Chrysanthemum ×hybridum MN 98-89-7 Shrub Garden Chrysanthemum

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Abstract. A new garden chrysanthemum with a shrub plant habit is released as a descendent of a cross involving two hexaploid species: Chrysanthemum weyrichii (Maxim.) Tzvel. (female) × C. ×grandiflorum Tzvel. (male). Chrysanthemum ×hybridum Anderson MN 98-89-7 [U.S. Plant Patent (PP) 14,495] is a vigorously growing shrub chrysanthemum for garden culture, exhibiting extreme hybrid vigor. Single daisy reddish-purple flowers cover the foliage in the fall, numbering >3000 on second-year plants. This selection displays excellent winterhardiness in U.S. Department of Agriculture (USDA) Z3b (–34.4 to –37.2 °C) as well as frost-tolerant flowers. In its second and subsequent years of growth after planting, MN 98-89-7 grows into a fall flowering (August–October), herbaceous shrub ranging in plant height from 61.0 to 91.4 cm with a diameter of 76.2 to 152.4 cm. Its spherical plant shape is achieved naturally with self-pinning, creating a highly manicured appearance; it also attracts honey bees and butterflies as pollinators. MN 98-89-7 is a vegetative product and this unnamed selection is being released for germplasm purposes as well as for potential licensing and naming.

A new garden chrysanthemum with the shrub plant habit has been developed by the public sector University of Minnesota Flower Breeding and Genetics program. The program is well known for introducing trend-setting plant traits (winterhardiness, frost tolerance, butterfly and bee attractants) or habits (upright, cushion, shrub, groundcover) that dominate market share in the United States as well as globally. This program is also the oldest, continuously operating garden chrysanthemum breeding program (Anderson, 2015; Anderson et al., 2001). Since the 1950s, cushion plant habits are the most popular garden types, retaining dominant market share in the United States and the globe (Anderson, 2004, 2006; Anderson and Gesick, 2003, 2004; Anderson et al., 2015; Kim and Anderson, 2006). More recent breeding program innovations include the shrub chrysanthemum that is coupled with the cushion plant habit, e.g., C. ×hybridum ‘Mammoth’™ series (nine cultivars to date). This reigned interest in garden mums, catapulting the garden chrysanthemum market share from the No. 2 or 3 herbaceous perennial (behind Hosta and Hemerocallis, respectively) to No. 1 ranking (Anderson et al., 2015). Garden chrysanthemums, Chrysanthemum ×grandiflorum (=Dendranthema ×grandiflora Tzvel.; =C. ×morifolium Ramat.) and C. ×hybridum, are the No. 1 herbaceous perennial in the top 15 U.S. producing states with a wholesale (w) farm gate value of $123.7 million (M) in 2015 (USDA NASS, 2016) from selling 47.211 M pots (all sizes). These figures are >2.6 greater than No. 2 Hosta at $34.9 M (w) sales (USDA NASS, 2016). For numerous decades, garden chrysanthemum sales have exceeded the sum of florist’s potted [$16.7 M (w)] and pompon cut flower chrysanthemums [$11.5 M (w)] (USDA NASS, 2016) due to their predominantly offshore production. This trend will likely continue since, unlike cut flowers, garden chrysanthemums cannot be imported with a root system and so they are produced onshore.

Origin

The pedigree of MN 98-89-7 (Fig. 1) is the result of a series of outcrosses of hybrid descendants of the original cross in 1989 between two allohexaploid (2n = 6x = 54) species, C. weyrichii (Maxi.) Miyabe ‘Pink Bomb’ (http://davesgarden.com/guides/pf/go/164055/#b) × C. ×grandiflorum ‘Adorn’ (PP 6059) or ‘Crusdaor’ (PP 6531) (Anderson et al., 2008). The resulting hybrid cross, MN 90-287, produced hundreds of viable seed in 1990 and hybrid MN 90-287-326 was selected and hybridized in 1991 as a male parent with MN 89-409-19 as the female inbred parent. This resulted in the hybrid seed of MN 92-321 and the 19th plant in this seed lot (MN 92-321-19) was clonally propagated and allowed to open pollinate in the St. Paul, MN, breeding fields (45°N lat.) during 1997. Open-pollinated seed from this outcross was harvested and identified as MN 98-89. When the seedlings were germinated the following year, the selected ortet (original seedling from which clonal ramets are derived) was the seventh plant in this cross of grow-outs in 1999 by the inventors (Anderson et al., 2004), i.e., MN 98-89-7, and was selected for further evaluations. The original ortet had reddish-purple daisy flowers with an “eye” in the golden center of disc florets; it flowered in the field starting in week 37 during 1998. Clonal ramets from terminal stem cuttings were taken from the ortet and rooted for subsequent trials that began in St. Paul, MN, in 1998 and elsewhere in North America by 2001. The shrub phenotype, a salient feature of MN 98-89-7, occurred in the 1999 field trials and distinguished it from upright and cushion
plant habits of garden chrysanthemums. Hybrid MN 98-89-7 was approved for release in 2001, by the Minnesota Agricultural Experiment Station, Horticultural Variety Release Committee and is now protected by a U.S. PP (14,495; Anderson et al., 2004). This cultivar is taxonomically designated as *Chrysanthemum ×hybridum* Anderson (= *Dendranthema ×hybrida* Anderson) MN 98-89-7.

**Description**

After the selection of the ortet, MN 98-89-7, one-half of the crown was dug from the breeding field (St. Paul, MN; 45°N lat.) in Oct. 1998 (the first year of growth). This crown segment was potted into a peat-based substrate (Sunshine #8/LC8 Professional Growing Mix; Sun Gro Horticulture Inc., Bellevue, WA) and kept at 4 °C for 1000 h (6 weeks; darkness). Subsequently, it was greenhouse forced to prompt vegetative shoots from rhizomes (long days, 0800–1600 hr + 2200–0200 hr night) with supplemental lighting at 150 μmol·m⁻²·sec⁻¹, 400-W high-pressure sodium lamps; 18.5 °C day/18.5 °C night), followed by annual field trials in 2000–08 at various sites in North America for field testing (see Performance).

Detailed botanical description for the U.S. PP filings (Anderson et al., 2004) was derived from clonal ramets flowered in greenhouse conditions, comparable to those used in commercial practice (Langevin, 1992), with 6.5 weeks of short days for flower bud initiation and development ([8 h (0800–1600 hr; 150 μmol·m⁻²·s⁻¹)] supplied by 400-W high-pressure sodium lamps; black cloth pulled closed at 1600 hr and opened at 0800 hr; 22.2 °C day/18.3 °C night). Identification of all colors described herein was derived from the RHS Color Chart (Royal Horticultural Society, 1995) and determined in week 3 (18 Jan. 2001) in St. Paul, MN (45°N lat.); readings were taken between 1300 and 1500 hr under ≈2500 foot candles (500 μmol·m⁻²·s⁻¹) of light.

MN 98-89-7 is a rhizomatous herbaceous perennial and the aboveground vertical stems do not root in situ (Anderson et al., 2004). This selection has a mounded, spherical shape or cushion plant habit after planting in landscapes, field trials, or containers; such a habit is maintained for the entire life of each clonal ramet (Anderson et al., 2004). Similar to the Mammoth™ cultivars after establishment (Year 2 onward), MN 98-89-7 possesses vigorous growth, achieving a shrub plant habit range of 61.0 to 91.4 cm vs. a Year 1 plant height of 45.7 cm (Table 1). Lateral branches (1/node) range in length from 15.2 to 27.9 cm with a stem color of RHS Yellow Green Group 148B (Anderson et al., 2004).

Numbers of leaves/lateral branch in MN 98-89-7 vary from 5 to 20 arranged in alternate phyllotaxy (one leaf/node). The total number of leaves/plant in Year 2 exceeds 3000 (based on actual counts; Anderson et al., 2004). Length × width of fully expanded leaves are 7.2 cm × 5.3 cm, respectively, with rounded tips, truncated side edges, and Mulberry-like incisions on the leaf margins (Fig. 2). Leaf bases are truncate with glaucous leaf textures and petioles averaging 2.7 cm in length (Fig. 2). Young foliage coloration is RHS Green Group 137A and RHS Yellow-Green Group 148B on the adaxial and abaxial surfaces, respectively. A color change to RHS Green Group 139A occurs on adaxial leaf surfaces in mature, fully expanded leaves, while the abaxial leaf coloration remains the same on young and mature foliage. Leaf venation colors vary from RHS Yellow-Green Group 147BC to 147B for adaxial and abaxial leaf surfaces, respectively, while the petioles are RHS Yellow-Green Group 148C (Anderson et al., 2004).

The phyllaries (involucral bracts) at the base of MN 98-89-7 flowers are crenulate with entire margins and a RHS Green Group 138C color (Anderson et al., 2004). Phyllaries range from 0.2 to 0.4 cm in length and are glabrous. The Asteraceae diagnostic trait of composite inflorescences is possessed by MN 98-89-7 with occasionally simplex (single) to predominantly duplex daisy flowers with a small “eye” in the center of the disc florets (Fig. 3). MN 98-89-7 is in the 6.5-week short-day response group (Table 1), producing as

**Table 1. Comparative plant traits of Chrysanthemum ×hybridum MN 98-89-7 (PP 14,495) grown in field trials with C. ×hybridum ‘Emily’ (PP 7754; VandenBerg, 1991) at St. Paul, MN [U.S. Department of Agriculture (USDA) Z4a, Anderson et al., 2004]. Quantitative traits are mean values, based on 10 replications.

| Plant trait                  | MN 98-89-7 | ‘Emily’ |
|------------------------------|------------|---------|
| Plant shape                  | Cushion (mounded, spherical) | Cushion (mounded, spherical) |
| Plant height (cm), Year 1    | 45.7       | 30.5–45.7 |
| Plant height (cm), Year 2    | 61.0–91.4  |         |
| Flowering response group     | No. of weeks of short days | 6.5       |
| Flower type                  | Duplex daisy | 6.0       |
| Flower diameter (cm)         | 5.0        | Decorative |
| Ray floret color             | RHS Red Purple Group 70A | RHS Red Purple Group 69D |
| Abaxial surface              | RHS Red Purple Group 69D, 70D | RHS Red Purple Group 69A |

*Plants did not survive the winter in USDA Z3b-4b.
many as 500 flowers/plant in the Year 1 field trials and increasing to >3000 in Year 2. Flower longevity is temperature dependent. Under normal field conditions during the fall season, frost-tolerant flowers will typically last ≈2–4 weeks. Flowering commences (first flower date) outdoors under natural daylengths during weeks 31–38 (mean = week 37) and reaches 100% flowering in weeks 39–40 (mean = week 39.7), depending on year, location, age of plants (first or second year), and occurrence of the first freeze.

Each composite inflorescence of ray and disc florets averages 5.2 cm in diameter with the mature disc florets comprising 1.4 cm (diameter) and a depth of 0.8 cm (Anderson et al., 2004). The opening flower bud shape is upright and conical with a size of 1.9 cm × 1.0 cm (length × width); the bud coloration is RHS Red-Purple Group 59A. Each inflorescence of MN 98-89-7 averages 25 ray petals (gynoeccious; cuneate at the base) and 144 center disc florets (hermaphrodite, perfect). The ray florets are spatulate shaped with a mean length × width of 2.4 cm × 0.5 cm, respectively. Each ray floret apex is rounded with entire margins, glabrous texture, and positioned horizontally or recurved downward with slight differences referring to the stem axis. Opening ray florets are colored RHS Red-Purple Group 70A and 69D-70D (Table 1). As the ray florets fade due to aging, the petal (on both sides) changes to RHS Red-Purple Group 70C. Perfect, carpellate disc florets are tubular and rounded at the tip. The mean length and width dimensions of each ray floret are 0.6 cm × 0.1 cm. Coloration of immature disc florets is RHS Yellow Green Group 150A, maturing to RHS Yellow Group 3A.

Peduncles of MN 98-89-7 are stiffly held at a 45° angle on the stems with a hisrute texture (Anderson et al., 2004). The first and fourth peduncles average 3.0 and 2.0 cm (length), respectively, both with RHS Green Group 138B coloration. Trinucleate pollen is abundantly produced and colored RHS Yellow Group 4A.

The fruits of MN 98-89-7 are dry, dehiscent achenes from a single locule producing one seed each. Each achene lacks a pappus of awns or bristles and is generally shaped as a half-inflated football oval with pointed ends; the surface texture is ridged. There is an average of 169 ovules/flower as the sum total of ray and disc florets (Anderson et al., 2004). Mature seeds are colored RHS Brown Group 200D and 0.2–0.5 cm (length × width), respectively.

**Performance**

In landscapes or as a field-grown plant, MN 98-89-7 has a cushion phenotype in Year 1 (Table 1; Fig. 3) and, in subsequent years, it achieves a shrub habit while maintaining the cushion phenotype (Year 2 onward). Comparison trials of MN 98-89-7 and ‘Emily’ (PP 7754) showed no difference in the cushion plant habit (Year 1; Table 1) and the mean plant heights overlapped: ‘Emily’ attained a height of 30.5–45.7 cm while MN 98-89-7 was 45.7 cm tall. However, due to the lack of winter survival of ‘Emily’ in USDA Z4a, Year 2 plant height comparisons were not possible. MN 98-89-7 survived, growing to a height of 61.0–91.4 cm. Both cultivars have a similar flowering response, differing by only 3–5 weeks (‘Emily’ is earlier than MN 98-89-7) and flower diameters also overlap (Table 1). However, flower types vary significantly with a duplex daisy type for MN 98-89-7 and a decorative type for ‘Emily’.

The coloration of ray florets also differs between the two genotypes for the adaxial and abaxial surfaces of the petals (Table 1).

The highest levels of winterhardiness in northern latitudes for MN 98-89-7 occur with snow cover, as is the case with other winter-hardy garden chrysanthemums (Anderson et al., 2012a). Without snow cover, soil surface mulch may substitute for additional crown protection (Anderson et al., 2012b). Winter survivorship was determined at five locations in Minnesota [USDA Z3b (Grand Rapids, MN), 3b/4a (Morris, MN), 4a (St. Paul, MN), 4b (Lamberton, MN; Waseca, MN)] and years (2000–08), as well as Verona WI (USDA Z5a) and Institute, WV (USDA Z6a; Table 2), although MN 98-89-7 was not planted and overwintered at each site every year in field trials or garden plots without protective mulch or covering. Mean percent winter survival ranged from 0.0% (2007, Grand Rapids, MN) to 100% (2000 and 2004, Grand Rapids, MN; 2000–01, Morris, MN; 2000, St. Paul, MN; 2001–05 and 2008, Waseca, MN; 2001, Verona, WI) with an overall grand arithmetic mean of 87.1% for the tested years and locations (Table 2). The range of annual arithmetic means was 46.6% in 2007 to 100% in 2000, 2005, and 2008 (Table 2). Occasional low (0.0, 50.0) percent winter survival in 2007 was most likely due to low amounts of snow.
cover in Grand Rapids and Morris, MN, respectively.

Geometric means for winterhardiness in garden chrysanthemums were first employed by Anderson et al. (2012b) as a more accurate gauge than arithmetic means such that no data points dominate the mean (Ouellet, 1976). Geometric means (\(G_n\)) for years and locations ranged from 65.4% (2002) to 100.0% (2000; Table 2); \(G_n\) were consistently lower than corresponding arithmetic means. \(G_n\) could not be calculated in 2007 as there was at least one case of 0.0% winter survival (Table 2) and \(G_n\) must include only positive numbers (Ouellet, 1976). In 2006, the \(G_n\) arithmetic mean could not be calculated since there was only one data point (Table 2). The grand \(G_n\) for all years and locations could not be calculated for MN 98-89-7 due to 0% winterhardiness at one location and year (2007; Table 2). In summary, the winterhardiness level of MN 98-89-7 is USDA Z3b+ (~34.4 to −37.2°C; Table 2).

**Propagation and Production**

Asexual propagation has firmly fixed all morphological traits in the clonal ramets. Herbaceous stem tip cuttings root in 1 week under intermittent mist or fog systems, after basipetal cut ends are dipped into 1000 ppm IBA in 50% EtOH (Anderson et al., 2004). Rooted cuttings are first grown for 3–4 weeks in long-day photoperiods (0800–1600 HR + 22.0 °C night for vegetative growth (Dole and Wilkins, 2005). They can then be programmed to flower for Mother’s Day or fall sales when followed with 6.5 weeks of short-day photoperiods [8 h (0800–1600 HR); black cloth pulled closed at 1600 HR and opened at 0800 HR at 18.5 °C day/22.0 °C night with 1361 g 5N–8.7P–16.6K (5–20–20; Peters Professional, Everris North America and the rest of the world."

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