URSCA Research, BoTs and TEELS Grant Application

Grant Requirements and Responsibilities.
All required parties must sign the form below to indicate they have read and understand UVU's policies and procedures. The grantee must receive proper approval from the IRB if the project involves research concerning human subjects and will abide by all General Terms and Conditions of Grants*. Identifying any special terms and conditions at the outset is critical to assure appropriate post-award management of the grant. Acceptance of grant funds implies acceptance of these terms and conditions. Failure to comply will result in appropriate action relative to university policies and procedures. (e.g. if unauthorized funds are spent, those funds must be repaid through the grantee's department or school). **It is the PI and Mentor's responsibility to be aware of the funding timeline guidelines, requirements and restrictions, and that all funds not spent or encumbered by the June 30 deadline in accordance with grant policy will be forfeited and jeopardize future funding.**

***General Terms and Conditions of Grants**
Acceptance of a grant to conduct an approved project obligates the receiver to use the funds as specified in the approved grant application and within university policy, state and/or federal regulations. Any change in the scope or direction of an approved project must be reported to the Office of Engaged Learning prior to implementing the change.

It is important that the grantee put in place a sound plan for maintaining appropriate documentation of expenses and expenditures at the outset of a project. A plan for reporting project outcomes should be completed as early as possible in the project.

All grant funds are to be used by June 30 of the year the grant is awarded unless otherwise specified in the grant request. If funds are needed to span two academic years to facilitate summer activities this must be clearly stated, to include amount and timing of needed funds, ex; $500 in the current academic year and $500 in the following academic year to be used in the summer months. This applies to all funds including travel. Travel MUST be completed by June 30 and no later, to include all paperwork, authorizations etc. If it will not be completed or paperwork, concur, authorizations etc. will not be completed it will not be funded in the current year and needs to have funds requested for the summer months in the next academic year. Any activities the go beyond summer will require a new application to be considered for funding.

This form is to be used to apply for the Undergraduate Research, Scholarship, and Creative Activity (URSCA) Research, Board of Trustee's Engaged Learning Award (BoTs) or Turner Endowment for Stem (TEELS) funding.

Project Information

Grant Type (choose one): URSCA Research _x_ BoTs TEELS

Principal Investigator Name: (Last, First MI) __Bowen, Lacee___

UVID: _10720417___

Phone Number: __385-707-7898__

Email Address: _10720417@my.uvu.edu

Faculty Mentor: __Geoff Zahn____

Faculty Mentor email address: ___gzahn@uvu.edu

Individual or Team Request (choose one**):** Team Individual **x**__
IMPORTANT: If more than one student is working on the same project, students must apply as a team.

Date Submitted: _____

College (choose one):

UVU college of science

Department (choose one):

Biology department

Project Title:

Determining the effect of soil pathogens on plant root structure and growth.

Project Abstract: (criteria: 1. Project has clearly stated objectives and outcomes that can be readily evaluated.
2. Project includes a product that significantly contributes to scholarship or creative work within its discipline. Higher priority will be given to products subject to some aspect of professional peer review extending beyond the confines of UVU campus.
3. Proposal is well written and organized, offering clear background, context, and outcomes to show how the project fits into the overall discipline, and how it contributes to that discipline in a meaningful and novel way. The proposal needs to be written clearly for readers outside of your discipline.
4. Project requires rigorous e□ort at the advanced undergraduate level.
5. Level of support indicated in faculty recommendation letter. Letter should address rubric items.)

Root architecture is the geometric positioning of the roots of a plant in the dirt or medium surrounding the roots. It has been studied to help predict crop performance when exposed to outside variables such as nutrient limitation and pathogen pressure. These variables may affect plant root architecture, ultimately leading to negative results such as stunted growth, death of the plant, limited fruit/flower production, etc.. One major limitation in studying roots, however, has been the opacity of soil. Many studies have used solid transparent growth media to investigate root growth, but these are limited by how different these artificial soils are from real conditions. For this reason, there remains much that is not yet understood about the factors that shape root architecture. Beginning in Jan of 2020, we started to build upon a new technique to observe root growth in a more realistic, yet transparent, medium. We developed and successfully used a transparent soil that allows us to photograph plant roots while still maintaining common soil properties such as variable pore structure and microhabitats. This soil is specially designed to be as similar to real soil as possible while allowing photographic observations of growing roots.

This transparent soil gives us an excellent system to study several aspects of plant-soil-microbe interactions that are relevant to agriculture and natural products industries. The project we are proposing builds on our previous proof-of-concept work with this system to investigate how plant pathogens and beneficial microbes interact to physically alter plant root structure.

Previously, we were rewarded a SAC grant for this same project but were cut short before finishing as COVID 19 halted our time in the lab. We will take the methods and lessons learned from the project and continue to move forward with the progress we had made up until that point.

Purpose/Hypothesis? (What the project hopes to accomplish?)

The purpose of this study is to understand the effects that different pathogens have on root architecture, with and without the presence of beneficial microbes that live in close association with plant roots. We will perform the study on native pine seedlings as they are economically important and are known to rely heavily on mutualistic microbes. In particular, we aim to discover how these beneficial microbes help protect pine seedlings from pathogen-induced negative changes to root architecture, and how this can affect Utah pine colonization after fires.

Our results will add to the scientific understanding of how economically important plants can benefit from mutualistic microbes. They will shed light on the processes involved with root growth and carbon sequestration, especially when pathogens are present. Root architecture is an important component of plant community resilience to disturbance such as forest fires and climate change, as well as pathogen pressure. This study contributes important knowledge about how to alter root architecture to achieve industry goals.

Methodology (How the project will be conducted? If applicable, include details about data collection and data analysis, evaluation of project progress.)

Most of the methods in this project were previously described in SAC grant SHS051.

We will surface-sterilize our pine seeds remove any microbes present. We will then make transparent soil using magnesium chloride, MS solution, and gellan gum as before. Custom clear growth pots will be constructed from Petri dishes filled with transparent soil. Pine seeds will be germinated in sterile conditions and planted in these custom growth containers. After several weeks of growth under sterile conditions, plants will be moved to the greenhouse and treated with various microbial slurries (described in Table 1). Microbial species have been selected for their relevance to local pine populations: Pathogens: *Alternaria* and *Phytophthora*; Beneficial microbes: *Russula sp..* The fully-factorial design of our experiment will allow us to resolve the effects of these common economically damaging pathogens with and without the beneficial fungus.

All other environmental conditions (light, temperature, water) will be held constant for all treatments. Plants will be randomly spaced in the greenhouse to minimize microclimate variation between groups.

To test the effect of the various pathogens along with the effect of endophytes present, there will also be a sterile control plant group with no pathogens or endophytes present, as well as a control plant group with only the beneficial fungus present. We will take standardized photographs once each week during the first 3 months of plant growth and analyze root architecture through the ImageJ and R programs to compare branching patterns against our controls. Statistical analyses will consist of generalized linear regression models with the following response and predictor variables: Responses = total root system length, 1st-order root length, lateral root length, branching intensity, and branching angle; Predictors = Microbial community treatment (Table 1). Our weekly observations will allow time-series analyses for each of these components (see Figs 1 & 2).

1 plant species
Pinus sp.
6 microbial treatments
Pathogen 1 (Alternaria)
Pathogen 2 (Phytophthora)
Pathogen 1 + beneficial mycorrhizal fungus
Pathogen 2 + beneficial mycorrhizal fungus
Beneficial mycorrhizal fungi (no pathogens)
Sterile control

	No pathogen	**Pathogen 1**	**Pathogen 2**
Beneficial fungus	10 plants	10 plants	10 plants
No beneficial fungus	10 plants	10 plants	10 plants

Table 1 - Treatment groups and number of replicates

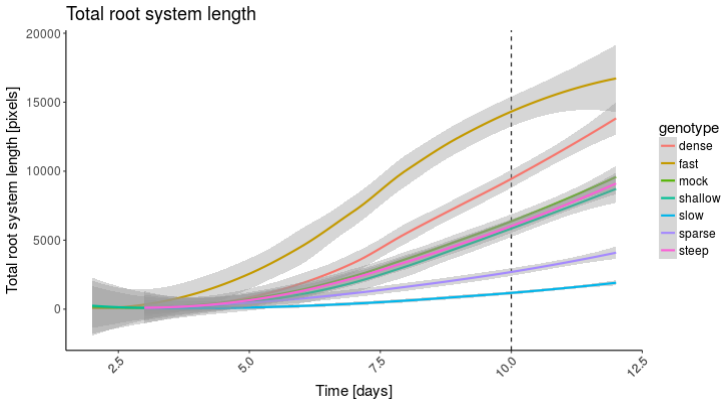

Fig 1 - Example of time-series model visualization

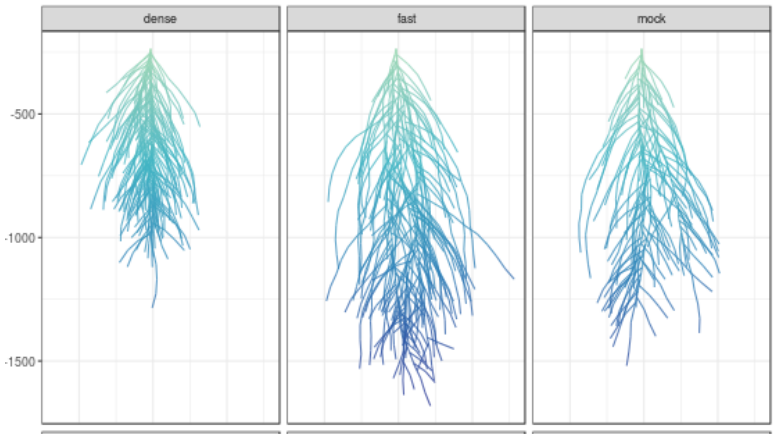

Fig 2 - Example of root architecture analysis

Dissemination (How do you plan to disseminate the results, ie: conference, paper, poster?)

We will present this research at UASAL as well as the UVU showcase. We will also write a journal article with our results to be submitted for peer review to *New Phytologist*. With the research done from our SAC grant, we learned how the project works, already made a bunch of mistakes, and have learned from them. We are confident that the research will be publishable once completed.

Discipline Importance (Please address how and why this project is meaningful to your discipline.)

The career that I am working toward completely revolves around lab work, so this experience is invaluable to my future. I will also be representing UVU as a female STEM student in research. I will be better connected with other professionals working in similar fields. Designing a project and publishing a paper will be an extreme benefit when applying for graduate schools. I also will gain knowledge in how to code using the programming language R.

Budget Request: **$2,000.00 Individual Project** $3,000.00 Team Project

Upload Budget Spreadsheet Here:_____

(You can access this document at: https://www.uvu.edu/undergrad-research/student-research/docs/grant_timeline_budget_and_support.xlsx). You **MUST** meet with your Financial Manager to approve your budget prior to them signing it. The first sections are designated for the student(s) to fill out while consulting the mentor.

International Travel

Is International travel required: (select one) Yes **No**

By selecting yes the Office for Global Engagement will be notified of your intent to travel. If you have any questions regarding the requirements for international travel, please contact Carlos Alarco at Carlos.Alarco@uvu.edu or visit uvu.edu/global/faculty/intravelreg.html.

IRB

Does this research require IRB approval? (Select one) Yes **No**

If you selected yes, what is your IRB protocol number? _____ (IRB applications are submitted via Axiom Mentor, for more information please see the uvu.edu/IRB webpage.

_____	_____	_____
PI Printed Name	PI Signature	Date

The below section is for Faculty Mentor use only

NOTE to MENTORS: In your statement of support below, please address the extent to which you believe the candidate can complete the project as described in the abstract. Please address the five criteria listed in the URSCA application: objectives clarity, project contribution to scholarship or creative work within its discipline, proposal organization, and rigorous efforts required at undergraduate level. In addition, **as a mentor, you are insuring that you are providing significant oversight and mentorship on the project and that it will be completed and funds will be expended as proposed**.

- Comment on the student's role in the proposal preparation in conceiving the proposed project and in preparing the proposal.

Lacee initially worked on a very similar project with a team during my Plant Pathology course. Their team received a SAC award for materials. They were very motivated and successfully created a transparent soil substrate, though which they were able to photograph plant roots while they grew. They set up their whole project and then COVID-19 struck and they had to abandon the research. While our class was still meeting, Lacee lamented that they couldn't do the full experiment that they wanted. I made them scale it back due to the fact that it needed to be completed during a single semester. So, when we had to leave campus, she asked if she could work with me in the future on mentored research to try the project again and expand it. Without the short time limit, we have a chance to get really cool results with Lacee's project!
Lacee and her team developed this project themselves. I simply pointed them to journal articles and helped with experimental design; they took it from there. Lacee prepared this proposal on her own, building off of her SAC proposal.

- Comment on the thoroughness of the student's research (did they employ sufficient literature sources, sufficiently incorporate earlier results from related work, etc.)

Lacee has definitely done a lot of background research. She spent hours digging into supplementary information for journal articles to develop and test her transparent soil system. She has even managed to grow sterile radishes in it as a test. She is using lessons learned from that "pilot study" in this proposal, and adding another method to observe plant uptake of mineralized nitrogen, in addition to root architecture.

- Comment on the expected effort on the part of the student (i.e. estimated total hours of work by the student, level of student's autonomy vs. required supervision, etc.)

I expect that since she has done so much background and preparatory work already, she will be able to hit the ground running on this project. I estimate that she will need to spend at least 4 hours per week in the lab and greenhouse. She will be autonomous and judging from her past work on this system, I'm confident that she is capable of leading this project. This is especially important given COVID-19 precautions...she will not need much in-person supervision.

- Comment on the student's level of preparation, creativity, enthusiasm, and motivation for conducting the proposed work.)

Lacee and her team geeked out so thoroughly about this transparent soil project that it got me excited as well. It's a very cool system and it's amazing that we can photograph plant roots growing in "soil!" She is very motivated to complete this project and build her research skills for her future career. It was a big disappointment to have to stop the previous study right in the middle, but I think she is being very positive about this: rather than just walking away with a good grade in the class, she is going out of her way to finish this project outside of class!