Evaluation of *Bauhinia acuminata* Cultural Requirements

In Brief

Diversity of street trees in urban environments of the United States is lacking. The genus *Bauhinia* has many species in cultivation across the world but none in North America. *Bauhinia acuminata* is a high-potential, under-utilized species, which could easily be integrated into existing production and distribution channels.

To meet this potential, experiments will follow the objectives on the right, resulting in an output of a product information guide, a brief overview on pests/diseases, and outreach in the form of an extension page detailing the research and a workshop with growers most likely to benefit.

Objectives

1. Determine requirements for the most economic propagation method. Includes test of stratification, scarification, light requirements, chemical application, and associated germination rates as well as vegetative propagation methods
2. Evaluate cultural requirements. Includes soil type and structure, pH, fertilization, humidity, photoperiodism
3. Address opportunities and challenges of integrating *Bauhinia acuminata* to existing grower production systems
4. Compile existing literature on pest/disease susceptibility for management purposes

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Region North Central
Project Type Graduate Student
Commodity Other
Practices Crop Production

Does this project serve or engage historically underserved farmers or ranchers? No.

Broad-Based Outcomes in the North Central Region

Profitability	Growers can charge premiums for offering a unique exotic species Establishing the first species of the largely unexplored and phenotypically distinct *Bauhinia* genus provides prime ground for breeding programs, further increasing the variety of unique exotic offerings Breeding *Bauhinia acuminata* with species of the Sahara could produce a wide range of hardiness (requires research beyond scope of proposal) *B. acuminata* could be marketed as a wetland or flood resistant option, a necessity in flood-prone MN
Environmental Quality	*B. acuminata* could be grown as a wetland or flood resistant option *B. acuminata s*upports the habitat of a less popular pollinator, bats (Hokche, 1990) and birds (Corlett, 2005) If established, could absorb CO_2 in urban environments
Quality of Life	The large showy flowers will draw attention to the scraggly, droopy branches, demonstrating an unconventional (yet still healthy) plant structure This is in artful contrast to the typical compact, upright nature preferred in most landscaping plants, which may increase appreciation for biodiversity

Statement of Problem, Background, and Justification

In a given urban environment, more than 60% of street trees belong to just six species (Ma et al., 2020). Limited urban tree diversity results in lower pest and disease resistance and provides habitat for a restricted range of organisms (Nitoslawski, 2016). *Bauhinia acuminata* has not been listed in literature on street trees in the United States, making it a novel addition to most urban areas in the North Central region. Moreover, the closely related *B. purpurea* has notable CO_2 absorption in wet conditions typical of the native range of *Bauhinia* (Tor-ngern, 2020, Wang et al, 2014).

The genus *Bauhinia* is within the Cercidae group (redbuds), which is in the family Fabaceae, commonly known as legumes (Wang et al., 2014). Cultural requirements for other legumes may not be applicable as evidence suggests that Cercidae evolved distinctly from other Fabaceae species (Wang et al., 2014). The closest related cultivated genus, *Cercis* can grow in a variety of conditions, but Ony (2019) shows that *Cercis* does not grow at coastlines, unlike *Bauhina* (Figs. 2, 3). *Bauhinia* is divided into two subgroups: *sensu stricto* (in the strictest sense) and *sensu lato* (in the broadest sense). The *sensu lato Bauhinia*s are liana, or woody vines. The white dwarf orchid tree is more tree-like, characteristic of the *sensu stricto Bauhina* (Wang et al., 2014). Even literature on this species is unclear; for example, *B. acuminata* and *Schnella macrostachya* are both listed as accepted names and are considered synonyms (Kew, n.d. 1, 2, & 3). While the name *Bauhinia acuminata* has been used in the Malay Archipelago (Indonesia, Malaysia, Philippines), the name *S. macrostachya* has been used in Brazil for the same species. Due to the genetic distance between Bauhinias and other genera in Fabacea, as well as a lack of consensus on the taxonomy of Bauhinias, relatives of *B. acuminata* may not be relevant when determining cultural requirements. The *Bauhinia* subgenus *sensu stricto* is the largest group that may be relevant. Thus, developing a comprehensive description for *B. acuminata* requires significant research.

Bauhinia acuminata has little existing literature. Within the *sensu stricto* subgenus and with more research is *Bauhinia purpurea* (Purple Dwarf Orchid Tree; Sinha, 2013). The cross of *B. purpurea* x *B. variegata* produced the only known cultivar (*B.* x*blakeana*), which is depicted on the Hong Kong flag, and produced the only known hybrid (*B. variegata* var. candida). Cultural information on *Bauhinia purpurea* and *B. variegata* will be used to fill in most gaps in

information on *B. acuminata* and provide a starting point for research, while some other *sensu stricto Bauhinia* species can fill the remaining gaps..

Common names of *B. acuminata* include Dwarf White Bauhinia, White Dwarf Orchid Tree, Snowy White Orchid Tree, White Orchid Tree, and 白花羊蹄 (Báihuā yángtí: white-flowered sheep's hooves) (HEAR, n.d.). The leaves of *Bauhinia* are characterized by bilobular leaf blades with palmate venation that arcs to a segmented submarginal perimeter, with a swollen leaf base, this is evident in *B. acuminata* (Fig.1; Wang et al., 2014). Fig 1 also depicts white 5-petal flowers in a raceme forming at axillary buds. Further peer-reviewed descriptions of traits other than leaf structure is lacking for *B. acuminata*. *Bauhinia* trees are also planted for ornamental value in India, especially as street trees (Kumari et al., 2021; Mazzini et al., 2013). The unique leaf shape and large, showy flowers will draw attention to the scraggly, droopy branches, demonstrating an unconventional (yet still healthy) plant structure. This is in artful contrast to the typical compact, upright nature preferred in most landscaping plants, which may increase appreciation for biodiversity, making this a desirable ornamental tree. *Bauhinia acuminata* would ideally be suited for large residential gardens, corporate green-walls, and recreational greenspaces.

Figure 1. Botanical illustration of *Bauhinia acuminata* showing bilobate leaves with white 5-petal flowers in a raceme forming at axillary buds (Lowis, 1878). The beautifully striking large flowers, unique leaf shape, and drooping branches make this a unique and attention-grabbing addition to any garden.

Supportive climatic conditions of the *Bauhinia* genus are equatorial with lower population density in drier areas like Saharan Africa, and higher population density in wetter areas such as the Malay Archipelago (Wang et al., 2014). The native range of *Bauhinia*

acuminata is central to the *Bauhinia* genus, in the Malay Archipelago (Fig. 3). Bauhinias tend to grow with more dense populations in wetter environments. I recommend the Great Lakes shoreline as the ideal growing environment within the North Central region

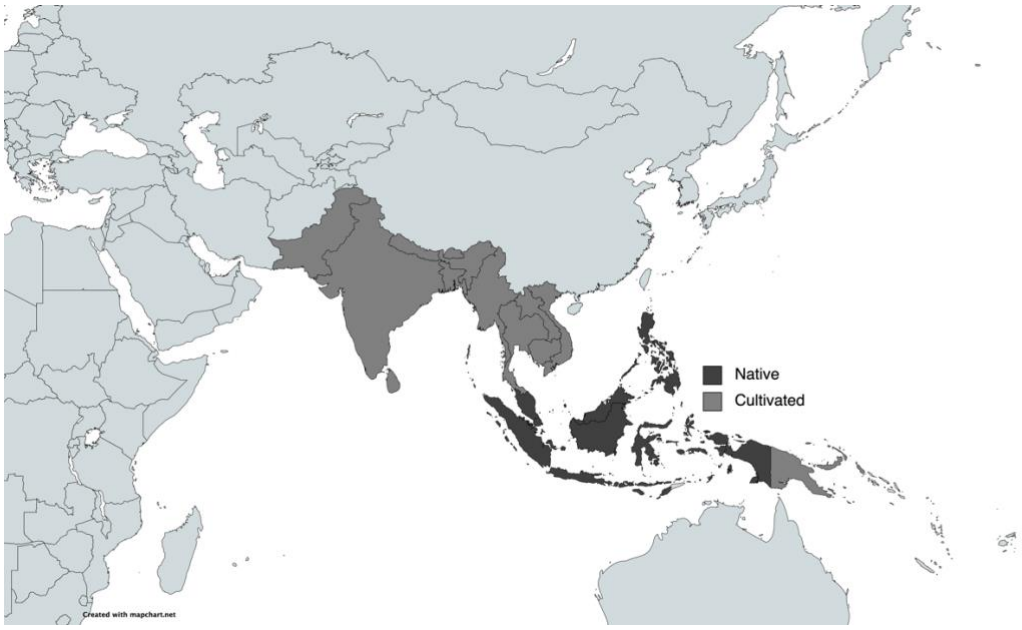

Figure 2. Native and cultivated range of *Bauhinia acuminata*. Map created with data from NPGS, 2022.

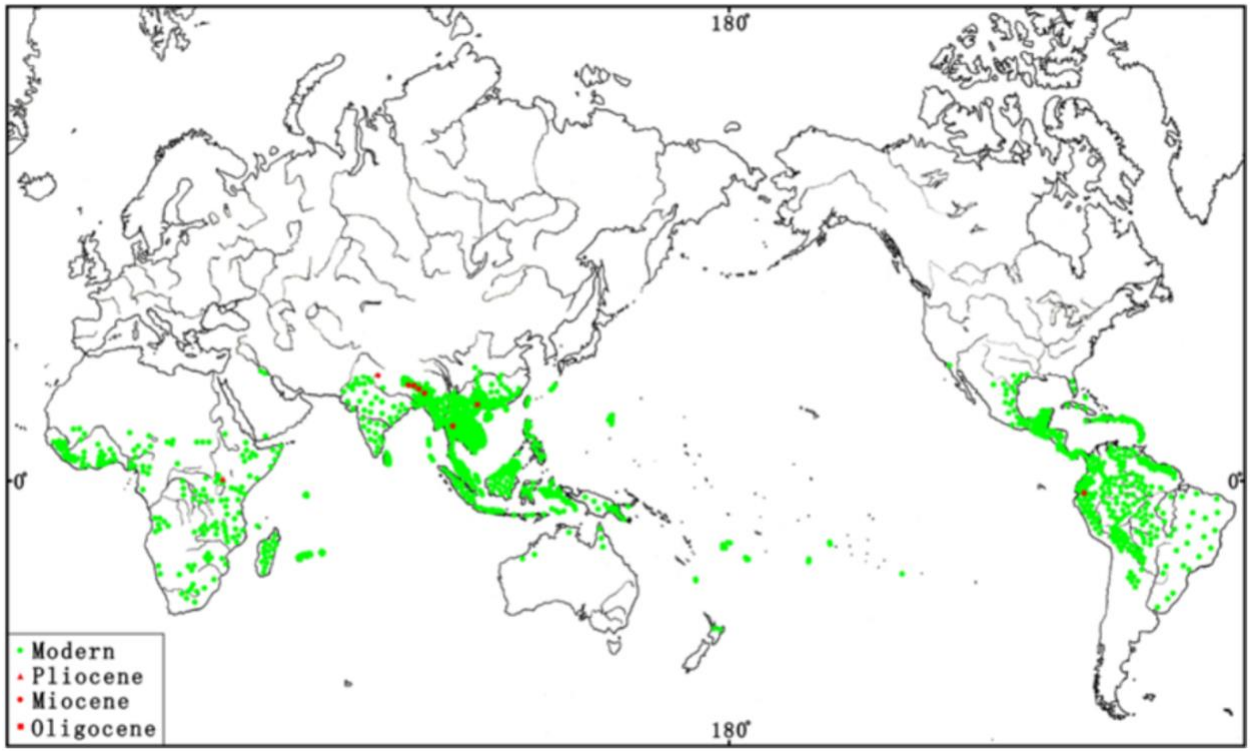

Figure 3. Range of the genus *Bauhinia*, showing higher population densities near equatorial coastlines, islands, and rivers and lower density in land-locked desert regions (Wang et al., 2014). The *Bauhinia* genus survives and propagates best in moist environments. Minnesota (*the land of ten-thousand lakes*) and other states of the Great Lakes in the North Central Region are the most supporting locations for new adoption of Bauhinias as a landscape feature.

To the best of my knowedlge, there are no previous SARE projects on incorporating ornamental trees to the landscaping industry as a sustainable flood-resistant option- especially such a unique species as *Bauhinia acuminata*.

Approach and Methods

Researcher inputs include greenhouse experiment space and University of Minnesota faculty background knowledge on woody perennial production. Grower involvement in the preliminary stages of this project is essential to ensure that the deliverables meet the needs of

existing market players. Producers who serve the Great Lakes states of the North Central region will be contacted about utilizing *B, acuminata* in shoreline and other wetland landscaping, since *B. acuminata* is well adapted to these environments. Pre-research/experiment interviews will directly address three of the four objectives: propagation, culture, and system integration, described in Table 1. Questions about propagation (Objective 1) will determine implementation feasibility of implementing various propagation methods on a three-point scale: methods the producer is experienced with and/or have specialized machinery for, methods infrequently used and/or they do not have specialized machinery for, and methods they do not currently use. Questions about culture (Objective 2) will determine producers' systems of control of growing conditions and willingness to establish control systems that will be tested. Questions regarding system integration (Objective 3) will determine common and individual producer restrictions, to directly address during workshops and prepare for production cycle follow-ups.

Pest and disease management (Objective 4) is beyond the scope of this research, and so will not be a focus in preliminary interviews. However, a literature review on pest and disease management will be included in output resources and workshops as it is an essential consideration in production.

Main Research			**Auxiliary Resources**
Objective 1	Objective 2	Objective 3	Objective 4
Determine requirements for the most economic propagation method. Includes test of stratification, scarification, light requirements,	Evaluate cultural requirements. Includes soil type and structure, pH, fertilization, humidity, photoperiodism	Address opportunities and challenges of integrating *Bauhinia acuminata* to existing grower production systems	Compile existing literature on pest/disease susceptibility for management purposes

chemical application, and associated germination rates as well as vegetative propagation methods			

Table 1. The four objectives of this proposal reflect four aspects of integrating a crop to production systems: propagation, culture requirements, opportunities and challenges of the existing system, and pest and disease management.

Existing literature on *sensu stricto Bauhinia* show increased seed germination with applications of hot water soak at 50°C for 15minutes (Gaisamudre, 2012; Mwase, 2011; Oopoku, 2018), GA_3 at 500ppm for 2 hours (Mathew, 2002), concentrated HCl for 90 seconds (Gaisamudre, 2012), and mechanical scarification of the seed coat (Prasad, 1996). Every permutation of these treatments will be tested with controls and 10 replications each, totaling 120 experimental units in the initial germination test, detailed in Table 2. After reviewing results of the initial germination test, a second round will be done with revised intensity and duration of treatments that had higher germination rates than the control, considering post-germination damping-off if applicable. Existing literature on vegetative propagation of *Bauhinia spp.* is even more limited than seed propagation. Thus, treatments for vegetative propagation will be determined after a review of a *B. acuminata* plug response to a general vegetative propagation method. Throughout these tests, costs will be tracked of inputs, labor, space requirements, etc. Germination/rooting rates will be compared to costs of each method to determine economic limiters on propagation. For example, if the method with the highest germination rate was 1% more than the second best but required 2x the input cost, this method would have too high of an economic limitation on propagation to be feasible for growers. This phase directly addresses Objective 1.

Scarification +	Chemical +	Heat +	= Treatment
control	control	control	control
		50C 15min	hot water
	GA_3 500ppm 2 hours	control	just GA
		50C 15min	GA and hot water
	HCl	control	HCl
		50C 15min	HCl and hot water
break seed coat	control	control	scarification
		50C 15min	scarification and hot water
	GA_3 500ppm 2 hours	control	scarification and GA
		50C 15min	scarification, GA, and hot water
	HCl	control	scarification and HCl
		50C 15min	scarification, HCl, and hot water

Table 2. The first three columns show treatment types that have been shown to increase germination of related species. Following this method, all combinations of treatment types will be tested to determine independent and compounding effects.

Seeds for the culture experiments will be sown with the treatment determined to have the highest germination rate. Equipment for soil used by large-scale growers is likely highly specialized so soil types to test will be determined after preliminary interviews with producers. Soil/substrate composition also impacts feasibility of pH adjustments in production. pH will be tested at a slightly broader range than identified in producers typical soil pH range. Humidity tests will also be based around typical levels identified by producers. Photoperiodism will be tested at control (natural light), short-day (8 hours of light), and long-day (16 hours of light) to determine impact on flower bud initiation and development. Fertilizer treatments will focus on

slow-release potassium and magnesium, both identified as common deficiencies in *B. xblakeana* and *B.aculeata* (Broschat, 2018; Gilman and Watson, 2016). This phase directly addresses Objective 2.

An approach to addressing Objective 3 can only be determined after learning about the existing production systems of the growers interviewed. A general, preliminary approach to integrating *B. acuminata* will focus on existing tropical plant production pipelines. Pre-experiment interviews will collect brief information on grower tropical production in anticipation that opportunities, challenges, propagation methods, and culture methods will align with other tropical plants. However, how this species fits with this system cannot be elaborated or assumed until interviews and experiments are complete.

Outputs

Since the main goal of this project is integration of *B, acuminata* into production, the most long-lasting and useful output is a product information guide (PIG). In the industry, these typically include much of the information that the experiments of this project were designed to generate germination and culture requirements. PIGs also include an abbreviated timeline annotating time from sowing to germination, germination to transplant, and overall time to maturity (flowering) as well as applications of *-icides (herbicide, pesticides, fungicides, etc.) and plant growth regulators (PGRs). As such, the timeline information will be documented during the experiments and adapted for inclusion in the PIG. *-icides and PGRs will not be included in the PIG as they are not outlined in the experiment, could alter production efficacy and efficiency, and should be built on previously established germination and culture

requirements. This PIG will be made publicly available and will also be used in the outreach workshop.

Beyond the single, reductive recommendation described in the PIG, germination and cultural alternatives will be presented based on plant vigor and economic factors. Here, opportunities and challenges of growers learned from the Objective 3 interview questions will be incorporated. For example, if flowering time is greatly quickened in short-day photoperiod treatments but no grower interviewed uses shade-cloths, alternatives are nigh essential. These alternative/adjustment recommendations will be included at the end of the PIG so that growers not directly involved in the project can determine their crop schedule with lowered risk of uncertainty.

Outreach

Experiments and the PIG developed and described in the outcomes section will be made available to the greater public via a page on the University of Minnesota Extension's website. The PIG itself will be a downloadable PDF, and the findings of the research will also be summarized on the web page for readers. The extension page will be one of two places where pests and diseases will be briefly addressed in relation to *B. acuminata*.

The page and PDF function as passive outreach, accessible when growers search for the information autonomously. Direct, active outreach will be conducted via a workshop. After experiments have been completed and the PIG has been developed, the growers contacted for the preliminary interview will be invited back to attend a workshop demonstrating best practices. Best practices demonstrated will be explained with data from experiments and anecdotal

experience of the researcher. The deliverable goal of the workshop is that all growers walk away with a clear, custom crop schedule based on their farm's conditions. To achieve this, alternatives will be addressed, noting specific opportunities and challenges brought to light during the preliminary interviews. Along with the crop schedule / PIG, growers will be provided a brief overview of literature on pests and diseases.

Evaluation plan

The impact of the four output and outreach items cannot be evaluated in the same way. The brief overview on pests and diseases is only intended to be a reference guide for growers should they encounter pests or diseases during production. As such, direct evaluation of the pest/disease brief is unreasonable. Similarly, the PIG is just a document resource for growers. However, the UMN Extension has a visible usage statistics tool for Sustainable Development. Here, the PIG download count can be tracked. Although this data does not directly suggest impact, it does track interest. The UMN Extension website will also display the impact of the research presented can be tracked with general website metrics, such as page views, bounce rate, traffic sources, session duration, and returning/new visitor. For example, traffic sources from unrelated extension pages may suggest that page views are exploratory and do not imply impact. However, if there is a high rate of returning visitors, that may suggest that the information is being reviewed, likely as a reference for implemented production.

Because of the impact of the pest/disease brief, PIG, and extension page are tracked by nothing more substantial than website metrics, it cannot be known if the intended outcome of the research is being achieved. Herein lies another great importance of the preliminary interviews and the workshop. By itself, attending the workshop is highly suggestive but again, it cannot be

known if intended outcome was successful. A follow-up interview will be scheduled to take place during the production cycle.

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: - Understanding of germination and culture requirements of *B. acuminata* - Increased knowledge of grower production opportunities and challenges Action Outcomes: - Growers have adopted production of this species to increase their offer of sustainable products	- Greenhouse experiment space - Faculty background knowledge on woody perennial production	-Product information guide - Extension page detailing research -Workshop with growers to establish production system - Pests/Diseases overview	- Pest/disease brief will not be evaluated - PIG will be tracked by download count - Extension page will be tracked by common website metrics - Impact of workshop will be evaluated by follow-up interviews

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