Researching Best growing practices for the production of *Zinnia acerosa* (desert zinnia) in a protected environment

START DATE: February 1, 2021
END DATE May 15, 2021

GRADUATE STUDENT INFORMATION:
Mary Magers, B.A. in International Relations and Minor in Spanish. Currently pursuing an MPS in Horticulture degree

FACULTY ADVISOR INFORMATION:
Dr. Neil Anderson, B.S in Ornamental Horticulture, M.S. in Horticulture, Ph.D. in Horticulture

INSTITUTION CONTACT INFORMATION:
University of Minnesota - Twin Cities
Department of Horticulture Science - 305 Alderman Hall
1970 Folwell Ave., St. Paul, MN 55108

WORK LOCATION:
The University of Minnesota Plant Production Facility - St. Paul Campus

PROJECT CATEGORY INFORMATION:
Floriculture; ornamental bedding; cut flower

TOTAL NCR-SARE REQUEST: $ 7,930

A. Application signoff page

Northeast SARE Graduate Student Grant Application Signoff Sheet Note: This form must be completed with signatures and attached to the online application at time of submission. The deadline is 5:00 p.m. ET on May 7, 2020. Signatures are required below from the graduate student applicant, the student's faculty advisor, and an authorized official from the institution's grants office.

Applicant (graduate student) name: **Mary Magers**

Project title: **Best growing practices for the production of *Zinnia acerosa* (desert zinnia) in a protected environment.**

Funding request: $7,930

APPLICANT'S ASSURANCE: I affirm that I am, or will be, a graduate student at the University of Minnesota, and that I have written this proposal and discussed it with my faculty advisor, listed below. Should I be awarded a grant, I will be the primary contact for managing the project. I will report results each December while the project is in progress and write a final report when the project is complete. I will keep Northeast SARE informed of any contact and e-mail changes for at least two years after the final report is written. Applicant signature: ***Mary Magers***

FACULTY ADVISOR: I affirm that I have read this proposal and understand that, for the purposes of this proposal, I will be named the principal investigator. I will supervise grant activities and support student compliance with SARE requirements as needed. Faculty advisor signature: _____
Date_____

Print advisor name: **Neil Anderson**

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286 Alderman
1970 Folwell Avenue
St. Paul, MN 55108

Telephone: **+1 612 624 6701**

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INSTITUTIONAL APPROVAL: The grants or sponsored programs office of the University of Minnesota hereby certifies that we have read this proposal, approve this budget, and have the capacity to manage grant funds on behalf of the faculty member named above should the proposal be funded. We further understand that SARE funds cannot be used except as outlined in the proposal and that for organizations with a current federally negotiated indirect cost rate, the USDA/NIFA allowed maximum is 10% of the total request.

Signature of authorized official: _____ Date_____

Name and title of authorized official:

Address:

Telephone:

Email Address:

B. Project summary

Growing native plant species has ecological benefits. Natives provide food and habitat for wildlife, are often tolerant of local pests and pathogens, and require fewer inputs in the landscape. Z*innia acerosa* (DC.) A. Gray (syn. *Z. pumila*), commonly known as desert zinnia and zinia del desierto (Spanish), is a perennial plant native to the United States that is said to be among the showiest of species in the grasslands after late winter rains (Bennett, et al., 2004) (Fig. 1). It is a species of interest for this project because it is a plant that provides horticultural benefits but is untapped and relatively unknown in the trade.

Figure 1: Example of prolific flowering of *Zinnia acerosa* in the wild
(Lady Bird Johnson Wildflower Center. 2019)

Z. acerosa is recommended for landscape restoration in its native range (Garner and Herschdorfer, 2014). It also has the potential to be valuable to the horticulture industry as a

species and cultivated plant due to its desirable morphological attributes and its potential for breeding. Yet, there is little to no growing information and germplasm available for production of Z. *acerosa*.

Through research of best practices for greenhouse production, this project will contribute to the information available about Z. *acerosa f*or growers, landscape managers, breeders, and educators interested in the benefits of working with this native perennial. I will use the results of the study to develop a one-sheet *Z. acerosa* production information guide (PIG) and to write an article for publication in commercial growing magazines, university extension publications, and promotion in other media related to horticultural and ecological education.

C. Program logic model

Program: Production of *Zinnia acerosa* (DC.) A. Gray as a horticulture crop logic model
Situation: *Zinnia acerosa* has the potential to be beneficial as a horticultural crop, but there is little published information on growing *Z. acerosa* and little availability of plant material.

Inputs	⇒	Outputs		⇒	Outcomes - Impacts		
Inputs		**Activities**	**Participation**		**Short**	**Medium**	**Long**
Seeds Stock plants Soilless media Plug containers Transplant containers Greenhouse PGRs Plant fertilizer PIG for *Zinnia spp.* plastic plant labels sharpie markers razors bleach solution laptop computer graph paper		Study the production of *Z. acerosa* using production guides for cultivated species. Test the viability of reproducing *Z. acerosa* vegetatively Create a one-sheet production guide for *Z. acerosa.* Write an article for commercial growers' magazines on the results of the study. Write an extension publication on the study and its results.	Seed vendors Commercial growing magazines University extension departments University of Minnesota Plant Growing Facility staff Professor Neil Anderson		Wider knowledge of the benefits of *Z. acerosa* among growers, breeders, educators, and landscape restorers. Increased availability of production information of *Z. acerosa*	Increase the production of *Z. acerosa* seeds. Increase the production of *Z acerosa* plants. Increased revenue for seed vendors, plant growers, and plant wholesalers and vendors Increased knowledge of *Z. acerosa* by farmers, ranchers, and other landowners. Breeding studies using *Z. acerosa.*	Increase the commercial availability of *Z. acerosa* for landscape use. Increase the commercial availability of *Z. acerosa* for use in restoration. Available cultivars of *Z. acerosa* that benefit growers' profits Available hybrids of *Z. acerosa* that have improved disease resistance and improved drought tolerance

Assumptions: Following guidelines for growing *Zinnia spp.* may be a useful guide for growing *Z. acerosa*.

External Factors:
Availability of *Z. acerosa* seed

Program Logic Model

Inputs: This logic model lays out the program's flow of inputs and processes that will result in the short and long-term goals of the program. Plant growing supplies and *Zinnia acerosa* germplasm in the form of seeds and vegetative cuttings inputs will be used in a greenhouse facility (inputs) to study the production of *Z. acerosa* in a protected environment.

Outputs and Partners: The outputs will include a one-sheet production guide to growing *Z. acerosa*, an article to be published in plant growers' magazines and university extension publications. The help of partners that include University of Minnesota Professor Neil Anderson, the University of Minnesota Plant Growth Facility staff, vendors of *Z. acerosa* seeds, the editorial staff members of plant growing magazines, and educators and researchers in university extension departments, will help facilitate conducting the propagation research and sharing the result information.

Outcomes: The short term outcomes from the research will be wider knowledge of the benefits of *Z. acerosa* for growers, breeders, educators, and landscape restorers, and increased availability of production information of *Z. acerosa.* Medium outcomes include an increase in production of *Z. acerosa* seeds and plants, increased revenue for seed vendors, plant growers, and plant wholesalers and vendors; increased knowledge of *Z. acerosa* by farmers, ranchers, and other landowners; and breeding studies using *Z. acerosa*. Long term outcomes will include an increase in the availability of *Z. acerosa* for commercial use in landscaping and restoration, and an increase of cultivars and hybrids with improved disease resistance and drought tolerance.

D.Proposal narrative

I. An Important Native Plant

Geographical Distribution and Habitat:

Z. acerosa is native to parts of the southwestern United States and Mexico (Torres, 1963). It grows in arid conditions in creosote mixed-shrub and grassland ecoregions (Torres, 1963, Bowers, J.E, 1989; Austin, 2010) on sandy washes, dry mesas, rocky alluvial slopes, and disturbed areas at elevations of 760 to 1,500 meters (Torres, 1963; USDA, 2012) (Fig. 2). It thrives in high pH soils that are calcareous to caliche (Bowers, 1989, Austin, 2010; USDA, 2012) (Fig. 3).

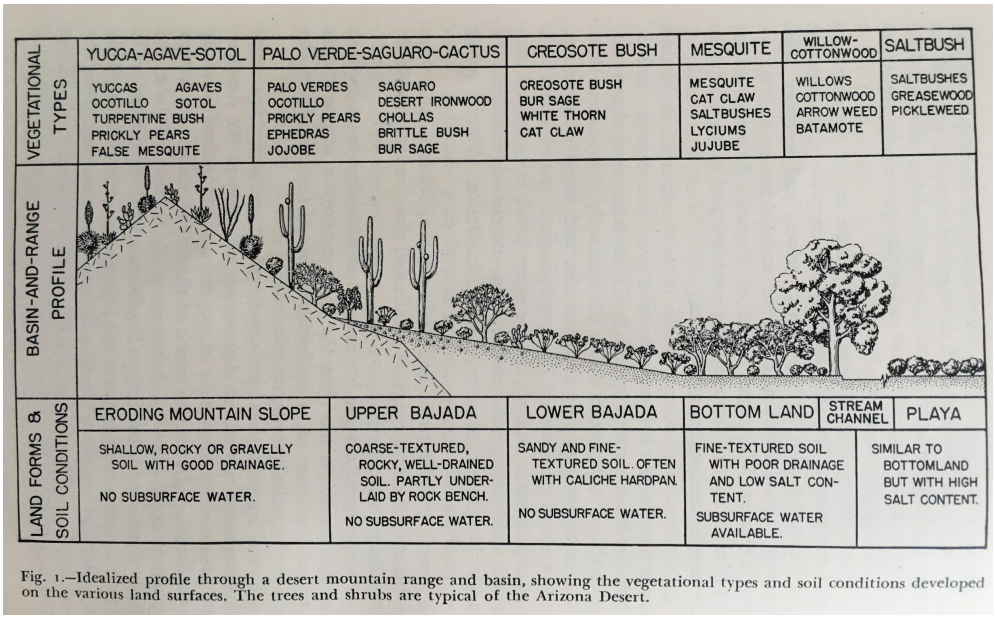


Fig. 1.—Idealized profile through a desert mountain range and basin, showing the vegetational types and soil conditions developed on the various land surfaces. The trees and shrubs are typical of the Arizona Desert.

Figure 2: Creosote Bush Topography, illustrating where *Z. acerosa* grows in the landscape (Benson, L. and Darrow, R.A. 1954)

Figure 3: Example of *Z acerosa* on calcareous to caliche soils (Academy Village, 2016)

Common Use and Restoration:

In the past, Native Americans reported using *Z. acerosa* in a topical anti-inflammatory paste and as a learning aid for children (Swank,1932). Today, despite its limited availability, it is recommended for use as a landscape plant and ground cover in its native range (Bradley, L. and Cromell, C., 2001; Miller, 2007), including as a low-input turfgrass substitute (Umeda, K. 2016). *Z. acerosa* has no serious pest problems (USDA, 2012), but it can suffer outbreaks of flower blight after high rainfall in summer, caused by *Alternaria alternata* (Colbaugh, P.F. et al., 2001). It provides ecological services that will benefit the industry and promote sales of the plant, including deer resistance (Miller, 2007) and food for native bees (Lady Bird Johnson Wildflower Center. 2019).

In the southwestern United States *Z. acerosa* is also recommended for use in restoration projects, for increasing plant diversity, and improving wildlife and pollinator habitat (USDA, 2012). It is

being evaluated as a water-conserving species (Colbaugh, 2001) and has been shown to be effective in bioremediation (Machado-Estrada, et al., 2013). It can be mowed and may have tolerance to burning. It has not demonstrated negative environmental impacts (USDA, 2012).

Looking forward, this very drought tolerant native is positioned to do well in a changing climate in the southwestern United States where increasing temperatures and drier conditions are projected (Collins, M. et al., 2013). In the North Central (NC) region of the United States *Z. acerosa* could be evaluated as a blooming cover crop, grown as an annual. In areas such as western Minnesota, relatively low precipitation and heavily farmed soils rich in $CaCO_3$ provide growing conditions similar to those required by *Z. acerosa*.

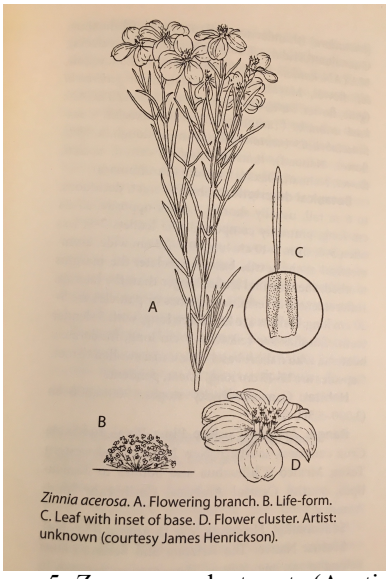
A study of *Z. acerosa* production will help provide information to increase cultivation and availability of plant material for the benefit of using the water-wise plant on small and large scales in the landscape.

II. A Potential Cultivated Plant

For many years, annual zinnias have been popular cultivated plants worldwide. Due to its morphological attributes and growing requirements, *Z. acerosa* also has the potential to be a successful horticulture crop. It is a multi-branched subshrub (Fig. 4) with a bloom time that rivals that of its popular cultivated annual cousins (spring to fall), but has the added benefit of being a hardy perennial in its native range. It has small linear to needle-like (acerose) leaves (Figs. 5 and 6), and produces an abundance of composite flowers made up of yellow disc flowers and ray flowers (Figs. 5 - 7) that appear in shades of white, whitish yellow (Torres,1963, Taylor, R.J. 1998) and orange in the wild (Neil Anderson, personal communication, 2020). Its low stature at a mature height of 10 to 16 cm and its mounded form (Torres, 1963, Taylor, R.J. 1998)

(Fig. 5) make it appropriate for public and private landscaping in both formal and naturalistic settings.

Figure 4: *Z. acerosa* (SEINet, 2020)



Zinnia acerosa. A. Flowering branch. B. Life-form. C. Leaf with inset of base. D. Flower cluster. Artist: unknown (courtesy James Henrickson).

Figure 5: *Z. acerosa* plant parts (Austin, 2010)

Fig. 6 Z. acerosa blossom and acerosa leaves. (Lehman, 2020)

Figure 7: *Z. acerosa* disc and ray flowers (SEINet, n.d.)

Only a small percentage of *Zinnia* germplasm has been utilized by breeders (Stimart and Boyle, 2007). *Z. acerosa* is in a different subgenus than current cultivated species (see Image 8), but may be a candidate for interspecific breeding, possibly helping to increase cultivar diversity and to produce cultivars with disease resistance and drought tolerance (Metcalf and Sharma, 1971)

Z. acerosa production information could help increase available seed and stock plants for use as germplasm for breeding research.

Table 1. Characteristics of *Zinnia* Subgenera (Compiled from Torres, 1963)

	Diplothrix	**Zinnia**
Life cycle	Perennial	Annual or perennial
Form	Cespitose shrub or subshrub	Erect or procumbent herb
Flower head	Cylindric or semi hemispheric	Campanulate to hemispheric
Leaves	Narrowly linear, filiform, or acerose	Much broader
Styles	Densely velutinous, acute	Penicillately truncate
Range	Temperate regions of the southwestern United States and northern half of Mexico.	Southeastern Arizona, Mexico, Central America, West Indies, Colombia, Ecuador, Peru, Argentina
Chromosome #	Base n=10 (n=11, n=19, n=20)	n=12
	Diploid and polyploid	
Cultivated species		*Z. angustifolia* *Z. elegans* *Z. haaganea*

III. Availability of germplasm and production information

Commercial availability of *Z. acerosa* germplasm is very limited (Grissell, USDA, 2012). There are two retail vendors (Alplains Seed Company and Plants of the Southwest) and one wholesale vendor (Granite Seed and Erosion Control) as found on Plant Information Online (2020). The U.S.D.A. reported that it made plants available to commercial growers for conservation purposes

(USDA, n.d.), but no further information is available. As of this writing, of these sources only Alplains Seed Company responded to my inquiries confirming they have seed available for sale. *Z. acerosa* produces a lot of seed (Fig. 8). Seeds collected in the wild seem to have a lower rate of germination than seeds collected under crop conditions (USDA, 2012). This is an area for further research.

Figure 8: Example of *Z. acerosa* seeds (Magers, 2020)

IV. Project Target Audience:

The potential of *Z. acerosa* as a horticultural crop outweighs the availability of growing information and plant material availability. Through research of best practices for greenhouse propagation, this project will contribute to the information available about Z*. acerosa f*or growers, landscape managers, breeders, and educators interested in the benefits of working with this native perennial. I will use the results of the study to develop a one-sheet *Z. acerosa* production information guide (PIG) and to write an article for publication in commercial growing magazines, university extension publications, and promotion in other media related to horticultural and ecological education

2. Inputs

Supplies and Equipment:

● greenhouse space rented from the University of Minnesota's Plant Growth Facility ● PIG for *Zinnia spp*. (see Image 11) ● *Zinnia acerosa* seeds ● soilless planting media ● 1020 flats ● 288 plastic plug growing trays ● 4" plastic growing containers ● 6" plastic plant labels	● Sharpie markers ● single-edge razor blades ● 3% bleach solution (sodium hypochlorite) ● plant growth regulator (PGR) daminozide (b-nine) ● 1 25g bottle of Indole-3-butyric acid (IBA) at 1000ppm ● laptop computer ● graph paper

Potential Partnerships:

- Horticulture trade publications
    - Greenhouse Grower Magazine
    - MNLA's *The Scoop* Magazine
    - Horticulture Magazine
    - Southwest Gardening Magazines
- University Extension offices
    - University of Minnesota Extension
    - University of Minnesota Libraries Digital Conservancy
    - University of New Mexico Extension
    - University of Arizona Extension
    - University of Texas Extension

3. Activities

Perennial *Zinnia spp*. can be propagated from seed and vegetative cuttings (Ranjan, P., 2017) in plugs and pots (USDA, 2012). However, production information on the best practices to propagate *Zinnia spp*., other than for the three popular cultivated annuals (*Z. elegans, Z.*

angustifolia, Z. haaganea), is not commonly available. To begin to identify best practices for growing *Z. acerosa*, I will propagate *Z. acerosa* seeds under the growing conditions at the University of Minnesota Plant Growing Facility and use production information for growing cultivated species (see Image 11) as a guide. Using transplants grown on from these seeds I will then test to see how feasible it is or not to propagate *Z. acerosa* vegetatively.

The results from the tests will be used to write a PIG for *Z. acerosa*. The PIG will be beneficial for anyone interested in growing *Z. acerosa*, but is intended for commercial growers who may be producing plants for retail and for wholesale to other growers, resellers, and organizations that may purchase stock for restoration purposes. The hope is that it will get more germplasm in circulation for growing (growers, seed vendors, distributors) for (residential, restoration, breeding) to take advantage of the benefits of this plant, especially in its native growing range.

I will test for the best methods of three production stages: propagation (by seed germination and vegetative cuttings), plug production, and growing on as transplants up to the points plants are ready for 4 inch pots. For the plug production and transplant production, I will test two alternative propagation methods. Refer to the production schedules in Tables 2 and 3 for seed and vegetative propagation, respectively.

Propagation: I will be propagating *Z. acerosa* by seed and vegetative cuttings and measuring the rate of germination/root production, days to germination/root production, height of seedlings/cuttings when they are ready to go to the greenhouse, and counting the number of leaves on the primary stem to calculate the mean internode lengths (stem length/no. of leaves)..

Plug production: I will treat some seedlings with a PGR and some with an adjusted temperature differential (DIF). Both are said to be effective in controlling plant height, as is withholding

water (Ball Seed, 2017). I will measure seedling height and number of seedlings/cutting height and number of cuttings, and the number of days of the plug stage.

Transplant production: Zinnias are essentially, but not exclusively, facultative short day (FSD) plants (Ranjan, 2017). I will grow some of the transplants under short day conditions (8 hours light) and some under long days (16 hours light). I will measure the height of the transplants, the number of transplants, the number of days to visible bud date,, and the total number of flowers per plant.

For each of these stages I will take notes on plant quality and track any signs and symptoms of disease, pests, and nutrient deficiency.

Table 2. Production Information Guide (PIG) for Cultivation of All Commercial *Zinnia* Species.

Production Information Guide

Cultivated *Zinnia spp.*

Plug crop time: 21 days
Transplant to finish:10-15 days

General Information

Exposure	Bloom Season	Height	Spread	Spacing
Full sun	Spring, summer, fall	varies	varies	varies

Germination

Seed Form	Recommended Plug Size	Seeds/Cell	Plug Crop Weeks	Days to Germinate	Initial Media pH/EC	Cover Seed
Raw	50 or 72. Can also be sown in final container. Seedlings grow rapidly.	1	3	3-7	pH 5.8-6.2 and salts EC less than 0.75 mmhos/cm (2:1 extraction)	Yes-lightly

Plug Production

	Stage 1	Stage 2	Stage 3	Stage 4
Moisture	Keep media on the dry side. Do not saturate.	As cotyledons emerge, reduce relative humidity levels. For the best root development, reduce medium moisture levels once the radicles emerge, allow soil to dry between irrigations	Allow soil to dry between irrigations	Allow soil to dry thoroughly between irrigations
Temperature	68-70° F (20-21° C)	decrease the night temperature to 65- 68° F	Air temperature 65° F (18° C) night, 70-75° F (21-24° C) day	Air temperature 65° F (18° C) night, 70-75° F (21-24° C) day
Light		FSD </= 10 hours		
Fertilizer		Increase feed to 50-75 ppm N every 2 - 3 irrigations;	Fertilize at 100 ppm with a low ammonium fertilizer such as 14-0-14. if stretch occurs, alternate with clear water.	Fertilize with 14-0-14 or CA/KNO3 feed at 50-75 ppm N as needed.
PGR		Use DIF whenever possible, especially the first 2 hours after sunrise, to control plant height.	Apply b-nine at 2,500 ppm at the first true leaf stage or 16 days after sowing. Apply at 1 to 2 week intervals or when growth begins to stretch.	
Soil	pH 5.8-6.2 and salts EC less than 0.75 mmhos/cm (2:1 extraction) Well-drained.			

Propagation Key Tips

Avoid overhead irrigation. Short day treatments promote more rapid flower initiation although flowers will form during long days. The long day flowers will have more disk flowers (no petals) while flower initiation under short days will have more petals. Maintain light levels as high as possible while maintaining moderate temperatures.

Transplant / Growing on to Finish

Growing on Temperature	Target Media pH/EC	Fertilizer	Daylength
55-60° F (13° -15.5° C) nights, 60-65° °F (15.5° -18° C) days	pH 5.8-6.2 and salts EC less than 0.75 mmhos/cm (2:1 extraction) Well-drained.	Fertilize every irrigation with 50-75 ppm from 13-2-13.	FSD

Crop Scheduling

Container Size	Plugs/Pot	Crop Time	Season	PGR
4	50 or 72	5 weeks	Spring/Fall	DIF; ARrest;Bonzi; B-Nine; tank mixes

Common Problems
Diseases: Alternaria blight (*Alternaria zinniae*), bacterial leaf and flower spot (*Xanthomonas campestris* pv. *zinniae*), and powdery mildew (*Golovinomyces cichoracearum*)

Boron: *Zinnia spp*. are prone to boron deficiency which can reduce branching and result in abortion of flower buds. .

Finishing Key Tips
Transplant at when there are at least 2 sets of true leaves. Avoid overhead irrigation. Use well-draining media.

Sources:

Ball Seed. 2017. *Zinnia elegans*. https://www.ballseed.com/PDF/BallSeed-AtRiskCrops-Zinnia.pdf

Johnny's Selected Seeds. 2016. *Zinnia Cut Flower Production*. https://www.johnnyseeds.com/on/demandware.static/-/Library-Sites-JSSSharedLibrary/default/dw23ccb203/assets/information/zinnia-production.pdf

Johnson, C.N., Kessler, J. R. 2007. *Greenhouse Production of Bedding Plant Zinnias*. Alabama A&M Cooperative Extension and Auburn University. https://ssl.acesag.auburn.edu/pubs/docs/A/ANR-1311/ANR-1311-archive.pdf

Kansas State University. 1993. *Commercial Specialty Cut Flower Production: Zinnias*.https://ag.umass.edu/sites/agcenter/files/pdf-doc-ppt/mf1079.pdf

Table 3 Production of *Zinnia acerosa* by seed

Seed Propagation				
Production Stage		**Greenhouse conditions affecting plant growth**	**Recommendations for Z. spp.**	**Measurements**
Germination		Night/day temps: 70°F/70°F Light: 16 hrs at 150 µmol m^{-2} s^{-1} Moisture: Mist every 10 mins for 7 secs Nutrients - none DIF - no	50 or 72. Can also be sown in final container. Seedlings grow rapidly. Lightly cover seeds	Rate of germination Days to germination Height of seedlings
Plug stage		Night/day temps: 70°F/70°F Light: 16 hrs at 150 µmol m^{-2} s^{-1} Moisture: reduced Nutrients - 125 ppm N CLF 15-5-15 Cal-Mag (CLF) DIF - sunrise for 2-3 hrs	Allow soil to dry thoroughly between irrigations. DIF; ARrest; Bonzi; B-Nine; or tank mixes beginning at plug stage 2 Reduce night temp to 65-68°F	Height of seedlings # of seedlings Days to transplant stage
With PGR	With DIF only			
Transplant stage		Night/day temps: 70°F/65°F Light SD: < 8 hours at 150 µmol m^{-2} s^{-1} Light LD: 16 hrs at 150 µmol m^{-2} s^{-1} Moisture: reduced Nutrients - 125 ppm N CLF 15-5-15 Cal-Mag (CLF) DIF - sunrise for 2-3 hrs	FSD = <10 hrs	Height of seedlings # of seedlings Days to flowering Number of flower buds/flowers
FSD	LD			

Table 4. Production of *Z. acerosa* by vegetative propagation

<table>
<tr><th colspan="4">Vegetative Propagation</th></tr>
<tr><th colspan="2">Production Stage</th><th>Greenhouse conditions affecting plant growth</th><th>Recommendations for Z. spp.</th><th>Measurements</th></tr>
<tr><td colspan="2">Rooting plugs</td><td>Night/day temps 70°F/70°F
Light 16 hrs at 150 µmol m^{-2} s^{-1}
Moisture: Mist every 10 mins for 7 secs
Nutrients - none
DIF - no</td><td>Information for Z. spp. is not available for veg. production. Follow information for seed production above regarding PGR’s</td><td>Rate of rooting
Days to rooting
Height of cuttings</td></tr>
<tr><td colspan="2">Transplant stage</td><td rowspan="2">Night/day temps:
70°F/65°F
Light SD: < 8 hours at 150 µmol m^{-2} s^{-1}
Light LD: 16 hrs at 150 µmol m^{-2} s^{-1}
Moisture: reduced
Nutrients - 125 ppm N CLF 15-5-15 Cal-Mag (CLF)
DIF - sunrise for 2-3 hrs</td><td rowspan="2">Information for Z. spp. is not available for veg production. Follow information for seed production above regarding photoperiod.</td><td rowspan="2">Height of cuttings
# of cuttings
Days to flowering
Number of buds/flowers</td></tr>
<tr><td>Short Day (SD) Photoperiod</td><td>Long Day (LD) Photoperiod</td></tr>
</table>

4. Timeline

Total timeline 14 to 16 weeks

Week 1 *Preparation (total time 7 days)*

1. Contact partners (University extensions, magazine publications)
2. Purchase and collect supplies
3. Set-up growing schedule/data sheet

Weeks 2-11 *Propagation (total time 68-70 days)*

1. Propagate seeds (43 days)
    a. Sow seeds (7 days)
    b. Grow plugs (21 days)

c. Grow transplants to finishing (15 days)

2. Propagate vegetative cuttings (total time 25 days)
    a. Take cuttings (10 days)
    b. Grow transplants to finishing (15 days)

Week 12 *Results (7 days)*

1. Create PIG
2. Write articles for growers' magazines and university extension

Week 13 *Submit articles (7 days)*

5. Outputs

1. A study of the production of *Z. acerosa* by seed using production guides for cultivated *Zinnia* species.
2. A study of the viability of propagating *Z. acerosa* by vegetative cuttings
3. A one-sheet production information guide for *Z. acerosa*
4. An article for commercial grower magazines
5. An article for university extension publications
6. Publication on the University of Minnesota Libraries Digital Conservancy

The audience of these materials includes seed vendors, commercial growers, wholesale and retail plant vendors, extension educators, landscape restoration organizations, famers, rangers, and other landowners. The exact number of participants (readers) will depend on the circulation of the respective publications and on the number of individuals and organizations specifically looking for growing information on *Z. acerosa*.

6. Outcomes

In the short term, the outcomes of this project will include an increased availability of production information for *Z. acerosa* and additional attention drawn to the benefits of the species for the target audiences. It is the goal of the study to use the results to engage with the horticulture industry and educators, and with the readers of their promotional and educational materials (magazines and extension publications) in order to bring attention to this species and to increase availability of germplasm for breeders, growers, seed and plant vendors, and Extension Educators. In the long run, the long term impacts may include an increase in commercial availability of plant material for landscape use, including restoration, and increased availability of improved zinnia cultivars.

The short and mid-term outcomes will be measured by the interest of the target audiences in the results of the study and any responses from the readers of the respective publications. If there proves to be a demand for the species, the behavioral change will include direct efforts within the horticulture industry to increase the availability of information on growing *Z. acerosa* and to consider it as a possible income source.

7. Program evaluation - The outcomes will be measured with follow-up contacts with partners to collect information and get feedback. One month from the publication of production information in growers' magazines and university extension publications I will obtain information on reader feedback, online comments, and online analytics to gauge interest in the information. I will also follow up with any inquiries that may come from the publication of the information.

8. Key personnel - self; Plant Growth Facility watering staff.

E. Budget $7,930

F. Budget narrative

Salaries	
Graduate research student (Mary Magers) ($18/hr x 15 hrs/wk x 16 wks)	$4,320
Undergraduate watering staff at Plant Growth Facility ($12/hr x 5 hrs/wk x 16 wks)	$ 960
Fringe benefits	$ 0
Non-expendable equipment	$ 0
General materials and supplies	$ 70
Trave (parking $10/dy x 3 days/week x 16 weeks)	$ 480
All other direct costs: Greenhouse rental and production supplies	$2,100
Indirect costs	$ 0
Not allowed costs	$ 0
Total costs	**$7,930**

G. Letter(s) of collaboration - N/A

References:

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Figure 1: Ladybird Johnson Wildflower Center, *Zinnia acerosa*, 2019

Figure 2: Benson, L. and Darrow, R.A. 1954. *The Trees and Shrubs of Southwestern Deserts*. The University of Arizona Press, Tucson.

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Figure 6: Lehman, J. 2020.

Figure 7: Makings, L. n.d. SEINet Arizona-New Mexico Chapter. http://swbiodiversity.org/seinet/imagelib/imgdetails.php?imgid=626822

Figure 8: Magers, M. 2020.