Mammoth™ ‘Twilight Pink Daisy’ Garden Chrysanthemum

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Abstract. Mammoth™ ‘Twilight Pink Daisy’ (U.S. Plant Patent 14,455; Canadian Plant Breeders’ Rights Certificate No. 4192) is an interspecific garden chrysanthemum cultivar, *Chrysanthemum* × *hybridum* Anderson (= *Dendranthema* × *hybrida* Anderson) with common names of hardy mum, chrysanthemum, and garden mum. It is a new and distinct form of shrub-type garden mums in the Mammoth™ series with rosy-pink ray florets, a dark “eye” color in the center of the disc florets, frost-tolerant flower petals, and self-pinching growth. This cultivar is a butterfly attractant in the garden. Mammoth™ ‘Twilight Pink Daisy’ is a winter-hardy herbaceous perennial in USDA Z3b–Z9 (Southeast)/Zone 10 (West) with its cushion growth form displaying extreme hybrid vigor, increasing in plant height from 0.46 m in its first year to a shrub of 0.76 to 1.22 m in the second year and thereafter with greater than 3000 leaves/plant. Flowering is prolific, covering the entire plant at full flowering with as many as greater than 3500 flowers in the second year. Chemical abbreviations: ethanol (EtOH), indole-3-butyric acid (IBA).

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Origin

Mammoth™ ‘Twilight Pink Daisy’ (Fig. 1) (Minnesota Sel’n. No. MN98-E90-15; U.S. Plant Patent 14,455; Canadian Plant Breeders’ Rights Certificate No. 4192) is a selection from the progeny of the open-pollinated interspecific cross No. 90-287 between two allohexaploid ($2n = 6x = 54$) species, *C. weyrichii* (Maxim.) Miyabe ‘Pink Bomb’ × [*C. ×grandiflora* Tzvelv. ‘Adorn’ (PP 6,059) or ‘Crusador’ (PP 6,531)] (Anderson et al., 2008). These unique interspecific hybrids, the descendants of which became the Mammoth™ series (Anderson et al., 2004, 2008, 2012), exhibit shrub-like growth in Year 2 onward. Mammoth™ genotypes are taxonomically distinguished from classic garden and/or greenhouse chrysanthemums (*Chrysanthemum* × *grandiflorum* Tzvelv.; = *Dendranthema* × *grandiflora* Tzvelv.), which have smaller and consistent plant sizes regardless of plant age. All Mammoth™ selections have been

taxonomically designated *Chrysanthemum* × *hybridum* Anderson (= *Dendranthema* × *hybrida* Anderson) (Anderson, et al., 2004, 2008, 2012). Hybrid genotype MN Sel’n. 90-287-145 was inbred (self-pollinated) in 1991 to produce cross No. 92-396 (Fig. 1). Plant no. 20 (92-396-20) from that cross was hybridized (as male) with MN Sel’n. 90-275-27 in 1994 to produce cross No. 95-331. In 1997, plant no. 6 (95-331-6) from that cross was open-pollinated to produce cross No. 98-E90 (Fig. 1). Plant no. 15 of this cross (MN Sel’n. No. 98-E90-15) was later selected for release as Mammoth™ ‘Twilight Pink Daisy’, which is now protected by U.S. Plant Patent (PP 14,455; Anderson et al., 2003) and Canadian Plant Breeder’s Rights (Certificate No. 4192; Strauss for the Regents of the University of Minnesota, 2011) certificates.

Description

Stem tip cuttings of Mammoth™ ‘Twilight Pink Daisy’ were first rooted in 1999. All vegetative generations (clonal ramets) thereafter have demonstrated that the characteristics of the new cultivar as described herein are firmly fixed and retained through successive years of each propagule (Anderson et al., 2003). Morphological traits for characterization of Mammoth™ ‘Twilight Pink Daisy’ are based on plants produced from rooted, vegetative tip cuttings treated with 1000 ppm indole-3-butyric acid (IBA) in 50% ethanol (EtOH), placed in Oasis wedges (Smithers-Oasis, Kent, OH), and kept under intermittent mist at 21 °C day/night (soil). Stem tip cuttings rooted in 1 week, whereupon they were transplanted and grown under greenhouse conditions (lat. 45° N; St. Paul, MN) for 4 weeks vegetative growth (long days, 0800 to 1600 hr supplied by 400-W high-pressure sodium lamps + 2200 to 0200 hr night interruption; 18.5/22.0 °C day/night) followed by 6 weeks short days [8 h (0800–1600 hr) supplied by 400-W high-pressure sodium lamps; black cloth pulled closed at 1600 hr and opened at 0800 hr; 18.5/22.0 °C day/night]. Plants were grown in 15.2-cm (diameter) black plastic standard containers (Belden Plastics, St. Paul, MN) filled with Sunshine LC8 Professional Growing Mix (Sun Gro Horticulture, Seattle, WA) with recommended fertilization and fungicide drenches applied (Langevin, 1992).

For the U.S. Plant Patent, determination of phenotypic coloration of aboveground plant parts was determined with the RHS Color Chart [Royal Horticultural Society (RHS), 1995]. Colors were determined on 7 Feb. 2001, between 1300 and 1400 hr under 500 μmol·m⁻²·s⁻¹ of light (Anderson et al., 2003).

This cultivar displays a cushion plant shape (Table 1) after planting in containers, fields, and landscapes; this is maintained for the life of the plant. Like with other cultivars in the Mammoth™ series (Anderson et al., 2008, 2012), Mammoth™ ‘Twilight Pink Daisy’ exhibits vigorous growth such that in Year 2 and thereafter, it attains the shrub

Chrysanthemum weyrichii 'Pink Bomb' x *C. x grandiflora* 'Adorn' or 'Crusador'

90-287-145 self-pollinated

90-275-27 x 92-396-20

95-331-6 Open-pollinated (OP)

98-E90-15

Fig. 1. Pedigree of *Chrysanthemum x hybridum* Mammoth™ 'Twilight Pink Daisy'.

Table 1. Comparative plant characteristics of *Chrysanthemum x hybrida* Mammoth™ 'Twilight Pink Daisy' grown with *C. x grandiflora* 'Soft Lynn' (PP 8,898) (Anderson et al., 2003).^z

Plant characteristic	Mammoth™ 'Twilight Pink Daisy'	'Soft Lynn'
Plant shape	Cushion	Cushion
Plant height, Year 1	0.46 m	0.46 m
Plant height, Year 2	0.76–1.22 m	— ^y
Flowering response group		
No. weeks short days	6.5	7.0
Flower type	Daisy	Decorative
Flower diameter	7.8 cm	7.8 cm
Ray florets (mature), color		
Adaxial surface	RHS red–purple group 69B	RHS red–purple group 69C
Abaxial surface	RHS red–purple group 69D	RHS red–purple group 69D

^zQuantitative traits are mean values based on 10 replications.

^yPlants did not survive the winter in USDA Z3–Z4.

RHS = Royal Horticultural Society.

plant habit of 0.76 to 1.22 m in height (Table 1) compared with a Year 1 plant height of 0.46 m (Table 1). On average, lateral branches grow as long as 12.7 to 17.8 cm with one/node initiated without removal of the apical meristem (pinching). Older stems have coloration of RHS yellow–green group 148A (Anderson et al., 2003).

The number of leaves/lateral branch ranges from five to 19 with alternate phyllotaxy (one leaf/node). In Year 2 plants, there are greater than 3000 leaves/plant (based on actual counts) (Anderson et al., 2003). Fully expanded leaves average 10.5 cm × 6.0 cm (length × width) ending in a apiculate apex. Each mature leaf has an auriculate leaf base with incised leaf margins (*Morus*-like shape) and glaucous surface. Mean petiole lengths are 3.0 cm. Coloration of the young foliage is RHS yellow–green group 148B (adaxial surface) changing to 139A (adaxial) and 147A (abaxial) on maturity. Leaf venation in mature leaves ranges from RHS yellow–green group 147B (adaxial) to 148A (abaxial), whereas the petiole is uniformly RHS yellow–green group 147B.

The inflorescence is a composite (*Asteraceae*) of numerous disc (231/flower on average)

and ray (21/flower, mean) florets totaling 252 on average and the flower is classified as a single daisy (Anderson et al., 2003). In some instances, the single daisy phenotype (single row of ray petals/florets) may have an additional half row of petalage (Fig. 2; for the Strauss Regents of the University of Minnesota, 2011). Mammoth™ 'Twilight Pink Daisy' flowering is classified with a 6.5-week short-day response group (Table 1) with greater than 3500 inflorescences (mean) in Year 2. Flower longevity of 2 to 4+ weeks in the field is temperature-dependent. Flower petals are frost-tolerant.

Opening inflorescences have a conical bud shape with flower buds that are 2.4 × 1.5 cm (mean length × width) and RHS red group 37B coloration. When completely open, inflorescences are 7.8 cm (diameter) × 1.3 cm (depth). Ray florets have a flattened lanceolate shape, averaging 3.7 cm × 0.9 cm (length × width). Each ray floret possesses a slightly dentate apex and an attenuate base; the margins are entire with a glabrous texture. Ray floret position in a mature flower at anthesis is horizontal (but perpendicular to the stem axis) to slightly reflexed. Ray florets (gynoeceous) during elongation (opening) are

RHS red–purple group 62C and RHS red group 38C, whereas those at maturity (anthesis) are RHS red–purple group 69B and 69D for adaxial and abaxial surfaces, respectively. There is one ovule contained in each ray and disc floret. Ray florets fade in color to RHS red–purple group 69C.

Disc florets (hermaphroditic) are tubular and rounded at the tip, 0.8 × 0.2 cm (length × width). Immature disc florets are RHS yellow group 153A in color changing to RHS yellow–orange group 17C on maturity (pollen dehiscence). Central immature disc florets also have a darker colored tip—either rounded or star-shaped, RHS red–purple group 69D in color, which creates an “eye” effect in the center of each opening flower (Fig. 2). As the central disc florets mature (post-pollen shed), the “eye” effect disappears as a result of pollen dehiscence. The “eye” may also not be present if plants are flowered under higher temperatures (greater than 23 to 25 °C; Fig. 3). Pubescent peduncles are RHS green group 137A in color, held stiffly at 45° angles to the stem, with lengths of 10.3 cm (terminal or first) to 11.0 cm (fourth subtending). Anthers have an RHS yellow–orange group 14B coloration, whereas the copious trinucleate pollen is RHS yellow–orange group 16A. Style color is RHS yellow–green group 151C.

The dry, indehiscent fruit is an achene with a single seed that lacks a pappus (awns for bristles). A half-inflated football, oval shape, and ridged texture characterize the shape of each achene.

Two comparative trials were conducted with Mammoth™ 'Twilight Pink Daisy' and market standards. The first comparison was with 'Soft Lynn' (PP 8,898) for the Mammoth™ 'Twilight Pink Daisy' U.S. Plant Patent Application (Anderson et al., 2003). Colors were determined on 7 Feb. 2001 for comparison with 'Soft Lynn'. When Mammoth™ 'Twilight Pink Daisy' were grown in comparison with 'Soft Lynn', both had cushion plant shapes and identical plant heights in Year 1 (Table 1). 'Soft Lynn' did not survive into Year 2, whereas Mammoth™ 'Twilight Pink Daisy' developed a shrub habit (Table 1). Mammoth™ 'Twilight Pink Daisy' had a 0.5-week earlier short-day response group with flower diameters (7.8 cm) in between the range (7 to 8 cm) found for 'Soft Lynn' (Table 1). 'Soft Lynn' had RHS red–purple group 69C coloration on its adaxial ray floret surface, whereas Mammoth™ 'Twilight Pink Daisy' displayed RHS red–purple group 69B. Both cultivars had the same abaxial ray floret surface color of RHS red–purple group 69D (Table 1).

The second comparative growth trial was between Mammoth™ 'Twilight Pink Daisy' and the comparison Mammoth™ 'Dark Pink Daisy' (PP 19,795) for the Canadian Plant Breeder's Rights (Certificate No. 4192) occurring in the summer of 2010 at BioFlora, Inc., in St. Thomas, Ontario, Canada. Phenotypic data collection occurred on 14 Sept. 2010 (Strauss for the Regents of the University of Minnesota, 2011). In this trial of Year 1

plants, Mammoth™ ‘Twilight Pink Daisy’ had a plant height of 25.1 cm, whereas Mammoth™ ‘Dark Pink Daisy’ was 18.9 cm tall. Mammoth™ ‘Twilight Pink Daisy’ possessed an

average of 22 ray florets/inflorescence, which surrounded a 2.2-cm disc diameter, whereas Mammoth™ ‘Dark Pink Daisy’ had 64.8 ray florets and a disc diameter of 1.8 cm. Floral

colors were recorded with a different edition of the RHS Color Chart (Royal Horticultural Society, 2007) and results differed from the first comparison, e.g., RHS 75B–C and 75D for abaxial and adaxial ray petals of Mammoth™ ‘Twilight Pink Daisy’, respectively, and RHS 70B with white underlay and RHS N74D, white toward base for said petal surfaces in Mammoth™ ‘Dark Pink Daisy’ (Strauss for the Regents of the University of Minnesota, 2011).

Winterhardiness of Mammoth™ ‘Twilight Pink Daisy’ is a USDA Z3b–Z9 (Southeast)/Zone 10 (West) herbaceous perennial (Anderson et al., 2003; Table 2). Snow cover throughout the winter period is required for adequate survival of Mammoth™ ‘Twilight Pink Daisy’ (Table 2). We evaluated garden performance and winter survival during 2000 to 2008 at seven sites in USDA Z3b (Grand Rapids, MN), 3b/4a (Morris, MN), 4a (St. Paul, MN), 4b (Lamberton, MN; Waseca, MN), 5a (Verona, WI), and 6b (Institute, WV), although not all sites had Mammoth™ ‘Twilight Pink Daisy’ planted each year (Table 2). Note that Institute, WV, in previous field trials, was listed as USDA Z6a (Anderson et al., 2012), but this change to Z6b reflects the new, revised USDA hardiness zone listings (USDA ARS, 2012). All trials were conducted in open-field or garden plots without protective mulch or covering. Mean winter survival ranged from 20% (2004, St. Paul, MN) to 100% (2000, Morris, MN; 2003, Waseca, MN; 2004, Grand Rapids and Waseca, MN; 2006, Morris, MN; 2007, Waseca, MN; Table 2) with an overall grand arithmetic mean of 66.4% for the tested years and sites. The lowest arithmetic mean was 49.2% in 2001 (four sites; Table 2), a year with low snow cover. In general, years with adequate snow cover (2000 to 2001, 2003, 2005 to 2007, Table 2) had higher percent winter survival than those without (2002, 2004, 2008) with the notable exception of 2004 with a wide range of winter survival (20%, St. Paul, MN, vs. 100% in Waseca and Grand Rapids, MN; Table 2). Geometric means were also used to express trends in winter

Fig. 2. Close-up of *Chrysanthemum x hybridum* Mammoth™ ‘Twilight Pink Daisy’ flowers, displaying the single daisy flower with an “eye” in the center of the disc florets. The “eye” is either round or star-patterned. Bar = 7 cm. Photo: David Hansen, Minnesota Agricultural Experiment Station.

Fig. 3. Flowering cuttings of *Chrysanthemum x hybridum* Mammoth™ ‘Twilight Pink Daisy’ in packs under naturally occurring short days in Year 1. Plants of this size are sold in the spring, typically for Mother’s Day for planting directly into the garden. Bar = 7 cm. Photo: Ball Horticultural Company, West Chicago, IL.

Table 2. Test sites, geographic locations, USDA plant hardiness zones, and geometric/arithmetic mean percent winter survival of Mammoth™ ‘Twilight Pink Daisy’ over multiple trial locations in Minnesota, WI, and West Virginia.^a

Test sites	Latitude	Longitude	USDA plant hardiness zone ^y	Percent winter survival over years								
				2000	2001	2002	2003	2004	2005	2006	2007	2008
Grand Rapids, MN	47.24739°N	93.54444°W	3 b	90.0	0.0	80.0	100.0	100.0	75.0	0.0		100.0
Lamberton, MN	44.23111°N	95.26389°W	4 b			10.0						
Morris, MN	45.62820°N	95.88908°W	3 b/4 a	100.0	50.0		78.0		80.0	100.0		
St. Paul, MN	44.98776°N	93.13700°W	4 a	78.0		25.0	25.0	20.0				40.0
Waseca, MN	43.90669°N	93.43338°W	4 b		80.0	90.0	100.0	80.0	65.0	94.4	100.0	
Verona, WI	43.06048°N	89.52742°W	5 a		67.0		75.0					
Institute, WV	38.41981°N	81.8339°W	6 b							10.0		80.0
Annual Geometric Means (Grand mean = — ^x)				88.9	— ^x	36.6	68.1	54.3	73.1	— ^x	N/A ^w	68.4
Annual Arithmetic Means (Grand mean = 66.4)				89.3	49.2	51.2	75.6	66.7	73.3	51.1	N/A ^w	73.3

^aData were collected in the spring (April to May) of each listed year. Years with adequate snow cover are noted in bold. There were n = 10 replications (clones) per site per year; blanks indicate the genotype was not planted at a particular location during that year.

^yLow air temperature ranges: Zone 3b (–34.4 to –37.2 °C), 4a (–31.7 to –34.4 °C), 4b (–28.9 to –31.7 °C), 5a (–26.2 to –28.8 °C), and 6b (–17.8 to –20.6 °C) (USDA ARS, 2012).

^xGeometric mean could not be calculated as data includes a non-positive number, i.e., zero (0).

^wN/A = means are irrelevant since there is only one average at one location for this year.

Fig. 4. Year 2 flowering plant size of an overwintered *Chrysanthemum x hybridum* Mammoth™ 'Twilight Pink Daisy' adjacent to a mammoth-sized pumpkin, demonstrating the shrub habit. Bar = 0.7 m. Photo: David Hansen, Minnesota Agricultural Experiment Station.

survival over multiple years and locations for this trial, because they are a measure for a mean survival rating (%), which calculates the normalized value of a range of positive numbers such that no particular data set for any location or year dominates the mean weighting (Ouellet, 1976). The geometric mean (G) for winter survival at l (locations) in y (years) formula is:

$$G_{ly} = \sqrt[n]{ly_1 * ly_2 * ly_3 \dots ly_n}$$

and n is the number of replications per ly site. Geometric means have been used to analyze winter survival of Gypsy moth eggs (Higashiura, 1989) and forage crops (Ouellet, 1976). Chrysanthemum winter survival has always classically used arithmetic means (where values are added rather than multiplied) to express winter survival, but geometric means may be more accurate. We present these for the first time for winter survival tests of Mammoth™ 'Twilight Pink Daisy' (Table 2). All G_{ly} for years across locations ranged from 36.6% (2002, a year with less than adequate snow cover) to 88.9% (2000) (Table 2); all were lower than the arithmetic means (which ranged from 49.2% for 2002 to 89.3% for 2000; Table 2). G_{ly} could not be calculated for 2001 and 2006 because these years contained 0.0% winter survival (Table 2) and G_{ly} can only include positive numbers greater than zero. In 2007, neither G_{ly} nor arithmetic means could be determined because there was only one average at one location (Table 2). The grand G_{ly} for all years and locations could not be calculated for Mammoth™ 'Twilight Pink Daisy' because, again, the data included zeroes. The grand arithmetic mean was 66.4% (Table 2) for all years. If the years with less than adequate snow cover (2002, 2004, 2008) were dropped from the averages, the arithmetic mean would be 68.4% (again, the G_{ly} could not be calculated). The occurrence of 0.0% winter survival means that use of the G_{ly} statistic is somewhat limited despite its use in previous winterhardness research (Ouellet, 1976). Regardless, for most years with adequate snow cover in the tested locations, Mammoth™ 'Twilight Pink Daisy' is winter-hardy in USDA Z3b. Data (not shown) in

lower latitudes demonstrated that Mammoth™ 'Twilight Pink Daisy' also survives to USDA 9 (Southeast)/Zone 10 (West). Thus, the complete winterhardness range of this cultivar is USDA Z3b–9 (Southeast)/Zone 10 (West).

Propagation and Production

Asexual propagation was routinely tested to ensure the morphological traits were firmly fixed year after year. Mammoth™ 'Twilight Pink Daisy' is vegetatively propagated through herbaceous stem tip cuttings, which root in 1 week under mist or fog propagation after treatment with 1000 ppm IBA in 50% EtOH (Anderson et al., 2003, 2008). Plants can then be programmed to flower by potting in a high-porosity soilless medium, 3- to 4-week long days for vegetative growth (0800 to 1600 HR + 2200 to 0200 HR night interruption lighting) at 18.5/22.0 °C day/night followed by 6.5 weeks short days [8 h (0800 to 1600 HR); black cloth pulled closed at 1600 HR and opened at 0800 HR]; 18.5/22.0 °C day/night, and standard fertilization, e.g., 300 ppm N 20N–10P–20K weekly liquid feed based on weekly soil tests and monthly fungicide drench rotations (Langevin, 1992).

Mammoth™ 'Twilight Pink Daisy' is a facultative short-day plant (Anderson et al., 2003). Similar to Mammoth™ 'Yellow Quill', this cultivar may be grown for spring bedding plant sales (Mother's Day) in packs or liners (Fig. 3), which can then be planted directly in the garden or containers for subsequent regrowth and fall flowering (Fig. 4; Anderson et al., 2003, 2008; Langevin, 1992). Mammoth™ 'Twilight Pink Daisy' may also be grown outdoors in "mum pans" to form flowers under naturally shorter daylength conditions for sale as larger plants in the fall. If either type is overwintered, the plants will display the shrub habit in Year 2 onward (Fig. 4).

To maximize summer growth potential in containers or direct-planted, full sun is required along with high fertilization and irrigation levels (Anderson, 2006; Anderson et al., 2003, 2004, 2008, 2012). Mammoth™ 'Twilight Pink Daisy' is classified as a "heavy" feeder requiring as much as 1361 g/30.48 m² of

5N–20P–20K preplant fertilizer or weekly 300 ppm N 20N–10P–20K postplant soluble fertilization (Anderson et al., 2008).

Use

All Mammoth™ garden chrysanthemums are notably winter-hardy herbaceous perennials that are butterfly attractants and frost-tolerant. Mammoth™ cultivars have standard plant dimensions in the first year (Anderson et al., 2008) but achieve shrub status in Year 2 onward (Anderson et al., 2003, 2004, 2008, 2012). The Mammoth™ series is a collection of low-maintenance perennials resulting from their genetic "self-pinching," removing the necessity to hand or mechanically pinch terminal shoots in midsummer to form the cushion habit (Anderson et al., 2008). Mammoth™ 'Twilight Pink Daisy' may be grown as a specimen shrub within the garden in Year 2 (Anderson et al., 2003) but should be spaced as much as 1 m away from adjacent plants and is enhanced when planted adjacent to fine or coarser perennials "... for an effective composition" (Sun Valley Garden Center, 2011). It has also been observed, but not scientifically tested, that deer will not eat Mammoth™ 'Twilight Pink Daisy' leaves, stems, or flowers (Sun Valley Garden Center, 2011). This cultivar may also be grown as a flowering hedge, spacing the plants 0.3 to 0.6 m on center. Likewise, Mammoth™ 'Twilight Pink Daisy' is well suited for large container plantings in landscapes, borders, and mass plantings—providing fall color at eye level. Fragrant foliage makes it an ideal cut flower as a "spray" mum.

Availability

Mammoth™ 'Twilight Pink Daisy' (U.S. Plant Patent 14,455; Canadian Plant Breeders' rights Certificate No. 4192) is available as certified unrooted or rooted cuttings from Ball Seed Company (622 Town Road, W. Chicago, IL, 60185; <<http://www.ballseed.com>>) under the Mammoth™ brand. European distribution rights are currently under negotiation.

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