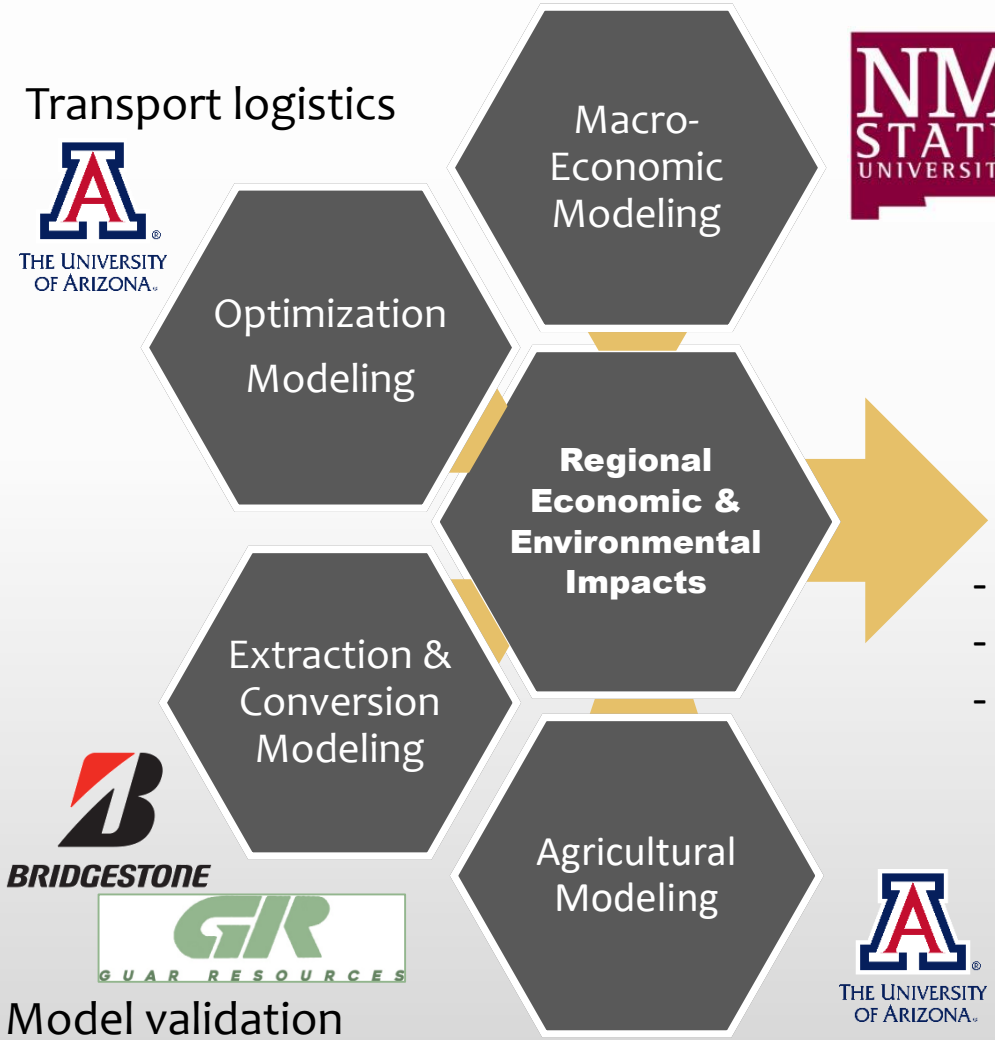
Colorado State University



Transport logistics

IMPLAN Modeling

- Sensitivity analysis
- Feedback to agricultural groups
- Feed forward to extension/education

Model validation

Selling prices
LCA impacts

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SBAR

Landis

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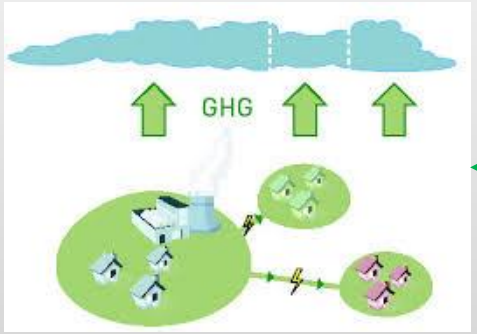
Future Directions

- Incorporate field data from SBAR teams into sustainability models
- Compare guar agriculture with traditional systems
- Complete scenario analyses focused on:
  - *Impacts of each agricultural process using minimum, max, & of interest values form literature*
  - *Impacts of irrigation and harvesting using various alternative methods*



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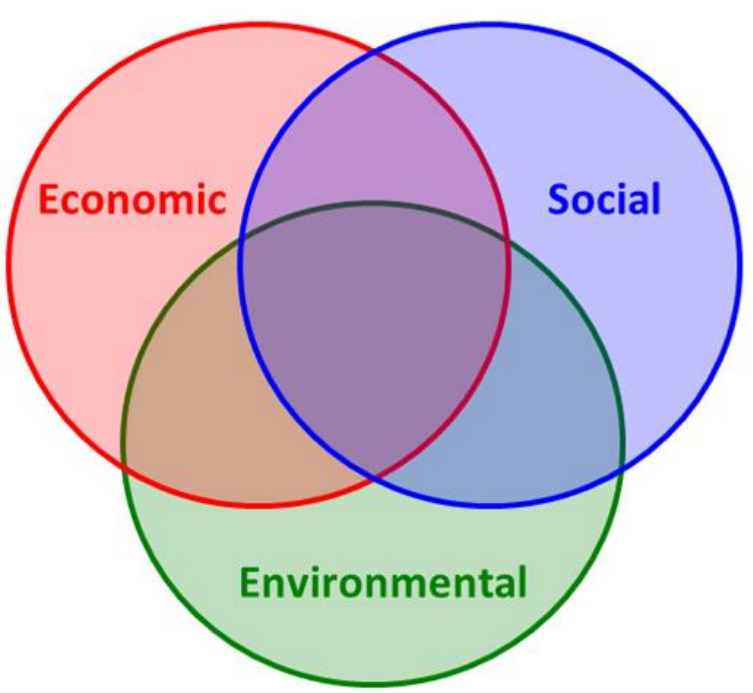
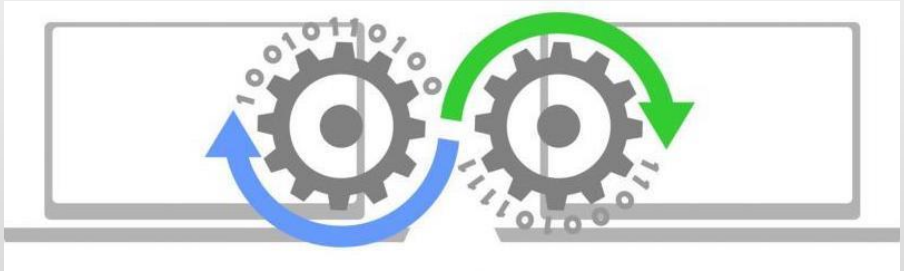
Future Needs

- Consult with most teams to collect data for all processes involved in both crops' production
  - *Ex. Field data from guar and guayule demonstration plots*
- Collaboration with other teams to integrate into social sustainability and economic sustainability assessments





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EDUCATION

Sara Chavarria, Catie Brewer, Kim Ogden

Education Team – Year 2

Sara Chavarria & Corey Knox – UA College of Education

Catie Brewer – NMSU Engineering

Torran Anderson & Cara Duncan – UA SBAR Coordinators

Stephanie Sikora – UA Institute for Energy Solutions

Istvan Molnar – UA Agriculture and Life Science

Kim Ogden – UA Engineering

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Education Goals

- Throughout project, support Graduate student fellows in learning about lesson design and effecting learning communication approaches.
- By year 5 have a national curriculum program addressing the role of biofuels, bioproducts, and bio-economy for arid regions.
- Incorporate biofuels into the graduate and undergraduate curriculum.

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What will be taking place Fall 2018-Spring 2019?

1. Fellows –**10 hours a week** on commitment to teacher partner (includes researching ideas, designing lessons, helping to deliver lessons, and meeting with their teacher regularly to discuss new ideas).
   - Fellows meet weekly in a graduate seminar. Sara, Corey and team will help the fellows with the lesson writing necessary to post lessons online.

2. Corey (and Sara) will **check in with teachers** throughout the year
   1. Evaluator will interview teachers and fellows during the academic year.

3. Begin **recording mini informative videos** on specific topics (30 seconds to 2 minutes in length).

Who will be recorded?: Graduate fellows, educators, researchers, partners, & extension personnel.

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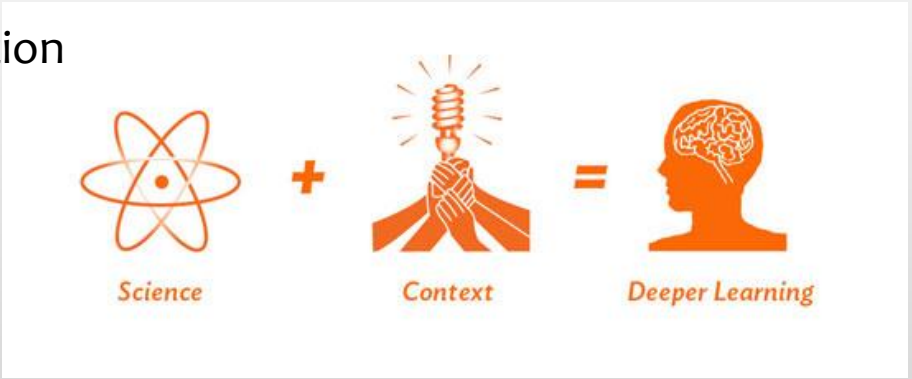
Graduate Student Seminar

Weekly one-hour meetings with UA based Fellows and New Mexico Fellows participating via **Zoom**.

Facilitated by Torran, Cara, Corey, Sara and guest presenters.

Proposed Topics:

- **Culturally relevant science**—place-based/culture infused science education
- **5 E Model**
- **Building learning around student interests**
- **Collaborating with teachers**
- **Lesson planning** and effective execution
- Exploring **classroom challenges**?



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What will be taking place Summer 2019?

Teacher cohort 1 – begin work for a second year - Dates: July 8-12.

-Teachers will work on refining lessons.
-Support Teacher Cohort 2 teachers
-Brainstorm the creation of a PD program for Summer 2020.

Cohort 2 begins – will recruit 4 new middle school teachers (from Native American and rural communities): 2 from NM and 2 from AZ. They will participate in the Train the Trainer effort at NMSU. Fellows to partner with cohort 2 will be recruited as well. Dates July 1-3.

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Train the Trainers -- Year 2 Plan (Brewer & Gutierrez groups @ NMSU)

- 3-Day camp for 4-H agents and volunteers, and NM teachers and fellows at NMSU
- July 8-12 teacher professional development for NM and AZ teachers and fellows
- Focus on middle school and rural/Native American-serving schools

July 1	July 2	July 3
Materials from Biomass	Growing Biomass	Bioeconomy and Careers
Nature/ Biochemistry of Biomass	Agriculture in Arid Regions	Research Methods
Biofuels and Biomass Conversion	Visit to Fabian Garcia and Leyendecker	Measuring Sustainability
	Guar and Guayule	SBAR Research Areas

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Needs from Collaborators

- Seeds, seedlings, material samples, and pictures for classroom show-and-tell
- Classroom visits and Q&A phone calls from researchers
- Field trips to industry partner and university research facilities
- Updates on project goals, successes, and challenges for a middle school audience
- Help with recruiting graduate fellows for Year 3: need 4 in New Mexico and 4 in Arizona for May 2019-May 2020
- Video-taping requests for our video resource library

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Year 2 – Evaluation and Courses

- Continue evaluation of summer programs and use analysis for improvement.
- Finalize tools for evaluating interest in STEM fields and methods for obtaining and analyzing data
- Identify existing courses that can readily include more examples related to biofuels and bioproducts and determine steps to developing graduate certificates and interdisciplinary programs

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Integration of Education Projects (Ogden – UA)

- Ensure that the 4H modules and Lessons developed through the teachers and fellows are shared and continuously improved
- Develop a detailed path forward and timeline for dissemination on a larger scale
- Develop path forward for training more rural teachers and students after modules and lessons are developed, tested, evaluated and improved locally in Tucson and Las Cruces.

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EXTENSION & OUTREACH

Channah Rock, Sangu Angadi, Paul Gutierrez,
Kulbhushan Grover, John Idowu, Jerry Lopez

SBAR – Extension Grower-Focused/4-H YEAR TWO PLANS

Main Objectives of this group

- 5.1 Produce Extension bulletins and web materials to inform growers of agronomic and irrigation requirements. Conduct needs assessment of growers
- 5.2 Hold workshops throughout the region on sustainable practices to expand crop production to new rural regions and Native Nation lands. Use existing meeting to introduce project.
- 5.5 Involve youth in 4-H projects and STEM summer camps.

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Key Contributors

Leads/Co-PIs

- Dr. Channah Rock – U of A
- Dr. Jerry Lopez – U of A
- Dr. Paul Gutierrez – NMSU
- Dr. Kulbhushan Grover – NMSU
- Dr. Sangu Angadi – NMSU
- Dr. John Idowu – NMSU

Staff members

- Natalie Brassill
- Darien Pruitt
- Sarah Acquah
- Craig Bal
- Matthew Katterman
- Graduate Students

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SBAR

Dr. Rock

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The SBAR Southwest EXTENSION TEAM

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Associate Professor & Water Quality Specialist
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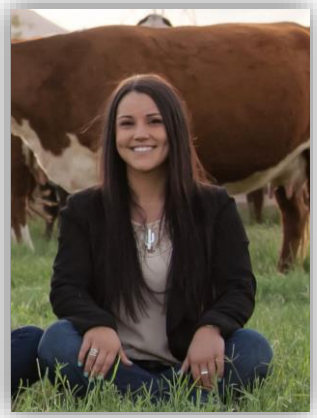

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Water Quality Microbiology

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WHERE EXTENSION FITS INTO EACH SBAR OBJECTIVE

OBJECTIVE 1: Feedstock Development

Extension: Take results from research and give feedback to industry about how to take action based on findings.

OBJECTIVE 2: Sustainable Production

Extension: Take findings from production experiments and build this knowledge into a useful resource guide for growers to make decisions about production agriculture. Communicate current practices back to the research team.

OBJECTIVE 3: Logistics

Extension: Take results from logistics models/assessments and make useful guides about what pathways work best for certain conditions or is most cost effective for growers.

OBJECTIVE 4: Economics and Sustainability

Extension: Translate grower needs into questions for the economics and sustainability teams to consider/answer.

OBJECTIVE 5: Extension, Education, Outreach

Extension: Design and deliver useful products/advice for growers and industry, take ideas from K-12 and 4-H education curriculum and apply those techniques to teaching adults about similar concepts around biofuels (etc.), develop student intern objectives to meet research goals.

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Year 2 Objectives – Extension SBAR

- Establish a clear pathway for Extension to familiarize ourselves with the current stage, and planned status, of research pertinent to stakeholders
- Clear development of the end goals for year 2 with collective input from Research, Education, and Outreach teams on anticipated outputs – **What are the key elements the extension team can use to prime industry?**
- Additional recruitment of Project Puente students for agricultural internships - Summer 2019
- Refined communication plan to involve Extension in broader program discussions – stakeholder needs important to research

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Dr. Lopez

Plans for next years 2019 4-H Summer Camp

- Recruit 20 students from diverse backgrounds
- Decide if it will be an overnight camp
- Make it available statewide

- Build on first years experience i.e. logistics, schedule, activities
- Build on the biofuel lessons/experiments
- Extend biofuel activities throughout the year

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Dr. Gutierrez

Future Extension/4-H

- On Farm Demonstration plots; Guayule and Guar
- Producer Educational Material
  - *Enterprise Budgets*
  - *Crop Rotation Scenarios*
- Experimentation and Farm Walks
- New Mexico SBAR 4-H Camp
  - *Train the Trainer*
  - *At least 4 SBAR 4-H Camps*
  - *Targeting Hispanic and Tribal communities*

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Extension/4-H Needs

- Connect with SBAR researches/current production and ergonomic data
  - *Guayule and Guar, NM & AZ*
- Connect with SBAR 4-H/Teacher professional development team
  - *Update 4-H/Teacher curriculum*

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Dr. Gutierrez

Future Research/Work

- Finalize Guayule Budget
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  - *Value Added*
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- Publication on Farm level Economic Impact Analysis
- Preliminary Regional Impact Analysis of Guar/Guayule production (Farm Income + Industry Sales)

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Research Needs

- Connect with Clark/Trent for Production Sales or Value (Gross Revenue)
  - *Guayule and Guar by County, NM & AZ*

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Dr. Grover

SBAR Guar extension outreach

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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SBAR Guar Demonstration Trials




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Guar Extension- Year 2

- On- Farm Demonstration Trial on Guar
- Field Day presentation on Guar
- Interaction with growers
- Information dissemination on SBAR/Guar

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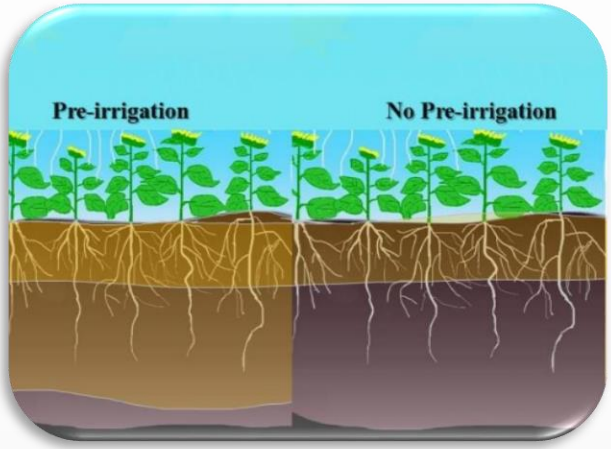
Dr. Angadi

Guar Extension and Outreach:

Sangu Angadi Plan for Year 2

Demonstrations/Agronomic Trials

- *Guar Phosphorus and Rhizobium Trial*
- *Guar Deficit Irrigation Management*
- *Guar Cultivar Demonstration*



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Guar Extension and Outreach:

Sangu Angadi Plan for Year 2

Extension Activities:

- *Special Guar Field day and Field Tours*
- *Visit and Interact Guar Farmers*
- *Visit Guar Resources and Discuss with Agronomists*
- *Collect Good Guar Pictures and Products for Future Extension Publications*
- *Visit Guar Producers, Researchers, Processors in India and Learn from their Long Experience*

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Dr. Idowu

Idowu – Plans for Year 2

- Introducing SBAR project to growers, Ag. Professionals, Extension educators and the public
  - *Will continue in NM*
  - *Need to strengthen efforts in AZ (working with Dr. Channah Rock; Rick Gibson and Dr. Randy Norton)*
- Recruitment of farmers to host on-farm trials
  - *Maintain links with identified growers in NM*
  - *Need to identify growers in AZ (work with Dr. Sam Wang, Rick Gibson and Dr. Randy Norton)*

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Idowu – Plans for Year 2

- Constituting local SBAR advisory committee for NM
  - *Schedule meetings for NM advisory committee (possible visit to guayule fields and Bridgestone processing facility in AZ)*
  - *Constitute an advisory committee in AZ???*
- On-farm/on-station demonstration trials
  - *Continue on-station trials in NM*
- Development of printed and web-based materials on production practices for guayule and guar
  - *Will depend on materials available from research groups*

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