SUSTAINABLE BIOECONOMY FOR ARID REGIONS (SBAR)

Summary Report – Quarter 3, 2020

Information submitted by project partners; synthesized by:
Alix Rogstad, Project 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**
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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*

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INTRODUCTION AND MANAGEMENT

General Overview: Organization

The Sustainable Bio-economy for Arid Regions (SBAR) Center of Excellence continued to succeed under the tutelage of Dr. Kimberly Ogden, who is the Executive Project Director leading the overall research effort and ensuring adequate progress toward meeting goals. The SBAR Project Director of Operations (Alix Rogstad) continued 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, continued 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. The next scheduled thorough review and update will be in August 2021.

Advisory Board

No changes were made to the Advisory Board makeup 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
Matt Chavez	Independent Grower, NM	2017
Steve Csonka	Commercial Aviation Alternative Fuels Initiative (CAAFI)	2017
Mark DeDecker	Bridgestone Americas, Inc.	2017
Gary Deen	Double D Farms, AZ	2017
William Goldner	USDA, National Institute of Food and Agriculture	2017
John Holladay	Pacific Northwest National Laboratory	2019
Chris Kuzdas	Environmental Defense Fund	2018
Homer Marks	Southwest Indian Agriculture Association, Tohono O'odham Nation	2017
Newt McCarty	NMSU, Extension Educator	2018
Jaroy Moore	Texas A&M Agrilife Research & Extension Center	2017
Alex Muravijov	Guar Resources	2017
Paul "Paco" Ollerton	Tierra Verde Farms, AZ	2019
Matt Payne	West Water Research, Inc.	2018
Bob White	Bridgestone Americas, Inc.	2017

Receiving the signed non-disclosure agreements (NDA) to ensure confidentiality of research data, information, and conclusions for the duration of the project remains ongoing. To date 7 NDAs have been completed and returned, 4 other Advisory Board members are subject to existing project NDA and confidentiality agreements, and the remaining 4 NDAs are pending.

Sensitive data is not shared with individuals until a signed NDA is on file. No further concerted effort will be made to acquire signed NDAs.

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 more frequent meetings is to ensure that SBAR can remain agile in addressing changing priorities and circumstances.

The Advisory Board met virtually during the 2020 SBAR Retreat in July 2020, where members were able to ask direct questions and work with the team to determine the best implementation strategy for ongoing research needs during a national pandemic. Future Advisory Meetings are currently being scheduled for the fall and spring to ensure that the research and outcomes remain on track.

Budget and Financial Management

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.

Sub-awards are fully activated with all project partner institutions: Bridgestone Americas, Inc., New Mexico State University (NMSU), Colorado School of Mines (CSM), Colorado State University (CSU), and the USDA-Agricultural Research Service (USDA-ARS). All sub-awards are progressing appropriately.

Planned budget allocations (based on annual scopes of work) for the fourth year of the project were approved by the SBAR Leadership Team this quarter. All sub-award modifications were initiated and/or completed to ensure continuity of workflow beyond August.

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 reporting period, the virtual meeting space (via Zoom) was utilized 55 times for over 73.1 hours. As with the previous quarter COVID-19 shifted most in-person meetings to virtual platforms, which resulted in more time in virtual meetings. The total number of participants was slightly fewer than previous quarters for all working group meetings (n=563), which is likely the result

Photo 1. *Screenshot of a Zoom working session for the Education Component.*

of university and partner institution's temporary closures.

LEADS Team Meetings

The component leaders and co-leaders (LEADS) continued to meet with Ogden and Rogstad during established twice-monthly 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.

As mentioned above (*Budget and Financial Management*), the LEADS discussed and made final decisions about the Year 4 budget cycle that were instituted in the subaward modification process.

SBAR Annual Retreat

Due to the COVID-19 pandemic, the decision was made in mid-June to shift the 2020 SBAR Annual Retreat to a virtual platform. The Retreat was hosted online over two days (27-29 July), with a modified agenda to reduce Zoom fatigue. Approximately 193 participants attended the sessions on the first day, and 177 participants attended the second day's sessions. Another 97 participants attended the individual component working sessions that were hosted via Zoom the day following the meeting.

As previous years, the 2020 SBAR Annual Retreat was hosted by the University of Arizona, and included updates from industry partners and visionaries, research highlights for each Component, Advisory Board meeting time, and open networking periods. Although no poster session was hosted, all SBAR students were encouraged to present their work during the Component update sessions. Agenda materials are included 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, and materials associated with the 2020 SBAR

Virtual Retreat. The Extension & Outreach pages – including the Grower-focused pages and the Youth Development page – are also currently under revision.

The SBAR webpage was visited by people in 42 different states of the USA during this reporting period (Table 2). Visits from two new states (Alaska and New Hampshire) occurred this quarter. Since inception, the website has been viewed by people in all 50 states, 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 – Mar 2020**	**Apr – Jun 2020**	**Jul – Sep 2020**
Alabama				X	
Alaska					X
Arizona	X	X	X	X	X
Arkansas		X	X		X
California	X	X	X	X	X
Colorado	X	X	X	X	X
Connecticut				X	X
Delaware		X	X		
District of Columbia	X	X	X	X	X
Florida		X	X	X	X
Georgia		X	X	X	X
Hawaii			X		X
Idaho		X	X	X	X
Illinois	X	X	X	X	X
Indiana		X	X		X
Iowa	X	X	X	X	X
Kansas	X	X	X	X	X
Kentucky		X	X	X	
Louisiana			X	X	X
Maine			X		
Maryland	X	X	X	X	X
Massachusetts		X	X	X	X
Michigan		X	X	X	X
Minnesota		X	X	X	X
Mississippi		X	X	X	
Missouri		X	X	X	X
Montana		X	X	X	X
Nebraska		X	X	X	X
Nevada		X	X	X	X
New Hampshire					X
New Jersey				X	X
New Mexico	X	X	X	X	X
New York	X	X	X	X	X

	Time Period				
State	**Jul – Dec 2018**	**Jan – Dec 2019**	**Jan – Mar 2020**	**Apr – Jun 2020**	**Jul – Sep 2020**
North Carolina	X	X	X	X	X
North Dakota		X		X	X
Ohio		X	X	X	X
Oklahoma		X	X		X
Oregon		X	X	X	X
Pennsylvania		X	X	X	X
Rhode Island				X	X
South Carolina	X	X	X	X	X
South Dakota		X		X	
Tennessee	X	X	X	X	X
Texas	X	X	X	X	X
Utah		X	X	X	X
Virginia		X	X	X	X
Washington	X	X	X	X	X
West Virginia		X			
Wisconsin		X		X	
Wyoming		X	X	X	X
Total	**15**	**41**	**40**	**41**	**42**

There were 957 unique sessions from July – September 2020. This is a substantial drop from the previous quarter, though it is likely a result of less activity associated with the COVID-19 pandemic. Page views occurred in 39 different countries this quarter (top three: USA, Finland, and India), including 3 countries that have not visited the website previously (Bolivia, Puerto Rico, and Tunisia). Visitors from the USA account for 85.7% of site visits during this reporting period. This quarter showed a high interest from Finland, India, China, Netherlands, and Mexico, which accounted for another 7% of site visits overall.

There have been 9,660 unique website sessions since July 2018. Since activation, the website has had visitors from 6 continents and 82 different countries around the world (Table 3). The highest visited website pages during this period included those that describe our team and partnerships, provide SBAR-generated resources like publications and curriculum, and those associated with the 2020 SBAR Virtual Retreat. Other highly visited pages included those that provide details about ongoing research and those that provide educational resources. 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 – Mar 2020**	**Apr – Jun 2020**	**Jul – Sep 2020**
Algeria			X		
Argentina		X			X
Australia	X	X	X		X
Austria	X	X	X	X	X

Country	Time Period				
	Jul – Dec 2018	Jan – Dec 2019	Jan – Mar 2020	Apr – Jun 2020	Jul – Sep 2020
Bahrain			X		X
Bangladesh		X	X	X	
Belgium		X		X	
Belize				X	
Bolivia					X
Brazil		X		X	X
Cameroon				X	
Canada	X	X	X	X	X
Chile		X			X
China	X	X	X	X	X
Colombia		X	X		
Congo-Kinshasa		X			
Côte d'Ivoire		X		X	X
Cyprus		X			
Ecuador			X	X	X
Egypt	X				
Estonia		X			
Ethiopia	X				
Finland			X	X	X
France		X	X	X	X
Germany	X	X	X	X	X
Ghana		X	X	X	
Grenada			X		
Greece			X		
Honduras		X			
Hong Kong	X	X			X
Hungary			X		
India	X	X	X	X	X
Indonesia		X			
Iran	X	X	X	X	X
Ireland		X			
Israel		X			
Italy	X	X	X	X	X
Japan	X	X	X	X	X
Jordan				X	
Kenya		X			X
Kuwait	X	X			
Lebanon		X			
Malaysia		X			X
Mexico	X	X	X	X	X
Morocco		X			
Namibia		X			
Nepal	X	X		X	X
Netherlands		X	X	X	X
New Zealand	X		X		X
Nigeria		X	X	X	X

Country	Time Period				
	Jul – Dec 2018	Jan – Dec 2019	Jan – Mar 2020	Apr – Jun 2020	Jul – Sep 2020
Norway				X	
Oman				X	X
Pakistan	X	X	X	X	X
Paraguay		X			
Peru		X			
Philippines	X	X	X		X
Poland		X	X		
Portugal		X			
Puerto Rico					X
Qatar		X	X		X
Romania			X		
Russia		X			
Saudi Arabia		X	X		
Serbia				X	X
Singapore		X			X
South Africa		X			
South Korea		X	X	X	X
Spain		X			
Sri Lanka		X			
Sweden		X			X
Switzerland			X	X	
Taiwan		X			
Thailand	X	X	X		
Tunisia					X
Turkey	X	X	X	X	X
Uganda				X	
Ukraine		X			
United Arab Emirates		X			
United Kingdom	X	X	X		X
United States	X	X	X	X	X
Vietnam		X			
Zambia		X			
Total	**22**	**60**	**36**	**32**	**39**

During this quarter in July, Rogstad and Wolfgang Grunberg generated a new marketing story piece using an ESRI Story Map digital tool that describes the SBAR Center's overall goals, ongoing research, and future strategies for building a sustainable bioeconomy.

The SBAR Story Map is accessible from the SBAR website, but is also available via ESRI's Story Map website. SBAR Story Map Direct URL: https://arcg.is/0OrOPT

Photo 2. *Front page of the SBAR Story Map, "SBAR Accomplishments."*

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. 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. Questions related to planting or harvesting schedules are generally worked out during these monthly meetings. 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: Due to global COVID-19 pandemic situation and USDA policies of minimal essential operations and maximum teleworking, HTP scanning data were collected awaiting reopening for final analyses, based on the current situation, it is yet unclear to predict if 2020 milestones will be met.

Angadi: Pandemic of COVID-19 has affected our research activities significantly. Field trials were conducted with special permission from Vice-President of Research, NMSU, but I am not able to hire a new graduate student due to VISA restrictions and non-availability of local students. My research scientist and temporary technician left for better opportunities. I am not allowed to replace research scientist position due to COVID related hiring freeze. I am trying to convert graduate student salary to hire a lab assistant to complete some of our research work. We are in the process of harvesting field trials (by borrowing help from other programs) and leave the samples in storage until some help joins the team to process those samples. If samples are not processed soon, some of the projects will move from yellow (at-risk) to red (behind schedule).

Dierig: Bridgestone Agro Operations partially shut down as a result of COVID-19 response. We anticipate to still meet the goals of our SOW. We completed most of the harvesting and processing of shrubs prior to shut-down. The analytics were slightly delayed but are now up-to-date.

Grover: The COVID-19 lockdown has somewhat impacted the activities with restricted face-to-face interactions.

McCloskey: The SARS-COV2 virus and the failure of the fall 2019 preemergence herbicide experiments caused some delays. I am also very worried about the success of the fall 2020 guayule planting at Eloy and MAC. However, I remain optimistic that herbicide registrations can be obtained in the winter of 2020-2021 with the data we have already collected.

McMahan: The USDA-ARS-WRRC location was closed, except for essential work, in response to the COVID-19 pandemic on March 17, 2020. In 2Q20 and 3Q20, due to the limited lab access, genotype/phenotype evaluations, and ASE testing for rubber/resin content did not take place (previously reported). Plants were maintained and grew in cultures. As of 10/15/2020,

plant care is permitted but lab access is still limited. We anticipate partial lab access starting next week. Year 4 Deliverables are still green. We have decided to prioritize moving plants to soil, as described.

Neilson/Maier: There are a number of items this quarter that are delayed because of COVID restrictions on lab availability. The good news is that all labs are now open and work is progressing well.

- Soils collected in March 2020 from Eloy and MAC irrigation trials were dried, but could not be processed due to lab closures. All labs are open now and soils will be processed by December 2020. The absence of this data is not slowing progress on other projects.
- Soil texture analysis was targeted to be completed March – May 2020, however the labs were closed due to COVID restrictions. The analysis lab reopened in September and that work is now in progress.
- Lab closures also prevented Kyle from completing DNA extractions on 2019 soil samples from the Eloy and MAC irrigation trials. The work is in progress now and the delay only affects his research.
- The 240 soil DNA extractions for this project were targeted to be started after the final sampling day in May 2020. The labs in Bio5 did not open until July. The lab is now open and exractions are progressing well.

Ogden: We are still being affected by the Coronavirus disease (COVID-19). The situation is better. The University and collaborators facilities are partially opened for students and employee safety. We can go to work more often and are still adjusting ourselves to work safely and efficiently. The work and shipment are still delayed but we are trying to catch up.

Ray: Many experiments were/are on hold due to the pandemic. Work is progressing slowly and safely.

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	Perform plant transformations using all 3 constructs (AP1, SEP3, FT, LEAFY)	Confirmed transformation for invitro plants – 6 lines AP1 Confirmed transformation for invitro plants – 6 lines SEP3 Confirmed transformation for invitro plants – 6 lines FT	31 Aug 20 31 Aug 20 31 Aug 20

		Confirmed transformation for invitro plants – 6 lines LEAFY	31 Aug 20
3 McMah	Determine effect of transgenes on rubber content by ASE (tissue culture)	% rubber data obtained for each construct line	31 Aug 20
4 McMah	Transfer plants to greenhouse for flowering phenotype	Transfer at least 2 lines to greenhouse	31 Aug 20
5 Ray	Evaluate growth and rubber/resin content in guayule germplasm lines	Rubber/resin content determined in 21 guayule germplasm lines	30 Jun 20
6 Ray	Compare root growth/architecture and water use in direct-seeded and transplant-established guayule	Plantings established Compare root growth and top growth for direct-seeded and transplant-established plants Compare root growth/top growth/water use	31 Jan 20 31 May 20 31 Mar 20

Evaluate Germplasm Lines (Variety Trials):

Two trials planted by direct seeding at Eloy, April and May 2018 were harvested in March, 2020. The first trial includes 55 USDA varieties and the second 30 varieties, both with 4 replications. One-m2 section was harvested from each plot. The same trial was planted in Maricopa, AZ and harvested at the same time. Below are the partial results for rubber content, dry biomass, and rubber yield. There were significant differences in both varieties and in replications. It is interesting that the mean separations show no significant differences for all three traits (rubber content, dry biomass, and rubber yield) between 36 of the total number of varieties. A full analysis and interpretation of data will be coming soon with all the trials together.

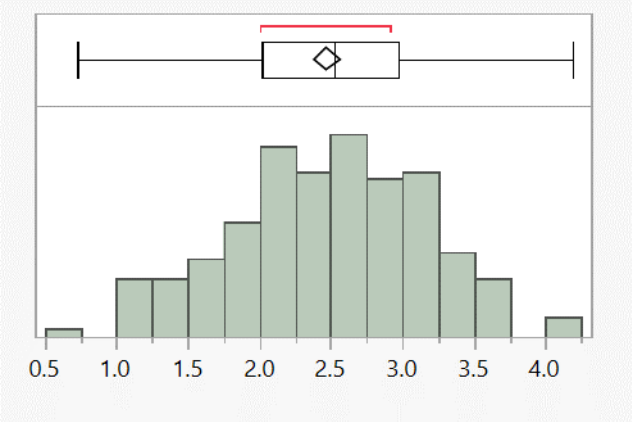


Figure 1. *Rubber content average for all lines.*

Table 4. *Quantiles and summary statistics for Figure 1.*

100.0%	maximum	4.2
99.5%		4.2
97.5%		3.7
90.0%		3.3
75.0%	quartile	2.9
50.0%	median	2.5
25.0%	quartile	2.0
10.0%		1.5
2.5%		1.0
0.5%		0.7
0.0%	minimum	0.7

Mean	2.5
Std Dev	0.7
Std Err Mean	0.04
Upper 95% Mean	2.6
Lower 95% Mean	2.4
N	213

Table 5. *Analysis of variance for Figure 1.*

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	58	69.588200	1.19980	6.7252
Error	154	27.474110	0.17840	**Prob > F**
C. Total	212	97.062310		<.0001*

Table 6. *Effect test results for Figure 1.*

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Repl	3	3	2.771306	5.1780	0.0020*
Pedigree	55	55	66.388736	6.7660	<.0001*

Table 7. *Least squares means table for Figure 1.*

Level	Least Sq Mean	Std Error	Mean
1	2.4662280	0.05895331	2.4
2	2.4345599	0.06034913	2.4
3	2.2833195	0.05804704	2.2
4	2.6013635	0.05882086	2.6

Table 8. LS Means Differences Tukey HSD (results for Figure 1).

α=0.050 Q=2.59731; Levels not connected by same letter are significantly different.

Level			Least Sq Mean
4	A		2.6
1	A	B	2.4
2	A	B	2.4
3		B	2.2

Table 9. *Pedigree - LSMeans Differences Tukey HSD results for Figure 1.*

Level												Least Sq Mean
AZ6	A											3.5
AZ2TC5	A	B	C	D	E	F	G	H	I			3.3
PARL 922	A	B										3.3
4265-X	A	B	C	D								3.1
AZ5	A	B	C	D								3.1
AZ2	A	B	C									3.1
11619	A	B	C	D								3.1
R1109	A	B	C	D								3.1
11591	A	B	C	D	E							3.0
11693	A	B	C	D	E							3.0
N576	A	B	C	D	E							3.0
PARL 919	A	B	C	D	E	F						2.9
11635	A	B	C	D	E	F						2.9
PARL 920	A	B	C	D	E	F						2.8
11633	A	B	C	D	E	F	G					2.8
N396	A	B	C	D	E	F	G					2.8
PARL 929	A	B	C	D	E	F	G					2.8
R1044	A	B	C	D	E	F	G					2.8
AZ2TC2	A	B	C	D	E	F	G	H				2.7
PARL 934	A	B	C	D	E	F	G	H				2.7
11604	A	B	C	D	E	F	G	H				2.7
CFS24	A	B	C	D	E	F	G	H				2.7
R1040	A	B	C	D	E	F	G	H				2.6
CFS18-2005	A	B	C	D	E	F	G	H	I			2.6
11609	A	B	C	D	E	F	G	H	I			2.6
CAL7	A	B	C	D	E	F	G	H	I			2.5
PARL 914	A	B	C	D	E	F	G	H	I			2.5
11646	A	B	C	D	E	F	G	H	I			2.5
R1110	A	B	C	D	E	F	G	H	I	J		2.4
N565	A	B	C	D	E	F	G	H	I	J		2.4
CFS21	A	B	C	D	E	F	G	H	I	J		2.4
593	A	B	C	D	E	F	G	H	I	J		2.3
PARL 917	A	B	C	D	E	F	G	H	I	J	K	2.3
R1092	A	B	C	D	E	F	G	H	I	J	K	2.3
R1093		B	C	D	E	F	G	H	I	J	K	2.3
11605	A	B	C	D	E	F	G	H	I	J	K	2.3
1203209.005	A	B	C	D	E	F	G	H	I	J	K	2.3
PARL 923		B	C	D	E	F	G	H	I	J	K	2.2
12231		B	C	D	E	F	G	H	I	J	K	2.1
PARL 915		B	C	D	E	F	G	H	I	J	K	2.1
PARL 916		B	C	D	E	F	G	H	I	J	K	2.1
PARL 930		B	C	D	E	F	G	H	I	J	K	2.1
PARL 921			C	D	E	F	G	H	I	J	K	2.0
PARL 931			C	D	E	F	G	H	I	J	K	2.0
PARL 932				D	E	F	G	H	I	J	K	2.0
R1108				D	E	F	G	H	I	J	K	1.9
N565 II					E	F	G	H	I	J	K	1.9
PARL 924					E	F	G	H	I	J	K	1.8
CAL2						F	G	H	I	J	K	1.7
R1103							G	H	I	J	K	1.6
R1096								H	I	J	K	1.5
R1037								H	I	J	K	1.4
CAL1									I	J	K	1.4
CAL3							G	H	I	J	K	1.3
CAL5										J	K	1.2
PARL 935											K	1.0

α=0.050 Q=4.13376

Levels not connected by same letter are significantly different.

Log 10 Dry matter (kg/ha)

Table 10. Summary of fit (Log 10 Dry matter)

RSquare	0.66
RSquare Adj	0.50
Root Mean Square Error	0.11
Mean of Response	4.41
Observations (or Sum Wgts)	183

Table 11. Analysis of variance (Log 10 Dry matter)

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	57	3.4863967	0.061165	4.3131
Error	125	1.7726532	0.014181	**Prob > F**
C. Total	182	5.2590500		<.0001*

Table 12. Effect Tests (Log 10 Dry matter)

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Repl	3	3	0.1833264	4.3091	0.0063*
Pedigree	54	54	3.2606125	4.2579	<.0001*

Table 13. Repl Least Squares Means Table (Log 10 Dry matter)

Level	Least Sq Mean	Std Error	Mean
1	4.3910099	0.01747064	4.38
2	4.3873407	0.01885688	4.39
3	4.4625746	0.01847431	4.47
4	4.3835756	0.01890999	4.38

Table 14. LS Means Differences Tukey HSD (Log 10 Dry matter)

α=0.050 Q=2.60394; Levels not connected by same letter are significantly different.

Level		Least Sq Mean
3	A	4.46
1	B	4.39
2	B	4.38
4	B	4.38

Table 15. *Pedigree – LS Means Differences Tukey HSD (Log 10 Dry matter)*

Level								Least Sq Mean
CAL5	A							4.71
PARL 934	A	B						4.69
CAL2	A	B	C					4.66
CAL7	A	B	C	D				4.60
11619	A	B	C	D	E			4.59
PARL 930	A	B	C	D	E	F		4.58
CAL1	A	B	C	D	E	F	G	4.56
R1103	A	B	C	D	E	F	G	4.56
AZ2TC5	A	B	C	D	E	F	G	4.54
R1109	A	B	C	D	E	F	G	4.52
11609	A	B	C	D	E	F	G	4.51
PARL 921	A	B	C	D	E	F	G	4.51
PARL 931	A	B	C	D	E	F	G	4.50
CFS24	A	B	C	D	E	F	G	4.50
R1040	A	B	C	D	E	F	G	4.49
12231	A	B	C	D	E	F	G	4.49
PARL 917	A	B	C	D	E	F	G	4.48
N565	A	B	C	D	E	F	G	4.48
11605	A	B	C	D	E	F	G	4.48
CFS18-2005	A	B	C	D	E	F	G	4.47
N396	A	B	C	D	E	F	G	4.45
PARL 920	A	B	C	D	E	F	G	4.44
R1110	A	B	C	D	E	F	G	4.43
PARL 929	A	B	C	D	E	F	G	4.43
PARL 915	A	B	C	D	E	F	G	4.42
PARL 923	A	B	C	D	E	F	G	4.42
11604	A	B	C	D	E	F	G	4.42
AZ2TC2	A	B	C	D	E	F	G	4.41
R1096	A	B	C	D	E	F	G	4.41
R1108	A	B	C	D	E	F	G	4.40
11646	A	B	C	D	E	F	G	4.39
AZ2	A	B	C	D	E	F	G	4.39
11693	A	B	C	D	E	F	G	4.39
R1037	A	B	C	D	E	F	G	4.38
PARL 914	A	B	C	D	E	F	G	4.35
N565 II		B	C	D	E	F	G	4.34
AZ5		B	C	D	E	F	G	4.33
PARL 916		B	C	D	E	F	G	4.33
PARL 924		B	C	D	E	F	G	4.31
11591				D	E	F	G	4.30
593				D	E	F	G	4.29
R1044				D	E	F	G	4.29
4265-X				D	E	F	G	4.29
N576			C	D	E	F	G	4.28
PARL 919				D	E	F	G	4.27
CFS21					E	F	G	4.24
11633						F	G	4.24
R1092						F	G	4.23
1203209.005	A	B	C	D	E	F	G	4.23
AZ6				D	E	F	G	4.22
PARL 922						F	G	4.22
11635						F	G	4.19
R1093							G	4.19
PARL 935					E	F	G	4.17
PARL 932				D	E	F	G	4.08

α=0.050 Q=4.14551

Levels not connected by same letter are significantly different.

Log 10 Rubber yield (kg/ha)

Table 16. Summary of Fit (Log 10 Rubber yield)

RSquare	0.688254
RSquare Adj	0.544951
Root Mean Square Error	0.130198
Mean of Response	2.831752
Observations (or Sum Wgts)	182

Table 17. Analysis of Variance (Log 10 Rubber yield)

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	57	4.6406311	0.081415	4.8028
Error	124	2.1019859	0.016951	**Prob > F**
C. Total	181	6.7426170		<.0001*

Table 18. Effect Tests (Log 10 Rubber yield)

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Repl	3	3	0.3317524	6.5236	0.0004*
Pedigree	54	54	4.0441845	4.4180	<.0001*

Table 19. Repl Least Square Means Table (Log 10 Rubber yield)

Level	Least Sq Mean	Std Error	Mean
1	2.7718944	0.01935846	2.77242
2	2.8967101	0.02091558	2.92912
3	2.8228377	0.02019118	2.81621
4	2.8124146	0.02049639	2.81788

Table 20. LS Means Differences Tukey HSD (Log 10 Rubber yield)

α=0.050 Q=2.60422; Levels not connected by same letter are significantly different.

Level			Least Sq Mean
2	A		2.8967101
3	A	B	2.8228377
4		B	2.8124146
1		B	2.7718944

Table 21. *Pedigree - LS Means Differences Tukey HSD (Log 10 Rubber yield)*

Level						Least Sq Mean
PARL 934	A					3.21
11619	A	B				3.12
AZ2TC5	A	B	C	D		3.12
CAL7	A	B	C			3.05
R1109	A	B	C			3.04
CFS24	A	B	C	D		3.02
PARL 930	A	B	C	D		2.99
R1040	A	B	C	D		2.96
PARL 929	A	B	C	D		2.95
11693	A	B	C	D		2.95
11609	A	B	C	D		2.93
11604	A	B	C	D		2.93
PARL 921	A	B	C	D		2.91
PARL 920	A	B	C	D		2.91
PARL 917	A	B	C	D		2.91
N565	A	B	C	D		2.90
R1110	A	B	C	D		2.90
N396	A	B	C	D		2.90
12231	A	B	C	D		2.89
CAL2	A	B	C	D		2.88
CFS18-2005	A	B	C	D		2.88
AZ2	A	B	C	D		2.88
AZ2TC2	A	B	C	D		2.87
N576	A	B	C	D		2.87
AZ5	A	B	C	D		2.87
PARL 931	A	B	C	D		2.86
CAL5	A	B	C	D		2.84
R1103	A	B	C	D		2.81
PARL 922	A	B	C	D		2.81
PARL 919	A	B	C	D		2.80
PARL 915	A	B	C	D		2.80
11605	A	B	C	D		2.80
11646		B	C	D		2.79
4265-X		B	C	D		2.79
11591		B	C	D		2.79
PARL 914	A	B	C	D		2.79
PARL 923		B	C	D		2.78
R1044		B	C	D		2.78
AZ6	A	B	C	D		2.77
R1108		B	C	D		2.75
11633		B	C	D		2.75
1203209.005	A	B	C	D	E	2.75
CAL1		B	C	D		2.74
PARL 916			C	D		2.71
11635			C	D		2.69
593			C	D		2.68
CFS21			C	D		2.67
N565 II				D	E	2.65
R1096				D	E	2.63
R1093				D	E	2.63
PARL 924				D	E	2.62
R1092				D	E	2.62
R1037				D	E	2.55
PARL 932			C	D	E	2.49
PARL 935					E	2.18

α=0.050 Q=4.14639

Levels not connected by same letter are significantly different.

Plant Transformations using AP1, SEP3, and FT Genes:
Our project seeks to enhance natural rubber content in guayule by downregulation of flowering. Previously, four target genes (*APETALA1, SEPATTALA3, FLOWERING TERMINUS, LEAFY)* all transcription factors related to flowering, were identified. Five guayule transformation constructs for downregulation (including one 2-gene version: *pND6 – AP1 – SEP3 (pAS))* were prepared and plant transformations performed.

In 3Q20, we discontinued transformations and focused on recovery of plants from live calli. As reported earlier, we had significant shoot regeneration issues for the AP1 and pAS (AP1 + SEP3) constructs. No plants were recovered from either, and we suspect that the AP1 gene downregulation may have inhibited shoot development. For the other 3 constructs we have been able to recover full plants (leaf, stem, root) *in vitro*.

SEP3 has been the most successful. We have full plants from 10 transformation events (6 PCR confirmed), and a set of plants ready to move to the greenhouse. For the FT2 and LEAFY constructs, we have so far recovered plants from 2 transformation events. We prefer 3-6, but some calli continue to grow, so it is possible we will recover additional event(s). We will continue to phenotype/genotype plants from all three constructs in Q420.

Table 22. *Status of transformed plant recovery October 15, 2020.*

Genotype	# plates (callus stage)	# shoots (non-rooting;boxes)	# plants (rooting;boxes)	# events
AP1	6	0	0	0
SEP3i	4	0	62	10
FT2i	6	25	5	2
LEAFY	12	2	8	2

Effect of transgenes on rubber content by ASE (tissue culture):
Our original plan was to do genotyping/phenotyping for tissue culture plants before moving to soil. That has changed. We have now prioritized getting a flowering phenotype by moving as many plants as possible to soil, with tissue culture backups.

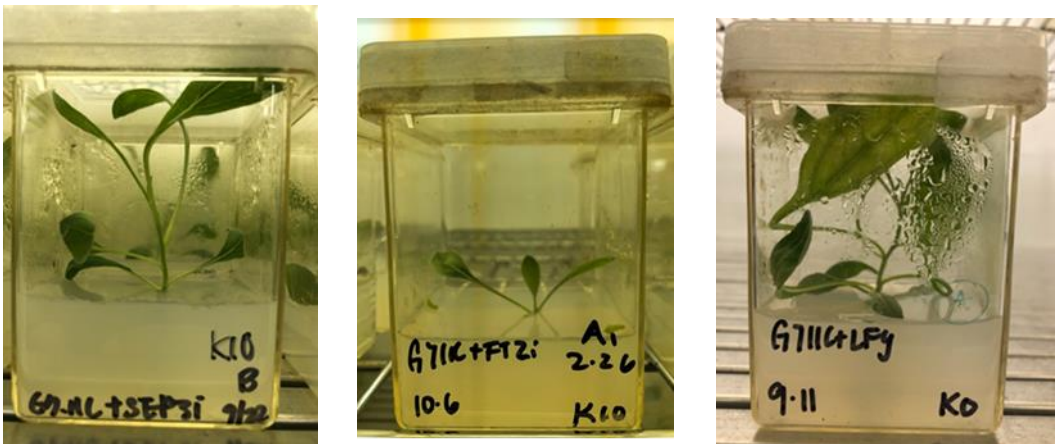


Figure 2. *Guayule plants with downregulated flowering genes growing in vitro (SEP3i, FT2i, LFY).*

In cases where we have limited biological reps, the contingency plan will be to transfer what we have to soil, then vegetatively propagate additional bio reps. This work can be done under limited lab access and the plants are expected to grow very well in soil. Also, moving them to soil in 4Q20 will allow them to grow sufficiently to expect flowering phenotypes in late 1Q21 when we typically see a lot of flowers for greenhouse plants.

Transfer plants to greenhouse for flowering phenotype:
Research continues as planned; no data to report.

Growth and Rubber/Resin Content in Guayule Germplasm Lines:
Nothing new to report.

Root Growth/Architecture Compared to Water Use in Direct Seed and Transplant-Established:
Nothing new to report.

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 Collect and analyze first set of available high-throughput phenotyping (HTP) parameters: vegetation indices and reflectance Summary report completed	31 Dec 21 31 Dec 21 30 Jun 22
2 Abdel-H.	Phenotypic characterization – Guayule under stress conditions and stability	Field planting – plant and maintain USDA guayule collections Collect and analyze available phenotypic data: plant ht, plant width, flowering time, rubber, resin Collect and analyze available high-throughput phenotyping (HTP) parameters: vegetation indexes and reflectance Summary report completed	30 Jun 20 31 Dec 21 31 Dec 21 30 Jun 22
3 Abdel-H	Guayule leaf waxes	Leaf wax extraction from guayule tissue Wax class determination Summary report completed	31 Jan 21 31 Dec 21 31 Jan 22
4 Angadi	Guar remote sensing	Seasonal multispectral data from deficit irrigation study	31 Mar 20
5 Dierig	Remote sensing evaluation of USDA germplasm lines	Rate of growth comparison between lines completed	31 Aug 20

Phenotypic characterization – Guayule:
Second year of the field trial containing 48 USDA guayule accessions are maintained at Maricopa, AZ. Plots are maintained by hand weeding as needed and surface irrigation at bi-weekly internal based on the weather and plant growth stage.

Two-year old shrubs were harvested, air-dried and are stored at 18C due to global COVID-19 pandemic situation and USDA policies of minimum essential operations at USDA-ALARC facility and maximum teleworking. Later, samples were chipped and ground. The samples were run using Bridgestone NIRS machine and models to estimate rubber and resin contents.

Due to current situation, weekly HTP run were continued and data are collected and stored at ALARC servers awaiting analysis due to COVID-19 situation.

There is a significant variation in genotypic component as shown in analysis of variances (ANOVA) for chemical and field traits of two years old guayule plants. That genotypic variance explained the wide phenotypic variations in USDA guayule germplasm under studied condition. Studying the response of those genotypes planted under different locations could explore the genotypic stability and interactions between genotypes and locations and its effect on rubber and resin yields.

Table 23. *ANOVA results for chemical and field traits of two year-old guayule plants grown in Maricopa, Arizona.*

trait	Mean Square	Pr > F
Resin Content % year 2	4.7	<.0001
Rubber content % year 2	2.3	<.0001
Fresh weight (kg/ha) year 2	2783141472.5	0.0017
Dry matter (Kg/ha) year 2	589181726.0	0.0008
Resin yield (Kg/ha) year 2	2709950.4	<.0001
Rubber yield (Kg/ha) year 2	644338.7	<.0001
Plant height 24 moths	713.6	<.0001

Genotypic means showed wide variations among guayule genotypes (Table 24: red and green cells showed high and lower values of a trait). For example, the rubber % ranges from 0.78% to 3.96%. The highest guayule genotypes in Rubber % are AZ5, AZ6 and PARL922, while CAL1, CAL2, R1037 and R1103 are the lowest. Taking in account that the highest in rubber are improved germplasm, bred for higher rubber is possible via breeding and genetic improvement techniques. Resin % ranges from 2.9% to 7.9%, with AZ2, CAL7, R1093 and R1109 are the highest, while 593, 11591 and N576 are the lowest in resin %. It is known that AZ2 and CAL7 are improved germplasm, N576 is an old variety and R1109 and R1093 are wild hybrid.

Table 24. *Genotypic means among guayule genotypes grown at Maricopa, Arizona.*

Pedigree	Resin Content % year 2	Rubber content % year 2	Fresh weight (kg/ha) year 2	dry matter (Kg/ha) year 2	resin yield (Kg/ha) year 2	Rubber yield (Kg/ha) year 2	plant height 24 moths
593	2.39	2.00	67944.08	32785.60	787.78	658.73	57.15
11591	3.18	3.14	33860.70	17450.98	551.48	545.30	78.74
11604	4.56	3.68	83776.98	43261.93	1984.90	1606.50	69.22
11605	3.65	2.39	110795.03	55263.70	1987.64	1268.59	67.10
11609	5.75	2.66	84426.58	42317.13	2454.53	1128.70	64.14
11619	4.74	3.13	92092.68	52706.30	2569.23	1621.35	69.85
11633	5.41	2.42	46173.65	23797.70	1284.85	574.45	67.31
11635	6.03	3.11	63518.68	30127.30	1731.85	942.43	73.03
11646	4.28	2.56	51372.98	25130.50	1027.95	597.73	66.68
11693	4.51	3.75	84873.18	39872.15	1815.40	1467.75	78.11
12231	3.87	2.43	105092.18	48503.23	1843.43	1164.88	71.12
AZ2	7.96	3.42	51115.63	26009.01	2016.17	872.18	102.88
AZ5	5.68	3.77	80122.95	40768.03	2306.13	1477.98	77.47
AZ6	4.86	3.70	76166.25	39198.15	1868.51	1469.09	74.93
CAL1	4.50	1.09	79897.70	39666.22	1788.41	417.30	97.16
CAL2	4.38	0.79	121583.30	54551.25	2349.88	433.35	87.63
CAL3	3.72	1.88	78339.07	33707.87	1347.59	680.08	50.53
CAL5	4.73	1.33	89310.93	42194.98	1897.65	477.98	104.14
CAL7	7.00	3.13	131427.03	63547.58	4336.38	1968.20	116.84
CFS18	5.02	2.02	84987.63	43044.65	2150.78	802.78	65.41
CFS21	5.16	2.42	47582.40	26492.90	1364.28	637.50	64.14
CFS24	4.58	2.93	78173.24	39797.61	1746.20	1016.51	74.30
N396	3.55	2.95	87148.43	50699.85	1810.19	1524.39	64.75
N565	3.32	2.18	73931.18	39006.38	1203.37	812.51	74.60
N565II	3.63	2.92	48534.63	22287.58	782.30	639.93	77.47
N576	3.20	2.68	63001.88	33091.45	1009.40	811.10	75.57
PARL914	4.88	2.93	77310.48	36019.78	1779.60	1051.45	69.22
PARL916	3.26	2.44	42064.43	19396.03	633.10	475.88	71.12
PARL917	3.71	2.14	42207.15	21179.60	788.43	441.65	68.58
PARL919	4.15	3.14	33993.55	18264.23	753.90	553.26	78.74
PARL920	4.59	2.89	61849.10	29137.28	1361.43	848.10	73.66
PARL921	3.67	1.98	52429.80	27331.83	1002.15	524.55	53.98
PARL922	5.16	3.96	50548.70	24618.63	1276.28	990.63	84.46
PARL923	5.54	1.90	113020.33	48909.00	2682.38	912.38	73.66
PARL929	5.49	3.20	80185.70	37328.18	2042.63	1199.60	81.28
PARL930	5.80	1.83	103649.38	58380.90	3461.54	1115.34	63.90
PARL931	5.66	1.46	163125.44	73329.13	4376.80	1164.10	81.42
PARL932	5.65	2.33	44184.25	21059.93	1448.40	431.13	64.14
PARL935	3.76	2.42	74766.27	43540.67	1763.89	1081.28	58.15
R1037	4.07	0.79	59669.34	37822.14	1481.47	305.71	74.60
R1040	5.21	3.34	70625.72	32607.98	1686.31	1084.26	80.01
R1092	5.86	1.96	34429.10	19843.28	1161.88	394.63	55.25
R1093	6.11	1.91	55002.40	26524.23	1631.68	480.60	57.79
R1103	5.54	1.07	76468.90	38283.33	2069.90	409.08	72.39
R1108	3.97	2.03	73061.54	36270.63	1485.37	703.36	66.18
R1109	6.36	2.97	125565.80	61511.70	4033.30	1824.63	107.32
R1110	4.48	3.20	61088.11	33306.89	1529.70	1042.70	68.72
range	2.9 - 7.9	0.78 - 3.96	33.86 - 163.12	17.45 - 73.33	551.47 - 4376.8	305.7 - 1968.2	50.53 - 116.84

These preliminary results demonstrate the possibility of increase resin and rubber and other economic guayule traits via breeding and/or introducing new alleles from wild or wild relatives. There are positive significant correlations among studied traits of 2-year-old plants (Table 25, red cells) and that reflected in several genotypes that are superior in all or most of the studied traits (Table 24). Those genotypes could be among the recommended genotypes for future establishment of agricultural system and rubber/resin mass production in Arizona.

Correlation analyses as well showed significant correlations among chemical and field traits of one year and two-year-old guayule plants, growing under Maricopa conditions (Table 25, yellow cells) indicating, with caution, that one-year plants could be used to predicate the two years plant productivity.

Table 25. *Correlation analysis for one-year and two-year-old guayule plants grown in Maricopa, Arizona.*

	Resin Content % year 1	Rubber content % year 1	Fresh weight (kg/ha) year 1	dry matter (kg/ha) year 1	plant height 4 moths	plant height 6 months	Plant height 15 months	resin yield (kg/ha) year 1	Rubber yield (kg/ha) year 1	moisture content% year 2	Resin Content % year 2	Rubber content % year 2	Fresh weight (kg/ha) year 2	dry matter (kg/ha) year 2	plant height 24 moths	resin yield (kg/ha) year 2	Rubber yield (kg/ha) year 2
moisture content% year 1	0.02152 0.8029	-0.30028 0.0004	0.55624 <.0001	0.54291 <.0001	0.45738 <.0001	0.49662 <.0001	0.42324 <.0001	0.51499 <.0001	0.3792 <.0001	0.27795 0.0012	0.09104 0.2973	-0.30027 0.0004	0.14632 0.0954	0.12229 0.1674	0.45245 <.0001	0.13208 0.1357	-0.10732 0.2261
Resin Content % year 1		0.19069 0.0256	0.22815 0.0073	0.22571 0.008	0.2484 0.0038	0.29705 0.0005	0.28022 0.001	0.47151 <.0001	0.37786 <.0001	0.32683 0.0001	0.73831 <.0001	0.20926 0.0156	0.06701 0.447	0.0714 0.4213	0.32832 0.0001	0.31612 0.0003	0.17002 0.0541
Rubber content % year 1			-0.35317 <.0001	-0.33677 <.0001	-0.22819 0.008	-0.18974 0.0275	-0.18177 0.0356	-0.23062 0.0067	0.12957 0.1313	-0.14902 0.0869	0.01117 0.8985	0.58356 <.0001	-0.11016 0.2104	-0.07913 0.3727	-0.18688 0.03	-0.07308 0.4105	0.26374 0.0025
Fresh weight (kg/ha) year 1				0.96963 <.0001	0.67723 <.0001	0.72688 <.0001	0.57544 <.0001	0.92426 <.0001	0.80114 <.0001	0.4208 <.0001	0.17307 0.0455	-0.31122 0.0003	0.36232 <.0001	0.33593 <.0001	0.63398 <.0001	0.31972 0.0002	0.0293 0.7407
dry matter (Kg/ha) year 1					0.71245 <.0001	0.74343 <.0001	0.5683 <.0001	0.95234 <.0001	0.8511 <.0001	0.42262 <.0001	0.19162 0.0266	-0.31942 0.0002	0.29687 0.0005	0.29418 0.0007	0.60835 <.0001	0.28768 0.0009	-0.01214 0.8909
plant height 4 moths						0.87279 <.0001	0.67889 <.0001	0.72176 <.0001	0.62368 <.0001	0.43015 <.0001	0.16119 0.043	-0.13019 0.103	0.18701 0.0194	0.17506 0.0304	0.65884 <.0001	0.19219 0.0173	-0.00201 0.9803
plant height 6 months							0.76866 <.0001	0.76829 <.0001	0.64912 <.0001	0.49811 <.0001	0.31864 <.0001	-0.05186 0.5189	0.27598 0.0005	0.26018 0.0012	0.77358 <.0001	0.33497 <.0001	0.11674 0.1521
Plant height 15 months								0.60927 <.0001	0.45659 <.0001	0.47675 <.0001	0.34655 <.0001	0.076 0.3349	0.29423 0.0002	0.26768 0.0007	0.79903 <.0001	0.37064 <.0001	0.24443 0.002
resin yield (Kg/ha) year 1									0.88369 <.0001	0.48786 <.0001	0.38607 <.0001	-0.18325 0.0847	0.28605 0.0009	0.28923 0.0009	0.66844 <.0001	0.36092 <.0001	0.07318 0.4098
Rubber yield (Kg/ha) year 1										0.35629 <.0001	0.23249 0.0071	-0.04315 0.6219	0.22395 0.0101	0.23962 0.0062	0.47981 <.0001	0.25937 0.003	0.1053 0.235
moisture content% year 2											0.12981 0.0906	0.04701 0.5415	0.29576 <.0001	0.28989 0.0002	0.52427 <.0001	0.29922 <.0001	0.29101 0.0001
Resin Content % year 2												0.15756 0.0396	0.10584 0.1708	0.11815 0.1295	0.31117 <.0001	0.46917 <.0001	0.22567 0.0035
Rubber content % year 2													-0.16072 0.0368	-0.1724 0.0263	0.14739 0.0544	-0.05667 0.4684	0.48506 <.0001
Fresh weight (kg/ha) year 2														0.96433 <.0001	0.29166 0.0001	0.88296 <.0001	0.6844 <.0001
dry matter (Kg/ha) year 2															0.26648 0.0005	0.90638 <.0001	0.72627 <.0001
plant height 24 moths																0.37356 <.0001	0.31341 <.0001
resin yield (Kg/ha) year 2																	0.73844 <.0001

Phenotypic characterization – Guayule Under Stress Conditions:

A new experiment with 60 guayule genotypes, including new genotypes that will be tested for the first time, and 6 common checks is initiated at Maricopa, AZ with the target to test guayule genotypes growing under stress and non-stress conditions. Differential irrigation schedules were started at stress and no stress treatments. At both trials, plots are maintained by hand weeding as needed.

Due to global COVID-19 pandemic situation and USDA policies of minimum essential operations at USDA-ALARC facility and maximum teleworking, HTP scans and for traits including canopy temperature, plant height and vegetation indexes are continued and data were collected and stored at ALARC servers awaiting final analysis.

Guayule Leaf Waxes:
SBAR-supported experiments for leaf waxes in guayule were halted. No further data will be reported.

Guar Remote Sensing:
This task is complete.

Remote Sensing Evaluation of USDA Guayule Germplasm Lines:
Research is continuing as planned; no new data to report.

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	Identify guar germplasm suitable for cooler and northern latitudes	30 Apr 20
		Summarize data after harvest; present at field day in Clovis, NM	31 Dec 19
		Assess available guar cultivars at Clovis, NM	31 Dec 19
2 Angadi	Galactomannan assay	Assess irrigation effect on guar gum content	30 Apr 20
3 Grover	Evaluate guar germplasm lines (increase # of seeds)	Collect data on field performance of guar germplasm lines	31 Aug 20
		Generate report on guar germplasm line field performance	31 Aug 20
4 Ray	Evaluate seed from plants surviving root rot inoculation	Screen 42 guayule germplasm lines for root rot fungus tolerance	31 Jan 20
	Determine root rot tolerance per guayule germplasm	New germplasm lines screened for the first time	30 Nov 20
		Seed from surviving plants screened for trait inheritance	31 Dec 21

5 Ray	Guayule salt tolerance trials	7 germplasm line's transplants evaluated for sensitivity under 11 saline treatments Initial estimate of lines with most tolerance complete Continue screening germplasm lines Seed from surviving plants collected and planted for 2nd round evaluation	31 Dec 19 31 Dec 19 31 Aug 20 31 Oct 20
6 Ray	Guar yield trials in Tucson, AZ; Las Cruces, NM; and Clovis, NM	Increase guar seed for yield tests Yield trial protocols established (3 different for comparison) Yield trials planted in 3 locations Yield trials harvested; yields compared	15 Apr 19 1 May 19 30 Jun 20 31 Dec 20
7 Ray	Guar genetic combination trials	Guar seed from crosses of partial male-sterile plants with 2 elite lines collected Genetic diversity evaluated	31 Dec 19 31 Jan 21

Guar Germplasm in New Mexico:
All planned field trials are being conducted this season. The season is extremely dry and hot. We have received just over 50% seasonal rainfall with a few record setting high temperature periods. That was coupled with an almost freezing temperature in the latter half of the season. Cold snap on September 6th, 2020 was also a record setting cool temperature that early in the season. We are seeing some green regrowth beginning of October. Probably because of cold spell stopped all growth and with current heat they are trying to restart. Thus, the season was extremely stressful for guar. The Pandemic of COVID-19 has also hurt guar research by restricting many research activities, hiring of technician and graduate student.

Guar Galactomannan Assay:
This task is complete.

Guar Germplasm Line Multiplication:
Data compiled and analyzed for evaluating guar germplasm for biomass, yield attributing characteristics from 2019 growth season at Las Cruces, NM. Results were summarized from years 2017 and 2018 and reports were submitted to the SBAR project director.

In 2019 study, genotypes PI 268629, PI 338811, and PI 126152 produced the highest above ground biomass (6,857-7,367 Kg/ha) while genotypes PI 253186, PI 5993049 recorded the lowest amounts of biomass (4,207-4,650 Kg/ha). PI 217923, PI 253182 and PI 186477 had the

highest harvest index among the genotypes. PI268229 had the highest seed yield followed by PI158126 and PI253187although the differences were not significant among genotypes.

The study is continuing in 2020 and was replanted at Lyendecker Plant Science Center, Las Cruces, New Mexico.

Seed Evaluation following Root Inoculation and Root Inoculation per Guayule Germplasm:
No new data to report. Work on new screenings has stopped until new sources of the root rot fungus are obtained.

Guayule Salt Tolerance Trials:
Another round of screenings began in September. Seed collection is ongoing.

Guar Yield Trials in Tucson, AZ; Las Cruces, NM; and Clovis, NM:
Guar plant heights were measured on September 22.

Table 26. *Means of guar plant heights by variety/accession measured on September 22, 2020.*

Levels not connected by the same letter are significantly different.

Level	Number	Mean	Std Dev	
PI 250360 COL NO K619	15	157.4	11.0	A
PI 593049 TX71-3292	15	154.3	10.2	AB
PI 338811 PLG 482	15	152.6	25.6	ABC
PI 176377 SIRSA 56	15	149.7	17.0	ABCD
PI 263698	15	147.6	9.5	ABCD
PI 338745 PLG 86	15	146.7	18.6	BCD
PI 180434 NO 10949	15	145.4	7.3	BCDE
PI 593059 TX 78-3726	15	144.7	14.9	BCDE
Matador	15	144.5	7.4	BCDE
PI 268229 COL NO 36 PUNJAB	15	144.3	16.5	BCDE
PI 262152 IC-83 NO 3	15	143.8	17.1	CDEF
PI 263406	15	143.7	8.8	CDEF
PLG 241	15	141.4	14.6	DEFG
PI 158126 SURTI	15	135.8	13.1	EFGH
PI 671848 SANTA CRUZ	15	135.7	11.4	EFGH
PI 537281 WKP-88-43	15	133.6	13.7	FGHI
PI 253186 B-49823	15	133.5	22.6	FGHI
PI 217923 EC 248A	15	133.1	9.6	GHI
PI 179926 NO 10521	15	131.8	16.0	GHIJ
PI 593058 G-05	15	131.5	7.8	GHIJ
PI 340261 TX73-2731	15	131.1	13.1	HIJK
Kinman	15	129.1	13.1	HIJK
PI 542608	15	125.6	7.6	HIJKL
PI 253187 B-49824	15	124.1	12.6	IJKL
PI 186477	15	122.1	20.2	JKL
PI 253182 B-49819	15	120.9	15.3	KL
Lewis AZ	15	116.3	12.7	L
Lewis TX	15	115.7	14.0	L

Guar Genetic Combination Trials:
Nothing new to report.

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	15 May 20 15 May 20
2 Angadi	Guar germplasm temperature requirement	Identify optimum soil temperature for planting USDA guar germplasm	31 Jul 20
3 Dierig	Density trials in Tucson and Eloy, AZ	Establish trial with different densities in Tucson, AZ Summarize plant growth, yield performance, and traits for density trial with 2 varieties and 5 densities in Eloy, AZ Final harvest and analysis completed for 5 plant densities and 2 varieties in Eloy	31 Dec 20 30 Apr 22 30 Apr 20
4 Dierig	Bi-monthly harvest from irrigation trials	Growth data over seasons from two locations Harvest plots for shrub dry biomass rubber/resin content and yield	31 May 20 30 Apr 20
5 Dierig	Irrigation Timing Study	Plant replicated trial and begin treatments	31 Aug 20
6 Grover	Evaluate guar response to moisture stress	Track and collect research data on moisture stress experiment Generate report/publication from results obtained Present research results at regional/national conferences	31 Aug 20 31 Aug 20 31 Aug 20
7 Grover	Evaluate guar response to planting density	Track and collect research data on guar density experiment Generate report/publication from results obtained	31 Aug 20 31 Aug 20
8 McClos	Conduct guayule herbicide tolerance study, at Eloy and Maricopa, AZ (Fall)	Collect data to support 24c SLN herbicide registrations – (a) topical, postemergence broadleaf herbicide; (b) post-directed herbicide; (c) herbicide application sequence for	28 Feb 20

		chemical weed control from seeding to 6mo old plants Generate research report/publication and Extension bulletin from results obtained	 30 Jun 20
9 McClos	Conduct guayule herbicide tolerance studies, at Eloy and Maricopa, AZ (Spring)	Collect data to support 24c SLN preemergence herbicide registrations – (a) topical, postemergence broadleaf herbicide; (b) post-directed herbicide; (c) herbicide application sequence for chemical weed control from seeding to 6mo old plants Generate research report/publication and Extension bulletin from results obtained	30 Jun 20 30 Jun 20
10 Ogden	Development and testing of AquaCrop model	Growth model compared to field data	30 Apr 20
11 Ogden	Development of BioCrop model	Preliminary output and evaluation of most important parameters	31 Aug 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 Waller	Install 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.	15 Jul 20 15 Jul 20
15 Waller	Integrate python MySQL WINDS model with existing tools	Integrate new python model with WINDS (winds.arizona.edu), and in-situ sensors Database available to economic modelers	15 Jul 20 15 Jul 20
16 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 Document effects of irrigation treatment on plant growth, soil moisture, plant stress, plant	15 Jul 20 15 Jul 20

		chemical response, plant vegetative indices, and crop coefficient Generate a publication on guayule irrigation experiments	 15 Jul 20
17 Waller	Deficit irrigation study (water stress); Eloy, AZ	Quantify effects of irrigation scheduling strategies on rubber/biomass yield and plant stress	15 Jul 20

Guar Critical Stage-Based Deficit Irrigation Trial:
In spite of COVID-19 travel restrictions and budget limitations, with the help of new collaborators, we took drone observations for five times and data is very promising (Figure 3). This data will be useful for Hadiqa Maqsood's research work. We thank Dr. Amanda Skidmore and Mrs. Miranda Kersten for drone image collection and Dr. Diaa El-Shikha for processing.

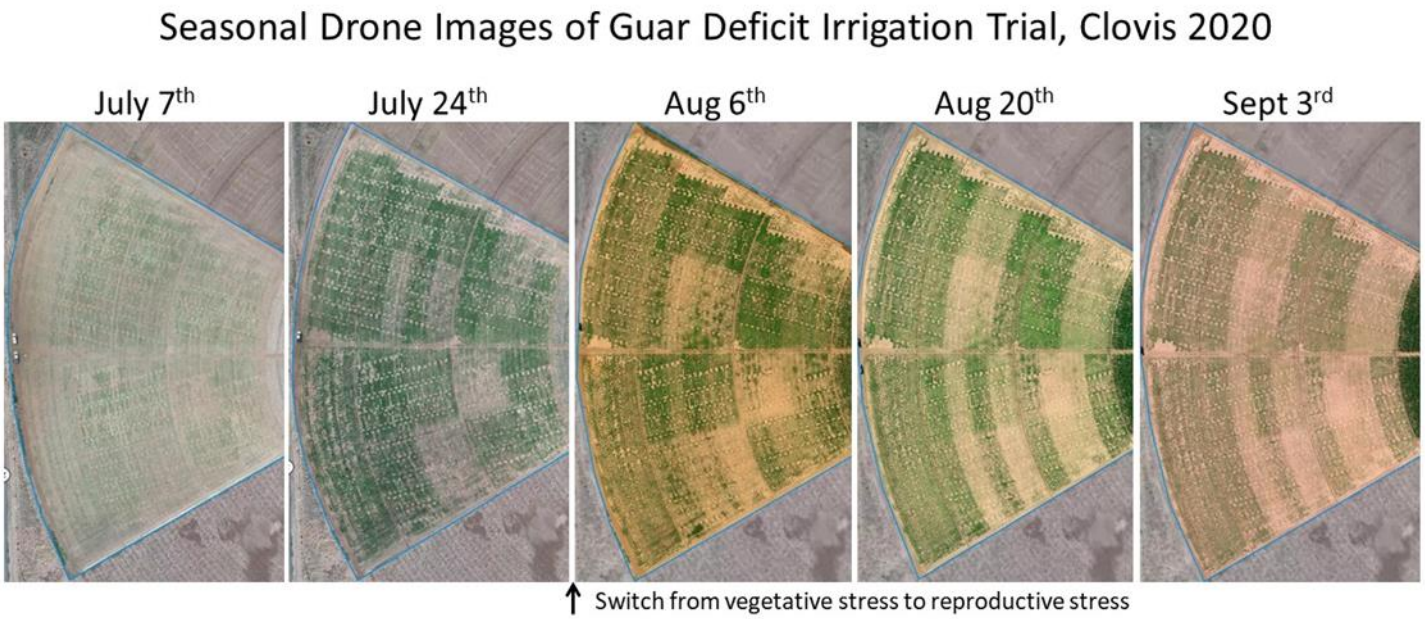


Figure 3. *Seasonal pattern of biomass production by guar under deficit irrigation strategies of using pre-irrigation or growth-stage based irrigation.*

All field trials are almost ready for harvest. Due to mid-season cold spell, guar started regrowth and we are planning to desiccate all trials (we don't do it every year) before combining. Lack of help has affected or delayed some of the observations. Some of the observations that need more manpower will be delayed. Samples will be stored until we have some help to complete that work.

Incubator Study to Understand Temperature and Germination Relationships:
The manuscript on temperature requirements for germination and crop establishment of available guar cultivars is reviewed by *Industrial Crops and Products* journal and we are addressing the reviewer's comments.

Figure 4. *Genetic variations for germination and early growth at cooler temperatures in available guar cultivars was completed in an incubator study run at 16 °C at Clovis, New Mexico.*

The incubator study to assess diverse guar germplasm germination temperature requirements has been delayed. COVID restrictions and not able to hire a graduate student is affecting this project. It is possible that this project will be postponed to next fall.

Density Trials in Tucson and Eloy, AZ:
The densities are 30, 18, 12, 6, 3-inch in-row spacing for density 1, 2, 3, 4, 5. Plots were harvested for year 1.5 at Eloy and year 1 at Tucson in October. Data for Tucson are found in PI D.T. Ray 2019 Q4 report.

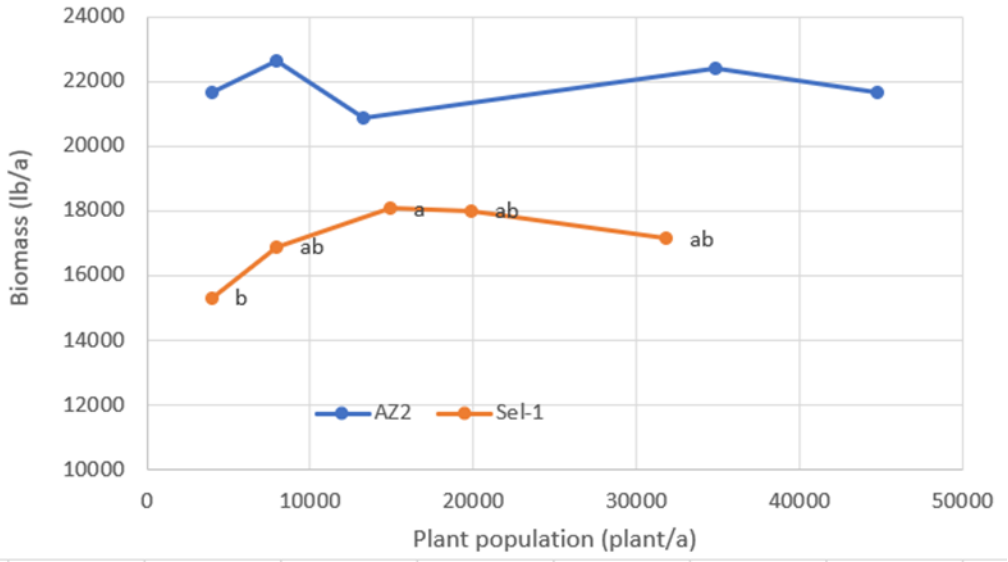


Figure 5. *Biomass production of AZ-2 and Sel-1 with different plant populations at Eloy, Arizona.*

Plant population experiment at Eloy was planted in April 2018. Final harvest was conducted in February 2020. The same experiment at Tucson was planted six months later and will be harvested late October, 2020. Five plant populations and two distinctly different guayule lines were planted and thinned to targeted population. Five in-row spacings (30, 18, 12, 6, and 3 inches) correspond with five targeted plant populations, 5227, 8712, 13068, 26136, and 52272 plants/a. The actual plant population after thinning at Eloy are included in the following table.

Table 27. *Plant population treatment with targeted and actual plant number for AZ-2 and Sel-1 at Eloy, Arizona.*

Density # in the figure	Targeted in-row spacing (inch)	Targeted plant/m for sampling	Targeted plant population (plant/a)	Actual plant population for AZ-2 (plant/a)	Actual plant population for Sel-1 (plant/a)
1	30	1	5227	3983	3983
2	18	2	8712	7966	7966
3	12	3	13068	13276	14936
4	6	6	26136	34851	19915
5	3	12	52272	44808	31863

The biomass data showed that AZ-2 had significantly higher biomass compared to Sel-1. For short-stature Sel-1, biomass increased from density ~4000 to ~15000 plant/acre, but then plateaued as plant population was higher. For AZ-2 with higher individual plant vigor and tall statue, there were no differences in biomass production among plant population from 4000 to 45000 plant/acre.

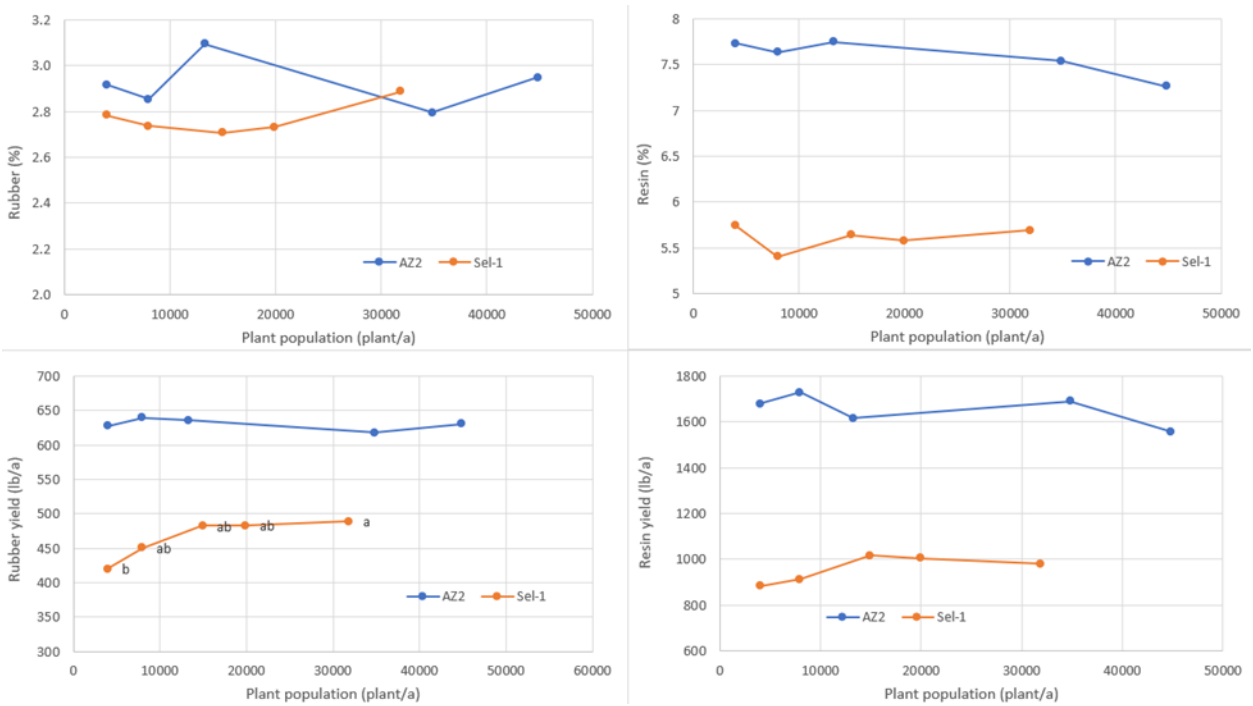


Figure 6. *Rubber yield and resin content in AZ-2 and Sel-1 plant populations in Eloy, Arizona.*

Rubber content between AZ-2 and Sel-1 was not significant. However, AZ-2 had significantly higher resin content. Because of higher biomass, AZ-2 had higher rubber and resin yield compared to Sel-1. While rubber and resin yield of AZ-2 did not respond to plant population treatment, rubber yield response to plant population was similar to biomass.

The same experiment was planted at Tucson in September 2018. The second harvest will be conducted there in Fall, 2020, when crop is 2-years old.

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

Irrigation Timing Study:
The field was prepared and planted on April 20. The treatments and varieties are listed below. Two germplasm lines (AZ-2 and Sel-1) and 3 replications planted at Eloy with furrow irrigation. There are 6 row plots 250 ft long plus a two-row buffer between plots.

1. Full Irrigation: Irrigate as determined by the model developed as part of this project.
2. Stress for Harvest: Irrigate as treatment 1 for 1.5 years, then no irrigation.
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, one irrigation in year 2.

Plants were established with solid state sprinklers for two weeks and then furrow irrigated. The last irrigation of all plots was at the end of June and first irrigation of treatments began July 15, 2020. Growth measurements are in progress and will be reported next quarter.

Guar Response to Moisture Stress:
The study was completed with 3-year data collected, compiled and analyzed. A Master's project was completed and thesis published. A presentation was delivered at Western Crop Science Society of America conference. A manuscript draft is under preparation from these titled as: "Growth and Performance of Guar *Cyamopsis tetragonoloba* (L.) Taub under various irrigation regimes and biogenic silica addition in southwest New Mexico". All the products from the projects including the abstracts, manuscript draft, thesis have been shared with the SBAR project director.

This task is complete.

Guar Response to Planting Densities:
Guar genotypes were evaluated for their seed yield and yield attributes under four seeding densities including 2, 4, 8 and 12 seeds/foot when planted on 40-inch spaced raised beds. Data was compiled and analyzed. Results were summarized for years 2018 and 2019 and a report was submitted to the SBAR project director.

The study is continuing in 2020 at Lyendecker Plant Science Center, Las Cruces, NM. The growing season data is being collected.

Guar Genotype Response to Salinity:
A new study was initiated on response of guar genotypes to salinity. Preliminary results show significant variation in salinity tolerance among selected genotypes. Results were shared with the SBAR project director. The study continues in 2020; tissue ion analysis will be performed, which may help us understand the underlying salt tolerance mechanisms in guar.

Screening of 28 diverse guar lines under salinity stress will be done to identify different sources of salinity tolerance and characterize those based on gene expression analysis. An RNA-sequence study will be done with a most salt tolerant and most salt sensitive guar genotype, to help identify salinity tolerance mechanisms specific to guar.

Guayule Herbicide Tolerance Study, Fall 2019:
The guayule herbicide tolerance studies of (1) topical, postemergence broadleaf herbicides, and (2) herbicide application sequences for chemical weed control from seedling to 6-month old plants, were repeated and completed 2020 Q1-Q3. Analysis of the data from these experiments will be completed in 2020 Q4.

Other associated tasks with these studies have been completed.

Guayule Herbicide Tolerance Study, Fall 2020:
These experiments were initiated in September 2020 at Bridgestone-Eloy (mid-September planting) and at MAC (September 28 planting). To date there is extensive loss of guayule

seedlings in all plantings due to flea beetles and birds. It is not yet clear whether we will have enough plants to continue with the experiments.

Guayule Herbicide Tolerance Study, Spring 2020:
After SARS-COV2 virus caused a delay in access, these field experiments at MAC and Bridgestone-Eloy were completed in Q2 and Q3; data analysis will be completed in Q4. A field trial was initiated in Q3 but because of some logistical problems, many of the plots were overgrown by weeds from a previous experiment and we were not able to control or remove them to conduct the experiment so it was abandoned.

Guayule Herbicide Tolerance Study, Spring 2021:
These studies are not yet initiated.

Herbicide Trials – Publication, Extension Bulletin and 24c SLN Applications
Due to SARS-COV2 and my retirement in Q3, I did not find time to get much writing accomplished. This work will be delayed to 2020 Q4 and 2021 Q1 and Q2.

Development and Testing of AquaCrop Model:
P. Lohr has been optimizing and updating the model parameters that were recently collected. The model should be completed when he finishes his master's degree next quarter. A new graduate student (Wanyu Huang) is being trained on the model/project.

Development of BioCrop Model:
We have determined that this model is not useful for our purposes, and will focus on the AquaCrop model. This model has been eliminated for Year 4.

Guayule Density Trials (Direct-Seeded and Transplant-Established):
Plants are scheduled to be harvested in October 2020.

Range of N and P Application:
Plants from the first round were harvested on July 31, 2020.

Table 28. *Mean weights of above-ground and root biomass by treatment for guayule plants harvested on July 31, 2020.*

Levels in a column not connected by the same letter are significantly different.

		Above-ground		Roots	
N rates from Ca(NO3)2 (ppm)	N	Mean dry wt (g)		Mean dry wt (g)	
25	12	10.5	d	14.6	c
50	12	31.8	a	29.1	a
75	12	27.1	b	21.2	b
100	12	27.9	b	25.9	a
150	12	27.2	b	21.5	b
200	12	19.8	c	15.3	c

Installation of TDR, Infrared Cameras, and Flowmeter System:
Six sensor (IR and TDR) systems were installed in the new Eloy stress irrigation experiment. They are functioning and sending data to Amazon Web Services.

Matt, Danielle, and Matt's brother Frank, installed the six TDR soil moisture and IR camera sensor systems in the irrigation stress experiment at Eloy. The sensors record soil moisture at 45 cm depth and plant temperature every half hour. The sensors upload data each night to a MySQL database at Amazon Web Services. Danielle is adding Bowen ratio ET measurements to one of the sensor systems at Eloy. The Bowen ratio is based on measurements of humidity and temperature at two elevations above the crop. This is useful because a grass area is not needed for a standard weather station. The cost is $600 so it will not impact the budget significantly.

Python MySQL WINDS Model Integration with Existing Tools:
We are processing images with PIX4D, analyzing vegetation indices, and adjusting the Python and MySQL WINDS to match Excel/VBA changes.

Hadiqa calibrated the WINDS model with the three seasons (2018-2020) of guar experimental data from Clovis (Sprinkler irrigation in clay loam soil). The model provides an accurate picture of soil moisture over time in irrigation layers. We are writing up the first paper, which focuses on correlation between the WINDS model and neutron probe soil moisture readings during the three seasons in the full irrigation treatments. The paper will also describe the algorithms that were added to the WINDS model in order to accomplish the simulations. Matt is calibrating the WINDS model for surface and drip irrigation in clay and sandy loam soils in the guayule experiments. The Excel/VBA WINDS model structure was refined in order to make it user friendly for researchers, and in a format in which the data stream is duplicated for the Python version. Pete is revising the Python and MySQL version of the WINDS model in order to run on Amazon Web Services as an irrigation management tool.

Irrigation Experiments – Guayule and Guar:
Guayule irrigation experiments in progress. Participated in 2020 guar experiment and writing up 3 years WINDS simulation of experiment.

The two original guayule experiments at Eloy and Maricopa are continuing in the second growth cycle. Not all treatments were continued, based on lack of regrowth in some treatments and lack of need to run the high irrigation treatments.

Deficit irrigation study (water stress):
This experiment is ongoing and is on track.

The new irrigation stress experiment at Eloy is proceeding well. Drone flights are conducted weekly in all experiments. Diaa and Matt are processing drone data from guayule experiments in order to develop crop coefficients, water stress, and vegetation indices with multispectral, infrared, and RGB cameras. Hadiqa and Diaa are processing drone data from the Clovis guar experiments, which in general were collected monthly during the 3-month guar growth cycles.

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

Task #	Description of Task	Deliverable	Target Completion Date
1 Maier/ Neilson	Chemical and physical analysis of 108 soil samples	pH, EC, OrgM, NO3-N, P, K, cations, and SAR analysis complete	31 Dec 19
		Soil texture characterization complete	31 Dec 19
		Identify commercial lab for sample processing	1 Feb 20
2 Maier/ Neilson	DNA extraction of soil samples for microbiome analysis	DNA extraction from samples	1 Apr 20
		Amplicon sequencing	1 Apr 20
		Bioinformatics analysis of data generated from amplicon sequencing	1 Jun 20
		Assess spatial/temporal distributions of fungal pathogens on microbial community dataset	1 Jun 20
3 Maier/ Neilson	Soil sample collection for guayule-microbe irrigation study	Collect/archive soil samples for DNA and RNA analysis from 108 samples immediately after harvest	1 Apr 20
4 Maier/ Neilson	Winter dormancy rubber production studies	Chemical analysis of root zone soils collected; analyzed for pH, EC NH_4-N, bioavailable P and Organic C	31 Dec 20
		DNA extraction of guayule root zone samples	31 Oct 20
		Quantification of bacteria and fungi	31 Dec 20
		Amplicon sequencing of bacteria, archaea, and fungi	1 Feb 20
		Statistical analysis of microbial community dynamics and associations	30 Jun 20
5 Maier/ Neilson	Temporal microbiome analysis of community interactions	Sample F50 and F100 treatments of Eloy irrigation trial	1 May 20
		Collect temperature data	1 May 20
		DNA extraction for 215 samples	30 Jun 20

		Amplicon sequencing: bacteria, archaea, fungi Generate microbial community profiles and network analysis	1 Aug 20 1 Oct 20

Chemical and Physical Analysis:
Chemical analysis by Brookside Labs is complete for Year 2 soils. Spatial heterogeneity analysis of soil fertility at MAC and Eloy have been presented by Kyle Brown. Year 2 soils will not be analyzed due to issues with NMSU analysis and lack of soils for repeat analysis. Labs needed to process the Year 3 soils are now open and so the soils will be prepped for analysis by Brookside labs.

DNA Extraction for Microbiome Analysis:
Kyle Brown is continuing to work on DNA extractions for soil samples collected in the spring of 2018 and 2019 from all irrigation treatments of the MAC and Eloy field trial. He was able to return to the lab in June and has 44 extractions remaining to be completed. Amplicon sequencing and bioinformatics analysis of these samples will be done when the final 44 extractions are complete.

Soil sampling for guayule-microbe irrigation study:
Soil samples collected in March 2020 from the Eloy and MAC irrigation trials have been dried and will be ground for soil chemical analysis at Brookside Lab. Access to labs and soil needed to grind these soils is no longer restricted due to coronavirus and so the chemical analysis will be done this fall.

Soil texture analysis will also be completed in the coming quarter. The lab used for texture analysis was reopened in September and so the work can now be completed.

Winter Dormancy Rubber Production Study:
A research meeting between the Neilson and McMahan groups was held in August. All data was discussed and it was decided that the project is complete and ready for publication. Figures and table for manuscript have been completed; a manuscript is in preparation.

Temporal microbiome analysis of community interactions:
Sampling for the temporal analysis of soil microbial ecology during the guayule growth cycle was completed in Q2. This experiment will allow an extension spatio-temporal analysis of the guayule soil microbiome. The objective of this study is to identify a core microbiome of the guayule plant root-zone that is consistent across plant growth stage, field spatial variability, and seasonal environmental variability. The core microbiome is being studied in the 50% irrigation treatment because this irrigation level is most representative of the conditions experienced by the native plant. 240 samples were collected and DNA extraction of these samples is in progress. 172 samples have been processed and 68 remain to be extracted. Amplicon sequencing for bacteria/archaea and fungi will be performed on all of these samples as soon as extractions are complete as described.

Temporal soil microbiome network associated with guayule growth cycle:
During Q3, Yongjian Chen worked on an arid soil microbiome publication that addresses data relevant to this project. The manuscript evaluates plant effects on soil microbial communities in natural arid ecosystems. This publication will inform Yongjian's objective for this research, which is to analyze interactions between members of the guayule root-zone microbiome (bacteria, archaea and fungi) in order to differentiate between core and non-core members of the microbiome. This analysis will reduce the immense diversity of the soil microbiome to a "most-wanted" list of microbes that characterize the critical guayule core microbiome. Correlations can then be evaluated between this microbial diversity profile and guayule rubber/resin production and plant health under a range of field management conditions. Yongjian hypothesizes that one could change plant fitness by manipulating the core guayule microbiome.

Y.Chen defined a revised objective for this project for the annual meeting presentation. His research objective is to define the core microbiome associated with the guayule plant across multiple growth stages and environmental conditions. The revised objective was informed by his work on a publication characterizing *Life-history strategies of soil microbial communities in an arid ecosystem*. This paper was published in the prestigious ISME J (International Society of Microbial Ecology Journal) in October 2020. In this manuscript, Yongjian compared the microbial traits of communities that colonize vegetated and barren soils in natural and arid ecosystems.

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: Demonstration of supercritical fluid extraction capabilities has been delayed in the last three quarters by equipment purchase availability and COVID-19 lab closures. Work was able to be resumed in Q3. The larger (2 L) supercritical fluid extraction unit was reassembled in high-pressure equipment lab. Working with the manufacturer, Dehghanizadeh was able to fix the operation software issue and assemble a list of replacement parts to order. Preparation of an experimental safety plan is now underway.

Work on the third of the three biomass conversion review manuscripts, on low-cost waste/residue feedstocks for biofuels, was delayed until Q4 as Bayat's time in Q3 was traken up by her work on another NSF education grant that is providing her research assistantship.

Holguin: Dr. Jarvis has resigned from NMSU. She was responsible for the high-resolution analysis of guayule products. We anticipate that we will continue our working collaboration through an affiliated faculty status.

COVID-19 guidelines allowing only essential activities to continue has delayed our activities. We are still optimistic about catching up by the end of Q4. We previously reported that a gas chromatography unit, this is our primary instrument for metabolomics work, was nonfunctional. Parts have been received and installed; the instrument is now undergoing verification.

Repairs are almost complete on our nitrogen generator that is used to support all of the LC/MS units, CHNOS analyzer, and nitrogen evaporator. Repairs are to be completed in early Q4. The -80C freezer was evaluated by a service engineer and is being repaired but may still need to be replaced.

Ms. Claudia Galvan is overseeing chemical analysis as a new laboratory manager for the Holguin lab. She began work in June 2020 and is diligently working to bring the projects back on schedule.

Molnar: Cascaes Inacio, the biologist for the project, received her work authorization during the second week of October. Her re-hiring process to join the project and start experimental work is expected to finish around 21 October.

Ogden: We are still being affected by the Coronavirus disease (COVID-19). The situation is better. The University and collaborators facilities are partially opened for students and employee safety. We can go to work more often and are still adjusting ourselves to work safely and efficiently. The work and shipment are still delayed but we are trying to catch up.

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	Metabolomics and lipidomic assessment during abiotic stress and adaptation Generate 2nd manuscript on metabolomics cold adaptation/ pathway regulation Generate manuscript on high resolution mass spectrometry analysis of guayule resin	31 Aug 20 31 Aug 20 31 Aug 20
2 Holg	Biochemical composition analysis of guar and respective products	Develop standard operational methods to characterize polysaccharide composition of purified guar gum	31 Aug 20
3 Holg	Analytical evaluation of thermochemical conversion products	Complete composition information and sample extracts Contribute to manuscripts	31 Aug 20 31 Aug 20

Guayule Biochemical Composition Analysis:

In order to determine major components of the resin mixture, direct tandem MS analysis was performed. Prior to that, resins were resuspended in the chloroform mixed with methanol for the more efficient ion spraying and sodium acetate for the better ionization. Several analyses were carried out differed in MS settings. MS chromatograms depicted a wide range of compounds belonging to the terpenoids and also lipids (Figure 7). Based on MS data, there were ~1198 compounds in the resin mixture. During MSMS analysis, ~150 of the most abundant compounds were fragmented, and MSMS spectra for them were obtained, including several Argentatins (Figure 8). MS2 spectra are not available for the majority of the detected peaks; most of them were searched against NIST library with low hits. CFM-ID 3.0 software will be used in the future. About 30 compounds had a major fragment of 219 m/z typical for Argentatins and distinctive patterns in the lower mass range (Figure 9). Supposedly, all these compounds are different modifications of Argentatins. It is yet to be confirmed. Additionally, several Guayulins were detected (Figure 10). MSMS spectra for Guayulins are also not available in the literature, and it is promising that these spectra might be of interest to many researchers. So we anticipate publishing new, unique MSMS spectra for unknown terpenoids found in the resin mixture. MSMS spectral data in the process of concatenation with FTICR/MS data obtained by Dr. Jarvis.

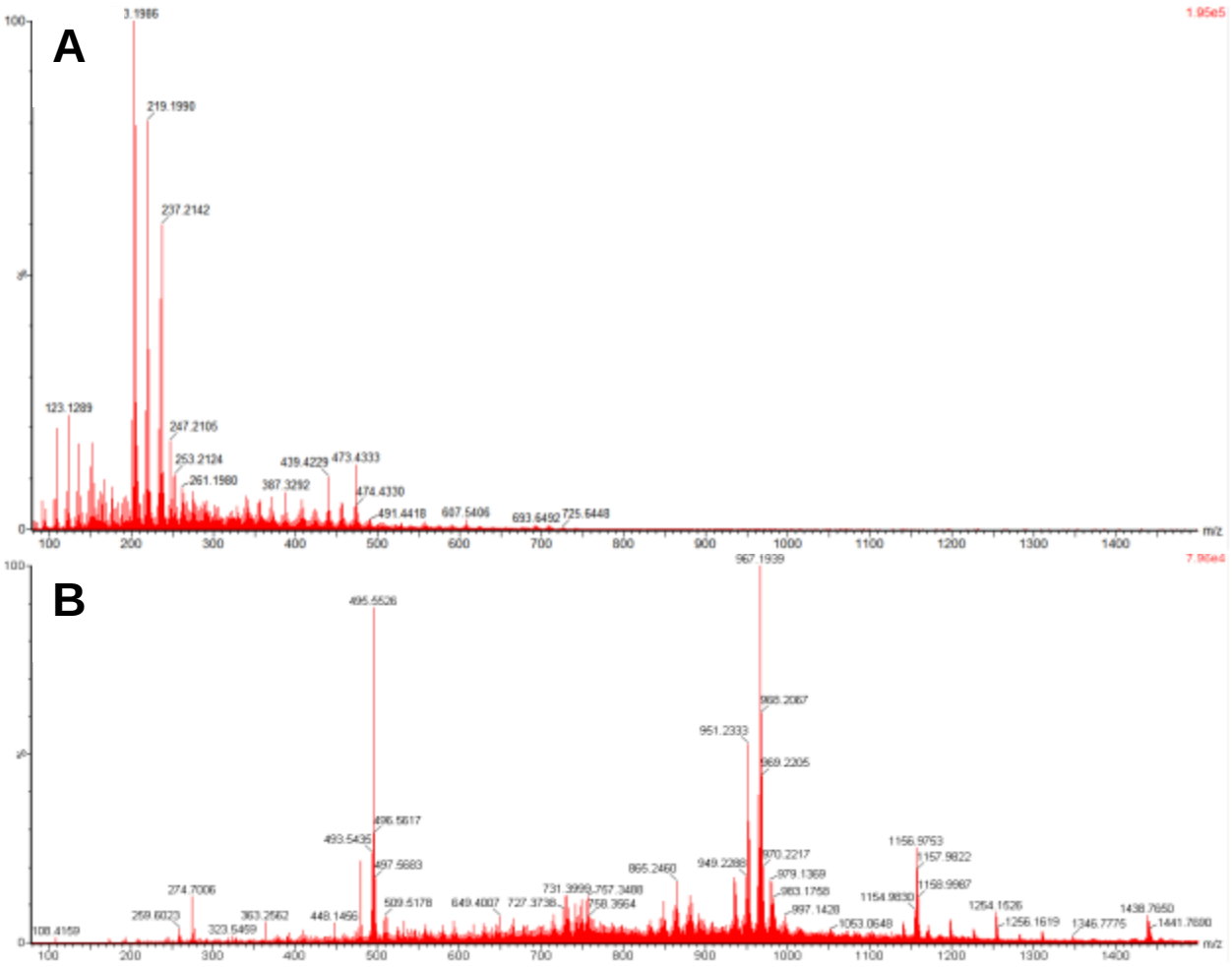


Figure 7. *Tandem MS spectra showing major metabolites from resin mixture. A. Most abundant peaks in the 100 to 500 m/z range showing terpenoids; B. Most abundant peaks showing lipids between 400-1000 m/z.*

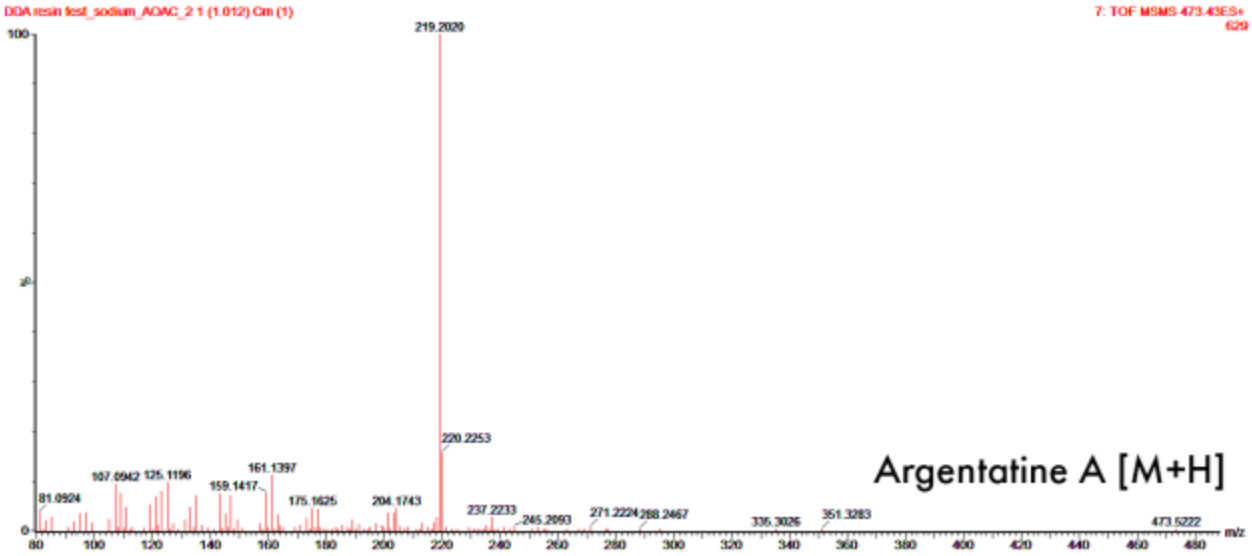


Figure 8. *MSMS spectrum showing unique fragmentation pattern of Argentatine A with 473 m/z.*

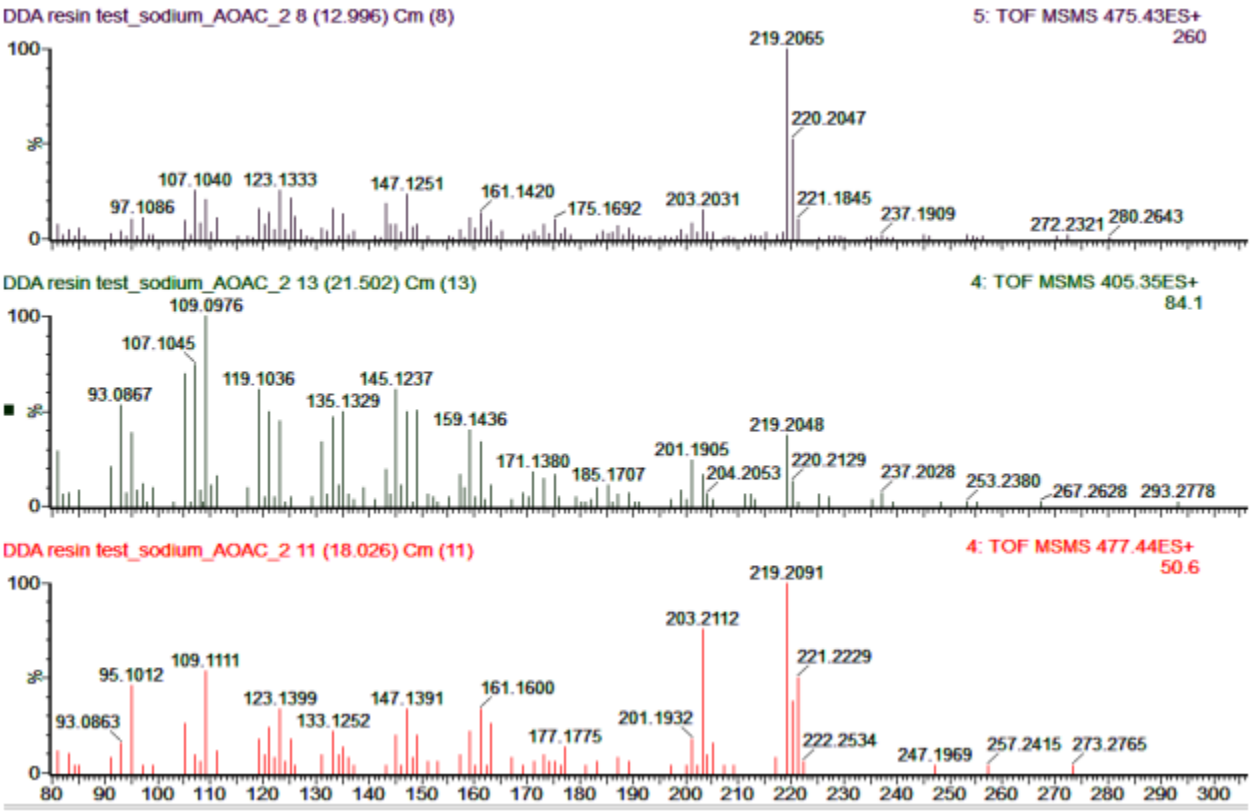


Figure 9. *MSMS similarities in the different types of Argentatins.*

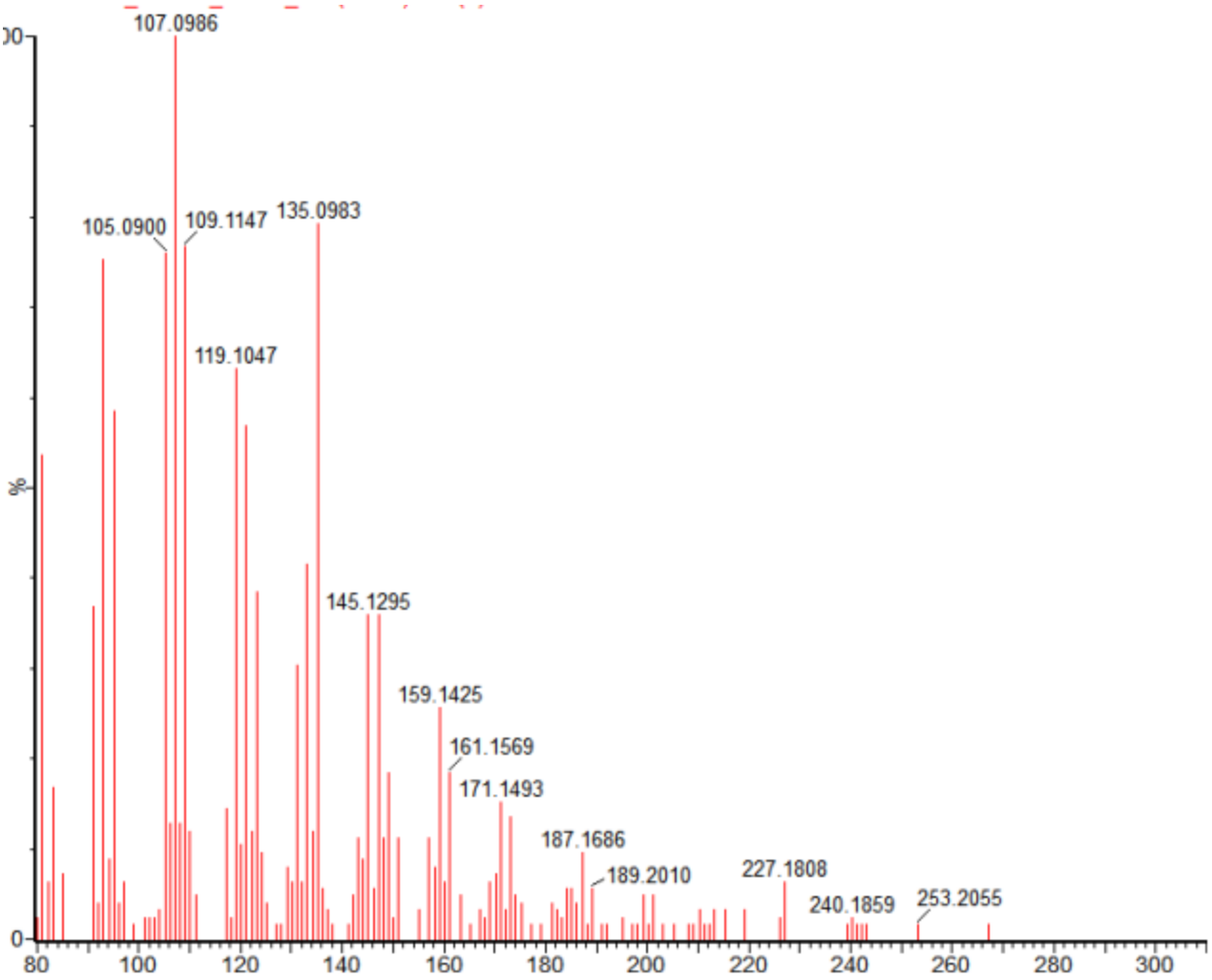


Figure 10. *MSMS spectrum for Guayulin B.*

Guar Biochemical Composition Analysis:
This task has been completed; SBAR Highlight posted 3 April 2020.

Analytical Evaluation of Thermochemical Conversion Products:

Phytohormone Analysis – LC/MS analysis was proposed to evaluate phytohormone content in guayule resin and leaves. MRM scanning was conducted in order to obtain specific fragments of interest. Guayule resin was resuspended in chloroform and diluted with methanol. The initial set of data will be used to determine the list of standards to purchase for future analysis.

Metabolomics and Biochemical Analysis – LR harvested leaf samples from CAL3 042, CAL3 043, CAL3 046, HS Bulk 062, and HS Bulk 063 and sent to Bridgestone for genotyping.

Day/night temperatures will be recorded daily, starting in the last two weeks of September. When the temperature (3-5 days) averages reach 65°C, leaf and bark samples will be harvested from selected guayule germplasms. The samples will be immediately frozen in liquid nitrogen and stored at -80 °C.

So far, we have done two rounds of sampling this quarter. The first round of sampling was done on September 15 and the second one was performed on the 30th of September. The leaf and stem samples were collected separately for each guayule plant. The tissues collected on Sep 15 have been lyophilized and are ready for metabolomics analysis- US.

LR isolation of Rhizobia from Guar Nodules – Guar plants from the Kinman variety, grown at Los Lunas NMSU Agricultural Science Center, were harvested by the SBAR Fellow student Darien Pruitt. Nodules were removed from the roots and used to isolate nitrogen fixing rhizobia and nodule-associated bacteria. Rhizobia was rescued and plated on selected media YM+Nalidixic acid 50ug/mL. Amplification of the 26S gene from the isolated Rhizobia and DNA sequencing for species identification will be carried out during the last quarter of 2020.

Publications – LR completed the first draft of the "Untargeted metabolome profiling of guayule (*Parthenium argentatum* A. Gray) to identify metabolic biomarkers for cold-acclimation and freezing temperature tolerance" manuscript. She has also addressed the co-authors edits and comments for the final draft publication in the peer-reviewed Industrial Crops and Products Journal. The document is currently under Dr. Holguin's final review.

Ms. Kelly Laje has completed revisions for the publication “Natural Products in the Desert Southwest: Guayule (*Parthenium argentatum*) and Guar (*Cyamopsis tetragonolobus*),” and has forwarded the document to co-authors for final approval before journal submission to the “Plant Management Network.” Two issues we faced during the finalization of this publication, which put us slightly behind in submission – 1) one co-author has been unable to respond to edits and concerns about some context within the publication; however, this has been resolved with additional effort from remaining co-authors; 2) COVID-19 resulted in some meeting delays, which has also been resolved, as adjustments to circumstances have been made successfully, and many previous restrictions have been eased.

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	Prepare manuscripts on low-cost biomass conversion methods review, and co-HTL of guayule bagasse and algae.	Prepare manuscript; Submit manuscript to peer review journal	31 Mar 20
2 Brewer	Perform separations and fraction characterization of guayule resin	Purchase supercritical solvent extraction system Perform liquid-liquid, accelerated, and filtration separations Prepare manuscript of guayule resin separation	31 Aug 20 31 Aug 21 31 Aug 21
3 Brewer	Conduct tests of guayule resin-derived materials for insect repellency applications	Manuscript on potential insect repellency	31 Aug 21
4 Brewer	Characterize biomass and fraction samples	Characterizations data provided to SBAR team to support sustainability models	31 Aug 21
5 Gunat	Chemical and microbial transformations	Develop chemical and/or microbial methods for the conversion of guayule by-products into value-added products	31 Dec 19
6 Gunat	Evaluate major metabolites of guayule	Evaluate transformation products of argentatins A, B, C for potential anticancer/ antimicrobial activities	30 Apr 20
7 Gunat	Isolate and characterize major metabolites of guayule terpene solution	Identify metabolites within solution that can be converted to value-added products	31 Jul 20
8 Molnar	Comprehensive literature/bioinformatic review to identify major classes of guayule secondary metabolites	Retrobiosynthetic analysis of major products of guayule resin/terpenes Bioinformatic identification in guayule genome/transcriptome databases	31 Dec 20 31 Jul 21
9 Molnar	Evaluation of microbial transformations in guayule resin or terpene solution	Develop methods for use of recombinant yeast strains, filamentous fungi, and chemical semisynthesis for conversion to value-added co-products	31 Aug 21
10 Molnar	Characterize novel compounds originating from biotransformation or semisynthesis as potential value-added co-products	Isolation, structure elucidation, and evaluation of antimicrobial and anticancer bioactivities	31 Aug 21

11 Ogden	Evaluation of major fractions of guayule resin	Recommendation of potential products that can be separated from resin fractions	31 Aug 20
12 Ogden	Cost analysis of potential resin products	Initial incorporation of resin products into TEA	31 Aug 20

Prepare Manuscript on Low-Cost Biomass Conversion Methods:
Brewer and Cheng completed and submitted a review article manuscript on biochemical conversion of high-protein, high-lignin feedstocks to *Renewable & Sustainable Energy Reviews*. Dehghanizadeh, Brewer, and members of the Quinn group at CSU completed and submitted a review article manuscript on guayule resin composition and applications to *Industrial Crops & Products*. Dehghanizadeh presented material from the review article at the (virtual) ASABE Annual International Meeting in July.

Rosalez continued his work on his MS thesis on algae + guayule co-hydrothermal liquefaction; his defense is scheduled for early November. The undergraduate students are currently assisting with the final characterization data collection. Preparation of that manuscript will resume after Rosalez' defense.

Insect Repellency of Guayule Resin:
NMSU return to research plans were developed and approved to allow four undergraduate students to assist Dehghanizadeh in the lab with set up of the supercritical fluid extraction equipment and with the insect repellency tests.

In collaboration with the Romero group in Urban Entomology at NMSU, Dehghanizadeh completed the replicates of single-time point repellency tests with German cockroaches using guayule resin. He designed and began repellency tests with Turkestan cockroaches using camera tracking over short time periods for whole resin, terpene-rich, and fatty acid-rich guayule resin fractions in comparison with a known plant-derived repellent, Java oil.

Photo 3. *A Turkestan cockroach used in a repellency study at New Mexico State University.*

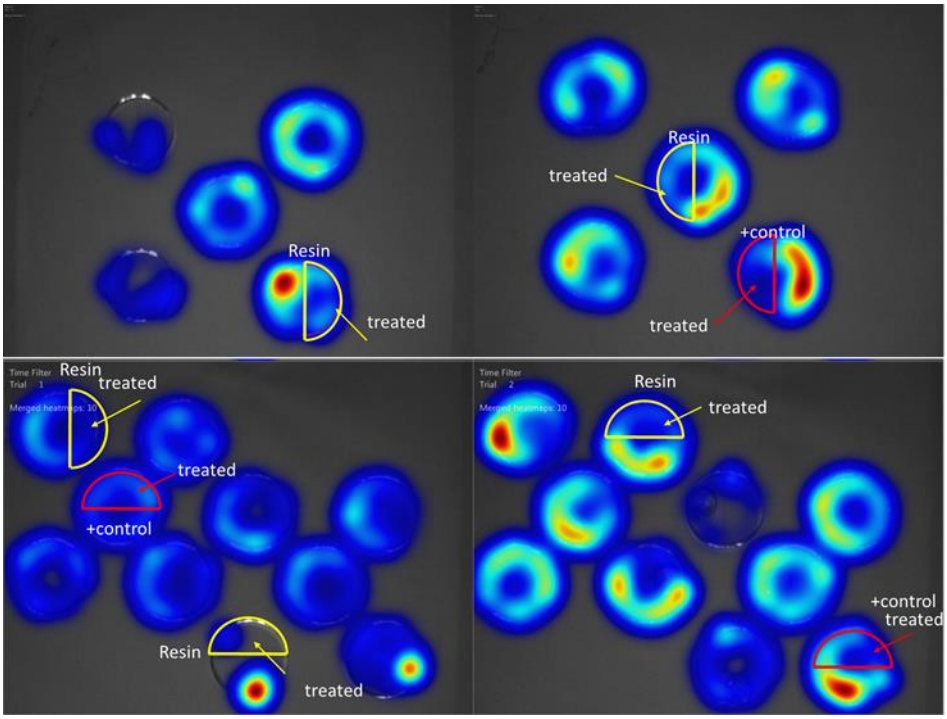


Figure 11. *Heat maps showing location of cockroaches over run time.*

Heat maps were generated that show cockroach preferred location over time (Figure 11). Preference for time spent in untreated areas indicates repellency.

Results from 9 replicates of repellency tests using Turkestan cockroaches by video tracking were obtained in recent tests that indicate the following:

- *Treatment rate: 5 µl/cm²*
- *Run time: 10 min*
- *Acclimation time: 20 min*
- *Test materials: resin, terpene, fatty acid (FA)*
- *(+) control: Java oil*
- *(-) control: Acetone*

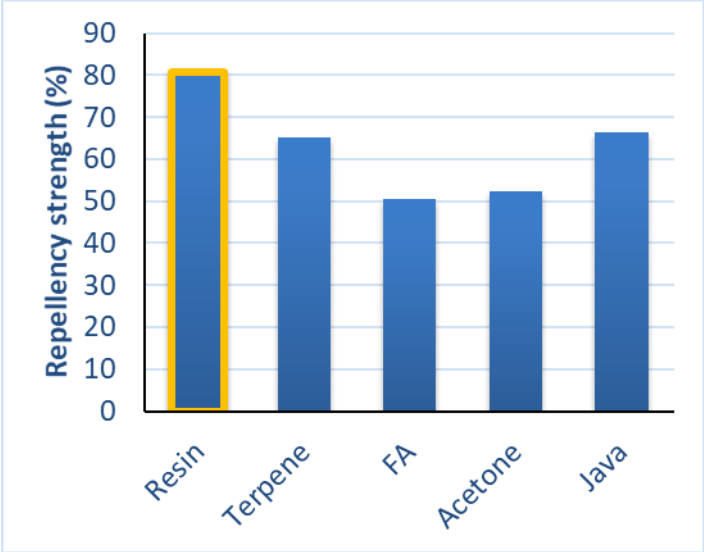


Figure 12. *Results from 9 replicates of repellency tests using Turkestan cockroaches by video tracking.*

Video tracking repellency tests will continue in Q4 with the current guayule resin fractions, and the add tests for 18 resin fractions obtained from the Gunatilaka group. Those results and resin fraction characterization data will be used to prepare a manuscript for publication in an entomology journal.

Chemical and Microbial Transformations:

In continuing our previously reported work (see: Q2, 2020), semi-syntheses of seven additional new ester derivatives of guayulin B hydrolyzed product (partheniol) were completed. The resulting analogues **2–9** (Figure 13) and the natural products, guayulin A and guayulin B are currently being evaluated for their cytotoxic activity

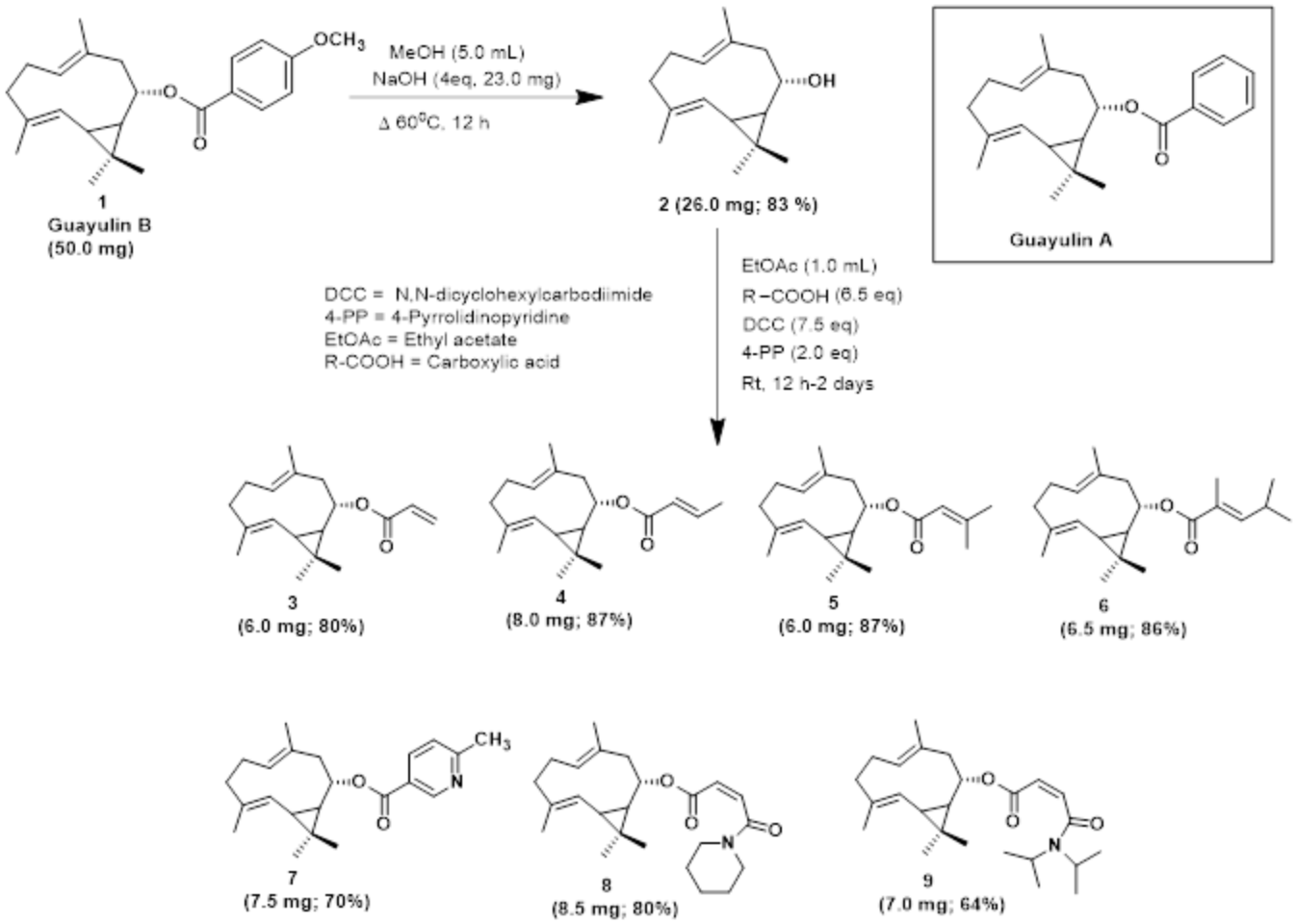


Figure 13. *Hydrolysis of guayulin B (1) to partheniol (2) and semi-synthesis of ester analogues 3-9 of partheniol.*

Evaluate Major Metabolites of Guayule:

All semi-synthetic analogues (**10**–**15**) of argentatins A–C were evaluated for their cytotoxic activity against three sentinel cancer cell lines (NCI-H460, SF-268, and MCF-7) and normal human lung epithelial cells (WI-38) at 5 and 10 □M concentrations. The results revealed that these compounds were inactive against all cancer cells and normal cells tested.

Literature/bioinformatic Review to Identify Guayule Secondary Metabolites:

Initial retrobiosynthetic analysis was carried out on argentatins, major triterpenoid products from guayule resin. Bioinformatic analysis of the draft genome sequence of guayule (provided by USDA-ARS) was conducted to find oxidosqualene cyclase (OSC) enzyme-encoding genes that represent the first committed step towards argentatin biosynthesis. OSC gene fragments were then manually extended with non-scaffold and/or non-assembled reads from the genome

sequencing, and the resulting contigs were manually annotated. Up till now, 3 full sequences of cycloartenol synthases were identified (these are the most likely candidate OSCs for argentatin biosynthesis). In addition, multiple beta-amyrin, dammarene, and lupeol synthase OSCs were also detected, with manual annotation continuing.

Evaluate Microbial Transformations in Guayule Resin/Terpene Solution:
Nothing to report.

Characterize Compounds from Biotransformation/Semisynthesis as Potential Value-Added Co-Products:
Nothing to report.

Isolate and Characterize Major Metabolites of Guayule Terpene Solution:
Work for this task is complete; nothing new to report.

Fractions of Guayule Resin:
We study the project sustainability and the potential of high-value-added products obtained from guayule resin. We resumed the resin experiments since the university and our collaborator facilities and laboratories partially re-opened. We started a bi-monthly meeting and have a better communication with Bridgestone partners.

Sarocha focused on resin-protein characterization and microscopic techniques in this quarter and tried to extend the study to identify the modified resin compositions and structure with collaborators but there were some delays and obstacles due to the global pandemic situation. Shas has done quite a bit of characterization, one of the most interesting characterizations is the TEM results.

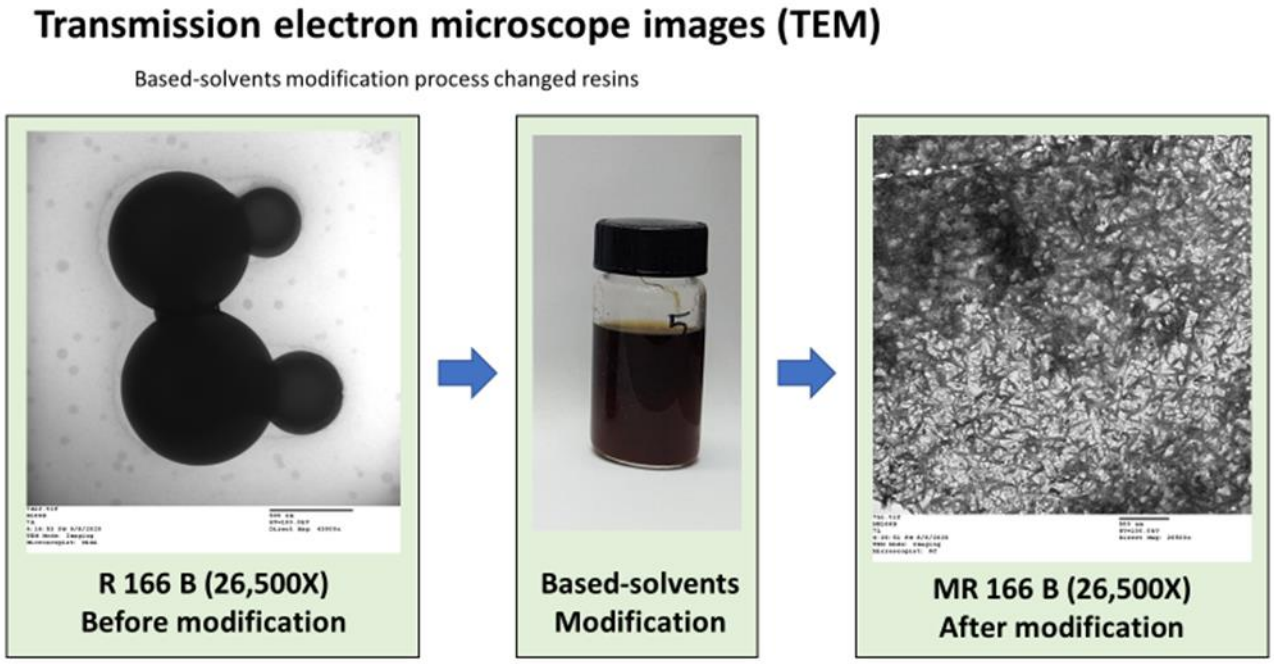


Figure 14. *Images of guayule resin using a Transmission electron microscope (TEM).*

Additional work is being done on patent applications and writing manuscripts.

Dr. Ogden is seeking local facilities to continue developing the guayule resin adhesives and particleboard studies since travel to Kansas has been curtailed due to University travel restriction orders. It looks like we may be able to do the work at Advanced Ceramics (located in Tucson).

A. Smith fractioned the resin at constant pressure, varying temperature vacuum distillations at 0.10, 0.15, 0.20, and 0.25 PSI using vacuum distillation. He has also done one constant temperature and then changing the pressure. The resin fractions were sent to Bridgestone for CG-FID analysis. Sample data is provided in the figure below. The system is working better and we are obtaining good separation between the components. In addition to completing experiments we will be working on transesterification and ASPEN modeling.

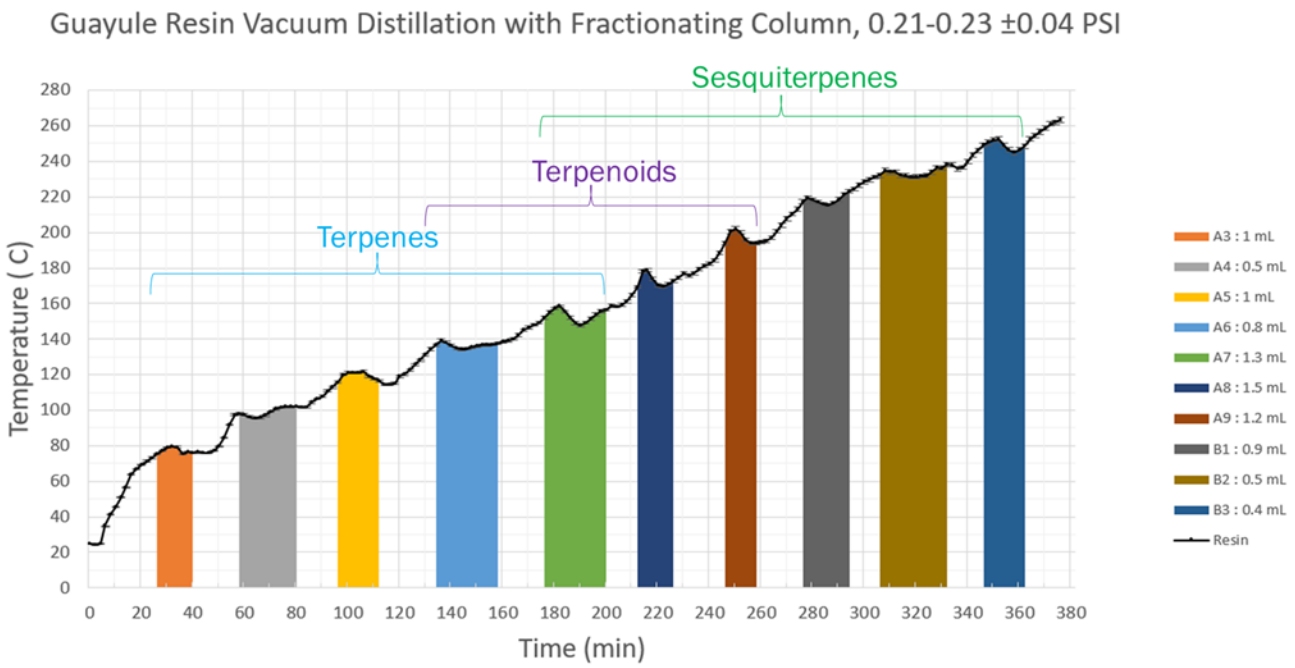


Figure 15. *Results of vacuum distillation fractioning of guayule resin.*

Table 29. *Compound fractions identified in guayule resin.*

	A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8	A-9	B-1	B-2	B-3	B-4B	B-4T	C-1
Total Area	4.77E+10	5E+10	5.05E+10	5.04E+10	4.99E+10	4.81E+10	4.6E+10	4.52E+10	4.66E+10	4.67E+10	4.66E+10	4.7E+10	4.69E+10	4.6E+10	2.27E+09
Acetone	94.21%	84.07%	82.39%	82.48%	85.27%	87.46%	89.90%	89.99%	88.99%	90.67%	89.55%	89.38%	92.04%	99.16%	1.87%
Hexanes	1.37%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	7.64%	0.47%	1.40%
Cyclohexanes	4.35%	0.03%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	29.51%
Santolina triene	8.12%	12.19%	3.27%	1.22%	0.08%	0.21%	0.08%	0.00%	0.08%	0.04%	0.04%	0.00%	0.00%	0.00%	4.66%
Alpha pinene	40.70%	43.69%	25.14%	13.69%	0.96%	1.61%	0.54%	0.24%	0.47%	0.26%	0.26%	0.06%	0.00%	0.00%	19.41%
Beta pinene	26.67%	40.63%	62.72%	74.99%	57.30%	3.30%	5.58%	0.37%	1.55%	1.01%	0.84%	0.03%	0.00%	0.00%	0.42%
limonene	1.94%	0.36%	5.84%	6.96%	36.54%	74.22%	11.81%	0.98%	0.06%	0.09%	0.01%	0.03%	0.00%	0.00%	0.15%
Total Terpenes	77.43%	96.86%	96.97%	96.86%	94.88%	79.34%	18.02%	1.58%	2.15%	1.40%	1.17%	0.13%	0.00%	0.00%	24.64%
Terpenoids	0.00%	0.45%	0.59%	0.72%	1.67%	7.03%	42.27%	24.00%	6.52%	2.47%	1.17%	0.84%	0.00%	0.00%	3.29%
Sesquiterpenes	0.00%	0.11%	0.17%	0.05%	0.47%	2.75%	36.44%	66.93%	77.35%	78.87%	69.80%	62.60%	2.36%	1.31%	9.69%
elemol	0.00%	0.00%	0.02%	0.00%	0.00%	0.05%	0.71%	2.15%	3.50%	5.21%	6.99%	8.72%	1.05%	1.20%	1.01%
Eudesmols	0.00%	0.00%	0.06%	0.05%	0.00%	0.13%	1.26%	4.44%	8.14%	10.29%	16.68%	23.82%	5.71%	5.79%	2.77%
Guayulins	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.98%	0.78%	0.20%
Argentatins	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.08%	0.16%	74.24%	73.47%	20.29%
Total "Resin"	77.43%	97.42%	97.81%	97.68%	97.03%	89.30%	98.70%	99.09%	97.66%	98.25%	95.88%	96.26%	84.34%	82.55%	61.89%

In the next quarter, we will still be working on patent applications. Sarocha will continue the experiments, write the manuscript and do further development with guayule resin adhesive and particleboard work. Andrew will continue doing the distillation experiments varying pressure and studying the effects of removing the low molecular weight rubber before the distillation process as well as writing a distillation model in ASPEN.

Cost Analysis of Potential Resin Products:
Nothing new to report.

SYSTEM PERFORMANCE & SUSTAINABILITY

Project Coordination: Colorado State University (Dr. Jason Quinn) leads the fortnightly working group webinar/phone calls. 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.

Standing agenda item include COVID-19, and field trial data integration which is currently being led by CSM. COVID-19 has had minimal impact on the CSU and sustainability team in general in terms of research productivity. The impacts of COVID for the sustainability team are limited to other SBAR Teams' members as data collection and laboratory work have been impacted.

The focus this quarter has been:

- Development and integration of downstream bagasse to fuel process models
- Supporting manuscripts and research in the area of co-products (Brewer)
- Refinement of the integrated models
- Model integration across the sustainability team focused on validation and improved fidelity
- Developing water LCA scenarios
- Development of moderation of sustainability team meetings on a bi-monthly basis in support of research goals
- Iterating with CSM and supporting the developing of year 4 scopes of work

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

Issues/Risks:
Fan: Although our work is focused on modeling and optimization, the inputs for the model play a crucial role in the results. Based on the feedback from the SBAR presentations, some of the harvesting equipment for guayule needs to be reconsidered to reduce costs. Some of the members of the sustainability team are discussing alternatives with Bridgestone. However, defining the new equipment may take a few months or even longer if the first alternative identified are not viable options.

Quinn: CSM continues to be a risk to the project.

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	Gather information for farm level scenarios using different	31 Aug 20

		avg. farm sizes, irrigation, and acreages Conduct input/output analysis of system model results Validate preliminary analysis for farm production and profitability Generate publication on the economic analysis for guar and guayule	 31 Aug 20 31 Aug 20 31 Aug 20
2 Gutierr	Initiate development/testing of online producer systems model	Create online tool for evaluating guar/guayule alternative crops	31 Mar 20
3 Landis	Field data transfer	Develop SOP/protocol for transferring field data to LCA team in useful formats	31 Dec 19
4 Landis	LCA first order model	Journal publication submitted for 1st order LCA	31 Mar 20
5 Landis	Integrate current field data into LCA/TEA model	Update LCA/TEA model inputs with field data; identify new scenarios Manuscript generated and submitted to peer review journal	31 Aug 20 31 Dec 20
6 Landis	Sensitivity and scenario analysis	LCA Scenario Analysis complete	31 Aug 20
7 Quinn	Techno-economic and Life Cycle Assessment results	Update/finalize economic and environmental impact results	1 Aug 19
8 Quinn	Data integration	Integrate experimental data into foundational processing model	31 Aug 20
9 Seav	Validated integrated model	Update and incorporate new information under various scenarios	31 Aug 20
10 Seav	Diversify integrated model for broader audience	Incorporate returns/costs of additional crops into integrated model	31 Aug 20
11 Teeg	Facilitate working agreement between Tribal Farms and Bridgestone to establish experimental plots	Signed agreement established between Gila River Farms and Bridgestone Experimental plots established on Tribal lands	31 Aug 20 31 Aug 20
12 Teeg	Validated integrated model	Update and incorporate new information under various scenarios	31 Aug 20

Functional Integration of Economic Analysis into System Model:

The goal of identifying farm level inputs to be used in the integrated systems model is currently being reevaluated for guayule. The whole farm-level economic analysis has been successfully

developed for integration into the system model. Efforts to update input and cost parameters based on research results is a continuous process.

Efforts will continue to coordinate with TEA and LCA team members to enhance the integrated model and provide economic information to the team for publications and presentations. As we learn more about the producers who may want to grow guayule and guar in other geographical regions, additional crop budgets in the model will be created.

Future work will look into the implications of adopting new crops into current cropping systems and how that changes break-even prices. The economic impact will be evaluated using IMPLAN, a regional I-O model. IMPLAN enables us to track inputs required for production through the supply chain, including the ability to purchase locally. By varying the scale and supply chain, we can investigate the impacts of SBAR growth on employment, real estate, income, trade, and local/regional business.

With a focus on encouraging participation of producers from two culturally distinct regions of Arizona and New Mexico (Northwestern New Mexico and Northeastern Arizona), we aim to engage growers in understanding potential future markets for selected alternative feedstock crops – guar and guayule.

Online Producer Systems Model:
Budget templates have been completed. Continue to have challenges with representative data. Cultural practices and related costs are being evaluated in research trials. Insufficient data is available presently to finalize the prototype, but still working on it.

Field Data Transfer:
First round of field trial data interviews are complete. Mealing has begun the second round of meetings with PIs of field trial data in order collect the new field data from the October 2020 most recent harvests. This Task is ongoing as we will integrate any and all new data from field trials as it becomes available. These meetings will also be used to collect some equipment and management practices needed specifically for the Economics/TEA updates with field data.

Converting the data sets' various formats to useful excel format for the integration continues as the data is received. Continued thanks to the support of the sustainability team and all field trial collaborators!

First Order LCA Model:
Nothing new to report.

Integrate Field Data into LCA/TEA Model:
Four of the guar field trials have been fully integrated into the integrated model. Capability to choose different field trial scenarios has been implemented and results figures are populated for each scenario. Mealing worked with Dr. Idowu for a presentation at ACLCA (and hopefully conference proceeding) using this capability for fertilizer specific trials, including scenario analysis of the datasets. As data continues to be collected, integration continues as well. Data probability (likely, unlikely, optimistic) has been collected via interviews (from previous task) with the field trial PIs and has been added to the field trial databases

Sensitivity and Scenario Analysis for Integrated Model
Nothing new to report.

Techno-economic and Life Cycle Assessment Results:
A variety of efforts were pursued as a part of this task with a summary presented below:
Model Integration: CSU continues to lead the integration effort with the development of a modeling framework to support the integration of the research across all research groups. This quarter, efforts have been focused on updating the guar model (details below) and downstream processing (details below). CSU continues to lead the environmental LCA and TEA components of the modeling work.

Guayule: The integrated model is currently being updated with the resin and bagasse to fuels modeling work. Simplified forms of these sub-process models have been brought into the integrated model. After a preliminary sensitivity analysis, it was determined that higher fidelity modeling work is needed for bagasse to fuels. Thus, ASPEN models are being generated to better inform the bagasse to fuels pathways (pyrolysis, gasification, others) and corresponding LCA/TEA.

Resin Work: This quarter, work has focused on supporting the submission of a manuscript with the Brewer research group.

Guar: Some foundational changes were made to the guar model this quarter to develop more accurate framework for field trial data integration.

Data Integration:
On the integrated modeling side of things, the CSU team is focused on supporting the propagation of field trial data through the model. To that end, the model can currently accommodate different scenarios with field trial data pulled from a central data tab. This foundation is developed and CSU is working with CSM to fully integrate field trial data.

Experimental data integration represents a critical need for the sustainability team. CSU continues to support CSM with seamless integration of data into the integrated model. Care is being used to ensure raw agricultural data is not accidently disseminated by imbedding data in uncertainty distributions.

Validated Integrated Model:
Validating machine operations and continuity of output between guar and guayule models. Working with others in the SUS team to validate model with research data and reasonable outputs for publications.

Diversify Integrated Model for Broader Audience:
Continue to update the integrated models with incorporating the costs and returns of fallow and three hemp crops – oil, seed, and fiber.

Facilitate and Foster Relationship between Tribal Farms and Bridgestone:
Continuing to assist in securing experimental plots on at least two tribal farms. 1) Connect Bridgestone and CRIT farms for experimental acreage agreement, establish introduction meeting and started contract negotiations 2) Connecting Bridgestone and Fort McDowell Farm or Ak Chin Farms for experimental acreage agreement. Started the conversation, but still trying to establish an agreement that will work for both parties. This continues to be a difficult task, but will keep trying.

Validated Integrated Model:
Continue enhancement to the farm level scenarios using different average farm sizes, irrigation technologies, and add in different crops into the mix for both New Mexico and Arizona.

Other Activities:
The CSU team is supporting various other SBAR activities. This has included working iteratively with the executive leadership committee on the SOW for CSM.

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	Downstream process modeling	Integrate downstream process modeling	1 Nov 20
2 Quinn	Scenario analysis	Generate results of scenario analysis Present results of scenario analysis at conferences for feedback	1 Feb 20 28 Feb 20
3 Quinn	Stochastic modeling	Evaluate system at a system level through Monte Carlo sensitivity modeling	30 Jun 20

Downstream Process Modeling
Research continues as planned; nothing new to report.

Scenario Analysis:
Scenario results have been generated and results were presented at the August ISSST virtual meeting.

Stochastic Modeling”
Research continues as planned; nothing new to report.

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	Clarify social sustainability metrics	Develop overview of sustainability tools and list of potential metrics Generate publication/presentation for conference proceedings	30 Nov 19 30 Apr 20
2 Landis	Social sustainability	Collect data from annual SBAR meeting Data analyzed and report drafted	31 Dec 19 31 Aug 20
3 Landis	Qualitative social sustainability manuscript	Complete manuscript: modify existing manuscript to focus on "hot spot assessment" of guar and guayule	31 May 21

Clarify Social Sustainability Metrics:
Nothing new to report.

Social Sustainability:
Nothing new to report.

Qualitative Social Sustainability Manuscript:
Qualitative social results for guar and guayule were shared with the SBAR team. The manuscript was revised based on feedback. The updated manuscript is complete and is under review with co-authors. It will be sent to SBAR team upon completion of the review.

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	31 Mar 20 31 Mar 20
2 Fan	Apply integer optimization approaches to design smart farm production plan/ scheduling	Manuscript submitted to conference/ journal summarizing research	31 Aug 20

3 Fan	System-level model/algorithm generation for decision support for guar and guayule	Preliminary results shared during project component team meetings Data/model/algorithm shared for Yr4 research (integration of 3 decision modules)	31 Aug 20 31 Aug 20

Comprehensive Sustainability and Regional Economics Analysis:
The research entitled “Integration Environmental and Social Impacts into Optimal Design of Guayule and Guar Supply Chains” was updated based on the feedback from several meetings from the SBAR sustainability and research teams, and the paper was submitted to *Computers and Chemical Engineering* in Aug 2020.

Integer Optimization Approaches for Smart Farm Production/Scheduling:
The first part of this research from the farmer’s perspective has been performed and presented. Results have been obtained including the optimal planting scheduling design and the optimal production planning, as presented below for guar and guayule, respectively. Valuable feedback has been obtained from the presentations to the SBAR sustainability and research teams and the model and input parameters are being updated accordingly.

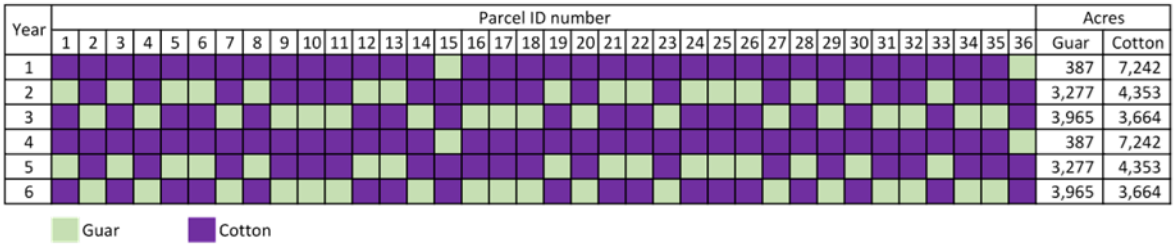


Figure 16. *Guar and cotton optimal production planning.*

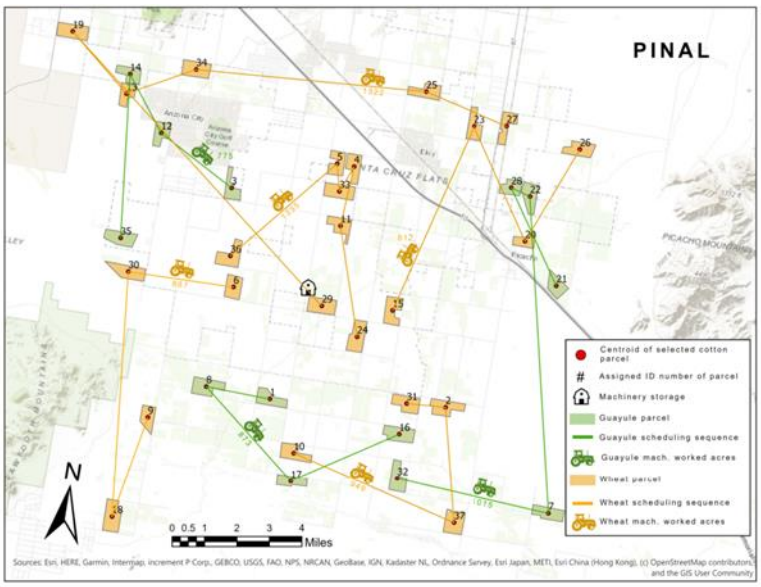


Figure 17. *Guayule, cotton, and wheat optimal planting scheduling for year 1.*

The final draft of the paper "Smart Farm Production Planning and Scheduling for Guar and Guayule" is being updated based on the feedback from the SBAR presentations and will be submitted to a journal by the end of Oct 2020.

Extend Optimization for Guayule and Guar:
We have continued to gather information to model the guayule and guar supply chains, for the following states:

- In Arizona – Cochise, Maricopa, Pinal, and Yuma counties.
- In New Mexico – Curry, Dona Ana, Quay, and Roosevelt counties.
- In Texas – almost 50 counties from Archer, Armstrong, and Bailey, to Wichita, Wilbarger, and Yoakum.
- Oklahoma

To model specific industry requirements for the guayule supply chain, preliminary information of the historic weather has been gathered as well.

System-level Model/Algorithm for Decision Support:
Preliminary results have been presented for the smart facility planning and transportation, smart farm production and scheduling, and sustainability and economics analysis studies.

The literature review continues to be performed to identify the best alternative to integrate all the models into one. All optimization models are coded using the programming language C++, the solver CPLEX, and the high-performance computing (HPC) Ocelote or SIE server from the University of Arizona. Integrating platform options are being analyzed to identify the compatibility with the developed codes.

Integrate Optimization Models of Guayule and Guar Supply Chains:
Based on the preliminary results of year 3, Visual Basics for Applications (VBA) and CPLEX have been identified to integrate the three optimization models with the guar and guayule integrated models. The three optimization models can be integrated directly through CPLEX using C++.

System-Level Transportation/Optimization Model for Feedstock Logistics:
A python-based platform is a potential candidate to integrate the GIS with the transportation system-level modeling and the feedstock logistic optimization modeling. Online GIS course are being reviewed to identify additional platforms to perform the integration.

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. Cara Duncan Shopa (UA) has been tasked with coordinating meeting details as well as ensuring that notes are captured and maintained in the Box folder for future access/reference.

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: Guar outreach was severely affected COVID-19 pandemic in multiple ways. First, state government and university restrictions limited travel, contacting producers and extension workers and organizing outreach events. Field days, farmer visits, photos and video development for outreach, demonstration on farmers' fields were not conducted. It also affected rehiring of technical help, graduate students, which in turn will affect timely data collection from all of our field-based activities. So extension publications will be delayed.

Evancho: While progress is still being made in several areas the impacts we see (in the community) have been greatly reduced due to implications from COVID-19 protection protocols and will continue to be impacted until resolved.

Fields: Because of the dramatic change in program delivery, much time was spent refocusing on the new program strategy under COVID this quarter. This has caused the annual evaluation report to be delayed; I will focus on completing the report in the next quarter.

Grover: The situation with the extension activities and funding is not clear for the coming year. As the extension plan was discussed with the guar grower-focused group meetings and a station trial/demonstration trial was already planted at Lyendecker Plant Science Center, Las Cruces that is continuing. For instance, a field event and educational presentation was delivered on guar and SBAR project a Lyendecker in September. Similarly, another virual guest presentation was delivered on guar production in first week of October. It will be helpful to know the criteria for the funding and decision to restore funding so that participation and efforts can continue with guar extension component.

Idowu: The COVID-19 pandemic limited some of our planned activities and participation in the summer events. For example, the Sustainable Agriculture Field Day was cancelled in Las Cruces, NM. The field days at Clovis and Los Lunas were also cancelled. In previous years, these field days provided an opportunity to engage with farmers and stakeholders on guar production and presentations of SBAR achievements. Due to pandemic regulations, the number

of participants for any given in-person program was limited to 10 individuals, making it difficult to plan any program that involves a large group.

Morris: The delays mentioned in last quarter report continue to impact our plans, however, many county 4-H programs are beginning re-entry phases. Positives are that we have determined a full state level 4-H STEM programming calendar to avoid potential conflicts moving forward.

Rock: Brassill has begun working with 4-H STEM leader Morris. She and Morris are now coordinating the recruitment of student interns, faculty mentors, and plans to navigate supporting interns on campus with the 4-H objectives in mind.

We are currently working within the University guidelines of Phase 2 where we can begin to discuss bringing student interns back to campus. Because our grant objectives specifically target in-person training and education for student interns, our project team is waiting patiently to bring students back to campus when it is safe to do so.

As stated previously, we have worked with the project PI to postpone the intern experiences to 2021. This would allow our research and extension teams to re-schedule interns for semesters when faculty, staff, and students return to campus, and allow the project team to fulfill remaining project objectives. This of course may change based on University guidance in coming months as well as student availability.

Seavert: COVID-19 pandemic has stalled in-person meetings, however we continue planning for online programs.

Teegerstrom: Future work is still dependent on COVID-19 restrictions and available programming efforts. However, we moving online options for the fall and hopefully by November holding some in-person meetings.

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 Provide photos and videos for publication	31 Aug 20 31 Aug 20 31 Aug 20
2 Angadi	Guar agronomy research	Gather/analyze data; develop peer-reviewed article on N and P fertilization study	31 Aug 20

		Train graduate students in guar agronomic management	31 Aug 20
3 Angadi	Guar critical stage irrigation study	Produce report on guar crop growth based on irrigation management	31 Aug 20
4 Evan	Produce guayule newsletter articles	At least 2 guayule articles drafted and published – targeting AZ growers	31 Aug 20
5 Evan	Develop outreach documents for guayule	Produce a USDA Plant Guide for guayule in Arizona	31 Aug 20
6 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 19 31 May 20 31 Jul 20 31 Aug 20
7 Fields	Track Grower Extension Team activities monthly	Compiled contact data totals submitted quarterly	31 Aug 21
8 Grover	Establish guar trial and showcase guar as potential crop in NM	Host field day Collect data; results synthesized Generate peer-reviewed Extension publication	31 Aug 20 31 Aug 20 31 Aug 20
9 Grover	Guar demonstration	Identify farm willing to host a demonstration field trial Collect data; results synthesized	31 Aug 20 31 Aug 20
10 Gutierr	Develop extension programs and reports for guar/guayule demonstrations	Summarize and validate guayule and guar demonstration farms' data Develop producer summary and presentations for agronomic, climatic, input/output, field emissions, and plant growth data Generate 3 extension bulletins	31 Aug 20 31 Aug 20 1 Feb 20
11 Idowu	Travel to conferences	Present SBAR info/materials at 4-5 grower commodity conferences	31 Aug 20
12 Idowu	Establish guayule and guar trials in Las Cruces, Los Lunas, Clovis, and Tucumcari, NM	Showcase trial experiments at field days	31 Aug 20 31 Aug 20

		Gather data/synthesize results (toward generating an Extension bulletin) Generate first year trial summary (published on SBAR website)	31 Aug 20
13 Idowu	Establish on-farm demonstration trials	Identify locations for 3 on-farm guar trials Plant guar on-farm trials Identify locations for 2 on-farm guayule trials Plant guayule on-farm trials Collect and summarize planting data for on-farm trials Schedule/Host on-farm walking tour for guar and guayule on-farm demonstration sites	31 Aug 20 31 Aug 20 31 Aug 20 31 Aug 20 31 Aug 20 31 Aug 20
14 Idowu	Host guar-focused conference for producers and ag professionals	Present research results and information on guar Showcase on-farm and on-station trials	31 Mar 20 31 Mar 20
15 Idowu	Newsletters to inform stakeholders	Produce 3 newsletters to highlight SBAR project Distribute fall newsletter Distribute spring newsletter Distribute summer newsletter	31 Aug 20 31 Dec 19 30 Apr 20 31 Aug 20
16 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 19 31 May 20 31 Jul 20 31 Aug 20
17 Teeg	Generate an interactive farm-level economic and financial model (guar and guayule)	Validate and revise BENCO Model for use in Extension/Outreach meetings	31 Aug 20
18 Teeg	Co-develop informational tools for driving profitability/feasibility of crop adoption in AZ & NM	Extension bulletins submitted for review Enterprise budget and BENCO Model available online	31 Aug 20 31 Aug 20
19 Teeg	Participate in Extension meetings; disseminate economic info for guar and guayule	Provide 2 presentations to growers in NM	31 Aug 20

		Provide 2 presentations to growers in AZ	31 Aug 20

Guar Photographs and Videos:
During the quarter, Struthers, temporary technician working in my program left for a better job. Chawla, who was hired to help guar program in summer, went back to school. At present, I do not have anyone to help with guar extension work. Lack of labor power and restrictions imposed by the university/state have delayed many of my projects. Most of the field projects, which were started with special permission from the Vice-president for Research, NMSU, are generating data for future extension publications.

During the quarter, we were more busy with field trials and did not focus on photography and video project. I did not have graduate student to take growth stage-based photographs. However, we installed multiple time-lapse video cameras in different treatments of deficit irrigation trials. We need to work on processing those videos and explore them to effectively communicate our research activities to clientele through web display or outreach activities. Due to severe shortage of help, our primary focus will be to finish fieldwork and process all field-based samples. Only after completing field work, if we have help we will work on processing videos or running new incubators studies to shoot new videos. In spite of all the problems, we included one preliminary time lapse video in conference presentation.

Guar Agronomy Research:
Nitrogen and Phosphorous response study was harvested by Dr. Idowu's students. Final samples will be threshed using our combine and data will be sent to Dr. Idowu.

Guar Critical Stage Irrigation Study:
We collected all planned seasonal observations, including drone data, from 2020 deficit irrigation management trial. Hiring Chawla to help guar research and extension at Clovis by Dr. Gutierrez was a great help. We are planning for final harvest and will be collecting samples for processing. Due to lack of help, it will take longer than usual get all data from it. The university had restriction on visitors and only Mr. Daugherty, an SBAR teacher fellow, visited our research. However, due to COVID, we will be delayed in summarizing results for an extension article for farmers.

Produce Guayule Newsletter Articles:
The second SBAR newsletter for 2020 was completed and sent to SBAR stakeholders as well as 315 growers and agricultural professionals in Pima, Pinal and Maricopa counties.

Develop Outreach Documents for Guayule:
The USDA Plant Guide for Guayule has been finalized and will be published online when the USDA Plants website is updated. (Appendix 1)

Design and Implement Evaluation Tools:
During the Q3 of 2020, due to the COVID pandemic, the majority of the EEO events that were originally intended to be in person have been canceled, and there have been limited virtual events.

Grower-Focused Extension – Grappling with COVID related challenges, outreach activities have been very limited. In NM, the last large event at which they were able to present SBAR information was at the *Alternative Crop Conference* in March, just before the shutdown. Since then, all planned in-person events had to be canceled including the 3-4 field days that they would normally have at each of their on-station field trial sites. They were able to participate in one 'virtual field day' from the Clovis location. This was not an event that was set up by the SBAR team, but Idowu was able to participate as a presenter and share information about Guar and about the SBAR project with the 300 attendees. The event was 'capped' at 300 (technology limit), and so it was clearly well attended and we don't know how many additional people had interest.

An additional focus of the team was around on-farm trials, however, they worked with two farmers who were both 'organic' or 'sustainable' growers who were opposed to any pest control. Consequently, the guar crops were overrun with weeds and the trials had to be abandoned. For the coming year, they are seeking farmers who are open to pest control for on-farm trials but given the challenges with COVID, they are uncertain if they will find willing farmers. There has been interest from a farmer in El Paso who has communicated with Brewer about their interest, and Idowu will follow up because there is some interest in understanding how guar would grow in this region that is hotter and the soil has higher salinity. The team was able to successfully get all four of the on-station field trials planted. In Clovis, they are already harvesting and collecting data, and the harvesting at the other sites will begin in the coming weeks. Although the research team will get good data, they were not able to show the plots to farmers in person. In the Clovis (eastern NM) on-station site, they also would normally be doing 'informal' outreach with regional farmers and with youth, but due to COVID that also has been canceled. The NMSU extension team should have two peer-reviewed research publications ready for release in late spring/early summer 2021.

In AZ, outreach was similarly stifled due to COVID. All events and grower interactions were canceled due to COVID March-June, and then Evancho (leading outreach efforts in AZ) was on leave during July/August. Planned events in October include a Bridgestone Virtual Field day, attended by approximately 94 people, for which a survey tool is under development and will be distributed shortly. This tool will be modified for use as a link in the bi-annual newsletter as an additional way to collect data from interested parties. Crops were also successfully planted on-station in AZ and research work on pest control, salinity and irrigation continue. The grower-focused extension group has not made much progress on website development, but are prioritizing this for Q4 2020.

Youth Development Extension – Efforts over Q3 were largely around refocusing and re-envisioning the AZ efforts under the leadership of (relatively) new team member Morris. Morris spent quite a lot of time figuring out how to incorporate SBAR activities into the ongoing efforts of the UA 4-H efforts rather than as a 'stand-alone' effort. He leveraged the virtual 4-H summer programs to incorporate some SBAR content. He is developing a STEM Ambassador program and is working with Brassill to translate what were *'Project Puente'* internships into a 4-H internship program. All of these are larger 4-H STEM efforts, but represent a vehicle to incorporate SBAR work into the activities as well as build the infrastructure needed for continued work after the grant period is over.

In NM, Rodriguez-Uribe 's work directly with youth groups also had to stop because of COVID so she too has focused on lesson development specifically for the partnership with FFA in Las Cruces. Evaluation activities included initial review and iterative feedback of lesson plans, videos and powerpoints as they are being developed. The AZ and NM teams are working more closely together now, thanks in part to meetings every two weeks, and they are also prioritizing website development during Q4 2020.

Track Grower Extension Team Activities Monthly:
I am working with the grower focused extension team on a process for how to best capture their outreach efforts. They have agreed that the data collection tool previously developed does work for the larger outreach events and when they attend conferences and tabling events, but what is proving more difficult to capture are the 'one-off' points of contact that sometimes occur through chance meetings, email exchanges or phone calls. We initially tried to collect data via emails but that has proven to be unsuccessful, so moving forward we have decided that the best approach will be a phone call every two weeks to those who are primarily focused on grower outreach to document any connections they have made during the prior two weeks.

Showcase Guar as Potential Crop in New Mexico:
All the plant samples were threshed from previous studies and yield data compiled and analyzed. Results were shared with the SBAR Project Directors. Guar information for SBAR website is being updated and will be shared within the guar extension group, then uploaded on the website in the coming months.

On-station demonstration trial on guar seeding density study is being conducted at Lyendecker Plant Science Center, Las Cruces, NM.

Two extension manuscripts as co-author are currently in internal peer review. Drafts were shared with the SBAR Project Directors. (1) Laje et al., Natural Products in the Desert Southwest: Guayule (*Parthenium argentatum*) and Guar (*Cyamopsis tetragonolobus*); (2) Khanal et al., Enterprise Budgets for Guar Production.

Guar Demonstration:
Due to the ongoing pandemic, it was agreed among the SBAR grower focus extension group that there will be no farmer field demonstrations conducted in summer 2020.

Develop Extension Programs and Reports for Guar/Guayule Demonstrations:
The enterprise budgets and narrative detailing costs and returns of guar and guayule have been drafted. Two publications (fact sheets) are currently under peer review by outside reviewers.

Extension bulletins (using needs assessment survey) to answer producer's questions on sustainability and production of guar and guayule are currently on hold due to insufficient data.

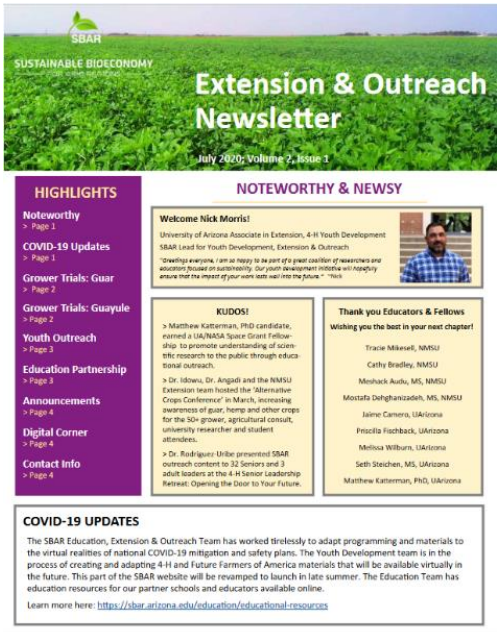
Travel to Conferences:
Nothing new to report.

Establish Guayule and Guar Trials in New Mexico:
Nothing new to report.

Establish On-Farm Demonstration Trials:
On-station N & P guar trial was harvested at one location (Clovis, NM). Harvesting of the other locations will take place within the next 3-4 weeks. There were some stresses observed during the mid-season for the guar trial at Las Cruces location. The leaves started turning pale yellow and drying out across the field. Micronutrients were applied as foliar spray, but we did not observe a full recovery. We will know from the yield data if the mid-season condition has affected the plot yields.

Host Guar-Focused Conference for Producers and Ag Professionals:
Information on SBAR guar research was presented on August 8th at the Tucumcari Agricultural Science Center Field Day. Information presented during this virtual field day included the cultivation practices for successfully growing guar in New Mexico and the activities of SBAR in relation to optimizing guar production in NM. About 300 people participated in this virtual field day.

Newsletter to Inform Stakeholders:
Release of Extension and Outreach Newsletter (volume 2, Issue 1): A newsletter to report the achievements of various SBAR items was released in July 2020. Information shared included the updates and results of guar in NM and guayule in AZ. Updates from Education and Youth Development teams were also presented in the newsletter.


SBAR
SUSTAINABLE BIOECONOMY
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NOTEWORTHY & NEWSY
Welcome Nick Morris!
University of Arizona Associate in Extension, 4-H Youth Development
SBAR Lead for Youth Development, Extension & Outreach
KUDOS!
Thank you Educators & Fellows
Wishing you the best in your next chapter!
COVID-19 UPDATES
The SBAR Education, Extension & Outreach Team has worked tirelessly to adapt programming and materials to the virtual realities of national COVID-19 mitigation and safety plans. The Youth Development team is in the process of creating and adapting 4-H and Future Farmers of America materials that will be available virtually in the future. This part of the SBAR website will be revamped to launch in late summer. The Education Team has education resources for our partner schools and educators available online.
Learn more here: https://sbar.arizona.edu/education/educational-resources

Figure 18. *Extension and Outreach Newsletter (vol 2:1) is available on the SBAR website.*

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

Interactive Farm-Level Economic and Financial Model (Guar and Guayule):
Basic model functionality is complete for this version, validating calculations, and working with Economic Team to update field-level inputs and field operations for all crops. Harvesting operations for guayule has changed significantly and we are researching other methods of harvest.

Continue to add and update relevant extension model scenarios and data. Now working on adding adjusted harvest information and cost.

Informational Tools for Driving Profitability/Feasibility of Crop Adoption in AZ & NM:
Continue to work with AZ and NM Extension team, with the inclusion of new hemp and fallow crop options with the current baseline crops (wheat, alfalfa, corn, cotton, etc.) for whole farm analysis to be used in the presentations during the extension/outreach activities. Future of this task depends on COVID-19 restrictions and preferred delivery methods. One Extension publication for New Mexico should be out soon with Arizona following.

Dissemination of Guayule and Guar Economic Information through Extension Meetings:
Working with the Economic Team to confirm meeting dates for online presentations. Was not able to schedule participate in any of the extension activities this past quarter but will be able to provide some base information this spring. Future of in-person presentations depends on COVID-19 virus restrictions. However, we are exploring all on-line options but now looking into the fall for delivery and have an online workshop set for October 15th.

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 Aug 20
2 Angadi	Educate local growers	Establish guar demonstration on a local farmer's field	15 Jul 20
1 Evan	Hold workshops and present information to growers in Arizona	Host two presentations on guayule agronomic production and irrigation at regional extension events Present guayule production to Native American farming communities Collect needs assessment information directly from Native American farming communities	31 Aug 20 31 Aug 20 31 Aug 20
2 Grover	Hold workshops and present information to growers	Host 2 presentations on guar agronomic production as an interim step to bulletin Present SBAR project information and materials	31 Aug 20 31 Aug 20

Educate Local Producers about Guar:
Center and college administration decided to cancel annual field day due to COVID restrictions. We are working on guar web page in collaboration with Drs. Idowu and Grover.

Establish Farm Demonstration Site in New Mexico:
We could not recruit farmers to conduct a field scale demonstration of guar in 2020 due to COVID and extremely dry season. We will make an effort to conduct demonstrations in 2021.

Grower Workshops in Arizona:
UA Cooperative Extension is slowly phasing each county back into programs. Extension events are planned for October and will be the first major events since the COVID lockdown.

Native American communities still lack interest in guayule have seen exceptionally high impacts from COVID-19, which further complicates our ability to deliver information.

All in-person meetings in Arizona have been cancelled until further notice per university guidelines. This has stopped our ability to meet with growers and ag professionals to discuss SBAR related topics. Unless something changes, there will no likely be any additional meetings this grant year.

Grower Workshops in New Mexico:
An abstract was published and oral presentation delivered on guar at Western Crop Science Society of America 2020 Virtual Conference in July 2020.

A field event and presentation on guar production and SBAR project was delivered to undergraduate students of *Sustainable Crop Production* (AGRO 483) class. (Total = 15 students)

Two students were taught *Special Problems/Special Topics* (AGRO 449/AGRO 500), where the students participated in hands-on research work in the SBAR guar project. (Total = 2 students)

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

Task #	Description of Task	Deliverable	Target Completion Date
1 Gutierr	Develop/improve SBAR 4-H Camp curriculum	Adapt camp curriculum for use in NM (train-the-trainer and FFA STEM curriculum)	31 May 20
2 Gutierr	School enrichment and 4H Camp/FFA activities	Plan/Host 6 SBAR Day camps targeting Hispanic and Native youth	31 Aug 20
		Plan/Host 15 SBAR school enrichment events	31 Aug 20
		Host a train-the-trainer camp for 4H Agents and teachers	31 Aug 20
		FFA Science Fair: Promote SBAR curriculum use	30 Jun 20

3 Morris	Adapt existing curriculum for 4H program	Two existing 4H curricula adapted for SBAR topics (bioeconomy)	1 Jun 20
4 Morris	Develop county level STEM Ambassador Program (SBAR-related)	Host focus group meeting with STEM Camp Counselors in June Ambassador guidebook for county implementation	31 Aug 20 31 Aug 20
5 Morris	Design STEM volunteer training program; recruit volunteers	Recruit 5 STEM certified volunteers Host 3 STEM volunteer trainings	30 Apr 20 30 Apr 20
6 Morris	Develop STEM internship program plan, recruitment plan, evaluation plan	Completed internship program plan, recruitment plan, and evaluation plan	30 Sep 20
7 Rock	Develop SBAR internal factsheets on *Project Puente*	Generate *Project Puente* resource document(s) for SBAR faculty	28 Feb 20
8 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	1 May 20 1 May 20
9 Rock	Recruit faculty mentors for summer *Project Puente* internships	Recruit 5 faculty mentors for Yr3 cohort of *Project Puente* interns	1 May 20
10 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	26 Jul 20 31 Aug 20
11 Rock	*Project Puente* case study video	Design and develop short video highlighting student/mentor experiences for future training needs	31 Aug 20

Adapt SBAR Curriculum for 4-H and FFA Camps:
Modules have been identified; currently under development.
Three PPT presentations have been created as support materials for the SBAR/FFA Lesson plans. The second SBAR/FFA lesson has been completed (*Thin Layer Chromatography (TLC) of Pigments from Chile Peppers*), along with the supporting materials.

SBAR 4-H Day Camps or Mini-Camps:
Submitted write-up of the NMSU/SBAR/E&O outreach 4-H Project Day and 4-H Leadership Retreat (Opening the Door to Your Future) activities for the July 2020 SBAR Extension & Outreach Newsletter.

Participated in the SBAR 2020 virtual retreat with the oral presentation, “Achievements of the SBAR Extension and Outreach team in New Mexico.”

Participated in meetings for the planning and discussions of the SBAR/YD website development. Updated the education excel spreadsheet with the lessons and activities currently in development.

Attended a graduate research zoom meeting with Dr. Stephanie Bestelmeyer, Executive Director of the nonprofit, Asombro Institute for Science Education in Las Cruces. The Asombro Institute provides hands-on science education programs for more than 20,000 K-12 students each year in classrooms, schoolyards, and at their Chihuahuan Desert Nature Park. There is a possibility of a future collaboration between NMSU SBAR and Asombro Institute for Science Education.

Adapt Existing Curriculum for 4H Program:
This has been slower than intended, but in continual progress. Team of 4-H curriculum writers have determined to incorporate the selected SBAR lessons into a larger more complete program for increased sustainability of the work.

We’ve changed the curriculum structure to include the three original SBAR lessons, but expand the overall experience to fit the 4-H program context and overall program needs.

Discover 4-H Arid Lands (10 lessons totals)
The Discover 4-H Arid Lands curriculum explores the intersections of ecology, culture, and agriculture in arid regions. Three units cover these topics from historical, contemporary, and future/sustainability perspectives. The curriculum is designed to be offered in an afterschool setting for middle school youth and comes with extension activities such as field trips and enrichment resources. A new committee of staff and tribal community partners is finalizing the three history lessons.

- History: Ecology, Culture and Agriculture
- Contemporary: Ecology, Culture and Agriculture
- Sustainability: Ecology, Culture and Agriculture

Develop County-Level STEM Ambassador Program (SBAR-related):
Training has been delayed due to National STEM Challenge conflict, and is now tentatively set for November 14th. This delay is an extension of the challenges we are facing with implementing Statewide STEM programming on a virtual platform.

Ambassador program expectations have been determined and outreach activities have begun. STEM Camp Youth STEM counselors have been notified of the opportunity. Seven youth STEM counselors from Greenlee, Maricopa, Pinal, Santa Cruz, and Yuma counties have gone through

skills training and leadership experience during two virtual camps. These youth are being recruited for the county STEM Ambassador program.

A new committee of staff will meet during the week of October 19th to finalize the training plan and determine final details for program implementation. In addition to staff, this committee will also include our newly inducted State STEM Ambassador youth. The youth will be trained in the demonstration and engagement of a guar bubble activity and a hands-on plant science pollination activity suitable for public outreach.

Design STEM Volunteer Training Program; Recruit Volunteers:
As of July 14th, two volunteer STEM trainings have occurred, and a third training is scheduled for November 14th.

Four volunteers (one each from Santa Cruz County, Pinal County, San Carlos Apache Tribe, and Hopi Tribe) participated in skills training and helped lead the Arizona 4-H Summit STEM programming and now have finished training for the AR Floating Farm virtual camp now. These adults and others will participate in a volunteer program held in November focused on the SBAR curriculum guidance and supervision of country-level STEM Ambassadors.

Develop STEM Internship Program, Recruitment, and Evaluation Plans:
Working with Brassill to combine the former *Project Puente* internship into a new 4-H SBAR Internship program. The intention for this collaboration is to create a pipeline from one to the other and ensure that there is a sustainability plan for the opportunity to survive beyond the end of the funded SBAR timeframe.

Continuing to recruit potential hosts and student mentors. In addition to the contacts made and shared in the last quarterly report, we are planning internships with Shamrock Farms and Cooperative Extension researchers.

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

Project Puente Internship Recruitment:
As stated in previous reports of 2020, during the last two reporting periods the extension team has continued to work to recruit additional SBAR faculty to participate in *Project Puente* for Summer of 2020. Part of our 2020 goals was to develop new resource documents for SBAR faculty on expectations of mentors, expectations of students, timelines, reporting structure, among other topics. We will also create a short PowerPoint presentation 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. Our initial goal was to increase participation to a total 6 student interns and associated SBAR faculty to participate in the project in year three. Additionally, at the culmination of year three, the extension team planned to create a short case study video to highlight the success of the program for broad dissemination.

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

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: Ongoing modifications to public school course delivery methods have limited fellow participation in classroom/afterschool activities and created the need to shift goals. Las Cruces Public Schools went from planning to be hybrid in the fall, to being remote the first half of the fall then hybrid, to being remote the entire fall semester. Teachers have had to spend extra time and energy on coordinating lessons across the district to teach new content and to meet standards, learning to use the Canvas delivery platform, and tracking/encouraging student participation. As such, little has been feasible to do in terms of SBAR lesson implementation.

In September, the EEO team decided to delay recruitment of teachers for remote participation until at least the spring, to give time to populate the five themes with complete lessons and to gauge the level of participation possible with teaching format decisions.

Brewer led a team preparing a large proposal in Q3 that occupied most of her time and led to insufficient communication. In Q4, she will reprioritize time to catch up with the NM fellows, in particular working with Usrey to put together theme 5 to meet the end of semester goals.

Chavarria: COVID has impacted program delivery. More details are provided in the narrative descriptions for specific tasks.

Fields: Because of the dramatic change in program delivery, much time was spent refocusing on the new program strategy under COVID this quarter. This has caused the annual evaluation report to be delayed; I will focus on completing the report in the next quarter.

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 Brewer	Supervise/Assist NM SBAR Fellows and Teacher Mentors through 2019-2020 school year	Design/deliver after school program for middle school Design/vet STEM activities	31 May 20 31 May 20
2 Brewer	Recruit and train SBAR Fellows and Teachers for 2020-2021 school year	Identify 4 new NM SBAR Fellows and any replacements, as necessary	31 Jul 20

		Identify 4 new NM SBAR Middle school teachers	31 Jul 20
3 Chav	Plan/Design/Coordinate Fall 2019 and Spring 2020 SBAR Fellow seminar	Plan Fall 2019 seminar content Plan Spring 2020 seminar content Generate education products on SBAR Fellow activities (digital publications)	31 Aug 19 31 Dec 19 31 Jul 20
4 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
4 Chav	Visit classrooms for observations (delivery of SBAR content)	Implement Fall teacher observation Implement Fall SBAR Fellow observation Implement Spring teacher observation Implement Spring SBAR Fellow observation	30 Nov 19 30 Nov 19 30 Apr 20 30 Apr 20
5 Chav	Recruit for summer Teacher Professional Development	Plan/develop itinerary for summer PD session Recruit 10+ teachers	31 Jan 20 30 Apr 20
6 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 19 31 May 20 31 Jul 20 31 Aug 20

Assist NM SBAR Fellows and Teacher Mentors (2019-2020):
Activities for this task are complete. Nothing new to report.

Recruit and Train SBAR Fellows and Teachers (2020-2021):
The two NM fellows (Singh and Pruitt) have been working with their respective partner teachers (Strand and Daugherty) to assist with remote science class learning as available. The purchased GoPro camera was used to record videos for sites and interviews.

Brewer met with the UA team in August and September to give input on the organization of current and future lessons into five themes, with the goal of having five complete lessons for each theme by the end of the fall semester for use by teachers remotely for spring 2021. Since the third NM fellow (Usrey) does not yet have NM teachers to support remotely, the 5th theme on chemistry, engineering, and technology was assigned to him. The focus of the fifth theme is to be on the production of bioproducts, to complement the third theme on the uses of bioproducts.

SBAR Fellow Seminar (Fall 2019 / Spring 2020):
Tasks completed; nothing new to report.

SBAR Fellow Seminar (Fall 2020 / Spring 2021):
The Fall 2020 semester is underway with a weekly Seminar course on Wednesdays from 1-2 pm. Brewer and NM SBAR Fellows have been invited to attend and are sent notes from each meeting.

Our COVID Pivot: In past years, Fellows have been paired with teachers to work in their classrooms. The Fellows have not been able to join in-person instruction under COVID restrictions. We have shifted from classroom time to developing virtual lessons and support. To support their digital content development work, a matrix of all lessons was created including those created by Rodriguez-Uribe for FFA and Morris for 4-H. The lessons have been related to five SBAR Themes.

1. Arid Lands, Agriculture & Sustainability
   --Theme Manager: Karina Martinez
2. Land Use and Culture, Life Ways, Resiliency in Arid Regions
   --Theme Manager: Tina Andrew
3. Building Bioeconomy in Arid Regions
   --Theme Manager: Arisbeth Ibarra Nieblas
4. Sustainable Crops, Plant Science, Guar and Guayule in Arid Regions
   --Theme Manager: Tenzin Phakdon
5. Technology, Engineering, Chemistry for the Future
   --Theme Manager: Jacob Usrey and NM Fellows

Spanning these five themes, Ali Yaylali is the manager for Science Literacy, Language, Creative Writing, Argumentation, and Sense Making.

The focus of the Seminar has been:

- Exploration of the identified five themes.
- Fellows evaluating the lessons in the theme they manage
- Picking five lessons to best represent the theme
- Revising a lesson with feedback from a partner and Knox/Anderson

The SBAR Education team meets with Fellows weekly with additional one-on-one meetings with Knox and Anderson to support their work developing digital products. Revised lessons/products are posted on the Educational Resource page: https://sbar.arizona.edu/education/educational-resources.

Classroom Observations (Delivery of SBAR Content):
Knox and Anderson typically visit classrooms in the Fall semester to observe SBAR teachers and Fellows.

> *Our COVID Pivot:* The SBAR Fellows gave presentations to 4-H and we were able to observe them teaching digitally. Chavarria has met weekly with Hinton-Causey to explore ways to continue SBAR content at her school along with Andrew and Phakdon. Discussions are underway to find ways for SBAR Fellows and staff to present to Hinton-Causey's classes digitally.

The Education Team was able to observe Phakdon and Ibarra Nieblas present at the SBAR Annual Retreat in July. Upcoming additional opportunities include Ibarra Nieblas being selected to present at the AIChE K-12 STEM Outreach Competition Showcase.

Teacher Recruitment for Summer Professional Development:
Nothing new to report.

Design and Implement Classroom Evaluation Tools:
During the Q3 of 2020, due to the COVID pandemic, the majority of the EEO events that were originally intended to be in person have been canceled, and there have been limited virtual events. The decision to limit virtual events was made largely due to the heavy burden faced by education and outreach professionals to move their own events and classrooms to a virtual format, and there was a clear understanding that educators shouldn't be asked during the summer of 2020 in particular to take on additional professional development (as had been planned for the teachers) or activities. Therefore, the primary tasks related to the evaluation of the education components of the SBAR project in July were centered around transcribing and synthesizing focus group interview responses from teachers/fellows; participation in the annual retreat and review of session materials, and preparing evaluation data for a detailed presentation and discussion at the EEO 'post-retreat' meeting.

In August and September tasks primarily included participating in regular team meetings in order to understand plans for the coming year and create a new evaluation plan given not only the changes in activities but also the uncertainty moving forward for the foreseeable future; holding individual interviews with select project staff for additional understanding of evaluation needs; and doing a deep dive into reviewing curricular materials (five thematic areas, lessons, videos, storymaps, etc.), newsletters, presentations & reports, and website materials in development.

For the Education team, plans changed dramatically with the onset and continued presence of COVID and the way that it has impacted school-based learning. Efforts shifted exclusively to curriculum development. They have continued to work with fellows remotely, primarily on lesson design and the accompanying resources to support lessons, such as videos with researchers (they have five complete and are working on more), storymaps (2 complete) and powerpoint presentations.

The fellows are also beginning to produce additional videos that are about 'career connections', which is a piece of the project that teachers indicated that they have struggled a bit with, beyond

‘scientists and researchers.’ The team is working towards getting all of the finalized products posted on the website. They have approximately 60 lesson plans in some state of development, but over the last few months have organized around 5 themes that will work for teachers (i.e. fit within the constructs of the content they are required to teach and the new science standards) and provide a framework for incorporating the SBAR content.

They are focusing on creating five solid lessons, with complementary resources, for each of the thematic areas. The thematic areas include: 1) arid lands & sustainability; 2) land use, the culture of agriculture, and resiliency of arid lands; 3) bioeconomies and bioproducts in arid regions; 4) plant science and 5) biochemical processes and products. The team has hired on of the SBAR teachers to work throughout the summer on curriculum design, and has kept in contact with the other SBAR teachers, supporting them as possible. Most teachers are ‘drowning’ in the chaos that is happening with public schools due to COVID and so aren’t able to be as active with SBAR curriculum as they were during the prior two years.

Moving forward, the group is working on plans for promoting the SBAR lesson plans over the next two quarters. This will include presenting at regional education conferences and also working through the AZ youth development team, who has recruited teachers in nine different localities across AZ already. They are also exploring ways to promote the SBAR curriculum through the Tucson Regional Education Collaborative. The team continues to meet weekly with fellows, and although most of the fellows are engaged with curriculum design, one fellow continues to be actively engaged with the teacher and community.

Efforts have also been focused on examining the ways that the education, extension and youth development efforts are overlapping or building on each other overall, or in certain communities, or if they are happening largely in isolation. In eastern NM (Clovis area), progress is being made on connecting educators, extension specialists and the SBAR research community. The NM education team has recruited a new SBAR teacher in that area and he has visited the Clovis station and interacted with the research team on a few occasions to see the plots and the processes for harvesting. This teacher recently was awarded $20K to improve science education in the area and he plans to use SBAR as the content/context for that. He will work with Singh (graduate student) and Angadi to develop a longer-term relationship and educational experience for his students.

There is also a new extension specialist assigned to the area (Curry County, NM) who will work directly with the teacher, so this relationship/work will become a case study for the evaluation efforts during Q4 2020 and Q1 2021 to better understand the collective impact in this rural community that may be impacted by an SBAR bioeconomy. Another potential case study is emerging in Santa Rosa, AZ working with the Tohono O’Odham community. The SBAR teachers in that region are continuing to work directly with the graduate fellow and are combining informal and formal learning environments to continue to serve students even in the face of COVID. The teachers have asked for stronger connections with extension/outreach efforts, and the 4-H team at UA is in the process of developing a ‘cultural relevancy’ tool for volunteers and staff working with indigenous communities. This will provide another opportunity to look at a specific example of how the collaborative efforts of the team impact a rural community that primarily serves Native American students and community members.

Another way that the three 'prongs' of the EEO team have collaborated is on the bi-annual newsletter, with two editions being released to date (December 2019 and July 2020). They are beginning to collect information for the December 2020 edition. It is difficult/impossible to assess how many individuals have been reached by the newsletter. It is posted on the SBAR website, so there are analytics there for page views, but each person connected with the EEO team was asked to broadly distribute the newsletter to their own contacts, so while there are some proxies that could be collected for who and how many people it was sent to, there is no way to know who of those read the newsletter. However, the publication is an important vehicle for the team to collaborate around and to update the community about developments around not only the grower-focused findings, but also the supporting education and youth development activities and resources available to interested educators and communities.

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

Task #	Description of Task	Deliverable	Target Completion Date
1 Brewer	Develop/Offer train-the-trainer biofuels education program for 4-H agents/volunteers and teachers/fellows	Develop/Host 3-day summer train-the-trainer program at NMSU Recruit 4-H youth and GK-12 participants	31 Jul 20 31 Jul 20
2 Brewer	Create/Refine SBAR digital resources	Ready-to-use SBAR lesson and activity resources available on SBAR website	31 Aug 21
3 Chav	Edit Cohort 1 lessons and materials for online publication	Edit lessons Submit final lessons/activities for SBAR website and online publication	31 Oct 19 31 Dec 19
4 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 Cohort 2 summer support on lesson redesign for publication	30 Nov 19 30 Apr 20 31 May 20 31 Jul 20 31 Jul 20

Design and Implement Train-the-Trainer Education Program for 4-H Youth Development:
Due to COVID-19, the summer PD was cancelled. Nothing new to report.

Refine SBAR Digital Resources:
In the second half of the summer, one NM teacher (Bradley) completed revisions on two lesson plans, including considerations for adaption for students with special needs. One NM fellow (Rosalez) translated student handout and presentation materials into Spanish. These materials were shared with the team at UA for incorporation into the materials available through the website.

Cohort #1 Lessons and Materials:
All activities for this task are complete; nothing new to report.

Support Lesson Plan Design by Teacher-Fellow Partnerships:
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	31 Dec 19

Development of Education Opportunities:
This task is complete; nothing new to report.

AWARDS

Items appearing in blue font are new in this quarter.

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 2020

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. **Chen, 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.
3. **Chen, F.; Brewer, C.E. N.D.** *Conversion of protein-rick lignocellulosic wastes to bio-energy: review and recommendations for hydrolysis + fermentation and anaerobic digestion.* (In Review)
4. **Chen, 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.
5. **Chen, Y.; Neilson, J.W.; Kushwaha, P.; Maier, R.M.; Barberan, A. 2020.** Life-history strategies of soil microbial communities in an arid ecosystem. ISME J (International Society of Microbial Ecology Journal) https://doi.org/10.1038/s41396-020-00803-y
6. **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.
7. **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.
8. **Cheng, F.; Bayat, H.; Jena, U.; Brewer, C.E. ND.** Impact of feedstock composition on pyrolysis of low-cost, protein-rich lignocellulosic biomass: a review. *Journal of Analytical & Applied Pyrolysis*, revised, under review.
9. **Cheng, F.; Dehghanizadeh, M.; Audu, M.; Jarvis, J.M.; Holguin, F.O.; Brewer, C.E. ND.** Characterization and evaluation f guayule bagasse and processing residues as potential feedstock for biofuel and chemical production. *Industrial Crop & Products*, in revision.
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*, 105989. https://doi.org/10.1016/j.dib.2020.105989.
11. **Dehghanizadeh, M.; Mendoza-Moreno, P.; Sproul, E.; Bayat, H.; Quinn, J.; Brewer, C.E. N.D.** *Guayule (Parthenium argentatum) resin: A review of chemistry, extraction techniques and applications*. (In Review)

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. **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.
15. **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
16. **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.
17. **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.
18. **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.2020.113082
19. **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
20. **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. N.D.** Economic and Environmental Analyses of Incorporating Guar into the American Southwest Agricultural Systems. (In Review)
21. **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.
22. **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.** Integrating Environmental and Social Impacts into Optimal Design of Guayule and Guar Supply Chains. *Computers and Chemical Engineering*. (In Review)

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. **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.

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.

Scholarly Presentations

1. **Angadi, S.V. 2018.** *Sustainable Bio-economy for Arid Regions: Growing Guar.* Extension Field Day. Clovis, New Mexico. 9 August.
2. **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.
3. **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.
4. **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.
5. **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.
6. **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.

7. **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.
8. **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.
9. **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]
10. **Brewer, C.E. 2018**. *Pairing biomass residues with conversion technologies*. Advanced Bioeconomy Leadership Conference, Washington, D.C. 28 February.
11. **Brewer, C.E. 2018**. *Polymerization and guar gum bubbles*. Outreach event activity. New Mexico 4-H State Conference. 11 July.
12. **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.
13. **Brown, K.S. 2020.** *Soil chemistry … and other topics*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 25 March.
14. **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]
15. **Brown, K.S.*; Neilson, J.W. 2018.** *Microbial contributions*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. April.
16. **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]
17. **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]
18. **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.
19. **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.
20. **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.
21. **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.

22. **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.
23. **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.
24. **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.
25. **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.
26. **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]
27. **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.
28. **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.
29. **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]
30. **El-Shikha, D.E.M. 2018.** *Update – Guayule irrigation experiments at Maricopa Agricultural Center*. SBAR UA Research Team Seminar Series, Tucson, Arizona. 12 September.
31. **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]
32. **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]
33. **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]

34. **Evancho, B. 2018.** *Guayule Fuels the Future*. IES – Energy Talks Seminar, Sky Bar, Tucson, Arizona. 9 October.
35. **Evancho, B. 2019.** *Guayule: How Close Are We?* Marana Winter Field Crops Clinic. Marana, Arizona. 10 January.
36. **Evancho, B. 2019.** *Guayule: How Close Are We?* Casa Grande Winter Field Crops Clinic. Casa Grande, Arizona. 15 January.
37. **Evancho, B. 2019.** *Comparing direct-seeded and transplanted guayule roots*. SBAR UA Research Team Seminar, University of Arizona, Tucson, Arizona. 13 November.
38. **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.
39. **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.
40. **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]
41. **Fan, N. 2018.** *Review on Optimization Methods for Biomass Supply Chain*. SBAR UA Research Team Seminar. University of Arizona, Tucson, Arizona. 28 November.
42. **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.
43. **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.
44. **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]
45. **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.
46. **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.
47. **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.
48. **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]
49. **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.

50. **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]
51. **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.
52. **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.
53. **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]
54. **Godfrey, D.J; Bennett, M.C.*; Willmon, J.; Waltz, Q.; Coronado, G.; Teetor, V.H.; Schmalzel, C.; Ray, D.T. 2018**. *Vegetative propagation of Parthenium argentatum (Guayule).* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 2 August. [poster] Won first place for undergraduate posters.
55. **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.
56. **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]
57. **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]
58. **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.
59. **Grover, K. 2018.** *Sustainable agriculture and guar production in New Mexico*. New Mexico State 4-H Conference, Las Cruces, New Mexico. 10 July.
60. **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.
61. **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.
62. **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.
63. **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.

64. **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.
65. **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.
66. **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]
67. **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.
68. **Grover, K. 2019.** *Guar: A potential alternative crop in New Mexico*. New Mexico Master Gardener's Meeting. Las Cruces, New Mexico. 8 May.
69. **Grover, K. 2019.** *Guar as an alternative crop in New Mexico*. New Mexico Sustainable Agriculture Field Day. Las Cruces, New Mexico. 26 June.
70. **Grover, K. 2019.** *Guar as an alternative crop in New Mexico*. SBAR Train-the-Trainer Workshop. Las Cruces, New Mexico. 2 July.
71. **Grover, K. 2019.** *Guar as an alternative crop in New Mexico*. SBAR Train-the-Trainer Workshop, Las Cruces, New Mexico. 2 July.
72. **Grover, K. 2019.** *Guar research and extension program in New Mexico*. Departmental External Review, Las Cruces, New Mexico. 10 October.
73. **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]
74. **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]
75. **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]
76. **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]
77. **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]
78. **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]
79. **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.
80. **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.

81. **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.
82. **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.
83. **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.
84. **Hoare, D.M. 2018.** *Irrigation Sensors and the WINDS Model.* SBAR UA Research Team Seminar Series, Tucson, Arizona. 26 September.
85. **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]
86. **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.
87. **Idowu, O.J. 2018.** *Introduction to the SBAR Project*. Las Cruces, New Mexico. 6 Feb.
88. **Idowu, O.J. 2018.** *Sustainable Bio-economy for Arid Regions: Update*. Extension Field Day, Clovis, New Mexico. 9 August.
89. **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.
90. **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.
91. **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.
92. **Katterman, M. 2020.** *Guayule sensor and irrigation modeling + SBAR Education update*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 18 March.
93. **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.
94. **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]
95. **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.
96. **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]

97. **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]
98. **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.
99. **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]
100. **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.
101. **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]
102. **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.
103. **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]
104. **Lewis, M. 2019.** *Salt stress tolerance in guayule*. SBAR UA Research Team Seminar, University of Arizona, Tucson, Arizona. 23 October.
105. **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]
106. **Lohr, P. 2020.** *AquaCrop modeling of guayule*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 5 February.
107. **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.
108. **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.
109. **Lopez, E.*; Fox, S.; Brewer, C.E. 2018.** *GK-12 Lesson Documentation Spreadsheet*. American Institute of Chemical Engineers Annual Meeting, Pittsburg, Pennsylvania. 29 October.
110. **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.

111. **Maqsood, H. 2018.** *Guar Crop Coefficient Development for New Mexico Environments*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 7 November.
112. **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.
113. **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]
114. **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.
115. **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]
116. **McCloskey, W. 2018.** *Weed Trial Results for Guayule*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 14 November.
117. **McCloskey, W. 2019.** *Guayule Weed Control Research.* The 9th Annual Central Arizona Farmer Field Day. Maricopa Agricultural Center (MAC), Maricopa, Arizona. 8 October.
118. **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.
119. **McMahan, C. 2018.** *Flowering Reduction in Guayule*. SBAR UA Research Team Seminar Series, Tucson, Arizona. 19 September.
120. **McMahan, C. 2019.** *USDA-ARS Rubber Lab Update*. SBAR UA Research Team Seminar Series, Tucson, Arizona. 27 March.
121. **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]
122. **McMahan, C.*; Placido, D.; Resendiz, M.; Ponciano, G. 2020.** Flowering downregulation in guayule. Update to SBAR Advisory Board. Online presentation. 12 February.
123. **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.
124. **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.
125. **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]

126. **Mealing, V. 2019.** *Field Data Collection and Integration*. SBAR System Performance and Sustainability Seminar, Colorado State University, Golden, Colorado. 13 November.
127. **Mealing, V. 2020.** *Field data collection update*. SBAR System Performance and Sustainability Seminar, Colorado State University, Golden, Colorado. 19 February.
128. **Mealing, V. 2020.** *Field data integration update*. SBAR System Performance and Sustainability Seminar, Colorado State University, Golden, Colorado. 25 June.
129. **Mealing, V. 2020.** *A framework for assessing the social sustainability of guar agriculture.* Congress on Sustainability and Engineering (ICOSSE) (virtual). Golden, Colorado. 3 August.
130. **Mealing, V. 2020.** *Towards a holistic sustainability assessment of guar and guayule*. SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
131. **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.
132. **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.
133. **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.
134. **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]
135. **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]
136. **Mealing, V.S.*; Landis, A.E. 2019.** *SBAR Sustainability.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
137. **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.
138. **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.
139. **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]
140. **Morris, N. 2020.** *SBAR 4-H opportunities and future directions*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 19 February.
141. **Morris, N. 2020.** *Arizona 4-H SBAR Capacity Building: Outcomes, progress, and plans.* SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.

142. **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]
143. **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.
144. **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.
145. **Niu, D., 2018.** *Partial cloning of APETALA1 (AP1) gene from guayule*. cDNA Lab Seminar, USDA-ARS Western Regional Research Laboratory. 28 March.
146. **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]
147. **Ogden, K. 2017.** *Sustainable Bioeconomy for Arid Regions*. Biomass Research and Development Technical Advisory Board Meeting. 15 November. [invited speaker]
148. **Ogden, K. 2018.** *Sustainable Bio-economy for Arid Regions*. Southwest Indian Agricultural Association Annual Meeting. Laughlin, Nevada. 16-18 January.
149. **Ogden, K. 2018.** *Potential of the Bioproducts and Biofuels Economy*. AIChE Annual Meeting, Pittsburg, Pennsylvania. October [invited speaker]
150. **Ogden, K. 2020.** *Sustainable Bioeconomy for Arid Regions.* Grain Processing Lecture Series, Michigan Technological University, Houghton, Michigan. 17 January [invited speaker]
151. **Ogden, K. 2020.** *SBAR Project Update.* Southwest Indian Agriculture Association (SWIAA) 32nd Annual Conference, Laughlin, Nevada. 20-23 January [invited speaker]
152. **Ogden, K. 2020.** *Sustainable Bioeconomy for Arid Regions.* University of Utah, Salt Lake, Utah. 2 March. [invited distinguished lecturer]
153. **Ogden, K.*, White, R., Brewer, C.E. 2018.** *Public Private Partnerships*. ABLC Conference. Washington, D.C. 27-28 February.
154. **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]
155. **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.
156. **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.
157. **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]
158. **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.

159. **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.
160. **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.
161. **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.
162. **Resendiz, M. 2020.** *Flowering downregulation of Parthenium argentatum*. USDA-ARS Lab Meeting, Albany, California. 14 May.
163. **Resendiz, M. 2020.** *Downregulation of floral identity genes in Parthenium argentatum*. SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
164. **Rock, C.*, Brassill, N. 2018.** *Importance of Cooperative Extension in University Research*. University of Arizona, Tucson, Arizona. 14 March.
165. **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]
166. **Rogstad, A**. **2019**. *SBAR Overview*. Association for the Advancement of Industrial Crops 31st Annual Meeting. Tucson, Arizona. 8 September. [invited speaker]
167. **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.
168. **Rodriguez-Uribe, L.*; Gutierrez, P. 2019.** *Implementing the Science of SBAR with Youth.* SBAR UA Research Team Seminar, University of Arizona, Tucson. 25 September.
169. **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.
170. **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]
171. **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.
172. **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.

173. **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.
174. **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]
175. **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.
176. **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.
177. **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]
178. **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.
179. **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.
180. **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.
181. **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.
182. **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]
183. **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]
184. **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.
185. **Smith, A. 2020.** *Valorization of guayule resin*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 22 April.
186. **Smith, A.*; Ogden, K. 2020.** *Vacuum distillation of guayule resin*. SBAR Annual Retreat (virtual). University of Arizona, Tucson, Arizona. 27-29 July.

187. **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]
188. **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.
189. **Sproul, E. 2020.** *Integrated Economic & Environmental Analysis of Guayule and Guar Production*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 22 January.
190. **Sproul, E. 2020.** Techno-economic analysis and life cycle assessment of guayule. SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
191. **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.
192. **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]
193. **Sun, O. 2018.** *GIS-Based Two-stage Stochastic Facility Location Considering Planting Plan Uncertainty*. INFORMS Annual Meeting, Phoenix, Arizona. 5 November.
194. **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.
195. **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.
196. **Sun, O. 2019.** *Biomass Supply Chain Configuration and Management*. SBAR UA Research Team Seminar. University of Arizona, Tucson, Arizona. 10 April.
197. **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.
198. **Sun, O.*; Fan, N. 2018.** *Harvest scheduling*. SBAR Logistics Team Group Meeting. (webinar) New Mexico State University. Las Cruces, New Mexico. 5 February.
199. **Sun, O.*; Fan, N. 2018.** *Optimization of feedstock logistics*. SBAR UA Research Seminar. University of Arizona. Tucson, Arizona. 14 February.
200. **Sun, O.*; Fan, N. 2018.** *Optimally locating biorefineries*. SBAR Sustainability Working Group Seminar. (webinar) Colorado State University. Lakewood, Colorado. 8 March.
201. **Summers, H. 2020.** *Techno-economic analysis and life cycle assessment of guar.* SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
202. **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.

203. **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.
204. **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.
205. **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.
206. **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.
207. **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.
208. **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.
209. **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]
210. **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.
211. **Waller, P. 2018.** *WINDS Model: A status report and connection to SBAR research*. SBAR UA Research Team Seminar Series, Tucson, Arizona. 10 October.
212. **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]
213. **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.
214. **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]
215. **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]
216. **Zuniga-Vasquez, D. 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]

217. **Zuniga-Vasquez, D. 2019.** *Stochastic scenarios for guayule production*. SBAR System Performance and Sustainability Seminar, Colorado State University, Fort Collins, Colorado. 8 October.
218. **Zuniga-Vasquez, D. 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.
219. **Zuniga-Vasquez, D. 2020.** *Optimization for guayule and guar logistics and transportation*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 8 April.
220. **Zuniga-Vasquez, D.*; Fan, N. 2020.** *Optimization for guayule and guar logistics and transportation*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 19 February.
221. **Zuniga-Vasquez, D.*; 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.
222. **Zuniga-Vasquez, D.*; 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.
223. **Zuniga-Vasquez, D.*; Fan, N. 2020.** *Smart farm production and scheduling design for guayule and guar*. SBAR Sustainability Team Meeting, University of Arizona, Tucson, Arizona. 30 September.
224. **Zuniga-Vasquez, D.*; Fan, N. 2020.** *Smart farm production and scheduling design for guayule and guar*. SBAR Research Team Meeting, University of Arizona, Tucson, Arizona. 30 September.
225. **Zuniga-Vasquez, D.*; 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	1,699	236	***1,935***
Females	791	121	***912***
Race/Ethnicity			
Hispanic	403	67	***470***
Asian	213	29	***242***
Native American	310	43	***353***
African American	63	10	***73***
Anglo/White	1,501	208	***1,709***

Audience Cumulative Total *(when captured)****: 2,847 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**. Provisional Patent UA21-25 – Adhesives.

4. **Sep 2020**. Provisional Patent 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

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.

→*Total Reach via Tabling Events and Workshops (when captured):* ***3,562 participants***

Note: Due to COVID-19 restrictions, in-person events have been on hiatus since March 2020.

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	433	40	***473***
Gender			
Males	834	24	***858***
Females	841	16	***857***
Race/Ethnicity			
Hispanic	893	3	***896***
Asian	33	0	***33***
Native American	159	24	***183***
African American	47	0	***47***
Anglo/White	538	5	***543***
Multiracial	6	8	***14***

Youth Cumulative Total *(when captured)****: 1,715 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 2020

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
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
Meshack Audu	*Graduate Student Fellow*	*Education* *Characterizations & Co-Products*
Valerie Bailey	*Undergrad Student*	*Feedstock Development & Production*
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 Carrero-Little	Undergrad Student	Characterizations & Co-Products
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*
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
F. Omar Holguin	Key Collaborator	Characterizations & Co-Products
John Idowu	Key Collaborator	Extension & Outreach
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*
Sicilee Macklin	*Undergrad Student*	*Education* *Characterizations & Co-Products*
Michael Mares	Undergrad Student	Extension & Outreach
Cesar Martinez-Bejarano	Undergrad Student	Characterizations & Co-Products
Frannie Miller	Professional	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
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*
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
Parameer 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*
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*
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*
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
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*
William McCloskey	Key Collaborator	Feedstock Development & Production
Wenzhe Mi	*Intern*	*Feedstock Development & Production*
Istvan Molnar	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
Zoe Scott	Undergrad Student	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*
Ya-ming Xu	Post-doc	Characterizations & Co-Products
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: ***36***
Total Active Postdoctoral Researchers: ***8***
Total Active Graduate Students: ***30***
Total Active Undergraduate Students: ***30***
Total Active Fellows: ***9***
Total Active /Interns: ***0***

*Total Active Participants:****129***
Total Past Participants (no longer active): ***101***
Total Individuals Involved Since SBAR Inception: ***230***

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 Agricultural Economics and Agricultural Business - Dept. of Chemical and Materials Engineering - Dept. of Plant and Environmental Sciences 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 - College of Agriculture and Life Sciences - College of Architecture, Planning and Landscape Architecture - College of Science - Institute of the Environment - 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. PUBLICATIONS

Documents Included

1. **Plant Guide for Guayule (*Parthenium argentatum*).** – Detailed plant description and guide for guayule available on the USDA-Natural Resources Conservation Service PLANTS Database. 2020. (3p)
2. **Extension and Outreach Newsletter (Volume 2, Issue 1) –** A biannual newsletter produced by the SBAR Education, Extension & Outreach (EEO) Teams. July 2020. (4p)

United States Department of Agriculture

Natural Resources Conservation Service Plant Guide

GUAYULE

Parthenium argentatum A. Gray

Plant Symbol = PAAR5

Common Names: guayule

Guayule. Photo by Blase Evancho. University of Arizona Cooperative Extension.

Description
General: Guayule is a perennial shrub with thick lignified stems, a low, spreading form, and an average height of approximately 20 inches (USDA, 1945). The leaves are greenish-grey and are covered with small hairs that aid in reducing evapotranspiration. Guayule has a deep, coarse taproot to collect water and nutrients from deep in the soil profile as well as a shallow fibrous system to collect moisture from brief desert rainfall (USDA, 1945; Muller, 1946). It flowers in the spring and through most of the summer months. The small, yellow composite flowers formed at the end of a stem are approximately 6 inches long. Reproduction is by facultative apomixis or sexual reproduction and results in small seeds, 0.12 inches long and 0.06 inches wide, of relatively low viability (Lloyd, 1911).

Distribution: Native guayule stands are distributed throughout the northeastern parts of the Chihuahuan Desert from Mexico to the Big Bend region of Texas. For current distribution, please consult the Plant Profile page for this species on the PLANTS Website.

Habitat: Guayule is frequently found in the foothills and hillslopes of the transitional zone between desert and desert grassland regions. It prefers shallow, sandy soils formed from limestone where it has the highest competitive advantage over other flora (Lloyd, 1911).

Adaptation
Guayule is a long lived, desert adapted shrub but requires more water than associated desert vegetation for active growth (Muller, 1946). During temperature or drought stress, it enters a semi-dormant state characterized by darker, grayer leaves and a lack of vegetative growth (Lloyd, 1911). Reduced metabolic periods are also seen in cultivated stands during the hottest and coldest parts of the year (Lloyd, 1911).

Uses
Guayule accumulates large amounts of natural rubber in its stems. Rubber production is the economic driver for its cultivation (Muller, 1946; Rasutis et. al., 2015). Globally, the main contributor to commercial natural rubber production is the Pará rubber tree (*Hevea brasiliensis*) (The Editors of Encyclopaedia Britannica, 2020). Pará tree plantations, made-up of genetically identical clones, cannot be harvested mechanically and are genetically fragile due to their lack of genetic diversity (Sethuraj and Mathew, 1992). Guayule fields are established with genetically diverse seed and can be harvested mechanically. Harvested materials are ground into bagasse, a fine wood pulp, and the solid rubber is chemically extracted from its cells (Rasutis et al., 2015).

Ethnobotany
Guayule use has been documented in Indigenous communities. Fangmeier et al. (1984) and Lloyd (1911) report that guayule stems were chewed to extract rubber particles which were then bound together to form a ball approximately twice the size of a baseball.

Status
Threatened or Endangered: No

Wetland Indicator: Guayule is an upland (UPL) species.

Weedy or Invasive: Guayule does not display invasive or weedy characteristics. Please consult with your local NRCS Field Office, Cooperative Extension Service office, state natural resource, or state agriculture department regarding its status and use.

Please consult the PLANTS Web site (http://plants.usda.gov/) and your state's Department of Natural Resources for this plant's current status (e.g., threatened or endangered species, state noxious status, and wetland indicator values).

Planting Guidelines
Plant guayule at a rate resulting in stand densities between 12,000 and 40,000 plants per acre (D. A. Dierig, personal communication, 5 June 2020). Foster and Coffelt (2005) recommend planting at a rate between 0.24 and 0.36 PLS (Pure Live Seed) pounds per acre. Seeding rate is highly variable and based on seed quality, planting equipment, soil type and local conditions.

Management
Guayule has two growth phases in a calendar year. In the warm season, guayule increases in biomass. In the cool season, rubber production is initiated and accumulates until spring. Harvest occurs after two to three years. During harvest, plants are cut nearly to the ground and the biomass is baled for rubber processing. After harvest, guayule sprouts back from the root stalk and supports another harvest cycle. Healthy guayule fields will be productive for at least two harvest cycles (Foster and Coffelt, 2005).

Pests and Potential Problems
Common pests of guayule during establishment are pale striped flea beetle and grasshoppers. Scout stands early and often for pests. Please contact your local agricultural extension specialist or county weed specialist to learn what works best in your area and how to use it safely. Always read label and safety instructions for each control method.

Environmental Concerns
None known.

Seeds and Plant Production
Guayule seed is planted in the spring or fall with a precision planter on well cultivated beds spaced 36-40 inches wide at a depth of ⅛ to ¼ inch. After planting, irrigate the furrows for 3-5 days for optimal germination and establishment. Sprinkler irrigation may be required on course textured soils or poorly prepared fields. Early season weed control is paramount. Use pre-emergent and post-emergent herbicide programs to control weeds. Please contact your local agricultural extension specialist or county weed specialist to learn what works best in your area and how to use it safely. Always read label and safety instructions for each control method. Once established, weeds will not outcompete guayule and will generally not require management. Reduce irrigation to approximately once a month during periods of active growth. Apply nutrients according to soil test results.

Commercial scale seed harvest is accomplished from spring through fall with a highly modified cotton picker. Seed can also be harvested by hand. Seed is cleaned with commercially available equipment used for small seeded plants. Seeds produced in the spring and fall generally have higher quality and germination rates than those produced in the heat of summer (Lloyd, 1911).

Cultivars, Improved, and Selected Materials (and area of origin)
Guayule breeding programs have existed since the late 1800's to develop varieties with increased rubber production but only incremental advances have been obtained. The variety grown commercially is AZ-2. It was selected for its increased biomass and rubber production compared to other lines (Ray et. al. 1999).

Literature Cited
Fangmeier, D. D., D. D. Rubis, B. B. Taylor and K. E. Foster. 1984. Guayule for Rubber Production in Arizona. University of Arizona Technical Bulletin 25. Tucson, AZ.

Foster, M. A., and T.A. Coffelt. 2005. Guayule Agronomics: Establishment, Irrigated Production, and Weed Control. Industrial Crops and Products 22 (1) 27-40.

Lloyd F. E. 1911. Guayule A Rubber-Plant of the Chihuahuan Desert. Carnegie Institute of Washington, Washington D. C.

Muller, C.H. 1946. Root Development and Ecological Relations of Guayule. USDA Technical Bulletin 923. U.S. Gov. Print Office, Washington, D.C.
Rasutis D., K. Soratana, C. McMahan, A. E. Landis. 2015. A Sustainability Review of Domestic Rubber from the Guayule Plant. Industrial Crops and Products 70 (1) 383-394.
Ray D. T, D. A. Dierig, A. E. Thompson and T. A. Coffelt. 1999. Registration of Six Guayule Germplasms with High Yielding Ability. Crop Science 39 (1) 300.
Sethuraj, M. R., and N. M. Mathew. 1992. Natural Rubber Biology, Cultivation, and Technology. Developments in Crop Science 23. Elsevier. Amsterdam, Netherlands.
The Editors of Encyclopaedia Britannica. 2020. Rubber Tree. [Online]. Available at https://www.britannica.com/plant/rubber-tree (accessed 6 June 2020). Encyclopaedia Britannica, Chicago, IL.
USDA-Forest Service. 1945. Soil-Guayule Relationships - The Salt Tolerance of Guayule, Emergency Rubber Project. U.S. Gov. Print Office, Washington, D.C.

Citation

Evancho, B. and H. Dial. 2020. Plant Guide for guayule (*Parthenium argentatum*). USDA-Natural Resources Conservation Service, Tucson Plant Materials Center. Tucson, AZ.

Published: October 2020

Edited:

For more information about this and other plants, please contact your local NRCS field office or Conservation District at http://www.nrcs.usda.gov/ and visit the PLANTS Web site at http://plants.usda.gov/ or the Plant Materials Program web site: http://plant-materials.nrcs.usda.gov.

PLANTS is not responsible for the content or availability of other Web sites.

Helping People Help the Land

SBAR

SUSTAINABLE BIOECONOMY FOR ARID REGIONS

Extension & Outreach Newsletter

July 2020; Volume 2, Issue 1

HIGHLIGHTS

NOTEWORTHY & NEWSY

Welcome Nick Morris!

University of Arizona Associate in Extension, 4-H Youth Development

SBAR Lead for Youth Development, Extension & Outreach

"Greetings everyone, I am so happy to be part of a great coalition of researchers and educators focused on sustainability. Our youth development initiative will hopefully ensure that the impact of your work lasts well into the future." ~Nick

KUDOS!

> Matthew Katterman, PhD candidate, earned a UA/NASA Space Grant Fellowship to promote understanding of scientific research to the public through educational outreach.

> Dr. Idowu, Dr. Angadi and the NMSU Extension team hosted the 'Alternative Crops Conference' in March, increasing awareness of guar, hemp and other crops for the 50+ grower, agricultural consult, university researcher and student attendees.

> Dr. Rodriguez-Uribe presented SBAR outreach content to 32 Seniors and 3 adult leaders at the 4-H Senior Leadership Retreat: Opening the Door to Your Future.

Thank you Educators & Fellows

Wishing you the best in your next chapter!

Tracie Mikesell, NMSU

Cathy Bradley, NMSU

Meshack Audu, MS, NMSU

Mostafa Dehghanizadeh, MS, NMSU

Jaime Camero, UArizona

Priscilla Fischback, UArizona

Melissa Wilburn, UArizona

Seth Steichen, MS, UArizona

Matthew Katterman, PhD, UArizona

COVID-19 UPDATES

The SBAR Education, Extension & Outreach Team has worked tirelessly to adapt programming and materials to the virtual realities of national COVID-19 mitigation and safety plans. The Youth Development team is in the process of creating and adapting 4-H and Future Farmers of America materials that will be available virtually in the future. This part of the SBAR website will be revamped to launch in late summer. The Education Team has education resources for our partner schools and educators available online.

Learn more here: https://sbar.arizona.edu/education/educational-resources

Grower Trials: Guar and Guayule Research Updates

Guar in New Mexico

Guar demonstration trials continue in New Mexico.

In 2019, we evaluated the effects of different rates of nitrogen and phosphorus on growth and yields of guar at four different locations of NMSU research centers in New Mexico. Kinman variety of guar was tested at all the locations. These sites were Leyendecker Plant Science Center in Las Cruces, Agricultural Science Center at Los Lunas, Agricultural Science Center at Clovis, and Agricultural Science Center at Tucumcari.

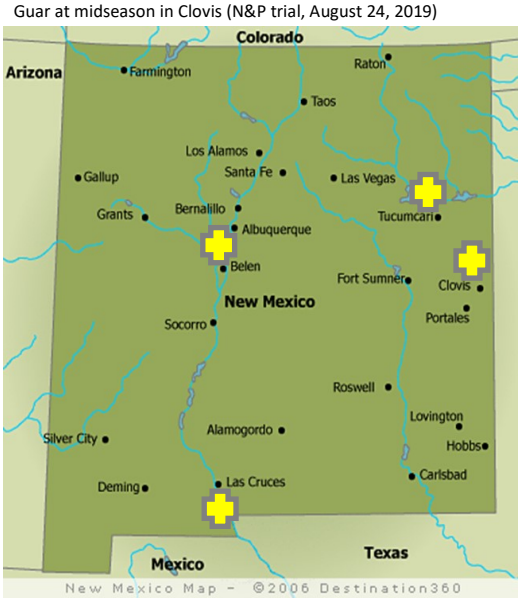
Three rates of nitrogen (0, 22.3, and 44.6 lb N/ac) and phosphorus (0, 22.3, and 44.6 lb P_2O_5/ac) were applied at all possible combinations to the soil at guar planting, which took place in June 2019 for Las Cruces, Clovis and Tucumcari, and July 2019 for Los Lunas site. The nitrogen fertilizer applied was Urea (45-0-0), while Triple Super Phosphate (0-45-0) was used as phosphorus fertilizer. Trials were harvested in November 2019 across the different locations.

Average guar yields across all treatments vary with location, with the Los Lunas site yielding lowest (566 lb/ac) presumably due to late planting of guar. Guar yield at Clovis site was highest (893 lb/ac) but it was not statistically different from the yield at Tucumcari (789 lb/ac). The yield at Las Cruces (760 lb/ac) was lower than the yields at Tucumcari and Clovis.

Generally, across all locations, the lowest yield occurred when no nitrogen or phosphorus were added to the soil, while the highest yield was recorded in plots with nitrogen at a rate of 22.3 lb/ac and phosphorus at a rate of 44.6 lb/ac.

Maximum plot yields of guar recorded were 685 lb/ac in Los Lunas; 1166 lb/ac in Las Cruces; 953 lb/ac in Tucumcari; and 1053 lb/ac in Clovis. This is an on-going study and the trial will be repeated in 2020 using the same treatments at the same locations. Other on-going research on guar in New Mexico include germplasm, seeding density and irrigation trials being conducted by Dr. Kulbhushan Grover and Dr. Sangu Angadi. Reports of these trials will be shared in future newsletters editions.

Guar at midseason in Clovis (N&P trial, August 24, 2019)



Denotes NMSU Science Center with guar trials

Guayule in Arizona

Denotes SBAR or Bridgestone plot with guayule trials

Even the best laid plans have been foiled by this pandemic. As we described in our last newsletter, SBAR researchers had many trials planned: a new irrigation trial, continued salt tolerance screening work, root structure work, and a nitrogen fertilizer trial. We had also planned to have another guayule grower field day at the Bridgestone research farm. Unfortunately, these projects were postponed to some degree by the pandemic. As COVID-19 mitigation practices begin to ease, we are proceeding with some trials, but others will be pushed into the fall and into next year. We hope to have more and clearer information available to you by this winter's newsletter.

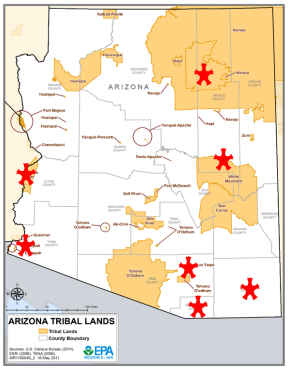
In contrast to these setbacks, Dr. Bill McCloskey's weed control trials were, fortunately, not affected by the COVID-19 pandemic. He installed field trials focusing on preemergent weed control in guayule. He is also working on how to control weeds in established guayule stands. This set of trials includes the effects of sequential applications of Aim herbicide and a comparison of how different spray adjuvants affect the efficacy of Aim in this production system. These trials will be key as we move toward commercial production of guayule to decrease the costs of stand establishment and to clean up any problems that may arise during its production.

Results from last year's guayule variety yield trial have been collected and are currently under analysis by the researchers at Bridgestone. These results will be available in the next few months and will be distributed in our next newsletter.

Initiatives and Recruiting

Above: Dr. Rodriguez-Uribe and 4-H Youth at NMSU Project Day

Above Left: 4-H Youth at UArizona; Above Right: 4-H Youth at NMSU



Above: locations of SBAR youth outreach initiatives in Arizona and New Mexico.

SBAR Collaborations with 4-H and FFA

We are expanding our outreach to youth by developing, revising and double-branding curriculum for both Future Farmers of American (FFA) and Regional 4-H that will be provided, initially, in New Mexico and Arizona. FFA and 4-H are traditional spaces for youth who have agricultural literacy and may serve in the future bioeconomy. Curriculum can be used by local branches for professionals and volunteers to support science literacy in youth.

SBAR at NMSU hosted workshops to share the science of SBAR.

The 4-H Project Day invited 6th – 8th graders to be scientists in the lab, testing antioxidant activity in guar seeds and guayule leaf extracts.

At the 4-H Leadership Retreat: Opening the Door to Your Future, Dr. Laura Rodriguez-Uribe led a workshop on designing methods to separate the components of complex mixtures. This workshop trained senior students and adult volunteers on SBAR curriculum.

SBAR at UArizona was active during the second annual AZ 4-H Summit. Dr. Kimberly Ogden and Dr. Dennis Ray presented to 4-H youth on the academic day. Four UArizona SBAR Fellows will be leading educational sessions on sustainability and plant science during the Science in Agriculture week at the end of July.

AZ 4-H staff, volunteers and STEM youth ambassadors will participate in the STEM Youniversity Greenhouse Camp in Fall 2020.

Volunteer Recruitment & Training: We are recruiting 4-H staff and volunteers in Arizona (see map to left) and FFA school staff and volunteers in New Mexico (see map on left). To learn more and get involved, contact Laura Rodriguez-Uribe (NMSU) or Nick Morris (UArizona).

SBAR Education Partnership

We are expanding our Education initiative by going statewide and virtual. SBAR curricula align with NGSS and focus on 5 main areas that connect to SBAR Research:

> Arid Lands, Agriculture & Sustainability

> Land Use, Farming & Culture in Arid Regions

> Building Bioeconomy in Arid Regions

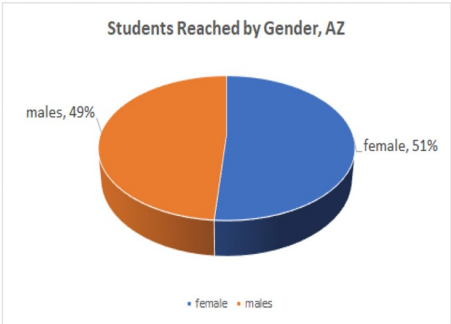
> Sustainable Crops: Guar & Guayule

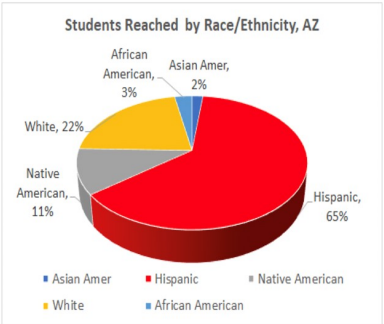
> Chemistry & Engineering

Students Receiving SBAR Curriculum (Schools)

Total Students: 550 AZ, 281+ NM

12 Schools AZ & NM





Educator Recruitment & Training

We are recruiting educators from across Arizona and New Mexico. SBAR curriculum, lesson supplies and graduate student Fellows will be available to all participating educators.

Professional Development (PD) is offered via UArizona and is fully online.

PD will provide asynchronous modules digitally for educators to train at their own pace, emphasize NGSS connections, and promote educator connections via list servs.

Check out the Digital Corner (page 4) for a link to the SBAR Story Map and more information. To sign up, contact Catie Brewer (NMSU) or Corey Knox (UArizona).

COMING SOON!

Guayule Field Day at Bridgestone Farm

Grower Event with Extension Agents and Operations Updates

Fall 2020

Contact: Blase Evancho

Recruiting: Growers

SBAR is seeking growers for trial plots of guar (NM) or guayule (AZ)

Available Spring 2021

Contact: John Idowu (Guar, NM)

Contact: Blase Evancho (Guayule, AZ)

Recruiting: Educators

SBAR is seeking educators for virtual partnership

Available Fall 2020

Contact: Catie Brewer (NM)

Contact: Corey Knox (AZ)

Recruiting: 4-H Volunteers

SBAR is seeking community members as 4-H volunteers

Available Fall 2020

Contact: Laura Rodriguez-Uribe (NM)

Contact: Nick Morris (AZ)

USDA Plant Guide on Guayule

Available Spring 2021

Contact: Blase Evancho

SBAR Plant Guide on Guar

Available Spring 2021

Contact: John Idowu

SBAR Whole Farm Analysis Tool

for Evaluating the Adoption of Guayule and Guar into Your Current Operation

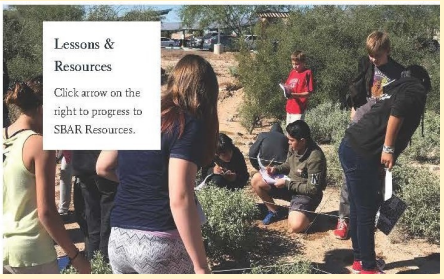
Available Spring 2021

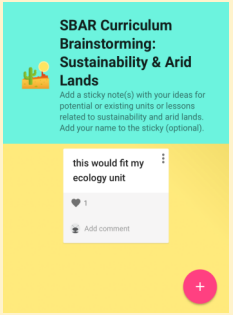
Contact: Trent Teegerstrom

EDUCATION DIGITAL CORNER

The SBAR Education Partnership offers a digital treasure trove of lessons, activities, videos and graduate students to support educators in creating and teaching arid regions themed lessons. Learn more from the interactive Story Map.

SBAR Story Map Orientation— created by Education Researcher Corey Knox, PhD





Images from SBAR Story Map

Educator Resources

·: Lesson Plans

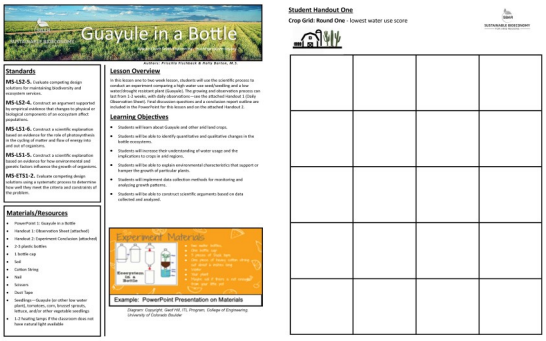
·: Power Point Presentations

·: "Explainer" Videos

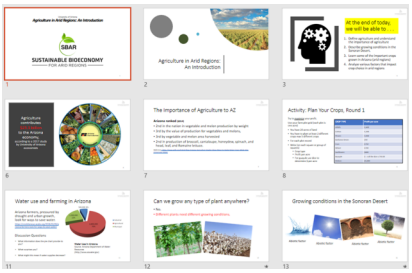
·: Activities

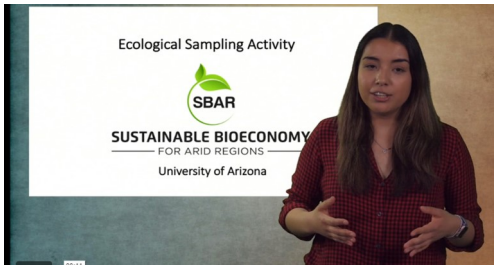
·: Career Interview Videos

·: Real time support from humans



Above: SBAR Lesson Plan (left) and companion classroom activity (right)





Above: SBAR lesson slides in Power Point (left) and lesson "explainer video" (right)

Above: SBAR "career interview" (left) and SBAR Educators, Fellows and UArizona Education Team in Sells, AZ (right)

Contact Our Team

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Any opinions, findings, conclusions or recommendations expressed in this publication/work are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.
Grant #: 2017-68005-26867