Chrysanthemum × *grandiflorum* MN Sel'n. 90-275-27 Groundcover Garden *Chrysanthemum*

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Another new garden chrysanthemum phenotype, the groundcover or prostrate plant habit, has been developed by the public sector University of Minnesota, Flower Breeding & Genetics Program. Winterhardiness and flowering before a killing frost were the first traits introduced by the breeding program with 'Duluth' in 1939 (Clark, 1962; University of Minnesota, Minnesota Agricultural Experiment Station, 2014); introduction of winter-hardy cultivars and genotypes has continued unabated ever since. Fall flowering remains a popular trait of all garden chrysanthemum types (Anderson, 2006; Dole and Wilkins, 2005). 'Duluth' has an upright plant habit (cut flower); such cultivars have limited market share due to potential lodging and decreased flower coverage (Anderson, 2006). Later, the cushion

plant habit was first developed in the 1950s–1970s at the University of Minnesota with plant growth in a spherical shape and complete flower coverage during fall flowering (Langevin, 1992; Widmer, 1980). 'Minn' was the first cushion series on the market with 'Minngopher' (PP 4327) the first patented cushion cultivar (Widmer, 1978). Cushion plant habits now retain dominant market share of garden chrysanthemums across the United States and the globe, whereas upright (cut types) are second (Anderson, 2004, 2006; Anderson and Gesick, 2003, 2004; Kim and Anderson, 2006). More recently, the large, expansive "shrub" and cushion plant habit, characteristic of the *Chrysanthemum* × *hybridum* Anderson 'Mammoth™' series (nine cultivars) reignited interest in garden mums, helping to move garden chrysanthemum market share from the no. 2 or 3 herbaceous perennial (behind *Hosta* and *Hemerocallis*) to the no. 1 ranking (Anderson, et al., 2015). Currently, garden chrysanthemums, *Chrysanthemum* × *grandiflorum* Tzvelv. (syn. *Dendranthema* × *grandiflora* Tzvelv.; syn. *Chrysanthemum* × *morifolium* Ramatuelle) and *Chrysanthemum* × *hybridum* Anderson, are the no. 1 herbaceous perennial in the top 15 U.S. producing states with a wholesale farm gate value of \$117.54 M in 2014 (USDA NASS, 2015). For the past several decades in the United States, garden chrysanthemum sales have exceeded the sum of both florist's potted [\$21.767 million (w)] and pompon cut flower chrysanthemums [\$11.497 million (w)] (USDA NASS, 2015).

The groundcover habit, exemplified by MN Sel'n. 90-275-27, is a genetically controlled, stable trait without the need for plant growth regulator or other chemical applications or hand manipulation to achieve the plant habit. The groundcover phenotype is characterized as horizontal growth of the lateral branches, creating a groundcover, wave, or prostrate growth form. In typical garden chrysanthemums, plant height:width follow a 1:1 ratio for cushion (hemispherical) types. In standard or upright garden chrysanthemums used as cut flowers (flowering only at the terminal branches), the height:width ratios = 1.5–2:1. Groundcover types exhibit height:width ratios of 1:3, 1:4, or 1:6. Groundcover MN Sel'n. 90-275-27 has a mean height:width ratio of 1:3.7, although it typically ranges from 1:1.7 to 1:3.2 or, in rare cases, 1:15.4 (Table 1). Groundcover chrysanthemums have lateral branches that grow horizontally along the soil surface in field and container trials (Anderson and Gesick, 2004; Gesick, 1997) and offer a genetic, rather than cultural, alternative to labor reduction. The effect of this growth creates a plant wider than it is tall. Thus, they differ from the cascade chrysanthemums used in botanic gardens for fall flowering shows, whose cascading effect results from downward vertical growth (negative geotropism) by training and pinching (Alfors, 1977; Bruckhaus, 1975; Miller, 1976). Cascade chrysanthemums are grown as hanging plants in large containers, achieving lengths of 1.8–2.1 m at flowering. Groundcover chrysanthemums may be useful in hanging baskets, rock gardens, large container plantings, and/or as edgings (Anderson and Gesick, 2004; Gesick, 1997). Given the increase in sales of petunias after the release of prostrate 'Wave™' petunias, e.g., \$58.692 million (w) sales in petunia (flats only) for 1994 vs. \$137.056 million (w; flats, potted, hanging baskets) for 2001 (USDA Statistics Board, 1995, 2002), a similar revolution could occur in the garden mum market with groundcover, prostrate, or wave-type cultivars.

We have conducted container and field trials of groundcover chrysanthemums since 1990; creation of hybrid and inbred selections with this plant habit has been a major breeding objective since that time (Anderson and Gesick, 2004). In excess of 30 genotypes with the groundcover habit, covering all flower color classes (yellow, white, purple/lavender, and bronze/red) and many flower types (daisy, duplex, semidouble, double, etc.) are contained within the breeding program.

Origin

Groundcover genotypes trace back to several inbred families and pedigrees within the University of Minnesota chrysanthemum germplasm bank (Anderson and Gesick, 2004; Gesick, 1997). The groundcover plant habit has been noted throughout the history of the breeding program, arising from a variety of pedigrees and parental sources. Several

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Table 1. Flowering date ranges (week no. of first and final flowering), plant dimensions [height (ht) × width (W)], and ht:W (height:width) ratios over three Minnesota locations and years for first and second year plants of groundcover chrysanthemum MN Sel'n. 90-275-27.

Yr	Location	Plant age		Flowering (wk no.)		Plant dimensions		ht:W Ratio
		First yr	Second yr	First	Final	ht (cm)	W (cm)	
2000	Morris, MN	x		38	41	21.6	53.3	1:2.5
2001	Grand Rapids, MN	x		30	— ^z	19.3	49.5	1:2.6
			x	33	—	25.1	62.2	1:2.5
	Morris, MN	x		37	—	5.1	78.7	1:15.4
	Waseca, MN	x		37	—	5.1	78.7	1:15.4
			x	38	—	20.3	71.1	1:3.5
2002	Grand Rapids, MN	x		31	47	34.3	59.9	1:1.7
	Morris, MN	x		36	43	27.9	88.9	1:3.2
2003	Grand Rapids, MN	x		36	—	26.9	63.2	1:2.3
	Morris, MN	x		39	—	24.1	68.6	1:2.8
2004	Morris, MN	x		39	—	24.1	68.6	1:2.8
			x	39	—	40.6	81.3	1:2.0
	Waseca, MN	x		35	45	30.5	91.4	1:3.0
2005	Grand Rapids, MN	x		36	—	28.4	78.2	1:2.75
2006	Waseca, MN		x	32	44	35.6	106.7	1:3.0
2007	Morris, MN	x		36	—	17.8	35.6	1:2.0
	Waseca, MN	x		36	44	22.9	63.5	1:2.8
Mean				36	44	21.6	63.1	1:3.7

^zData not recorded.

species used in the breeding program, including *Chrysanthemum indicum* L., *Chrysanthemum lavandulifolium* (Fischer ex Trautvetter) Makino, and *Chrysanthemum zawadskii* Herbach var. *latilobum* Kitamura (Longley, 1943, 1949, 1950; Teynor, 1990) may have led to the creation of the groundcover plant habit. One wild species, *Chrysanthemum weyrichii* (Maxim.) Miyabe, with the same ploidy level as cultivated chrysanthemums ($2n = 6x = 54$) has a semigroundcover plant habit. There are two cultivars of *C. weyrichii* on the market (Pink Bomb, [http://davesgarden.com/guides/pf/go/164055/no. b.](http://davesgarden.com/guides/pf/go/164055/no. b;); White Bomb, <http://www.perennials.com/plants/chrysanthemum-weyrichii-white-bomb.html>). However, *C. weyrichii* occupies an inconsequential place in the market due to the “wild” phenotype, small plant diameter, insufficient flower cover for commercialization, tendency to form rosettes (obligate cold requirement to flower), disease susceptibility, and reduced plant vigor. Our groundcover forms have the same flower coverage of commercial greenhouse and garden chrysanthemum cultivars, differing only for plant dimensions. They are readily accepted by consumers (Anderson and Gesick, 2003).

Interspecific hexaploid crosses between *C. weyrichii* and cultivated chrysanthemums rarely (<0.1%) produce groundcover types (N.O. Anderson, 1990–2000, unpublished data). Most derived, interspecific progeny from the cross *C. weyrichii* ‘Pink Bomb’ × [*C. ×grandiflorum* ‘Adorn’ (PP 6059) or ‘Crusador’ (PP 6531)] were either nonflowering (rosetted) or have large, shrub-like plant habits characteristic of the ‘MammothTM’ series (Anderson et al., 2008).

MN Sel'n. 90-275-27 (U.S. Plant Patent No. 14,749) is the first groundcover type of winter-hardy garden chrysanthemum. The pedigree of MN Sel'n. 90-275-27 is the result of multiple levels of inbreeding parents and then hybridizing with an unrelated cultivar (Fig. 1). Anderson and Ascher (2000) noted

that Fisher's coefficient of inbreeding (F) was an incomplete disomic or hexasomic mathematical equation to encapsulate all of the allohexaploid genetic factors (Anderson et al., 1992a, 1992b) and inbreeding was thus expressed as “I” to represent the number of selfed, and/or half- or full-sib generations. On both sides of the pedigree, two third-generation selfed inbreds (I = 3,0), MN Sel'ns. 79-Z142-2 × 82-124-3 were full-sib mated to produce inbred MN Sel'n. 86-135-38 (I = 3,1) (Fig. 1). In 1989, this was crossed as the female parent (yellow flowers) with ‘Patriot’ (male parent; PP 3897; Yoder Brothers, Barberton, OH), a cultivar also with yellow flowers, to produce the groundcover selection MN Sel'n. 90-275-27; the selected ortet was the 27th seedling selected in the cross 90-275 grow outs during 1991 by the inventors, Neil Anderson and Peter Ascher, in Saint Paul, MN (Anderson and Ascher, 2004). The 77-AM3 inbred family has been a major source of groundcover types (cf. Anderson and Ascher, 2004). The original ortet plant flowered from weeks 36 to 41 in 1991.

The groundcover phenotype, a salient feature of MN Sel'n. 90-275-27 (Fig. 2), distinguishes it from all other plant habits of garden chrysanthemums (upright, cushion, shrub). Hybrid MN Sel'n. 90-275-27 is now protected by a U.S. Plant Patent (PP 14,729; Anderson and Ascher, 2004) and was approved for release in 2002 by the Minnesota Agricultural Experiment Station, Horticultural Variety Release Committee. This cultivar is taxonomically designated as *C. ×grandiflorum* Tzvelv. MN Sel'n. 90-275-27.

Description

After the ortet, MN Sel'n. 90-275-27, was selected as a groundcover chrysanthemum in Fall 1991 (first year of growth), one-third of its crown was dug from the breeding field (Saint Paul, MN; 45°N lat.). The crown portion was stored at 4 °C for 1000 hr

Fig. 1. Pedigree of *Chrysanthemum ×grandiflorum* MN Sel'n. 90-275-27 (Anderson and Ascher, 2004). The female (seed) parents are listed first, followed by the male (pollen) parent. Asterisk represents the same parent, MN Sel'n. 77-AM3-7 was self-pollinated in two different years: 1978 (producing MN Sel'n. 79-Z142-2) and 1981 (resulting in MN Sel'n. 82-124-3). Thus, MN Sel'n. 79-Z142-2 and 82-124-3 are full-sib inbreds and MN Sel'n. 86-135-38 is the product of their full-sib mating.

Fig. 2. A first year MN Sel'n. 90-275-27 plant displaying the prostrate or groundcover plant habit. Bar = 0.375 m. Photo credit: Neil Anderson.

by 400-W high-pressure sodium lamps + 2200 to 0200 HR night interruption, 150 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{sec}^{-1}$; 18.5 °C day/22.0 °C night).

Clonal ramets of the new selection were first taken via stem cuttings in Saint Paul, MN in Spring 1991 and the characteristics were stable, being true to type and firmly fixed, retained through successive generations of asexual propagation (ramets) during 1992–2000 (Anderson and Ascher, 2004). Stem tip cuttings were dipped in 1000 ppm indole-3-butyric acid (IBA) in 50% ethanol (EtOH), placed in Oasis wedges (Smithers-Oasis, Kent, OH) under intermittent mist at 21 °C day/night (soil). Cuttings rooted (100%) in about ≈ 1 week and were grown in greenhouses (44°59'17.8" N lat., -93°10'51.6" W long.; Saint Paul, MN) for vegetative growth (4 weeks of long days, 0800–1600 HR supplied by 400-W high-pressure sodium lamps + 2200 to 0200 HR night interruption; 18.5 °C day/22.0 °C night), followed by yearly transplanting at various sites in North America for field testing during 2000–08 trials.

Detailed botanical description for the U.S. Plant Patent filings (Anderson and Ascher, 2004) was derived as follows. The Royal Horticultural Society (RHS) Color Chart (RHS, 1995) was used in the identification of colors described herein. The color values were determined on week 3 (18 Jan. 2001) in Saint Paul, MN (44°59'17.8" N lat., -93°10'51.6" W long.); readings were taken between 1300 and 1500 HR under ≈ 2500 foot candles ($500 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$) of light from cool white fluorescent bulbs. The plants were produced from cuttings taken from stock plants, grown under greenhouse conditions comparable to those used in commercial practice (Langevin, 1992). The plants were ≈ 10 weeks old in week 3 of 2001 when the readings were taken. Expression of all phenotypic traits was deemed stable (Anderson and Ascher, 2004).

Herbaceous stem cuttings of MN Sel'n. 90-275-27 root in ≈ 1 week displaying vigorous root growth (Anderson and Ascher, 2004). Stem coloration is RHS Yellow-Green Group 146C with lateral branches (maximum 1/node when pinched or apical dominance is broken) range from 5 to 28 cm in length. The range in plant size recorded on plants grown in field trials over 8 years (2000–07) and three locations was from 5.1 to 40.6 cm height $\times$ 35.6–106.7 cm width (diameter) in first- and second-year-old plants (Table 1). Mean height $\times$ width dimensions for all years and locations was 21.6 cm $\times$ 63.1 cm (Table 1). The average height:width ratio for MN Sel'n. 90-275-27 was 1:3.7 (Table 1). While the lateral branches in this selection are "self-pinching," it is recommended the terminal shoot or meristem is hand pinched before planting to prevent the occurrence of a non-flowering, open center (Fig. 3; Anderson and Ascher, 2004).

MN Sel'n. 90-275-27 produces rhizomes, which are the overwintering form in this herbaceous perennial (Anderson and Gesick, 2004). The aboveground stems, which grow horizontally along the soil surface, do not

root (Anderson and Ascher, 2004). The genetic causes allowing this groundcover genotype to produce both nonrooting stolons and rhizomes are unknown (Anderson and Gesick, 2004)—a unique set of structures for dicotyledons. It is unknown if the Chinese groundcover chrysanthemums (Chen et al., 1995) also have nonrooting stolons and rhizomes.

The leaf size of fully expanded leaves is 8.9 cm $\times$ 6.0 cm (length $\times$ width) in MN Sel'n. 90-275-27 (Anderson and Ascher, 2004). Leaf bases are cuneate with mucronulate leaf apices and glabrous leaf textures with incised mulberry-like incisions on the leaf margins (Fig. 4). Characteristic of the species, alternate leaf phyllotaxy is present (one leaf/node). There are ≈ 20 leaves (nodes)/stem (=long day leaf number) initiated below the terminal flower bud under noninductive long day photoperiods. Coloration of young foliage is RHS Green Group 137C and RHS Greyed-Green Group 191A on the adaxial and abaxial surfaces, respectively. This shifts in color to RHS Green Group 137B and RHS Yellow-Green Group 147B in mature, fully expanded leaves on the adaxial and abaxial surfaces, respectively. Abaxial leaf venation and petioles have identical coloration of RHS Yellow-Green Group 147B, whereas adaxial surface venation is RHS Greyed-Green Group 191A.

Characteristic of the Asteraceae, the MN Sel'n. 90-275-27 double, decorative flowers are composite inflorescences with ≈ 100 –206 ray petals (gynoeceous; spatulate at base) but 0–6 or 7 center disc florets (hermaphroditic, perfect). Second year and older plants produce >100 flowers/plant although the number varies (Anderson and Ascher, 2004). Flower buds are flattened, inverted ball-shaped flower buds with an opening size of 1.1 cm $\times$ 2.2 cm colored RHS Yellow Group 7A. Mature flowers at stigmatic receptivity are 6 cm (diameter) with a depth of 2 cm. Flowering commences outdoors under natural daylengths in MN Sel'n. 90-275-27 during weeks 30–39 (mean = week 36) and ends in weeks 41–47 (mean = week 44; Table 1), depending on year, location, age of plants (first or second year), and occurrence of the first freeze.

All flower petals are frost tolerant without damage; they do, however, exhibit frost damage symptoms after a hard frost of < -2.2 °C (Fig. 5). Flower petals (ray florets) are spatulate shaped, are held upright (center) to reflexed (outer) and glabrous on both adaxial and abaxial surfaces (Anderson and Ascher, 2004). Immature, opening ray florets are RHS Yellow Group 6A and 6B, while changing to RHS Yellow Group 5C and 2C, on the adaxial and abaxial surfaces, respectively, when mature. Occasionally, the ray florets may fade slightly to RHS Yellow Group 2C although this is not distracting. Style color is RHS Yellow-Green Group 154B. Mature seeds are achenes (indehiscent fruit), lacking pappi (awns or bristles), with a compressed oval shape with pointed ends.

Fig. 3. The phenotypic result of not removing the terminal meristem of MN Sel'n. 90-275-27 with a soft pinch before planting, producing a nonflowering center. Bar = 0.375 m. Photo credit: Neil Anderson.

Fig. 4. Adaxial (left) and abaxial (right) leaf profiles of MN Sel'n. 90-275-27. Bar = 1 cm. Photo credit: Neil Anderson.

Fig. 5. Light frost tolerance of flower petals is a salient feature in MN Sel'n. 90-275-27 as illustrated after a hard frost of < -2.2 °C. Bar = 0.375 m. Photo credit: Dave Hansen, Minnesota, Agricultural Experiment Station.

Peduncles of Mn Sel'n. 90-275-27 are held at a 45° angle with intermediate stem strength on the stems with a pubescent texture (Anderson and Ascher, 2004). The first and fourth peduncles average 1.8 and 2.5 cm (length), respectively, colored RHS Yellow-Green Group 144A.

When present (rarely), tubular disc florets of MN Sel'n. 90-275-27 average 0.4 cm $\times$ 0.1 cm, sporting colors of RHS Yellow-Green Group 154A and RHS Green-Yellow Group 1A in immature and mature forms, respectively. The few (0–6 or 7) but perfect, carpellate disk florets of MN Sel'n. 90-275-27 are tubular in shape with toothed tips producing very little trinucleate pollen, which is colored RHS Yellow-Green Group 1A (Anderson and Ascher, 2004).

Performance

MN Sel'n. 90-275-27 in landscapes or as field-grown plants has a groundcover phenotype in Year 1 (Fig. 2) and, thereafter, in all subsequent years (Year 2 onward). Year 1 and 2 plants grow to a height of 7.5 and 15.25 cm, respectively (Anderson, unpublished data). Chinese groundcover or "creeping" chrysanthemums reach a greater height (20–30 cm) in Year 1 field-grown plants (Chen et al., 1995). In contrast, Year 1 container growth dimensions of MN Sel'n. 90-275-27 average 27.8 cm × 44.0 cm (height × width; Anderson and Gesick, 2004). MN Sel'n. 90-275-27 grows taller in containers than first- or second-year plants the field due to the effect of container rims, which can increase plant height. Anderson and Gesick (2004) observed horizontal growing stems were predominantly forced upward when they reach container rims if there is a 2.5 cm headspace. After vertically growing stems exceed the rim of the container, a varying number of nodes were grown until each stem resumed growing horizontally. In occasional instances, when stems were forced geotropically downward they never rooted (unlike rhizomes).

Comparison trials of MN Sel'n. 90-275-27 and 'Lisa' (PP 8992) showed major differences in plant habit of Year 1 with the former being a groundcover (prostrate) and the latter with a cushion (mounded, spherical) shape (Table 2). In Year 1 of the trials, mean plant height of 'Lisa' was 30.48–45.72 cm

(based on $n = 10$ replications), 4x to 6x that of MN Sel'n. 90-275-27 (7.62 cm). In Year 2, 'Lisa' had died from lack of winterhardiness in USDA Z4a, MN Sel'n. 90-275-27 reached a height of ≈15 cm (Table 2). Both cultivars have decorative double flowers and only the abaxial petal surfaces differ slightly in coloration. While both 'Lisa' and MN Sel'n. 90-275-27 have a 7-week short-day flowering response group in greenhouse production, in outdoor container trials under natural daylengths at 45°N lat., it takes MN Sel'n. 90-275-27 84.5 d (12 weeks) and 103 d (14 weeks) to reach first flower and 100% flowering, respectively (Anderson and Gesick, 2004). Because of its frost tolerance, the flowering season of MN Sel'n. 90-275-27 in USDA Z4b occurs until the first freeze.

Maximal winterhardiness of MN Sel'n. 90-275-27 in northern latitudes occurs with snow cover similar to other winter-hardy garden chrysanthemums (Anderson et al., 2012a, 2014, 2015). Without snow cover, soil surface mulch can substitute (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), and 4b (Lamberton, MN; Waseca, MN)] and years (2000–08; Table 3), although MN Sel'n. 90-275-27 was not at each site every year. Field trials in fields or garden plots were without protective mulch or covering. Mean % winter survival ranged from 0.0% (2008, Saint Paul,

MN) to 100% (2000, 2001, 2003, 2004, and 2007 in Grand Rapids, MN; 2001 and 2008, Morris, MN; 2002 and 2008, Waseca, MN) with an overall grand arithmetic mean of 69% for the tested years and locations (Table 3). The range of annual arithmetic means was 53% in 2000 to 93% in 2007 (Table 3). Percent winter survival in Saint Paul, MN was consistently low in all test years, most likely due to low amounts of snow cover; colder sites (e.g., Grand Rapids, MN) had increased snow pack that resulted in higher rates of overwintering.

Geometric means for winterhardiness in garden chrysanthemums were first employed by Anderson et al. (2012b) as a more accurate gauge than arithmetic means so that no data dominate the mean (Ouellet, 1976). Geometric means (G) for winter survival at l (locations) in y (years) formula are calculated as:

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

where n representing the number of replications at each ly site. Annual geometric means (G_{ly}) for years and locations ranged from 19.1% (2003) to 92.7% (2007; Table 3); G_{ly} were consistently lower than corresponding arithmetic means. G_{ly} could not be calculated in 2008 as there was one instance of 0.0% winter survival (Table 2); G_{ly} includes only positive numbers >0.0 (Ouellet, 1976). In 2006, neither G_{ly} nor arithmetic means were calculated since there was only one data point (Table 2). The grand G_{ly} for all years and locations could not be calculated for MN Sel'n. 90-275-27 due to a 0% winterhardiness at one location and year. One occurrence of 0.0% winter survival limited the use of G_{ly} in this year (2005; Table 3). In summary, the winterhardiness level of MN Sel'n. 90-275-27 is USDA Z3b (Table 3).

Propagation and Production

The groundcover trait is genetically controlled, allowing for consistent clonal propagation of MN Sel'n. 90-275-27. Plant growth regulator applications, such as B-9 or dazide (daminozide), are not necessary for height control since the terminal and all lateral

Table 2. Comparative plant traits of *Chrysanthemum ×grandiflorum* MN Sel'n. 90-275-27 (PP 14,749) grown in field trials with *C. ×grandiflorum* 'Lisa' (PP 8992) at Saint Paul, MN (USDA Z4a; Anderson and Ascher, 2004). Quantitative traits are mean values, based on 10 replications.

Plant trait	MN Sel'n. 90-275-27	'Lisa'
Plant shape	Groundcover (prostrate)	Cushion (mounded, spherical)
Plant height, Year 1	7.62 cm	30.48–45.72 cm
Plant height, Year 2	15.24 cm	— ^z
Flowering response group		
No. weeks short days	7	7
Flower type	Decorative double	Decorative double
Flower diameter	6.0 cm	6.0–7.0 cm
Ray florets (mature), color		
Adaxial surface	RHS Yellow Group 5B	RHS Yellow Group 5B
Abaxial surface	RHS Yellow Group 5C	RHS Yellow Group 5B

RHS = Royal Horticultural Society.

^zPlants did not survive the winter in USDA Z3b-4b.

Table 3. Test sites, geographic locations, U.S. Department of Agriculture (USDA) plant hardiness zones, and mean % winter survival of MN Sel'n. 90-275-27 over five trial locations in Minnesota.

Test sites	Latitude	Longitude	USDA hardiness zone ^y	% Winter survival over yr ^z								
				2000	2001	2002	2003	2004	2005	2006	2007	2008
Grand Rapids	47.24739°N	93.54444°W	3b	100.0	100.0	50.0	100.0	100.0			100.0	
Lamberton	44.23111°N	95.26389°W	4b			80.0						56.0
Morris	45.62820°N	95.88908°W	3b/4a		100.0		10.0		80.0			100.0
Saint Paul	44.98776°N	93.13700°W	4a	6.0 ^x	17.0 ^x	4.0 ^x	7.0 ^x					0.0 ^x
Waseca	43.90669°N	93.43338°W	4b		70.0	100.0	100.0	80.0	90.0	90.0	86.0	100.0
Annual geometric means (grand mean = — ^w)	—	—	—	24.5	58.7	35.6	19.1	89.4	84.8	N/A ^v	92.7	— ^w
Annual arithmetic means (grand mean = 69.0)	—	—	—	53.0	71.8	58.5	54.2	90.0	85.0	N/A	93.0	64.0

^yData were collected in the spring (April to May) of the years listed. When winters had adequate snow cover at most sites, the years are noted in bold. There were $n = 9$ –10 replications (clonal ramets) in each site each year; blanks denote the genotype was not planted at this location during that specific year.

^zLow 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 winter at this site, coupled with a lack of mulch and dry conditions, resulted in higher mortality.

^vGeometric mean could not be calculated as data includes a nonpositive number, i.e., zero (0).

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

branches grow horizontally. Mechanical manipulations are also unnecessary to induce horizontal growth. Similarly, in field and garden trials, lodging never occurs due to a lack of appreciable height (mean = 21.6 cm; Table 1) in MN Sel'n. 90-275-27.

Cuttings are derived from certified, virus-free stock plants of MN Sel'n. 90-275-27. Asexual propagation firmly fixes morphological traits in clonal ramets. Cuttings are propagated as herbaceous stem tip cuttings that root in ≈ 1 week under intermittent mist or fog systems, after basipetal cut ends are dipped into 1000 ppm IBA in 50% EtOH (Anderson and Ascher, 2004). Rooted cuttings are first grown for 3–4 weeks in long day photoperiods (0800–1600 HR + 2200–0200 HR night interruption lighting) at 18.5 °C day/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 weeks of short-day photoperiod [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/30.48 m² of N using 5N–8.7P–16.6K (5–20–20; Peter’s Professional, Everris Na Inc., Marysville, OH) preplant fertilizer or 300 ppm using 20N–4.4P–16.6K (20–10–20, Peat-Lite Special; The Scotts Co., Marysville, OH) weekly liquid feed (Langevin, 1992). MN Sel'n. 90-275-27 is a facultative short-day plant (Anderson and Ascher, 2004) and may be produced for Mother’s Day spring bedding plant sales in packs or liners for direct planting in gardens, containers or fields for growth and fall flowering (Fig. 2).

Use

MN Sel'n. 90-275-27 is a winter-hardy, groundcover herbaceous perennial with flower petal frost tolerance. It is a low maintenance plant that benefits from pinching before July 4 to induce lateral branching and prevent an open hole in the center during flowering (Langevin, 1992; Widmer, 1980). When growing individual specimens of MN Sel'n. 90-275-27, space each plant 0.3 m on center. Groundcover chrysanthemums will provide a new and unusual use, i.e., groundcovers, rock garden plantings, container use as trailing specimens, border edgings, and as hanging baskets.

Availability

Chrysanthemum $\times$ *grandiflorum* MN Sel'n. 90-275-27 (U.S. Plant Patent 14,749) is available for commercialization. Please contact the primary author to negotiate a Material Transfer Agreement and arrange for unrooted or rooted cuttings for trialing. Exclusive or nonexclusive licensing is available through the Office of

Technology Transfer, University of Minnesota for North America and the rest of the world.

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