Chinese Silvergrass Seed Shows Long-term Viability

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SUMMARY. **Chinese silvergrass (*Miscanthus sinensis*) is native to East Asia and South Africa and has been grown as an ornamental in the United States for over 100 years. Chinese silvergrass is on the invasive species list for 12 states in the United States and is regulated for sale in New York state. It is often found along roadsides in middle-Atlantic states and Long Island, NY. In 2019 and 2020, we sowed chinese silvergrass seed harvested in Fall 2002 and Spring 2003 from several locations in North Carolina where it had naturalized and from the Minnesota Landscape Arboretum, Chaska, MN. The seed had been stored in a seed storage vault (4 °C) from 2002 to 2020. Germination in 2003 showed variation between 53% to 95% from 19 different individual plants. This same seed when resown in 2019 and 2020 had much lower germination that could be divided into three categories: no germination (five plants), germination of 1% or less (seven plants), and germination of more than 2% (seven plants). Results from this study show that seed viability may be a long-term problem in locations where chinese silvergrass has naturalized.**

Native to East Asia and South Africa (Ohwi, 1964), chinese or japanese silvergrass (*Miscanthus sinensis*) has been grown as an ornamental in the United States for over 100 years (Hitchcock, 1901) with numerous garden cultivars (Darke, 1999). This species is listed as invasive in 12 U.S. states (Swearingen and Bargeron, 2016); is regulated for sale requiring specific invasive signage in New York state (New York Department of Environmental Conservation, 2020); and has naturalized in 25 states, the District of Columbia, and Ontario, Canada [U.S. Department of Agriculture (USDA), 2020].

Seed of this species may have little dormancy and a high germination capacity over a wide range of environmental conditions (Waggy, 2011). It is known for abundant widespread seed produced in native habitats (Stewart et al., 2009). Meyer and Tchida (1999) tested seed set and germination for 41 cultivars of chinese silvergrass grown in four USDA plant hardiness zones (Z4, Z5, Z6, and Z7) over 2 years and found high seed set in most cultivars. Wilson and Knox (2006) found similar results in northern Florida. Madeja et al. (2012) found potential invasiveness of 34 cultivars of chinese silvergrass in Z5 by quantifying differences in fecundity among cultivars over 5 years in a common garden setting. They found most cultivars set filled seed; only four produced no seed over the 5-year trial, while the majority "represent a high risk for self-seeding in Zone 5." The numerous showy flowers of ornamental cultivars of chinese silvergrass have a "long history of localized escape in the eastern especially within the Appalachian region" (Quinn et al., 2010) and are categorized as invasive by the horticultural industry (Peters et al., 2006). A similar species, amur silvergrass (*Miscanthus sacchariflorus*), often confused with chinese silvergrass, shows little seed set (Mutegi et al., 2016) but also has naturalized in several states (USDA, 2020).

Studies attempting to improve the feasibility of using this species as a biomass fuel source found baseline (50% germination) soil temperatures between 9.7 and 11.6 °C were necessary for field germination of chinese silvergrass (Clifton-Brown et al., 2011). Unprimed seed sown in May under film and only when soil is moist has also been recommended for increased germination of this species (Ashman et al., 2018).

Despite the known invasiveness of these two species (chinese silvergrass and amur silvergrass), the natural male-sterile hybrid between the two, giant miscanthus (*Miscanthus ×giganteus*), is of interest as a biomass fuel source (Heaton et al., 2010) due to its strong perennial root system and ability to grow in colder climates. Biomass crop establishment via seed has been limited (Christian et al., 2005), and increased seed set is being pursued (Awty-Carroll et al., 2020) despite the recognized risk for environmental escape (Miriti et al., 2017; Quinn et al., 2010, 2011). Quinn et al. (2010) called for "the development of sterile or functionally sterile varieties of *M. sinensis* or the restriction of its usage as a donor of genetic material to new sterile cultivars of *M. ×giganteus*." Sterile forms of chinese silvergrass have been developed (Hanna and Schwartz, 2020).

Few reports could be found concerning seed longevity of miscanthus (*Miscanthus* sp.), with none for seed from the United States. Priestley (1986) points out that plants in the grass family (Poaceae) are not generally noted for longevity in the dry state, with studies showing 5–12 years for plants in the grass family seed viability. A 10-year study in Russia concluded chinese silvergrass had high self-incompatibility, low viability, and extremely poor seed set in cultivated and wild populations; propagation via seed was unreliable (Nechiporenko et al., 1997), which may reflect the environmental variability of species in different climates. Hsu (2000) reported that pacific island silvergrass (*Miscanthus floridulus*) and silvergrass (*Miscanthus transmorrisonensis*) seed stored at 4 °C

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Units

To convert U.S. to SI, multiply by	U.S. unit	SI unit	To convert SI to U.S., multiply by
29.5735	fl oz	mL	0.0338
25.4	inch(es)	mm	0.0394
(°F – 32) ÷ 1.8	°F	°C	(°C × 1.8) + 32

Table 1. Chinese silvergrass germination data from 2003 and 2019–20 from 19 plants collected in North Carolina and Minnesota.

		2003				2019–20			
Location[z]	Coordinates (latitude, longitude)	Total seeds (no.)	Replications (no.)	Germination (no.)	Germination (%)	Total seeds (no.)	Replications (no.)	Germination (no.)	Germination (%)
Bilt Est Deer Park	35°55′07″ N, 82°56′18″ W	90	3P[y]	48	53 c[x]	210	5P/2S[y]	5	2
Mars Hill BXH 5	35°49′19″ N, 82°36′33″ W	na	na	na	na	180	3P/3S	6	3
Days Inn Exit 55 Rt 40 Asheville	35°60′42″ N, 82°37′42″ W	90	3P	87	97 a	300	8P/2S	11	4
Mars Hill BXH 6	35°49′19″ N, 82°36′33″ W	na	na	na	na	270	3P/6S	12	4*[w]
Mars Hill BXH 7	35°49′19″ N, 82°36′33″ W	na	na	na	na	270	3P/6S	20	7**
Mars Hill BXH 4	35°49′19″ N, 82°36′33″ W	na	na	na	na	180	3P/3S	15	8**
Mars Hill BXH 3	35°49′19″ N, 82°36′33″ W	90	3P	63	70 abc	300	5P/5S	33	11**
Bilt Est Low Overlook, Fall	35°53′70″ N, 82°54′64″ W	90	3P	66	73 abc	210	5P/2S	2	<1%
Upper Grassy Road B	35°60′42″ N, 82°48′63″ W	90	3P	68	76 abc	210	5P/2S	2	<1%
Bilt Est, Upper Overlook	35°53′70″ N, 82°54′64″ W	90	3P	74	82 abc	210	5P/2S	1	<1%
Upper Grassy Road A	35°61′32″ N, 82°49′06″ W	90	3P	74	82 abc	210	5P/2S	1	<1%
Grove Park Inn	35°61′97″ N, 82°54′49″ W	90	3P	76	84 abc	210	5P/2S	3	1%
MLArb, Purpurescens, MN	44°85′66″ N, 93°61′61″ W	90	3P	66	73 abc	180	4P/2S	1	<1%
Barnardsville Rd	35°78′18″ N, 82°50′08″ W	90	3P	71	80 abc	210	5P/2S	3	1%
MLArb, Blondo, MN	44°85′66″ N, 93°61′61″ W	90	3P	58	63 bc	210	5P/3S	0	0
Exit 50, Route 40	35°55′90″ N, 82°53′99″ W	90	3P	63	70 abc	210	5P/2S	0	0
Bilt Est Low Overlook, Spring	35°53′70″ N, 82°54′64″ W	90	3P	78	87 a	210	5P/2S	0	0
Bilt Tic Office, Spring	35°56′61″ N, 82°54′69″ W	90	3P	69	77 abc	210	5P/2S	0	0
Bilt Tic Office, Fall	35°56′61″ N, 82°54′69″ W	90	3P	51	56 bc	180	4P/2P	0	0

[z]North Carolina unless indicated.
[y]P = petri plates, S = germination mix.
[x]Means followed by different letters are significantly different as determined by Tukey's significant difference test at $P < 0.05$.
[w]Means followed by * and ** are significantly different as determined by Poisson regression analysis at $P < 0.05$ and $P < 0.01$, respectively.

for 2 years in Japan was not reduced in germination but that "miscanthus seeds might lose their germination ability 6 months after being dispersed by the wind under natural conditions" and that "seed dispersal is the primary mechanism for population growth in *M. sinensis*" (Quinn et al., 2011).

The objective of this project was to determine the viability of chinese silvergrass seed collected from naturalized populations known to have high seed set and viability nearly 20 years previously.

Materials and methods

Mature inflorescences were harvested in Nov. 2002 from 15 random individual naturalized plants at 11 locations in and around Asheville, NC (Meyer, 2003). Seed was also collected in Nov. 2002 from 'Blondo' and 'Purpurascens' chinese silvergrass growing at the Minnesota Landscape Arboretum, Chaska, MN. In Mar. 2003, seed was collected from additional plants at two of the same locations visited in Nov. 2002 and are noted as "Spring" in Table 1. Inflorescences were stored at room temperature for less than 2 weeks until the seed was hand-cleaned to remove all floral parts surrounding the seed, after which it was weighed, labeled, and stored in envelopes in a 4 °C, 40% relative humidity seed storage vault until germination experiments commenced.

All treatments were conducted at the Plant Growth Facilities at the University of Minnesota, Saint Paul (lat. 44°98′ N, long. 93°17′ W). Seed were sown in 128-cell (14 mL individual cell volume) plug trays (T.O. Plastics, Clearwater, MN) filled with moistened soilless mix (Fafard Germinating Mix; Sun Gro Horticulture, Agawam, MA). Two seeds (uncovered) were placed in each cell, with 15 cells (or 30 seeds) as one replicate. Seeds were lightly covered with medium-grade vermiculite and placed in a 24/18 °C (day/night) glass-glazed greenhouse with intermittent mist (5 s mist every 8 min) and 600-W high-pressure sodium lighting (Gavita, Vancouver, WA and GE Lighting, Cleveland, OH) and 16-h daylength (0800–2200 HR).

For the treatments in petri plates, seed was removed from storage and placed on blotter paper moistened with deionized water in 60- × 15-mm petri dishes (Becton, Dickinson and Co., Franklin Lakes, NJ) sealed with waxed film (parafilm M; Bemis, Neenah, WI) and placed at 24 °C with 12 or 14 h lighting supplied with two cool white fluorescent bulbs with 67 $\mu mol \cdot m^{-2} \cdot s^{-1}$ intensity.

Petri plates were remoistened with deionized water when blotter paper was dry. Thirty seeds per plate was considered one replicate. A minimum of two replicates per soil germination and three petri plates per plant were sown. Germination counts began at 7 d and continued for 30 d. Germination was defined as the visible emergence of plumule and radicle or seedlings were visible above the soil. Treatments took place in Apr. and May 2003 and Jan. 2019 through Apr. 2020. Means were separated by Tukey's significant difference test at $P < 0.05$ for the 2003 germination. Poisson regression analysis was used to determine if there was a significant difference at $P < 0.05$ between germination data for the 2019–20 experiments.

Results and discussion

Germination in 2003 showed variation between 53% to 95% for the 19 plants (Table 1). These same seeds when sown in 2019 and 2020 had significantly lower germination that could be divided into three categories: no germination (five plants), germination of 1% or less (seven plants), and germination of 2% or greater (seven plants). Fourteen of the 19 plants studied showed some viability (>0% germination), although quite small. The Poisson regression analysis showed significant differences between plants in 2019–20 germination data (Table 1). The germination in 2019–20 was lower for all plants compared with the 2003 data, as would be expected. Five of the plants showing the highest germination (although still only 2% to 11%) came from one collection site, Bax Hensley Road, north of Asheville, NC near the town of Mars Hill, NC. Multiple inflorescences were collected at this location from multiple plants that still had measurable viable seed after 18 years in cold storage. Seed in a natural setting would probably be less viable due to environmental conditions; however, this has not been investigated or verified. Although the seed we tested was held in traditional cool, dry conditions (4 °C, 40% relative humidity), knowing the potential for long-term viability adds to the biological knowledge of this species. From an invasive plant view, long-term seed viability is a negative trait that can be a long-term problem. It is interesting to note that we found significant germination from some plants at certain collection points, and 0 or very low germination from others, even though all the plants were the same species. Whether this is environmental or genetic variation is not known but shows the complexities of understanding and managing invasive species. Unfortunately, we could not locate additional references to further verify seed longevity in this genus. Land care managers should be aware that eliminating chinese silvergrass plants may not totally eradicate this species because seed may continue to germinate after the mother plants are gone. Based on our findings, when replacing chinese silvergrass, we recommend choosing aggressive grasses such as switchgrass (*Panicum virgatum*) that can compete with chinese silvergrass seedlings (Meyer et al., 2010). The more information that can be collected about the biology and growth of any invasive plants will help people make informed management decisions for the future.

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