Selecting Species to Produce Wildflower Seeds

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ADDITIONAL INDEX WORDS. dame's rocket (*Hesperis matronalis*), lemon mint (*Monarda citriodora*), catchfly (*Silene armeria*), bur marigold (*Bidens aristosa*), cornflower (*Centaurea cyanus*), plains coreopsis (*Coreopsis tinctoria*), baby's breath (*Gypsophila elegans*), standing cypress (*Ipomopsis rubra*), black-eyed susan (*Rudbeckia hirta*), seed maturation, germination

SUMMARY. Twenty-nine annual and perennial wildflower species were evaluated for commercial seed production potential in South Carolina. Species selection was based on adaptability to southeastern conditions and potential for use in wildflower sod. Potential for seed production was based on seed maturation ratings, percent germination 4 to 6 weeks after harvest, and yield. Individual species were seeded into 1-m^2 plots (3.3 ft^2), on 7 Oct. Seeds were collected, cleaned, and counted, and total seed yield (lb) was calculated based on seed germination and weight of 100 seeds. Species with potential for production were *Hesperis matronalis* L. (2605 lb/acre), *Monarda citriodora* Cer. ex Lag. (1247 lb/A), *Silene armeria* L. (1122 lb/acre), *Bidens aristosa* (Michaux) Britton. (41 lb/acre), *Centaurea cyanus* L. (823 lb/acre), *Coreopsis tinctoria* Nutall (185 lb/acre), *Gypsophila elegans* L. (120 lb/acre), *Ipomopsis rubra* (L.) (2301 lb/acre) Wherry, and *Rudbeckia hirta* L. (500 lb/acre).

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Large-scale wildflower plantings, such as in roadside beautification programs by state transportation departments, are becoming increasingly popular in the southeastern United States (Corley and Smith, 1990). These highway plantings can be established by direct seeding from seed harvested on site or, more commonly, when purchased from growers in the western and southwestern United States (Wilson, 1993). Western states like California have a climate conducive to quality seed production, but some species native to the southeastern United States may not be successfully grown in these major seed-producing areas. For example, *Bidens aristosa*, a southeastern annual, is not available from any of the large wildflower seed companies. Yet, this plant is an easy and attractive species to grow in the southeast.

Previous studies present information on germination and storage requirements (Carpenter and Ostmark, 1992; Kaspar and McWilliams, 1982; Salac and Hesse, 1975) for a limited number of wildflower species that are currently available in the seed trade. There is little information available on seed yields, germination capacities, seed maturation, and harvesting methods for species that may have potential for seed production in the southeastern United States (Phillips, 1985; Young and Young, 1986; Wilson, 1993).

The objectives of this study were to evaluate 29 wildflower species for commercial seed production in a southeastern environment. Wildflower species were selected for evaluation based on regional performance (Corley and Smith, 1990; Cramer 1993) and potential for wildflower sod production (Johnson and Whitwell, 1994). Production potential for these species was based on seed yields, germination percentages shortly after harvest, and seed maturation rates.

Materials and methods

PLANTING. Research plots were located in coastal plain region of South Carolina on a Goldsboro fine-loamy, siliceous, thermic Aquic Paleudults. The soil was characterized by a pH of 5.0, 0.0N–105P–84K (lb/acre), and 0.8% organic matter. The plots were cleared of existing turf and weeds by a nonselective herbicide application then tilled (5 inches) and fumigated with methyl bromide. In December, plots received an application of 6.3N–2.4P–9.1K (lb/acre) as a commercial slow-release nitrogen-based fertilizer. Overhead irrigation was used during the study to maintain adequate soil moisture when necessary.

Seeding date was 7 Oct., except for *Cosmos bipinnatus*, *Cosmos sulphureas*, *Gypsophila elegans*, *Lobularia maritima*, and *Salvia coccinea*, which were planted the following March. Seeding rates were based on supplier's recommended rates for wildflower meadow establishment (Wildseed Farms of Eagle Lake, Tex.). Seeding rates varied from species to species and ranged from 1 lb/acre for *Silene armeria* to 12 lb/acre for *Echinacea pupurea*. Seeds were mixed with contractor's sand (2 seed : 1 sand) for even dispersal and then broadcast using jars with perforated lids onto respective 1-m^2 plots, separated by 1-m^2 buffers. Seeds were lightly raked into the soil to an approximate depth of 0.2 inches, then rolled with a turf roller. The experiment was arranged in a randomized complete-block design with four replications of each species.

MATURATION, HARVESTING, AND YIELDS. For each species, data were collected for flowering dates, seed maturation rate, seed number and weight, dates of optimum seed harvest, and germination percentages. Flowering dates were recorded when the first inflorescence opened. Seed maturation was determined by seed color, seed softness when pinched, and percent of mature seed structures present compared to immature seed structures present. The rating scale was 1 = 85% to 100% of seeds matured at one time; 2 = 60% to 84% of seeds matured at one time; 3 = seeds matured over a period of weeks, seed heads remained intact until plant senescence; 4 = seeds matured and shattered over a period of 2 to 4 weeks; and 5 = seeds matured and shattered over a period of 1 to 2 months as inflorescence production continued.

The number of seeds produced was determined by observing the amount and maturation condition of seed-bearing structures present in each plot. Seeds in a 1-ft^2 area per plot were collected, cleaned, and counted, or subsampled and counted, depending on the number of seeds present. Optimum date of seed harvest was based on maximum amount of mature seed present at a given harvest time. Seeds

were stored for 2 weeks in paper envelopes at 26 °C at 58% relative humidity (RH) to dry them before counting. Total seed yield was calculated based on seed germination and weight of 100 seeds.

Germination tests. Germination tests were conducted 4 to 6 weeks after harvest. Following drying, undersized and green seeds were removed. Seeds were surface sterilized in a 5% sodium hypochlorate solution followed by three rinses in deionized water, placed on moistened Whatman's no. 5 filter paper in petri dishes, sealed with parafilm, and exposed to continuous fluorescent light for 2 weeks at 23 °C. Following germination tests, the remaining untested seeds were stored in a sealed metal can at 7 °C and 33% RH.

Due to poor initial results, a second germination test for the same seed stock of *Bidens aristosa*. was conducted. This included moist stratification in damp, whole sphagnum moss followed by storage in plastic freezer bags placed inside sealed plastic containers at 7 °C and 33% RH for 120 d. Seeds were subsequently surface sterilized, sown in river sand at a 0.1 in depth, and placed under mist irrigation for 3 weeks. Average greenhouse high temperature was 28 °C and low was 17 °C.

Results and discussion

An arbitrary categorization of species potential for commercial seed production was established based on seed maturation rating and percent germination. Germination and seed maturation habits varied from species to species. Species with the highest germination percentages and most even maturation period were *Hesperis matronalis*, *Monarda citriodora*, and *Silene armeria* (Table 1). These species were considered to have excellent seed production potential with seed maturation ratings of 1 or 2 and germination percentages >75% and were given a category I rating.

Species placed in category II had moderate seed production potential based on seed maturation ratings of 1, 2, 3, or 4, and germination percentages between 45% and 75% (Table 1). These species were *Bidens aristosa*, *Centaurea cyanus*, *Chrysanthemum leucanthemum*, *Coreopsis tinctoria*, *Gypsophila elegans*, *Ipomopsis rubra*, and *Rudbeckia hirta*. Although seed maturation rates varied from 1 (85% to 100% of seeds mature at one time) to 4 (seeds mature and shatter over a period of 2 to 4 weeks) in this category, this was considered acceptable for harvesting purposes. Flowering and seed maturation habits exhibited by these species may be due to determinate flowering characteristics. Young and Young (1986) observed that determinate annual crop plants flowered in sequence and seeds matured at the same time, which facilitated harvesting.

Species placed in category III had low seed production potential with a seed maturation rating of 5 or germination lower than 45% (Table 1). Those species were *Achillea millefolium*, *Coreopsis lanceolata*, *Cosmos bipinnatus*, *Cosmos sulphureus*, *Eschscholzia californica*, *Gaillardia aristata*, *Gaillardia pulchella*, *Oenothera speciosa*, *Papaver rhoeas*, *Phlox drummondii*, *Salvia coccinea*, and *Verbena tenuisecta*. Although several species in this category exhibited determinate flowering and had a seed maturation rating of 1 (85% to 100% of seeds mature one time), germination percentages were extremely low. *Gaullardia pulchella*, *Coreopsis lanceolata*, and *Phlox*

Table 1. Flowering and harvest dates, seed maturation rating, and germination and and yield components of wildflower species evaluated in 1994.

Category[z]	Species	Flowering date	Harvest date	SMR[z]	Germination (%)	Yield (lb/acre)	Viable seed yield (lb/acre)
I	*Silene armeria*	4 Apr.	26 May	1	100	1,122	1,122
I	*Hesperis matronalis*	14 Apr.	1 July	2	98	2,658	2,605
I	*Monarda citriodora*	29 Apr.	18 July	1	78	1,426	1,112
II	*Coreopsis tinctoria*	26 Apr.	21 June	1	63	293	185
II	*Bidens aristosa*	19 Aug.	20 Oct.	1	59	70	41
II	*Rudbeckia hirta*	18 May	26 July	1	53	944	500
II	*Centaurea cyanus*	11 Mar.	9 June	2	50	1,646	823
II	*Ipomopsis rubra*	18 May	2 Sept.	1	45	5,112	2,301
II	*Gypsophila elegans*	18 May	21 June	2	68	176	120
III	*Chrysanthemum leucanthemum*	23 Mar.	18 May	4	22	120	27
III	*Achillea millefolium*	29 Apr.	1 July	2	10	170	17
III	*Coreopsis lanceolata*	22 Apr.	5 June	4	43	326	140
III	*Cosmos bipinnatus*	26 May	12 Aug.	5	0	935	0
III	*Cosmos sulphureus*	18 May	26 July	5	48	228	110
III	*Eschscholzia californica*	8 Mar.	5 June	4	28	132	37
III	*Gaillardia aristata*	29 Apr.	10 Sept.	3	14	227	32
III	*Gaillardia pulchella*	29 Apr.	24 June	3	20	783	157
III	*Oenothera speciosa*	4 Apr.	26 May	2	0	270	0
III	*Papaver rhoeas*	4 Apr.	9 June	1	0	55	0
III	*Phlox drummondii*	8 Mar.	5 June	5	68	414	281
III	*Salvia coccinea*	5 June	2 Sept.	5	68	249	20
III	*Verbena tenuisecta*	8 Mar.	18 May	5	5	42	2

[z]Categories for the potential commercial seed production species were as follows: I = excellent potential, seed maturation rating 1 or 2, and germination >75%; II = moderate potential, seed maturation rating 1, 2, 3, or 4, and germination >44%; III = low potential, seed maturation rating 5, or germination <45%.
[y]Seed maturation rating (SMR) was based on a scale of 1 to 5, with 1 = 85% to 100% of seeds mature at one time; 2 = 60% to 84% of seeds mature at one time; 3 = seeds mature over a period of weeks, seed heads remain intact; 4 = seeds mature and shatter over a period of 2 to 4 weeks; and 5 = seeds mature and shatter over a period of 4 to 8 weeks.

drummondii require conditions for breaking dormancy other than those provided in this study, such as alternating temperatures and a longer germination period (Banovietz and Scheiner, 1994; Baskin et al., 1992; Carpenter et al., 1993) . In addition, for species in this category with a maturation rating of 5, the best harvesting date was difficult to determine due to the extended shattering period.

A Spearman's Rho correlation coefficient test was conducted to determine a relationship between the seed maturation rating and germination percentages for each species. There were no evidence of a correlation at $P = 0.05$.

Acceptable germination percentages may indicate that seeds were nondormant at the time of testing and germinated well in moist conditions at 23 °C in light. Acceptable germination was set at >45% to include native species with potential for production.

Seed yields varied from species to species. Species with the lowest yields were *Chrysanthemum leucanthemum* at 31 lb/acre, *Verbena tenuisecta* at 42 lb/acre, and *Papaver rhoeas* at 55 lb/acre. Species with the highest yields were *Ipomopsis rubra* at 5112 lb/acre, *Hesperis matronalis* at 2658 lb/acre, and *Monarda citriodora* at 1426 lb/acre. From a seed-production standpoint, high yields are desirable. However, low yield species, such as *Verbena tenuisecata*, sell for high retail prices ($85/lb).

Several species were eliminated from the study due to poor establishment or insufficient flowers and seed development: *Chrysanthemum maximum*, *Echinacea purpurea*, *Lobularia maritima*, *Oenothera missouriensis*, *Ratibida columnaris*, *Rudbeckia amplexicaulis*, and *Solidago rugosa*.

In a separate study examining seed-cleaning techniques and mechanical harvesting of *Silene armeria*, *Rudbeckia hirta*, and *Coreopsis tinctoria*, mechanical harvesting resulted in significantly lower yields than hand harvesting. Also, to accommodate the variations of seed sizes and weights, adaptations to existing seed cleaning equipment or specialized equipment was required.

Results of this evaluation indicate that several species had maturation characteristics and germination percentages suitable for commercial seed production in a southeastern environment. Native species not typically found in the wildflower seed trade, such as *Bidens aristosa*, also have potential for commercial seed production.

A quality wildflower seed source in the southeast would be advantageous for state departments of transportation and other organizations requiring wildflowers that are well adapted to regional conditions. A regional seed source would also provide purchasers with southeastern native species less commonly found in the seed trade and more easily grown in the southeast.

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