# Selecting Species to Develop a Field-grown Wildflower Sod

Anne Marie Johnson[1] and Ted Whitwell[2]

**ADDITIONAL INDEX WORDS.** yarrow (*Achillea millefolium*), ox-eye daisy (*Chrysanthemum leucanthemum*), lance-leafed coreopsis (*Coreopsis lanceolata*), plains coreopsis (*Coreopsis tinctoria*), blanketflower (*Gaillardia aristata*), lemon mint (*Monarda citriodora*), black-eyed susan (*Rudbeckia hirta*), moss verbena (*Verbena tenuisecta*), field harvested, aerial growth control, seeding date

**SUMMARY.** Twenty-nine annual and perennial wildflower species were evaluated for sod development based on ratings for appearance, root mat density, and stability following undercutting and storage and performance after replanting. Species selection was based on the lack of a large taproot, adaptability to the southeastern climate, flowering period, and potential for surviving root undercutting. Species were seeded in fall and spring, and leaf area and root mass samples were compared. Wildflower sod was undercut at a 5 cm (2 in) depth in March (fall-seeded plots) and May (spring-seeded plots) and then stored on clear plastic for 7 weeks and replanted. Fall-planted species had a higher survival rate than spring-planted species. Species selected for sod development were *Achillea millefolium* L., *Chrysanthemum leucanthemum* L., *Coreopsis lanceolata* L., *Coreopsis tinctoria* Nutt., *Gaillardia aristata* Foug., *Monarda citriodora* Cerv. ex Lag., *Rudbeckia hirta* L., and *Verbena tenuisecta* Briq. To reduce damage to aerial growth during harvesting, paclobutrazol, daminozide, and uniconazole were tested on eight greenhouse-grown wildflower species. Uniconazole had limited growth control over *Rudbeckia hirta*, *Monarda citriodora*, *Coreopsis lanceolata*, and *Coreopsis tinctoria*.

Recently, wildflowers have become popular for providing low-maintenance color and diversity in the cultivated landscape. However, failure to achieve the desired effect of a wildflower meadow often occurs due to improper seed-planting techniques and weed competition (Gallitano et al., 1992; Zajicek et al., 1986). Also, achieving peak color by direct seeding is often complicated by the 2 to 3 years required by some perennial species to reach flowering (Corley and Smith, 1990). Planting established young plants, however, would alleviate the risks involved in direct seeding and provide the look and color of a mature wildflower meadow in a much shorter time. Currently available wildflower sod products are often comprised of a soil-like medium in which young plants are rooted, then shipped and planted in the landscape as a solid mat (Milstein, 1990). However, sod can be relatively expensive to produce, and species adaptibilty to southeastern conditions remains undocumented.

The objective of this study was to evaluate 29 annual and perennial wildflower species for potential use in a field-grown wildflower sod. Species were selected for evaluation based on the absence of a large taproot, adaptability to the southeastern climate, flowering period, floral aesthetics, and potential for survival after root undercutting.

As in turfgrass sod production, aerial shoot growth must be managed to reduce damage to plants when undercut and to extend the harvesting window. Paclobutrazol, uniconazole, and daminozide were selected for a preliminary greenhouse evaluation to determine their potential for stem elongation control in eight of the most promising species used in this study.

## Materials and methods

**PLANTING.** Seeds were sown in the fall (7 Oct.) and spring (16 Mar.) on the coastal plain region of South Carolina to determine optimum sowing time for sod survival and harvesting. Procedures for soil preparation, sowing, fertilizing, and irrigating were the same for the two dates. The research site soil was a Goldsboro fine-loamy, siliceous, thermic Aquic Paleudults. Soil pH was 5.0 and contained 0N–105P–84K (lb/acre) and 0.8% organic matter. Three months after sowing, plots received an application of fertilizer at 6.3N–2.4P–9.1K lb/acre.

The site was cleared of existing vegetation by a nonselective herbicide application and deep tilled to ≈13 cm (6 inches) and fumigated with methyl bromide 1 month before sowing. Seeds were mixed with contractor's sand (2 seed : 1 sand) for even dispersal and were broadcast using jars with perforated lids onto respective 1-$m^2$ (3.3-$ft^2$) plots, separated by 1-$m^2$ buffers. Seeds were lightly raked into the soil to a depth of ≈0.5 cm (0.2 inches), then rolled with a turf roller. To ensure dense plantings, individual species were sown at triple the supplier's suggested seeding rate (Wildseed Farms, Eagle Lake, Tex.). Recommended seeding rates varied from species to species and ranged from 1 lb/acre for *Silene armeria* to 12 lb/acre for *Echinacia purpurea*. The experimental design was a randomized complete block with four replications of each species. Each planting date was a separate experiment. Overhead irrigation was used as needed to maintain adequate soil moisture during the experiment.

**UNDERCUTTING AND TRANSPLANTING.** Sod was undercut at a depth of 5 cm (2 inches) with a Ryan walk-behind sod harvester. Plots planted 7 Oct. were undercut 8 Mar. and plots planted 16 Mar. were undercut 27 May. To evaluate plant responses to stresses incurred by sod pieces in a retail situation, sod strips were removed from the field and placed on transparent plastic sheeting under overhead irrigation for 7 weeks.

To determine differences between October and March plantings, leaf areas and root mass were taken before undercutting. Leaf area readings were taken with an area meter (LI-3100; LI-COR, Lincoln, Nebr.). Root samples were collected with a soil auger at a 5 cm depth and a 255 $cm^3$ volume.

After 7 weeks on the plastic, wildflower sod pieces were replanted. Seven

Department of Horticulture, Poole Agricultural Center, Clemson University, Clemson, SC 29634-0375.

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[1]Graduate research assistant.

[2]Professor.

days after replanting, transplants received an application of fertilizer at 6.3N–2.4P–9.1K lb/acre. A final visual appearance rating for fall-seeded sod was taken 49 d after replanting and a final appearance rating for spring-seeded sod was taken 17 d after replanting. Final appearance ratings for spring-seeded species were made at 17 d due to high plant mortality.

Wildflower sod pieces were rated on appearance, root density, and sod stability when removed from the field after undercutting and at the termination of the storage on plastic period. Appearance ratings were based on a scale of 5 = normal size, no damage to top growth, vigorous, healthy appearance; 4 = normal size, slight damage to top growth, vigorous appearance; 3 = normal size, slight damage to top growth, some yellowing of foliage; 2 = undersized, foliage damaged, at least half yellowing and brown; and 1 = undersized, foliage damaged, most foliage and stems yellowing and brown. Plants that were not undercut served as a rating comparison for appearance.

Root density and stability ratings were 5 = no separation, full and solid root growth; 4 = minimal separation, full and solid root growth; 3 = minimal separation, root growth less dense; 2 = minimal matting, slight loss of roots and soil; and 1 = no matting, excessive loss of roots and soil, damage to plants. All ratings were totaled for each species to determine those species with the best potential and to compare spring and fall plantings. All data were subjected to ANOVA procedure.

**PLANT GROWTH REGULATORS**. Paclobutrazol, daminozide, and uniconazole were evaluated for the potential to control the top growth of the following species so as to minimize the damage from sod harvesting equipment: *Achillea millefolium*, *Chrysanthemum leucanthemum*, *Coreopsis lanceolata*, *Coreopsis tinctoria*, *Gaillardia aristata*, *Monarda citriodora*, *Rudbeckia hirta*, and *Verbena tenuisecta*. All plants were grown from seed in the greenhouse. The experimental design was a completely random design with four replications of each species.

At indications of stem elongation (71 d after sowing), growth regulator treatments were applied as a single foliar spray at the rate of 204 $mL \cdot m^{-2}$. Concentrations were paclobutrazol at 50 ppm (4 mg a.i./mL), daminozide at 5000 ppm (85% a.i.), and uniconazole at 25 ppm (0.5 mg a.i./mL).

Growth index measurements (main stem length from first true leaves to apical tip, plus the distance from leaf tip to leaf tip across the length and width of the pot, divided by 3) were taken before treating and weekly thereafter for 1 month. Aerial growth was harvested 30 d after treatment, then dried at 40 °C for 3 weeks and weighed. Data were subjected to ANOVA procedure.

## Results and discussion

**FALL AND SPRING PLANTING**. After

**Table 1. Wildflower species and survival outcomes for fall and spring plantings.**

| | Fall planting[z] | | | | Spring planting | | | |
|---|---|---|---|---|---|---|---|---|
| Species | DP | DU | PE | S | DP | DU | PE | S |
| *Achillea millefolium* | | | | X | | | | X |
| *Bidens aristosa* | X | | | | X | | | |
| *Centaurea cyanus* | | | | X | X | | | |
| *Chrysanthemum luecanthemum* | | | | X | X | | | |
| *Chrysanthemum maximum* | | | | X | X | | | |
| *Coreopsis lanceolata* | | | | X | | | | X |
| *Coreopsis tinctoria* | | | | X | | | | X |
| *Cosmos bipinnatus* | | | NP[y] | | | X | | |
| *Cosmos sulphureus* | | | NP | | | X | | |
| *Echinacea purpurea* | | | | X | X | | | |
| *Eschscholzia californica* | | X | | | | X | | |
| *Gaillardia aristata* | | | | X | | | | X |
| *Gaillardia pulchella* | | | | X | X | | | |
| *Gypsophila elegans* | | | NP | | | | X | |
| *Hesperis matronalis* | X | | | | | | X | |
| *Ipomosis rubra* | X | | | | X | | | |
| *Lobularia maritima* | | | NP | | | | X | |
| *Monarda citriodora* | | | | X | | | | X |
| *Oenothera missouriensis* | | | X | | | | NE[x] | |
| *Oenothera speciosa* | | | | X | X | | | |
| *Papaver rhoeas* | | X | | | | | X | |
| *Phlox drummondii* | X | | | | | X | | |
| *Ratibida columnaris* | | | X | | | | NE | |
| *Rudbeckia amplexicaulis* | | | X | | | | NE | |
| *Rudbeckia hirta* | | | | X | | | | X |
| *Salvia coccinea* | | | NP | | X | | | |
| *Silene armeria* | | | | X | X | | | |
| *Solidago rugosa* | | | X | | | | NP | |
| *Verbena tenuisecta* | | | | X | | | | X |

[z]DP = died while stored on plastic, DU = excessive damage to aerial growth, PE = poor emergence, S = good emergence, survived undercutting and storage.
[x]NP = not planted.
[y]NE = no emergence.

harvesting (undercutting), storing, and replanting fall-planted and spring-planted wildflowers, several species showed potential for further sod development based on our criteria. Species that did not survive may have experienced excessive root loss and damage to aerial growth from the sod harvester, inability to survive simulated nursery stresses, or had poor seedling emergence (Table 1). Plant death from excessive damage to aerial growth was especially common among fall-planted species that already had elongated stem and leaf growth by March.

Of the species planted in October 1993 and undercut in March 1994, *Verbena tenuisecta*, *Achillea millefolium*, *Coreopsis tinctoria*, *Rudbeckia hirta*, *Chrysanthemum leucanthemum*, *Coreopsis lanceolata*, *Gaillardia aristata*, *Monarda citriodora*, *Oenothera speciosa*, *Silene armeria*, *Gaillardia pulchella*, *Chrysanthemum maximum*, *Echinacea purpurea*, and *Centaurea cyanus* survived the undercutting, storage on plastic, and replanting (Table 2). The average rating total was 17.6 out of a maximum of 25.0. *Verbena tenuisecta*, *Achillea millefolium*, *Coreopsis tinctoria*, *Rudbeckia hirta*, and *Chrysanthemum leucanthemum* were not significantly different from the maximum of 25.0 (Table 2).

For October-seeded survivors, an increase in ratings of root density and stability occurred from the removal of sod from the field (average rating 3.5) through the storage period (average rating 4.0) (Table 2). Appearance ratings generally decreased from the beginning (average rating 3.8) to the end of the storage period (average rating 2.9) (Table 2). Appearance ratings of replanted species taken 49 d (average rating 3.8) after replanting increased for most species.

Of the wildflower species planted in March and undercut in May, *Verbena tenuisecta*, *Achillea millefolium*, *Coreopsis lanceolata*, *Monarda citriodora*, *Coreopsis tinctoria*, *Gaillardia aristata*, and *Rudbeckia hirta* survived the stress of undercutting, storage, and replanting (Table 2). These seven species rating totals were significantly lower than the maximum rating total of 25.0. The average rating total for all 7 was 12.7 (Table 2).

For March-seeded survivors, a decrease in ratings of root density and stability occurred for all seven species from the time of removal from the field (average rating of 4.4) to the end of storage (average rating of 2.0). Appearance ratings also decreased from the beginning (average rating of 2.2) to the end of the storage period (average rating of 1.9), except for *Verbena tenuisecta* and *Gaillardia aristata* (Table 2). The average appearance rating was 2.3, 17 d after replanting.

Root mass, density, and stability and appearance ratings for the 7 Oct. planting and the 17 Mar. planting suggest that 7 Oct. was the superior planting date for the maximum number of species to survive harvesting, storage, and replanting. Of the October-planted species, 52% survived, while only 25% of the March planted species survived. Leaf samples from October (1868 cm$^2$) and March (1554 cm$^2$) were not significantly different (data not shown) (Johnson, 1996). However, the total fresh mass of root samples of October-planted species when removed from the field was significantly greater at 147.8 g (5.2 oz) than the total of fresh root mass samples of spring-planted species at 90.9 g (3.2

**Table 2. Ratings of fall-planted (October 1993) and spring-planted (March 1994) wildflower species sod density and stability and appearance of fall and spring plantings after undercutting (U) after storage (S) on plastic for 7 weeks and 49 (fall) and 17 (spring) d after replanting (R) in the field. Underlined numbers represent that a flower was present when the plant was stored or replanted.**

| | Fall | | | | | | Spring | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Density rating[z] | | Appearance rating[y] | | | | Density rating | | Appearance rating | | | |
| Species | U | S | U | S | R | Total | U | S | U | S | R | Total |
| *Verbena tenuisecta* | 3.7 | 5.0 | 4.3 | 4.3 | 5.0 | 22.3[x] | 5.0 | 3.0 | 2.7 | 3.0 | 2.5 | 16.2 |
| *Achillea millefolium* | 4.3 | 5.0 | 4.3 | 3.3 | 5.0 | 21.8 | 5.0 | 3.0 | 2.3 | 2.0 | 3.0 | 15.3 |
| *Coreopsis tinctoria* | 4.3 | 4.8 | 3.8 | 3.3 | 5.0 | 21.0[x] | 5.0 | 1.0 | 2.3 | 1.5 | 1.5 | 11.3 |
| *Rudbeckia hirta* | 4.3 | 4.3 | 4.0 | 3.0 | 5.0 | 20.5[x] | 5.0 | 1.0 | 1.5 | 1.0 | 2.0 | 10.5 |
| *Chrysanthemum leucanthemum* | 4.0 | 5.0 | 4.5 | 2.5 | 4.5 | 20.5 | | | | | | |
| *Coreopsis lanceolata* | 3.3 | 5.0 | 3.5 | 3.0 | 5.0 | 19.8[x] | 3.0 | 2.0 | 3.7 | 2.0 | 2.5 | 13.2 |
| *Gaillardia aristata* | 4.3 | 4.0 | 3.3 | 3.7 | 4.0 | 19.2[x] | 3.0 | 2.0 | 1.7 | 2.0 | 2.0 | 10.7 |
| *Chrysanthemum maximum* | 3.0 | 3.0 | 5.0 | 2.7 | 5.0 | 18.7 | | | | | | |
| *Monarda citriodora* | 3.0 | 3.8 | 4.0 | 3.0 | 3.7 | 17.5 | 5.0 | 2.0 | 1.0 | 2.0 | 2.0 | 12.0 |
| *Oenothera speciosa* | 3.0 | 3.3 | 4.0 | 2.7 | 3.0 | 16.0 | | | | | | |
| *Silene armeria* | 4.0 | 3.5 | 3.3 | 2.7 | 1.7 | 15.2 | | | | | | |
| *Gaillardia pulchella* | 3.3 | 2.8 | 4.3 | 2.3 | 2.0 | 14.7 | | | | | | |
| *Echinacea purpurea* | 1.5 | 4.0 | 2.0 | 2.5 | 3.5 | 13.5 | | | | | | |
| *Centaurea cyanus* | 3.3 | 2.8 | 3.0 | 1.3 | 1.3 | 11.7 | | | | | | |
| Average of ratings | 3.5 | 4.0 | 3.8 | 2.9 | 3.8 | 17.6 | 4.4 | 2.0 | 2.2 | 1.9 | 2.3 | 12.7 |

[z]Sod density and stability ratings were taken when undercut and after storage on a scale of 1 to 5, with 5 = no separation, full and solid root growth, 4 = minimal separation, full and solid root growth, 3 = minimal separation, root growth less dense, 2 = minimal matting, slight loss of roots and soil, and 1 = no matting, excessive loss of roots and soil, damage to plants.

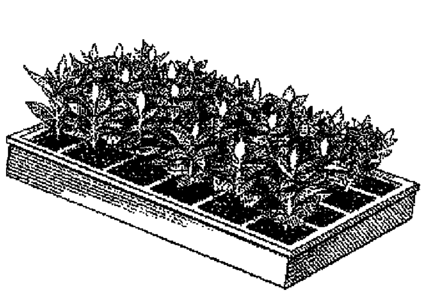
[y]Appearance ratings were taken when undercut, after storage, and after replanting on a scale of 1 to 5, with 5 = normal size, no damage to top growth, vigorous, healthy appearance, 4 = normal size, slight damage to top growth, vigorous appearance, 3 = normal size, slight damage to top growth, some yellowing of foliage, 2 = undersized, foliage damaged, at least half yellowing and brown, and 1 = undersized, foliage damaged, most foliage and stems yellowing and brown.

[x]Individual species fall mean rating significantly greater than corresponding spring mean rating ($P = 0.05$)

oz) (LSD = 2.8, $P = 0.05$). Greater root mass and higher sod density and stability ratings for fall-planted species was probably due to a 6-month period for root development as opposed to only a 3-month root developmental period for spring-planted species. Fewer roots present in spring-planted species resulted in an inability to recover from undercutting and storage stress. Also, warmer temperatures in early June may have further inhibited recovery from undercutting during storage and replanting.

**SPECIES SELECTION**. From the results of the spring and fall plantings, several species were selected for wildflower sod development based on two criteria: 1) no single rating of sod density and stability and appearance could be <3.0 and 2) plants had to flower before, during, or after storage. The species that met these criteria were *Verbena tenuisecta*, *Achillea millefolium*, *Coreopsis tinctoria*, *Rudbeckia hirta*, *Chrysanthemum leucanthemum*, *Coreopsis lanceolata*, *Gaillardia aristata*, and *Monarda citriodora*. One exception was *Chrysanthemum leucanthemum*, which had an appearance rating of 2.5 after storage, but was selected due to a high total rating of 20.5, which was statistically similar to the maximum rating of 25 (Table 2).

**PLANT GROWTH REGULATORS**. Of the three plant growth regulators, uniconazole had reduced foliar growth of *Rudbeckia hirta*, *Monarda citriodora*, *Coreopsis lanceolata*, and *Coreopsis tinctoria*. Relatively minor growth suppression occurred with paclobutrazol and daminozide (Table 3).



Minimal growth regulator effects observed in this study could be attributed to several factors. Because plants were propagated from seed, seedling variations may have played a role in plant response (Deneke, 1992). Drench applications of uniconizole and paclobutrazol are more effective than foliar sprays as translocation of the chemical is through the xylem with little translocation via the phloem (Davis and Curry, 1991). Another possibility for minimal activity may have been due to inadequate coverage of the foliar sprays of paclobutrazol and uniconazole to stem surfaces.

Optimum species performance seemed to be based on biologically, morphologically, and physiologically desirable characteristics that increased the chances of surviving undercutting and resumption of vigorous regrowth when replanted. Root development appears to be the key to producing a wildflower sod that holds together well, withstanding the rigors of lifting, storage, and transplanting. Field and Jayaweera (1985) conducted a study on the regeneration of *Achillea millefolium* rhizomes and demonstrated that, when released from apical dominance, fragmented rhizomes of *Achillea millefolium* regenerate rapidly, producing an extensive lateral root system. Folgate and Scheiner (1992) have shown that the high root to shoot ratio of *Coreopsis lanceolata* may enhance nutrient acquisition and drought resistance in dry, low-nutrient environments. These characteristics may make the selected sod species desirable for landscaping purposes requiring adaptability to a broad range of stresses. Plant life cycles also affected selection. By the end of the storage period, spring and summer annuals had gone through most of their life cycle and ratings had decreased accordingly.

A fall seeding date was superior to a spring seeding date for a spring harvest date. Salac et al (1982) found that fall seeding dates were better for midwestern wildflower establishment, flowering, and winter survival. However, if the harvest window and species selection for sod use is to be expanded, controlling vegetative top growth will be essential. The plant growth regulator uniconazole had limited control over stem elongation of *Rudbeckia hirta*, *Monarda citriodora*, *Coreopsis lanceolata*, and *Coreopsis tinctoria*. Other factors, such as seeding dates in the fall and winter growing period, will impact root growth and sod success.

A field-harvested wildflower sod composed of species adapted to southeastern conditions has potential as a landscape product for low-maintenance sites such as highway rights-of-way, land restoration, and erosion control. Growing a wildflower sod comprised of regionally adapted species in a manner similar to that of turfgrass sod would provide an alternative product for wildflower establishment that is currently not available.

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