

# Evaluation of Species and Cultivars of Coneflower for Southeastern U.S. Landscapes<sup>1</sup>

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## Abstract

Twenty-one cultivars of coneflower (*Echinacea* sp.) were evaluated from June 2008 to August 2010 in two locations in North Carolina. Plant size was measured once during each growing season. Evaluators rated overall plant quality, as well as flower and foliage aesthetics. Plants were rated on a scale from 1 to 4, with 1 = poor and 4 = excellent. Any disease and insect problems were noted. Over the two-year study, average mortality rate was 34%. Cultivars 'Bravado', Kim's Knee High®, 'Pink Double Delight', and 'White Swan', had consistently high ratings, while 'Emily Saul' and yellow coneflower (*E. paradoxa*) rated the lowest. Kim's Knee High®, 'Pink Double Delight', and 'White Swan' received some of the best scores for flower quality, whereas yellow coneflower and 'Ruby Star' rated the lowest. There were minor differences between the locations regarding plant size and ratings, particularly for yellow coneflower. Evaluators either favored or abhorred this plant. This may be due to reflexed ray flowers that mimic water stress. 'Crazy Pink' also had a similar petal presentation and rated about 2.0 for overall and flower quality. In 2009, after an exceptional bloom, many cultivars were infested with mites, causing aborted blooms and distorted flowers.

**Index words:** native plants, *Eriophyid* and *Tarsonemid* mites.

**Species used in this study:** *Echinacea purpurea* and *Echinacea paradoxa*.

## Significance to the Nursery Industry

Numerous coneflower cultivars are introduced into the trade each year. Nurseries propagate cultivars that offer numerous flower color choices, unique double flowers, or have a strong fragrance. Most of these cultivars are tested in one area, that of the nursery facility. Results from university-implemented cultivar trials can provide valuable, unbiased information for nursery growers. Such research will provide information on plant performance and survival, as well as aesthetics of flowers. Nursery growers can then target their production and marketing on a regional basis, growing and promoting those cultivars that not only survived regional climates, but also rated high aesthetic scores. With new introductions constantly entering the market, it is often difficult for landscapers to know what to recommend to their clients. The results of this field study will help guide those selections for southeast United States gardens.

## Introduction

Herbaceous perennial plant species have become exceedingly popular components of nearly every garden. The economic returns from the breeding and sale of these plants directly benefit propagators, growers, installation and maintenance firms, and retail markets. In recent years, sales from herbaceous perennials increased from \$65 million in 1995 to \$625 million in 2004 (5) and likely have continued to increase. In their 1998 survey of garden centers, Garber and Bondari (10) predicted such an increase in demand for perennials over many other plant categories. An additional survey conducted by the Garden Writers Association Founda-

tion found that of 737 consumer respondents, 34% indicated they would add perennial plant species to their garden during the next growing season (4). The introduction of cultivars of native species that are adaptable, relatively low maintenance, offer dynamic new colors, and have longer bloom periods has greatly contributed to the increased use of these plants (6).

Nursery growers seek new plant introductions, often prompted by consumer demand. Typically these are found through cultivars, botanical varieties or hybrids, and occasionally through introductions (or reintroductions) of seldom used species (2). Such introductions not only add interest to our landscapes but also add diversity, which is critical to sustainability of the nursery trade and landscape health.

Along with its medicinal uses, *E. purpurea* and other members of this genus have become garden favorites, planted for season-long blooms that attract butterflies, birds, and bees. It has also gained favor because it is native to most of the eastern United States (15). Most coneflowers grow in full sun and well-drained soil, but in warmer climates, they may need a bit of afternoon shade to enhance flower color (15).

In the wild, coneflowers are purple, white, and yellow. Newer hybrids offer various shades of yellow, orange, pink, and red and often produce a sweet fragrance. According to Armitage (1), purple coneflower epitomizes the garden 'workhorse.' With its season-long blooms and attractive foliage, this species has earned great favor in gardens around the world. Most purple coneflowers grow upright between 0.61–1.2 m (2.0–3.9 ft) tall, and have dark-green, broadly lanceolate shaped leaves (15).

A lesser-known native coneflower is *E. paradoxa* (yellow coneflower), which grows to about 0.76–0.91 m (2.5–3.0 ft) tall and wide and has shiny, lanceolate shaped leaves and bright yellow, reflexed ray flowers (1). Along with its purple cousin, yellow coneflower is used for prairie and meadow plantings and in ornamental landscapes throughout the United States.

Objectives of this study were to evaluate plant quality and survivability in two locations in North Carolina, and identify plants that may be suitable for nursery production and sale

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throughout similar landscapes in the southeast U.S. The study focused on native and cultivated species of coneflower.

## Materials and Methods

**Field site.** We conducted the experiment from March 2008 through August 2010 at North Carolina State University's Horticultural Field Laboratory (HFL) located in Raleigh, North Carolina at latitude N 35° 47.6' and longitude W 78° 41.9' and at the Horticultural Crops Research Station, Castle Hayne in Castle Hayne (CH), North Carolina at latitude N 34° 19.4' and longitude W 77° 54.65'. The HFL site was level, in full sun, and exposed to moderate/strong southwesterly winds throughout the year. The soil was an Appling sandy loam that drains well. This soil is characterized as moderately eroded with 2–6% slopes. The top 0–10.2 cm (0–4.0 in) is a sandy loam, 10.2–45.7 cm (4.0–18.0 in) is a sandy clay loam, and 45.7–91.4 cm (18.0–36.4 in) is clay (13). The CH site was also level and in full sun, but was not typically exposed to continuous winds as at HFL. The soil was Leon sand that drains poorly. This soil occurs on flats or marine terraces with a 0–2% slope. The top 0–38 cm (0–15.0 in) is a sand, and 38–203 cm (15.0–82.0 in) is a fine sand (13).

**Plant and site preparation and installation.** Two species and 19 cultivars of coneflower (Table 1) were obtained as either cuttings or plugs ranging in size from 21 to 72 round cell trays were transplanted on March 15, 2008, into 15.9 cm (6.3 in) diameter round 4.4 liter plastic pots filled with Fafard® 1B (Fafard, Anderson, SC) substrate. Plants were obtained from Germania Seed Company (Chicago, IL),

Gro<sup>™</sup> Sell (Chalfont, PA), and Jolly Farmer (Houlton, ME). Plant species, sources, and sizes are indicated in Table 1. Plants were grown in a minimum heat polyhouse with mean day/night temperatures of 26.7/7.2C (80.1/45.0F). The plants were grown under natural day lengths. Plants were fertilized once with a granular slow release N using 15N-2.1P-12.5K (Excel® 15-5-15 Cal-Mag, Scotts, Marysville, OH).

At both HFL and CH raised planting beds were prepared by tilling in 10.2 cm (4.0 in) of composted leaves to a depth of 22.4 cm (8.8 in). Beds were 1.3 m (4.25 ft) wide and 26.7 m (87.6) long, with grass strips 1 m wide between each bed. The pH at CH was 5.3, therefore lime was also added at a rate of 50 lbs-1,000 ft<sup>-2</sup> three weeks prior to planting. The bed at CH was 1.3 m (4.25 ft) wide and 35 m (115 ft) long. Plants were installed on May 5, 2008, at HFL and on May 8, 2008, at CH. After planting, leaf compost was used at a depth of 2.5 cm (1 in) as mulch at both sites. Plants were spaced to accommodate for projected mature sizes of each species. There were three plants of each cultivar within each of three replicates for nine plants per cultivar. Replicates and cultivars were assigned randomly within the bed. Plants were thoroughly watered at planting. When there was a three-week period without rain and plants wilted significantly, we watered using overhead sprinklers. Plants were not fertilized over the study period. At CH, due to heavy deer browsing pressure, the entire site was enclosed with electric fencing.

Plants were allowed to flower to completion and then deadheaded according to generally accepted practices for each species. This practice was done to simulate what a home gardener might typically do in their landscape. All

**Table 1. Species/cultivar list of *Echinacea* used in the trial at North Carolina State University (NCSU), indicating nursery source, plant type, number of plants installed, and mortality rate by location and year.**

Species/cultivar <sup>a</sup>	Number of plants		Mortality rate (%) <sup>c</sup>			
	2008		2009		2010	
	Location <sup>x</sup>		Location			
	HFL	CH	HFL	CH	HFL	CH
<i>Echinacea paradoxa</i> (p/GS)	9	9	0	44	11	44
<i>Echinacea paradoxa</i> ‘Yellow Mellow’ (p/G)	9	9	11	44	33	44
<i>Echinacea purpurea</i> (p/JF)	9	9	0	78	33	78
<i>Echinacea purpurea</i> All That Jazz® (p/G)	9	9	56	33	33	67
<i>Echinacea purpurea</i> ‘Bravado’ (p/JF)	9	9	0	0	33	22
<i>Echinacea purpurea</i> ‘Bright Star Improved’ (p/GS)	9	9	0	0	33	11
<i>Echinacea purpurea</i> ‘Crazy Pink’ (p/GS)	8	7	33	33	17	33
<i>Echinacea purpurea</i> ‘Doubledecker’ (p/JF)	9	9	0	0	22	0
<i>Echinacea purpurea</i> ‘Emily Saul’ After Midnight™ [Big Sky™ Series] (p/G)	9	9	100	44	100	78
<i>Echinacea purpurea</i> ‘Evan Saul’ Sundown™ [Big Sky™ Series] (p/G)	9	9	56	0	56	0
<i>Echinacea purpurea</i> ‘Katie Saul’ Summer Sky™ [Big Sky™ Series] (p/G)	9	9	0	0	0	0
<i>Echinacea purpurea</i> Kim’s Knee High® (p/G)	9	9	0	0	0	11
<i>Echinacea purpurea</i> ‘Magnus’ (p/JF)	9	9	0	0	22	0
<i>Echinacea purpurea</i> ‘Matthew Saul’ Harvest Moon™ [Big Sky™ Series] (p/GS)	9	9	11	33	22	33
<i>Echinacea purpurea</i> ‘Pink Double Delight’ (p/G)	9	9	11	0	33	11
<i>Echinacea purpurea</i> Prairie Splendor™ (p/G)	9	9	11	11	44	33
<i>Echinacea purpurea</i> ‘Primadonna Deep Rose’ (p/JF)	9	9	0	11	22	11
<i>Echinacea purpurea</i> ‘Primadonna White’ (p/GS)	9	9	33	67	44	67
<i>Echinacea purpurea</i> ‘Ruby Star’ (p/JF)	9	9	0	0	44	11
<i>Echinacea purpurea</i> ‘Sunrise’ [Big Sky™ Series] (p/G)	9	9	44	33	89	67
<i>Echinacea purpurea</i> ‘White Swan’ (p/GS)	9	9	22	67	44	67

<sup>a</sup>Mortality rate calculated based on the difference between 2008 and 2009, and 2008 and 2010.

<sup>x</sup>In parentheses: c – cutting and p – plugs. Capital letters indicate the nursery origin of the plants: JF – Jolly Farmer, G – Germania, and GS – Gro<sup>™</sup> Sell.

<sup>x</sup>HFL – Horticultural Field Lab, Raleigh, NC; and CH – Horticultural Crops Research Station, Castle Hayne, Castle Hayne, NC.

plants were cut back to the ground in November each year. We did not apply any chemical or other controls for insect and disease problems in order to assess cultivar susceptibilities. Problems were noted as they occurred. Beds were hand weeded during the growing season as needed. Chemical control of Bermudagrass in the beds was implemented using Fusilade II (fluzafop-P-butyl; Syngenta Crop Protection, Greensboro, NC), spraying over the top of the perennials at prescribed rates.

**Evaluation of cultivars.** Plant height, bloom height, and plant width were collected at each site once in 2008, 2009, and 2010. This was done in an effort to get plant height when most cultivars were blooming. Plant height was measured from ground level to top of the vegetative portion of the plant, and when in flower from ground level to the top of the inflorescences. Plant widths were taken in one direction and then at 90° angle from the first; values were then averaged for total plant width.

Plants were rated at HFL for overall quality, foliage color, and foliage texture in June 2008, July 2008, August 2008, May 2009, July 2009, and June 2010; due to the travel requirements to CH, plants were evaluated for all traits during peak bloom in June 2008 and June 2009. Flower traits were assessed only during peak bloom each year, therefore statistical comparisons were only made when date was a factor in the model. To assess each trait, ratings were developed based

on a system similar to that of Thomas and Schrock (16) with a scale of 1 = poor, 2 = fair, 3 = good, and 4 = excellent. At HFL four reviewers rated plants independently. Ratings were averaged for each attribute across all reviewers. At CH, due to travel limitations, only the primary investigator assessed plants. Ratings were subjective. Attempts were made to examine the plants as a homeowner would, looking at quality of the plant overall, flower quality, and foliage quality. Therefore any insect, disease, or abiotic factors that negatively affected the plant, i.e. mite damage, would likely lead to a reduction in quality not only for the foliage, but also for the entire plant. Overall plant quality was based on form desirability [including its habit and tendency to lodge (break or bend at stem crown)], foliage and flower quality, flower presentation, and general appearance. Flowers were rated based on their general appearance, color intensity, clarity, and coverage over the plant. Foliage color and texture assessed the clarity and intensity of the foliage as well as its coarseness. In addition, attributes such as fragrance, aggressiveness, and re-seeding ability were noted. Each year survival data were taken at the end of the growing season.

During the study, total rainfall at HFL for 2008, 2009 and 2010 was 93.0, 102.6 and 61.0 cm (36.6, 40.4 and 24.0 in), respectively (14). At Castle Hayne, total rainfall for 2008 was 14.7 cm (5.8 in), and 15.7 cm (6.2 in) for 2009 (14). This information represents only that portion of each year that plants were in the ground. During the growing season (March

**Table 2. Height at bloom (Htbl), height of plant without including blooms (Ht), and plant width (Wd) for each species and cultivar of coneflower at each of the dates measured for plants at Horticultural Field Lab location.**

Species/cultivar	Julian date <sup>a</sup>								
	172			184			165		
				Plant size variable <sup>b</sup>					
	Ht bl <sup>c</sup> (cm)	Ht (cm)	Wd (cm)	Ht bl (cm)	Ht (cm)	Wd (cm)	Ht bl (cm)	Ht (cm)	Wd (cm)
<i>Echinacea paradoxa</i>	41.4a	20.2ab	17.7b	nb <sup>w</sup>	12.5b	10.1b	58.9a	36.4a	29.2a
'Yellow Mellow'	45.0b	18.5b	16.4b	nb	14.1b	11.5c	60.3a	41.4a	33.9a
All That Jazz®	11.7b	7.9b	12.5a	19.2b	15.5b	10.8a	41.4a	33.6a	26.7a
'Bravado'	21.3b	21.3b	20.1a	26.2b	21.0b	15.9a	42.5a	33.3a	24.0a
'Bright Star Improved'	32.9b	19.2b	19.2b	31.9b	24.8b	16.8b	58.3a	48.3a	33.8a
'Crazy Pink'	17.4b	11.8b	5.3b	18.8b	14.6b	12.2b	40.3a	30.9a	27.8a
'Doubledecker'	41.6b	20.2b	18.7b	28.1c	21.3b	16.8b	56.4a	44.9a	34.2a
<i>Echinacea purpurea</i>	nb	13.3c	14.1b	30.9b	24.6b	17.4b	70.3a	57.4a	36.7a
'Emily Saul'	nb	10.9a	12.0a	nb	17.0a	20.0a	d <sup>y</sup>	d	d
'Evan Saul'	37.6ab	22.3a	20.5a	16.5b	12.8a	10.5a	46.7a	35.0a	26.7a
'Katie Saul'	nb	10.0b	12.3b	26.7b	21.1b	15.3b	57.8a	40.5a	29.4a
Kim's Knee High®	27.0ab	16.9a	19.7ab	17.7b	13.4a	11.3b	39.3a	29.8a	27.1b
'Magnus'	nb	16.2c	17.6a	32.9b	25.7b	20.8a	48.3a	34.7a	28.1a
'Matthew Saul'	24.9a	14.6a	15.7a	14.6a	10.3a	8.0b	28.3a	21.4a	19.0a
'Pink Double Delight'	33.3a	21.4b	21.8ab	17.5b	12.8b	10.1b	42.6a	33.1a	32.9a
Prairie Splendor™	27.7a	19.9a	17.5ab	18.8a	14.9a	10.7b	38.4a	27.1a	20.9a
'Primadonna Deep Rose'	nb	15.7a	18.3a	30.8a	22.2a	15.8a	39.2a	32.2a	24.5a
'Primadonna White'	20.5a	11.7a	14.4a	23.2a	18.1a	13.7a	38.3a	26.7a	20.6a
'Ruby Star'	nb	10.9b	12.5b	27.7b	21.1b	15.0b	55.0a	37.5a	30.8a
'Sunrise'	26.0a	19.1a	18.3a	28.3a	24.5a	16.3a	nb	12.0a	10.0a
'White Swan'	27.9a	13.7a	18.2a	26.9a	21.1a	17.0a	47.5a	34.5a	23.3a

<sup>a</sup>Dates based on the Julian calendar: 246 = September 3, 2009; 263 = September 15, 2010; and 264 = September 20, 2008.

<sup>b</sup>Plant size was measured once per year, mean values followed by different letters indicate a significant difference for each cultivar and each measurement across dates at  $P \leq 0.05$ , using Duncan's multiple range test.

<sup>c</sup>Htbl – height taken when plants were in bloom.

<sup>w</sup>nb – indicates plants were not in bloom at this date.

<sup>y</sup>d – all plants were dead at this date.

to October) mean high and low temperatures were 22 and 16C (71.6 and 60.8F), respectively for HFL, and 37 and 26C (98.6 and 78.8F), respectively for CH (17).

**Statistical analysis.** Data for plant size, overall, and foliage ratings were evaluated separately and were subjected to analysis of variance (ANOVA) using general linear model PROC GLM (SAS Institute, Cary, NC). The main effects of the model were species, date of measurement, location, and replicate. In addition, interactions between the main effects were assessed. Elements of the model were judged significant or non-significant using Duncan's multi-range test at  $\alpha \leq 0.05$  level.

## Results and Discussion

**Mortality.** The average mortality rate across all the cultivars was 35% at HFL and 33% at CH (Table 1). At HFL 'Emily Saul' had the highest mortality rate of 100% and those with 0% mortality were 'Katie Saul', and Kim's Knee High® (Table 1). At CH 'Emily Saul' and *E. purpurea* had the highest mortality rate at 78%, and 'Doubledecker', 'Evan Saul', 'Katie Saul', and 'Magnus' had a rate of 0% (Table 1).

**Plant size (at the HFL site).** For all three measures of plant size, there was an interaction between the date and species/cultivar. The majority of cultivars did increase in size over

time, some significantly, while others changed little (Table 2). All That Jazz® and 'Emily Saul' were the shortest when planted at 7.9 and 10.9 cm (3.1 and 4.3 in), respectively (Table 2). All That Jazz® increased in height from 2008 to 2010 by 325%; while by 2010, there was 100% mortality of 'Emily Saul' (Table 2). The species coneflower (*E. purpurea*) had the largest percent increase in height from 2008 to 2010 at 332% (Table 2). 'Crazy Pink' was a relatively short and narrow plant at 11.8 and 5.3 cm (4.6 and 2.1 in), respectively (Table 2). This cultivar grew taller by 158% and wider by 425% from 2008 to 2010. 'Sunrise' showed a decrease in height and width from 2008 to 2010 by 37 and 45%, respectively (Table 2). The overall quality ratings for this plant also decreased over time, thereby indicating that over time these plants seemed to deteriorate.

There was also a significant relationship between the date measured and the replication (data not shown). While there was a difference in the magnitude of the variations between each replicate within a particular size measurement, the trend was that plants tended to get larger over time.

**Plant size (at the Castle Hayne site).** There was no significant interaction between species/cultivar and date in Castle Hayne. In general, however, plants declined and most decreased in size between 2008 and 2010 (Table 3). Yellow coneflower (*E. paradoxa*) species and its cultivar 'Yellow Mellow' showed a 59 and 75% decrease in height growth,

**Table 3. Height at bloom (Htbl), height of plant without blooms (Ht), and plant width (Wd) for each species and cultivar of coneflower at each of the dates measured at the Horticultural Crops Research Station, Castle Hayne.**

Species/cultivar	Julian date <sup>a</sup>								
	263			222			157		
	Plant size variable <sup>b</sup>								
	Ht bl <sup>c</sup> (cm)	Ht (cm)	Wd (cm)	Ht bl (cm)	Ht (cm)	Wd (cm)	Ht bl (cm)	Ht (cm)	Wd (cm)
<i>Echinacea paradoxa</i>	nb <sup>w</sup>	18.0a	12.3a	26.2a	12.4b	10.3b	29.2a	12. 4b	15.3a
‘Yellow Mellow’	nb	12.5a	16.3a	24.7a	8.3c	7.5a	24.2a	10.3b	10.8a
All That Jazz®	nb	8.8a	15.1a	21.5a	8.2a	7.9a	nb	12.8a	10.3a
‘Bravado’	26.0 a	14.1a	18.1a	25.0 <sup>v</sup>	16.1a	10.3a	nb	14.2a	11.7a
‘Bright Star Improved’	nb	11.2a	6.7a	22.5a	15.8a	10.8a	nb	10.7a	10.8a
‘Crazy Pink’	nb	20.6a	21.6a	16.8a	8.8a	6.4a	12.0b	7.0a	7.7a
‘Doubledecker’	32.0a	13.1a	15.7a	22.3	14.8a	10.8b	nb	13.0a	11.0b
<i>Echinacea purpurea</i>	nb	7.2a	10.6a	26.5	19.5a	13.5a	nb	17.0a	12.5a
‘Emily Saul’	24.0a	10.3a	13.3a	17.0	6.3a	5.3b	nb	4.5a	5.5b
‘Evan Saul’	24.6a	14.8a	18.0a	24.8b	16.0a	14.5b	17.0b	15.7a	12.5b
‘Katie Saul’	29.0a	11.8b	19.2a	22.2a	14.8a	10.2a	20.0a	15.8a	12.1a
Kim’s Knee High®	nb	11.8a	16.5a	17.9b	12.2a	9.6b	16.8b	12.2a	9.9b
‘Magnus’	28.8a	16.5a	18.1a	23.8b	15.7a	8.9b	12.0a	13.4a	11.3b
‘Matthew Saul’	22.5a	12.9a	17.9a	15.7b	10.8a	7.5a	nb	8.0a	7.7a
‘Pink Double Delight’	12.3a	9.4a	12.3a	18.7b	12.5a	9.3b	nb	12.9a	11.4b
Prairie Splendor™	30.0a	10.3a	16.4a	20.7a	12.5a	8.6a	nb	8.4a	7.7a
‘Primadonna Deep Rose’	25.5 a	13.8a	17.7a	23.8b	17.0a	8.5b	nb	12.9a	10.8b
‘Primadonna White’	nb	12.3a	18.0a	17.0b	12.8a	9.8b	nb	8.0a	9.0b
‘Ruby Star’	25.0a	9.6b	11.5a	23.0	14.7a	10.7b	nb	13.1a	11.0b
‘Sunrise’	31.3a	13.9a	16.2a	17.7a	12.4a	8.7b	20.0a	13.3a	13.3b
‘White Swan’	nb	18.0a	12.3a	16.5a	11.8a	5.8b	11.0a	6.4a	7.2b

<sup>a</sup>Dates based on the Julian calendar: 157 = June 10, 2010; 222 = August 10, 2009; and 263 = September 6, 2008.

<sup>b</sup>Plant size was measured once per year, mean values followed by different letters indicate a significant difference for each cultivar and each measurement across dates at  $P \leq 0.05$ , using Duncan's multiple range test.

<sup>c</sup>Htbl – height taken when plants were in bloom.

<sup>w</sup>nb – indicates plants were not in bloom at this date.

<sup>d</sup>Shaded numbers indicate the height of plant in flower, but this was the only date height was obtained, so there is no statistics available for these values.



respectively, between 2008 and 2010 (Table 3). Yellow coneflower also had a 30% reduction in width during the same period (Table 3). The only cultivars that had a significant increase in height were ‘Katie Saul’ and ‘Evan Saul’ by 39 and 25%, respectively (Table 3). ‘Primadonna White’ and ‘White Swan’ had a 97 and 125% increase in width, respectively, between 2008 and 2010, but did not show an increase in height (Table 3).

There was also a significant relationship between replicate and date for size measurements (data not shown). Unlike the plants at HFL, however, the general trend here were smaller plants in 2010 than in 2008.

**Plant size at both locations.** The location played a role in how plants grew. Height at bloom for yellow coneflower, ‘Yellow Mellow’, ‘Crazy Pink’, and ‘Katy Saul’ plants was significantly higher at HFL than plants at CH ( $P \leq 0.05$ ). Height for ‘Bravado’, ‘Bright Star Improved’, ‘Crazy Pink’, ‘Doubledecker’, ‘Magnus’ and ‘Katie Saul’ was also significantly larger for HFL plants than those at CH ( $P \leq 0.05$ ). These were the only size differences between the two locations of any significance, indicating that despite the soil differences most species/cultivars grew similarly in both locations. The similar mortality rates support this as well.

**Plant ratings at the HFL site.** Plants at this location were rated for overall and foliage quality six times over the two-year period. Each cultivar rated differently across the dates (Table 4). The cultivars ‘White Swan’, ‘Primadonna Deep Rose’, and ‘Bright Star Improved’, had consistently high ratings, mostly over 3.0 (Table 4). Although, ‘Crazy Pink’ started out with low ratings, over time its overall quality

greatly improved, going from 1.0 to 3.1 (Table 4). ‘Sunrise’, ‘Prairie Splendor’, and ‘Pink Double Delight’ declined over the study period to some degree, dropping by less than a point to over two points (Table 4). ‘Sunrise’ had the most noteworthy drop, going from a rating of 3.9 to 1.3 (Table 4); however, this plant performed well until 2010 with an average rating of 3.1. ‘Prairie Splendor’ dropped only a half a point by the final year, but maintained about the same average rating at 2.8 (Table 4). Although dropping significantly from 2008, ‘Pink Double Delight’ was still one of the best purple coneflowers overall with an average rating of 3.2. In their 2007–2009 study, reviewers at the Mt. Cuba Center near Wilmington, DE, gave ‘Sunrise’ 3.5, ‘Pink Double Delight’ 2.5, and ‘Bravado’ 4.3 for overall performance out of 5 possible points (9). In addition, both ‘Bravado’ and ‘Pink Double Delight’ received ratings of 5 in the TUGA (3). Mt Cuba Center evaluators did not evaluate Kim’s Knee High®, but gave ‘White Swan’ 4.0 (9). ‘Bravado’ (3.2 overall) and ‘White Swan’ (3.0 overall) were also strong performers in the current study (Table 4).

The cultivar receiving the lowest overall rating was ‘Emily Saul’ (Table 4). This plant rated 2.0 for overall quality, and by July 2009 all plants had died. The Big Sky™ Series was a popular introduction in 2006 by Sauls Nursery, Inc., Atlanta, GA, and included at that time ‘Emily Saul’, ‘Evan Saul’, ‘Katie Saul’, ‘Matthew Saul’, and ‘Sunrise’ (3). These cultivars were evaluated in the current study and by TUGA. They rated all of these 4.0 out of 5.0, with the exception of ‘Evan Saul’, which received 5.0 rating (3). Participants on the iVillage Garden Blog indicated that many of the Big Sky™ Series are undependable regarding survival, performance, and bloom color. Some comments were ‘they fade within a

**Table 4.** Mean ratings of overall quality for each coneflower species/cultivar growing at Horticultural Field Lab location.

Species/cultivar	Overall quality rating <sup>a</sup>					
	Julian date <sup>b</sup>					
	172	204	236	150	200	166
<i>Echinacea paradoxa</i>	2.6a	2.8a	2.3a	2.9a	2.3a	2.6a
‘Yellow Mellow’	2.3a	3.0a	2.5a	2.7a	2.3a	2.4a
All That Jazz®	2.6a	2.9a	2.6a	2.9a	2.4a	2.7a
‘Bravado’	3.7a	3.5a	3.3a	2.9a	2.8a	2.8a
‘Bright Star Improved’	3.1a	2.9a	2.4a	3.0a	2.5a	3.5a
‘Crazy Pink’	1.0c	1.5bc	1.6bc	2.7a	2.0b	3.1a
‘Doubledecker’	3.0a	2.7a	2.5a	3.3a	2.5a	3.0a
<i>Echinacea purpurea</i>	2.4cd	2.5cd	2.1d	3.1ab	2.7bc	3.5a
‘Emily Saul’	2.1a	2.1a	1.8a	d <sup>c</sup>	d	d
‘Evan Saul’	3.8a	3.2a	3.4a	2.3a	3.3a	2.8a
‘Katie Saul’	2.2b	2.4b	2.0b	3.4a	2.5b	2.6b
Kim’s Knee High®	3.6a	2.9b	2.4b	2.5b	2.8b	3.4a
‘Magnus’	3.0a	3.2a	2.5a	3.2a	2.8a	2.6a
‘Matthew Saul’	3.3a	2.7a	2.3a	2.1a	2.8a	2.8a
‘Pink Double Delight’	3.7a	3.6ab	3.2abc	2.7c	2.8c	3.0bc
Prairie Splendor™	3.2a	2.8ab	2.3c	2.9ab	2.8ab	2.7b
‘Primadonna Deep Rose’	3.5a	3.3a	3.2a	2.9a	2.8a	3.1a
‘Primadonna White’	2.5a	2.3a	1.9a	3.0a	2.7a	3.0a
‘Ruby Star’	2.1d	2.4cd	2.0d	3.1a	2.6bc	3.1ab
‘Sunrise’	3.9a	3.3b	3.0b	3.7a	3.2b	1.3c
‘White Swan’	3.2a	3.1a	2.7a	2.7a	3.0a	3.3a

<sup>a</sup>Means of ratings (scale: 1 = poor, 2 = fair, 3 = good, and 4 = excellent); means within each row (species/cultivar) having different letters indicate a significant difference between dates at  $P \leq 0.05$ , using Duncan’s multiple range test.

<sup>b</sup>Dates based on the Julian calendar: 172 = June 20, 2008; 204 = July 22, 2008; 236 = August 24, 2008; 150 = May 30, 2009; 200 = July 19, 2009; and 166 = June 15, 2010.

<sup>c</sup>d – all plants were dead at this date.

**Table 5. Mean flower color ratings for each coneflower for each date measured for plants grown at Horticultural Field Lab.**

Species/cultivar	Flower color mean ratings <sup>a</sup>		
	Julian date <sup>b</sup>		
	172	200	166
<i>Echinacea paradoxa</i>	1.1c	1.5b	2.2a
'Yellow Mellow'	1.2a	1.7a	2.2a
All That Jazz®	1.3b	2.4a	2.4a
'Bravado'	nb <sup>c</sup>	2.4a	2.9a
'Bright Star Improved'	2.3a	2.5a	2.9a
'Crazy Pink'	1.3b	2.1ab	3.0a
'Doubledecker'	2.1b	2.4b	3.1a
<i>Echinacea purpurea</i>	nb	2.4a	3.1a
'Emily Saul'	3.0 <sup>w</sup>	d <sup>v</sup>	d
'Evan Saul'	3.5a	3.0a	3.7a
'Katie Saul'	3.5a	nb	2.3a
Kim's Knee High®	3.8a	2.9a	3.5a
'Magnus'	2.6a	2.5a	nb
'Matthew Saul'	2.9a	3.0a	2.8a
'Pink Double Delight'	3.3a	2.8a	3.1a
Prairie Splendor™	3.5a	2.7a	2.6a
'Primadonna Deep Rose'	nb	2.5a	2.6a
'Primadonna White'	3.8a	3.0a	2.8a
'Ruby Star'	nb	2.4b	2.9a
'Sunrise'	3.5a	2.3a	nb
'White Swan'	3.8a	3.3a	3.6a

<sup>a</sup>Means of ratings (scale: 1 = poor, 2 = fair, 3 = good, and 4 = excellent); means within each row (species/cultivar) having different letters indicate a significant difference between dates at  $P \leq 0.05$ , using Duncan's multiple range test.

<sup>b</sup>Dates based on the Julian calendar: 172 = June 20, 2008; 200 = July 19, 2009; and 166 = June 15, 2010.

<sup>c</sup>nb – not blooming at date evaluated

<sup>w</sup>Shaded numbers indicate the height of plant in flower, but this was the only date height was obtained, so there is no statistics available for these values.

<sup>d</sup> – all plants were dead at this date.

day or two and become this ugly pastel color.' 'Not one of them survived the summer,' and 'I replaced 3 of them and only 1 is still alive this year' (11). As some of the bloggers indicated, there may be survival issues with many of the Big Sky™ Series. In this two-year study, 'Emily Saul', 'Sunrise', 'Evan Saul', and 'Matthew Saul' had mortality rates at HFL of 100, 89, 56, and 33%, respectively (Table 1). 'Emily Saul' did not survive the winter at the Mt. Cuba Center (9). When in bloom in North Carolina, however, 'Emily Saul' scored a rating of 3.2 for flower quality (Table 5), 3.0 for flower color, and 2.4 for flower coverage (Table 6). In addition, despite having a high mortality rate 'Evan Saul' rated 3.1 for overall quality (Table 4), 3.4 for flower color (Table 5), 3.0 for flower quality, and 2.9 flower coverage (Table 6).

There was an interaction between flower color and date, with only a few cultivars showing changes over time (Table 5). 'Crazy Pink' (1.3 to 3.0), 'Double Decker' (2.1 to 3.1), and 'Ruby Star' (2.4 to 2.9) all showed a significant improvement in color from 2008 to 2010 (Table 5), although none of these had the highest scores for flower quality (Table 6). Kim's Knee High® had the highest flower rating at 3.4 followed by 'White Swan' (3.3), 'Emily Saul' (3.2), and 'Evan Saul' at 3.0 (Table 6). Kim's Knee High® and 'White Swan' rated the best flower display with good quality, color, and coverage (Tables 4, 5 and 6).

Yellow coneflower (*E. paradoxa*) and its cultivar 'Yellow Mellow' rated an average score for the three flower traits of 1.7 and 1.8, respectively (Tables 5 and 6), the lowest for all cultivars. The flowers for this species are atypical with heavily reflexed ray flowers that may mimic water stress to some observers, which may have led to the lower scores. However, reviewers at the Mt. Cuba Center rated yellow coneflower at 3.4 (9). In their 1996–2001 field trials, Thomas and Schrock (16) gave yellow coneflower a rating of 4.0 (out of 4 possible) for flower effectiveness and 3.7 for season-long quality. Its loose habit, flower color, and ray flower configuration would make it a strong possibility for a prairie or naturalized plantings rather than in a more managed setting. It is obvious this species has found favor in certain gardens, and lower scores here should not preclude its use. This cultivar has particular traits that may be attractive to many consumers, depending on their garden style.

Another flower that did not perform up to its reputation was 'Doubledecker'. This cultivar was introduced by Eugen Schleipfer in 2004 (12). It was marketed for its unique two-tiered blooms. In our trials, the bloom did not hold true to a pink color, many often reverting to white, and few blooms produced the two-tiered effect (Fig. 1). Of those that produced a secondary set of ray flowers, most of these were distorted and sparse. This led to ratings of 2.5 for both color (Table 5) and flower quality (Table 6). Despite the fact the plant did not perform as indicated, these in general are not poor scores.

**Fragrance evaluation.** While some cultivars of coneflower are sold extolling an improved fragrance, our trials found no significant difference between cultivars, and fragrances were faint, if present at all (data not shown).

**Table 6. Mean flower quality and flower coverage ratings for coneflower plants growing at Horticultural Field Lab.**

Species/cultivar	Plant trait <sup>a,b</sup>	
	Flower quality	Flower coverage
<i>Echinacea paradoxa</i>	1.8	1.8
'Yellow Mellow'	1.9	1.9
All That Jazz®	2.0	2.5
'Bravado'	2.6	2.6
'Bright Star Improved'	2.7	2.8
'Crazy Pink'	2.2	2.3
'Doubledecker'	2.5	2.8
<i>Echinacea purpurea</i>	2.9	3.4
'Emily Saul'	3.2	2.4
'Evan Saul'	3.0	2.9
'Katie Saul'	2.2	2.7
Kim's Knee High®	3.4	3.7
'Magnus'	2.4	2.6
'Matthew Saul'	2.9	2.8
'Pink Double Delight'	2.8	3.1
Prairie Splendor™	2.9	2.8
'Primadonna Deep Rose'	2.6	2.6
'Primadonna White'	3.0	2.8
'Ruby Star'	2.8	2.9
'Sunrise'	2.6	2.7
'White Swan'	3.3	3.4

<sup>a</sup>Means of ratings (scale: 1 = poor, 2 = fair, 3 = good, and 4 = excellent), ratings averaged over three years as there was no date interaction.

<sup>b</sup>Flower quality traits were recorded only once per year during peak bloom.



**Fig. 1.** *Echinacea purpurea* 'Doubledecker' illustrating flower development, lacking the top-tier unique bloom for which it is sold.

**Additional information.** In 2009 at the HFL site, after an excellent initial bloom and deadheading, many of the coneflower plants did not completely rebloom. Plants showed distorted growth of flower buds (Fig. 2). This distortion was due to high infestations of eriophyid and tarsonemid mites as well as Aster yellows. Aster yellows is a complex of related phytoplasmas and phytoplasma-like organisms and is vectored by several species of leafhoppers (8). Although Aster yellows was not isolated from the plants, symptoms characteristic of this disease were found in the flower heads.

**Plant ratings at the Castle Haynes site.** Plants were rated twice at CH, in 2008 and 2009, and only by the primary investigator. Despite fewer evaluations, in many cases plants received similar ratings for overall, flower, and foliage qualities as those at HFL, with one notable exception. At CH, yellow coneflower received one of the highest overall ratings (3.4) and a 3.7 mean flower quality rating (Table 7); while plants growing at HFL tended to rate below 2.0 (Tables 5 and 6). The CH scores are more in keeping with the ratings this plant received at Mt. Cuba Center (9) and by Thomas and Schrock (16), indicating that it may be quite acceptable in certain landscapes, based as well on its 56% survival rate in both locations.

The date of assessment affected the overall quality and foliage ratings (data not shown,  $P < 0.0001$ ). As would be expected, each of these plants rated higher in the second year of the study when compared to the first year. In 2008, plants received mean ratings of 2.4, 2.5, and 2.5 for overall quality, foliage color, and foliage texture, respectively. In 2009, the ratings had improved to values of 3.0, 3.3, and 3.2.

In addition, ratings varied by species/cultivar for overall, foliage, and flower qualities (Table 7). In general, those cultivars that rated over 3.0 for overall quality were *E. paradoxa*, 'Bravado', purple coneflower (*E. purpurea*), 'Evan Saul', 'Magnus', 'Pink Double Delight', and 'Sunrise' (Table 7). These ratings are somewhat different than those obtained at the HFL site, but many of the best-rated cultivars are common between both sites. The poorest rated cultivars in Castle Hayne were 'Matthew Saul' and 'Crazy Pink' (Table 7). Both of these had a 33% mortality rate by 2010 (Table 1). When

doing well, however, 'Matthew Saul' rated a 3.3 for flower quality; although 'Crazy Pink' scored only a 2.2 (Table 7). Along with this cultivar, yellow coneflower, 'Bravado', and All That Jazz® also rated marks over 3.0 for flower quality (Table 7). In CH, the poorest bloomers were 'Ruby Star', 'Primadonna Deep Rose', 'Katie Saul', and 'Doubledecker', all scoring a 1.0 (Table 7).

Although lime was added to recommended levels, pH may still have been a factor in performance and longevity of plants at this location. In addition, during the study period there was much less rain in Castle Hayne than at the HFL location. Water was applied, but only every 3 weeks without rain.

**Comparison of plant ratings at both locations.** When comparing plant ratings between the two locations, the only differences found were for flower quality, flower color, and flower coverage (data not shown). There was no relationship between location and species/cultivar for overall quality rating. For the cultivars where location was a significant factor regarding flower traits, plants at the HFL site typically received higher ratings than those at CH, with two exceptions. 'Bright Star Improved', 'Doubledecker', Kim's Knee High®, 'Pink Double Delight', 'Primadonna Deep Rose', and 'Ruby Star' rated significantly higher than the same cultivars at CH. As mentioned earlier, yellow coneflower rated higher for flower traits at CH than HFL. This is also true of 'Bravado'.

**Foliage evaluation.** At the HFL site, many cultivars showed different ratings over time for foliage color and texture (data not shown). However, most of the changes occurred during a single growing season, which is not unexpected considering changing heat and precipitation conditions. 'Sunrise' rated the highest at 3.6 and 3.4 for foliage color and texture, respectively. In addition, 'Primadonna Deep Rose' (3.5), 'Evan Saul' (3.5), 'Bravado' (3.5), and 'Magnus' (3.4) rated highly. Many of these cultivars were also the top rated plants overall (Table 4).

A number of plants succumbed to *Rhizoctonia* sp. root/crown rot and *Sclerotinia* sp. infection (determined by samples taken to NCSU Plant Disease and Insect Clinic).



**Fig. 2.** Eriophyid and tarsonemid mite damage to purple coneflower (*Echinacea purpurea*) blooms, preventing re-bloom.



**Table 7. Mean plant ratings for overall, foliage, and flower qualities for each coneflower species/cultivar for plants growing at Horticultural Crops Research Station, Castle Hayne.**

Species/cultivar	Plant trait <sup>z</sup>			
	Overall quality	Foliage color	Foliage texture	Flower quality <sup>y</sup>
<i>Echinacea paradoxa</i>	3.4a	3.3abc	3.3abc	3.9
'Yellow Mellow'	2.2def	2.8abcde	2.2def	2.5
All That Jazz®	2.5a	3.0abcd	3.0abcde	3.0
'Bravado'	3.3ab	3.6a	3.4ab	3.7
'Bright Star Improved'	2.7abcd	3.2abc	3.0abcde	1.8
'Crazy Pink'	1.8ef	1.8f	1.6f	2.0
'Doubledecker'	2.7abcde	3.0abcd	2.7abcde	1.0
<i>Echinacea purpurea</i>	3.5a	3.5a	3.5a	nb
'Emily Saul'	1.6f	2.6bcdef	2.2ef	nb
'Evan Saul'	3.2abc	3.4ab	3.4ab	2.9
'Katie Saul'	2.8abcd	2.8abcde	3.0abcde	1.0
Kim's Knee High®	2.5bcde	3.0abcd	3.0abcde	2.6
'Magnus'	3.0abcd	3.3abc	3.3ab	nb
'Matthew Saul'	2.5bcde	2.3cdef	2.7abcde	3.3
'Pink Double Delight'	3.3ab	2.7abcde	3.1abcde	2.4
Prairie Splendor™	2.5bcde	3.0abcd	2.4bcdef	nb
'Primadonna Deep Rose'	2.7abcde	3.1abcd	3.0abcde	1.0
'Primadonna White'	2.3def	2.3def	2.5abcdef	1.9
'Ruby Star'	2.9abcd	3.3abc	3.2abcd	1.0
'Sunrise'	3.0abcd	3.0abcd	3.3abc	2.1
'White Swan'	2.4cdef	2.1ef	2.3cdef	2.8

<sup>z</sup>Mean ratings for overall quality, foliage color, and foliage texture (scale: 1 = poor, 2 = fair, 3 = good, and 4 = excellent) from 6 temporal assessments combined from 2008 to 2010; means within each column having different letters indicate a significant difference at  $P \leq 0.05$ , using Duncan's multiple range test.

<sup>y</sup>Flower quality was recorded only once per year during peak bloom.

Plant death was typically preceded by stem lodging, yellowing foliage that turned nearly black, and then the entire plant wilted and typically died within a week. Water may have collected at plant crowns due to the lodging, and potentially predisposed the plants to the fungi. The disease infection obviously affected plant health, and thereby likely reduced overall and foliage ratings. Deadheading plants affected by these fungi may help reduce weight on flowering stems and could help prevent lodging, potentially minimizing the collection of water at the plant base. In addition, ensuring plants are mulched with 2.5 cm or less of mulch is important. Some cultivars showed no disease symptoms, denoted by their higher ratings and low mortality.

Over the two-year study, on average there was a 34% mortality rate. The likely cause of death of many of the plants growing at the HFL site may have been due to the wet winter soils that provided a favorable environment for root rot fungi. Heavy blossoms and weak stems led to lodging that likely allowed water to collect at the plant base, further encouraging infection. Although disease was not assayed from plants at CH, symptoms were quite similar to those seen at HFL.

To determine the actual conditions that led to death of these plants it would be necessary to conduct greenhouse studies varying temperature and media wetness.

Deadheading promoted additional flowering, extending the bloom season. Cutting back in the fall may help minimize incidence of certain insect and disease pests, improve aesthetics of the winter garden, and promote better spring growth (7). In addition, providing well-drained soils in raised beds, and removing the mulch from plant crowns may help reduce disease infection (7).

While it would be impossible to make broad generalizations regarding the overall performance of these species across the south, there is some evidence provided from these

trials that do indicate the resilience of particular cultivars. Some of the best performers were older cultivars such as 'Bravado', 'Pink Double Delight', 'Primadonna Deep Rose', 'White Swan', 'Magnus', Kim's Knee High®, and 'Bright Star Improved'. Any of these would likely do well in typical landscapes of the southeast with either clay type or sandy soils. On the other hand, many of the Big Sky™ Series, such as 'Emily Saul', 'Evan Saul' and 'Sunrise' scored well for overall appearance and flower effectiveness but had high mortality rates and would not be recommended for southern gardens. Although the yellow coneflowers did not score well at the HFL facility, they did receive high ratings at the CH site and for many of the trials cited here. They had a survival rate over 78% and may be quite appropriate in prairie or naturalized planting areas.

This study provides preliminary information regarding the use of coneflower in southern landscapes of two differing soil types, but further trialing throughout the southeast would benefit growers, retailers, landscapers, and consumers.

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