# NC SARE Grant Proposal

**Project Title**: Exploring Different Seed Propagation Methods of *Gillenia trifoliata* for Commercial Applications

**Author:** Jordan Bergstrom, Currently pursuing an M.P.S. in Horticulture

**Start Date**: September 2023
**End Date**: November 2024

**Requested Amount of Funding**: $13,497.82

**Faculty Adviser Information**: Professor Neil Anderson. Email is ander044@umn.edu.
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**Work Location**: 1552 Gortner Ave, St Paul, MN 55108
**Resubmission**: No
**Underserved Farmers and Ranchers**: Research/Outreach will not focus on historically underserved farmers and ranchers
**Systems Category**: Natural Resources/Environment
**Commodity Category**: Native Plant

**Summary**

This project is titled Exploring Different Seed Propagation Methods of *Gillenia trifoliata* for Commercial Applications. It involves an intensive study of the ideal germination requirements for *Gillenia trifoliata*, as well as a series of mobile workshops across the North Central region. These workshops will disseminate the project findings and inform nursery producers on the propagation of this species. This will benefit North Central nursery plant

producers through the introduction of a new product while also providing environmental benefits due to its potential applications for rain gardens, erosion control, and pollinator gardens. Additionally, this project will benefit horticultural and native plant enthusiasts through the diversification of woody perennials available in the North Central region.

*Gillenia trifoliata* is a flowering shrub native to the eastern United States, including the eastern portion of the North Central region. This species has long been used as a traditional medicine by the Cherokee Nation and, as a native shrub, it has potential environmental benefits. However, there are significant gaps in production knowledge surrounding this crop. Through trialing different pre-germination methods to identify the ideal germination requirements for *Gillenia trifoliata*, this project can fill the gaps in botanical knowledge surrounding this species and unlock its full potential from a commercial and environmental standpoint.

The methods for identifying the preferred germination methods involve running experiments that vary different mechanical, chemical, hormonal, and stratification treatments and comparing and contrasting different strategies and applications for their effects on germination. Overall, total germination rates, germination times, and seedling dry weight will be measured to determine vigor. If there is any effect on germination rates, then the most impactful treatment in each category will be identified as the recommendation for commercial growers. If there is no effect on germination, then that will also be recorded and factored into the grower recommendations. These treatments will also be subject to input from North Central nursery growers to reflect methods that they want to see tested.

After initiation of the workshops, impact measurement methods will be implemented to capture the effects of the workshops on nursery growers in the North Central region. Intake and Outake surveys will capture knowledge, skills, and attitudes surrounding *Gillenia trifoliata*

germination before and after attending the workshops. Feedback from these surveys will also be incorporated into the workshop curriculum and implemented through monthly updates. A final report will be sent to NC SARE highlighting the impacts of this project.

**Description**

This project is an intensive study into the ideal propagation treatments and conditions for seed germination of *Gillenia trifoliata*.

**Outcomes**

The desired learning outcomes of this project will be an increased awareness of *Gillenia trifoliata* as a potential nursery plant in addition to increased knowledge of seed production for this species. Those who attend the mobile workshop series will gain valuable germination skills and an improved attitude surrounding *Gillenia trifoliata* production. Action outcomes from this project will be increased utilization of *Gillenia trifoliata* in nursery production. Potential action outcomes could include research in breeding research and environmental benefits of this plant. These outcomes will be measured through the implementation of a quiz regarding germination methods as well as a survey that will capture changes in attitudes and knowledge of *Gillenia trifoliata*. A second survey will be sent out six months after the workshops to gauge commercial adoption and subsequent research done with this species.

The practices identified in this project will provide the groundwork for commercial production schedules of *Gillenia trifoliata*, aiding woody perennial nurseries in the North Central region. Additionally, given its status as a native flowering plant, there is potential for *Gillenia trifoliata* to be used for rain garden, pollinator habitat, and erosion control purposes in this region. Gaining cultural information on this shrub will provide the foundation for future research

into the environmental benefits of this shrub. Lastly, this research will improve the quality of life for horticultural enthusiasts by making this native, ornamental shrub feasible to cultivate in gardens, public spaces, and in the local environment.

**Statement of the Problem, Background, Justification**

Until fairly recently, the horticultural industry in North America has been dominated by exotic plant species (Wilde et al., 2015). Gardens were filled with imported species revered for their showy foliage, vibrant flowers, and unique habits. However, in the modern era, there has been a societal shift towards restoring natural landscapes and a growing awareness of the ecosystem services provided by native foliage. Native plants started becoming selected for gardens and landscapes as methods for improving rainwater infiltration, reducing runoff, facilitating soil remediation, providing habitat and food for pollinators, and serving as food for wildlife (The National Wildlife Foundation n.d.). This is largely to do with a rising interest in environmental protection and consciousness around human impacts on the natural world. As shown in Figure 1, native plant production is increasing due to consumer interest.

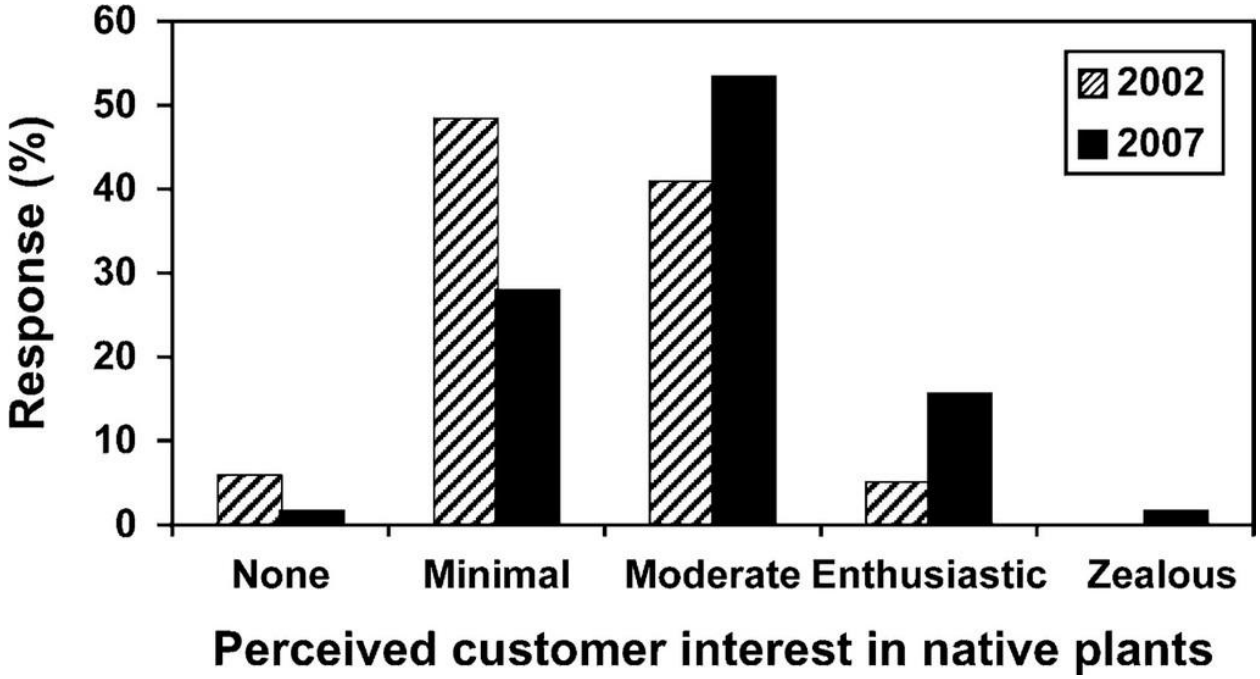


**Figure 1**. Results of a survey given to the Southern Nursery Association members highlighting the growth of interest in native plants in recent years, (Brzuszek et al., 2009).

The explosion in popularity of native plantings has highlighted crucial gaps in societal knowledge surrounding plant propagation: many native plants have comparatively little information on their cultural requirements in comparison with conventional ornamental cultivars (Wheeler et al., 2022). Additionally, many native species have not had the long history of domestication and human breeding that many exotic species have (Wilde et al., 2015). Therefore, there are fewer established varieties whose phenotypes are largely based on environmental adaptation rather than aesthetic appearance. Due to these contextual factors, there is a great need for research on the culturing of native plant varieties. There is also the potential for further breeding research to maximize the environmental benefits and ecosystem services of these species.

An example of this issue is *Gillenia trifoliata*, otherwise known as *Porteranthus trifoliatus* or Bowman's Root (Missouri Botanical Garden n.d.). Bowman's Root is a leguminous, woody shrub native to eastern North America (Lady Bird Johnson Wildflower

Center 2016). The species was used as a laxative and emetic by the Cherokee Nation, who dried and ground up the root for consumption (Native American Ethnobotany n.d.). Bowman's Root is currently sold as an ornamental native plant for landscaping and gardening purposes; however, it has untapped commercial potential which is inhibited by the lack of cultural information in regard to its germination and propagation needs.

**Figure 2.** Late Spring flowering of Bowman's Root (Mt. Cuba Center, n.d.).

Compared to other native plant species, there is slightly more cultural information on Bowman's Root. According to the Missouri Botanical Garden (n.d.), Bowman's Root prefers well-drained, humus-rich soil, full sun to partial shade, and is not susceptible to any serious disease or pest issues. Hardy in USDA Zones 4–8, Bowman's Root grows 2–4 feet (0.6–1.2 meters) tall and 1.5–3 feet (0.5–0.9 meters) wide (Missouri Botanical Garden n.d.). Phenotypically, the plant has white, 5-petaled flowers growing on red branches that bloom from May to July (Figure 2; Missouri Botanical Garden n.d.).

Most of the cultural information on this species comes from different U.S. botanical gardens, such as the Mt. Cuba Center, the Lady Bird Johnson Wildflower Center, and the Missouri Botanical Gardens (Lady Bird Johnson Wildflower Center 2016). While these institutions have amassed a sturdy basis of knowledge for cultivating Bowman's Root, it is lacking the precision and detail required for the creation of a commercial crop schedule. Information such as germination methods, time to maturity, multi-year pruning habits, and most effective plant growth regulators is missing from these databases. Even information regarding the preferred propagation method is lacking; seed germination and division are both mentioned, however there is no indication of the benefits and drawbacks of either method for this species (Missouri Botanical Garden n.d.).

In order to fill this gap in germination information for Bowman's Root, more research needs to be done surrounding seed propagation of this species. This project will generate critical information for commercial propagation including optimal germination temperatures, different pre-germination treatments such as scarification and stratification, light or dark requirements, as well as the average time to germinate. These are all necessary for this plant to be produced by seed propagation on a commercial scale.

While there is a large amount of research needed to better understand this native plant species, there are also huge potential benefits for adoption of this species into the horticultural and landscaping industries. As a prolific flowering shrub that is native to North America, Bowman's Root has huge potential as a beneficial addition to pollinator habitats (Native Plant Trust n.d.). As a perennial woody shrub, this species shows potential as a rain garden species for rainwater infiltration and erosion and runoff control due to a more robust root system when compared with herbaceous species. Also, due to its lack of pest and disease issues and low

maintenance requirements, Bowman's Root can be a sustainable alternative for common landscaping shrubs (Missouri Botanical Garden n.d.).

In addition to sustainable applications of this species, Bowman's Root also plays an important ethnobotanical role to many indigenous nations of North America. The Cherokee tribal nation has a long history with the plant, using it as a treatment for colds, respiratory issues, liver and kidney problems, as well as a toothache aid, emetic, and antirheumatic agent (Native American Ethnobotany n.d.). The Iroquois Confederacy is also documented as having used Bowman's Root to treat colds, diarrhea, sore throats, and as a general disease remedy (Native American Ethnobotany n.d.). To better understand how these nations' relationships to Bowman's Root have changed over time, further research and exploration must be done to identify the cultural significance and medicinal value of this plant.

This project loosely ties into other SARE initiatives. One such initiative is the "Scaling up organic botanical production in the Upper Midwest" (Scaling up organic botanical production 2022). One of the aims of this project is to "establish perennial colonies of native botanicals for… value added products," which, given the medicinal significance of Bowman's Root, might make it an ideal candidate for a project such as this. Additionally, there is another project that is currently dedicated to exploring "Medicinal Root Production for Small Scale Agriculture," which doesn't currently have Bowman's Root listed as a possible target for research (Medicinal Root Production 2022). Given that this medicinal root plant is native to the region, as opposed to some of the other selections (Ashwagandha), the project may be interested in Bowman's Root for further studies (Medicinal Root Production 2022). While this project does connect to previous research, the direct study of propagation methods for Bowman's Root has not been funded through SARE before.

Overall, there are many benefits to studying the germination and cultural requirements of Bowman's Root. Given its potential benefits to pollinator populations, rain garden applications, landscaping as a low maintenance ornamental alternative, and as a potential new botanical product, this germination and cultural research is essential in helping establish Bowman's Root as a commercially viable crop.

**Impact on sustainable agriculture in the North Central Region**

This research will improve the profitability of nurseries in the North Central region, and specifically native plant nurseries in the eastern portion of the region. By providing the groundwork for productization of a previously underutilized native shrub, this project will help nursery growers expand their product offerings and increase their revenues. Other organizations and businesses that will benefit from this project include landscaping firms, organizations that plant rain gardens and pollinator gardens, and possibly floral designers.

This project will also contribute to improving environmental quality and natural resources in the North Central region. *Gillenia trifoliata* has applications in rain garden construction; its deep root system is effective at controlling erosion, reducing runoff, and improving groundwater permeation. Another sustainable application for *Gillenia trifoliata* is as an addition to provide food and shelter for pollinators in pollinator gardens. Due to its prolific flowering, it is well suited for pollinator habitats.

Lastly, the combination of ornamental value and ecosystem services provided by *Gillenia trifoliata* will improve the quality of life among communities within the North Central Region. The shrub's characteristic delicate white flowers, lush foliage, and cozy habit make it an aesthetically appealing addition to local landscapes. Additionally, its North American origins will make it more appealing to those who are interested in restoring native habitats.

**Approach and Methods**

This project will determine the best methods for seed propagation of *Gillenia trifoliata*. Using a variety of seed treatments, these experiments will measure the germination rate, rate of seedling growth, and vigor of seedlings within a given time frame. These tests will identify the optimal pre-germination treatments and stratification period for germination of *Gillenia trifoliata* seeds. The results of these experiments will inform the writing of an academic paper that will inform growers of the best germination practices for Bowman's Root. The project results will also be used to facilitate workshops and distribute online resources on germination requirements.

These experiments will take place at the Plant Growth Facilities on the University of Minnesota campus, St. Paul MN. All repetitions will use *Gillenia trifoliata* seed from the Wild Seed Project. Germination trials will all take place in the Plant Growth Facility mist house and will therefore be exposed to the same light, temperature, relative humidity, growing media, and watering. This will eliminate the possibility of confounding the results of this study as a result of environmental conditions or the type of seed used. A control group of seeds will be sown simultaneously with the other trials to establish an untreated seed germination rate. The control group will follow the recommendations of the Wild Seed Project for germination, which are limited to 60 days of stratification at under 4.5 degrees celsius in moist soil (Wild Seed Project n.d.).

Inputs for this experiment will consist of seeds, media, plant hormones, equipment, and facility requirements. Each individual treatment will require its own seed packet, which consists of 30 seeds (Wild Seed Project n.d.). This will provide a substantial sample size for each treatment, which will improve the accuracy of the results. Equipment needed will include shallow 288 plug trays, spray bottles for hormone applications, scoopers for media, glass beakers

for soaking seeds, grow tents and heaters for heat treatments.. This experiment will also make use of the seed cooler and mist house in the Plant Growth Facilities.

The experiment will measure the effectiveness of different pre-germination treatments and stratification periods on the germination rate, growth rate, and vigor of *Gillenia trifoliata* seedlings. Treatments will be tested against other treatments in their respective categories: the categories include mechanical treatments, chemical treatments, hormone treatments, and stratification period. Mechanical treatments will include damaging seeds with a hammer and nail file, while chemical treatments will measure hydrogen peroxide concentrations of 1%, 2%, and 3%, and sulphuric acid concentrations of 70%, 80%, and 90%. Hormone treatments will involve gibberellic acid soaks in 250 ppm, 500 ppm, and 1000 ppm solutions, and scarification periods will last 60 days, 65 days, 70 days, and 75 days. Each treatment will have 5 repetitions. Including the control group, the total number of experimental units is 70.

The treatment that shows the best overall results between the three success criteria will be deemed the optimal treatment for that category. If there is no significant difference in the results, then the treatment will be deemed insignificant. Regardless of whether there is an effect or not, the results will still be valuable for the germination of *Gillenia trifoliata*. Seeds will be observed daily to record how many seedlings have germinated.

The experiment will last 20 weeks total, including 4 weeks of germination. The average time to germination as well as the total germination rate will be recorded at the end of the experiment. The seedlings will also be dried and weighed to determine total dry weight of each tray, which will be used to determine the average dry weight per seedling.

Success of this project will be measured through the discovery of whether or not different pre-germination treatments have an effect on the germination of *Gillenia trifoliata*, and if so, to

what extent these treatments influence germination. Criteria for whether or not treatments influence germination will be based on the overall germination rate, speed of germination, and seedling dry weight at the end of the experimental period. Discriminant analysis will be performed for each treatment using each three of these metrics to determine the most beneficial treatment. Using this analysis, an ideal treatment for each category (mechanical, chemical, hormonal, and stratification) will be determined based on the overall performance of each treatment by measuring their performance in each category.

To make sure that the results of this experiment will be the most beneficial to the end-users, nursery growers in the North Central Region will play a pivotal role in the design of this project. Growers will be surveyed to determine which pre-germination treatments they would like to see included in this experiment. The survey will be sent to multiple nursery growers from each state in the North Central region and feature a ranked choice system for choosing their top treatments from each category as well as an open response section for other treatments. The results will inform the type of scarification methods, hormone treatments, and other pre-germination treatments present in the experiment.

**Outputs**

The outputs of this project will include an academic paper, a series of informative workshops, and an online resource to be posted on the University of Minnesota Extension website. The academic thesis will outline the specifics of the experiment performed: starting with the context, the paper will cover the experimental design, materials and methods, results, and discussion. The thesis will be peer reviewed and posted online for anyone to access. The thesis will also be sent to different journals as a candidate for publishing, however success in getting published is out of the scope of the success of this project.

While this thesis will be marketed towards an academic audience, the workshop series will be marketed towards commercial growers. This workshop will be a more practically-oriented presentation of the results of the experiment. In addition to presenting the findings, there will also be a question-and-answer session between researchers and industry professionals to address any misunderstandings within the results and to ensure that all growers are aware of the best practices for germinating *Gillenia trifoliata* seeds.

The online resource on the UMN Extension website will briefly describe the experiment and summarize the results. This resource will provide simple guidelines for germinating *Gillenia trifoliata* seeds. It will be directed primarily towards growers; however, it will still function as a valuable resource for gardeners and the general public. It will contain the most effective treatment for each test category as well as how much each treatment influenced growth.

**Outreach**

In order to distribute the results of these experiments to nursery growers in the North Central region, part of this project includes the publishing of an academic thesis, a series of mobile workshops throughout the North Central Region, and an online resource highlighting the results posted on the UMN Extension website and electronically distributed to nursery growers.

The academic thesis will help distribute the results of this experiment online and act as a resource for other researchers who wish to further understand the best practices for culturing *Gillenia trifoliata*. The workshops will consist of a series of short demonstrations and question and answer sessions with nursery growers. These events will be marketed to the nurseries who participated in the survey as well as other nurseries throughout the North Central Region. For those who aren't able to attend the workshops, and for whom an academic paper may be

inaccessible, an online resource published to the University of Minnesota Extension website will provide the ideal pre-germination treatments for each category.

By distributing the results of this research, nursery growers will be better equipped to produce *Gillenia trifoliata*. While there is still much of *Gillenia trifoliata* production that remains beyond the scope of this project, growers will have a basis from which to create their own crop production schedules for this crop. By maximizing germination and seedling vigor, it will be more feasible for growers to introduce this crop into commercial production.

**Evaluation Plan**

In order to evaluate the outcomes of this project, impact measurement tools will be utilized throughout the project implementation process to determine how this project is impacting nursery growers in the North Central region. This impact measurement will consist primarily of surveys and skills tests that will evaluate the changes in competency of growers to cultivate *Gillenia trifoliata* from seed as well as their shifting attitudes and knowledge surrounding the crop. Data metrics such as participant backgrounds, prior knowledge, and attitudes towards *Gillenia trifoliata* will be measured during an intake survey using a short quiz and 1-10 scale questions that will be revisited after completion of the workshop. Additionally, sections for feedback will be included in the survey and recommendations will be implemented in subsequent workshops. This process will take place monthly and will also examine quiz scores and responses to determine the impact of feedback on the impact of the workshops.

For measuring commercial adoption of *Gillenia trifoliata* after the workshops, email communications will be sent out to program participants six months after attending the workshop. These communications will inquire about any subsequent commercial adoption of *Gillenia trifoliata*, and if so, ask whether the information provided in the workshop has proved

useful for them. This correspondence will also ideally capture any subsequent research or observations growers had about this species. This information will be compiled in a final report after the workshop tour is finished which will be sent to NC SARE highlighting the impact of this project.

**Logic Model**

| **Situation**: *Gillenia trifoliata* has potential as a new product offering among nursery growers in the North Central region, however its production is being hampered through lack of awareness and lack of understanding of germination requirements. Through identifying ideal germination conditions for *Gillenia trifoliata*, this project can help bolster commercial adoption of this flowering shrub and positively impact nursery growers in the North Central region. | | | | | |
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| **Process** | | | **Outcomes** | | |
| **Inputs and Activities** | **Participants** | **Outputs** | **Learning** | **Actions** | **Conditions** |
| **Inputs**:<br>1) Plant Growth Facilities at the University of Minnesota, Twin Cities.<br>2) Project personnel.<br>3) Materials and Supplies.<br>**Activities**:<br>1) Experiments to determine the optimal pre-germination treatments for *Gillenia trifoliata*.<br>2) Incorporation | **Graduate Researcher**: Jordan Bergstrom<br><br>**Faculty Advisor**: Dr. Neil Anderson<br><br>Plant Growth Facilities Staff<br><br>Nursery Growers in the North Central region | **Outputs**:<br>1) Academic paper highlighting the results of the experiment<br>2) Extension resources providing salient information from the academic paper in a more accessible format<br>3) Series of mobile workshops to teach nursery growers in the North | **Learning Outcomes**:<br>1) Improved attitudes about *Gillenia trifoliata* production<br>2) Increased knowledge and awareness of *Gillenia trifoliata*.<br>3) Building skills in seed propagation of *Gillenia trifoliata*. | **Action Outcomes**:<br>1) Adoption of *Gillenia trifoliata* into commercial production by nursery growers.<br>2) Potential breeding research with *Gillenia trifoliata*.<br>3) Potential future research into ecosystem service potential of *Gillenia trifoliata.* | **Conditions**:<br>1) More product offerings for nursery growers in the North Central region.<br>2) Potential utilization for environmental benefits such as erosion control, rainwater infiltration, and pollinator habitats.<br>3) Potential for horticultural adoption among gardeners in |

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| of nursery grower feedback into experimental design. | | Central region about cultivating *Gillenia trifoliata*. | | | the North Central region. |

**Table 1:** SARE R&E logic model for Exploring Different Seed Propagation Methods of *Gillenia trifoliata* for Commercial Applications.

**Summary Table of Outcomes, Outputs, Activities, Inputs, and Evaluation**

| **Expected Outcomes** | **Inputs and Activities** (What you're investing) | **Outputs** (What's produced—information products) | **Evaluation/Monitoring Plan; Measurement Methods** |
|---|---|---|---|
| **Learning Outcomes**:<br>1) Increased awareness of *Gillenia trifoliata* as a potential nursery crop.<br>2) Improved knowledge surrounding *Gillenia trifoliata* cultivation.<br>3) New or improved skills in seed germination of *Gillenia trifoliata*.<br>4) Increased positivity and improved attitudes around *Gillenia trifoliata*.<br>**Action Outcomes**:<br>1) Increased utilization of *Gillenia trifoliata* in nursery production.<br>2) Potentially increased breeding research of *Gillenia trifoliata*. | **Inputs**:<br>1) Plant Growth facilities at UMN Twin Cities.<br>2) Graduate students and faculty advisors<br>3) Supplies and materials.<br>4) Previous research on *Gillenia trifoliata* cultivation.<br>**Activities**:<br>1) Research the effects of different pre-germination treatments on germination rates of *Gillenia trifoliata*.<br>2) Gather feedback on pre-germination treatments that nursery growers are interested in and incorporating that into the experiment | **Outputs**:<br>1) An academic paper showcasing the methods and results of this project and providing scientific credibility behind the recommendations in the workshop<br>2) A series of workshops on seed propagation of *Gillenia trifoliata* geared towards nursery growers.<br>3) Extension resources providing accessible online recommendations and facts about *Gillenia trifoliata* and its cultivation. | **Evaluation**:<br>1) Intake and post-workshop surveys that measure changes in germination skills, botanical knowledge, and attitude towards producing *Gillenia trifoliata*.<br>2) Feedback sections on post-workshop surveys for improvement of workshop facilitation and curriculum. Subsequent measurement in changes of impact scoring to determine effectiveness.<br>3) Follow-up communications set six months after the workshops to gather information on adoption of *Gillenia trifoliata* cultivation and feedback |

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| 3) Potential research into the use of *Gillenia trifoliata* to provide valuable ecosystem services. | | | on the relevance of this project to their commercial cultivation. |

**Table 2:** Summary table of outcomes, outputs, activities, inputs, and evaluation for Exploring Different Seed Propagation Methods of *Gillenia trifoliata* for Commercial Applications

**Experience and roles**

**Faculty Advisor**: Dr. Neil Anderson, B.S. in Ornamental Horticulture, M.S. in Horticulture, Ph.D in Horticulture

The faculty advisor will provide assistance with designing the experimental procedure and formulating questions and hypotheses. They will also supervise the graduate researcher throughout the experimental process.

**Graduate Researcher**: Jordan Bergstrom, B.A. in Urban Studies, Currently pursuing a M.P.S in Horticulture

Jordan has completed many keystone courses in the Horticulture M.P.S. program. He has gained skills in vegetative and seed propagation, crop scheduling, greenhouse maintenance, and experimental design. Through running an aquaponic microgreen farm at Spark-Y: Youth Action Labs, he has gained work experience in seed propagation and plant care. His graduate researcher role will be responsible for designing, executing, and reporting on this project. For this project, he will require access to the Plant Growth Facilities at the University of Minnesota, Twin Cities.

**Plant Growth Facilities Staff**

The Plant Growth Facilities staff will assist with the everyday greenhouse maintenance requirements of this project. They will be responsible for tasks such as watering, stocking materials, and applying necessary chemicals and fertilizers.

**Nursery Growers in the North Central Region**

Nursery growers in the North Central region will be the participants in the workshops and will play an active role in determining what pre-germination treatments to add to the experiment.

**Budget and Budget Justification**

The overall budget required for the implementation of this project is $13,497.82. Table 3 shows the total budget broken down by category.

The graduate researcher will receive a monthly stipend of $600 per month, totalling $4200 over the 14-month timeline of this project. This stipend is for designing and implementing the experiment, creating the academic paper and extension resources, and facilitating the series of workshops. The Plant Growth Facilities staff salaries are covered through the Plant Growth Facilties rental fee. The Plant Growth Facilities staff will be responsible for stocking supplies and maintaining the mist house.

Supplies and materials requirements are listed below. In parentheses is the source and the totals are in bold. Many supplies are included in the Plant Growth Facilites rental fee. The total amount needed for supplies and materials is $3076.22.

- *Gillenia trifoliata* seeds (from Wild Seed Project) - 20,160 seeds / 30 seeds per packet = 672 packets, 672 packets X $4.50 per packet = **$3,024**
- 288 plug trays (Plant Growth Facilities) - Included in direct costs
- Germination mix (Plant Growth Facilities) - Included in direct costs
- Hydrogen peroxide (Amazon) - 1 gallon X $12.95 per gallon = **$12.95**
- Sulphuric acid (Amazon) 1 Liter X $24.74 per liter = **$24.74**
- Gibberellic acid (Plant Growth Facilities) - Included in direct costs

- Spray bottles (Plant Growth Facilities) - Included in direct costs
- Media scoops (Plant Growth Facilities) - Included in direct costs
- Glass beakers (Plant Growth Facilities) - Included in direct costs
- Hammer (Amazon) - 1 hammer X $8.54 per hammer = **$8.54**
- Nail File (Amazon) - 1 Nail File X $5.99 per set = **$5.99**
- Plant Labels (Plant Growth Facilities) - Included in direct costs
- Fertilizer (Plant Growth Facilities) - Included in direct costs

The workshop facilitation for this project involves heavy travel. There will be 12 workshops total, including ones in Minneapolis (5 miles), Madison (269 miles), Milwaukee (336 miles), Chicago (408 miles), Detroit (689 miles), Cleveland (750 miles), Columbus (765 miles), Cincinnati (701 miles), Indianapolis (590 miles), St. Louis (538 miles), Kansas City (441 miles), and Omaha (382 miles). All distances are one way and must be multiplied by 2 for the total trip mileage. All together, these workshops require 11,200 miles total, which, divided by 25 mpg = 448 gallons, and 448 gallons X $3.50 per gallon = $1,568 for gas. Additionally, $600 will be required for lodging. The total travel costs of this project will be $2,168.

The direct costs section covers the rental fee for the Plant Growth Facilities. This includes growing space, water, fertilizer, lighting and heating, and supplies such as plug trays, germination mix, gibberellic acid, spray bottles, growing media scoops, glass beakers, and plant labels. Overall, this project requires 70 plug trays. A plug tray is 200 $in^2$ which is 1.39 $ft^2$ per tray. 1.39 $ft^2$ multiplied by 70 trays = 97.3 $ft^2$ in total greenhouse bench space needed per day. Since the going rate for greenhouse space is $0.0333/ft2/day, it costs $3.24 per day to rent the space. Since the growing portion of the experiment will take 140 days, this results in a total of $453.60 needed for direct costs.

| **Project Budget** | |
|---|---|
| Personnel | $7200 |
| Supplies and Materials | $3076.22 |
| Travel | $2,168 |
| Printing and Publications | - |
| Other Direct Costs | $453.60 |
| Indirect Costs | - |
| **Total** | **$13,497.82** |

**Literature Cited**

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