SUSTAINABLE BIOECONOMY FOR ARID REGIONS (SBAR)

Summary Report – Quarter 3, 2021

Information submitted by project partners; synthesized by:
Alix Rogstad, Director of Operations

USDA Cover Page

Federal Agency and Organization Element to Which Report is Submitted	**United States Department of Agriculture – National Institute of Food and Agriculture**
Federal Grant or Other Identifying Number Assigned by Agency	**2017-68005-26867**
Project Title	**Sustainable Bioeconomy for Arid Regions (SBAR), Center of Excellence**
PD/PI Name, Title and Contact Information (email address and phone number)	**Kimberly L. Ogden, Ph.D.** **ogden@email.arizona.edu** **520.621.9484**
Name of Submitting Official, Title, and Contact Information (email address and phone number), if other than PD/PI	**Same**
Submission Date	
DUNS and EIN Numbers	**DUNS 94-336-0412** **EIN 74-2652689**
Recipient Organization (name and address)	**Arizona Board of Regents** **University of Arizona** **Tucson, Arizona 85721-0518**
Recipient Identifying Number or Account Number	
Project Grant Period (start date, end date)	**01 Sep 2017 – 31 Aug 2022**
Reporting Period End Date	
Report Term or Frequency (annual, semi-annual, quarterly, other) *USDA-NIFA Project Number*	**Annual** **ARZW-206-11192**
Name of Submitting Official	*Signature / Date*

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PHOTOS

ACCOMPLISHMENTS
July 2021 – September 2021

INTRODUCTION AND MANAGEMENT

General Overview: Organization

The Sustainable Bio-economy for Arid Regions (SBAR) Center of Excellence continues under the direction of Dr. Kimberly Ogden, Executive Project Director, who leads the overall research effort and ensures adequate progress toward meeting goals. The SBAR Director of Operations (Alix Rogstad) continues to oversee operations and manage all of the day-to-day project administration and business affairs, as well as coordination, communication, and data sharing among partnering organizations and institutions.

A comprehensive project evaluation plan, approved in July 2018, continues to effectively capture detailed progress on the project's defined objectives. As a living document, the evaluation plan will change to reflect revised research questions, project goals and big-picture, overall objectives. An overall management review and update will be implemented in February 2022.

Advisory Board

The research has moved to a point that requires executed non-disclosure agreements (NDA). As of August 2021, five Advisors chose to leave the Board (Matt Chavez, Gary Deen, Homer Marks, Newt McCarty, and Matt Payne). No other changes were made to the Advisory Board make-up during this quarter (Table 1).

Table 1. *SBAR Advisory Board members.*

Advisory Board Member	Company/ Representation	Year Joined Board
Chris Cassidy	USDA, Rural Development	2018
Steve Csonka	Commercial Aviation Alternative Fuels Initiative (CAAFI)	2017
William Goldner	USDA, National Institute of Food and Agriculture	2017
John Holladay	Pacific Northwest National Laboratory LanzaTech	2019-2021 2021
Chris Kuzdas	Environmental Defense Fund	2018
Jaroy Moore	Texas A&M Agrilife Research & Extension Center	2017
Alex Muravijov	Guar Resources	2017
Paul "Paco" Ollerton	Tierra Verde Farms, AZ	2019
Ron Shaffer	Bridgestone Americas, Inc.	2021
Bob White	Bridgestone Americas, Inc.	2017

The Advisory Board meets frequently (4 times/year) so that (1) relevant research updates can be shared; (2) Advisors can drill down into specific Component work as it is underway; and (3) the researchers can solicit comments/suggestions for improving research direction or overcoming challenges. Ultimately, the goal for these meetings is to ensure that SBAR can remain agile in addressing changing priorities and circumstances.

The Advisory Board met in-person (some virtually) during the 2021 Annual Retreat on Thursday, 12 August. During the meeting, the Advisory Board discussed facets of the research that are working well and the pieces that are not progressing as anticipated. They offered guidance for priority work that needs to be the focus for Year 5 and any subsequent proposals for future work. The next Advisory Board meeting will be scheduled in November 2021 to ensure that the research and outcomes remain on track. It is anticipated that an additional 3 Advisory Board meetings will be held in 2022.

Budget and Financial Management

No budget issues occurred during the last quarter. Budget management activities continued to work effectively, and all project expenditures are on track. Rogstad continued to maintain sub-award agreements and sub-award modifications, non-disclosure agreements, and work with partners to ensure grant funds are spent according to the project plan and approved scopes of work.

As of the end of August 2021, Colorado School of Mines (CSM) completed their portion of the project and the subaward will be closed out by November. All other sub-awards remain fully activated with project partner institutions: Bridgestone Americas, Inc., New Mexico State University (NMSU), Colorado State University (CSU), and the USDA-Agricultural Research Service (USDA-ARS). All sub-awards are progressing appropriately.

Component Working Group Meetings

All five SBAR component working groups continued to participate in scheduled online meetings to ensure forward momentum on all project tasks. Smaller focus group meetings were scheduled and facilitated as necessary, including budget meetings and partnership development meetings. During this quarter's reporting period, the virtual meeting space (via Zoom) was utilized 59 times for over 57.25 hours, which included over 21 hours for the virtual portion of the 2021 Annual Retreat in August. The total number of participants during this quarter showed a steady participation rate for all working group meetings (n=453) as compared with previous quarters. September did show a bump upward in participation as compared with participation numbers in July and August, which is likely a result of the fall semester getting underway with in-person classes and reduced COVID restrictions nationwide.

Photo 1. *The Education Component met in hybrid fashion (in New Mexico and Arizona) to finalize future implementation plans.*

LEADS Team Meetings

The component leaders and co-leaders (LEADS) continued to meet with Ogden and Rogstad during established fortnightly meetings held via SBAR's dedicated Zoom online meeting space. The LEADS provide guidance for project decisions, and assist with resolving internal conflicts that are brought for discussion. This has proven to be an effective way to communicate key issues requiring short turn-around times.

During the third quarter, the LEADS finalized Year 5 spending and budget allocations, resolved a minor budget issue related to a supercritical fluid extractor at NMSU, completed preparations for the 2021 Annual Retreat (hosted in August), prepared briefing papers on specific SBAR topics, and prepared for the Domestic Rubber Symposium to be hosted during the *Tech Connect* Conference in Washington DC in October.

SBAR Annual Retreat

The 2021 SBAR Annual Retreat was planned and hosted as a hybrid event at the University of Arizona in Tucson from 11-13 August 2021. The full meeting agenda is available in the Appendices. (Appendix 1) The Retreat included updates from industry partners and visionaries, research highlights for each Component, an Advisory Board meeting and open networking periods. There were also multiple opportunities for student engagement through dialogue with colleagues and oral/poster presentations. Component working sessions were scheduled and hosted on Wednesday, 11 August, to provide ample time for working team discussions and prioritization for Year 5 and potential Year 6 work.

Photo 2. *Feedstock & Development Component working session during the 2021 SBAR Annual Retreat.*

The Retreat plenary sessions were hosted in hybrid format to allow participation from those not yet able to travel. Approximately 45 people attended sessions virtually while another 50 people attended in-person.

JASON QUINN HAS SAID
"IS THE JUICE WORTH THE SQUEEZE?" AND
MANY LAUGHS WERE HAD
~Valerie Teetor

Figure 1. A *haiku submitted during the 2021 SBAR Annual Retreat.*

An interactive "Haiku Corner" was a highlight for this year's Annual Retreat, which proved to be an interesting and fun conversation starter for many. A compiled list of all haikus generated are provided in Appendix 1.

Communication and Reporting

Rogstad continues to be the main point-of-contact for most SBAR communication. Various listservs are maintained that enable quick dissemination of pertinent and critical information. Rogstad also fields questions and liaises among project researchers, Advisors, partners, and students.

Reporting schedules for researchers are established and working well. Quarterly reports submitted are synthesized and made available to the research team and Advisory Board members. Summary reports are also posted to the SBAR website for wider dissemination. Each researcher is required to submit a self-evaluation score/rank with their report, and they are asked to describe all issues that may put them at risk for meeting annual goals (as articulated in annual scopes of work). A Task Tracker Report is provided to the LEADS, which gives a status update for each team member per component. The Task Tracker Report is a proactive management tool that allows the identification of issues before they become risks for overall project completion.

Website, Social Media and Digital Tools

The SBAR-specific website (www.sbar.arizona.edu) continues to be regularly updated and maintained, serving as the digital "face" of the SBAR Center. Updates this quarter included project highlights that showcased new work, the addition of materials for the annual retreat, and major updates and revisions for the Extension & Outreach pages, including the Youth Development materials.

The SBAR webpage was visited by people in 41 different states of the USA during this quarter (Table 2). Since inception, the website has been viewed by people in all 50 states and the District of Columbia, which is an indication of wide interest in the ongoing research as well as the broad dissemination of information implemented by project partners.

Table 2. *Web traffic to the SBAR Center webpage from within the United States since inception.*

	Time Period					
State	**Jul – Dec 2018**	**Jan – Dec 2019**	**Jan – Dec 2020**	**Jan – Mar 2021**	**Apr – Jun 2021**	**Jul – Sep 2021**
Alabama			X	X	X	X
Alaska			X			
Arizona	X	X	X	X	X	X
Arkansas		X	X	X		X
California	X	X	X	X	X	X
Colorado	X	X	X	X	X	X
Connecticut			X			
Delaware		X	X	X		
District of Columbia	X	X	X	X	X	X
Florida		X	X	X	X	X
Georgia		X	X	X	X	X
Hawaii			X	X	X	X
Idaho		X	X	X		X
Illinois	X	X	X	X	X	X
Indiana		X	X	X		X
Iowa	X	X	X	X	X	X
Kansas	X	X	X	X	X	X
Kentucky		X	X	X	X	
Louisiana			X		X	
Maine			X			X

	Time Period					
State	**Jul – Dec 2018**	**Jan – Dec 2019**	**Jan – Dec 2020**	**Jan – Mar 2021**	**Apr – Jun 2021**	**Jul – Sep 2021**
Maryland	X	X	X	X	X	X
Massachusetts		X	X	X	X	X
Michigan		X	X	X	X	X
Minnesota		X	X	X	X	X
Mississippi		X	X	X	X	X
Missouri		X	X	X	X	X
Montana		X	X	X		X
Nebraska		X	X	X		X
Nevada		X	X	X	X	X
New Hampshire			X			
New Jersey			X	X	X	X
New Mexico	X	X	X	X	X	X
New York	X	X	X	X	X	
North Carolina	X	X	X	X	X	X
North Dakota		X	X			X
Ohio		X	X	X	X	X
Oklahoma		X	X	X	X	X
Oregon		X	X	X	X	X
Pennsylvania		X	X	X	X	X
Rhode Island			X			
South Carolina	X	X	X	X	X	X
South Dakota		X	X			X
Tennessee	X	X	X	X	X	X
Texas	X	X	X	X	X	X
Utah		X	X	X	X	X
Vermont				X		
Virginia		X	X	X	X	X
Washington	X	X	X	X	X	X
West Virginia		X				
Wisconsin		X	X		X	X
Wyoming		X	X	X	X	X
Total	**15**	**41**	**49**	**41**	**36**	**41**

There were 1,106 unique sessions from July – September 2021. During this quarter, page views occurred in 36 different countries (top three: USA, India, and China), including 2 countries that have not visited the website previously (Lithuania and Zimbabwe). Visitors from the USA accounted for 81% of site visits during this reporting period, which was a decrease from previous quarters indicating a more world-wide interest in SBAR research. Site visits this period also showed a high interest from India, China, Canada, United Kingdom, and Philippines, which accounted for another 9% of site visits overall.

There have been 14,297 unique website sessions since July 2018. Since activation, the website has had visitors from 6 continents and 90 different countries around the world (Table 3). The highest visited website pages during this reporting period included those associated with the

annual meeting and retreat, those associated with digital lessons and educational resources, those that describe our team and partnerships, and those that showcase ongoing research for characterization and co-products. Other highly visited pages included those highlighting feedstock and development research and those that provide grower-focused information for guayule and guar. The website will continue to be updated regularly as the project unfolds.

Table 3. *International web traffic to the SBAR Center webpage since inception.*

Country	Time Period					
	Jul – Dec 2018	Jan – Dec 2019	Jan – Dec 2020	Jan – Mar 2021	Apr – Jun 2021	Jul – Sep 2021
Afghanistan				X		
Algeria			X		X	
Argentina		X	X	X	X	
Australia	X	X	X	X		X
Austria	X	X	X	X	X	
Bahrain			X			
Bangladesh		X	X	X	X	X
Belgium		X	X		X	X
Belize			X			X
Bolivia			X			X
Brazil		X	X	X	X	X
Cameroon			X			
Canada	X	X	X	X	X	X
Chile		X	X		X	
China	X	X	X	X	X	X
Colombia		X	X	X		X
Congo-Kinshasa		X				
Costa Rica				X		
Côte d'Ivoire		X	X			
Cyprus		X				
Denmark			X		X	
Ecuador			X			X
Egypt	X				X	
Estonia		X				
Ethiopia	X		X			
Finland			X	X	X	X
France		X	X	X	X	X
Germany	X	X	X	X	X	X
Ghana		X	X	X		
Grenada			X			
Greece			X	X		
Honduras		X			X	
Hong Kong	X	X	X	X	X	
Hungary			X		X	
India	X	X	X	X	X	X
Indonesia		X	X			X
Iran	X	X	X	X	X	X

Country	Time Period					
	Jul – Dec 2018	Jan – Dec 2019	Jan – Dec 2020	Jan – Mar 2021	Apr – Jun 2021	Jul – Sep 2021
Iraq			X			
Ireland		X		X		X
Israel		X		X	X	
Italy	X	X	X	X	X	X
Japan	X	X	X	X	X	
Jordan			X	X		
Kenya		X	X		X	
Kuwait	X	X	X			
Lebanon		X				
Libya			X			
Lithuania						X
Malaysia		X	X	X		X
Mexico	X	X	X	X	X	X
Morocco		X				
Namibia		X				
Nepal	X	X	X	X		
Netherlands		X	X	X	X	X
New Zealand	X		X			X
Nigeria		X	X	X	X	X
Norway			X	X		
Oman			X			
Pakistan	X	X	X	X	X	X
Papua New Guinea				X		
Paraguay		X				
Peru		X				
Philippines	X	X	X	X	X	X
Poland		X	X			
Portugal		X				
Puerto Rico			X	X		
Qatar		X	X			
Romania			X			
Russia		X		X		X
Saudi Arabia		X	X	X		
Serbia			X	X	X	X
Singapore		X	X		X	X
South Africa		X			X	X
South Korea		X	X	X		
Spain		X	X	X	X	X
Sri Lanka		X		X		
Sweden		X	X			
Switzerland			X		X	X
Taiwan		X				
Thailand	X	X	X		X	X
Tunisia			X			
Turkey	X	X	X	X	X	

Country	Time Period					
	Jul – Dec 2018	Jan – Dec 2019	Jan – Dec 2020	Jan – Mar 2021	Apr – Jun 2021	Jul – Sep 2021
Uganda			X			
Ukraine		X				
United Arab Emirates		X			X	
United Kingdom	X	X	X	X	X	X
United States	X	X	X	X	X	X
Vietnam		X	X		X	
Zambia		X				
Zimbabwe						X
Total	**22**	**60**	**65**	**43**	**39**	**36**

FEEDSTOCK DEVELOPMENT & PRODUCTION

Project Coordination: The Feedstock Development (FD) Team holds a single joint monthly meeting and periodically meets on an as-needed basis in between monthly meetings to address specific topics. The UA leads these meetings (Dr. Dennis Ray), which are leveraged to ensure all team members are on schedule and research work can seamlessly integrate between components. The FD team members also meet during weekly research team meetings (all-hands) hosted at the UA and monthly at New Mexico State University. These briefings provide an opportunity for open communication regarding on-going experiments, issues/challenges, and results for both guayule and guar research. Quarterly summary reports provide an opportunity to discuss relevant research topics and questions that may need further exploration.

Issues/Risks:
Abdel-Haleem: Even with COVID-19 pandemic situation and USDA policies of minimum essential operations and maximum teleworking, it is expected to meet the 2021 milestones.

Angadi: Publications from deficit irrigation trial were delayed. First draft of manuscript summarizing guar biomass and seed yield production in response to different deficit irrigation management strategies is prepared and second manuscript on water extraction patterns and water use efficiencies under deficit irrigation management strategies is being prepared. We target to submit both manuscripts by the end of summer.

We are hoping to start trial assessing temperature requirement for germination and early growth of USDA germplasm after field trials are harvested and samples are processed.

Dierig: We have experienced more rain than usual during the second season of growth.

Grover: Funding situation has been uncertain and insufficient for hiring students and staff affecting the overall progress.

McMahan: The USDA-ARS-WRRC location was closed, except for essential work, in response to the COVID-19 pandemic on March 17, 2020. While we have been able to maintain plants with essential staff, genotype/phenotype evaluations were delayed. Starting April 6, 2021, the laboratory was approved for non-essential work at 25% of the workforce. This has allowed us to begin rubber extractions and other phenotyping, but limited staff means even this work is proceeding slower than anticipated. We anticipate return to full staffing will begin Jan. 3, 2021.

Ray: Guayule inoculation project has been abandoned because fungal samples cannot be obtained.

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

Task #	Description of Task	Deliverable	Target Completion Date
1 Dierig	Evaluate USDA germplasm lines	Ploidy analysis completed Harvest/Analysis of first growth cycle completed	31 Aug 19 30 Apr 22
2 McMah	Complete first set of phenotyping results for soil grown SEP3i plants	Dataset in charts and tables	30 Sep 21
3 McMah	Transfer FT2 and LEAFY explants to soil	Plants in greenhouse	31 Dec 21
4 McMah	Publish results	Draft manuscript on SEP3i downregulation in guayule	30 Mar 22
5 Ray	Evaluate growth and rubber/resin content in guayule germplasm lines	Rubber/resin content determined in 21 guayule germplasm lines	30 Apr 21
6 Ray	Compare root growth/architecture and water use in direct-seeded and transplant-established guayule	Compare root growth/top growth/water use	31 Mar 21

Evaluate Germplasm Lines (Variety Trials):
Nothing new to report at this time. A full analysis and interpretation of data will be coming soon with all the trials together.

Complete first set of phenotyping results for soil grown SEP3i plants:
Flowering downregulation to increase yield: Our project seeks to enhance natural rubber content in guayule by downregulation of flowering. We are evaluating 3 genes/approaches, all involving downregulation (by RNAi) of genes known to have a role in flowering: Flowering Terminus (*FT2*), Sepallata (*SEP3*), and *LEAFY*.

Flowering Terminus-2 (*FT2*):
In growth chamber evaluations, transgenic guayule plants with downregulated *FT2* had a similar number of flowers to empty vector (yellow) and wildtype (green) plants. Recall, this contrasts with results from plants with downregulated *SEP3* which showed fewer flowers. Rubber and resin analyssi for the *FT2* set are now underway.

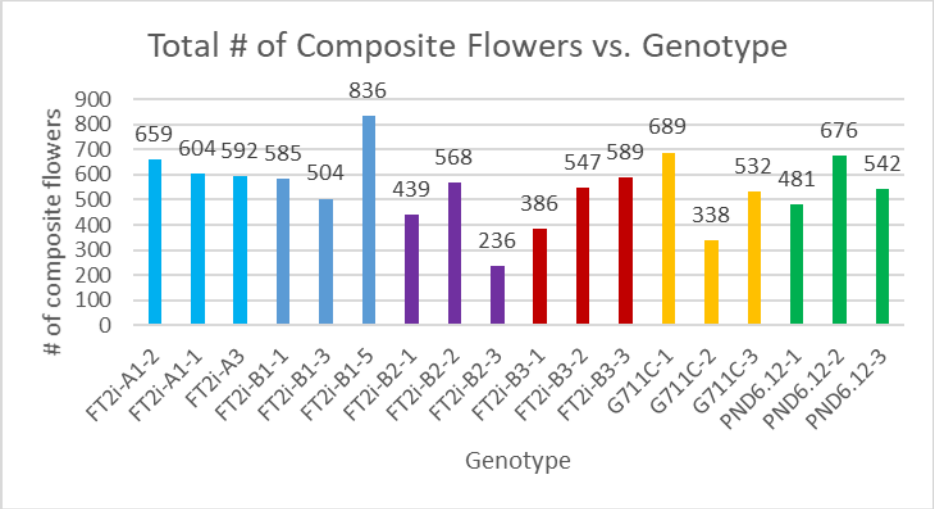


Figure 2. *Total number of flowers for FT2 transgenics and controls.*

Overall, other plant growth characteristics were also similar between *FT2* plants and controls.

Figure 3. *Plants following growth chamber testing (30 days 25C days/10C nights).*

Upper panel: G711C controls showing flowering. L to R: G711C-1, 2, 3.
Lower panel: "A" type transgenics showing flowering. L to R: FT2i-A1, A3, A2.

Sepallata (*SEP3*):

In 2Q21 a sample of greenhouse plants exhibited a low flowering phenotype. These plants grew under greenhouse conditions from 12/30/2020 to 8/27/21. The composite flower heads in most of the transgenics were discolored (grey) and peduncles (if any) were stunted in size.

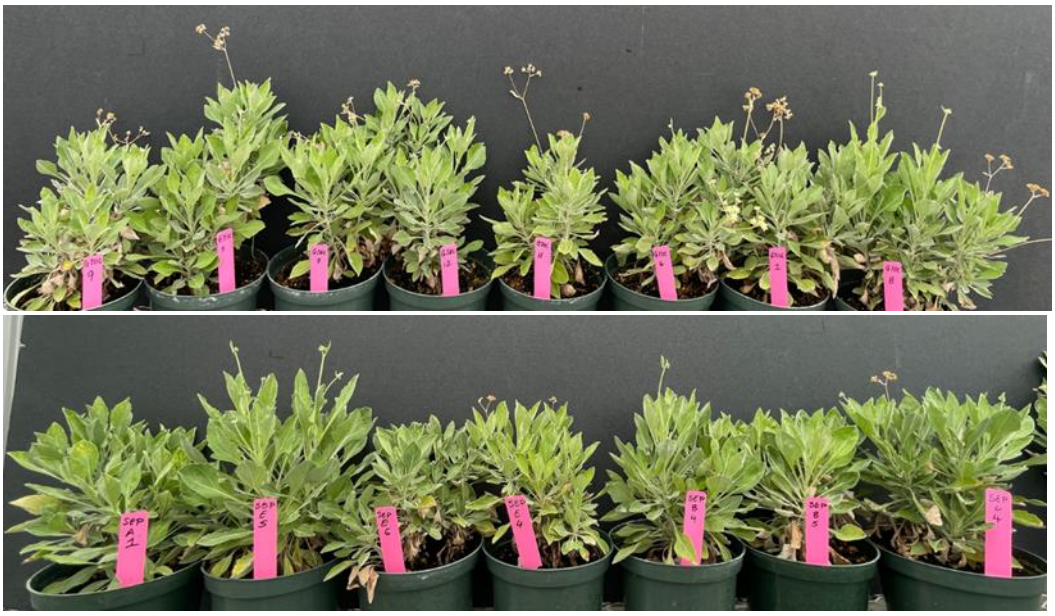


Figure 4. *Greenhouse-grown guayule plants' flowering comparison.*

Upper panel: G711C controls. L to R: G711C-9, 5, 7, 12, 11, 6, 1, 8.
Lower panel: Transgenics. L to R: SEP3i-A1, E5, E6, E4, B4, B5, C4.

Quantification of % rubber and resin for the *SEP3i* plants was performed by Accelerated Solvent Extraction. While rubber values were low, they are as expected for these young plants in pots. The general trend was for lower % rubber for *SEP3i* downregulated plants. There does not appear to be any difference in stem resin content for *SEP3i* compared to controls. The rubber and resin extraction and quantification for the rootbark of these transgenics and their controls is underway.

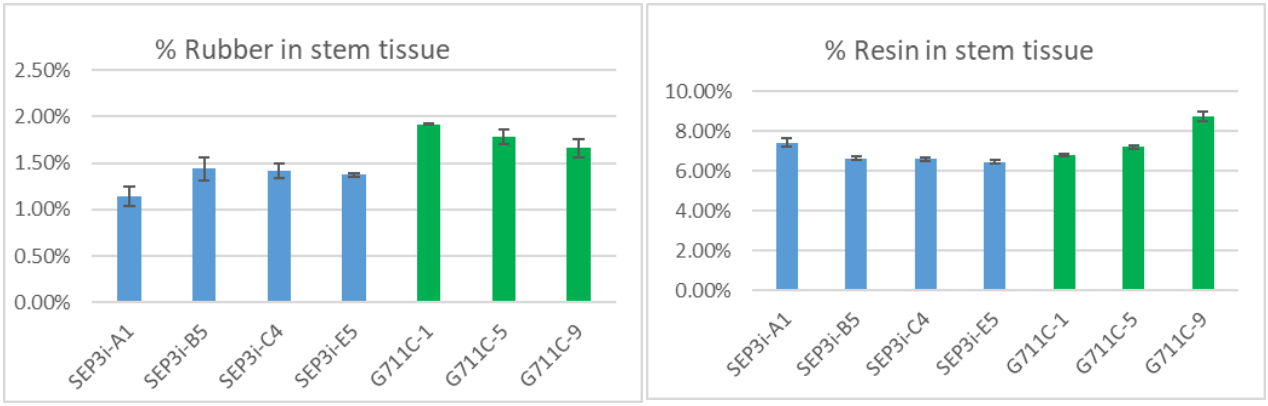


Figure 5. *Rubber (L) and resin (R) phenotype for guayule plants with downregulated SEP3i. Plants were transferred from tissue culture to soil, hardened in the greenhouse, then subjected to 30 days with 25C days/10C nights.*

LEAFY:

We continue to maintain a set of tissue cultured guayule plants with putative downregulation of the LEAFY gene. Confirmation of transformation by PCR has proven problematic (lack of

repeatability, possible amplification of an endogenous gene). It is also possible the plants are non-transformed escapes, so before they are moved to greenhouse/growth chamber testing, we are re-evaluating the plants' genotypes. A new set of primers has been prepared. Stay tuned.

Transfer FT2 and LEAFY explants to soil:
Nothing new to report.

Publish results:
Nothing new to report.

Growth and Rubber/Resin Content in Guayule Germplasm Lines:
A subset of samples was harvested to explore differences in irrigation treatments (full [every two weeks during active growth] or minimal [one per year]) over two years. Results of parameters measured and calculated are presented below.

Table 4. *Mean fresh weight (a), % resin (b), % rubber (c), height (d), yields of biomass (e), resin (f), and rubber (g) over two years and two irrigation types (min=one per year; full=every two weeks during active growth).*

a. MEAN FRESH WT (g)

Level	FALL 2019		SPRING 2020		FALL 2020		SPRING 2021	
MIN	242.3	a	165.9	b	449.9	b	714.3	b
FULL	208.9	a	303.5	a	1151.4	a	2178.3	a

b. MEAN % ACETONE EXTRACT ("RESIN")

Level	FALL 2019		SPRING 2020		FALL 2020		SPRING 2021	
MIN	3.13	b	5.87	a	6.50	a	7.47	a
FULL	4.22	a	4.96	b	6.00	a	7.00	a

c. MEAN % CYCLOHEXANE EXTRACT ("RUBBER')

Level	FALL 2019		SPRING 2020		FALL 2020		SPRING 2021	
MIN	2.48	a	4.70	a	5.62	a	8.03	a
FULL	1.75	b	4.05	b	3.77	b	5.93	b

d. MEAN HEIGHT (cm)

Level	SPRING 2020		SPRING 2021	
MIN	18.9	b	29.4	b
FULL	25	a	39.7	a

e. MEAN DRY WT YIELD (g/plant)

Level	FALL 2019		SPRING 2020		FALL 2020		SPRING 2021	
MIN	19.2	a	19.06	b	59.51	b	176.2	b
FULL	20.69	a	35.74	a	96.83	a	427.5	a

f. MEAN RESIN YIELD (g/plant)

Level	FALL 2019		SPRING 2020		FALL 2020		SPRING 2021	
MIN	0.6	b	1.08	b	3.75	b	13.18	b
FULL	0.84	a	1.75	a	5.89	a	29.73	a

g. MEAN RUBBER YIELD (g/plant)

Level	FALL 2019		SPRING 2020		FALL 2020		SPRING 2021	
MIN	0.47	a	0.87	b	3.29	a	14.24	b
FULL	0.35	b	1.44	a	3.78	a	25.73	a

Values in a column followed by the same letter are not significantly different.

Root Growth/Architecture Compared to Water Use in Direct Seed and Transplant-Established: This task is complete.

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

Task #	Description of Task	Deliverable	Target Completion Date
1 Abdel-H.	Phenotypic characterization - Guayule	Collect and analyze available phenotypic data; plant stand and establishment, plant height and width, flowering time, rubber, resin	31 Dec 21
		Collect and analyze first set of available high-throughput phenotyping (HTP) parameters: vegetation indices and reflectance	31 Dec 21
		Summary report completed	30 Jun 22
2 Abdel-H.	Phenotypic characterization – Guayule under stress conditions and stability	Field planting – plant and maintain USDA guayule collections	30 Jun 20
		Collect and analyze available phenotypic data: plant ht, plant width, flowering time, rubber, resin	31 Dec 21
		Collect and analyze available high-throughput phenotyping (HTP) parameters: vegetation indexes and reflectance	31 Dec 21
		Summary report completed	30 Jun 22
3 Angadi	Guar remote sensing	Seasonal multispectral data from deficit irrigation study	31 Mar 20

Phenotypic characterization – Guayule:
Final data analysis and publication preparation us underway.

Phenotypic characterization – Guayule Under Stress Conditions:
An experiment to test stress responses in USDA guayule genotypes, including genotypes are first time to be tested, and 6 common checks is planted at Maricopa, AZ to study responses of guayule genotypes growing under stress and non-stress conditions, and explore the interactions of irrigation treatments by genotypes (G x E) interactions. Normal irrigation schedules were stated as non-stress while reduced irrigation is stated as stress treatments. At both trials, plots are maintained by hand weeding as needed. The remote sensing data were collected 2 times and preliminary analyses were conducted. Even though the rainfall this year was above normal historically, it was enough to expose reduced plots to drought conditions. Estimation of the vegetation indexes and canopy temperatures were analyzed and results are shown below.

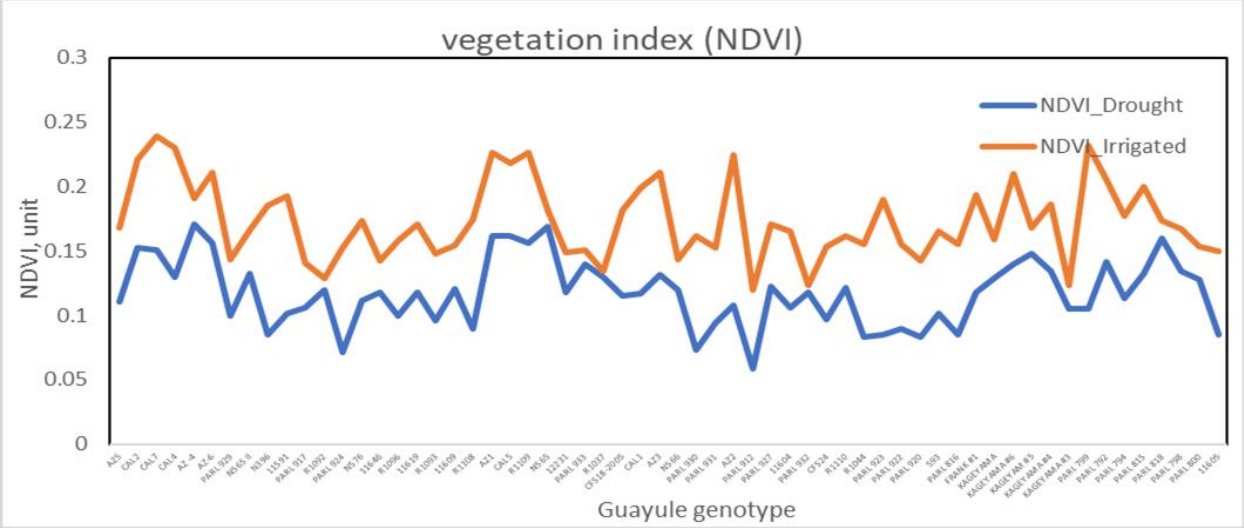


Figure 6. *Guayule genotype exposed to drought (stressed) and non-drought (irrigated) conditions.*

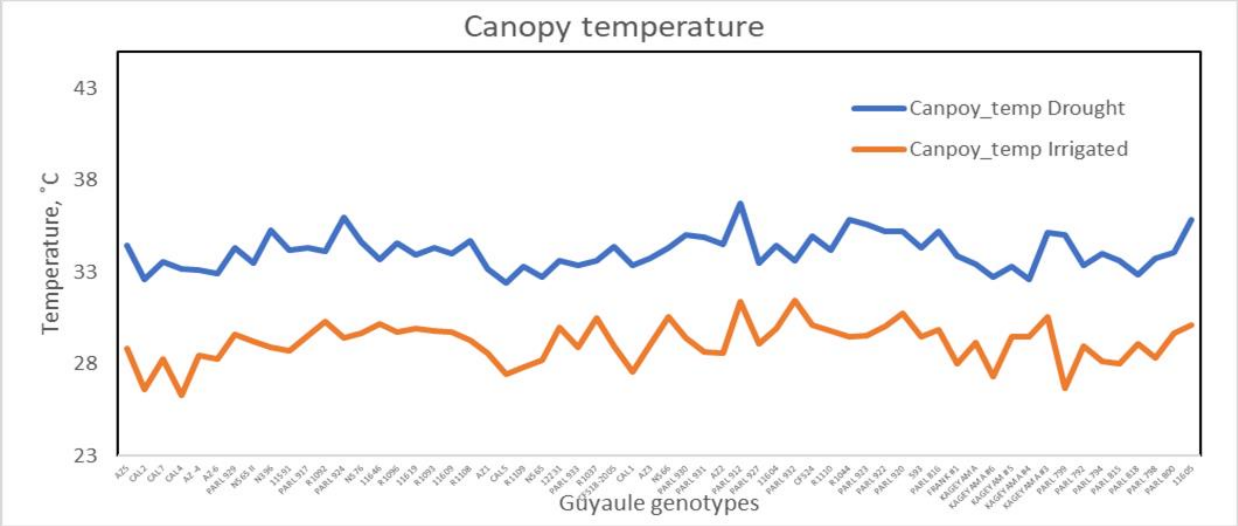


Figure 7. *Canopy temperature variance.*

Preliminary results showed that vegetation indexes and canopy temperatures are affected by genotypes as well as irrigation levels (stress conditions). In general, drought stress condition reduced those traits still the reduction rates were varied among genotypes, indicating that there are different genetic bases for that variation and drought stress tolerance among guayule genotypes could follow different mechanisms.

Guar Remote Sensing:
This task is complete.

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

Task #	Description of Task	Deliverable	Target Completion Date
1 Angadi	Evaluate guar germplasm in New Mexico high plains environment	Screen guar germplasm for adoptability in High Plains Assess available guar cultivars at Clovis, NM	31 Mar 21 31 Jul 21
2 Grover	Evaluate guar germplasm lines for field performance	Thresh remaining Yr3 samples for seed collection	31 Oct 20
3 Ray	Evaluate seed from plants surviving root rot inoculation	New germplasm lines screened for the first time	31 Aug 21
4 Ray	Guayule salt tolerance trials	Screen new germplasm lines with most tolerance Surviving plants transplanted to field to increase seed Seed from surviving plants collected and planted for 2nd round of selection	31 Jul 21 30 Apr 21 31 Aug 21
5 Ray	Guar yield trials in Tucson, AZ; Las Cruces, NM; and Clovis, NM	Yield trials planted in 3 locations Yield trials harvested; yields compared	30 Jun 20 31 Dec 20

Guar Germplasm in New Mexico:
This task is complete.

Guar Germplasm Field Performance (threshing):
Nothing new reported.

Seed Evaluation following Root Inoculation and Root Inoculation per Guayule Germplasm:
This task has been abandoned. No further data will be reported.

Guayule Salt Tolerance Trials:
Research is ongoing; nothing new to report.

Guar Yield Trials in Tucson, AZ; Las Cruces, NM; and Clovis, NM:
This task is complete.

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

Task #	Description of Task	Deliverable	Target Completion Date
1 Angadi	Conduct guar critical stage-based deficit irrigation trial	Report on growth stage-based irrigation management Present data at regional and national conferences	30 Nov 20 30 Nov 20
2 Dierig	Bi-monthly harvest from irrigation trials	Growth data over seasons from two locations	31 May 22
3 Dierig	Irrigation Timing Study	Plant replicated trial and begin treatments	31 Aug 21
4 Grover	Evaluate guar germplasm lines for field performance	Collect field data and harvest samples. Process lab data and complete data analysis. Generate report/publication from results obtained	30 Jun 21 30 Jun 21 31 Aug 21
5 Grover	Evaluate guar response for salinity tolerance	Screen 27 diverse guar lines under salinity stress Identify sources of salinity tolerance characterized by gene expression analysis. Summarize results	30 Jun 21 31 Aug 21 31 Dec 21
6 Grover	Evaluate guar response to moisture stress	Review, edit manuscript draft Revise, complete, submit manuscripts to journals	31 Dec 20 31 Mar 21
7 Grover	Evaluate guar response to planting density	Track and collect research data on guar density experiment Generate report/publication from results obtained	30 Jun 21 31 Aug 21
8 McClos	Conduct guayule herbicide tolerance study, at Eloy and Maricopa, AZ (Fall)	Collect data to support 24c SLN herbicide registrations – (a) post-directed herbicide; (b) herbicide application sequence for chemical weed control from seeding to 6mo old plants; (c) evaluate topical postemergence broadleaf herbicide	31 May 21
9 McClos	Conduct guayule herbicide tolerance studies, at Eloy and Maricopa, AZ (Spring)	Collect data to support 24c SLN herbicide registrations – (a) post-directed herbicide; (b) herbicide application sequence for chemical weed control from	31 Aug 21

		seeding to 6mo old plants; (c) evaluate topical, postemergence broadleaf herbicide	
10 McClos	Generate manuscripts and Extension bulletins	Research reports and manuscripts complete Extension bulletin and 24c SLN ADA application complete	31 Dec 20 31 Aug 21
11 Ogden	Development and testing of AquaCrop model	Growth model compared to field data	31 Dec 20
12 Ray	Guayule density trial	Yields for 2 lines, 5 densities, 2 locations, and 2 seasons compared	30 Nov 21
13 Ray	Range of N and P application	Compare N and P utilization and effects of nutrients on biomass, rubber and resin production	30 Nov 20
14 Ray	Direct-seeded vs. Transplant-established guayule	Compare root growth and top growth vs. water usage under varying conditions	31 Mar 21
15 Waller	Monitor TDR, infrared camera and flowmeter system	Provide data on guayule irrigation experiments Provide data set that can be used to refine the use of sensors for WINDS crop irrigation mgmt.	31 Aug 21 31 Aug 21
16 Waller	Integrate WINDS model with existing tools	Integrate new model with WINDS (winds.arizona.edu), and in-situ sensors	31 Aug 21
17 Waller	Irrigation experiments: Guayule and Guar	Collect data; image collection, neutron probe readings, in-situ sensors, crop coefficient development and destructive plant samples for chemical analysis Develop automated calibration system for WINDS	31 Aug 21 31 Aug 21

Guar Critical Stage-Based Deficit Irrigation Trial:

Late onset of rains and some good rains helped guar research trials at Clovis. Diverse observations were collected from the new trial combining deficit irrigation and fertility management effects on diverse guar cultivars. We also collected forage samples three times during the season in collaboration with Dr. Miller to assess seasonal productivity and quality of guar forage. We are working on final observations and harvesting the crop in coming week. Dr. Idowu's new plant population demonstration study will also be harvested this week.

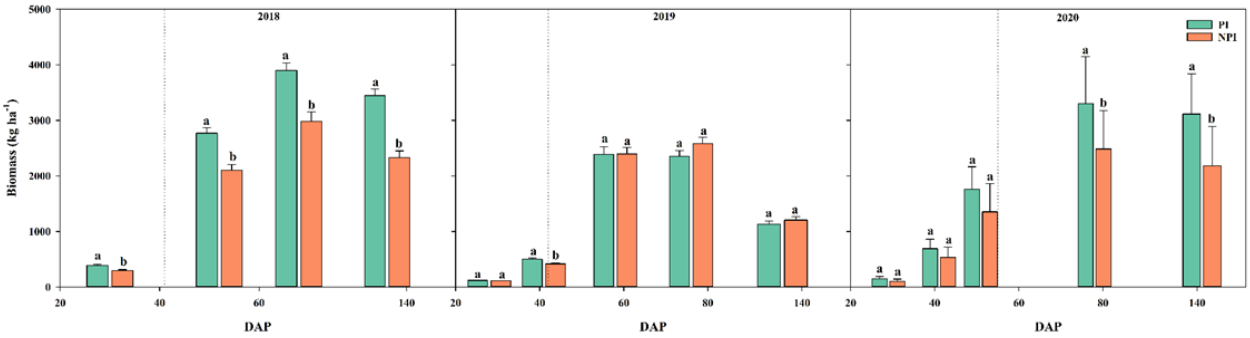


Figure 8. *Aboveground biomass of guar during crop season under pre-irrigated (PI) and no-pre-irrigation (NPI) treatments in 2018-20.*

Bars on the same day having different letters are statistically different at 5% p-value. Dotted line indicates the shift of irrigation treatment from Vst to Rst.

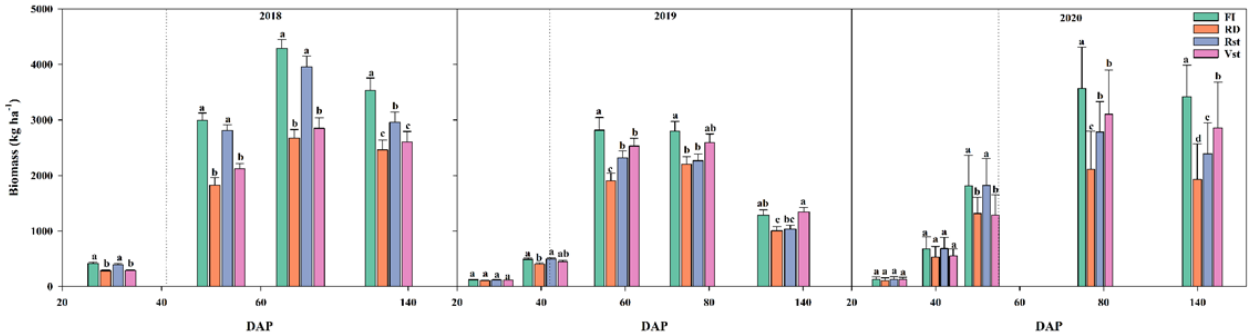


Figure 9. *Aboveground biomass of guar during crop season under fully irrigated (FI), rainfed (RD), stress at reproductive stage (Rst), and stress at vegetative stage (Vst) treatments in 2018-20.*

Bars on the same day having different letters are statistically different at 5% p-value. Dotted line indicates the shift of irrigation treatment from Vst to Rst.

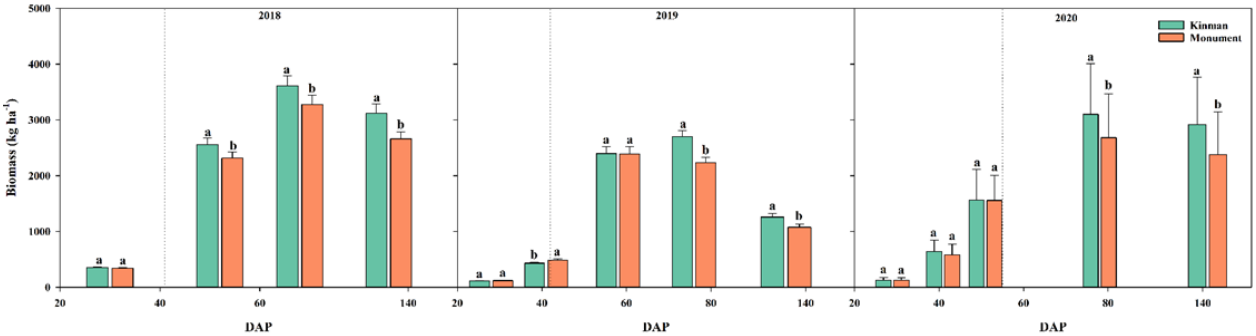


Figure 10. *Pooled avarage of aboveground biomass of two different guar cultivars in 2018-20.*

Bars on the same day having different letters are statistically different at 5% p-value. Dotted line indicates the shift of irrigation treatment from Vst to Rst.

Table 5. *Seed yield, harvest index, and yield components of guar cultivars under different irrigation treatments in 2020.*

Treatment	Seed yield (kg/ha)	Pods plant^{-1}	Seeds pod^{-1}	1000 seed weight (g)	Harvest Index (%)
Pre-irrigation					
Yes	761 a	58.8 a	4.3 a	32.3 a	27.5 a
No	448 b	45.8 b	3.8 a	34.0 a	31.3 a
Growth Stage Based Irrigation					
Full irrigation	815 a	68.7 a	4.1 a	32.0 a	27.3 b
Vegetative stage stress	702 a	55.2 b	4.1 a	32.4 a	27.3 b
Reproductive stage stress	508 b	46.7 bc	4.2 a	33.5 a	31.4 a
Rainfed	392 b	38.5 c	3.8 a	34.8 a	31.7 a
Cultivars					
Kinman	668 a	57.3 a	3.9 a	32.6 a	29.6 a
Monument	540 b	47.2 b	4.2 a	33.7 a	29.3 a

Jagdeep Singh, my former graduate student, worked on one of the two manuscripts from the deficit irrigation trial. I am working on the revisions. He will continue to work on the second manuscript, which will be ready by end of November. Preliminary results were presented in 2021 UCOWR Annual Virtual Meeting. I am preparing a poster for presentation in ASA-CSSA-SSSA Annual Meeting to present final analysis and interpretation of the study results.

We will initiate the next stage of assessing temperature requirements for germination and early growth to assess USDA germplasm as well as diverse breeding lines will be started in winter.

Bi-Monthly Harvest from Irrigation Trials:
Nothing new to report.

Irrigation Timing Study:
Field experiment was established in spring 2020 to study deficit irrigation timing on guayule. The field was prepared and planted in April 2020. This study will help to determine if we are able to produce enough rubber yield with a low amount of irrigation. The different irrigation treatments started in late June.

Treatments:

1. Full Irrigation: Irrigate as determined by the model developed as part of this project. (75% ETo)
2. Stress before Harvest: Full irrigation for the first 16 months, then stop irrigation. Sample plants every two months to study if stress helps rubber and resin content before final harvest.
3. Half Irrigation: Irrigate every other irrigation as determined by the model.

4. Minimum Irrigation: Irrigate three times per year, approximately every growth stage (May/June, September, and February).
5. Minimum Year2: Year 1 irrigate as determined by the model, and Year 2 irrigate three times (February, May/June, September).
6. One Irrigation: One irrigation after establishment in the first year (Sept), one irrigation in year 2 (Apr).

Data and Results:
In the first year, treatment 1, 4, and 6 received the same amount of irrigation. Treatments 3 and 5 are also the same in the first year.

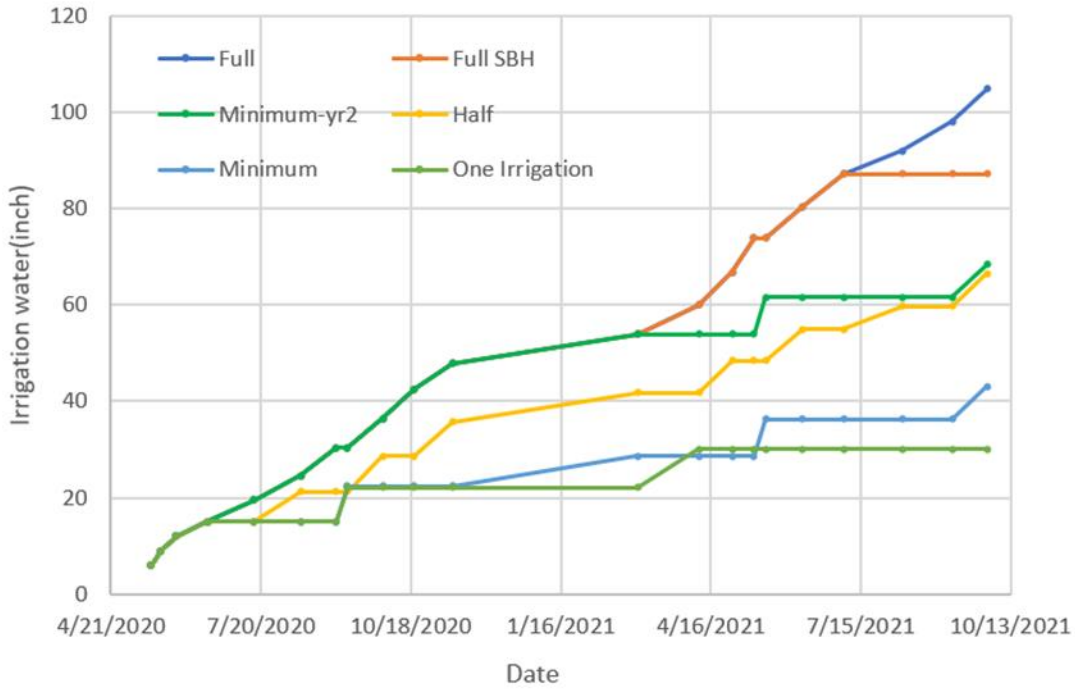


Figure 11. *Irrigation amount (inches) by October 2021 for all six treatments (Full and Full SBH treatments received the same amount of irrigation in the first 16 months).*

By October 2021, the guayule crop in the irrigation study is 18 months old. The total irrigation amount applied to all treatments ranged from 30 inches (One irrigation treatment) to 105 inches (Full irrigation treatment).

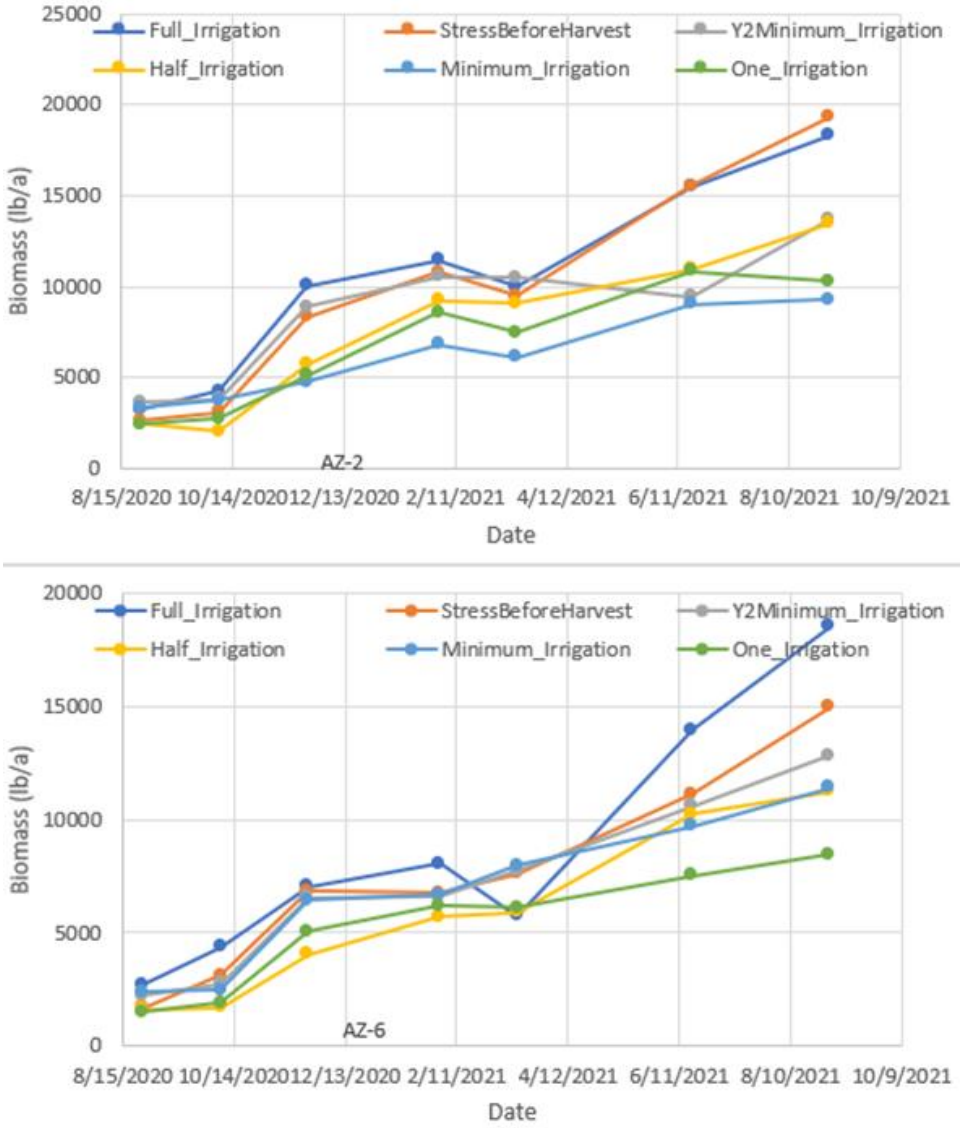


Figure 12. *Biomass yield over time for two varieties AZ-2 (above) and AZ-6 (below).*

In the first year, full irrigation, stress before harvest, and minimum irrigation in year 2 received the same amount of irrigation. Generally, although plants in deficit irrigation treatment survived the summer, the plants are smaller. AZ-6 seemed to tolerate drought stress better compared to AZ-2. In 2021, the difference in biomass among the irrigation treatments became wider.

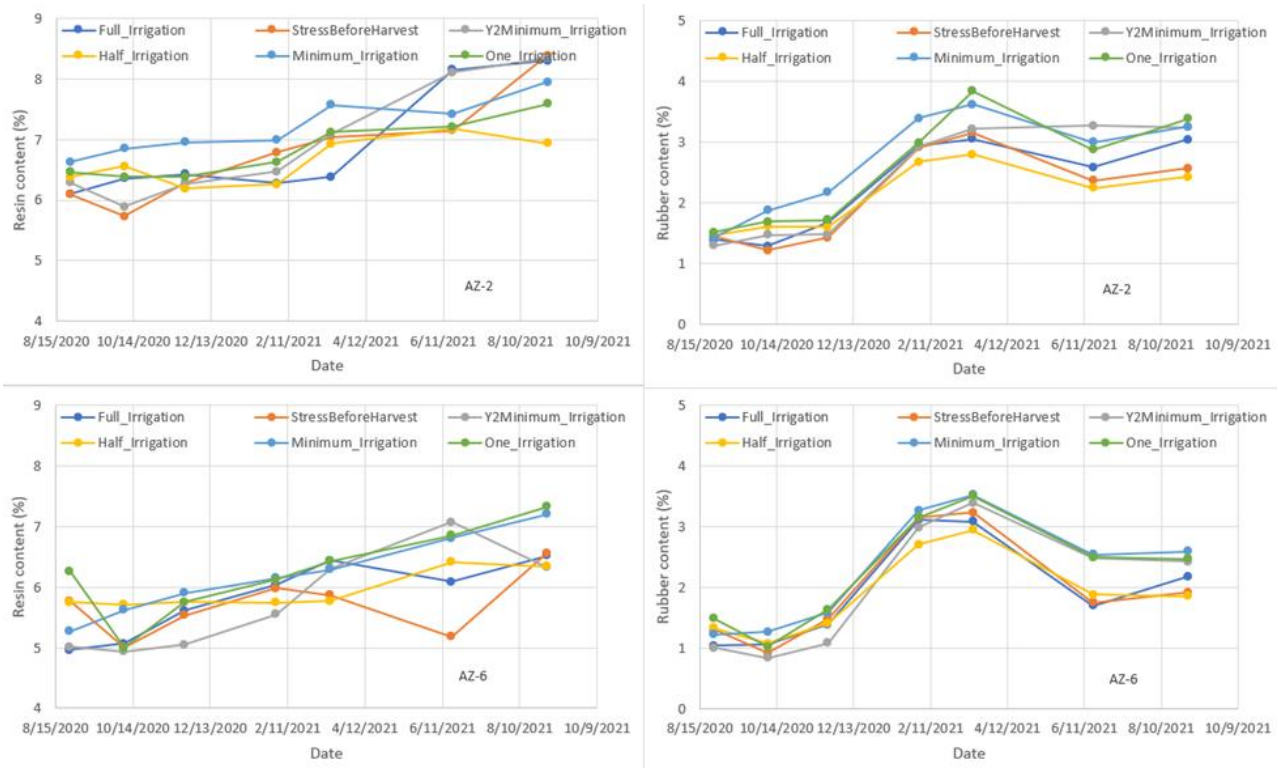


Figure 13. *Resin and rubber content under different irrigation treatments for two varieties: AZ-2 (above) and AZ-6 (below).*

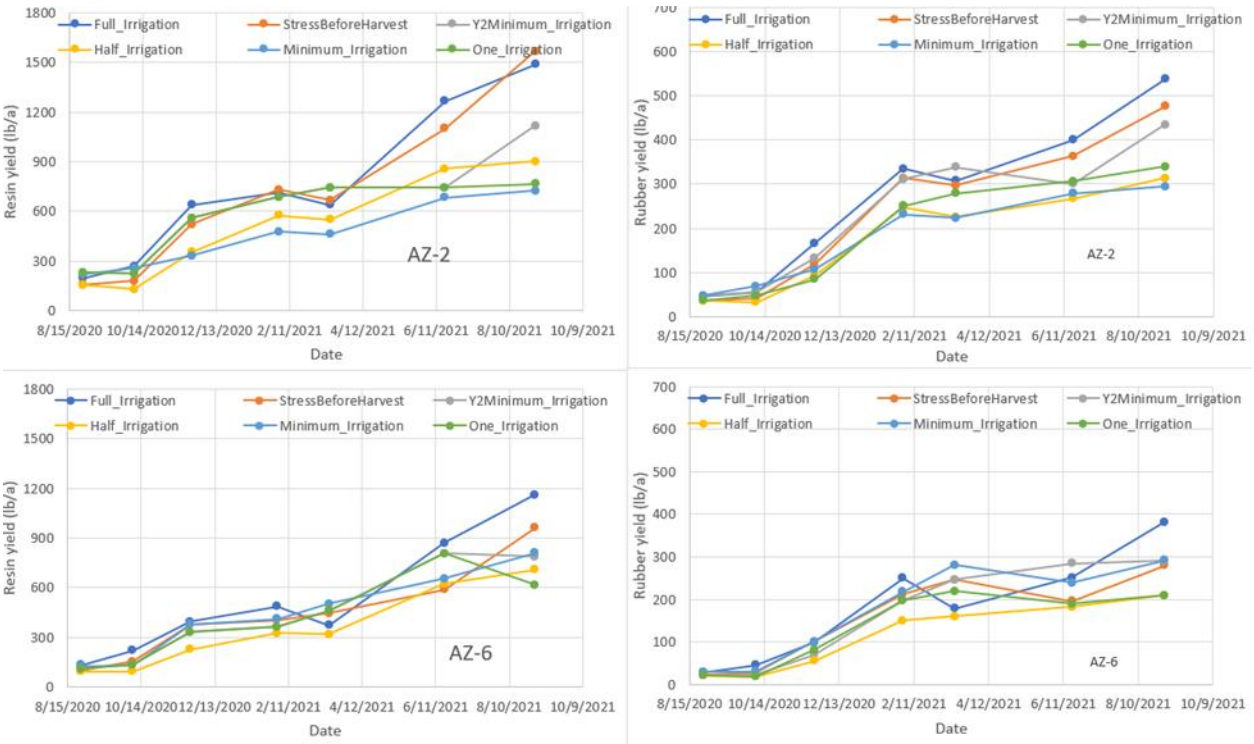


Figure 14. *Resin and rubber yield under different irrigation treatments: AZ-2 (above) and AZ-6 (below).*

Resin content was high at an early stage for both AZ-2 and AZ-6 and increased continuously over time. Rubber content increased significantly during the first winter. Rubber content in AZ-2 was flat in summer 2021, which rubber content in AZ-6 decreased during summer 2021. The differences among irrigation treatments on rubber content is not clear. In the spring 2021, biomass increased significantly. The decrease in rubber content was the effect of dilution. The dilution effect of resin was not as significant.

Trends for rubber and resin yield are similar to biomass.

Next Step: Work with SBAR scientists to manage the experiments, collect data, and prepare the final harvest in spring 2022.

Guar Response for Field Performance:
Nothing new reported.

Guar Response to Salinity Tolerance:
Nothing new reported.

Guar Response to Moisture Stress:
This task is complete. A manuscript is in process.

Guar Response to Planting Densities:
Nothing new reported.

Guayule Herbicide Tolerance Study, Fall 2020:
These field experiments were initiated in September 2020 at Bridgestone-Eloy (mid-September plantings) and at MAC (9/28/2020 planting. Subtask 1a was completed at the Bridgestone Eloy farm in field 6B with the last data being collected on May 25, 2021. The data from this experiment are being analyzed as time permits. The fall sequential application studies (primarily with Aim) were completed at MAC and Eloy.

Table 6. *Details of the 2021 preemergence and post-directed herbicide experiments (Spring).*

Spray Date	Chemicals Applied	Location/ Field	Method of Incorporation	ARM File Name / Data Tables?	Data Collected to Date
4/12/2021 7/21/2021	Appl. Code-B Prowl H2O Dual Magnum Warrant Spartan Prefar Aim Activator 90 Appl. Code-C Goal Tender Caparol Sandea Liberty Chateau	MAC / F2 B 63, 64, 65	PPI-flat, field cultivator, lister, bed-top, incorporvator, irrigation Hooded Sprayer	Field 2 MAC Spring 2021 Herbicide Systems F2	3/24/2021 – Farm applied application code A – PPI flat 4/12/2021 – applied application code B – PPI flat 4/14/2021 – Planted at 1 lb/A 5/1/2021 –Farm applied Pyrethroid at 4 oz/A 5/5/2021 –Farm applied Pyrethroid at 1.8 oz/A 5/25/2021 – Stand Counts 5/28/2021 – Nadir Pictures 6/5/2021 – Prespray Leaf Counts 6/9/2021 – applied bulk Aim @ 2 oz/A 6/10/2021 – Farm applied bulk Prowl H2O @ 4 pt/A 6/15/2021 – Stand Counts

	Aim Activator 90				6/18/2021 – Nadir Pictures 7/21/2021 – Applied application code C 8/2/2021 – Injury Rating 8/24/2021 – Injury Rating 8/26/2021 – Height data collected
4-12-2021 7/21/2021	Appl. Code-B Prowl H2O Dual Magnum Warrant Spartan Prefar Aim Activator 90 Appl. Code-C Dual Magnum Karmex Warrant Goal Tender Spartan Stringer HL Matrix Sandea Aim Activator 90	MAC / F3 B 66, 67, 68	PPI-flat, field cultivator, lister, bed-top, incorporvator, irrigation Hooded Sprayer	MAC Spring 2021 Herbicide Systems Field 3	3/24/2021 – Farm applied application code A – PPI flat 4/12/2021 – applied application code B – PPI flat 4/14/2021 – Planted at 1 lb/A 5/1/2021 –Farm applied Pyrethroid at 4 oz/A 5/5/2021 –Farm applied Pyrethroid at 1.8 oz/A 5/25/2021 – Stand Counts 5/28/2021 – Nadir Pictures 6/5/2021 – Prespray Leaf Counts 6/9/2021 – applied bulk Aim @ 2 oz/A 6/10/2021 – Farm applied bulk Prowl H2O @ 4 pt/A 6/15/2021 – Stand Counts 6/10/2021 – Farm applied bulk Fusilade @ 24 oz/A 6/18/2021 – Nadir Pictures 7/21/2021 – Applied application code C 8/2/2021 – Injury Rating 8/24/2021 – Injury Rating 8/26/2021 – Height data collected

Guayule Herbicide Tolerance Study, Spring 2021:

These studies were initiated and conducted at MAC and field operations are detailed in the operations table below. The final Aim studies were completed in July. The herbicide sequence/ post-directed herbicide experiments are continuing and will be completed during winter 2021-2022. See the 2021 Operations table below for a comprehensive list of field activities.

Table 7. *Postemergence herbicide studies (Spring) field operations.*

Spray Date	Chemicals Applied	Location/ Field	Method of Incorporation	ARM File Name / Data Tables?	Data Collected to Date
4-5-2021	Chateau Goal Tender Liberty Caparol Aim Karmex Matrix Sandea Spartan Aim	Bridgestone B6	Hooded Sprayer Furrow irrigation	Guayule Bridgestone Eloy Field B6 Spring 2021 Post Direct	4/14/2021 – Planted 4/2/2021 – Plant Height (cm) 4/19/2021 – Plant Height (cm) 4/19/2021 – Necrosis/Chlorosis rating in sprayed canopy zone and an injury rating above the sprayed canopy zone. 4/19/2021 – Malva injury rating 5/13/2021 – applied application code B (second application of all chemicals) 5/26/2021 – Height Rating 5/26/2021 – Canopy Injury
    5-20-2021	Prowl H2O, Aim Activator 90 MSO Appl. Code B	MAC / F2 B61/62	PPI-flat, field cultivator, lister, bed-top, incorporvator, irrigation CAPS	F2 Aim Sequential Spring 2021 MAC F2	3/24/2021 – Farm applied application code A – PPI flat 4/14/2021 – Planted at 1 lb/A 5/1/2021 –Farm applied Pyrethroid at 4 oz/A 5/5/2021 –Farm applied Pyrethroid at 1.8 oz/A

Spray Date	Chemicals Applied	Location/ Field	Method of Incorporation	ARM File Name / Data Tables?	Data Collected to Date
4-5-2021	Chateau Goal Tender Liberty Caparol Aim Karmex Matrix Sandea Spartan Aim	Bridgestone B6	Hooded Sprayer Furrow irrigation	Guayule Bridgestone Eloy Field B6 Spring 2021 Post Direct	4/14/2021 – Planted 4/2/2021 – Plant Height (cm) 4/19/2021 – Plant Height (cm) 4/19/2021 – Necrosis/Chlorosis rating in sprayed canopy zone and an injury rating above the sprayed canopy zone. 4/19/2021 – Malva injury rating 5/13/2021 – applied application code B (second application of all chemicals) 5/26/2021 – Height Rating 5/26/2021 – Canopy Injury
6-7-2021	1st Aim treatments Appl. Code C 2nd Aim treatments		CAPS		5/20/2021 – Pre-spray leaf counts/plant 5/20/2021 – Appl. Code B 5/25/2021 – Stand Counts 5/28/2021 – Nadir Pictures 6/5/2021 – Prespray Leaf Counts 6/7/2021 – Appl. Code C applied 6/10/2021 – Farm applied bulk Prowl H2O @ 4 pt/A 6/15/2021 – Stand Counts 6/18/2021 – Nadir Pictures 7/29/2021 – Height data collected
5-20-2021 6-7-2021	Prowl H2O, Aim Activator 90 MSO Appl. Code B 1st Aim treatments Appl. Code C 2nd Aim treatments	MAC / F3 / B65/66	PPI-flat, field cultivator, lister, bed-top, incorporvator, irrigation CAPS CAPS	F3 Aim Sequential Spring 2021 MAC F3	3/24/2021 – Farm applied application code A – PPI flat 44/14/2021 – Planted at 1 lb/A 5/1/2021 –Farm applied Pyrethroid at 4 oz/A 5/5/2021 –Farm applied Pyrethroid at 1.8 oz/A 5/20/2021 – Pre-spray leaf counts/plant 5/25/2021 – Stand Counts 5/28/2021 – Nadir Pictures 6/5/2021 – Prespray Leaf Counts 6/7/2021 – Appl. Code C applied 6/10/2021 – Farm applied bulk Prowl H2O @ 4 pt/A 6/15/2021 – Stand Counts 6/10/2021 – Farm applied bulk Fusilade @ 24 oz/A 6/18/2021 – Nadir Pictures 7/29/2021 – Height data collected

Herbicide Trials – Publication, Extension Bulletin and 24c SLN Applications

This work is ongoing. Data and summaries will be prepared and submitted to herbicide manufacturers in the fourth quarter of 2021 in order to develop submissions for 24c SLN registrations. The data summaries were used to produce an Extension IPM Short on guayule weed control ("Guayule Weed Management During Establishment in Arizona – September 2021"). This will be expanded into an Extension Bulletin in Q4 and other publications will also be produced during winter 2021-2022.

Research technician, Bryan Pastor, was largely responsible for setting up the experiments, spraying the herbicide treatments, and collecting the data. He also managed all experiments during McCloskey's absence from Tucson in summer 2021.

Development and Testing of AquaCrop Model:
Huang calibrated AquaCrop parameters. She increased the values of Emergence, MaxRooting, Senescence, and Maturity, whereas decreased the values of CDC and CGC. She also added irrigation as the fourth environmental condition besides the other three parameters: soil class, crop class, and weather. A summary of the results is shown below. During the next quarter, Huang will change the equations to get a new model and continue to find the canopy coverage and biomass equations in Python.

Crop Type: Guayule2018
Harvest Date (YYYY/MM/DD): 2018-10-30
Harvest Date (Step): 301
Yield (tonne/ha): 5.449846
Seasonal irrigation (mm): 1511.636265

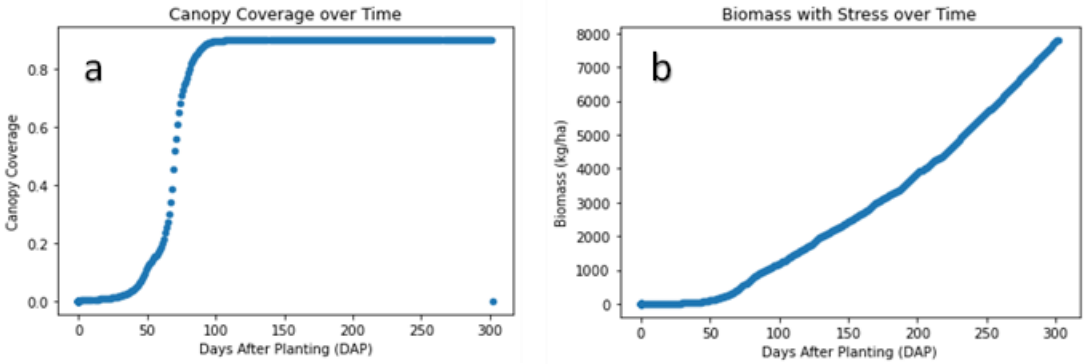


Figure 15. *The simulation of canopy cover (a) and biomass (b).*

Guayule Density Trials (Direct-Seeded and Transplant-Established):
This study has been completed.

Range of N and P Utilization:
Samples harvested in March were analyzed for resin and rubber. Second set of samples harvested on August 25.

Direct-seeded vs. Transplant-established Guayule:
This study has been completed.

Monitor TDR, Infrared Cameras, and Flowmeter System:
D. Hoare continues to maintain the sensors in the Eloy guayule experiment. D. Hoare, M. Katterman, and D. El-Shikha have conducted several field sampling days with drone, electronic sensor, plant growth, and neutron probe readings in the guar experiment in Tucson. M. Katterman is taking weekly neutron probe measurements in Tucson, Eloy and Maricopa.

WINDS Model Integration with Existing Tools:
H. Maqsood submitted 1 paper (peer review); we are finalizing the 2nd paper for submission. M. Katterman's 1st paper has been edited once. Work on AquaCrop for guayule is continuing.

The WINDS website is live on an Amazon Web Services (AWS) platform. This website allows users to view and download model data, predict irrigation events, and input data into the model for analysis. A login and registration system ensures that only applicable users can input data for the model. Furthermore, this system uses Advanced Encryption Standard (AES) encryption algorithms to protect sensitive information.

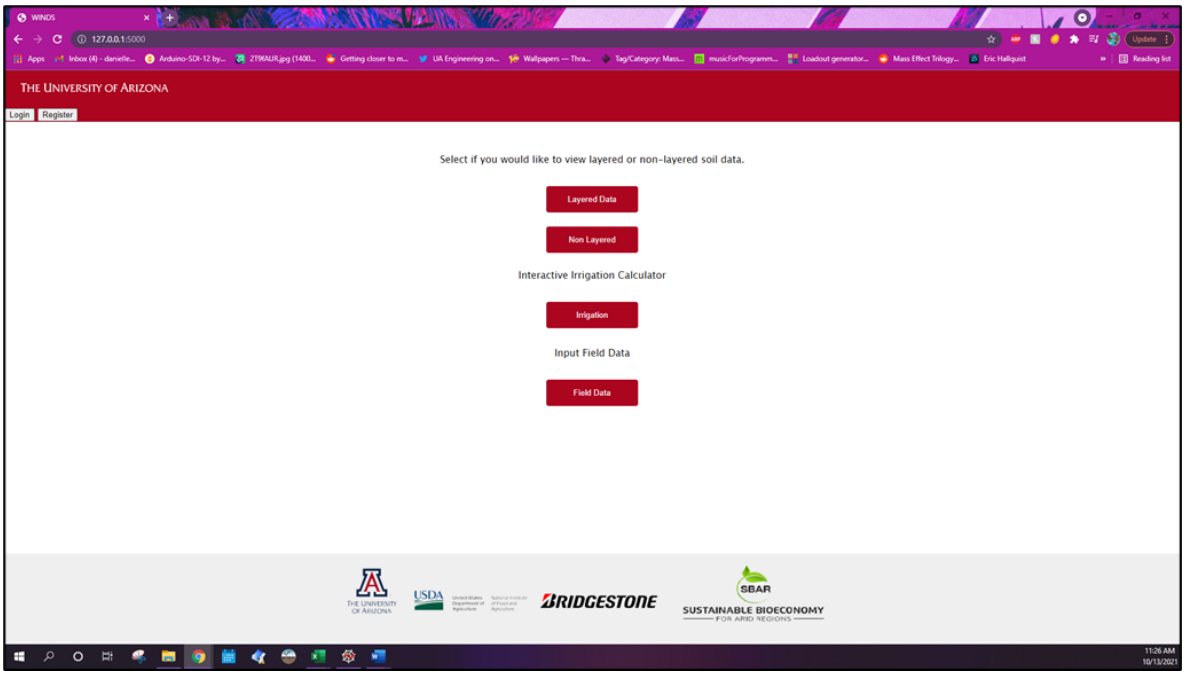


Figure 16. *Landing page for the WINDS model web app.*

The website is currently being modified to allow users to input CSV files for the model and to add an about and acknowledgement pages, per project authorship guidelines. This website is accessible on mobile platforms but will be further optimized once these additions are complete. The WINDS python model of irrigation still needs some work. We can run the model and post to AWS , but we still need to make sure all of the algorithms are correct and match the VBA version that we have been using for experiment analysis. The VBA version is being submitted as an appendix with the submitted papers, and it is a useful tool for researchers. We are currently compiling all irrigation experiments onto a table in Excel. The table can be copied as-is to AWS. We should have all guar and guayule experiment simulations ready in a few months.

Irrigation Experiments – Guayule and Guar:

D. El-Shikha submitted a paper on drone remote sensing of guayule (peer review). He continues to run the irrigation experiments at Eloy and Maricopa. Soil moisture and plant data was collected weekly, bi-weekly, and monthly. Also, multispectral and RGB images were collected via drones every 1-4 weeks for the two experiments. Weekly moisture data was analyzed with the neutron probe and used for irrigation scheduling.

D. El-Shikha, M. Katterman, and D. Hoare participated in the guar experiment in Tucson with remote sensing, neutron probe, electronic sensor, and plant growth measurements.

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

Task #	Description of Task	Deliverable	Target Completion Date
1 Maier/ Neilson	Physical analysis of Yr1 soil samples (n=108)	Soil texture characterization complete	31 Dec 20
2 Maier/ Neilson	DNA extraction of soil samples for microbiome analysis (Yr1 and Yr2)	MAC Yr1 complete MAC & Eloy Yr2 complete	28 Feb 21 28 Feb 21
3 Maier/ Neilson	Amplicon sequencing: bacteria, archaea, and fungi	MAC Yr1 and Yr2 complete Eloy Yr2 complete MAC and Eloy Yr3 samples complete	30 Apr 20 30 Apr 21 31 Oct 21
4 Maier/ Neilson	Winter dormancy rubber production studies	Manuscript submitted for review and publication	31 Aug 21
5 Maier/ Neilson	Temporal microbiome network analysis of community interactions	DNA extraction for 240 samples Bioinformatics of soil samples collected monthly	30 Jun 21 1 Mar 21
6 Maier/ Neilson	Belowground associations with guayule 2020 harvest metrics	Chemical analysis of all soils sampled from MAC and Eloy, Spring 2020 DNA extraction of field soils associated with guayule harvest of irrigation field trial Amplicon sequencing of bacteria, archaea, and fungi from root zone DNA extracts Multivariate statistical analysis of sequence data set to identify associations between guayule metrics measured at harvest Manuscript preparation	31 Oct 21 1 Feb 22 1 Mar 22 1 Jun 22 1 Sep 22

Chemical and Physical Analysis:
This task is complete.

DNA Extraction for Microbiome Analysis:
DNA extractions for 2018 and 2019 soil samples are complete.

Amplicon Sequencing: Bacteria, Archaea, Fungi:
Relative abundance of putative guayule soil fungal pathogens: guayule irrigation field trial at MAC and Eloy:
The soil quality study is focused on the relative abundance of putative fungal pathogens across all irrigation treatments at MAC and Eloy fields for the 2018 irrigation field trial. K. Brown continues to work on a draft of the literature review for the introduction to his dissertation that summarizes current knowledge on guayule pathogens and the field conditions that influence their relative abundance and infectivity. The chapter is entitled *Fungal pathogens and guayule (Parthenium argentatum): optimizing crop production in an arid environment.*

The relative abundance of putative guayule pathogens is being compared in 216 soil samples from 18 plots in each of the fields. Samples were collected prior to guayule establishment in 2018 and following one year of growth (2019) to facilitate an analysis of the effect of plant establishment on putative fungal pathogen relative abundance. Chemical analysis was performed on the 2019 soil samples from all treatment plots. DNA extraction of the 2018 and 2019 soil samples is complete. Amplicon sequencing of bacterial, archaeal, and fungal DNA is in process at the UA Microbiome Center and is targeted for completion by November 1, 2021. The bioinformatics analysis described in Year 5 SOW – Tasks 1c will be done during Q4 of 2021.

Winter Dormancy Rubber Production Study:
The research for this study is complete and the figures are prepared for publication. The current goal is to complete the manuscript draft by December 31, 2021.

Temporal soil microbiome associated with guayule growth cycle:
The overall objective of this study is to define the core microbiome associated with the guayule root zone across multiple growth stages. Bacterial, archaeal, and fungal taxa are being identified as proposed essential components of a productive guayule soil microbiome using multiple bioinformatics strategies. Characterization of the soil microbiome is important because it contributes significantly to plant nutrient availability and plant pathogen control. Less well understood contributions of the soil microbiome to plant health include plant hormone and signaling compound production. These plant-microbe interactions could strengthen the guayule stress-response to cold temperatures during winter dormancy and potentially enhance robust rubber production. Microbial community dynamics are being evaluated as a function of time from October 2019 through May 2020. The study focuses on the Eloy F50 irrigation treatment to mimic the natural environment of the guayule plant. Y. Chen is employing novel bioinformatics techniques to characterize the microbial communities of root-zone samples collected in October, November, January, February, March and May. Thirty samples were collected at each time point to facilitate a complex analysis of microbial community interactions. The initial microbial community alpha- and beta-diversity results and community functional predictions are presented in the 2021 Q1 and Q2 reports.

During Q3, Y. Chen completed his comparison of multiple network analysis tools that are used to quantify microbe-microbe co-occurrence patterns in soil communities and selected the Molecular Ecological Network Analysis Pipeline (MENAP) as the optimal method for the temporal comparison of both the bacterial/archaeal and fungal communities. MENAP was

selected over the other network analysis methods due to its ability to analyze fungal data sets and incorporate them into bacterial/archaeal analyses. The quantification of the connectivity of different members of the community is considered an index of their relative importance in the function of the community as a whole and is a cutting-edge tool being developed to identify the core microbiota of a plant-associated community. Network analysis defines “hub species’ as those taxa that demonstrate high levels of connectivity with other members of the microbiome and thus are considered critical players in the community. MENAP was also preferable to the other methods tested because it is not subject to arbitrary selection of the correlation threshold for determination of connectivity.

The hub or keystone species identified by the MENAP network analysis are shown below and were presented by Y. Chen in a poster at the 2021 SBAR Annual Retreat. Blue squares indicate the presence of a given keystone species (listed in the first column) in the sampling month identified on the X-axis. Bacteria/archaea are represented in the left plot and fungi on the right.

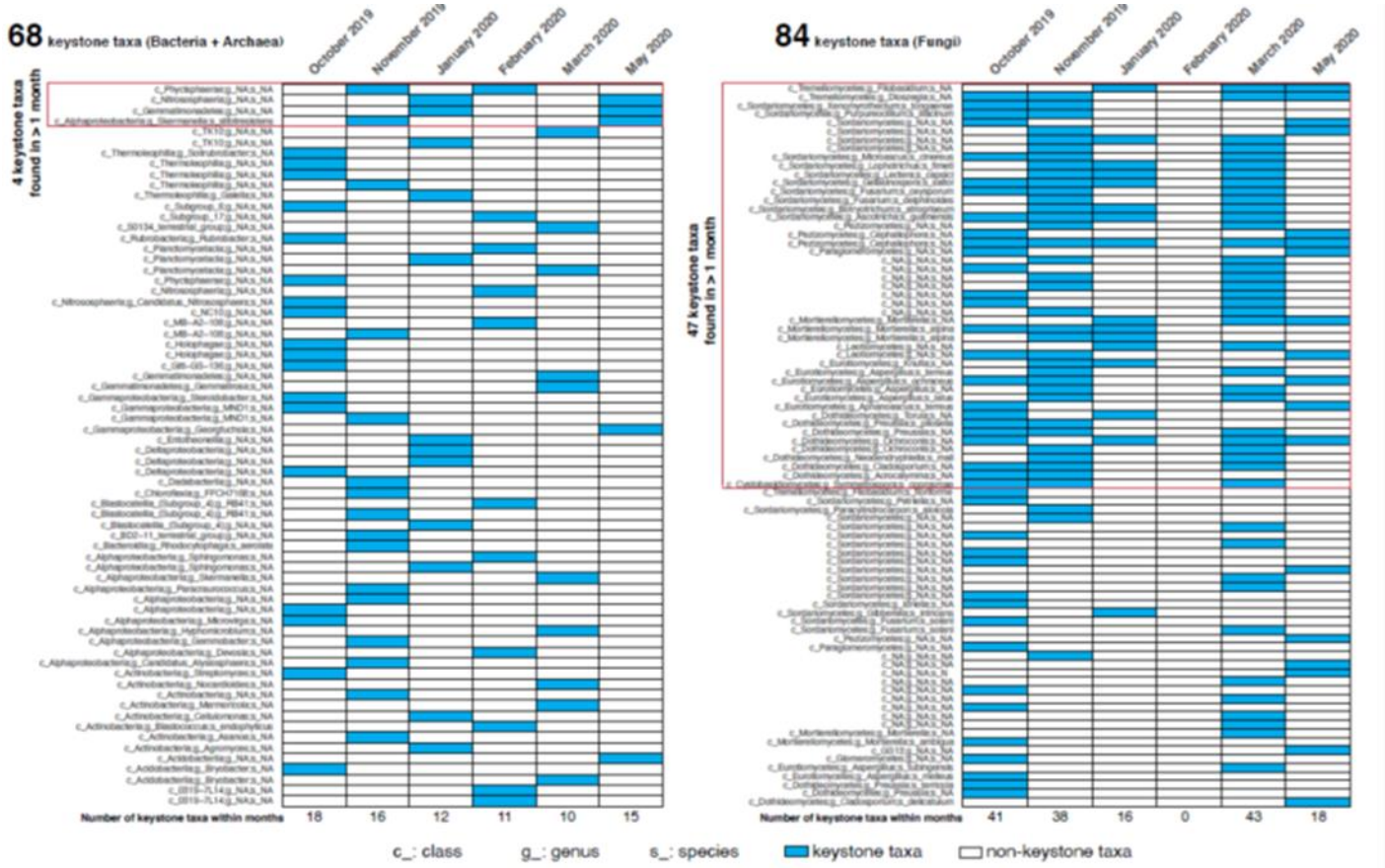


Figure 17. *Keystone root microbiome taxa associated with six sampling months from October 2019 through May 2020 (x-axis). Blue squares indicate presence of a taxon in a given month for bacteria/archaea on left and fungi on right.*

Several important patterns were revealed through this analysis. First, there were more keystone fungal species than bacteria and archaea despite the fact that bacteria/archaea had greater species diversity. Second, significant differences were observed between the keystone species characterizing each sampling timepoint, with the greatest numbers for bacteria/archaea

associating with October, November, and May; and the greatest for fungi associating with October, November, and March. Third, keystone microbial species in the guayule root zone are dynamic. There was minimal overlap between the keystone species associated with each sampling month, although a greater overlap was observed among keystone fungal species. For bacteria and archaea, just 4 (of 68) species were identified as keystone species in more than one month. In contrast, 47 fungal taxa were identified as keystone species for more than one time point.

A parallel analysis was performed to identify microbes associated with distinct guayule growth stage. Guayule growth stage was defined using the normalized difference vegetation index (NDVI). High NDVI values characterized active growth and low values were associated with plant dormancy. The NDVI data for the F50 field is shown below.

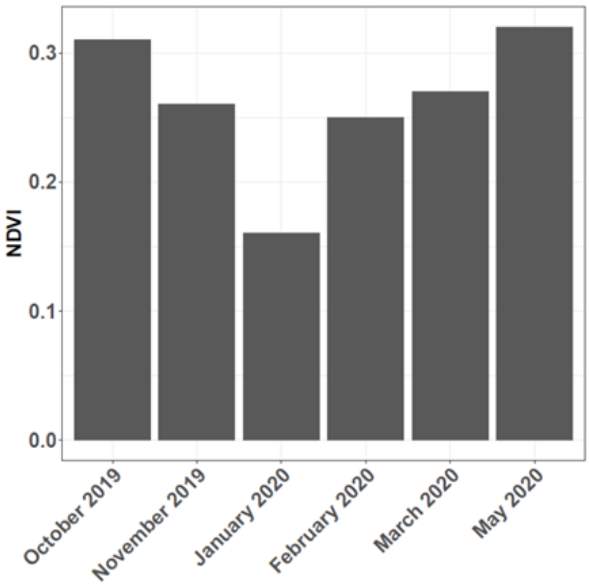


Figure 18. *NDVI values associated with each sampling method. Data was provided by D. El-Shikha and S. Wang.*

Based on the NDVI, October and May were classified as months of active growth and November through March were defined as months of dormancy. Classifications were assigned in collaboration with D. Dierig, S. Wang, and D. El Shikha. Positive and negative correlations were then identified between the NDVI index and the cummulative relative abundance of bacterial, archaeal, and fungal taxa (see figure below). Microbial taxa showing a strong negative correlation with NDVI are more abundant in the guayule root zone during plant dormancy than during active growth.

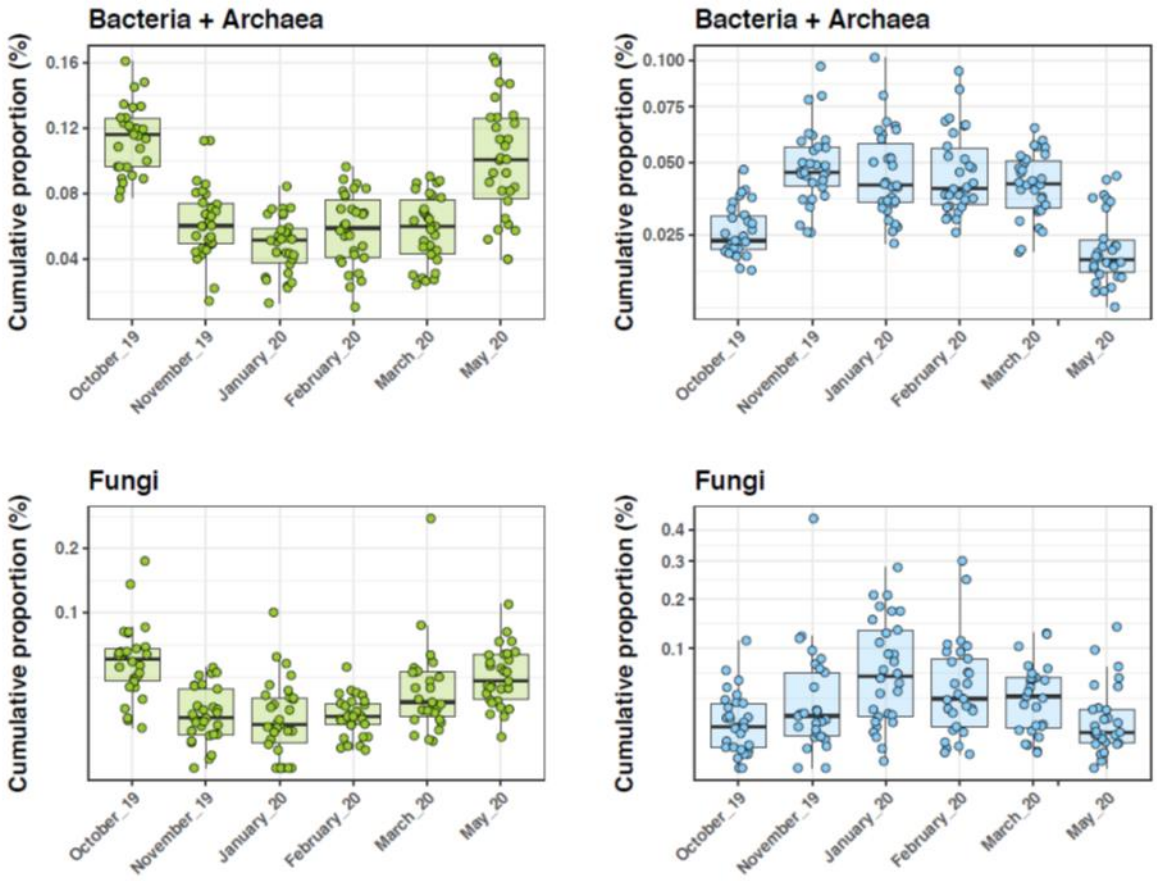


Figure 19. *Microbial taxa that demonstrate a positive (green) or negative (blue) correlation between the cumulative relative abundance of the taxon and guayule NDVI.*

During Q4, Y. Chen will combine the results of these two analyses to evaluate overlaps between microbial taxa showing strong positive or negative associations with NDVI in a specific sampling month and the keystone taxa identified for that sampling month. This analysis will determine whether the temporal changes in keystone microbes are associated with guayule growth stage to identify putative plant-microbe interactions.

Belowground Associations with Guayule 2020 Harvest Metrics:
Undergrad, A. Soto, was hired this semester to process the soils and send them to Brookstone Labs for analysis. She is being trained to complete this work.

DNA extraction of soils from guayule root zone continues.

Sequence data will be used to generate microbial community profiles associated with plant sample sites at harvest.

Collaborative analysis will be conducted with Bridgestone and/or D. El-Shikha to identify associations between root zone microbial community metrics and guayule production.

CHARACTERIZATIONS & CO-PRODUCTS

Project Coordination: The Characterizations working group meetings are hosted by NMSU once monthly, and led by Dr. Catherine Brewer. During these meetings, progress reports for all component tasks are provided by team members, issues and challenges are discussed for resolution, and specific tasks are integrated where possible. Data exchange is accommodated via a shared access folder online, and meeting minutes are maintained as a reference.

Issues/Risks:
Brewer: Shakedown tests for the SFE are ongoing. For Year 5, $10K was requested and approved to be held in reserve in case a pump needs to be replaced, the remaining $40K from the equipment grant was swept. Shakedown trials will recommence after the Tech Connect conference (October); demonstration is still expected by the end of quarter 4, starting with whole guayule shrub biomass, then guayule resin.

Holguin: We are still working through our backlog of chemical analysis. We hope to have this resolved by end of 2021. However, we are now making progress to catching up with our commitments. As the samples are adequately preserved, we do not expect any negative impact to the outcomes of the analysis.

Molnár: Dr. M. Cascaes-Inacio resigned from her postdoc position early September to take up permanent employment in the biotech sector. We are searching for a replacement. While routine biocatalytic fermentations are continued by Dr. Zhong, work with genetically manipulated strains are delayed until a biologist with expertise is found.

Our newer LC-MS equipment was out of order for approximately 1.5 months total with various maintenance-related problems, with the other machine still only working in the LC mode (no MS). This caused significant problems with our compound isolation work. Commercial synthesis of the synthetic genes was repeatedly delayed by the company citing pandemic supply chain disruptions and technical problems. We are still awaiting delivery.

Objective 1. Evaluate how seasonality, processing, and storage affect product quality, conversion efficiency, and economics.

Task #	Description of Task	Deliverable	Target Completion Date
1 Holg	Biochemical composition analysis of guayule and respective products	Identify metabolic pools and gene targets for cold adaptation, rubber production, and survivability Identify minor resin components for resin byproducts	31 Dec 20 31 Aug 21
2 Holg	Biochemical composition analysis of guar and respective products	Develop methods to characterize polysaccharide composition of select varieties of guar	31 May 21

3 Holg	Commissioning and testing of supercritical fluid extraction equipment and analyses	Chemical analysis of SFE extracts and contribute to manuscript development	31 Aug 21

Guayule Biochemical Composition Analysis:

Multiple meetings with Dr. Brewer group resulted in the development of the strategy for the resin research, which was mostly to finish mass balance of the resin mixture. For that, accurate mass UPLC-MS2 analysis (on Orbitrap mass spectrometer) of fresh resin in comparison to extracted one will be performed. GNPS Feature-Based Molecular Networking will be use for the data analysis. Collaboration with Dr. Gunatilaka group (University of Arizona) resulted in retrieval of multiple (H+, Na+, Li+, and H-) fragmentation patterns of 8 selected Argentatins. GNPS system was utilized in order to compare fragmentation patterns obtained from the Orbitrap versus Q-Tof. Both fragmentation patterns will enrich public searching libraries.

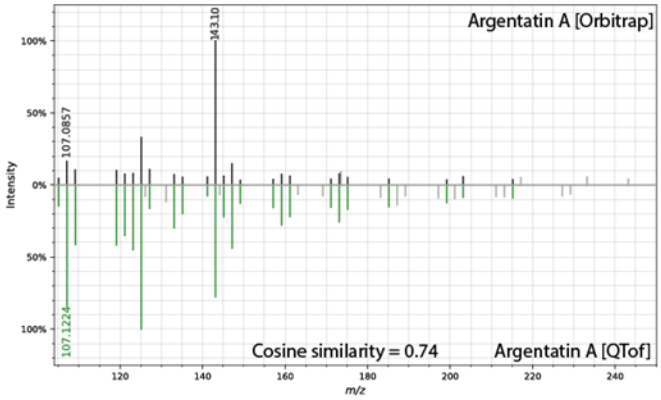


Figure 20. *Comparative mirror spectrum of Argentatin-A, note relatively high cosine index.*

Additionally, MS2 fragments of Argentatine A were assigned to the preliminary chemical structures. Lastly, quantification method development (for total/individual argentatins) was initiated using Shimadzu QqQ LCMS-8060NX.

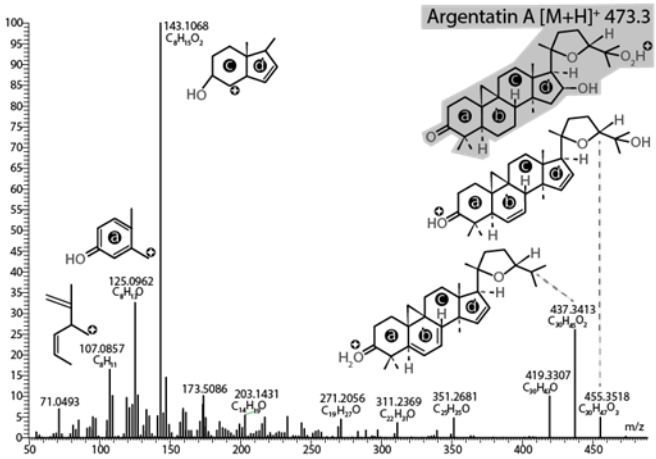


Figure 21. *Preliminary chemical formulae assignment for the Argentatin-A fragments.*

Guar Biochemical Composition Analysis:
Dr. Laura Rodriguez isolated guar gum and determined yield from whole seeds of 27 USDA guar samples. Four guar gum samples were quantitatively hydrolyzed to D-galactose and mannooligosaccharides by a mixture of α-galactosidase plus β-mannanase. The content of galactomannan and the ratio of mannose and galactose in these samples will be determined next by HPLC.

Commissioning and Testing Supercritical Fluid Extraction Equipment and Analyses:
No chemical analysis activities occurred this quarter.

OTHER
Metabolomics: Attended bi-monthly meetings with Bridgestone to discuss revision of guayule manuscript. Initiated review of the guayule metabolome manuscript and searching for a scientific journal to resubmit. We also identified a method for isolation, purification, and quantification of total RNA from the guayule plants harvested. Dr. Laura Rodriguez Isolated RNA from leaves and stems of the HSBulk, CAL3, and AZ6 guayule germplasms. These RNA samples were shipped to Los Alamos National Laboratory for transcriptomic analyses.

Publications:
The comments from the Industrial Crops and Products Journal reviewers were addressed. Metabolic pathways were assigned to the metabolites from the multivariate analysis of pre, and post-acclimated AZ-2 germplasm. Our manuscript entitled “Natural Products in the Desert Southwest: Guayule (*Parthenium argentatum*) and Guar (*Cyamopsis tetragonolobus*),” is still on hold as suggested significant revisions to the economics sections of the paper is underway.

Objective 2. Demonstrate feasibility of farm to fuel conversion of bagasse.

Task #	Description of Task	Deliverable	Target Completion Date
1 Brewer	Prepare 2 manuscripts on guayule/guar bagasse composition, biomass-to-conversion method matching (HTL product yields)	Manuscripts prepared Manuscripts submitted for peer-review process	31 Aug 20 31 Aug 20

Manuscript Preparation:
This task is complete; nothing new to report.

Objective 3. Identify economic co-products in guayule and guar, e.g., biologically active components.

Task #	Description of Task	Deliverable	Target Completion Date
1 Brewer	Evaluate supercritical fluid (CO2) extraction (SFE) and fractionation of guayule including impacts on residual biomass	Shakedown trials completed; parts/repairs needed have been identified	30 Sep 21
		Operation of continuous SFE of guayule resin demonstrated; experimental design completed for resin fractionation	31 Dec 21
		SFE experiments completed with samples sent for characterization	31 Mar 22
		Manuscript on methods of guayule biomass and resin SFE and fraction composition submitted	31 Aug 22
2 Brewer	Evaluate IP potential of guayule fractionation for insect repellent applications	Completion of IP disclosure and evaluation with NMSU business development	31 Dec 21
3 Brewer	Test insect repellency of guayule resin fractions on multiple urban/agricultural pests	Manuscript on insect repellency effects of guayule resin on second pest species submitted for peer review	31 Aug 22
4 Molnár	Identify and characterize key steps in guayule biosynthetic pathways that yield argentatin and guayulin as potential value-added coproducts	Cloned or custom-synthesized oxidosqualene cyclase and sesquiterpene synthase genes (8 genes)	31 Dec 21
		Completed functional characterization of oxidosqualene cyclases and sesquiterpene synthases in a yeast host	31 Mar 22
		Extracts generated from scaled-up synthetic biology reactions	31 Aug 22
		Preparation of draft manuscript or report	31 Aug 22
5 Molnár	Conduct microbial biotransformations of major metabolites in guayule resin	Completed screening of the fungal collections of NPC to biotransform guayule resin components	31 Dec 21
		Completed screening of the recombinant yeast collection of NPC to biotransform guayule resin components	31 Mar 22

		Extracts from scaled-up biotransformation reactions	31 Aug 22
6 Molnár	Isolate the structures and evaluate the potential anticancer and antimicrobial activities of novel compounds originating from microbial biotransformation or synthetic biology	Isolated novel compounds (2-10mg) Completed structure elucidation of novel compounds using 1D and 2D NMR techniques IC50 values (inhibitory concentration, 50%) determined against a panel of cancer cell lines and normal human cells MIC (min. inhibitory concentration) and MBC/MFC (min. bactericidal/fungicidal concentration) values determined against a panel of Gram-positive and Gram-negative bacteria and Candida Preparation of draft manuscript or report	31 Aug 22 31 Aug 22 31 Aug 22 31 Aug 22 31 Aug 22
7 Ogden	Characterization of pure resin and blended adhesives	IP disclosures 2 papers submitted for review	31 Oct 20 31 May 21
8 Ogden	Development of guayule-based adhesives	Results with possibility of patents and/or publications	31 Dec 21
9 Ogden	Distillation of resin into multiple fractions	Distilled fractions analyzed MS Thesis complete; separation strategy hypothesized	31 Dec 20 31 May 21

The review article manuscript on low-cost waste/residue feedstocks for biofuels was accepted in *Energy & Fuels*. The manuscript on the co-HTL of guayule bagasse and wastewater algae was submitted and accepted for a special issue on Bioenergy Conversion Methods in *Energies*; publication is on hold pending IP review by Bridgestone as not enough time for review had been given at the original submission.

At the SBAR Annual Retreat Characterization & Co-Products breakout, advisory board members present suggested that guayule resin is likely to be a good starting material for production of jet fuels to the elemental composition. A new work task was added to conduct hydrothermal liquefaction of guayule resin to study molecule fractionation and deoxygenation, alone and in combination with guayule bagasse. Armijo submitted this research area as a proposal for a NM AMP Undergraduate Research Scholar project, which was awarded starting in September. To do, two runs have been conducted at 270 and 310°C with ~80% bio-crude oil yields with very little solids. Experiments will continue in the next quarter with characterization and eventual economic evaluation. Resin for fuel is not expected to be a high-value application,

however, the baseline data is desirable for comparison, especially for those fractions that may remain after removal of insect-repellent and/or adhesive fractions.

Evaluate Supercritical Fluid (CO2) Extractor (SFE) and Fractionation of Guayule Including Impacts on Residual Biomass:
Dehghanizadeh and the undergraduates completed supercritical fluid extraction (SFE) set-up and safety review approval.

Shalygin worked on the characterization/quantification of resin components using the LC-MS (as described in quarterly report from Holguin group).

Evaluate IP Potential of Guayule Fractionation for Insect Repellent Applications:
Research continues; nothing new to report.

Test Insect Repellency of Guayule Resin Fractions on Multiple Urban/Agricultural Pests:
Dehghanizadeh and the undergraduate students completed the cockroach repellency tests for the guayule resin fractions from vacuum distillation from the UA group with very promising results. Dehghanizadeh prepared a presentation of the results for the *Tech Connect* Conference, which is currently under review at Bridgestone and around which a manuscript will be prepared for *Bioresource Technology*. Dehghanizadeh, Romero, and Brewer worked with NMSU's Arrowhead Center to prepare a provisional patent application on the guayule resin-based insect repellents.

Characterize Steps in Guayule Biosynthetic Pathways that Yield Argentatin and Guayulin as Potential Value-Added Coproducts:
Custom synthesis of bioinformatically selected oxidosqualene cyclase and sesquiterpene synthase genes was requisitioned, but suffered repeated delays at the gene synthesis company, with delivery expected only in the second half of October. After receipt of the genes, we will complete QC and deposit the gene-containing plasmids into our collections. Next, we will initiate cloning and functional characterization, and complete the remaining objectives.

Conduct Microbial Biotransformations of Major Metabolites in Guayule Resin:
Small-scale biotransformations were attempted with actively growing cultures ("feeding assay") using 2 filamentous fungi: *Cunninghamella elegans*, and *Mucor mucedo*. A mixture of argentatin A and *iso*-argentatin A (**argA**) and argentatin B (**argB**) were used as substrates. Argentatin C was not used as a substrate due to the relatively low amount of compound we have. The products were characterized by LC-MS-ELS, determining their putative molecular weights, and the conversion rates were quantitated at different time points each to determine optimal biotransformation conditions.

- *Cu. elegans* provided 14 putative products with **argA** in yields of 0.8-20.4%, with some variation of relative yields between day 6 and day 10 of the biotransformation. For **argB**, 2 prominent products were seen on day 6, which were further transformed to a smattering of up to 15 potential products upon continued growth of the fungus. Only a few of the potential products derived from either substrate will eventually be possible to isolate due to their low individual yields. Scaling up the biotransformations under optimized conditions is planned for the next project period to isolate products.

- *M. mucedo* provided 2-3 putative products each with either **argA** or **argB**, but at very low yields even after extended biotransformations. It is unlikely that these products could be obtained in isolable yields.

Isolate Structures and Evaluate Anticancer and Antimicrobial Activities of Novel Compounds from Microbial Biotransformation or Synthetic Biology:

After several attempts of large-scale biotransformation and compound isolation, argentatin A-P1 was finally obtained in amounts and purity sufficient for structure elucidation by NMR. Argentatin A-P1 turned out to be another Baeyer-Villiger type oxidation product with a *seco* ring A of the argentatin scaffold.

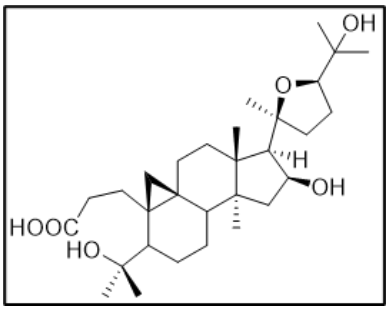


Figure 22. *Chemical structure of Argentatin A-P1.*

The cytotoxicity of argentatins A-P1, A-P3, *iso*A-P2, *iso*A-P4, C-P3, and C-P4 were determined using human non-small cell lung cancer (NCI-H460), central nervous system glioma (SF-268), breast cancer (MCF-7), and human lung normal cell line (WI-38). Doxorubicin and DMSO were used as positive and negative controls, respectively. Argentatin C-P3 was found to show significant cytotoxicity at IC_{50} of 38.95 +/- 1.83 µM against the NCI-H460 lung cancer cells.

The antimicrobial activities of argentatins A-P1, A-P3, *iso*A-P2, *iso*A-P4, C-P3 and C-P4 were determined against *Staphylococcus aureus* ATCC 25923, *Streptococcus pyogenes* ATCC 14289, *Escherichia coli* ATCC 25922, and *Candida albicans* ATCC 10261. No significant antimicrobial activities were found in concentrations up to 100 µg/mL.

Characterization of Pure Resin and Blended Adhesives:

One paper has been submitted for peer review.

Development of Guayule Resin-based Adhesives:

S. Pradyawong, A. Hinojosa, and T. Lane worked at the Advanced Ceramics Company. They mainly focused on replacement of urea-formaldehyde (UF) adhesive with guayule resin and enhance the adhesion property of UF adhesive by using the guayule resin. They performed the adhesion test of resin-UF blends by dissolving modified/unmodified guayule in different solvents and mixed with UF with different concentrations. Approximately 75% of UF could be replaced by guayule resin without any effects on either wet or dry adhesion strength.

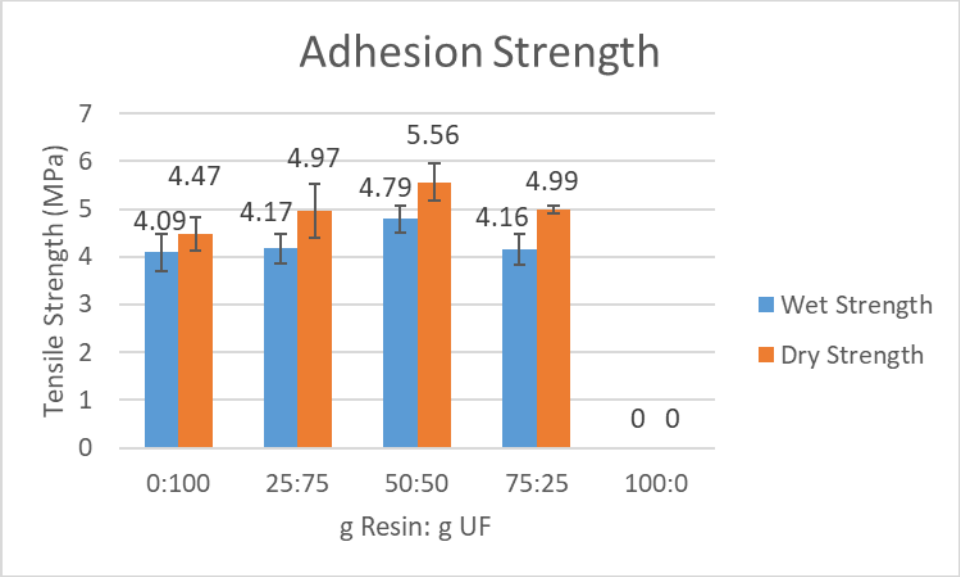


Figure 23. *Adhesion strength of resin-UF blends.*

Additionally, the adhesion performance of UF could be improved by mixing with small amount of resin. Some of the modified/unmodified resin samples were sent to Dr. Brewer and Dr. Holguin groups to test for the insect repellent property and to identify the resin contents, respectively. We also tested the adhesion property of A. Smith's distillated guayule resin fractions. We tested both modified and unmodified fractions. The project was going on well with a little bit of delay at the end of the quarter due to the Instron grips issues and the changes of the working schedules for students.

Distillation of Resin into Multiple Fractions:

A. Smith, who mentors K. Burke, worked on drying of guayule bagasse as a pretreatment, and he will finish his master's thesis next quarter.

SYSTEM PERFORMANCE & SUSTAINABILITY

Project Coordination: Colorado State University (Dr. Jason Quinn) leads the fortnightly working group meetings. The meetings are leveraged to ensure all team members are on schedule and work can seamlessly integrate across institutions. The structure for the team meetings has been alternating between team updates and individual deep-dive presentations.

The team has at least two meetings each month with presentations being done every other meeting and slide updates on the other. COVID-19 has had minimal impact on the CSU and SUS team in general in terms of research productivity.

The focus this quarter has been:

- Submission of bagasse to fuels manuscript
- Presentation of results at virtual conference
- Advancement of guayule integrated model
- Published paper on water LCA
- Developed and moderated sustainability team meetings on a bi-monthly basis in support of research goals
- Supported CSM data integration and modeling
- Leading the all-hands working session and attendance at the in-person project meeting in Tucson

All notes and presentation materials are maintained in a community workspace available to all partners for future reference.

Issues/Risks:
Fan: D. Zuniga-Vasquez graduated from University of Arizona in August 2021, a new student should be recruited. Currently, a PhD student S. Yao is working on part of this project. Now we are in the process to have a new student joining our group next spring semester.

Miller: The IMPLAN modelling is not complete because reevaluation of prior work identified some potential improvements that could be made to the approach. This puts the work behind schedule but is an improvement in quality. I have some concerns about the importance of this work now – with the lack of interest in growing guar, is improving the IMPLAN modelling of the economic impact worth the time investment?

The hemp project is on hold for now. Waiting on co-author to finish an unrelated project.

There are two projects that were not in the original 5-year plan, but were identified as important at the SBAR retreat. Work is progressing on these two projects, which will be part of graduate theses projects.

Quinn: E. Sproul has transitioned off the project. A new graduate student, Brooke Silagy, was brought on with a one-month overlap with Sproul to support transition of work. Based on the all-hands retreat, a posting for a post doctorial scholar has been posted and recruitment activities have been initiated. Currently, the position has not yet been filled.

Objective 1. Develop a scalable engineering process model for crop production and processing that is coupled with Techno-Economic Analysis (TEA) and Life Cycle Analysis (LCA) to understand the economic impact to rural communities through input-output methods.

Task #	Description of Task	Deliverable	Target Completion Date
1 Gutierr	Functional integration of economic analysis into system model	Conduct input/output analysis of system model results (IMPLAN) Validate preliminary analysis for farm production and profitability Develop market/transportation study to optimize industry location	31 Aug 21 31 Aug 21 31 Aug 21
2 Gutierr	Develop/test online producer systems model	Create online tool for evaluating guar/guayule alternative crops	31 Mar 21
3 Landis	Field data transfer	Field trial database updated with data quality codes for guar and guayule	31 Oct 20
4 Landis	Integrate guayule field data into LCA/TEA model	Updated LCA/TEA results and capability to choose likelihood for guayule	1 Dec 20
5 Landis	Support incorporation of guar data into LCA/TEA model	Collect data that enables LCA/TEA results for guar	15 Dec 20
6 Landis	Define guayule Monte Carlo parameters within model; run Monte Carlo analysis	Updated guayule field data Monte Carlo analysis report for guayule (integrated model)	15 Jan 21
7 Landis	Guayule: Statistical analysis on field data; compare to baseline model	Statistics report and comparative graphs generated/complete	15 Feb 21
8 Landis	Guar: Support best-fit probability distributions	Field data updated; methods documented	28 Feb 21
9 Landis	Sensitivity analysis (integrated model)	Tornado plots and report on model parameters causing most impact	15 Mar 21
10 Landis	Support guar manuscript development	Data support provided to sustainability team	15 May 21
11 Landis	Guayule scenario analysis	LCA/TEA results and report comparing scenarios to baseline	30 Apr 21
12 Landis	Guayule manuscript development	Draft manuscript circulated within sustainability team for review Manuscript generated and submitted to peer review journal	15 Mar 21 15 May 21

13 Miller	Transition NM SBAR Sustainability work to new personnel	Attend meetings; identify and articulate specific contributions	31 Mar 21
14 Miller	Validate farm level scenarios within system model	List of assumptions compiled; parameters for acreage, production values, and relevant technology	30 Apr 21
15 Miller	Evaluate economic impacts in rural areas using whole farm budgets and input models	IMPLAN model analysis for crop adoption; report generated for Extension dissemination	30 Mar 22
16 Miller	Addition of NM Specialty Crops to BENCO model	Add chili, onions, and pecans to the model to allow farmers the option to compare conventional crops to guar and guayule	30 Sep 21
17 Miller	Evaluate the over-adoption of hemp in NM, lessons learned in contract growing for new crop marketing	Manuscript submitted	31 Jan 22
18 Miller	Evaluate the potential for using guar as water-saving forage for dairy rations in eastern NM	Manuscript submitted	31 Jan 22
19 Miller	Develop sensitivity analysis for water usage and labor costs of guar and guayule adoption	Presentation abstract and manuscript submitted	30 Jun 22
20 Miller	Feasibility research on having guayule custom-harvested instead of using farmer's own equipment (BENCO)	Presentation abstract and manuscript submitted	30 Apr 22
21 Quinn	Techno-economic and Life Cycle Assessment results	Update/finalize economic and environmental impact results Manuscript on water use for guar submitted to peer review	1 Aug 21 1 Sep 21
22 Quinn	Data integration	Integrate experimental data into foundational processing model	1 Sep 21
23 Seav	Validated integrated model, including alternative crops	Updated integrated model to evaluate farm-level economics	31 Aug 21
24 Teeg	Facilitate working agreement between Tribal Farms and Bridgestone to establish experimental plots	At least one experimental plot established on Tribal lands	31 Aug 21
25 Teeg	Validated integrated model	Update and incorporate new information under various scenarios	31 Aug 21

Functional Integration of Economic Analysis into System Model:
This task has transitioned to new personnel and is reported below.

Online Producer Systems Model:
This task has transitioned to new personnel and is reported below.

Field Data Transfer:
This task is complete.

Integrate Current Guayule Field Data into LCA/TEA Model:
Nothing new to report.

Support Incorporation of Guar Data into LCA/TEA Model:
Nothing new to report.

Define Guayule Monte Carlo Parameters Within Model and Analyze:
Nothing new to report.

Guayule: Statistical Analysis on Field Data Compared to Baseline:
Nothing new to report.

Guar: Support Best-Fit Probability Distribution:
Nothing new to report.

Sensitivity Analysis (Integrated Model):
Nothing new to report.

Support Guar Manuscript Development:
Nothing new to report.

Guayule Scenario Analysis:
Nothing new to report.

Guayule Manuscript Development:
The guayule LCA and TEA outline is complete. Results have been produced and added; the manuscript is in progress.

Transition NM SBAR Sustainability Work to New Personnel:
This task is complete.

Validate Farm Level Scenarios within System Model:
The IMPLAN discussion is being re-evaluated to better capture the economic impacts of growing guar as opposed to conventional grains. We are beginning to work on modeling the impact of guayule planted in Arizona, at the stage of collecting information on what the correct model parameters should be.

Evaluate Economic Impacts in Rural Areas Using Whole Farm Budgets and Input Models:
Many of the projects use the BENCO model as the basis for analysis. This model is almost fully updated. Two new student research projects have begun. One uses BENCO to assess the feasibility of offering custom-harvesting of guayule to attract growers. The other will use a modified BENCO to discuss strategies for participating in USDA risk management programs when growing guayule.

16 Addition of New Mexico Specialty Crops to the BENCO Model:
Miller and Omotayo obtained information from New Mexico farmer and custom harvester to incorporate New Mexico prices and farm operations into the New Mexico BENCO developed by Seavert. Still need to collect parameters for established pecans, have a commitment from New Mexico pecan grower and harvester to meet and discuss.

17 Evaluate the Over-adoption of Hemp in NM, Lessons Learned in Contract Growing for New Crop Marketing:
Research for this task is currently on hold.

18 Evaluate Potential for Using Guar as Water-Saving Forage for Dairy Rations in Eastern NM:
The evaluation of guar as a potential dairy forage is progressing. Omotayo met with researcher at Leyendecker ASC to learn how samples were dried for writing the methodology section of the manuscript. We are currently waiting on decision about best method to use for forage analysis.

19 Develop Sensitivity Analysis for Water Usage and Labor Costs of Guar and Guayule Adoption:
Nothing new to report.

Feasibility Research for Guayule Custom-Harvest vs. Farmer Equipment (BENCO):
Nothing new to report.

Techno-economic and Life Cycle Assessment Results:
Process Modeling: The focus this quarter was updating the model based on feedback from the all-hands meeting. Specifically, two areas were modified: 1) biomass pre-processing and 2) resin distillation. Harvesting logistics have been identified as a potential scalability limitation. Current practices have the biomass harvested and transferred to the plant for just-in-time processing. Based on feedback from the industry partner, it is expected this model will not be realistic at large-scale due to the need for having on-site biomass storage. A way to address this issue is to dry and shred the biomass upon arrival. This will extend the life of the rubber in the plant. A drum dryer model was developed and integrated with the integrated model on the front end of the system. Additionally, work has been dedicated to the development of a distillation model. This is at the preliminary phase and we have identified experimental data as being critical to accurately capturing the performance of the system. Additionally, property data has been developed for the resin to support accurate calculations of the energy for distillation.

Water LCA: This quarter, the water LCA methods paper was accepted for publication. The reviewer comments in general were positive and we were invited to submit a revised manuscript. In addition, the methods were presented at the American Center of Life Cycle Assessment (ACLCA) conference.

Co-Product Analysis: The CSU team is working on resin co-product modeling and supporting NMSU as they lead the co-product analysis. The CSU team and NMSU team are meeting weekly to collaborate on furthering potential co-product pathways. A vacuum distillation model is being developed around a promising value add pest repellent.

Data Integration:
Research continues as planned; nothing new to report.

Validated Integrated Model, Including Alternative Crops:
Updated to integrated models as changes were needed for machinery calculations, budget modifications, and guayule yields, as well as other minor modifications within the model.

Facilitate and Foster Relationship between Tribal Farms and Bridgestone:
Nothing new to report.

Validated Integrated Model:
Nothing new to report.

Objective 2. Integrate regionally appropriate metrics and combine results from SBAR-developed data into sustainability models to provide a path to commercialization of biofuels and bioproducts.

Task #	Description of Task	Deliverable	Target Completion Date
1 Quinn	Scenario analysis	Generate results of scenario analysis	1 Apr 21
		Present results of scenario analysis at conferences for feedback	1 Apr 21
		Submission of manuscript based on field trial data	1 Jul 21

Scenario Analysis:
The CSU team continues to work on the integrated models and supporting CSM as they lead the guayule modeling efforts. This past quarter, collaboration with CSM has been minimal. A drum dryer unit has been added to the integrated model. The dryer includes separation of monoterpenes with steam distillation.

Bagasse to Fuels:
A bagasse to fuels model and corresponding manuscript have been developed with the manuscript submitted. The model includes pyrolysis and pelletization pathways. Results include economic and environmental assessments of both pathways.

Objective 3. Interface with regional growers to de-risk US production of guayule and guar while evaluating social impacts.

Task #	Description of Task	Deliverable	Target Completion Date
1 Landis	Qualitative social sustainability manuscript	Complete manuscript: modify existing manuscript to focus on “hot spot assessment” of guar and guayule	31 May 21

Qualitative Social Sustainability Manuscript:
Nothing new to report.

Objective 4. Develop and optimize system-level logistics models for demand-driven harvesting.

Task #	Description of Task	Deliverable	Target Completion Date
1 Fan	Comprehensive sustainability and economics analysis	Conference presentation Manuscript submitted to peer review journal	30 Apr 21 30 Apr 21
2 Fan	Apply integer optimization approaches to design smart farm production plan/ scheduling	Computer codes and programs with embedded optimization models and algorithms	31 Aug 21
3 Fan	System-level model/algorithm generation for decision support for guar and guayule	Data/model/algorithm shared for Yr4 research (integration of 3 decision modules)	31 Aug 21
4 Fan	Develop optimization approaches for general harvest scheduling	Collect data and information for guar and guayule harvest scheduling Preliminary optimization models and results for harvest scheduling Final version of results summarized into manuscript; submission	30 Sep 21 31 Dec 21 31 Mar 22
5 Fan	Identify the optimal strategies related to the harvesting process for guayule	Comprehensive tests and modifications for proposed models related to guayule harvest scheduling complete	30 Jun 22
6 Fan	Continue integration of developed optimization modules for both guar and guayule	Summary of input data/parameters complete Summary of optimization models, algorithms complete	30 Sep 21 31 Dec 21
7 Fan	Construct system-level for optimal strategies for guar and guayule supply chains	Preliminary version of the instructions manual draft complete Final version complete	31 Mar 22 31 Aug 22

Comprehensive Sustainability and Regional Economics Analysis:
The results of this task were reported in Q2. This quarter, the results were presented in the 32nd AAIC Annual Meeting, and the full version of this paper was submitted for the special issue on *Industrial Crops and Products* after this conference.

Integer Optimization Approaches for Smart Farm Production/Scheduling:
The input parameters for the optimization modules of guayule and guar supply chains (mainly the facility location, transportation logistics, farm production planning, and machinery scheduling) are integrated by using macros with Visual Basics for Applications (VBA) and designed to meet the CPLEX model's requirements.

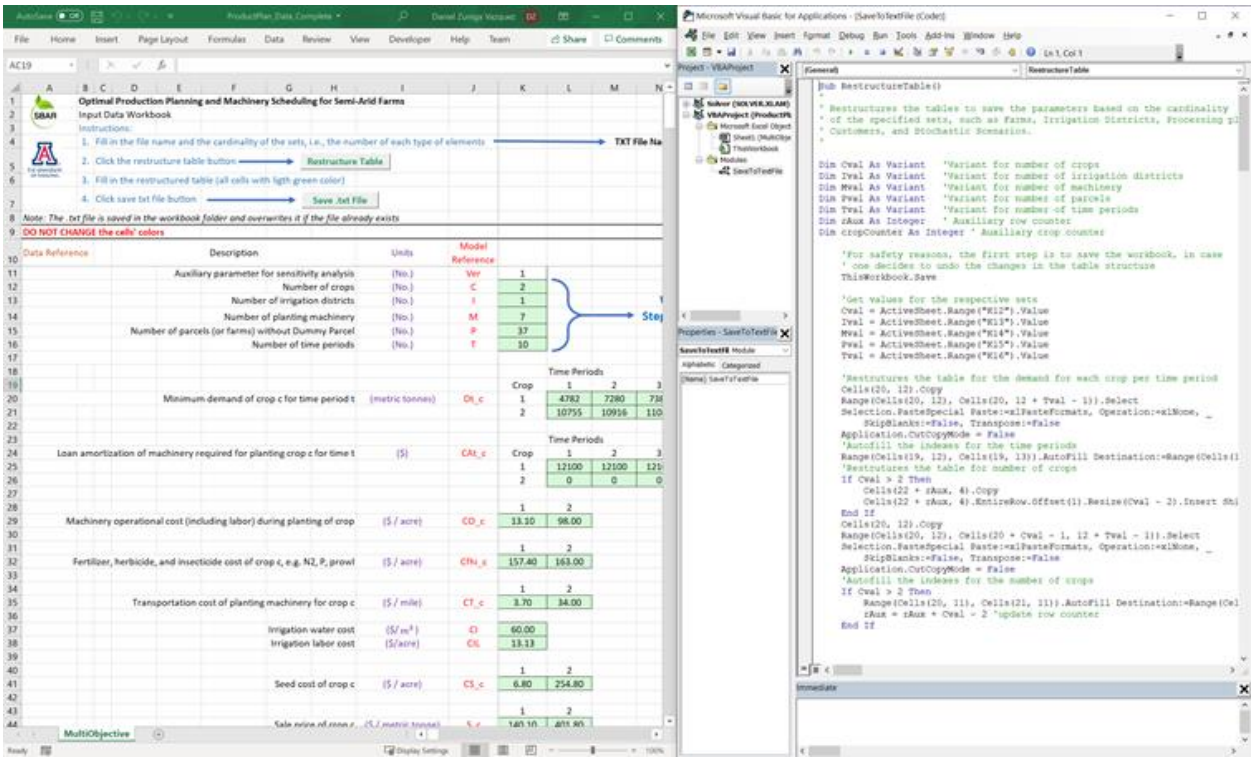
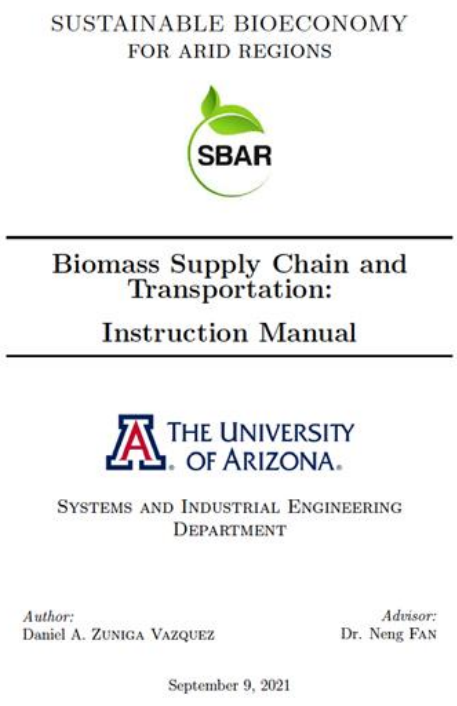


Figure 24. *Integration of input parameters for optimization modules.*

System-level Model/Algorithm for Decision Support:
A draft of instruction manual for the biomass supply chain and transportation (BSCT) optimization tools is being prepared and updated. The instruction manual will provide detailed instructions on how to perform the entire optimization analysis from the accessing of online CropScape information, its implementation in ArcGIS Pro, to obtaining the optimal solution using a High-Performance Computer (HPC) and the interpretation of results (sample pages are shown below).



SUSTAINABLE BIOECONOMY
FOR ARID REGIONS

SBAR

Biomass Supply Chain and Transportation:

Instruction Manual

THE UNIVERSITY OF ARIZONA.

SYSTEMS AND INDUSTRIAL ENGINEERING DEPARTMENT

Author: Daniel A. ZUNIGA VAZQUEZ

Advisor: Dr. Neng FAN

September 9, 2021

Contents

2

Figure 25. *Draft of instruction manual for the biomass supply chain and transportation optimization tools.*

Develop Optimization Approaches for General Harvest Scheduling:
In this quarter, the data and information for guar and guayule harvest scheduling are collected through existing research results, collaborations, and public information. Also, the literatures were reviewed, and our ideas and plan for this part of research were discussed with the whole group (UA Research Team, Sustainability Team). The focus will be “demand-driven harvesting planning and equipment scheduling”, and models will be developed in the following quarter.

Identify the Optimal Strategies Related to the Harvesting Process for Guayule:
Nothing new to report.

Continue Integration of Developed Optimization Modules for both Guar and Guayule:
As mentioned above, currently two optimization modules (facility location and transportation production planning and machinery scheduling) are integrated in this quarter for guar and guayule supply chains and transportation. The data, input parameters, algorithm codes and other collected information were summarized and organized for further integration.

Construct System-Level for Optimal Strategies for Guar and Guayule Supply Chains:
The 3rd version of the “Instructions Manual for Biomass Supply Chain and Transportation”, on how to use the developed optimization modules and to perform the analysis on economic benefits, social and environmental impacts, was prepared in this quarter. With the development of module on harvesting optimization, the manual will be updated in the following quarters.

EXTENSION & OUTREACH

Project Coordination: Dr. O. John Idowu (New Mexico State University) and Blase Evancho (University of Arizona) continue to serve as the co-leads for the Extension & Outreach working team. When the larger Education and Extension & Outreach components jointly meet, Dr. Idowu and Evancho work with Dr. Chavarria to draft meeting agendas.

The Extension & Outreach team has two main foci – youth development (through 4-H activities and STEM mini-camps), and grower education/outreach. These two sub-groups meet at least once per month to discuss tasks and to improve component integration. The combined Education and Extension & Outreach teams meet once monthly to provide updates and address larger concerns regarding over-arching tasks that facilitates seamless project implementation in Arizona and New Mexico.

Issues/Risks:
Angadi: Not able to timely hire graduate students delayed development of some of the outreach activities but will be completed soon. Field demonstration was delayed by COVID and prolonged drought.

Evancho: Plant Population and other previously published information for website update has been adjusted in the year 5 SOW, indicating when they will be delivered. Native American outreach is slowed, but recent interest in the field day could allow for some increased involvement in Q4.

Idowu: Fortunately, we had all the field days as in-person events in NM because they were held in open fields. Most of the indoor events/conferences scheduled for the fall were either cancelled or moved to a virtual platform due to the anticipation of an increased spread of the Delta variant of coronavirus.

Miller: This year there was considerable difficulty in promoting the contest. Many teachers indicated that they were unaware of the contests – despite multiple emails announcing the contests and promotions through social media. However, having the contests and announcing that they were annual contests should help with next year's interest. Additionally, the contests provided an opportunity to visit with teachers about the planned workshop and about expanding participation in general.

The science fair division of the Southern New Mexico Sate Fair was cancelled, and only the public speaking portion was held. However, a request was made to add the speaking and AgriScience contests to Eastern NMSF. These were added and funds were raised for scholarships. SBAR bags were given to speakers at SNMSF. SBAR pointer/slide advancers were given at ENMSF.

Progress has been made on setting up fellow support *Guar*-dians of the Biosphere, but is still moving slower than we had hoped.

Morris: Lesson adaptation is behind but in progress. *Guar-dians of the Biosphere* work is delayed due to lack of engagement from the active teachers.

Rock: As stated previously, because our grant objectives specifically target in-person training and education for student interns, our project team has waited patiently to bring students back to campus when it is safe to do so. Due to recent University developments, we believe that we are now able to begin recruiting students and the mentors for internship deployment for Summer 2022.

As stated previously, we have worked with the project PI to postpone the intern experiences to 2022. This would allow our research and extension team to re-schedule interns for semesters when faculty, staff, and students return to campus, and allow the project team to full-fill remaining project objectives. This of course may change based on University guidance as well as student availability.

Objective 1. Produce Extension bulletins and web materials to inform growers of agronomic and irrigation requirements.

Task #	Description of Task	Deliverable	Target Completion Date
1 Angadi	Guar photographs and videos	Obtain photographs of guar growth stages Create videos of guar germination and growth	31 Dec 20 31 Dec 20
2 Angadi	Guar agronomy research	Gather/analyze data; develop peer-reviewed article on N and P fertilization study	31 Mar 21
3 Angadi	Guar critical stage irrigation study	Produce report on guar crop growth based on irrigation management	28 Feb 21
4 Evan	Produce guayule newsletter articles	At least 2 guayule articles drafted and published – targeting AZ growers	31 Aug 21
5 Evan	Develop outreach documents for guayule	Background and introduction of guayule Guayule yield by variety Plant population management Guayule weed management Infographics for use in materials	31 Apr 21 30 Jun 21 30 Jun 21 31 Aug 21 31 Aug 21
6 Idowu	Travel to conferences	Present SBAR info/materials at 4-5 grower commodity conferences	31 Aug 21
7 Idowu	Establish guayule and guar trials in Las Cruces, Los Lunas, Clovis, and Tucumcari, NM	Showcase trial experiments at field days	31 Aug 21 31 Aug 21

		Gather data/synthesize results (toward generating an Extension bulletin) Generate trial summary (published on SBAR website)	31 Aug 21
8 Idowu	Establish on-farm demonstration trials	Collect and summarize planting data for on-farm trials Final report prepared for website	31 Aug 21 31 Aug 21
9 Idowu	Newsletters to inform stakeholders	Distribute fall newsletter Distribute spring newsletter	31 Dec 20 31 Jul 21
10 Idowu	Design/schedule/implement E&O evaluation	Fall evaluation data gathered Spring evaluation data gathered Summer eval data gathered Eval info synthesized; report generated	31 Dec 20 31 May 21 31 Jul 21 31 Aug 21
11 Seav	Validate/Revise Sensitivity Analysis Model for use in Extension meetings; Participate in grower workshops	User manual for model targeting Extension educators Workshop hosted (Title: The Costs and Benefits of Producing Alternative Crops in NM and AZ: Guayule and Guar)	31 Oct 20 30 Nov 20
12 Seav	Develop percentage of returns for tenant-landowner contributions	Draft Extension publication re: equitable lease arrangements; target audience: SW tenant/landowners	31 Aug 21
13 Seav	Demonstrate trade-offs of machinery ownership to custom hiring operations	Draft Extension publication re: machine needs and options for guayule and guar	31 Aug 21
14 Seav	Develop enterprise budgets for all crops in Sensitivity Analysis Model	Generate six Extension cost of production bulletins for AZ and NM Generate one Extension cost of production bulletin on growing hemp Hemp budgets accessible online via *AgBiz Logic*	31 Mar 21 31 Aug 21 31 Aug 21
15 Teeg	Generate an interactive farm-level economic and financial model (guar and guayule)	Validate and revise BENCO Model for use in Extension/Outreach meetings Develop PPT/guide for using the farm-level economic financial mode	31 Jul 21 31 Jul 21

16 Teeg	Participate in Extension meetings; disseminate economic info for guar and guayule	Provide 2 presentations to growers in NM Provide 2 presentations to growers in AZ	31 Aug 21 31 Aug 21

Guar Photographs and Videos:
We made good progress is made in spite of adverse weather and COVID. Research Asst, M. Nielson, is helping on guar extension and outreach projects.

Continued working on developing animations and editing of video showing guar crop growth in response to different deficit irrigation strategies. We will put some caption and add some commentary to it. We collected weekly photos and additional time lapse of guar plant growth in irrigation and nutrient management trial. Special focus was given to record time lapse of guar flowering. We are working on putting some captions, some info and voice over.

Guar Agronomy Research:
This task is complete; nothing new to report.

Guar Critical Stage Irrigation Study:
First draft of factsheet on Guar Response to Temperature has been developed and is being reviewed and revised. Former graduate student, J. Singh, has analyzed three years data of deficit irrigation project and first draft of research manuscript is written. We will use that information to develop factsheet on Guar Deficit Irrigation

Produce Guayule Newsletter Articles:
Nothing new to report.

Develop Outreach Documents for Guayule:
The variety trial document has been completed and submitted to FastTrack for revisions. The weed control rough draft is completed and awaiting edits before submission to FastTrack. Infographics on guar and guayule were completed. The guayule infographic rough draft is completed and will be edited and completed early in the 4th quarter.

Travel to Conferences:
Nothing new to report.

Establish Guayule and Guar Trials in New Mexico:
In-person field days focusing on guar production in NM were held on the following dates and locations:

- August 3, 2021 – Clovis Field Day at Clovis Agricultural Center, Clovis, NM (60 people attended the field day)
- August 18, 2021 – Los Lunas Field Day at Los Lunas Agricultural Science Center, Los Lunas, NM (200 people attended the field day)
- August 25, 2021 – Las Cruces Field Day at the Leyendecker Plant Science Center, Las Cruces, NM (100 people attended the field day)

During the field days, we also held tabling events to distribute recent extension publications on guar and other related materials on SBAR.

Establish On-Farm Demonstration Trials:
The on-station guar spacing trials at 4 locations (Los Lunas, Clovis, Tucumcari and Las Cruces) in NM are progressing well. Harvest will start in the second half of October.

The guayule demonstration trial is progressing well in NM. Information on guayule was presented during the field day in Las Cruces (August 25, 2021). The guayule cold tolerant trial at Leyendecker PSC, Las Cruces, in partnership with Bridgestone is also progressing well.

Newsletter to Inform Stakeholders:
Nothing new to report.

Design and Implement Extension & Outreach Evaluation:
Nothing new to report.

Validate Sensitivity Analysis Model for use in Extension/Outreach Meetings:
Demonstrated the BENCO Model to a grower and extension agent in AZ. Both support providing the model to other producers to assist in guayule adoption. As per last quarter, instructional manual/videos for Extension educators will be postponed to the 2021-22 year due to several changes to the model mentioned above.

Develop Percentage of Returns for Tenant-Landowner Contributions:
Lease calculations in the BENCO Model caught the interest of the grower and agent mentioned above. No tools or information is currently available for producers that estimates equitable annual cash rent, crop-share, or flexible cash rent leases.

Demonstrate Trade-Offs of Machinery Ownership to Custom Hiring Operations:
Bridgestone demonstrated a new harvesting method in July, due to unforeseen circumstances, I was not in attendance. However, I was provided feedback that more work needs to be conducted on the cost of this new harvesting technique. Publication on machinery will be postponed due to this new information into the 2021-22 year.

Develop Enterprise Budgets for all Crops in Sensitivity Analysis Model:
Guar and guayule enterprise budgets are complete. Other crops are underway by team members in AZ and NM.

Interactive Farm-Level Economic and Financial Model (Guar and Guayule):
Nothing new to report.

Dissemination of Guayule and Guar Economic Information through Extension Meetings:
Nothing new to report.

Objective 2. Hold workshops throughout the region on sustainable practices to expand crop production to new rural regions and Native Nation lands.

Task #	Description of Task	Deliverable	Target Completion Date
1 Angadi	Arrange guar field day/field walk at Agricultural Science Centers, NM	Present guar crop information to ~100 producers in the region	31 Dec 20
2 Angadi	Educate local growers	Establish guar demonstration on a local farmer's field	31 Dec 20
3 Evan	Hold workshops and present information to growers in Arizona	Host two presentations on guayule agronomic production and irrigation at regional extension events	31 Aug 21
4 Evan	Present guayule production intormation to Native American farming communities	Presentation to Native American Farm Boards	31 Aug 21
5 Evan	Communicate with AZ growers and producers	Maintain relationships with local growers to share SBAR/guayule information	31 Aug 21
6 Fields	Track Grower Extension Team activities monthly	Compiled contact data totals submitted quarterly	31 Aug 21

Educate Local Producers about Guar:
We will continue working on developing guar web page for producers. Seasonal growth of guar was captured in artistic drawings. These drawings will be used in presentations, web pages, fact sheets, and other outreach activities. Our efforts to further improve guar presentation materials continue.

I along with Idowu presented our guar research in the field day at the Agricultural Science Center at Clovis on August 3, 2021. The field day was well attended by interested crowd of 60 people. The interactions with diverse clientele led to initiate seasonal forage quality analysis of guar forage in collaboration with Miller.

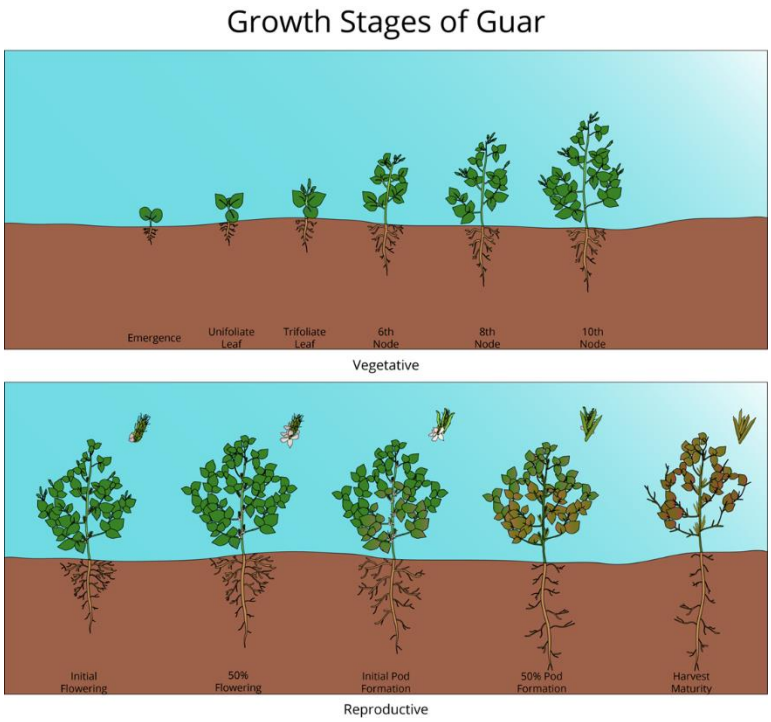


Figure 26. *Artistic rendering for guar's seasonal growth stages.*

Cultivating Young Minds program at Clovis Agricultural Science Center attempts to educate primary school students of Clovis and surrounding school districts. This year 600 fifth grade

students along with 45-50 teachers and parent chaperones visited the science center in October 13 and 14, 2021. They were educated on different agricultural crops including guar and their products those are used in day-to-day life. In addition to getting a pumpkin of their choice from the field, they learned about growing and making pumpkin pie. Guar bubble demonstration was effectively used to make students remember the science center.

Establish Farm Demonstration Site in New Mexico:
Due to severe drought and COVID we could not conduct demonstration during the year. We will plan to conduct a field scale demonstration of guar in 2022 and make an effort to recruit farmers for the demonstration.

Grower Workshops in Arizona:
Guayule Field Day is scheduled for October 6th. Advertisement through Facebook and the Casa Grande Dispatch (local newspaper) is ongoing.

Guayule and Native American Communities:
Bridgestone is scheduled to plant a guayule field with Tohono O'odham Native American Tribe next spring. A private grower from the Gila River Indian Community has registered to attend the Guayule Field Day in October.

Communications with Arizona Growers:
There were no conferences or meetings attended this quarter due to COVID uncertainties. Two interviews were given to Pinal Central (newspaper) reporters. Guayule/SBAR was discussed in both interviews. Casa Grande Dispatch (local newspaper) has a current daily circulation of 8,313.

Track Grower Extension Team Activities Monthly:
The table below quantifies outreach by event during Q3 2021. Due to the ongoing impact of the COVID-19 pandemic, no events were scheduled in AZ. Field days resumed in NM as described below. Extension staff continued to build relationships as possible with farmers who are most likely to be potential growers of guar and/or guayule.

Table 8. *Outreach events conducted during Q3 2021 in Arizona and New Mexico.*

	Event	**Date**	**Number participating**
AZ	None to report	N/A	0
NM	Los Lunas Field Day	8/18/21	Approx. 200 attendees, including ~30 farmers
	Las Cruces Field Day at Leyendecker Plant Science Center	8/25/21	Approx. 100 attendees, including ~10 farmers and ~30 Ag Industry professionals
	Clovis Field Day	8/3/21	Approx. 60 attendees, including ~40 farmers and Ag Industry professionals

Objective 3. Involve youth in internships, 4-H projects, and STEM summer camps.

Task #	Description of Task	Deliverable	Target Completion Date
1 Fields	Design/schedule evaluation tools, protocols, and metrics for all Extension & Outreach activities	Fall tools developed/refined; evaluation data gathered Spring tools developed/refined; evaluation data gathered Summer tools developed/ refined; evaluation data gathered Data synthesized; evaluation report generated	31 Dec 20 31 May 21 31 Jul 21 31 Aug 21
2 Miller	Create video presentations under specific Agri-Business topics	10 videos (5-7min/ea) complete	31 Dec 21
3 Miller	Finalize SBAR Ag Science project development on bioeconomy	Create formal proposal for 4H Leadership (NM) Initiative 4H curriculum review process Recognition of SBAR-related science fair projects at NM State Fair Final manual (publication) for starting an Agri-Sci project Host workshop with FFA teachers and 4H Agents (coaches for Agri-Sci students) Host mentoring session for interested students to support FFA SAE project development	31 Mar 21 31 Aug 21 30 Sep 21 31 Dec 21 31 Mar 22 30 Jun 22
4 Miller	Co-lead development of *Guardians of the Biosphere* curricula and activities	Draft bioeconomy-related 4-H project curricula for grades 5-7; initiate curriculum review	30 Jun 22
5 Morris	Adapt existing curriculum for 4H program	Two existing 4H curricula adapted for SBAR topics (bioeconomy)	15 Nov 21
6 Morris	Adapt *Guar-dians of the Biosphere* curriculum	*GOB* curriculum finalized	30 Jun 22
7 Morris	Design STEM volunteer training program; recruit volunteers	Recruit 5 STEM certified volunteers Host 3 STEM volunteer trainings	31 Dec 21 31 Dec 21
8 Morris	Develop STEM internship program plan, recruitment plan, evaluation plan	Completed internship program plan, recruitment plan, and evaluation plan	31 Jan 22

9 Rock	Develop SBAR internal factsheets on *Project Puente*	Generate *Project Puente* resource document(s) for SBAR faculty	28 Feb 20
10 Rock	Recruit students for summer *Project Puente* internships	Update application materials to highlight on-going SBAR research opportunities Recruit 6 students for Yr3 cohort of *Project Puente* interns	pending
11 Rock	Recruit faculty mentors for summer *Project Puente* internships	Recruit 5 faculty mentors for Yr3 cohort of *Project Puente* interns	pending
12 Rock	*Project Puente* student project development and deployment	Work with SBAR faculty to identify appropriate internship projects (research and extension) Facilitate SBAR internship projects; final poster presentations highlighting student work	pending
13 Rock	*Project Puente* case study video	Design and develop short video highlighting student/mentor experiences for future training needs	pending

Design and Implement Evaluation Tools:

Q3 of 2021, the primary tasks related to the evaluation of the EEO components of the SBAR project included: 1) continued participation in regular team and EEO all-hands meetings; 2) ongoing analysis and review of evaluation data, meeting notes, and other artifacts for the purpose of developing quarterly and annual reports, and contributions towards publications in progress; 3) participation in the annual SBAR retreat; 4) travel to NM to attend Clovis Field Day and conduct multiple interviews with key stakeholders (described further below); 5) meetings with co-authors on graduate student publication in progress; 6) continued work on a second publication about the various formal and informal modalities that SBAR-developed content and resources are being tested in and how these models/frameworks can be used more broadly across arid regions; and 7) initial work on drafts of two surveys – follow up grower's assessment survey and graduate student summative project survey.

> ***Grower-Focused Extension*** – The grower-focused extension team saw the resurgence of in-person field days. I traveled to NM from August 2-4 to attend the Clovis Field Day. The event highlighted the SBAR project through an approximately 15-minute presentation that was first in the tour. While the focus was on guar, which is the crop more commonly grown in NM, there was also mention of guayule. Several local farmers asked questions about the crops including water use, crop rotation, and of course whether there is a market for the crops. The NM processing facility for guar has closed, and farmers expressed concerns that water use consistency and viable market are concerns. Yet, there was clear interest. The event was well organized, well attended, and informative. A hosted BBQ lunch after the field tour allowed for more discussion and relationship building.

Youth Development Extension – For the Youth Development team, the impacts of staff turnover and COVID necessitated the need to closely examine the work in years 1-3 and jointly develop a plan for years 4-5 that will best leverage and capitalize on that work. In addition, a new AZ 4-H Lead was being onboarded during this quarter. A number of programmatic activities are planned and in process, to be implemented through the existing UA 4-H structure, that will disseminate SBAR resources including: in AZ recruitment and training of youth STEM ambassadors that will leverage SBAR content; a junior and senior internship program that will seek to find SBAR placements; a series of trainings for adult 4-H volunteers that will include SBAR content and activities. Once trained, these regional volunteers will conduct these SBAR activities with youth in their communities. In NM, there was significant progress made in working through the science fair to incorporate SBAR content including trainings for teachers. This was piloted with a small group last year and will continue this year. It is anticipated that the reach will grow this year as COVID begins to allow for more in-person school-based activities.

Create Video Presentations on Specific Agri-Business Topics:
The video project is moving forward, with the new goal of incorporating BENCO model case study as the final component, once kids have learned more about using Excel through the videos. Taping will begin in 4th quarter, but PowerPoints for videos 1-3 have been developed.

Finalize SBAR Ag Science Project Development re: Bioeconomy:
The 4H Agri-Science Project is moving forward. The contest were held, and conversations held during the contests will hopefully generate support for the planned science fair workshops. Ramos-Coronado was invited to work with students at Hatch Middle and High School about how to do an Agri-Science Project.

The SBAR kids developed for changed in focus to support science teachers interested in helping kids develop independent science projects. The remaining kits were distributed to San Juan County Extension – where they will use it in their farm classroom; and to Tucumcari FFA (Tucumcari population 4,900). San Juan County is 38% Native American.

Co-Lead Development of *Guar-dians of the Biosphere* Curricula and Activities:
Nothing new to report.

Adapt Existing Curriculum for 4H Program:
First three lessons are back in adaptation process. Finally, detailed notes are included into them. Notes are focused on context changes for 4H youth and cultural inclusion content. Additionally, Morris and Shafer are partnering with NMSU to develop an Ag-Science Research Project for 4H youth.

Adapt *Guar-dians of the Biosphere* Curriculum:
Adaptation of *Guar-dians of Biosphere* content is stalled, but the NMSU partners have reached out to active teachers regarding their participation in curriculum development. If they continue to be unresponsive, the youth development team will develop a curriculum with the available resources.

Design STEM Volunteer Training Program; Recruit Volunteers:
The first of multiple AZ 4H STEM Adult Experience is scheduled for November 13 at the Maricopa County Cooperative Extension office. Youth development professionals and current volunteer are recruited to participate. Participants will get to experience many of the AZ 4H STEM opportunities.

Develop STEM Internship Program, Recruitment, and Evaluation Plans:
The internship project is back on the books for hopeful completion Summer 2022. Brassill has agreed to partner again an we have updated all documents for this year. Host recruitment will begin on November 3, 2021. The College of Agriculture and Life Sciences has committed to partnering in 2022 for recruitment of intern hosts and to explore sustainability of the program.

Internal Factsheets on *Project Puente* Internships:
Nothing new to report.

Project Puente Internship Student Recruitment:
Nothing new to report.

Project Puente Internship Faculty Recruitment:
As stated previously, our teach switched gears to offer internships in two alternate forms. We continued to share new resource documents for SBAR faculty on expectations of mentors, expectations of students, timelines, reporting structure, among other topics We will be disseminating content in Q4 directed at recruitment of faculty to participate in the program as well as to be used as an advertisement of the program to the broader campus community (as appropriate). Our initial goal was to increase participation to a total of 6 student interns and associated SBAR faculty to participate in the project in year three.

Project Puente Student Project Development and Deployment:
Nothing new to report.

Project Puente Case Study Video:
The extension team is continuing with the plan to create a short case study video to highlight the success of the program for broad dissemination once internships are deemed “ok”.

EDUCATION

Project Coordination: Dr. Sara Chavarria (University of Arizona) serves as the lead for the Education Team, which meets once monthly to cover broader topics related to specific Education objectives and tasks. Smaller working groups meet as-needed for specific action items (such as planning and coordinating the weekly SBAR Fellow Seminar). The Education Team also meets monthly with the Extension & Outreach Team to ensure that selected curriculum and activities is integrated for associated workshops and camps.

Issues/Risks:
Brewer: Daugherty has continued to be overloaded with COVID-related teaching disruptions and has not been available to work with Fernando on SBAR lesson/activity implementation. Likewise, Bradley and Mikesell were not available to being classroom/afterschool planning for fellows until mid-September. Continued disruptions have delayed completion of the needed background checks.

Contact will be maintained with teachers and travel/participation undertaken as personnel are available. Current COVID case counts and vaccination levels suggest later fall and spring semester will be more open.

Objective 1. Train teams of students and teachers with focus on rural and under-represented groups.

Task #	Description of Task	Deliverable	Target Completion Date
1 Chav	Plan/Design/Coordinate Fall 2020 and Spring 2021 SBAR Fellow seminar for hybrid approach	Plan Fall 2020 semester digital content Plan Spring 2021 semester digital content	31 Aug 20 31 Jan 21
2 Chav	Visit classrooms for observations (delivery of SBAR content)	Implement Fall teacher observation Implement Spring teacher observation	30 Nov 20 30 Apr 21
3 Fields	Design/Schedule classroom evaluation tools, protocols and metrics for all Education activities	Fall tools developed/refined; evaluation data gathered Spring tools developed/refined; evaluation data gathered Summer tools developed/ refined; evaluation data gathered Data synthesized; evaluation report generated	31 Dec 20 31 May 21 31 Jul 21 31 Aug 21

SBAR Fellow Seminar (Fall 2020 / Spring 2021) / hybrid approach:
The Spring 2021 semester began with a weekly Seminar courses on Wednesdays from 1-2PM. An All SBAR Fellow meeting was held on 1.13.21 where AZ and NM SBAR Fellows discussed NM priority areas:

A. Where the templates are located for lesson plans, PPT, etc.
B. Questions concerning single lessons with multiple sessions vs. multiple separate lessons
C. Rules for how to organize files and communication location/status
D. Discussion comparing video storage/editing options

This meeting set the tone for the semester where Dr. Brewer, Dr. Miller and the NM SBAR Fellows joined the weekly seminar.

Our COVID Pivot: Because the majority of the SBAR Fellows are still not able to work with teachers due to COVID, our focus has been on digital lesson development.

The focus of the end of the Spring Seminar has been:

1. The development and refinement of Community Share profiles for the UA SBAR Fellows to connect with local teachers. Community Share (https://www.communityshare.us/) is an online platform where community members can create a profile and teachers can go to look for people to visit their classroom (virtually during COVID).
2. Sessions on emphasizing the story of our lesson plans and science. This included an assignment to identify all questions that are asked in each of the five themes. Reviewing these questions allowed us to clarify the "stories" the different themes are telling and evaluate if the questions are simple enough to be relevant to middle school classrooms.
3. Refining SBAR Fellow selected lesson plans for publication. This process included:
    a. Feedback from Chavarria, Knox and Anderson
    b. Lesson plans workshopped during the seminar
    c. SBAR Fellows paired with each other to provide additional feedback
    d. The development of a Lesson Plan Tracking form to keep track of where each lesson is in the revision process
    e. Copy editing from Shopa
    f. Detailed review from Rogstad
    g. One-on-one in-depth meetings with fellows and Anderson/Knox to review/incorporate suggestions from the review process and prepare for publication

Classroom Observations (Delivery of SBAR Content):
Nothing new to report.

Design and Implement Classroom Evaluation Tools:
During the Q3 of 2021, the primary tasks related to the evaluation of the EEO components included 1) continued participation in regular team and EEO all-hands meetings; 2) ongoing analysis and review of evaluation data, meeting notes, and other artifacts for the purpose of

developing quarterly and annual reports, and contributions towards publications in progress; 3) participation in the annual SBAR retreat; 4) travel to NM to attend Clovis Field Day and conduct multiple interviews with key stakeholders (described further below); 5) meetings with co-authors on graduate student publication in progress; 6) continued work on a second publication about the various formal and informal modalities that SBAR developed content and resources are being tested in, and how these models/frameworks can be used more broadly across arid regions; and 7) initial work on drafts of two surveys – follow up grower's assessment survey and graduate student summative project survey.

For the Education team, activity in AZ over Q3 continued to focus on finalizing curriculum lessons with the continued assistance of 2 graduate fellows who are continuing with the project. Weekly seminars are held with these students and they work to finalize curriculum and add resources (ie., videos). At the annual retreat, the education team demonstrated two of the SBAR classroom activities while participants asked questions and provided feedback about the experience in real time. They also debuted the 'SBAR Loteria' activity and collected suggestions for additional SBAR-themed loteria cards. A third fellow is working with myself and Knox on a publication about the importance and impact of the fellow model – working directly with teachers and with students in classrooms (pre-COVID), developing curriculum lessons, and exploring issues of cultural responsiveness.

While in NM, I also had the chance to meet with or interview a number of key stakeholders including 1) one of the NM teacher/fellow pairs were interviewed separately; 2) project staff including Angadi, Idowu, Brewer, Miller and Singh as well as a number of NMSU faculty and graduate students who were familiar with the SBAR project; 3) the newest recruited NM teacher, Daugherty, who teaches science at a K-8 school in Melrose, which is about 30 minutes from the Clovis field station. This proximity will allow Daugherty and his students to interact with SBAR researchers and fellows as they incorporate SBAR content and resources. As Daugherty was recruited just before COVID first emerged, he has had time to connect with the NM SBAR team but this will be the first year he works with students with SBAR. We were able to tour his classroom, the school and see his planned greenhouse project and hear his plans to disseminate SBAR content more broadly to nearby schools and teachers.

Objective 2. Develop and disseminate agricultural bioenergy and bioproduct K-12 modules.

Task #	Description of Task	Deliverable	Target Completion Date
1 Brewer	Refine/Implement afterschool/4-H youth development curricula based on *Guar*-dians of the Biosphere	Two-semester curricula of SBAR-related activities and concepts suitable for middle school available on website	31 May 22
2 Brewer	Implement SBAR lessons in rural NM classroom, including in-person support	Feedback for refinement and dissemination of SBAR lesson plans in rural areas	31 May 22
3 Brewer	Dissemination of SBAR resources through conferences and online	Two conference presentations/workshops	31 Aug 22

		SBAR lessons for all 5 themes posted to website	31 Aug 22
4 Chav	Edit Cohort 2 lessons and materials for online publication	Edit lessons Prep for digital posting	30 Nov 20 31 Dec 20
5 Chav	Support lesson plan design by teacher-Fellow partnerships	Fall lesson plans from each Fellow developed Spring lesson plans from each Fellow developed Advice and support NM teach as requested/needed Draft lesson plans from Cohort 2 teachers	30 Nov 20 30 Apr 21 31 May 21 31 Jul 21
6 Chav	Design, scheduling and implementation of evaluation tools and metrics	Fall evaluation data gathered Spring evaluation data gathered Evaluation report complete	31 Dec 20 31 May 21 31 Aug 21

Refine/Implement 4H Youth Development Curricula Based on *Guar-dians of the Biosphere*:
A chemical engineering PhD student, Shermal Fernando, was recruited to serve as a fellow to interact with partner teacher, Daugherty, in Melrose NM. Fernando began work reviewing the existing SBAR lessons and revising the Theme 5 lesson plans in late August. No new lesson plans were published to the website.

Implement SBAR Lessons in Rural NM Classroom:
Brewer and SBAR evaluator, Fields, attended the NMSU field day at Clovis, NM in early August to view guar research and to visit Daugherty at Melrose Middle/High School. They toured the classroom, investigated space to set up hoop house/demonstration garden, and met with district superintendent to review plans for classroom visits and STEM recruitment.

Brewer and Fernando participated in weekly meetings with Miller, Ramos-Coronado, and Omotayo to coordinate work on 4-H and science fair events, interactions with LCPS teachers (Bradley and Mikesell) on *Guar*-dians of the Biosphere, and completion of background checks/training for work in the classrooms.

Dissemination of SBAR Resources through Conferences and Online:
Nothing new to report.

Cohort #2 Lessons and Materials:
The Education Team's work this quarter connected with the SBAR Retreat. Since this event was the final SBAR Retreat for the larger team, this was an opportunity to capture the group's expertise through expert interviews. In working with the Tucson Media Studio, the Education Team set up interviews during the treat. Nine interviews were conducted and one recording of

an SBAR Fellow-delivered lesson demo was recorded. Chavarria conducted the interviews with the following interview questions for SBAR Scientists/Experts:

Matrix-related questions:

1. Could you please introduce yourself and share how you got interested in your job or career?
2. What does a typical day look like in your job?
3. What kind of major problems related to nature or humans do you try to solve through your work? What are the impacts of your work on the environment or our lives?
4. How is your work related to agriculture? What agricultural problems are you addressing in your work?
5. What advice would you give young students (or middle school students) about choosing careers?

Advice Video Question

1. What are some thoughts you have about how to diversify your field?

Optional Question:

1. Would you like to add anything else before we end this interview?

SBAR Fellow, Arisbeth Ibarra Nieblas, led the demonstration of SBAR lessons. Tucson Media Studio filmed conference participants as they interacted with the following SBAR lessons:

1. Biofuels are made from biological materials, and these are renewable energy sources. Ethanol (a biofuel) is added to gasoline, and it is produced when the sugars inside plants are broken down by yeast to make carbon dioxide and ethanol. In this activity, participants, using sugar and yeast, will produce ethanol by the chemical reaction of fermentation.
2. Guar gum comes from the ground endosperm of a plant called guar. Guar gum is a polymer used to thicken foods and medicines for humans and animals and has recently been used in fracking and mining. In this activity, participants, using guar gum and sodium borate, will produce a gel-like slime from polymer cross-linking.
3. Loteria. In this activity, participants will familiarize themselves with vocabulary pertaining to the Sonoran Desert, agriculture, bioeconomy, and SBAR. The Loteria cards are all in English and Spanish, and a selected number are also in O'odham.

The rough recordings of the SBAR Expert interviews and Lesson Demo were sent to Chavarria, Knox, and Anderson for initial editing. The Education Team worked collaboratively to outline a vision and consistent framework for the videos. Detailed feedback for two of the videos included: edits to shorten the videos, questions to insert, scientific terms to put on the screen were sent to Tucson Media Studios to create polished videos. This iterative process will set the stage for editing of future videos.

In addition to the video recordings, the Education Team developed an education poster for the Retreat that highlights the pedagogical approach of the SBAR educational component. This poster was displayed at the SBAR Retreat and will be used for future conference presentations.

Other accomplishments this quarter include:

- Worked on education journal articles – Education Team (Knox and Yaylali) and evaluator (Fields). Target completion date is December 2021.
- Designed and finalized five theme logo/infographic for SBAR lessons
- List of activity kits completed. Inventory of supplies/connected to 5 activities.
- Web content writing for the education section of the website.
- Wrote and submitted three abstracts for conferences (two were accepted)

Support Lesson Plan Design for Digital Transition by Teacher-Fellow Partnerships:
Nothing new to report.

Design, Scheduling and Implementation of Evaluation Tools and Metrics:
Nothing new to report.

Objective 3. Develop a biofuel certificate program at the university level.

Task #	Description of Task	Deliverable	Target Completion Date
1 Molnar	Develop MS and/or PhD education opportunities within the University of Arizona around the theme of "Sustainable Bioeconomy"	At least 2 tracks (study concentration areas) within UA GIDPs	

Development of Education Opportunities:
This task is complete.

The certificate program description is accessible on the SBAR website:
https://sbar.arizona.edu/education/students/graduate-interdisciplinary-program

AWARDS

Items appearing in blue font are new in this quarter.

2021

2020

Ibarra Nieblas, A. *2nd Place, American Institute of Chemical Engineers (AIChE) K-12 STEM Outreach Competition.* Awarded in the Professional/Combined category for her innovative classroom lesson, “Exploring Bioproducts: Glue for Piñatas”. December.

Ossanna, L. *National Science Foundation Graduate Research Fellowship.* Awarded 3 years of funding to complete a PhD.

Wilburn, M. *Middle School Science Teacher of the Year, Arizona Science Teacher Association*. Awarded for Arizona Competition. December.

2019

Bayat, H.; Hoare, D.; Moreno, L.; Singh, J.; Steichen, S.; Summers, H.; Wright, A. *SBAR Interdisciplinary Face-Off – Silver Lightning Award for Best Overall Design*. SBAR Annual Retreat, University of Arizona, Tucson, Arizona.

Bayat, H.; Hoare, D.; Moreno, L.; Singh, J.; Steichen, S.; Summers, H.; Wright, A. *SBAR Interdisciplinary Face-Off – Smooth Moves Award for Most Creative Concept*. SBAR Annual Retreat, University of Arizona, Tucson, Arizona.

Brown, K.; Dehghanizadeh, M.; Lohr, P.; Singh, P.; Soto, A.; Zuniga-Vasquez, D. *SBAR Interdisciplinary Face-Off – Ninja Visionary Award for Best Overall Concept*. SBAR Annual Retreat, University of Arizona, Tucson, Arizona.

Katterman, M.; Ossanna, L.; Pruitt, D.; Soliz, N.; Sproul, E. *SBAR Interdisciplinary Face-Off – Energy Zone Award for Overall Audience Favorite*. SBAR Annual Retreat, University of Arizona, Tucson, Arizona.

Wilburn, M. *Honorable Mention, Science Teacher Association*. Awarded in the Middle School Science Teacher of the Year Competition in Arizona. December.

PRODUCTS GENERATED.
September 2017 – September 2021

PUBLICATIONS, CONFERENCE PAPERS AND PRESENTATIONS

Items appearing in blue font are new in this quarter.

Publications

1. **Abdell-Haleem H.; Luo Z.; Ray, D. 2019.** Chapter 6. Genetic Improvement of Guayule (*Parthenium argentatum* A. Gray): An Alternative Rubber Crop. *In.* J. Al-Khayri (ed.). Advances in Plant Breeding Strategies: Industrial and Food Crops. Springer Nature Switzerland AG (Invited Book Chapter). p.151-178.
2. **Bayat, H.; Cheng, F.; Dehghanizadeh, M.; Brewer, C.E. 2021.** Recovery of nitrogen from low-cost plant feedstocks used for bioenergy: a review of availability and process order. *Energy & Fuels*, 35(18), 14361-14381. DOI:10.1021/acs.energyfuels.1c02140
3. **Chen, Y.; Martinez, A.; Cleavenger, S.; Rudolph, J.; Barberán, A. 2021.** Changes in soil microbial communities across an urbanization gradient: a local-scale temporal study in the arid southwestern USA. *Microorganisms* 9:1470. DOI:10.3390/microorganisms9071470.
4. **Chen, Y.; Neilson, J.W.; Kushwaha, P.; Maier, R.M.; Barberán, A. 2020.** Life-history strategies of soil microbial communities in an arid ecosystem. *International Society of Microbial Ecology Journal (ISME J).* DOI:10.1038/s41396-020-00803-y
5. **Cheng, F.; Bayat, H.; Jena, U.; Brewer, C.E. 2020.** Impact of feedstock composition on pyrolysis of low-cost, protein and lignin-rich biomass: a review. *Journal of Analytical & Applied Pyrolysis*, 147, 104780, DOI: 10.1016/j.jaap.2020.104780.
6. **Cheng, F.; Brewer, C.E. 2021.** Conversion of protein-rich lignocellulosic wastes to bio-energy: review and recommendations for hydrolysis + fermentation and anaerobic digestion. Renewables & Sustainable Energy Reviews, 146, 111167. DOI:10.1016/j.rser.2021.111167
7. **Cheng, F.; Dehghanizadeh, M.; Audu, M.A.; Jarvis, J.M.; Holguin, F.O.; Brewer, C.E. 2020.** Characterization and evaluation of guayule processing residues as potential feedstock for biofuel and chemical production. *Industrial Crops and Products*, 150, 112311. DOI: 10.1016/j.indcrop.2020.112311.
8. **Cheng, F.; Jarvis, J.M.; Yu, J.; Jena, U.; Nirmalakhandan, N.; Schaub, T.M.; Brewer, C.E. 2019.** Bio-crude oil from hydrothermal liquefaction of wastewater microalgae in a pilot-scale continuous flow reactor, *Bioresource Technology*, 294, 122184, DOI:10.1016/j.biortech.2019.122184.
9. **Cheng, F.; Le-Doux, T.; Treftz, B.; Miller, J.; Woolf, S.; Yu, J.; Jena, U.; Brewer, C.E. 2019.** Modification of a pilot-scale continuous flow reactor for hydrothermal liquefaction of wet biomass. *MethodsX*, 6, 2793-2806, DOI:10.1016/j.mex.2019.11.019.
10. **Dehghanizadeh, M.; Cheng, F.; Jarvis, J.M.; Holguin, F.O. Brewer, C.E. 2020.** Characterization of resin extracted from guayule (*Parthenium argentatum*): A dataset including GC-MS and FT-ICR MS. *Data in Brief*, 31, 105989. DOI:10.1016/j.dib.2020.105989.
11. **Dehghanizadeh, M.; Mendoza-Moreno, P.; Sproul, E.; Bayat, H.; Quinn, J.; Brewer, C.E. 2021.** Guayule (*Parthenium argentatum*) resin: A review of chemistry,

extraction techniques and applications. *Industrial Crops & Products*. 165 (2021) 13410. DOI:10.1016/j.indcrop.2021.113410.

12. **Khanal, S.; Gutierrez, P.; Seavert, C.; Bhandari, P.; Grover, K.; Teegerstrom, T.; Blayney, D. N.D.** Enterprise Budgets for Guar Production. *New Mexico State University Extension Publication*. [In Review]
13. **Khanal, S.; Robbs, J.; Gutierrez, P.; Seavert, C.; Teegerstrom, T.; Wang, S.; Dierig, D. N.D.** Guayule Enterprise Budget: Establishment, Growing and Harvesting. *New Mexico State University Extension Publication*. [In Review]
14. **Khanal, S.; Seavert, C.; Gutierrez, P.; Teegerstrom, T.; Summers, H.M.; Sproul, E. N.D.** Enterprise Budgets: Guar, Flood Irrigation, Southern New Mexico Production. *New Mexico State University Extension Publication*. [In Review]
15. **Luo, Z.; Thorp, K.R., Abdel-Haleem, H. 2019.** A high-throughput quantification of resin and rubber contents in *Parthenium argentatum* using near-infrared (NIR) spectroscopy. *Plant Methods* 15, 154 (2019) DOI:10.1186/s13007-019-0544-3.
16. **Mealing, V.; Turek, J.; Smith, J.; Landis, A. 2021.** Social sustainability of new bio-based feedstocks in the Southwest. *The International Journal of Social Sustainability in Economic, Social, and Cultural Context.* 18(1): 23-42. DOI:10.18848/2325-1115/CGP/v18i01/23-42.
17. **Nelson, A.D. L.; Ponciano, G.; McMahan, C.; Ilut, D.C.; Pugh N.A.; Elshikha, D.E.; Hunsaker, D.J.; Pauli. D. 2019.** Transcriptomic and evolutionary analysis of the mechanisms by which *P. argentatum*, a rubber producing perennial, responds to drought. *BMC Plant Biology*. 19:494. https://bmcplantbiol.biomedcentral.com/articles/10.1186/s12870-019-2106-2
18. **Rodriguez-Uribe, L.; Von Cruz, V.M.; Willette, S.; Gil, S.; Khadijeb, M.; Dierig, D.A.; Holguin, F.O. N.D.** Untargeted metabolome profiling of guayule (*Parthenium argentatum* A.Gray) to identify metabolic biomarkers for cold-acclimated and freezing temperature tolerance. *Industrial Crops and Products*. [Submitted 31 Dec 2020; In Review]
19. **Rosalez, R.; Cheng, F.; Dehghanizadeh, M.; Bayat, H.; Cui, Z.; Jarvis, J.M.; Brewer, C.E. 2021.** Co-hydrothermal liquefaction of guayule bagasse and wastewater treatment algae. *Energies*. [Accepted; In Press]
20. **Sandhu, D.; Pallete, A.; Pudussery, M.V.; Grover, K.K. 2021.** Contrasting responses of guar genotypes shed light on multiple component traits of salinity tolerance mechanisms. *Agronomy*. 11(6). Article 1068. DOI:10.3390/agronomy11061068.
21. **Sproul, E.; Summers, H.M.; Seavert, C.; Robbs, J.; Khanal, S.; Mealing, V.; Landis, A.E.; Fan, N.; Sun, O.; Quinn, J.C. N.D.** Integrated Techno-Economic and Environmental Analysis of Guayule Rubber Production. *Journal of Cleaner Production* [In Press]. Accepted June 2020.
22. **Singh, J. N.D.** Guar Growth and Development Under Pre-Irrigation and In-Season Irrigation Management in the Southern High Plains. *Journal of Industrial Crops and Products*. Accepted June 2020.
23. **Singh, J.; Guzman, I.; Begna, S.; Trostle, C.; Angadi, S.V. 2021.** Germination and early growth response of guar cultivars to low temperatures. *Industrial Crops and Products*. Volume 159, 2021, 113082, ISSN 0926-6690. DOI:10.1016/j.indcrop.2021.113082

24. **Sun, O.; Fan, N. 2020.** A Review on Optimization Methods for Biomass Supply Chain: Models and Algorithms, Sustainable Issues, Challenges and Opportunities. *Process Integration and Optimization for Sustainability*, published online first, 3/2020. DOI:10.1007/s41660-020-00108-9
25. **Summers, H.M.; Quinn, J.C. ND.** Improving water scarcity footprint capabilities in arid regions through expansion of characterization factor methods. *Science of the Total Environment* [In Press]
26. **Summers, H.M.; Sproul, E.; Seavert, C.; Angadi, S.; Robbs, J.; Khanal, S.; Gutierrez, P.; Teegerstrom, T.; Zuniga Vasquez, D.A.; Fan, N.; Quinn, J.C. 2021.** Economic and Environmental Analyses of Incorporating Guar into the American Southwest. *Agricultural Systems*, Volume 191, 2021,103146, ISSN 0308-521X. DOI:10.1016/j.agsy.2021.103146.
27. **Teegerstrom, T.; Seavert, C.; Gutierrez, P.; Summers, H.A.; Sproul, E. N.D.** Guayule Enterprise Budget: Guayule, Flood Irrigated, Southern Arizona. *University of Arizona, Extension Publication*. [In Review]
28. **Wang, S.; Lynch, A.; VonCruz, M.; Heinitz, C.; Dierig, D. N.D.** Temperature Requirements for Guayule Seed Germination. *Industrial Crops and Products* [In Press] [Accepted September 2020]
29. **Xu, Y.; Madasu, C.; Liu, E.M.; Wijeratne, K.; Dierig, D.; White, B.; Molnár, I.; Gunatilaka, A.A. 2021.** Cycloartane and Lonostane Type Triterpenoids from the Resin of Guayule (*Parthenium argentatum*), A Byproduct of Bridgestone Rubber Production. *ACS Omega* 6:15486-15498, 2021.DOI:10.1021/acsomega.1c01714, PMID: 34151127, PMCID: PMC8210430.
30. **Zuniga-Vasquez, D.A.; Sun, O.; Fan, N.; Sproul, E.; Summers, H.M.; Quinn, J.C.; Khanal, S.; Gutierrez, P.; Mealing, V.A.; Landis, A.E.; Seavert, C.; Teegerstrom, T.; Evancho, B. 2021.** Integrating Environmental and Social Impacts into Optimal Design of Guayule and Guar Supply Chains. *Computers and Chemical Engineering*. DOI: 10.1016/j.compchemeng.2021.107223.
31. **Zuniga-Vasquez, D.A.; Fan, N.; Teegerstrom, T.; Seavert, C.; Summers, H.M.; Sproul, E.; Quinn, J.C. 2021.** Optimal Production Planning and Machinery Scheduling for Semi-Arid Farms. *Computers and Electronics in Agriculture*. DOI:10.1016/j.compag.2021.106288, 6/2021.

Number of Graduated SBAR Students (Undergraduate, Masters, and PhD)

Student Classification	CSM	CSU	NMSU	UA	Other
Undergraduate (BS, BA)		3	7	5	
Masters			7	6	1
PhD		2	2	2	

**Totals are through July 2021.*

Capstone Projects, Theses, and Dissertations

1. **Ledesma, J.*; Ossanna, L; Pacido, D.; El-Shikha, D.E.; Dong, C.; Ponciano, G.; McMahan, C.; Maier, R.M.; Neilson, J.W. 2020.** *Associations between soil*

rhizosphere bioavailable phosphorus, phosphorus solubilizing microorganisms, and guayule growth stage and rubber production. Senior Capstone Thesis, University of Arizona, Tucson, Arizona.

2. **Pruitt, Darien. 2021.** *Guar Growth and Yield as Affected by Mycorrhizal Colonization, Soil Amendment Applications, and Fertility Management*. Master of Science Thesis, New Mexico State University, Las Cruces, New Mexico.
3. **Singh, Jagdeep. 2020.** Guar growth and development under pre-irrigation and in-season irrigation management in the Southern High Plains. Master of Science Thesis, New Mexico State University, Las Cruces, New Mexico.
4. **Sproul, Evan. 2020.** *Integrated Techno-Economic and Life-Cycle Analysis of Emerging Technologies with Temporal Resolution*. Ph.D. Dissertation. Colorado State University, Fort Collins, Colorado.
5. **Summers, Hailey. 2021.** *Evaluating the Sustainability of Agricultural Systems Using Life Cycle Assessment and Techno-Economic Analysis*. Ph.D. Dissertation. Colorado State University, Fort Collins, Colorado.
6. **Sun, Ou. 2019.** *Novel Integer Optimization Methods and their Applications in Biomass Supply Chain and Power Dominating Set*. Ph.D. Dissertation, University of Arizona, Tucson, Arizona.
7. **Zuniga-Vazquez, Daniel A. 2021.** *Large-Scale Optimization for Planning of Reliable Power Systems and Design of Sustainable Biomass Supply Chains*. Ph.D. Dissertation, University of Arizona, Tucson, Arizona.

Conference Papers

1. **Audu, M.; Dehghanizadeh, M.; Cheng, F.; Bayat*, H.; Holguin, O.; Jena, U.; Brewer, C.E. 2019.** *Co-Products and Biofuels from Guar and Guayule Processing Residues*. 2019 ASABE Annual International Meeting. Boston, Massachusetts. 8 July. Paper #1900361.
2. **Cruz, V.M.V.; Lynch, A.; Wang, G.S.; Dittmar, S.; Sullivan, T.; Prock, R.; Niaura, W.; Dierig, D.A. 2019.** *Guayule germplasm characterization for variation in ploidy and biomass production.* In: 31st Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.).Tucson, Arizona. 8-11 September. p. 36.
3. **Dehghanizadeh, M.*; Cheng, F.; Jarvis, J.M.; Holguin, F.O.; Brewer, C.E. 2019.** *High Resolution Mass Spectrometry for Characterization of Resin from Guayule (Parthenium argentatum).* In: 31st Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.). Tucson, Arizona. 8-11 September. p. 39.
4. **Dehghanizadeh, M.*; Brewer, C.E. 2020.** *Guayule resin: chemistry, extraction, and applications,* 2020 ASABE Annual International Meeting, Virtual. 13-15 July. DOI: 10.13031/aim.202001143.
5. **Dierig, D.A.; Wang, G.S.; El-Shikha, D.E.M.; Sullivan, T.; Dittmar, S.; Cruz, V.M.V. 2019.** *Guayule growth and yield over time at two locations at high and low irrigation treatments.* In: 31st Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.).Tucson, Arizona. 8-11 September. p. 31.
6. **Dong, C.; Ponciano, G.; Wang, Y.; Huo, N.; Hunsaker, D.; El-Shikha, D.E.M.; Gu, Y.Q.; McMahan, C. 2019.** *Gene expression of guayule field plants under drought*

stress: A comparative RNA-Seq study. In: 31st Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.).Tucson, Arizona. 8-11 September. p. 35.

7. **El-Shikha, D.E.M.*; Waller, P.M.; Hunsaker, D.J.; Dierig, D.A.; Wang, G.S.; Cruz, V.M.V.; Thorp, K.R.; Bronson, K.F.; Katterman, M.E. 2019.** *Growth and yield of direct-seeded guayule under SDI and furrow irrigation.* In: 31st Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.).Tucson, Arizona. 8-11 September. p. 30.
8. **Khanal, S.; Robbs, J.; Acharya, R.; Gutierrez, P. 2019.** *Import demand and potential for domestic production of guar.* In: 31st Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.).Tucson, Arizona. 8-11 September. p. 43.
9. **Maqsood, H.; Waller, P.; El-Shikha, D.E.M.; Hunsaker, D.; Katterman, M.E.; Dierig, D.A.; Wang, G.S.; Ogden, K. 2019.** *Assessment of irrigation requirement for guayule using WINDS model.* In: 31st Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.).Tucson, Arizona. 8-11 September. p. 32.
10. **Maqsood, H.; Angadi, S.; El-Shikha, D.E.M.; Waller, P.; Singh, J.; Hunsaker, D.; Barau, B. 2019.** *Evaluating crop water status for guar using WINDS model.* In: 31st Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.).Tucson, Arizona. 8-11 September. p. 42.
11. **McCloskey, W.; Wang, G.S. 2019.** *Guayule (Parthenium argentatum A. Gray) seedling tolerance to topically applied carfentrazine-ethyl herbicide.* In: 31st Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.). Tucson, Arizona. 8-11 September. p. 34.
12. **Placido, D.F.; Dong, N.; Pham, T.; Huynh, T.; Amer, B.; Baidoo, E.; McMahan, C. 2019.** *Down-regulation of squalene synthase in guayule (Parthenium argentatum).* In: 31st Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.).Tucson, Arizona. 8-11 September. p. 37.
13. **Seavert, C.; Teegerstrom, T.*; Gutierrez, P.; Khanal, S. 2019.** *Whole farm analysis tool for evaluating the adoption of guayule and guar into southwest producers' current operation.* In: 31st Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.).Tucson, Arizona. 8-11 September. p. 40. Best Oral Presentation Award for the Rubber and Resin Division.
14. **Wang, G.S.; Dierig, D.A.; Ray, D.T. 2019.** *Guayule response to plant population*. In: 31st Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.). Tucson, Arizona. 8-11 September. p. 38.
15. **Zuniga-Vasquez, D.A.; Fan, N.; Teegerstrom, T.; Seavert, C.; Summers, H.M.; Sproul, E.; Quinn, J.C. 2021.** *Optimal Design of guayule and guar supply chains for the American Southwest*. 32nd Association for the Advancement of Industrial Crops. Annual Meeting for the special issue on *Industrial Crops and Products*, 9/2021.

Scholarly Presentations

1. **Abdel-Haleem, H.; Mullen, C.; Luo, Z. 2021.** *Guayule – A promising biofuel and bioproducts crop.* Association for the Advancement of Industrial Crops 32nd Annual Meeting (hybrid). Bologna, Italy. 5-9 September.
2. **Angadi, S.V. 2018.** *Sustainable Bio-economy for Arid Regions: Growing Guar.* Extension Field Day. Clovis, New Mexico. 9 August.
3. **Angadi, S.V.; Idowu O.J. 2021.** *Sustainable Bio-economy for Arid Regions: Guar Research.* Extension Field Day, Agricultural Science Center. Clovis, New Mexico. 3 August.
4. **Angadi, S.V.*; Begna, S.H.; Singh, S.; Katuwal, K.; Singh, J.; Gowda, P.; Ghimire R. 2018.** *Multiple Approaches to Sustain Ogallala Aquifer in the Southern Great Plains of the United States of America*. Agrosym 2018. Jahorina, Bosnia. 4-7 December.
5. **Angadi, S.V.*; Begna, S.H.; Singh, S.; Katuwal, K.; Singh, P.; Singh, J.; Umesh, M.R. 2019.** *Crop Diversification and Critical Stage-Based Irrigation to Sustain Ogallala Aquifer*. UCOWR/NIWR Annual Water Resources Conference, Snowbird, Utah. 11-13 June.
6. **Angadi, S.V.*; Begna, S.H.; Umesh, M.R. 2018.** *Crop diversification for sustainable soil and water resources use in semi-arid regions of USA*. XXI Biennial National Symposium of Indian Society of Agronomy, Udaipur, India. 24-26 October.
7. **Angadi, S.V.*; Singh, J.; Begna, S.H. 2019.** *Crop growth stage based deficit irrigation management in guar crop*. Annual Report, Agricultural Science Center at Clovis, New Mexico. 20 February.
8. **Angadi, S.V.; Singh, J.*; Begna, S.H. 2020.** *Crop growth stage-based deficit irrigation management in guar crop*. Annual Report, Agricultural Science Center at Clovis, New Mexico. 29 February.
9. **Angadi, S.V.; Singh, J.*; Begna, S.H. 2020.** *Germination temperature for expanding guar across to cooler regions*. ASA, CSSA and SSSA International Annual Meetings (Virtual). 8-11 November.
10. **Angadi, S.V.; Singh, J.; Gowda, P.; Singh, P.; Begna, S.; Guzman, I.; Idowu, J. 2021.** *Deficit Irrigation Strategies to Fit Desert Crop Guar in the Southern High Plains Cropping Systems*. Universities Council on Water Resources (UCOWR) Annual Meeting (Virtual). 8-11 June.
11. **Angadi, S.V.; Singh, J.; Guzman, I.; Begna, S. 2020.** *Germination temperature for expanding guar acres to cooler regions.* American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America (ASA-CSSA-SSSA) Joint International Annual Meeting. Virtual. 8-11 November.
12. **Armijo, J.; Bayat, H.; Dehghanizadeh, M.; Brewer, C.E. 2021.** *Hydrothermal liquefaction of hazardous biomass*. 2021 AICHE Student Annual Meeting. Boston, Massachusetts. 8 November.
13. **Audu, M.*; Dehghanizadeh, M.; Cheng F.; Bayat H.; Holguin, O.; Jena U.; Brewer, C.E. 2019.** *Co-Products and Biofuels from Guar and Guayule Processing Residues*. ASABE Annual International Meeting, Boston, Massachusetts, 7-10 July.
14. **Bayat, H.*; Cheng, F.; Jena, U.; Brewer, C.E. 2019.** *Introduction to low-cost protein-rich lignocellulosic biomass for advanced biofuels.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
15. **Brewer, C.E. 2018**. *Pairing biomass residues with conversion technologies*. Advanced Bioeconomy Leadership Conference, Washington, D.C. 28 February.

16. **Brewer, C.E. 2018**. *Polymerization and guar gum bubbles*. Outreach event activity. New Mexico 4-H State Conference. 11 July.
17. **Brewer, C.E. 2018**. *Identifying Co-Products from Guar and Guayule Processing Residues*. 2018 American Institute of Chemical Engineers Annual Meeting. Pittsburgh, Pennsylvania. 30 October.
18. **Brown, K.S. 2021.** *Fungal Pathogens and Guayule (Parthenium argentatum): Optimizing Crop Production in an Arid Environment*. UA ENViSion Annual UA Earthweek Symposium. Online. 31 March.
19. **Brown, K.S. 2020.** *Soil chemistry … and other topics*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 25 March.
20. **Brown, K.S. 2020**. *Pathogens and Guayule (Parthenium argentatum): Literature Review*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. [virtual] 18 November.
21. **Brown, K.S.*; Neilson, J.W.; Waller, P.M.; Ray D.T.; Dierig, D.; Maier, R.M. 2018.** *Microbial contributions to soil health: Optimizing guayule (Parthenium argentatum) production in an arid environment*. SWESx Earthday Symposium. Tucson, Arizona. 15 April. [poster]
22. **Brown, K.S.*; Neilson, J.W. 2018.** *Microbial contributions*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. April.
23. **Brown, K.S.*; Neilson, J.W.; Waller, P.M.; Ray D.T.; Dierig, D.; El-Shikha, D.;Maier, R.M. 2019.** *Microbial contributions to soil health: Optimizing guayule (Parthenium argentatum) production in an arid environment*. SWESx Earthday Symposium. Tucson, Arizona. 27 March. [poster]
24. **Brown, K.S.*; Neilson, J.W.; Waller, P.M.; Ray, D.T.; Wang, S.; Dierig, D.; El-Shikha, D.E.M.; Maier, R.M. 2019.** *Soil health and guayule microbial community metrics.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
25. **Brown, K.S.*; Neilson, J.W.; Waller, P.M.; Ray, D.T.; Wang, S.; Dierig, D.; El-Shikha, D.E.M.; Maier, R.M. 2020.** *Fungal pathogens and guayule (Parthenium argentatum): Optimizing crop production in an arid environment.* University of Arizona ENViSion Virtual Earth Week Conference, Tucson, Arizona. April.
26. **Chen, Y.; Dierig, D.A.; Wang, S.; Ray, D.T.; Barberan, A.; Neilson, J.W. 2021.** *Using network analysis to identify critical soil microorganisms associated with guayule growth stages*. 2021 SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 August. [poster]
27. **Cheng, F.*; Audu, M.; Dehghanizadeh, M.; Treftz, B.; Le-Doux, T.; Jena, U.; Brewer, C.E. 2018.** *Characterization and Conversion of Guar and Guayule Bagasse as Potential Resources for Biofuels Production.* Symposium on Thermal and Catalytic Sciences for Biofuels and Bio-based Products. Auburn, Alabama. 9 October.
28. **Cheng, F.; Le-Doux, T.; Jena, U.; Brewer, C.E.* 2018.** *Characterization and Conversion of Guar Bagasse.* Symposium on Thermal and Catalytic Sciences for Biofuels and Bio-based Products. Auburn, Alabama. 9 October.
29. **Cheng, F. 2018.** *Hydrothermal Liquefaction of Microalgae in Batch and Continuous Flow Reactors.* PhD Dissertation Defense. New Mexico State University, Las Cruces, New Mexico. 24 October.
30. **Cheng, F.*; Rosalez, R.; Dehghanizadeh, M.; Brewer, C.E. 2019.** *Co-Hydrothermal Liquefaction of Guayule Bagasse and Wastewater Treatment Microalgae*. American

Institute of Chemical Engineers (AIChE) Annual Meeting, Orlando, Florida. 10-15 November.

31. **Cheng, F.*; Le-Doux, T.; Treftz, B.; Woolf, S.; Guillen, S.; Usrey, J.; Martinez Bejarano, C.; Bayat, H.; Jena, U.; Brewer, C.E. 2018.** *Characterization of Flow and Heat Transfer Parameters in a Continuous Flow Hydrothermal Liquefaction Reactor.* 2018 American Institute of Chemical Engineers Annual Meeting, Pittsburg, Pennsylvania. 1 November.
32. **Cheng, F.*; Rosalez, R.; Dehghanizadeh, M.; Brewer, C.E. 2019.** *Co-Hydrothermal Liquefaction of Guayule Bagasse and Wastewater Treatment Microalgae.* 2019 American Institute of Chemical Engineers Annual Meeting, Orlando, Florida. 10-15 November.
33. **Creegan, E.; Grover, K.*; DuBois, D.; Khan, N. 2020.** *Global climate change mitigation and resiliency: Agriculture Curriculum Collaborations.* North America Colleges and Teachers of Agriculture Virtual Conference, Online. 15-18 June.
34. **Dehghanizadeh, M.*; Cheng, F.; Jarvis, J.M.; Holguin, F.O.; Brewer, C.E. 2019.** *High Resolution Mass Spectroscopy for Characterization of Resin from Guayule*. SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
35. **Dehghanizadeh, M.*; Brewer, C. 2020.** *Guayule resin: Advanced extraction techniques and promising commercial applications*. SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
36. **Dehghanizadeh, M.; Brewer, C. 2020.** *A study on chemistry and fractionation of guayule resin as a source of secondary metabolites and energy*. AIChE Annual Meeting (virtual). 15 November.
37. **Dehghanizadeh, M.; Brewer, C.E. 2021.** *Supercritical CO2 extraction of resin and rubber from guayule (Parthenium argentatum Gray)*. 2021 AICHE Annual Meeting, Boston, Massachusetts. 7-11 November.
38. **Dehghanizadeh, M.; Knagg, A.; Romero, A.; Holguin, O.; Brewer, C.E. 2021.** *Testing of non-rubber extracts of guayule (Parthenium argentatum) as a bio-based urban insect repellent*. Tech Connect World Innovation Conference. National Harbor, Maryland. 18 October.
39. **Deirig, D. 2017.** *Bridgestone's perspective on a domestic source of natural rubber in the desert.* Invited Speaker at the New Mexico Sustainable Agriculture Conference. Los Lunas, New Mexico. 13 December.
40. **Dong, C.; Ponciano, G.; Wang, Y.; Huo, N.; Hunsaker, D.; Elshikha, D.; Gu, Y.Q.; McMahan, C. 2019.** *Transcriptome analysis of guayule reveals rubber biosynthesis pathways' response to drought stress*. SBAR Annual Retreat, University of Arizona, Tucson Arizona. 11-13 September. [poster]
41. **El-Shikha, D.E.M. 2018.** *Update – Guayule irrigation experiments at Maricopa Agricultural Center*. SBAR UA Research Team Seminar Series, Tucson, Arizona. 12 September.
42. **El-Shikha, D.E.M.*; Waller, P.M.; Hunsaker, D.J.; Dierig, D.; Wang, S.; Cruz, V.M.V.; Bronson, K.F.; Katterman, M.E. 2019.** *Direct seeded guayule grown in Arizona under furrow and subsurface drip irrigation.* American Society of Agricultural and Biological Engineers (ASABE) Annual International Meeting, Boston, Massachusetts. 8 July. [poster]

43. **El-Shikha, D.E.M*.; Waller, P.M.; Hunsaker, D.J.; Dierig, D.; Wang, G.S.; Cruz, V.M.V.; Thorp, K.R.; Katterman, M.E.; Bronson, K.F.; Wall, G. 2019.** *Growing direct-seeded guayule with furrow and subsurface drip irrigation in Arizona.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
44. **Evancho, B.*; Schmalzel, C.; Lewis, M.; Teetor, V.H.; Ray, D.T. 2021.** *Response by guayule to nitrogen fertilizer in a semi-hydroponic system.* American Society for Horticulture Science Annual Conference, Denver, Colorado. 5-9 August. [poster]
45. **Evancho, B.*; Teetor, V.H.; Willmon, J.; Bennett, M.C.; Montes, M.; Schmaltzel, C.; Ray, D.T. 2018.** *Root structure differentiation between common guayule planting methods.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 2 August. [poster]
46. **Evancho, B. 2018.** *Guayule Fuels the Future*. IES – Energy Talks Seminar, Sky Bar, Tucson, Arizona. 9 October.
47. **Evancho, B. 2019.** *Guayule: How Close Are We?* Marana Winter Field Crops Clinic. Marana, Arizona. 10 January.
48. **Evancho, B. 2019.** *Guayule: How Close Are We?* Casa Grande Winter Field Crops Clinic. Casa Grande, Arizona. 15 January.
49. **Evancho, B. 2019.** *Comparing direct-seeded and transplanted guayule roots*. SBAR UA Research Team Seminar, University of Arizona, Tucson, Arizona. 13 November.
50. **Evancho, B. 2020.** *Growth response of guayule to a gradient of nitrogen fertilizer*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 29 April.
51. **Evancho, B. 2021.** *Determining guayule minimum nitrogen requirements*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 5 May.
52. **Evancho, B.*; Lewis, M.; Schmalzel, C.; Teetor, V.; Ray, D. 2020.** *Agronomic investigations to improve guayule production.* SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
53. **Evancho, B.*; Moreno, L.; Peck, A.; Teetor, V.H., Schmalzel, C.; Ray, D.T. 2019.** *Root structure differentiation between guayule planting methods.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
54. **Fan, N. 2018.** *Review on Optimization Methods for Biomass Supply Chain*. SBAR UA Research Team Seminar. University of Arizona, Tucson, Arizona. 28 November.
55. **Fan, N. 2021.** *Harvesting planning for guayule*. SBAR Research Team Seminar, University of Arizona, Tucson, Arizona. 29 September.
56. **Fan, N.; Sun, O. 2019.** *GIS-based, two-stage stochastic facility location problem considering planting plan uncertainty*. American Institute of Chemical Engineers (AIChE) Annual Meeting, Orlando, Florida. 11 November.
57. **Garcia, A.*; Grover, K.; Stringam, B.; Schutte, B.; VanLeeuwen, D. 2018.** *Growth and performance of guar (Cyamoposis tetragonoloba L.) under various irrigation regimes in semi-arid region of New Mexico*. 73rd SWCS International Annual Conference, Albuquerque, New Mexico. 29 July – 1 August.
58. **Garcia, A.*; Grover, K.; Stringam, B.; Schutte, B.; VanLeeuwen, D. 2018.** *Growth and performance of guar under various irrigation regimes in semi-arid region of New Mexico*. Annual SBAR Retreat, University of Arizona, Tucson, Arizona. 1-3 August. [poster]
59. **Garcia, A.*; Grover, K.; Stringam, B.; Schutte, B.; VanLeeuwen, D. 2018.** *Performance of guar under various irrigation regimes in southern New Mexico*.

Extension Field Day, New Mexico State University Agricultural Science Center, Artesia, New Mexico. 23 August.

60. **Garcia, A.*; Grover, K.; Stringam, B.; Schutte, B.; VanLeeuwen, D. 2018**. *Performance of guar under various irrigation regimes in southern New Mexico.* New Mexico Sustainable Agriculture Science Conference, Los Lunas, New Mexico. 12 December.
61. **Garcia, A.*; Grover, K.; Schutte, B.; Stringam, B.; VanLeeuwen, D. 2018.** *Growth and performance of guar under various irrigation regimes*. Proceedings of the 2018 Annual Meeting of the American Society of Agronomy, Crop Science Society of America and the Soil Science Society of America. Baltimore, Maryland. 4-7 November.
62. **Garcia, A.*; Grover, K.; Schutte, B.; Stringam, B.; VanLeeuwen, D. 2019.** *Growth and performance of guar under different irrigation regimes*. NMSU College of Agriculture, Consumer and Environmental Sciences (ACES) Open House. 6 April. [poster]
63. **Gardia, A.* Grover, K.; Stringam, B.; Schutte, B.; VanLeeuwen, D. 2020.** *Growth and performance of guar genotypes under various irrigation regimes and addition of biogenic silica in Southwest New Mexico.* SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
64. **Gloria, T.*; Grover, K.; Garcia, A. 2018.** *Guar: a potential alternative crop in New Mexico*. Annual SBAR Retreat, University of Arizona, Tucson, Arizona. 1-3 August. [poster]
65. **Gloria, T.*; Grover, K.; Garcia, A. 2018.** *Guar: a potential alternative crop in New Mexico*. Extension Field Day, New Mexico State University Agricultural Science Center, Artesia, New Mexico. 23 August.
66. **Gloria, T.*; Grover, K.; Garcia, A. 2018.** *Guar: a potential alternative crop in New Mexico.* New Mexico Sustainable Agriculture Science Conference, Los Lunas, New Mexico. 12 December.
67. **Gloria, T.*; Flores, M.; Allen, R.; Valenzuela, V.; Ben, G.; Moore, K.; Castillo, P.; Garcia, A.; Grover, K. 2019.** *Evaluating guar as a potential alternative crop in New Mexico.* NMSU College of Agriculture, Consumer and Environmental Sciences (ACES) Open House, Las Cruces, New Mexico. 6 April. [poster]
68. **Godfrey, D.J; Bennett, M.C.*; Willmon, J.; Waltz, Q.; Coronado, G.; Teetor, V.H.; Schmalzel, C.; Ray, D.T. 2018**. *Vegetative propagation of <u>Parthenium</u> <u>argentatum</u> (Guayule).* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 2 August. [poster] Won first place for undergraduate posters.
69. **Godfrey, D.*; Willmon, J.; Teetor, V.H.; Schmalzel, C.; Ray, D.T. 2018.** *Vegetative propagation of guayule*. 2018 Annual Conference, American Society for Horticultural Science, Washington D.C. 30 July – 3 August 2018.
70. **Gonzalez, C.; Dierig, D.A.; Cruz, V.M.V.* 2019.** *Pollen studies in guayule: Comparison of staining and sampling procedures and survey of pollen size variation.* 31st Annual Meeting for the Association for the Advancement of Industrial Crops. Tucson, Arizona. 8-11 September. [poster]
71. **Gonzalez, C.*; Cruz, V.M.V.; Dierig, D.A. 2019.** *Pollen viability and size variation in guayule germplasm.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]

72. **Grover, K. 2017.** *Guar as a potential alternative crop in New Mexico*. Invited Speaker at the New Mexico Sustainable Agriculture Conference. Los Lunas, New Mexico. 13 December.
73. **Grover, K. 2018.** *Sustainable agriculture and guar production in New Mexico*. New Mexico State 4-H Conference, Las Cruces, New Mexico. 10 July.
74. **Grover, K. 2018**. *An overview of guar and other research in the Plant and Environmental Sciences Department*. A presentation to student ambassadors of College of Agriculture, Consumer and Environmental Sciences, New Mexico State University, Las Cruces, New Mexico. 8 August.
75. **Grover, K. 2018**. *Guar as an alternative crop in New Mexico.* Extension Field Day, New Mexico State University Agriculture Science Center, Clovis, New Mexico. 9 August.
76. **Grover, K. 2018**. *Guar as an alternative crop in New Mexico.* Extension Field Day, New Mexico State University Agriculture Science Center, Artesia, New Mexico. 23 August.
77. **Grover, K. 2018**. *Guar and Sustainable Crop Production.* An invited presentation to students of *AGRO/HORT 100 Introductory Plant Sciences*. New Mexico State University, Las Cruces, New Mexico. 31 August.
78. **Grover, K. 2018**. *Guar and Sustainable Crop Production.* An invited presentation to students of *AXED 466V: "John Muir: Lessons in Sustainability."* New Mexico State University, Las Cruces, New Mexico. 25 September.
79. **Grover, K. 2019.** *Guar as an alternative rotation crop in the chili production system of New Mexico.* New Mexico Chili Industry and Researcher Meeting, Las Cruces, New Mexico. 5 February.
80. **Grover, K. 2019.** *Guar: A potential alternative crop in New Mexico.* Climate Change Strategies for a Changing World Workshop, New Mexico State University, Las Cruces, NM. 5 February. [invited speaker]
81. **Grover, K. 2019.** *Do you know what plants are these and what's in them?* Future Farmers of America (FFA), New Mexico Chapter Presentation. Las Cruces, New Mexico. 5 April.
82. **Grover, K. 2019.** *Guar: A potential alternative crop in New Mexico*. New Mexico Master Gardener's Meeting. Las Cruces, New Mexico. 8 May.
83. **Grover, K. 2019.** *Guar as an alternative crop in New Mexico*. New Mexico Sustainable Agriculture Field Day. Las Cruces, New Mexico. 26 June.
84. **Grover, K. 2019.** *Guar as an alternative crop in New Mexico*. SBAR Train-the-Trainer Workshop. Las Cruces, New Mexico. 2 July.
85. **Grover, K. 2019.** *Guar as an alternative crop in New Mexico*. SBAR Train-the-Trainer Workshop, Las Cruces, New Mexico. 2 July.
86. **Grover, K. 2019.** *Guar research and extension program in New Mexico*. Departmental External Review, Las Cruces, New Mexico. 10 October.
87. **Grover, K. 2020.** *Guar as an alternative crop in southwest USA*. 18th International Congress of Soil Science, Sindh Agriculture University, Tandojam, Pakistan. 11-13 Februrary. [invited speaker]
88. **Grover, K. 2020.** *Guar in changing climate*. Climate Change Strategies for a Changing World, New Mexico State University, Las Cruces, New Mexico. 3 March. [invited speaker]

89. **Grover, K. 2020.** *Guar as a potential alternative crop*. Introductory Plant Sciences course (AGRO/HORT 100G), New Mexico State University, Las Cruces, New Mexico (Online). May. [invited speaker]
90. **Grover, K. 2020.** *Evaluating performance of guar genotypes*. Special Problems/Special Topics Seminar (AGRO 449/AGRO 500), New Mexico State University, Las Cruces, New Mexico (Online). May. [invited speaker]
91. **Grover, K. 2020.** *Teaching principles of plant growth and development.* Teaching Assistant Training and Supervised University Teaching Experience (AGRO 697), New Mexico State University, Las Cruces, New Mexico (Online). May. [invited speaker]
92. **Grover, K. 2020.** *Evaluating guar for its adaptability in New Mexico.* Research and Education Training Workshop. New Mexico State University, Las Cruces, New Mexico (Online). May. [invited speaker]
93. **Grover, K. 2020.** *Growth and Performance of Guar Under Various Moisture Stress Regimes*. Proceedings of the 2020 Annual Meeting of the American Society of Agronomy, Crop Science Society of America and the Soil Science Society of America. [Virtual Meeting] 9-11 November.
94. **Grover, K. 2021.** *Guar as a potential crop in New Mexico.* Farm Field Day, Lyendecker Plant Science Center, New Mexico State University, Las Cruces, New Mexico. 25 August.
95. **Grover, K. 2021.** *Guar as a potential crop in New Mexico.* Farm Field Day, Fabian Garcia Plant Science Center, New Mexico State University, Las Cruces, New Mexico. 22 September.
96. **Grover, K. 2021.** *SBAR and guar in desert Southwest.* New Mexico State University Agriculture Day, Las Cruces, New Mexico. 25 September.
97. **Grover, K.*; Garcia, A. 2018.** *Evaluating guar as a potential alternative crop in New Mexico*. University Research Council Meeting, New Mexico State University. Las Cruces, New Mexico. 15 February.
98. **Grover, K.*; Garcia, A.; Schutte, B.J.; Stringam, B.; Darapuneni, M.K.; VanLeeuwen, D. 2019.** *Response of guar to various irrigation regimes*. ASA-CSSA-SSSA International Annual Meetings, San Antonio, Texas. 12 November.
99. **Grover, K.*; Garcia, A.; Schutte, B.J.; Stringam, B.; Darapuneni, M.K.; VanLeeuwen, D; Flynn, R.P. 2020.** *Growth and performance of guar under various moisture stress regimes.* Western Crop Science Society of America Annual Virtual Conference, Online. 7 July.
100. **Grover, K.*; Stovall, S. 2020.** *Integrating experiential learning in a crop production course.* North America Colleges and Teachers of Agriculture Virtual Conference, Online. 15-18 June.
101. **Grover, K.*; Torres, S.; Cazarez, K. 2020.** *Response of Guar to Various Seeding Rates.* Proceedings of the 2020 Annual Meeting of the American Society of Agronomy, Crop Science Society of America and the Soil Science Society of America. [Virtual Meeting] 9-11 November.
102. **Gutierrez, P.; Khanal, S.; Seavert, C.; Teegerstrom, T. 2020.** *Economic impacts of producing alternative crop: guar, guayule and industrial hemp in New Mexico*. Alternative Crops Conference. Portales, New Mexico. 10 March.
103. **Hoare, D.M. 2018.** *Irrigation Sensors and the WINDS Model.* SBAR UA Research Team Seminar Series, Tucson, Arizona. 26 September.

104. **Hoare, D.M.*; Katterman, M.; Waller, P. 2019.** *Development of a remote crop condition sensing system utilizing Internet of Things.* 31st Annual Meeting of the Association for the Advancement of Industrial Crops. Tucson, Arizona. 8-11 September. [poster]
105. **Huynh, T.*; Resendiz, M.; McMahan, C.; Dong, N. 2019.** *The Content and State of the In-Vitro Guayule Inventory in Tissue Culture and Opportunities to Improve our Methods*. Seminar Presentation and Discussion, USDA-ARS WRRC, Albany, California. 18 November.
106. **Idowu, O.J. 2018.** *Introduction to the SBAR Project*. Las Cruces, New Mexico. 6 Feb.
107. **Idowu, O.J. 2018.** *Sustainable Bio-economy for Arid Regions: Update*. Extension Field Day, Clovis, New Mexico. 9 August.
108. **Idowu, O.J. 2018.** *Sustainable Bio-economy for Arid Regions: Guar and Guayule*. Extension Field Day, New Mexico State University Agricultural Science Center, Artesia, New Mexico. 23 August.
109. **Idowu, O.J. 2020.** *Potential of guar for Eastern New Mexico (Sustainable Bioeconomy for Arid Regions Project).* Tucumcari Agricultural Science Center Virtual Field Day, Tucumcari, New Mexico.6 August.
110. **Idowu O.J. 2021.** *Guar – A Low Input Alternative Crop.* Extension Field Day, Agricultural Science Center. Clovis, New Mexico. 3 August.
111. **Idowu O.J. 2021.** *Prospect of Guar, a High-Value Alternative Crop in Valencia County.* Los Lunas Extension Field Day, Los Lunas Agricultural Science Center. Los Lunas, New Mexico. 18 August.
112. **Idowu O.J. 2021.** *Alternative Crops for Sustainable Bioeconomy for Arid Regions.* Las Cruces Extension Field Day, Leyendecker Plant Science Center. Las Cruces, New Mexico. 25 August.
113. **Idowu, O.J.*; Pruitt, D. 2019.** *Sustainable Bio-economy for Arid Regions*. Extension Field Day. Fabian Garcia Research Center, Las Cruces, New Mexico. 26 June.
114. **Katterman, M. 2020.** *Guayule sensor and irrigation modeling + SBAR Education update*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 18 March.
115. **Khanal, S. 2020.** *Industrial uses of guar as a rural economic development strategy in the Southwest.* SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
116. **Khanal, S.*; Gutierrez, P. 2020.** *The economic impact of the alternative crops: Guar and guayule production in the Southwest.* Agricultural and Applied Economics Association (AAEA) 2020 Virtual Meeting. 10-11 August. [poster]
117. **Khanal, S.*; Gutierrez, P. 2019.** *Farm-level impact analysis of growing guar (at 5% total acres adoption rate) in Dona Ana, New Mexico*. SBAR System Performance and Sustainability Team Seminar, Colorado State University, Ft. Collins, Arizona. 11 November.
118. **Khanal, S.*; Gutierrez, P.; Robbs, J.; Acharya, R. 2019.** *The Economic Potential of Producing Guayule in the Southwest.* Department of Agricultural Economics and Agricultural Business, New Mexico State University, Las Cruces, New Mexico. [poster]
119. **Khanal, S.; Gutierrez, P.; Seavert, C.; Teegerstrom, T. 2020.** *The economic impacts of producing guar using the input-output model.* New Mexico Alternative Crops Conference, Portales, New Mexico. 10 March. [poster]

120. **Khanal, S.; Gutierrez, P.; Seavert, C.; Teegerstrom, T. 2020.** *Guar research manuscript update.* SBAR System Performance and Sustainability Seminar. Colorado State University, Fort Collins, Colorado. 15 April.
121. **Khanal, S.; Seavert, C.; Gutierrez, P.; Teegerstrom, T.* 2019.** *The economic potential of producing guayule in the Southwest.* 31st Annual Meeting of the Association for the Advancement of Industrial Crops. Tucson, Arizona. 8-11 September. [poster]
122. **Ledesma, J.*; Ossanna, L; Pacido, D.; El-Shikha, D.E.; Dong, C.; Ponciano, G.; McMahan, C.; Neilson, J.W.; Maier, R.M. 2020.** *Associations between soil bioavailable phosphorus and guayule plant growth and rubber production*. 31st Annual Undergraduate Biology Research Program Conference, University of Arizona, Tucson, Arizona. 25 January.
123. **Ledesma, J.*; Ossanna, L; Pacido, D.; El-Shikha, D.E.; Dong, C.; Ponciano, G.; McMahan, C.; Maier, R.M.; Neilson, J.W. 2020.** *Associations between soil bioavailable phosphorus, phosphorus solubilizing microorganisms, and guayule growth stage and rubber production*. University of Arizona ENViSion Virtual Earth Week Conference, Tucson, Arizona. April. [poster]
124. **Leo, A. 2019.** *Microbial adaptations for arid regions and middle schoolers*. Institute for Energy Solutions (IES) Energy Talks public lecture series, Sky Bar, Tucson, Arizona. 14 March.
125. **Levy, T.*; Rock, C.; Idowu, O.J.; Dery, J.; Brassil, N.; Zozaya, S. 2019.** *Growers' perceptions and comprehension of biofuel, bioproducts, and guar in the Southwest Arid Region.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
126. **Lewis, M. 2019.** *Salt stress tolerance in guayule*. SBAR UA Research Team Seminar, University of Arizona, Tucson, Arizona. 23 October.
127. **Lewis, M.*; Judkins, A.; Teetor, V.H.; Ray, D.T. 2019.** *Evaluating guayule germplasm for salt tolerance.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
128. **Lohr, P. 2020.** *AquaCrop modeling of guayule*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 5 February.
129. **Lohr, P*; Ogden, K. 2020.** *Modeling guayule: Adapting AquaCrop model for a perennial crop*. SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
130. **Lopez, E. 2018.** *Sustainable Bioeconomy for Arid Regions: Activities for education, extension and outreach*. American Institute of Chemical Engineers Rocky Mountain Regional Student Conference. Provo, Utah. 23 March.
131. **Lopez, E.*; Fox, S.; Brewer, C.E. 2018.** *GK-12 Lesson Documentation Spreadsheet*. American Institute of Chemical Engineers Annual Meeting, Pittsburg, Pennsylvania. 29 October.
132. **Madasu, C.*; Gunatilaka, L. 2020.** *Semi-synthesis and cytotoxicity evaluation of some pyrimidine analogues of argentatins A-C isolated from guayule (Parthenium argentatum) resin*. SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
133. **Maqsood, H. 2018.** *Guar Crop Coefficient Development for New Mexico Environments*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 7 November.

134. **Maqsood, H. 2020.** *Model parameterization for guar irrigation schedule and biomass estimation using remote sensing*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 1 April.
135. **Maqsood, H.*; Angadi, S.; El-Shikha, D.E.M.; Waller, P.; Singh, J.; Hunsaker, D.; Barua, B. 2019.** *Evaluating crop water status for guar using WINDS model.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
136. **Maqsood, H.*; Waller, P.; El-Shikha, D.; Katterman, M.; Hoare, D.S.L.; Angadi, S.; Dierig, D. 2020.** *Analysis of soil moisture and crop vegetation for guayule and guar using irrigation models and remote sensing techniques*. SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
137. **Marinez, C.*; Lopez, G.U.; Cabrera D.d.J. 2019.** *The University of Arizona Cooperative Extension 4H Program Collaborating Statewide in Preparing the Next Generation of STEM Innovators.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
138. **McCloskey, W. 2018.** *Weed Trial Results for Guayule*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 14 November.
139. **McCloskey, W. 2019.** *Guayule Weed Control Research.* The 9th Annual Central Arizona Farmer Field Day. Maricopa Agricultural Center (MAC), Maricopa, Arizona. 8 October.
140. **McCloskey, W. 2020.** *2019 Herbicide Progress Report: Aim herbicide experiments and preemergence herbicide experiment failures*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 29 January.
141. **McMahan, C. 2018.** *Flowering Reduction in Guayule*. SBAR UA Research Team Seminar Series, Tucson, Arizona. 19 September.
142. **McMahan, C. 2019.** *USDA-ARS Rubber Lab Update*. SBAR UA Research Team Seminar Series, Tucson, Arizona. 27 March.
143. **McMahan, C.*; Placido, D.; El-Shikha, D.E.M.; Dong, C.; Ponciano, G.; Neilson, J.W. 2019.** *Dormancy and the guayule (Parthenium argentatum A. Gray) soil microbiome*. 31st Annual Meeting of the Association for the Advancement of Industrial Crops. Tucson, Arizona. 8-11 September. [poster]
144. **McMahan, C.*; Placido, D.; Resendiz, M.; Ponciano, G. 2020.** Flowering downregulation in guayule. Update to SBAR Advisory Board. Online presentation. 12 February.
145. **McMahan, C.*; Placido, D.; Resendiz, M.; Ponciano, G.; Dong, C. 2020.** Flowering downregulation in (*Parthenium argentatum*). SBAR UA Research Team Seminar Series, Tucson, Arizona. 9 December.
146. **Mealing, V. 2018.** *An overview of sustainability analysis methods of a new biofuel feedstock: bagasse from guar*. 6th Colorado School of Mines Graduate and Discovery Symposium. Golden, Colorado. 5 April.
147. **Mealing, V. 2019.** *Criteria, Methods, Opportunities, and Needs for Social Sustainability of Emerging Technology*. 7th Colorado School of Mines Graduate Research and Discovery Symposium. Golden, Colorado. April.
148. **Mealing, V. 2019.** *Sustainability assessment of guayule agriculture: Potential processing improvements for guayule co-products*. USDA-ARS, Western Regional Research Center, Albany, California. 3 July. [invited speaker]

149. **Mealing, V. 2019.** *Field Data Collection and Integration*. SBAR System Performance and Sustainability Seminar, Colorado State University, Golden, Colorado. 13 November.
150. **Mealing, V. 2020.** *Field data collection update*. SBAR System Performance and Sustainability Seminar, Colorado State University, Golden, Colorado. 19 February.
151. **Mealing, V. 2020.** *Field data integration update*. SBAR System Performance and Sustainability Seminar, Colorado State University, Golden, Colorado. 25 June.
152. **Mealing, V. 2020.** *A framework for assessing the social sustainability of guar agriculture.* Congress on Sustainability and Engineering (ICOSSE) (virtual). Golden, Colorado. 3 August.
153. **Mealing, V. 2020.** *Towards a holistic sustainability assessment of guar and guayule*. SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
154. **Mealing, V. 2020.** *Agricultural LCA of guar: Comparing N&P fertilizer scenarios from field trials.* American Center for Life Cycle Assessment Conference (ACLCA) (virtual). Golden, Colorado. 22 September.
155. **Mealing, V. 2020.** Sustainability assessment of guar and guayule cultivation: Utilizing unique field trial data. USDA Rubber Lab Meeting (virtual). Golden, Colorado. 10 December.
156. **Mealing, V.*; Harris, T.; Landis, A.E. 2019.** *Criteria, Methods, Opportunities, and Needs for Social Sustainability of Emerging Technology*. 15th International Conference on Environmental, Cultural, Economic and Social Sustainability. Vancouver, Canada. February.
157. **Mealing, V.*; Summers, H.M.; Sproul, E.; Eranki, P.L.; Landis, A.E.; Quinn, J.C. 2018.** *Life Cycle Assessment of Cultivating Guar in the American Southwest*. LCA XVIII Conference. Fort Collins, Colorado. October [poster] Won second place in graduate student posters.
158. **Mealing, V.*; Summers, H.M.; Sproul, E.; Eranki, P.L.; Quinn, J.C.; Landis, A.E.. 2018.** *Life Cycle Assessment of Cultivating Guar in the American Southwest.* National Society of Black Engineers, Fall Regional Conference. Las Vegas, Nevada. November [poster]
159. **Mealing, V.S.*; Landis, A.E. 2019.** *Life cycle assessment of guar agriculture in the Southwest, USA.* 31st Annual Meeting of the Association for the Advancement of Industrial Crops. Tucson, Arizona. 8-11 September. [poster]
160. **Mealing, V.S.*; Landis, A.E. 2019.** *SBAR Sustainability.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
161. **Mealing, V.S. 2020.** *Towards a holistic sustainability assessment of guar and guayule*. SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
162. **Mendoza, P.*; Sproul, E.; Quinn, J. 2020.** *High-value co-products from guayule resin and bagasse.* SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
163. **Mi, W.*; Teetor, V.H.; Ray, D.T. 2018.** *Rubber and Resin Extraction of Differentially Treated Biomass in Guayule (Parthenium argentatum)*. SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 2 August. [poster]
164. **Moreno, P.M.; Quinn, J.C.; Sproul, E. 2021.** *Economic and environmental sustainability assessment of thermochemical conversion of guayule bagasse to biofuels.* International Symposium on Sustainable Systems and Technology (ISSST). (Virtual) 21-25 June.

165. **Morris, N.A. 2020.** *SBAR 4-H opportunities and future directions*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 19 February.
166. **Morris, N.A. 2020.** *Arizona 4-H SBAR Capacity Building: Outcomes, progress, and plans.* SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
167. **Morris, N.A. 2020.** *Realizing the Aim of Education for Sustainability Through 4-H*. National Association of Extension 4-H Youth Development Professionals (NAE4-HYDP) Annual Meeting. Boise, Idaho. October.
168. **Neilson, J.W. 2019.** *Soil Microbiome Resilience to Stress: How much is too much?* USDA-ARS, Western Regional Research Center, Albany, California. June. [invited speaker]
169. **Neilson, J.W.; Ossanna, L. 2020.** *Associations between the guayule rhizosphere microbiome and plant growth architecture, and rubber/resin production*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 4 March.
170. **Nieblas, A. I. 2020.** *Development of educational materials with a focus on arid regions.* SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
171. **Niu, D., 2018.** *Partial cloning of APETALA1 (AP1) gene from guayule*. cDNA Lab Seminar, USDA-ARS Western Regional Research Laboratory. 28 March.
172. **Ogden, K. 2017**. *Introducing new USDA NIFA CAP grant awardees – Developing regional AJF supply chains: Sustainable Bioeconomy for Arid Regions*. CAAFI-SOAP Jet Webinar. Hosted online. 13 October. [invited speaker]
173. **Ogden, K. 2017.** *Sustainable Bioeconomy for Arid Regions*. Biomass Research and Development Technical Advisory Board Meeting. 15 November. [invited speaker]
174. **Ogden, K. 2018.** *Sustainable Bio-economy for Arid Regions*. Southwest Indian Agricultural Association Annual Meeting. Laughlin, Nevada. 16-18 January.
175. **Ogden, K. 2018.** *Potential of the Bioproducts and Biofuels Economy*. AIChE Annual Meeting, Pittsburg, Pennsylvania. October [invited speaker]
176. **Ogden, K. 2020.** *Sustainable Bioeconomy for Arid Regions.* Grain Processing Lecture Series, Michigan Technological University, Houghton, Michigan. 17 January [invited speaker]
177. **Ogden, K. 2020.** *SBAR Project Update.* Southwest Indian Agriculture Association (SWIAA) 32nd Annual Conference, Laughlin, Nevada. 20-23 January [invited speaker]
178. **Ogden, K. 2020.** *Sustainable Bioeconomy for Arid Regions.* University of Utah, Salt Lake, Utah. 2 March. [invited distinguished lecturer]
179. **Ogden, K.*, White, R., Brewer, C.E. 2018.** *Public Private Partnerships*. ABLC Conference. Washington, D.C. 27-28 February.
180. **Omatayo, O. 2021.** *Harnessing the environmental and economic potentials of guar in arid regions.* International Arid Lands Consortium Conference (Virtual). University of Arizona, Water Resources Research Center, Tucson, Arizona. 24-26 May.
181. **Ossanna, L.*; Placido, D.; El-Shikha, D.E.M.; Dong, C.; Ponciano, G.; McMahan, C.; Maier, R.M., Neilson, J.W. 2019.** *Root-zone microbiome dynamics and guayule rubber production*. SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
182. **Ossanna, L.*; Brown, K.; Chen, Y.; Maier, R.; Neilson, J.; Placido, D.; Dong, C.; Ponciano, G.; McMahan, C.; El-Shikha, D.; Waller, P.; Wang, S.; Dierig, D. 2020.**

The significance of the soil microbiome to guayule production. SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.

183. **Phakdon, T. 2020.** *Plant adaptation in the Sonoran Desert: A lesson for middle school students.* SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
184. **Ponciano, G.*; Dong, N.; Placido, D.; Borg, K.; Fonseca, L.; Howard, C.; Shintani, D.; McMahan, C. 2019.** *Bioengineering of guayule (Parthenium argentatum) to enhance tocopherols content.* 31st Annual Meeting of the Association for the Advancement of Industrial Crops. Tucson, Arizona. 8-11 September. [poster]
185. **Pruitt, D.*; Idowu, O.J.; Sanogo, S.; Angadi, S.; Steiner, R.L. 2019.** *The effects of mycorrhizae inoculation and soil amendments on growth of guar and pinto beans*. ASA-CSSA-SSSA International Annual Meetings, San Antonio, Texas, 13 November.
186. **Pruitt, D.*; Idowu, O.J.; Angadi, S.; Darapuneni, M.; Sanogo, S. 2020.** *Guar growth and yield as affected by nitrogen and phosphorus inputs*. SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
187. **Pruitt, D.J.*; Idowu, O.J.; Angadi, S.; Darapuneni, M.K.; Sanogo, S. 2020.** *Guar growth and yield as affected by nitrogen and phosphorus inputs*. ASA-CSSA-SSSA Annual Meeting (virtual), 11 November.
188. **Quinn, J.C.*; Summers, H.M.; Sproul, E.; Seavert, C.; Teegerstrom, T.; Gutierrez, P.; Robbs, J.; Mealing V.; Landis, A.E.; Fan, N.; Sun, O.; Zuniga-Vasquez, D. 2020.** *Integrated economic and environmental analysis of emerging industrial crops in arid regions of the Southwest United States*. International Symposium on Sustainable Systems and Technologies (virtual). 4 August.
189. **Quinn, J.C.*; Sproul, E.; Summers, H.M.; Seavert, C.; Gutierrez, P.; Teegerstrom, T.; Zuniga-Vazquez D.; Robbs, J.; Khanal, S.; Fan, N.; Sun, O.; Moreno, P.M. 2020.** *Integrated economic and environmental analysis of emerging industrial crops in arid regions of the Southwest United States.* American Chemical Society Fall 2020 Meeting and Expo (virtual). 17-20 August.
190. **Ray, D.T.; Teetor, V.H. 2021.** *Resin and rubber results from different irrigation types over two years.* SBAR UA Research Team Seminar, University of Arizona, Tucson, Arizona. 8 September.
191. **Ray, D.T.; Teetor, V.H.; Schmalzel, C. 2021.** *Guar as an alternative crop in semi-arid areas of Arizona, New Mexico, and Texas.* American Society for Horticulture Science Annual Conference, Denver, Colorado. 5-9 August. [poster]
192. **Resendiz, M. 2020.** *Flowering downregulation of Parthenium argentatum*. USDA-ARS Lab Meeting, Albany, California. 14 May.
193. **Resendiz, M. 2020.** *Downregulation of floral identity genes in Parthenium argentatum*. SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
194. **Rock, C.*, Brassill, N. 2018.** *Importance of Cooperative Extension in University Research*. University of Arizona, Tucson, Arizona. 14 March.
195. **Rogstad, A. 2018.** *Real World Supply Chain Development: USDA Coordinated Agriculture Projects. SBAR Overview*. CAAFI Biennial General Meeting and Integrated ASCENT Symposium. Washington, D.C. 4-6 December. [invited speaker]
196. **Rogstad, A**. **2019**. *SBAR Overview*. Association for the Advancement of Industrial Crops 31st Annual Meeting. Tucson, Arizona. 8 September. [invited speaker]
197. **Rogstad, A. 2021.** *SBAR Overview*. Arizona Institutes for Resilience: Solutions for the Environment and Society Seminar. Tucson, Arizona. 10 February [invited speaker]

198. **Rodriguez-Uribe, L.. 2020.** *Identification of metabolic biomarkers for cold-acclimation and freezing temperature tolerance in guayule (Parthenium argentatum, A. Gray).* Fall 2020 Friday Kick-off of the PES Graduate Research Seminar (virtual), Las Cruces, New Mexico. 28 August.
199. **Rodriguez-Uribe, L.*; Gutierrez, P. 2019.** *Implementing the Science of SBAR with Youth.* SBAR UA Research Team Seminar, University of Arizona, Tucson. 25 September.
200. **Rodriguez-Uribe, L.*; Gutierrez, P.; Rogstad, A.; Fields, J. 2020.** *Achievements of the SBAR Extension and Outreach Team in New Mexico.* SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
201. **Rosalez, R.*; Brewer, C.E.; Jena, U. 2019.** *Co-Hydrothermal liquefaction (HTL) of guayue bagasse and wastewater treatment microalgae.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
202. **Sapkota, P.*; Imel, R.K.; Liu, W.; Angadi, S.; Trostle, C.; Williams, R.B.; Peffley, E.B.; Auld, D.L.; Burrow, M.D. 2019.** *Evaluation of breeding populations of guar for cultivation in Southwestern United States*. ASA-CSSA-SSSA International Annual Meetings, San Antonio, Texas, 12 November.
203. **Sehar, U.*; Rodriguez-Uribe, L.; Von Cruz, M.; Willette, S.; Mozaffari, K.; Dierig, D.; Holguin, F.O. 2020.** *Untargeted metabolome profiles on the guayule germplasms AZ-2 and W6-429 to identify metabolic biomarkers for cold-acclimation and freezing temperature tolerance*. SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
204. **Singh, J. 2020.** *Guar growth and development under pre-season and in-season irrigation management in the southern High Plains*. Master of Science Thesis. New Mexico State University, Las Cruces, New Mexico. 3 April.
205. **Singh, J**.*; **Angadi, S.V.; Begna, S.H. 2018**. *Crop Growth Stage Based Deficit Irrigation Management in Guar Crop.* The Western Sustainable Agriculture Conference (WSARE), University of New Mexico – Valencia Campus, Los Lunas, New Mexico. 12 December [poster]
206. **Singh, J.*; Angadi, S.V.; Begna, S.H. 2019.** *Identify guar germplasm suitable for cooler northern latitudes*. SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster] Won 2nd Place in graduate student poster presentation competition.
207. **Singh, J.*; Angadi, S.V.; Begna, S.H. 2020.** *Identify guar germplasm suitable for cooler northern latitudes of the Southern High Plains*. ***In***: Agricultural Science Center 2020 Annual Report. New Mexico State University, Clovis, New Mexico.
208. **Singh, J.*; Angadi, S.V.; Begna, S.H.; Guzman, I.; Idowu, O.J. 2019.** *Sustaining water resources using guar crop under different irrigation practices.* ACES-Open House, New Mexico State University, Las Cruces, New Mexico. 6 April. [poster]
209. **Singh, J.*; Angadi, S.V.; Begna, S.H.; Idowu, O.J. 2019.** *Guar as an alternative crop*. Annual Agricultural Field Day. Agricultural Science Center, Clovis, New Mexico. 8 August.
210. **Singh, J.*; Angadi, S.V.; Begna, S.H.; Idowu, O.J.; Guzman, I.; VanLeeuwen, D. 2019.** *Water extraction patters of guar under different irrigation strategies in the Southern High Plains.* Western Society of Crop Science Annual Meeting. Pasco, Washington. 25-26 June. [poster] Won 1st Place in student poster competition.

211. **Singh, J.*; Angadi, S.V.; Begna, S.H.; Idowu, O.J.; Guzman, I.; VanLeeuwen, D. 2019.** *Evaluating the effect of different irrigation practices on guar in the Southern High Plains.* Western Society of Crop Science Annual Meeting. Pasco, Washington. 25-26 June. Won 2nd Place in student oral presentation competition.
212. **Singh, J.*; Angadi, S.V.; Begna, S.H.; VanLeeuwen, D.; Idowu, O.J. 2019.** *Drought response and yield formation of guar under different water regimes in the Southern High Plains*. ASA-CSSA-SSSA International Annual Meetings, San Antonio, Texas. 10 November.
213. **Singh, J.*; Angadi, S.V.; Begna, S.H.; VanLeeuwen, D.; Idowu, O.J.; Guzman, I. 2020.** *Sustaining Irrigation Water of the Southern High Plains Using Guar*. New Mexico Alternative Crops Conference, Portales, New Mexico. 10 March. [poster]
214. **Singh, P.*; Angadi, S.V.; Idowu, O.J.; Brewer, C.E.; Knox, C.J.; Chavarria, S.P. 2021.** *Graduate Fellows as Conduits to Sustainability Education in Middle School and Youth Settings: Communication Science with Cultural and Community Relevancy*. Soil Science Society of American Annual Meeting, Salt Lake City, Utah. 7-10 November.
215. **Skuse, K.*; Dery, J.; Zozaya, S.; Brassill, N.; Rock, C. 2018.** *Public interest in guayule being used as a biofuel.* University of Arizona, Maricopa Agricultural Center, Maricopa, Arizona. 26 July. [poster]
216. **Skuse, K.*; Dery, J.; Zozaya, S.; Brassill, N.; Rock, C. 2018.** *Public interest in guayule being used as a biofuel.* Oral presentation of student internship work. University of Arizona, Maricopa Agricultural Center, Maricopa, Arizona. 26 July.
217. **Smith, A. 2020.** *Valorization of guayule resin*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 22 April.
218. **Smith, A.*; Ogden, K. 2020.** *Vacuum distillation of guayule resin*. SBAR Annual Retreat (virtual). University of Arizona, Tucson, Arizona. 27-29 July.
219. **Soliz, N.*; Brewer, C.E.; Jena, U.; 2019.** *Bomb calorimetry of guayule bagasse and hydrothermal liquefaction products.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
220. **Soto, A.L.*; Placido, D.; Dong, C.; Ponciano, G.; McMahan, C.; Maier, R.M.; Neilson, J.W. 2019.** *Soil parameters that influence natural rubber production in guayule (Parthenium argentatum) during winter dormancy*. SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster] Won 2nd Place in intern student poster presentation competition.
221. **Sproul, E. 2020.** *Integrated Economic & Environmental Analysis of Guayule and Guar Production*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 22 January.
222. **Sproul, E. 2020.** Techno-economic analysis and life cycle assessment of guayule. SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
223. **Sproul, E.*; Summers, H.M.*; Quinn, J.C. 2019.** *Techno-Economic and Environmental Impact Analysis of Guayule and Guar.* International Symposium on Sustainable Systems and Technology, Portland, Oregon. June. [poster] Won 1st Place in student poster competition.
224. **Sproul, E.; Summers, H.M.; Seavert, C.; Fan, N.; Zuniga Vazquez, D.A.; Landis, A.E.; Mealing, V.; Quinn, J.C. 2021.** *Sustainability assessment of producing guayule rubber with coproducts.* Association for the Advancement of Industrial Crops (AAIC) 32nd Annual Meeting. Bologna, Italy (virtual). 5-8 September.

225. **Sproul, E.*; Summers, H.M.; Mealing, V.; Landis, A.E.; Seavert, C.; Teegerstrom, T.; Gutierrez, P.; Robbs, J.; Fan, N.; Sun, O.; Quinn, J.C. 2019.** *Integrated environmental and economic assessment of guar and guayule.* American Center for Life Cycle Assessment (ACLCA) LCA XIX, Tucson, Arizona. 24-26 September. [poster]
226. **Summers, H.M. 2020.** *Techno-economic analysis and life cycle assessment of guar.* SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
227. **Summers, H.M.; Quinn, J.C. 2021.** *Advancing water scarcity footprint methods for arid regions.* International Symposium on Sustainable Systems and Technology (ISSST). (Virtual) 21-25 June.
228. **Summers, H.M.; Quinn, J.C. 2021.** *Advancing water scarcity footprint methods for arid regions.* American Center for Life Cycle Assessment (ACLCA) Virtual Conference. 21-24 September.
229. **Summers, H.M.*; Sproul, E.; Johnson, J.; Quinn, J.C. 2017.** *Sustainability assessment of bioproducts from southwest arid crops*. 21st Century Energy Transition Symposium, Colorado State University, Fort Collins, Colorado. October.
230. **Summers, H.M.*; Sproul, E.; Johnson, J.; Quinn, J.C. 2017.** *Sustainability assessment of bioproducts from southwest arid crops*. Colorado State University Graduate Student Showcase, Colorado State University, Fort Collins, Colorado. November.
231. **Summers, H.M.*; Sproul, E.; Johnson, J.; Quinn, J.C. 2018**. *Economic Viability and Environmental Impact of processing arid crops in the American Southwest.* International Congress on Environmental Modelling and Software. Colorado State University, Fort Collins, Colorado. June.
232. **Summers, H.M.*; Sproul, E.; Johnson, J.; Quinn, J.C. 2019.** *Economic and Environmental Impact Assessments of Drought Tolerant Crops in the American Southwest*. 21st Century Energy Transition Symposium, Denver, Colorado. April.
233. **Summers, H.M.*; Sproul, E.; Mealing, V.; Eranki, P.L.; Landis, A.E.; Quinn, J.C. 2018**. *Process Modeling and Life Cycle Assessment of Rubber from Guayule.* LCA XVIII Conference, Fort Collins, Colorado. October.
234. **Sun, O. 2018.** *GIS-Based Two-stage Stochastic Facility Location Considering Planting Plan Uncertainty*. INFORMS Annual Meeting, Phoenix, Arizona. 5 November.
235. **Sun, O. 2018.** *GIS-Based Two-stage Stochastic Facility Location Considering Planting Plan Uncertainty*. SBAR UA Research Team Seminar. University of Arizona, Tucson, Arizona. 28 November.
236. **Sun, O. 2019.** *Optimization of a Biomass Supply chain from Economic, Environmental, and Social Perspectives*. Dr. Fan's Group Meeting, University of Arizona, Tucson, Arizona. 13 March.
237. **Sun, O. 2019.** *Biomass Supply Chain Configuration and Management*. SBAR UA Research Team Seminar. University of Arizona, Tucson, Arizona. 10 April.
238. **Sun, O. 2019.** *Integrating Environmental and Social Impacts into Biomass Supply Chain*. SBAR System Performance and Sustainability Team Seminar. Virtual meeting space, Tucson, Arizona. 2 May.
239. **Sun, O.*; Fan, N. 2018.** *Harvest scheduling*. SBAR Logistics Team Group Meeting. (webinar) New Mexico State University. Las Cruces, New Mexico. 5 February.
240. **Sun, O.*; Fan, N. 2018.** *Optimization of feedstock logistics*. SBAR UA Research Seminar. University of Arizona. Tucson, Arizona. 14 February.

241. **Sun, O.*; Fan, N. 2018.** *Optimally locating biorefineries*. SBAR Sustainability Working Group Seminar. (webinar) Colorado State University. Lakewood, Colorado. 8 March.
242. **Teegerstrom, T; Seavert, C. 2020.** *Whole farm analysis for evaluating the adoption of guayule and guar into Southwest producers' current operations*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 12 Februrary.
243. **Teegerstrom, T.*; Seavert, C.; Khanal, S.; Gutierrez, P. 2020.** *Whole farm analysis and enterprise budget tools for evaluating the adoption of guayule and guar into Southwest producers' current operation*. SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
244. **Usrey, J.*; Dehghanizadeh, M.; Audu, M.; Rosalez, R. 2019.** *SBAR Education/Outreach at Lynn Middle School and Mesilla Valley Leadership Academy.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
245. **Usrey, J. 2020.** *Development of middle school STEM classroom lesson plans for after school program activities*. SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
246. **Usrey, J.*; Rosalez, R.; Brewer, C.E. 2020.** *Development of middle school STEM classroom lesson plans and afterschool program activities to support USDA-sponsored project on alternative crop bioeconomy*. American Institute of Chemical Engineers (AIChE) Annual Meeting. (Virtual) 15 November.
247. **Waller, P. 2018.** *WINDS Model: A status report and connection to SBAR research*. SBAR UA Research Team Seminar Series, Tucson, Arizona. 10 October.
248. **Wang, G.S.*; Lynch, A.; Cruz, V.M.V.; Dierig, D.A. 2019.** *Temperature requirements for guayule seed germination.* 31st Annual Meeting of the Association for the Advancement of Industrial Crops. Tucson, Arizona. 8-11 September. [poster]
249. **Willmon, J.*, Hu, J., Teetor, V.H., and Ray, D.T. 2018.** *Screening Parthenium argentatum for resistance to Phymatotrichum omnivorum*. 2018 Annual Conference, American Society for Horticultural Science, Washington, D.C. 30 July – 3 August.
250. **Willmon, J.; Montes, M.*; Coronado, G.; Bennett, M.C.; Teetor, V.H.; Hu, J.; Ray, D.T. 2018**. *Screening Parthenium argentatum for Resistance to Phymatotrichum omnivora*. SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 2 August. [poster]
251. **Wright, A.*; Brewer, C.E.; Jena, U. 2019.** *CHNS elemental analysis of guayule and products.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
252. **Zuniga-Vasquez, D.A. 2019.** *Two-stage stochastic multi-objective optimization for biomass supply chain integrating environmental and social impacts.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
253. **Zuniga-Vasquez, D.A. 2019.** *Stochastic scenarios for guayule production*. SBAR System Performance and Sustainability Seminar, Colorado State University, Fort Collins, Colorado. 8 October.
254. **Zuniga-Vasquez, D.A. 2019.** *Stochastic multi-objective optimization for guayule supply chain integrating environmental and social impacts*. SBAR UA Research Seminar, University of Arizona, Tucson, Arizona. 4 December.
255. **Zuniga-Vasquez, D.A. 2020.** *Optimization for guayule and guar logistics and transportation*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 8 April.

256. **Zuniga-Vasquez, D.A. 2021.** *Optimal design of guayule and guar supply chains for the American Southwest.* SBAR Annual Retreat. University of Arizona, Tucson, Arizona. 11 August. [poster]
257. **Zuniga-Vasquez, D.A.*; Fan, N. 2020.** *Optimization for guayule and guar logistics and transportation*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 19 February.
258. **Zuniga-Vasquez, D.A.*; Fan, N. 2020.** *Integrating environmental and social impacts into optimal design of guayule and guar supply chains*. SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
259. **Zuniga-Vasquez, D.A.*; Fan, N. 2020.** *Smart farm production and scheduling design for guayule and guar*. SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
260. **Zuniga-Vasquez, D.A.*; Fan, N. 2020.** *Smart farm production and scheduling design for guayule and guar*. SBAR Sustainability Team Meeting, University of Arizona, Tucson, Arizona. 30 September.
261. **Zuniga-Vasquez, D.A.*; Fan, N. 2020.** *Smart farm production and scheduling design for guayule and guar*. SBAR Research Team Meeting, University of Arizona, Tucson, Arizona. 30 September.
262. **Zuniga-Vasquez, D.A.; Fan, N.; Teegerstrom, T.; Seavert, C.; Summers, H.M.; Sproul, E.; Quinn, J.C. 2021.** *Optimal design of guayule and guar supply chains for the American Southwest.* Association for the Advancement of Industrial Crops (AAIC) 32nd Annual Meeting. Bologna, Italy (virtual). 5-8 September.
263. **Zuniga-Vasquez, D.A.*; Sun, O.; Fan, N. 2020.** *Optimization for guayule and guar logistics and transportation integrating environmental and social impacts on the supply chain.* New Mexico Alternative Crop Conference, Portales, New Mexico. 10 March. [poster]

Total Audience Demographics for Project-Related Presentations (when captured)

Audience Demographic Parameter	Previous Total (Cumulative)	This Quarter Total	Cumulative Project Total
Gender			
Males	2,111	41	***2,152***
Females	1,024	19	***1,043***
Race/Ethnicity			
Hispanic	487	15	***502***
Asian	250	3	***253***
Native American	365	5	***370***
African American	77	0	***77***
Anglo/White	1772	35	***1,807***
Unknown	184	2	***186***

Audience Cumulative Total *(when captured)****: 3,195 ppl***

WEBSITE(S) OR INTERNET SITE(S)

SBAR Project Website

1. .https://sbar.arizona.edu

NEW TECHNOLOGIES OR TECHNIQUES GENERATED

None this reporting period.

INVENTIONS, PATENT APPLICATIONS, AND/OR LICENSES

1. **Dec 2017.** 24c SLN Label for Gramoxone SL 2.0 Herbicide (Paraquat dichloride), for control of weeds in guayule. SLN Registration Number: AZ120005. Expiration: 31 Dec 2022. Arizona Department of Agriculture, Environmental Services Division.

2. **Dec 2017.** 24c SLN Label for Fusilade DX Herbicide (*Propanoic acid, 2-(4-((5-(trifluoromethyl)-2-pyridinyl)oxy)phenoxy)-, butyl ester, (R)-*), for control of emerged weeds in guayule. SLN Registration Number: AZ070006. Expiration: 31 Dec 2022. Arizona Department of Agriculture, Environmental Services Division.

3. **Sep 2020**. Patent # 506319647 (REEL/FRAME: 054154/0921) UA21-25 – Adhesives.

4. **Sep 2020**. Patent # 506319660 (REEL/FRAME: 054154/0977) UA21-26 – Particle Board.

OTHER PRODUCTS GENERATED

Brochures, Factsheets, and Flyers

1. **Duncan, C.M. 2018.** SBAR USDA-NIFA graduate student fellowship: UA Students. One page promotional flyer. February and March.
2. **Duncan, C.M. 2018.** SBAR USDA-NIFA graduate student fellowship: NMSU Students. One page promotional flyer. February and March.
3. **Duncan, C.M. 2018.** SBAR call for middle and high school science teachers. One page promotional flyer. February and March.
4. **Duncan, C.M. 2018.** SBAR 4-H summer camp: Biofuels powering your world. One page promotional flyer. March.
5. **Duncan, C.M. 2019.** SBAR Call for Middle & High School Science Teachers. One page promotional flyer. March.
6. **Duncan, C.M. 2019.** SBAR USDA-NIFA graduate student fellowship: UA Students. One page promotional flyer. March.
7. **Duncan, C.M. 2019.** SBAR USDA-NIFA graduate student fellowship: NMSU Students. One page promotional flyer. March.
8. **Duncan, C.**M. 2019. SBAR USDA-NIFA graduate science education fellowship. One page general recruiting flyer. April.
9. **Evancho, B. 2019.** Guayule Information & Feedback Session. One page invitation to attend field day and tour. May.
10. **Grover, K. 2018**. Guar – A potential alternative crop in New Mexico. Two page informational handout. January.
11. **Kiela, C. 2018.** Guayule. SBAR Project two-page fact sheet. March.
12. **Kiela, C. 2018.** Guar. SBAR Project two-page fact sheet. April.
13. **Kiela, C. 2018.** History of Guayule. SBAR Project two-page fact sheet. April.
14. **Rogstad, A. 2017.** SBAR – Sustainable Bioeconomy for Arid Regions. One-page informational and promotional card. November.

Press Releases and News Articles

1. 26 Sep 2017. “As NIFA awards $21.1M to grow the bioeconomy, CABLE debuts to bridge students and industry.” BiofuelsDigest. http://www.biofuelsdigest.com/bdigest/2017/09/26/as-nifa-awards-21-1m-to-grow-the-bioeconomy-cable-debuts-to-bridge-students-and-industry/

2. 16 Oct 2017. “UA to Head New Center Focusing on Biofuels and Bioproducts.” UA News. https://uanews.arizona.edu/story/ua-head-new-center-focusing-biofuels-and-bioproducts

3. 4 Nov 2017. “Biofuels, bioproducts, and an Arizona bioeconomy?” Arizona Daily Wildcat. http://www.wildcat.arizona.edu/article/2017/11/science-biofuels-and-bioproducts

4. 29 Nov 2017. “NMSU to host state sustainable agriculture conference in Los Lunas.” News Bulletin. http://www.news-bulletin.com/news/nmsu-to-host-state-sustainable-agriculture-conference-in-los-lunas/article_a45281f6-d540-11e7-9530-27dc93258a79.html

5. 16 Jan 2018. “Dr. Quinn’s Sustainability Expertise Recruited for Multi-Million Dollar DOE and USDA Grants.” Colorado State University, Mechanical Engineering Featured Projects. http://www.engr.colostate.edu/me/2018/01/16/dr-quinns-sustainability-expertise-recruited-for-multi-million-dollar-doe-and-usda-grants/

6. 21 Feb 2018. “NMSU collaborating in Sustainable Bio-economy for Arid Regions project.” New Mexico State University News Center. http://newscenter.nmsu.edu/Articles/view/12961/nmsu-collaborating-in-sustainable-bio-economy-for-arid-regions-project

7. 27 Feb 2018. “Bridgestone receives guayule research grant from USDA.” The Smithers Report - A daily and weekly tire industry news source. (4,500 daily subscribers) https://www.smithersrapra.com/publications/the-smithers-report

8. 27 Feb 2018. “Bridgestone and research partners earn $15 Million grant for guayule work.” MTD (Modern Tire Dealer). UMV: 62,085. http://www.moderntiredealer.com/news/728673/bridgestone-and-research-partners-earn-15-million-grant-for-guayule-work

9. 12 Oct 2021. “Keeping growers up-to-date on guayule research may encourage more to plant the crop.” Pinal Central. https://www.pinalcentral.com/eloy_enterprise/news/keeping-growers-up-to-date-on-guayule-research-may-encourage-more-to-plant-the-crop/article_113af80f-e34e-53cb-afe8-07bdb3231ff5.html

Tabling Events and Workshops – Marketing and Outreach

1. 14 July 2017. New Mexico Cotton Ginners Conference. New Mexico.
2. 17 Aug 2017. SBAR Project Kick-off Meeting. Tucson, Arizona.
3. 28 Oct 2017. Rocky Mountain Zone Summit (sustainability focus). Denver, Colorado.
4. 05 Dec 2017. Valencia County (New Mexico) Forage Conference. New Mexico.
5. 13 Dec 2017. New Mexico Sustainable Agriculture Conference. Los Lunas, New Mexico.
6. 15-17 Feb 2018. SBAR Display Table. New Mexico Organic Farming Conference. Albuquerque, New Mexico.
7. 24 Feb 2018. Farm Science Day. USDA-ARS, Arid-Land Agricultural Resource Center. Maricopa, Arizona.
8. 24 Feb 2018. 2018 Engineering Fair – Recycled papermaking and guar gum bubbles activity. Las Cruces Museum of Science and Nature. Las Cruces, New Mexico.
9. 15 Mar 2018. Zia Middle School Project – Lead the Way NMSU College of Engineering Day. Recycled papermaking and guar gum bubbles activity. Las Cruces, New Mexico.
10. 22-24 Feb 2018. Southwest Ag Summit. Yuma, Arizona.
11. 19 Mar 2018. Roosevelt Irrigation District Board Meeting. Buckeye, Arizona.
12. 28 Mar 2018. Alfalfa and Forage Workshop. Maricopa, Arizona.
13. 11 Jul 2018. New Mexico 4-H State Conference – Polymerization and guar gum bubbles activity. Albuquerque, New Mexico.

14. 9 Aug 2018. Extension Field Day, New Mexico State University Agricultural Science Center, Clovis, New Mexico.
15. 23 Aug 2018. Extension Field Day, New Mexico State University Agricultural Science Center, Artesia, New Mexico.
16. 12 Dec 2018. New Mexico Sustainable Agriculture Conference, Las Cruces, New Mexico.
17. 10 Jan 2019. Marana Winter Field Crop Clinic. University of Arizona Cooperative Extension, Marana, Arizona.
18. 15 Jan 2019. Casa Grande Winter Field Crop Clinic. University of Arizona Cooperative Extension, Casa Grande, Arizona.
19. 23 Jan 2019. New Mexico Cotton Growers Association Conference, Ruidoso, New Mexico.
20. 13 Feb 2019. Desert Hills S.T.E.A.M. Night. (Science, Technology, Engineering, Art, and Math) Desert Hills Elementary School, Las Cruces, New Mexico.
21. 15-16 Apr 2019. New Mexico Organic Farming Conference, Albuquerque, New Mexico.
22. 11 Apr 2019. Spring Extension Field Day, New Mexico State University Agricultural Science Center, Clovis, New Mexico.
23. 15 May 2019. Annual Agricultural Research Congressional Exhibition and Reception. Rayburn House, Washington, D.C.
24. 30 May 2019. Market Discussion and Field Day. Bridgestone Guayule Research Farm, Eloy, Arizona.
25. 26 Jun 2019. Extension Field Day. Fabian Garcia Research Center, Las Cruces, New Mexico.
26. 2 Jul 2019. SBAR Train the Trainers Workshop. Las Cruces, New Mexico.
27. 8 Aug 2019. Annual Agricultural Field Day. Agricultural Science Center, Clovis, New Mexico.
28. 8 Aug 2019.Agricultural Science and Field Day. Agricultural Science Center, Tucumcari, New Mexico.
29. 15 Aug 2019. Annual Agricultural Field Day. Agricultural Science Center, Los Lunas, New Mexico.
30. 21 Aug 2019. USAID Cochran Fellows Visit from Mali, Clovis, New Mexico.
31. 12 Oct 2019. Cooperative Extension Day. Maricopa Agricultural Center (MAC), Maricopa, Arizona.
32. 14 Jan 2020. Winter Field Crops Meeting, Pima County, Arizona.
33. 15 Jan 2020. Winter Field Crops Meeting, Pinal County, Arizona.
34. 29 Jan 2020. New Mexico Cotton Grower's Conference, New Mexico.
35. 30 Jan 2020. NexGen Cotton Symposium, Pinal County, Arizona.
36. 3-4 Feb 2020. New Mexico Chili Pepper Conference, New Mexico.
37. 5 Feb 2020. Deltapine Seed Meeting, Pinal County, Arizona.
38. 21-22 Feb 2020. New Mexico Organic Farming Conference, New Mexico.
39. 10 Mar 2020. New Mexico Alternative Crops Conference, Portales, New Mexico.
40. 3 Aug 2021. Clovis Field Day, Clovis Agricultural Science Center, Clovis New Mexico.
41. 13-14 Aug 2021. Cultivating Young Minds, Clovis Agricultural Science Center, Clovis, New Mexico.
42. 18 Aug 2021. Los Lunas Field Day, Los Lunas Agricultural Science Center, Los Lunas, New Mexico.

43. 25 Aug 2021. Las Cruces Field Day, Leyendecker Plant Science Center, Las Cruces, New Mexico.
44. 31 Aug 2021. Las Cruces School 3rd Grade Exploration Day, Las Cruces, New Mexico.

→*Total Reach via Tabling Events and Workshops (when captured):* ***4,855 participants***

Note: Due to COVID-19 restrictions, in-person events have were restricted between March 2020 and August 2021.

YOUTH ACTIVITIES

Biofuel Lessons in Classrooms (SBAR Teacher/Fellow Cohort 2018-2019)

1. Apollo Middle School, Tucson, Arizona.
2. Mesilla Valley Leadership Academy, Las Cruces, New Mexico.
3. Pueblo High School, Tucson, Arizona.
4. Quail Run Elementary School, Marana, Arizona.
5. Sierra Middle School, Las Cruces, New Mexico.
6. Valencia Middle School, Tucson, Arizona.
7. Walter Douglas Elementary School, Tucson, Arizona.

Biofuel Lessons in Classrooms (SBAR Teacher/Fellow Cohort 2019-2020)

1. Apollo Middle School, Tucson, Arizona.
2. Camino Real Middle School, Las Cruces, New Mexico.
3. Mesa Middle School, Las Cruces, New Mexico.
4. Mesilla Valley Leadership Academy, Las Cruces, New Mexico.
5. Quail Run Elementary School, Marana, Arizona.
6. Pueblo High School, Tucson, Arizona.
7. Saguaro National Park Environmental Education, Tucson, Arizona.
8. Santa Rosa Ranch School, Sells, Arizona.
9. Sierra Middle School, Las Cruces, New Mexico.
10. Walter Douglas Elementary School, Tucson, Arizona.

Biofuel Lessons in Classrooms (SBAR Teacher/Fellow Cohort 2020-2021)

1. Camino Real Middle School, Las Cruces, New Mexico
2. Melrose High School, Melrose, New Mexico
3. Saguaro National Park Environmental Education, Tucson, Arizona
4. Santa Rosa Ranch School, Sells, Arizona
5. Sierra Middle School, Las Cruces, New Mexico
6. Valencia Middle School, Tucson, Arizona

Youth participation through classroom activities is tracked at the beginning of the school year in September because the same students are being reached each week by the teacher fellow pairs. ***NOTE****: Due to COVID-19 response, direct youth contact did not occur after March 2020.*

Other SBAR youth activities (4H camps, after school programs, Native Youth Outreach, etc.) are also included in the total when they occur.

Youth Participation Demographics for Project-Related Activities (when captured)

Youth Participation Demographic Parameter	Previous Total (Cumulative)	This Quarter Total	Cumulative Project Total
Age Level			
11-13 years	1,242	0	***1,242***
14-16 years	487	0	***487***
Gender			
Males	862	0	***862***
Females	867	0	***867***
Race/Ethnicity			
Hispanic	904	0	***904***
Asian	33	0	***33***
Native American	184	0	***184***
African American	47	0	***47***
Anglo/White	545	0	***545***
Multiracial	17	0	***17***

Youth Cumulative Total *(when captured)****: 1,729 ppl***

****Note: Due to COVID-19 restrictions, in-person and in-school activities have been on hiatus since March 2020.****

PARTICIPANTS AND COLLABORATING ORGANIZATIONS. September 2017 – September 2021

PARTNER ORGANIZATIONS

Organization Person*	Project Role	Project Component
Bridgestone Americas,		
Von Mark Cruz	Professional	Feedstock Development & Production
David Dierig	Key Collaborator	Feedstock Development & Production
Stefan Dittmar	Professional	Feedstock Development & Production
Chloe Gonzalez	*Intern*	*Feedstock Development & Production*
Amber Lynch	Professional	Feedstock Development & Production
Russell Prock	Professional	Feedstock Development & Production
Theresa Sullivan	Professional	Feedstock Development & Production
Sam Wang	Professional	Feedstock Development & Production
Jocelyn Zhu	*Intern*	*Feedstock Development & Production*
Colorado School of Mines		
Pragnya Eranki	*Post-doc*	*System Performance & Sustainability*
Amy Landis	Key Collaborator	System Performance & Sustainability
VeeAnder Mealing	Graduate Student	System Performance & Sustainability
Jane Turek	*Undergrad Student*	*System Performance & Sustainability*
Colorado State University		
Austin Banks	*Undergrad Student*	*System Performance & Sustainability*
Jack Johnson	*Undergrad Student*	*System Performance & Sustainability*
Paula Mendoza Moreno	*Undergrad Student*	*System Performance & Sustainability*
Jason Quinn	Key Collaborator	System Performance & Sustainability
Brooke Silagy	Graduate Student	System Performance & Sustainability
Evan Sproul	*Graduate Student*	*System Performance & Sustainability*
Hailey Summers	*Graduate Student*	*System Performance & Sustainability*
New Mexico State University		
Ram Acharya	*Professional*	*System Performance & Sustainability*
Sarah Acquah	*Post-doc*	*Extension & Outreach* *System Performance & Sustainability*
Rowen Allen	*Undergrad Student*	*Extension & Outreach*
Sangu Angadi	Key Collaborator	Extension & Outreach Feedstock Development & Production
Matt Armijo	*Undergrad Student*	*Characterizations & Co-Products*
Justice Armijo	Undergrad Student	Characterizations & Co-Products
Meshack Audu	*Graduate Student Fellow*	*Education* *Characterizations & Co-Products*
Valerie Bailey	*Undergrad Student*	*Feedstock Development & Production*
Thomas Baca	*Undergrad Student*	*Extension & Outreach*
Hengameh Bayat	Graduate Student	Characterizations & Co-Products
Sultan Begna	*Professional*	*Feedstock Development & Production*
Geneva Ben	*Undergrad Student*	*Feedstock Development & Production*

Pratima Bhandari	*Graduate Student*	*System Performance & Sustainability*
Catherine E. Brewer	Key Collaborator	Education Characterizations & Co-Products
Nicolas Carrera-Little	Undergrad Student	Characterizations & Co-Products
Alyssa Castaneda	Undergrad Student	Extension & Outreach
Pedro Castillo	*Undergrad Student*	*Feedstock Development & Production*
Kenneth Cazarez	Undergrad Student	Extension & Outreach
Shivam Chawla	*Graduate Student*	*Feedstock Development & Production*
Feng Cheng	*Post-doc*	*Characterizations & Co-Products*
Murali Darapuneri	*Professional*	*Extension & Outreach*
Mostafa Dehghanizadeh	Graduate Student Fellow	Education Characterizations & Co-Products
Malachai Dehler-Egan	*Undergrad Student*	*Characterizations & Co-Products*
Barry Dungan	*Professional*	*Characterizations & Co-Products*
Shermal Fernando	Graduate Student	Education
Dominic Flores	*Undergrad Student*	*Feedstock Development & Production*
Miguel Flores	*Undergrad Student*	*Extension & Outreach*
Leonel Fournier	*Undergrad Student*	*Feedstock Development & Production*
Sarah Fox	*Undergrad Student*	*Characterizations & Co-Products*
Ryan Fullerton	*Undergrad Student*	*Feedstock Development & Production*
Claudia Galvan	Professional	Characterizations & Co-Products
Alonso Garcia	*Graduate Student*	*Feedstock Development & Production*
Adah Gellis	*Undergrad Student*	*Extension & Outreach*
Saba Gill	*Graduate Student*	*Characterizations & Co-Products*
Thomas Gloria	*Undergrad Student*	*Feedstock Development & Production*
Kulbhushan Grover	Key Collaborator	Extension & Outreach Feedstock Development & Production
Erin Gutierrez	*Undergrad Student*	*Characterizations & Co-Products*
Maria Gutierrez	Undergrad Student	Extension & Outreach
Paul H Gutierrez	*Key Collaborator*	*Extension & Outreach* *System Performance & Sustainability*
Befekadu Habteyes	*Professional*	*System Performance & Sustainability*
Jose Hackleen	*Undergrad Student*	*Feedstock Development & Production*
Mia Herrera	Undergrad Student	Feedstock Development & Production
F. Omar Holguin	Key Collaborator	Characterizations & Co-Products
John Idowu	Key Collaborator	Extension & Outreach
Moustapha Idrissa	Undergrad Student	Feedstock Development & Production
Jackie Jarvis	*Professional*	*Characterizations & Co-Products*
Umakanta Jena	*Professional*	*System Performance & Sustainability*
Sita Khanal	*Graduate Student*	*System Performance & Sustainability*
Alix Knagg	*Undergrad Student*	*Characterizations & Co-Products*
Kelly Laje	*Graduate Student*	*Characterizations & Co-Products*
Travis Le-Doux	*Undergrad Student*	*Characterizations & Co-Products*
Esai Lopez	*Undergrad Student*	*Education*
Alberto Lorenzo	*Undergrad Student*	*Feedstock Development & Production*
Andrea Loya Lujan	Undergrad Student	Characterizations & Co-Products
Sicilee Macklin	*Undergrad Student*	*Education* *Characterizations & Co-Products*
Michael Mares	*Undergrad Student*	*Extension & Outreach*
Cesar Martinez-Bejarano	*Undergrad Student*	*Characterizations & Co-Products*
Maryfrances Miller	Key Collaborator	System Performance & Sustainability Extension & Outreach
Julie Miller	*Undergrad Student*	*Extension & Outreach*
Sa'Rae Montoya	*Graduate Student*	*Characterizations & Co-Products*

Kyle Moore	*Undergrad Student*	*Feedstock Development & Production*
Hasti Mozaffari	*Graduate Student*	*Characterizations & Co-Products*
Angel Navarro-Cruz	*Undergrad Student*	*Feedstock Development & Production* *Extension & Outreach*
Mallory Nielson	Undergrad Student	Extension & Outreach
Oluwatobi Omotayo	Graduate Student	System Performance & Sustainability
Mohammed Omer	Professional	Extension & Outreach
Jasmine Paquin	*Graduate Student*	*Extension & Outreach*
Kaavya Polisetti	*Graduate Student*	*Characterizations & Co-Products*
Camila Prieto	*Undergrad Student*	*Extension & Outreach*
Darien Pruitt	*Graduate Student Fellow*	*Education* *Extension & Outreach*
Jason Quintana	*Undergrad Student*	*Extension & Outreach*
Lucas Ramirez	*Undergrad Student*	*Feedstock Development & Production*
Rodolfo Ramirez	Undergrad Student	Extension & Outreach
Luis Ramos-Coronado	Graduate Student	Extension & Outreach
Joram Robbs	*Graduate Student*	*Extension & Outreach* *System Performance & Sustainability*
Laura Rodriguez-Uribe	Professional	Extension & Outreach Characterizations & Co-Products
Alvaro Romero	Professional	Characterizations & Co-Products
Rodrigo Rosalez	*Graduate Student Fellow*	*Education* *Characterizations & Co-Products*
Kimberly Salinas	*Undergrad Student*	*Extension & Outreach*
Nathan Schavz	*Undergrad Student*	*Characterizations & Co-Products*
Tarah Schuman	*Undergrad Student*	*Characterizations & Co-Products*
Ujala Sehar	*Graduate Student*	*Characterizations & Co-Products*
Sergei Shalygin	Graduate Student	Characterizations & Co-Products
Jagdeep Singh	*Graduate Student*	*Education* *Feedstock Development & Production*
Paramveer Singh	Graduate Student Fellow	Feedstock Development & Production Education
Peter Skelton	*Professional*	*Extension & Outreach*
Nicolas Soliz	Undergrad Student	Characterizations & Co-Products
Grant Stoner	*Undergrad Student*	*Feedstock Development & Production*
David Struthers	*Undergrad Student*	*Feedstock Development & Production*
Stephen Taylor	*Undergrad Student*	*Education*
Brian Treftz	*Graduate Student*	*Education* *Characterizations & Co-Products*
Alejandra Trejo	Undergrad Student	Extension & Outreach
Stephanie Torres	*Graduate Student*	*Feedstock Development & Production*
Jacob Usrey	*Graduate Student Fellow*	*Education* *Characterizations & Co-Products*
Justin Valdez	*Undergrad Student*	*Characterizations & Co-Products*
Victoria Valenzuela	*Undergrad Student*	*Feedstock Development & Production*
Jorge Vega	*Undergrad Student*	*Extension & Outreach*
Stephanie Willette	*Graduate Student*	*Characterizations & Co-Products*
Scott Woolf	*Undergrad Student*	*Characterizations & Co-Products*
April Wright	*Undergrad Student*	*Characterizations & Co-Products*
Other		
Jennifer Fields	Professional	Education Extension & Outreach
Clark Seavert	Professional	System Performance & Sustainability

		Extension & Outreach
University of Arizona		
Torran Anderson	Professional	Education Extension & Outreach
Nick Ashley	*Graduate Student*	*Feedstock Development & Production*
Craig Bal	*Graduate Student*	*Education* *Extension & Outreach*
Gloria Villa Barbosa	*Undergrad Student*	*Extension & Outreach*
Armando Barreto	*Professional*	*Feedstock Development & Production*
Holly Barton	*Graduate Student Fellow*	*Education*
Kaitlyn Benally	*Undergrad Student*	*Extension & Outreach*
Megan Bennett	*Undergrad Student*	*Feedstock Development & Production*
Natalie Brassill	Professional	Extension & Outreach
Kyle Brown	Graduate Student	Feedstock Development & Production
Kale Burke	*Undergrad Student*	*Characterizations & Co-Products*
Daniela Cabrera	*Professional*	*Extension & Outreach*
Marielle Cascaes Inacio	Post-doc	Characterizations & Co-Products
Madasu Chandrashekar	*Post-doc*	*Characterizations & Co-Products*
Connor Chaney	*Undergrad Student*	*Feedstock Development & Production*
Sara Chavarria	Key Collaborator	Education
Yongjian Chen	Post-doc	Feedstock Development & Production
German Coronado	*Undergrad Student*	*Feedstock Development & Production*
Kamel Didan	*Professional*	*Feedstock Development & Production*
Cara Duncan Shopa	*Professional*	*Education* *Extension & Outreach*
Diaa El-Shikha	Post-doc	Feedstock Development & Production
Blase Evancho	Key Collaborator Graduate Student	Extension & Outreach Feedstock Development & Production
Neng Fan	Key Collaborator	System Performance & Susainability
Krista Farmer	*Undergrad Student*	*Feedstock Development & Production*
Charles Ferini	*Undergrad Student*	*Feedstock Development & Production*
Gunnar Fritz	*Undergrad Student*	*Education*
Daryan Godfrey	*Undergrad Student*	*Feedstock Development & Production*
Leslie Gunatilaka	Key Collaborator	Characterizations & Co-Products
Wolfgang Grunberg	Professional	ALL AREAS
Matthew Harmon	*Undergrad Student*	*Feedstock Development & Production*
Alejandra Hinojosa	Undergrad Student	Characterizations & Co-Products
Danielle Hoare	Graduate Student	Feedstock Development & Production
Stephanie Honeker	*Undergrad Student*	*Feedstock Development & Production*
Wanyu Huang	Graduate Student	Feedstock Development & Production
Arisbeth Ibarra Nieblas	Graduate Student Fellow	Education
Aaron Judkins	*Undergrad Student*	*Feedstock Development & Production*
Pujan Kafle	*Graduate Student*	*System Performance & Sustainability*
Matthew Katterman	Graduate Student *Fellow*	Education Feedstock Development & Production
C. Kasia Kiela	*Undergrad Student*	*ALL AREAS*
Corey Knox	Professional	Education
Trisha Lane	Undergrad Student	Characterizations & Co-Products
Jessica Ledesma	*Undergrad Student*	*Feedstock Development & Production*
Ashton Leo	*Graduate Student Fellow*	*Education*

Taylor Levy	*Intern*	*Extension & Outreach*
Myles Lewis	Professional	Feedstock Development & Production
Manping Liu	*Professional*	*Characterizations & Co-Products*
Patrick Lohr	*Graduate Student*	*Feedstock Development & Production*
Gerardo Lopez	*Key Collaborator*	*Extension & Outreach*
Jasmine Lopez	*Undergrad Student*	*Extension & Outreach*
Raina Maier	Key Collaborator	Feedstock Development & Production
Jonathan Maldonado	*Undergrad Student*	*Feedstock Development & Production*
Hadiqa Maqsood	Graduate Student	Feedstock Development & Production
Celestina Marinez	*Intern*	*Extension & Outreach*
Karina Martinez	Graduate Student Fellow	Education
William McCloskey	Key Collaborator	Feedstock Development & Production
Wenzhe Mi	*Intern*	*Feedstock Development & Production*
István Molnár	Key Collaborator	Characterizations & Co-Products Education
Madison Montes	*Undergrad Student*	*Feedstock Development & Production*
Leobardo Moreno	Undergrad Student	Feedstock Development & Production
Madison Morris	Undergrad Student	Feedstock Development & Production
Nick Morris	Key Collaborator	Extension & Outreach
Julie Neilson	Professional	Feedstock Development & Production
Andrew Nelson	*Post-doc*	*Feedstock Development & Production*
Kimberly Ogden	Key Collaborator	ALL AREAS
Huitzilin Ortiz	*Graduate Student Fellow*	*Education*
Lia Ossanna	*Professional*	*Feedstock Development & Production*
Bryan Pastor	Professional	Feedstock Development & Production
Duke Pauli	*Key Collaborator*	*Feedstock Development & Production*
Livvi Pearson	*Undergrad Student*	*Feedstock Development & Production*
Alexandra Peck	*Undergrad Student*	*Feedstock Development & Production*
Shaira Perez	*Undergrad Student*	*Extension & Outreach*
Sam Pernu	*Undergrad Student*	*Feedstock Development & Production*
Tenzin Phakdon	Graduate Student Fellow	Education
Sarocha Pradyawong	Post-doc	Feedstock Development & Production
Dennis T. Ray	Key Collaborator	Feedstock Development & Production
Jaspreet Rekhi	*Professional*	*Characterizations & Co-Products*
Channah Rock	Key Collaborator	Extension & Outreach
Alix Rogstad	Professional	ALL AREAS
Juan Salas	*Undergrad Student*	*Feedstock Development & Production*
Luis Anguiano Sanchez	*Professional*	*Feedstock Development & Production*
Carl Schmalzel	Professional	Feedstock Development & Production
Caroline Schulte	Graduate Student	Feedstock Development & Production
Zoe Scott	*Undergrad Student*	*Extension & Outreach*
David Shafer	Professional	Extension & Outreach
Rebecca Sheng	*Undergrad Student*	*Feedstock Development & Production*
Stephanie Sikora	*Professional*	*Education*
Andrew Smith	Graduate Student	Feedstock Development & Production
Ana Lucia Soto	Undergrad Student Intern	Feedstock Development & Production
Seth Steichen	*Graduate Student Fellow*	*Education*
Ou Sun	*Graduate Student*	*System Performance & Sustainability*
Trent Teegerstrom	Key Collaborator	Extension & Outreach

		System Performance & Sustainability
Valerie Teetor	Professional	Feedstock Development & Production
Mira Theilmann	*Undergrad Student*	*Feedstock Development & Production*
Christine Toering	*Undergrad Student*	*Feedstock Development & Production*
Gianni Velasco	*Undergrad Student*	*Feedstock Development & Production*
Tony Viola	*Undergrad Student*	*Education*
Peter Waller	Key Collaborator	Feedstock Development & Production
Quinn Waltz	*Undergrad Student*	*Feedstock Development & Production*
John Willmon	*Undergrad Student*	*Feedstock Development & Production*
Gaven Wolkon	Undergrad Student	Characterizations & Co-Products
Ya-ming Xu	*Post-doc*	*Characterizations & Co-Products*
Shunyu Yao	Graduate Student	System Performance & Sustainability
Ali Yaylali	Graduate Student Fellow	Education
Stevi Zozaya	*Undergrad Student*	*Extension & Outreach*
Weimao Zhong	Post-doc	Characterizations & Co-Products
Daniel Zuniga-Vazquez	Graduate Student	Characterizations & Co-Products System Performance & Sustainability
USDA Agriculture Research Service – US Arid Lands Research Center, Maricopa AZ		
Hussein Abdel-Haleem	Key Collaborator	Feedstock Development & Production
Adrianna Chambers	*Undergrad Student*	*Feedstock Development & Production*
Amber Dearstyne	*Undergrad Student*	*Feedstock Development & Production*
Tristan Dunton	*Professional*	*Feedstock Development & Production*
Harmony Glover	*Undergrad Student*	*Feedstock Development & Production*
Doug Hunsaker	*Professional*	*Feedstock Development & Production*
Greg Leake	*Professional*	*Feedstock Development & Production*
Avery Luna	Undergrad Student	Feedstock Development & Production
Lily Luo	*Professional*	*Feedstock Development & Production*
Aaron Szczepanek	Professional	Feedstock Development & Production
Brandon Vera	*Undergrad Student*	*Feedstock Development & Production*
USDA Agriculture Research Service – Western Regional Research Center, Albany CA		
Milagro Adom	*Student (SEED)*	*Feedstock Development & Production*
Sheyla Aucar	*Professional*	*Feedstock Development & Production*
Brandon Bartelmie	*Student*	*Feedstock Development & Production*
Matthew Canonizado	*Professional*	*Feedstock Development & Production*
George Chong	*Professional*	*Feedstock Development & Production*
Chen Dong	*Professional*	*Feedstock Development & Production*
Niu Dong	Professional	Feedstock Development & Production
Trinh Huynh	Professional	Feedstock Development & Production
Kumiko Johnson	Professional	Feedstock Development & Production
Colleen McMahan	Key Collaborator	Feedstock Development & Production
Dante Placido	Post-doc	Feedstock Development & Production
Grisel Ponciano	Professional	Feedstock Development & Production
Mariano Resendiz	Graduate Student	Feedstock Development & Production

** Individuals no longer actively working on the SBAR project appear in italic.*

Total Active Key Collaborators: ***24***
Total Active Professional Staff: ***28***
Total Active Postdoctoral Researchers: ***6***
Total Active Graduate Students: ***24***
Total Active Undergraduate Students: ***19***
Total Active Fellows: ***5***
Total Active /Interns: ***0***

*Total Active Participants:****106***
Total Past Participants (no longer active): ***146***
Total Individuals Involved Since SBAR Inception: ***252***

COLLABORATIONS AND OTHER CONTACTS

Collaborations:

Academic Institutions:	CSM (Colorado School of Mines) - Dept. of Civil and Environmental Engineering CSU (Colorado State University) - Dept. of Mechanical Engineering FSU (Florida State University) - National High Magnetic Field Laboratory NMSU (New Mexico State University) - Cooperative Extension - Dept. of Agriculture, Consumer and Environmental Science - Dept. of Agricultural Economics and Agricultural Business - Dept. of Chemical and Materials Engineering - Dept. of Plant and Environmental Sciences - Urban Entomology Research Center UA (University of Arizona) - Arizona Institutes for Resilience - Agricultural and Biosystems Engineering - College of Agriculture and Life Sciences - College of Education - College of Engineering - Cooperative Extension - Dept. of Agriculture and Resource Economics - Dept. of Chemical and Environmental Engineering - Dept. of Language, Reading and Culture - Dept. of Soil, Water and Environmental Sciences - Dept. of Systems and Industrial Engineering - Dept. of Teaching and Teacher Education - Institute of Energy Solutions - Natural Products Center - School of Natural Resources and the Environment - School of Plant Sciences UNM (University of New Mexico) – Gallup - Dept. of Mathematics, Physical and Natural Science
Nonprofits:	Environmental Defense Fund, Phoenix AZ Asombro Institute for Science Education, Las Cruces NM

Industrial or Commercial Firms:	BASF Bridgestone Americas, Inc. Central Arizona Project (CAP) FMC Guar Resources Syngenta
Federal Government	Saguaro National Park (West), Tucson AZ - Environmental Education Department USDA – Agricultural Research Service, Western Regional Research Center, Albany CA - Chemistry (Bioproducts) - Plant Genetics USDA – Agricultural Research Service, Grassland Soil and Water Research Laboratory, Temple TX - Crop Modeling USDE – Pacific Northwest National Laboratory, Richland WA
State or Local Governments:	Arizona Department of Agriculture, Environmental Services Division
Tribal Governments:	**Ak-Chin Indian Community**, Maricopa, Arizona **Tohono O'odham Nation**, Sells, Arizona
Schools or School Systems:	**BASIS Charter Schools**, BASIS Tucson North (high school), Tucson, Arizona **Flowing Wells Unified District**, Walter Douglas Elementary School, Tucson, Arizona **Las Cruces Public Schools**, Camino Real Middle School, Mesa Middle School, Mesilla Valley Leadership Academy, and Sierra Middle School, Las Cruces, New Mexico **Marana Unified School District**, Quail Run Elementary School, Marana, Arizona **Melrose Municipal Schools**, Melrose High School, Melrose, New Mexico **Tucson Unified School District**, Pueblo High School, and Valencia Middle School, Tucson, Arizona **Santa Rosa Ranch School District**, Santa Rosa Ranch School, Sells, Arizona

	Sunnyside Unified School District, Apollo Middle School, Tucson, Arizona
Other Organizations (foreign or domestic):	

Other Contacts:

Contacts with others within recipient's organization (interdepartmental or interdisciplinary collaborations):	UA (University of Arizona) - Applied Biosciences - Arid Lands Resource Sciences - Arizona Institutes for Resilience - College of Agriculture and Life Sciences - College of Architecture, Planning and Landscape Architecture - College of Science - Water Resources Research Center
Contacts with others outside the organization:	Denver Museum of Nature and Science, Denver CO Central Arizona College, Coolidge AZ
Contacts with others outside the United States or with an international organization:	

APPENDICES

APPENDIX 1. SBAR 2021 RETREAT MATERIALS

Documents Included

1. **2021 SBAR Annual Retreat Agenda** – Full agenda for the SBAR Retreat hosted at the University of Arizona. 11-13 August 2021. (3p)
2. **Haiku** – Description and instructions for SBAR Retreat participants to contribute to the Haiku Corner, University of Arizona. 11-13 August 2021. (1p).
3. **SBAR Haikus** – Collection of the Haikus submitted by participants that the SBAR Annual Retreat hosted at the University of Arizona. 11-13 August 2021. (1p).

2021 SBAR Annual Retreat

Wednesday, 11 August 2021	**RETREAT SESSION – DAY 1**
1000 – 1200	**Pre-Sessions** (*Agenda determined by LEAD*)
	System Performance & Sustainability ***ENR2 S210***
Meeting over lunch	Education ***ENR2 S225***
Meeting over lunch	Extension & Outreach ***ENR2 S215***
1200 – 1330	~LUNCH (*brown-bag provided on site*)~
1300 – 1330	**Check-In** ***ENR2 S107***
1330 – 1630	**SBAR Working Session I** (*SBAR Collaborations and Component Breakouts*)
	Feedstock Development & Production – ***ENR2 S215*** Characterizations & Co-Products – ***ENR2 S225*** System Performance & Sustainability – ***ENR2 S210*** *Education – select another team to join* *Extension & Outreach (Youth Development) – select another team to join* - Split as component teams to develop priority list of the following: 1. Focus on Component Objectives… what is complete? what still needs work? 2. Prioritize Remaining Pieces… what is most critical to complete the story? 3. Final Deliverables… who is going to do what (to hit the objectives that still need work)? 4. Publications… what is in process? who is responsible for what? what is missing that we should target? 5. Deadlines… what is a realistic timeline for final deliverables? make sure these jive with SOWs
1630 – 1645	~BREAK~
	SBAR Poster Session & SBAR Mixer ***Café, ENR2 S120*** (happy hour drinks and heavy hors d'oeuvres; ID check at the door)
1645 – ?	- Open Poster Session and Discussion: 1. Written abstracts submitted prior to event. 2. Oral Poster Overviews; Q&A

2021 SBAR Annual Retreat

Thursday, 12 August 2021	**RETREAT SESSION – DAY 2**
0745 – 0830	**Morning Coffee/Tea** *(provided on site)* ***ENR2 S107***
0830 – 0845	**Welcome** ~ *Alix Rogstad* - Overview of schedule; intended retreat outcomes
0845 – 0945	**SBAR Highlights and Progress** (*Where we started; Where we've been*) **Key Research, Education, and Extension Findings and Accomplishments** ~ *Kim Ogden*
0945 – 1100	**Industry Update/Perspective** • Domestic and global rubber outlook • How SBAR has impacted industry? • Are we close to hitting the target for commercialization? • What are the missing pieces? • What are the national alternative agriculture opportunities? • Future vision • - Bridgestone Americas, Inc. ~ *Dave Dierig & Bob White* - Commercial Aviation Alternative Fuels Initiative ~ *Steve Csonka*
1100 – 1115	~BREAK~
1115 – 1145	**Grower Update/Perspective** • How regional growers will adjust to new agricultural landscape and what influences grower decisions • Are we close to hitting the target for expanded new crop adoption? • What are the missing pieces from the grower perspective? • Future vision • - Guayule Grower Perspective ~ *Paco Ollerton*
1145 – 1200	**The SBAR Story** (video)
1200 – 1300	~LUNCH *(provided on site)*~
1300 – 1500	**SBAR Working Session II** (*Narrowing Down Year 5; Prioritize for Possible Year 6*) ***FD → ENR2 S215; CoP → ENR2 S225; SUS → ENR2 S210*** - Split as research teams (Extension and Education select a research team to join). Using the information gained in Working Session I (from Wednesday), discuss the following: 1. Priorities for Year 5… review and add to list from previous discussion. Is there anything you missed that should be added? 2. 1-year No-Cost Extension… what **2 key things** would add value and amplify SBAR accomplishments? who needs to be a part of the research? is something (subject area expertise) missing? how can Education/Extension work contribute to hitting the target?
1500 – 1515	**Team Photo**
1515 – 1530	~BREAK~
1530 – 1645	**Advisory Board Working Session** ***ENR2 N604*** **Open Collaborative Meeting Time** - Video Booth ***ENR2 S225*** - Explore SBAR Lessons! ***ENR2 S210*** - Haiku Corner ***ENR2 S215*** - 1:1 meetings ***ENR2 S215*** - Small team discussions ***ENR2 S215***
1645 – 1730	~BREAK~
1730 – ??	**Happy Hour & SBAR Group Supper** (off-site location; Downtown Tucson near the street car)

2021 SBAR Annual Retreat

Friday, 13 August 2021	RETREAT SESSION – DAY 3
0745 – 0830	**Morning Coffee/Tea** *(provided on site)* ***ENR2 S107***
0825 – 0830	**Good Morning Welcome** ~ *Alix Rogstad* - Reminders; logistics for the day
0830 – 0900	**Setting the Stage for Working Session III** - Brief review of Working Session II discussions per Team *(Yr5 Priorities; Future Work)* 1. Education 2. Extension & Outreach (including Youth Development) 3. Feedstock Development & Production 4. Characterizations & Co-Products 5. System Performance & Sustainability
	SBAR Working Session III (*Narrowing Down Year 5; Prioritize for Possible Year 6*)
0900 – 1030	(To improve virtual experience, please speak into the microphone with your questions/comments.) - As a full SBAR Team, discuss the following: 1. Combined efforts… what are the cross-functional products? 2. Identify gaps… are there any realistic opportunities or achievable goals we should add to our task? what are the missing pieces to get to commercialization? (Marketing plan) 3. Co-products to enable commercialization…how do these pieces fit together to create a sustainable bioeconomy? 4. Priorities for potential Year 6 (no-cost extension)
1030 – 1040	~BREAK~
	(*Creating the bioeconomy; Getting to Commercialization; Sustainability*)
1040 – 1145	**Reflections and Q&A Discussion** ~ *SBAR Advisory Board* - General Thoughts (overall picture) - Areas of Excellence (achieving objectives) - Critical Gaps; Suggestions for Improvement - Outlook – adjustments to meet current conditions and expectations (in industry, government, or public perception)
1145 – 1230	**SBAR Final Comments and Outcomes** ~ *Kim Ogden (facilitator)* - Potential commercialization plan (Bridgestone) - Future collaborative work (education/research team) - Vision for Year 5. - Vision for no-cost extension (Year 6).
1230	**Safe Travels; Safe Home** *Sack Lunch Available at Departure*
	Final SBAR Evaluation (***To be sent via email!***)

We respectfully acknowledge the University of Arizona is on the land and territories of Indigenous peoples. Today, Arizona is home to 22 federally recognized tribes, with Tucson being home to the O'odham and the Yaqui. Committed to diversity and inclusion, the University strives to build sustainable relationships with sovereign Native Nations and Indigenous communities through education offerings, partnerships, and community service.

Haiku

Basics and Key Characteristics:

- A type of short form poetry originally from Japan
- Traditionally consists of 17 syllables in three phrases in a 5-7-5 pattern
- Generally draws on concise wording and has a reference to nature or a biological item
- An emphasis on imagery over exposition, and avoids metaphors or similes
- Little to no punctuation or capitalization
- Non-rhyming lines

Haiku Corner

During the 2021 SBAR Retreat, we are offering an opportunity to engage in a little creativity! Please join us! 😊

A *Haiku Corner* has been set up in ***ENR2 S215***. We invite you to write a haiku that represent your SBAR-related work and share it on the large post-it boards that are established in the room. Please be sure to include your name below your work so that we can provide proper credit.

All Haikus submitted will be shared with SBAR partners and included in SBAR reports, with full credit given to the author(s).

Examples (provided by Alix)

Southwest solution
for a bioeconomy:
guayule and guar

arid lands support
rubber-producing plantings
of guayule crops

growers with Southwest
farms consider guar as an
alternative crop

SBAR Haikus

Compiled during 2021 SBAR Annual Retreat (11-13 Aug 21)

Southwest solution
for a bioeconomy:
guayule and guar
~Alix Rogstad

arid lands support
rubber-producing plantings
of guayule crops
~Alix Rogstad

growers with Southwest
farms consider guar as an
alternative crop
~Alix Rogstad

guayule uses
rainfall and irrigation
efficiently … pow!
~Alix Rogstad

weeds are attacking
Guayule is suffering
herbicides do help
~Bill McCloskey

the plants are growing
but there are no more flowers
carbon for rubber?
~Colleen McMahan

She once loved algae
but now guayule and guar
our fearless leaders
~Colleen McMahan

Jason Quinn has said
"Is the juice worth the squeeze?" and
many laughs were had
~Valerie Teetor

new technologies
advance sustainable crops
improving growing
~Sara Chavarria

Education rocks
revealing innovation
for inspiration
~Sara Chavarria

saving arid lands
putting guar and guayule
in farm heads and hands
~Frannie Miller

Oh…¿Que es SBAR?
irrigation and bagasse
Zoom's a pain in the …
~Frannie Miller

growers' perspectives
are very important
to commercialize
~Mark Von Cruz

Oh no more water –
alternative crops should be
put on farmer's list
~Mark Von Cruz

$F = \frac{kH}{x}$ *"k H over x" = flux*

$Se = (hb/hc)^{mu}$ *"h b over h c mu" = effective saturation*

krw = k/ksat *"k over ksat" = relative permeability*

~Peter Waller

enjoyable heat
happy models play
on the life cycle
~Jason Quinn

Year 5 begins
where are we going
look to TEA
~Jason Quinn

modeling is hard
how can I make it right?
loving what I do
~Jason Quinn