Chrysanthemum × *hybridum* Mammoth™ ‘Dark Pink Daisy’ Garden Chrysanthemum

Neil O. Anderson^{1,10}

Department of Horticultural Science, University of Minnesota, 286 Alderman Hall, 1970 Folwell Avenue, St. Paul, MN 55108

Vincent Fritz¹ and Charlie Rohwer²

Southern Research and Outreach Center, University of Minnesota, Waseca, MN 56093

Steven Poppe²

West Central Research and Outreach Center, University of Minnesota, Morris, MN 56267

Barbara E. Liedl³

Department of Biology & Agricultural and Environmental Research Station, West Virginia State University, Institute, WV 25112

Shengrui Yao^{4,8} and Patricia Johnson⁵

North Central Research and Outreach Center, University of Minnesota, Grand Rapids, MN 55744

Judith Reith-Rozelle⁶

West Madison Agricultural Research Station, Verona, WI 53593

Lee Klossner⁷ and Neal Eash^{3,9}

Southwest Research and Outreach Center, University of Minnesota, Lamberton, MN 56162

Additional index words. Asteraceae, chrysanthemum breeding, *Dendranthema*, herbaceous perennials, winterhardiness

Greenhouse and garden chrysanthemum cultivars, *Chrysanthemum* × *grandiflorum* Tzvelv. (syn. *Dendranthema* × *grandiflora* Tzvelv.; syn. *C. morifolium* Ramatuelle), are grown for use as floral cuts, potted plants, and garden annuals or perennials worldwide with a wide array of flower colors and petal and inflorescence types (Anderson, 2006). Garden forms are the number one herbaceous perennial in the top 15 U.S.-producing

states with a wholesale farm gate value of \$27.854 million in 2012 (U.S. Dept. of Agriculture, National Agricultural Statistics Service, 2013). Upright plant habit types (for cuts) still maintain limited popularity as a result of their tendency to lodge and provide less flower power (flowering only at the stem apices of each plant). Fall flowering is a popular trait of the garden types, prompting both spring sales in packs or liners (Mother’s Day) as well as fall container or field-dug products (Anderson, 2006; Dole and Wilkins, 2005). The cushion habit, with each plant forming a spherical shape completely covered with fall flowers, was first developed at the University of Minnesota in the 1950s and released in the 1970s. ‘Minngopher’ (PP 4327) was the first patented cultivar with this habit (Widmer, 1978). The cushion habit is now the dominant garden phenotype worldwide (Anderson, 2004, 2006; Anderson and Gesick, 2003, 2004; Kim and Anderson, 2006). Mammoth™ ‘Dark Pink Daisy’ garden chrysanthemum was bred, selected, and introduced to continue this popular and economically successful phenotype.

Origin

The Mammoth™ series currently has a flower color palette including red, white,

yellow, coral, lavender, twilight pink, and dark pink cultivars (Anderson, 2008; Anderson et al., 2004, 2008, 2012a, 2012b). Mammoth™ ‘Dark Pink Daisy’ (MN Sel’n. No. 01-127-1; U.S. Plant Patent 19,795) exhibits a new flower color for this series of winter-hardy garden chrysanthemums (Anderson, 2008). The pedigree of Mammoth™ ‘Dark Pink Daisy’ (Fig. 1) has an intricate series of outcrosses, backcrosses to descendants of the parental species, and self-pollinations (inbreeding) beginning in 1989 after the original interspecific cross between two allohexaploid ($2n = 6x = 54$) species, *C. weyrichii* (Maxim.) Miyabe ‘Pink Bomb’ × [*C. ×grandiflorum* Tzvelv. ‘Adorn’ (PP 6059) or ‘Crusador’ (PP 6531)] (Anderson et al., 2008). The female parent (MN Sel’n. 92-11-1) of Mammoth™ ‘Dark Pink Daisy’ has quadruplex daisy inflorescences with bronze ray florets (petals), whereas the male parent (MN Sel’n. 00-4-30) is semi-double with bronze flowers as well. The new chrysanthemum was selected in 2001 (MN Sel’n. 01-127-1; Fig. 1) as being unique for its single to duplex, daisy-type inflorescences with dark pink ray flowers and gold disk florets spread across the cushion habit and a large shrub habit occurring in the second year of plant growth of the original hybrid seedling (ortet).

Mammoth™ series cultivars have to display the cushion phenotype in Year 1 (Fig. 2) and onward (Fig. 3) with the large shrub habit occurring only in the second year of growth and onward (Fig. 3). This shrub growth distinguishes them from classic, dwarfed forms of garden chrysanthemums that match Mammoth™ series Year 1 plants in size that are classified as *Chrysanthemum* × *grandiflorum* Tzvelv. (Anderson et al., 2004, 2008, 2012a, 2012b). Hybrid MN Sel’n. 01-127-1 was selected and approved for release in 2006, by the Minnesota Agricultural Experiment Station, Horticultural Variety Release Committee, as Mammoth™ ‘Dark Pink Daisy’, which is now protected by a U.S. Plant Patent (PP 19,795; Anderson, 2008). This cultivar is taxonomically designated as *Chrysanthemum* × *hybridum* Anderson (= *Dendranthema* × *hybrida* Anderson) Mammoth™ ‘Dark Pink Daisy’ (Anderson, 2008).

Description

After selection of the Mammoth™ ‘Dark Pink Daisy’ ortet as a shrub chrysanthemum in Fall 2002, one-third of its crown was dug from the field (St. Paul, MN; lat. 45° N). The crown portion was kept at 4 °C in darkness for 1000 h whereupon it was potted into Sunshine #8/LC8 Professional Growing Mix (Sun Gro Horticulture, Bellevue, WA) and forced in a greenhouse to produce vegetative shoots (long days, 0800 to 1600 h supplied by 400-W high-pressure sodium lamps + 2200 to 0200 h night interruption; 18.5/22.0 °C night/day). Clonal ramets of the new cultivar were first taken by stem cuttings in St. Paul, MN, in 2003

Received for publication 6 Aug. 2014. Accepted for publication 15 Oct. 2014.

This research has been supported by the Minnesota Agricultural Experiment Station and a grant from the Ball Horticultural Company (W. Chicago, IL).

¹Professor.

²Scientist.

³Associate Professor.

⁴Research Fellow.

⁵Non/Exempt Temporary or Casual Scientist.

⁶Emeritus Assistant Superintendent.

⁷Senior Research Fellow.

⁸Current address: Assistant Professor/Fruit Specialist, Sustainable Ag Service Center, New Mexico State University, Alameda, NM 87511.

⁹Department of Biosystems Engineering and Soil Science, University of Tennessee, Knoxville, TN 37996.

¹⁰To whom reprint requests should be addressed; e-mail ander044@umn.edu.

Chrysanthemum weyrichii 'Pink Bomb' x [*C. xgrandiflorum* 'Crusador' and/or 'Adorn']

Fig. 1. Pedigree of *Chrysanthemum xhybrida* Mammoth™ 'Dark Pink Daisy' (MN. Sel'n. No. 01-127-1) (Anderson, 2008). The female (seed) parents are listed first, followed by the male (pollen) parent. Note: x denotes self-pollinated.

Fig. 2. First-year Mammoth™ 'Dark Pink Daisy' plant displaying the tight cushion plant habit. Bar = 0.375 m. Photo credit: Dave Hansen, Minnesota Agricultural Experiment Station.

Fig. 3. Second-year growth of Mammoth™ 'Dark Pink Daisy' plants (0.6m O.C.). Bar = 1.0 m. Photo credit: Dave Hansen, Minnesota Agricultural Experiment Station.

and the characteristics of this cultivar proved to be stable, reproducing true to type in successive generations of clonal ramets in subsequent years of propagation (Anderson,

2008). Vegetative tip cuttings were dipped in 1000 ppm indole-3-butyric acid (IBA) in 50% ethanol (EtOH) placed in Oasis wedges (Smithers-Oasis, Kent, OH) in intermittent mist at 21 °C day/night (soil). Cuttings rooted (100%) in ≈1 week. They were subsequently grown in greenhouse conditions (lat. 45° N; St. Paul, MN) for 4 weeks of vegetative growth (long days, 0800 to 1600 h supplied by 400-W high-pressure sodium lamps + 2200 to 0200 HR night interruption; 22.0/18.5 °C day/night) followed by transplanting into field trials in May of 2004 and 2005 for 2- and 1-year-old plants, respectively, at the Southern Research and Outreach Center, University of Minnesota, Waseca, MN (lat. 43.9° N). Plants were grown under natural daylengths until flowering in Sept. 2005 when the comparative trait data were collected.

A detailed description of Mammoth™ 'Dark Pink Daisy's above-ground morphological traits as grown outdoors under natural lighting in a trial bed in Waseca, MN, were observed and recorded over a period of 2 years (2004–05). For the U.S. Plant Patent (Anderson, 2008), the detailed botanical data using taxonomic descriptors of Harris and Harris (1994) were collected from 1- and 2-year-old plants between 1300 and 1700 HR on 27 Sept. 2005. Descriptors using RHS Color Charts [Royal Horticultural Society (RHS), 2007] (except where general color terms of ordinary dictionary significance are used) were characterized indoors under fluorescent lighting, 150 μmol·m⁻²·s⁻¹, on the same date (Anderson, 2008). The phenotype of the new cultivar may vary slightly in differing environmental, climatic, and cultural conditions, but the overall phenotypic range of expression has been deemed stable (Anderson, 2008).

Mammoth™ 'Dark Pink Daisy' has stem coloration of RHS 144A and 144B–C in the first and second years of growth. Lateral branch lengths averaged 24 cm with mean diameters of 2.5 mm (Anderson, 2008). On average, Mammoth™ 'Dark Pink Daisy' will produce 160 shoots per plant crown in the second year. Each shoot has as many as 3.7 lateral branches if the apical meristems are removed; mean length of internodes is 1.3 cm.

Simple leaf division and leaf blade shape of ovate to obovate with a narrow region extending toward the base of each leaflet (Harris and Harris, 1994) characterizes Mammoth™ 'Dark Pink Daisy' (Fig. 4; Anderson, 2008). The leaf base is cuneate with a mucronate leaf apex with leaf margins that are incised (*Morus* or mulberry-like incision) to a depth of 1 cm. Leaf venation has coloration of RHS 147C on the glabrous upper (adaxial) surface and RHS 138C on the lower (abaxial) slightly pubescent side (Fig. 4). An alternate leaf phyllotaxy occurs (one leaf/node) with a sessile attachment to the stem. There are 18.25 leaves (nodes) per stem (= long-day leaf number) initiated before the terminal flower bud. Leaf coloration is RHS 137A and RHS 137C on the adaxial and abaxial sides of the young foliage and changing to RHS 137B and RHS 138B, respectively, on the mature foliage. Fully expanded leaf size, on average, is 5.5 cm × 2.9 cm (length × width).

Mammoth™ 'Dark Pink Daisy' capitulate inflorescences (hence referred to as "flowers") are composite inflorescences, as a member of the Asteraceae (syn. Compositae), consisting of ray (petal; gynoeceous) and disk (hermaphroditic; perfect) florets. A second-year plant may produce as many as 6080 flowers on average based on actual counts (Anderson, 2008). Flower buds are flattened, globose in shape with an average depth of 7.4 mm and 5 mm diameter with a color of RHS 138C and involucre bract or phyllary stripes (RHS 138A). Involucre bracts are crenulate, glabrous on the surface, 2 to 4 mm × less than 1 mm (length × width) with a color of RHS 137B. On average, mature flowers at anthesis have a depth of 1.4 cm and a total diameter of 6.35 cm of which 1.3 cm is the disk diameter (Fig. 5).

Peduncles of Mammoth™ 'Dark Pink Daisy' are strongly held at an angle of 55° to the stem and have an hirsute texture with an RHS 144D color rating (Anderson, 2008). The first and fourth peduncles average 11 cm and 15.25 cm (length), respectively, with coloration of RHS 144A.

The perfect, carpellate disk florets of Mammoth™ 'Dark Pink Daisy' are tubular in shape with toothed tips produced with an average of 158 ovules/floret (Anderson, 2008). Anther coloration is RHS 16A with the moderately abundant trinucleate pollen colored RHS 13A. At the culmination of embryogenesis (mature seeds), each achene (indehiscent fruit), lacking pappi (awns or bristles), is a compressed oval shape with pointed ends, ≈2 to 5 mm × 1 to 2 mm

Fig. 4. Adaxial (above) and abaxial (below) leaf profiles of MN Sel'n. 01-127-1, Mammoth™ 'Dark Pink Daisy'. Arrow denotes the fine extension of the leaf to the base of the petiole. Bar = 1 cm.

Fig. 5. Close-up of Mammoth™ 'Dark Pink Daisy' composite flowers (inflorescences). Bar = 3 cm. Photo credit: Dave Hansen, Minnesota Agricultural Experiment Station.

(length × width). The outer surfaces are ridged and RHS 200D in color.

Each individual flower possesses a mean of 65 carpellate ray florets (petals), which are arranged in double whorls (duplex or two rows of petals). Flower petals are spatulate in shape and are held horizontal to upright from the stem at an angle of 45° (Anderson, 2008). Flower petals of Mammoth™ 'Dark Pink Daisy' average 2.74 cm × 4.6 mm (length × width). All flower petals are tolerant of frosts without damage. Petal apices and bases are acute and cuneate, respectively, with entire margins (Fig. 4). All petals are glabrous on both the adaxial and abaxial surfaces (Fig. 4; Anderson, 2008). When petals are opening and showing color, the adaxial surfaces are RHS 70B, whereas the abaxial are RHS 75A along with an RHS 70B inner stripe of the leaf vein. When fully open, flower petals are

RHS 76C on both the adaxial and abaxial surfaces with the inner stripe changing to RHS 76B (Table 1). As the flower petals senesce, the adaxial and abaxial surfaces change to RHS 76B and the inner stripe to RHS 76A.

Performance

Mammoth™ 'Dark Pink Daisy' in containers, landscapes, or as field-grown plants at first has a semiprostrate phenotype in Year 1 (Fig. 2), whereas in Year 2 and thereafter the cultivar maintains a tight cushion and shrub plant habit (Fig. 3). Characteristic of the Mammoth™ series (Anderson et al., 2004, 2008, 2012a, 2012b), Mammoth™ 'Dark Pink Daisy' has extreme heterosis after two seasons of growth and onward with unclipped/unpinched shrubs growing to 62 cm × 133 cm (height × width; Anderson, 2008).

'Cecilia' (a nonpatented cultivar) was chosen as the comparison in this study because it has the same flower color and a cushion habit; this could not be compared for second-year growth with Mammoth™ 'Dark Pink Daisy' as 'Cecilia', like most garden chrysanthemums cultivars, and is not winter hardy in USDA Z3-4. Side-by-side growth of Mammoth™ 'Dark Pink Daisy' and its comparison, 'Cecilia', demonstrated slight differences in plant shape for Year 1 with the former being semiprostrate changing to a cushion in Year 2, which matches 'Cecilia' in Year 1 (Table 1). The plant height of 'Cecilia' is 0.508 m (Year 1), nearly two times that of Mammoth™ 'Dark Pink Daisy'. However, in Year 2 Mammoth™ 'Dark Pink Daisy' attains a height of 1.33 m, whereas 'Cecilia' did not overwinter (Table 1). Both cultivars have duplex flowers, although 'Cecilia' may occasionally become triplex with three rows of petals. Ray floret coloration of both petal surfaces is RHS 76 for both cultivars with Mammoth™ 'Dark Pink Daisy' being solidly RHS 76C, whereas 'Cecilia' sports RHS 76D color.

Mammoth™ 'Dark Pink Daisy' flowers 1 week earlier (6-week short-day response group) than 'Cecilia' (7-week short-day response group) under short-day conditions (Table 2). As a result of its early-season flowering, Mammoth™ 'Dark Pink Daisy' commences flowering from approximately Week 30 at Waseca, MN (USDA Z4b) to Week 33 in Grand Rapids, MN (USDA Z3b) (Anderson, 2008). As a result of its frost tolerance, the flowering season of Mammoth™ 'Dark Pink Daisy' in USDA Z4b may last as long as 10 weeks (through Week 40) if the first freeze is late in the season.

Snow cover is required throughout the winter in northern latitudes for winter survival of Mammoth™ 'Dark Pink Daisy', similar to all other winter-hardy Mammoth™ cultivars (Anderson et al., 2012a, 2012b). In the absence of snow cover, winter survival can be enhanced by a soil surface mulch (Anderson et al., 2012b). Garden performance and winterhardiness were determined at multiple locations [seven sites; 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)] and years (2003–08) (Table 2), although Mammoth™ 'Dark Pink Daisy' was not planted at each site every year. Field trials at all locations were done in open fields or garden plots without protective mulch or covering. Mean percent winter survival ranged from 0.0% (2005, Institute, WV) to 100% (2004, Grand Rapids, MN; 2005, Morris, MN, 2007–08, Waseca, MN) with an overall grand arithmetic mean of 72% for the tested years and locations (Table 2). The lowest annual arithmetic mean of 50% was in 2005; the highest was 86.7% in 2004 (Table 2).

Geometric means were calculated for comparative trends in winter survival with arithmetic means over multiple years and locations for these trials, because the former measure means survival ratings (%), determining 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 calculated as:

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

with n representing the number of replications at each ly site. With garden chrysanthemums, winterhardiness (percent survivorship) has classically been expressed with arithmetic means (where values are added rather than multiplied). Geometric means were first used by Anderson et al. (2012b) to express winterhardiness in garden chrysanthemums and, later, by Anderson et al. (2014) as a more accurate gauge of winter survival. Annual geometric means (G_{ly}) for years and locations ranged from 44.7% (2008) to 85.73% (2004), a year with inadequate snow cover (Table 2); all G_{ly} were lower than the corresponding

arithmetic means. G_{ly} could not be calculated in 2005 because it contained 0.0% winter survival (Table 2); G_{ly} includes only positive numbers greater than zero (Ouellet, 1976). In 2003, neither arithmetic means nor G_{ly} were calculated 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™ ‘Dark Pink Daisy’ because, again, data included zeroes. One occurrence of 0.0% winter survival limited the use of G_{ly} in this year (2005; Table 2). The grand arithmetic mean was 72.0% for all years (Table 2). Winter survival in lower latitudes (data not shown) demonstrated that Mammoth™ ‘Dark Pink Daisy’ also survives to USDA 9 (Southeast)/Zone 10 (West). Thus, the complete winterhardiness range of Mammoth™ ‘Dark Pink Daisy’ is USDA Z3b to Z9 (Southeast)/Zone 10 (West) (Anderson, 2008; Table 2).

Propagation and Production

Commercial propagation of Mammoth™ ‘Dark Pink Daisy’ is accomplished using certified, virus-free stock plants. Asexual propagation is used to ensure the morphological traits in clonal ramets are firmly fixed each year. Mammoth™ ‘Dark Pink Daisy’

vegetative clonal ramets are propagated through herbaceous stem tip cuttings that root in ≈ 1 week under intermittent mist or fog systems after dipping the basipetal cut ends with 1000 ppm IBA in 50% EtOH (Anderson et al., 2008, 2012a, 2012b, 2014). Rooted cuttings are programmed to flower by potting in a high-porosity soilless medium followed by 3 to 4 weeks of a long-day photoperiod (0800 to 1600 HR + 2200 to 0200 HR night interruption lighting) at 18.5/22.0 °C day/night for vegetative growth (Dole and Wilkins, 2005). These conditions are followed with 6 weeks of short-day photoperiods [8 h (0800 to 1600 HR); black cloth pulled closed at 1600 HR and opened at 0800 HR] at 18.5/22.0 °C day/night with 1361 g per 30.48 m² of 5N–20P–20K preplant fertilizer or 300 ppm N 20N–10P–20K weekly liquid feed based on weekly soil tests and monthly fungicide drenches (Langevin, 1992). To maximize summer growth potential of Mammoth™ ‘Dark Pink Daisy’ in containers or direct-transplanted, full sun is required along with high fertilization and irrigation levels (Anderson, 2006; Anderson et al., 2004, 2008, 2012a, 2012b; Langevin, 1992; Widmer, 1980). All Mammoth™ cultivars are ‘heavy’ feeders

(Anderson et al., 2004). Plants will display the cushion and shrub habit in Year 2 onward (Fig. 3).

Use

Mammoth™ ‘Dark Pink Daisy’ is a winter-hardy herbaceous perennial, garden chrysanthemum shrub that attracts butterflies. Each Mammoth™ cultivar has flower petal frost tolerance and standard garden chrysanthemum plant dimensions in the first year (Anderson et al., 2008; Langevin, 1992), but achieve shrub status after two seasons of growth and thereafter (Anderson et al., 2004, 2008, 2012a, 2012b). Mammoth™ ‘Dark Pink Daisy’ is low maintenance and does not require pinching before 4 July to induce lateral branching and enhanced plant dimensions (Langevin, 1992; Widmer, 1980). When growing individual specimens of Mammoth™ ‘Dark Pink Daisy’, each plant should be spaced 1 m or greater on center (OC). For a flowering hedge in the second or subsequent years, space Mammoth™ ‘Dark Pink Daisy’ plants 0.3 to 0.6 m OC.

Mammoth™ ‘Dark Pink Daisy’ is a facultative short-day plant (Anderson, 2008) and may be produced for Mother’s Day spring bedding plant sales in packs or liners for subsequent direct transplanting in gardens, containers, or fields for growth and fall flowering (Figs. 2 and 3). Mammoth™ ‘Dark Pink Daisy’ may also be grown in “mum pans” outdoors for fall sales (Langevin, 1992).

Availability

Chrysanthemum ×hybridum Mammoth™ ‘Dark Pink Daisy’ (U.S. Plant Patent 19,795) is available as certified, unrooted, or rooted cuttings from Ball Seed Company (622 Town Road, W. Chicago, IL, 60185; <www.ballseed.com>) under the Mammoth™ brand. European distribution rights are currently under negotiation.

Table 1. Comparative plant characteristics of *Chrysanthemum ×hybrida* Mammoth™ ‘Dark Pink Daisy’ grown with *C. ×grandiflora* ‘Cecilia’ (not patented) (Anderson, 2008).^z

Plant characteristic	Mammoth™ ‘Dark Pink Daisy’	‘Cecilia’
Plant shape	Semi-prostrate (Year 1) to cushion (Year 2)	Cushion
Plant height, Year 1	0.27 m	0.508 m
Plant height, Year 2	1.33 m	— ^y
Flowering response group		
No. of weeks of short days	6	7
Flower type	Duplex (double whorl)	Duplex to triplex
Flower diameter	6.35 cm	5.75 cm
Ray florets (mature), color		
Adaxial surface	RHS 76C	RHS 76D
Abaxial surface	RHS 76C	RHS 76D

^zQuantitative traits are mean values based on 10 replications.

^yPlants did not survive the winter in USDA Z3b to 4b.

RHS = Royal Horticultural Society.

Table 2. Test sites, geographic locations, U.S. Department of Agriculture (USDA) plant hardiness zones, and mean percent winter survival of Mammoth™ ‘Dark Pink Daisy’ (MN. Sel’n. No. 01-127-1) over multiple trial locations in Minnesota, WI, and West Virginia.^z

Test sites	Latitude	Longitude	USDA hardiness zone ^y	Percent winter survival over years					
				2003	2004	2005	2006	2007	2008
Grand Rapids, MN	47.24739° N	93.54444° W	3b		100.0		70.0		
Lamberton, MN	44.23111° N	95.26389° W	4b					40.0 ^x	—
Morris, MN	45.62820° N	95.88908° W	3b/4a	—		100.0	70.0	80.0	—
St. Paul, MN	44.98776° N	93.13700° W	4a	92.3	70.0				20.0 ^x
Waseca, MN	43.90669° N	93.43338° W	4b	—	90.0			100.0	100.0
Verona, WI	43.06048° N	89.52742° W	5a	—					
Institute, WV	38.41981° N	81.8339° W	6a			0.00 ^x	70.0		
Annual geometric means (grand mean = — ^w)	—	—	—	N/A ^v	85.73	— ^w	70.0	68.4	44.7
Annual arithmetic means (grand mean = 72.0)	—	—	—	N/A ^v	86.7	50.0	70.0	73.3	60.0

^zData were collected in the spring (April to May) of the years listed. When winters had adequate snow cover, years are noted in bold. There were n = 10 replications (clonal ramets) in each site each year (except for 2008, which had n = 5 at all tested sites); blanks denote the genotype was not planted at this location during that specific year.

^yLow air temperature ranges: Zone 3b (–34.4 to –37.2 °C), 4a (–31.7 to –34.4 °C), and 4b (–28.9 to –31.7 °C) (<<http://www.usna.usda.gov/Hardzone/hzm-nm1.html>>).

^xLittle snow during this winter, coupled with a lack of mulch and dry conditions, resulted in higher mortality.

^wGeometric mean could not be calculated as data includes a non-positive number, i.e., zero.

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

Literature Cited

- Anderson, N. 2004. Breeding flower seed crops, p. 53–86. In: McDonald, M. and F. Kwong (eds.). Flower seeds. CABI, Oxfordshire, England.
- Anderson, N.O. 2006. Chrysanthemum. *Dendranthema* × *grandiflora* Tzvelv, p. 389–437. In: Anderson, N.O. (ed.). Flower breeding & genetics: Issues, challenges, and opportunities for the 21st century. Springer, Dordrecht, The Netherlands.
- Anderson, N.O. 2008. Chrysanthemum plant named ‘01-127-1’. U.S. Plant Patent No. 19,795. U.S. Patent Office, Washington, DC.
- Anderson, N.O., P. Ascher, E. Gesick, L. Klossner, N. Eash, V. Fritz, J. Hebel, S. Poppe, J. Reith-Rozelle, R. Wagner, S. Jacobson, D. Wildung, and P. Johnson. 2008. Winter hardy Mammoth™ series garden chrysanthemums ‘Red Daisy’, ‘White Daisy’, and ‘Coral Daisy’ sporting a shrub plant habit. HortScience 43:648–654.
- Anderson, N.O. and E. Gesick. 2003. Container production of prostrate garden chrysanthemums. HortScience 38:1344–1348.
- Anderson, N.O. and E. Gesick. 2004. Phenotypic markers for selection of winter hardy garden chrysanthemum (*Dendranthema* × *grandiflora* Tzvelv.) genotypes. Sci. Hort. 101:153–167.
- Anderson, N.O., E. Gesick, P.D. Ascher, S. Poppe, S. Yao, D. Wildung, P. Johnson, V. Fritz, C. Rohwer, L. Klossner, N. Eash, B.E. Liedl, and J. Reith-Rozelle. 2012a. Mammoth™ ‘Twilight Pink Daisy’ garden chrysanthemum. HortScience 47:1–5.
- Anderson, N.O., E. Gesick, V. Fritz, C. Rohwer, S. Yao, P. Johnson, B.E. Liedl, L. Klossner, N. Eash, and J. Reith-Rozelle. 2014. Mammoth™ series garden chrysanthemum ‘Lavender Daisy’. HortScience In Press.
- Anderson, N.O., S. Poppe, P.D. Ascher, E. Gesick, S. Yao, D. Wildung, P. Johnson, V. Fritz, J. Hebel, L. Klossner, N. Eash, B.E. Liedl, and J. Reith-Rozelle. 2012b. Mammoth™ ‘Yellow Quill’ garden chrysanthemum. HortScience 47:285–288.
- Anderson, N.O., S. Poppe, E. Gesick, and P. Ascher. 2004. Chrysanthemum plant named ‘MN98-M91-1’. US Plant Patent 15,027. U.S. Plant Patent Office, Washington, DC.
- Dole, J. and H.F. Wilkins. 2005. Floriculture: Principles and species. 2nd Ed. Prentice Hall, Upper Saddle River, NJ.
- Harris, J.G. and M.W. Harris. 1994. Plant identification terminology: An illustrated glossary. Spring Lake Publishing, Spring Lake, UT.
- Kim, D.-C. and N.O. Anderson. 2006. Comparative analysis of laboratory freezing methods to establish cold tolerance of detached rhizomes and intact crowns in garden chrysanthemums. Sci. Hort. 109:345–352.
- Langevin, D. 1992. The growing and marketing of fall mums: How you can turn your backyard into...A money-making, growing machine! Annedawn Publishing, Norton, MA.
- Ouellet, C.E. 1976. Winter hardiness and survival of forage crops in Canada. Can. J. Plant Sci. 56:679–689.
- Royal Horticultural Society. 2007. RHS colour chart. The Royal Horticultural Society, London, UK.
- U.S. Dept. of Agriculture, National Agricultural Statistics Service. 2013. Floriculture crops, 2012 summary. Publication No. SP CR6-1 (13). 14 July 2014. <<http://usda01.library.cornell.edu/usda/current/FlorCrop/FlorCrop-04-25-2013.pdf>>.
- Widmer, R.E. 1978. Chrysanthemum named Mingopher. U.S. Plant Patent, No. 4327. U.S. Patent Office, Washington, DC.
- Widmer, R.E. 1980. Garden chrysanthemums. Horticulture Fact Sheet No. 38. 2nd Ed. University of Minnesota, Agricultural Extension Service, St. Paul, MN.