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Figure 3 Our route through Texas. The stars indicate collection sites for *Gaura*

replaced by residential area, but we found several plants a couple miles down the road on a hillside above the highway. We stopped there and set up camp, and were almost eaten alive by mosquitoes! So after we had doused ourselves with bug spray we set to work. This time the plants were taller than either of us! I could barely reach the top of the shortest plants. We quickly took our data and collected plant material and seeds because the mosquitoes were still biting and it was getting dark.

We had a very interesting and successful trip. The cuttings were rooted and are growing in the greenhouse now. They were planted in the field last summer to see how well they do in Minnesota. We have set up crosses within the different *G. calcicola* plants which we think are promising, and between the different species and some cultivated *G. lindheimeri* plants already in our breeding program. As mentioned earlier, I am screening the *G. coccinea* populations along with the populations collected in Minnesota and California to determine chromosome numbers and morphological characteristics common to the different ploidy levels.

Trends in Garden Mums- Past, Present, and Future

By David Zlesak

Garden mums (*Dendranthema x grandiflora*), followed by spring flowering bulbs and pumpkins, are the main tools retailers use to draw consumers back to garden centers to boost autumn sales - a time of the year when sales tend to be down between the bedding plant and Christmas seasons. Profit margins, however, are continuing to narrow for garden mums as competition continues between discount retailers and local green industry businesses. Exasperating the issue is the fact that there is little product differentiation, with almost everyone growing the same cultivars supplied by the same major wholesale propagule supplier. Reflecting this situation, Minnesota-grown garden mum sales have experienced ~33% reduction (648,000 to 431,000) in the number of garden mums in >5" pots (typical fall sale container sizes) sold between 2001 and 2002 (USDA, 2003). Some area garden centers have given up growing fall mums or have cut their numbers because they are

merely breaking even.

The University of Minnesota has been a leader in garden mum breeding and development for decades. There is much room for product differentiation and development of premium product lines that can command a higher price. Following are some trends in garden mum plant habit, flowering response, and bloom color and also ideas for growers that want to capitalize on the more unique garden mum traits available and set themselves apart.

Plant Habit

When the University of Minnesota mum breeding program began, there was not yet the great divergence for plant habit that we have today among cut flower (tall upright), potted florist (short plants with generally large flowers), and garden mum (upright cushion) cultivars. In general, the commercial mums available at the program's outset were strongly upright (much like the cut flower mums of

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Figure 1. This mum selection displays the typical cushion plant habit with flowers borne from soil to soil in a perfect hemisphere.

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today) and developed flower buds too late to open reliably in Minnesota. In addition to available cultivars, chrysanthemum species were also utilized as parents and included ones such as *D. weyrichii* and *D. rubellum*.

Early releases from the program were selected to flower early outdoors in Minnesota and were strongly upright. Cultivars such as 'Duluth' (double yellow, 1939) are still in commerce today. A significant transition in garden mum plant habit began in 1950's with the first release of cushion mums ('Minnpink', 1957). Cushion mums form rounded, hemispherical plants with numerous flowers often obscuring the foliage from soil to soil (Figure 1). The floriferous habit and strong color display in the landscape of cushion mums quickly led them to grow in popularity and has changed the public's expectation for garden mums. Almost every garden mum worldwide falls under the cushion habit. The end of the popularity of this plant habit is nowhere in sight.

In 1996 the program released the first cultivar of the "shrub" plant habit called 'Betty Lou' in honor of the woman who helped in their development. These shrub types are currently marketed as My Favorite™. Cultivars with this habit are cushion mums, but have substantial vigor, winter hardiness, and rhizome development. Mature plants of some cultivars routinely attain a couple feet in height and a few feet in width! Variability for flower color and form (daisy, quill...) exists within this series and a current focus of the program is to incorporate additional flower colors and forms on plants possessing this habit. In the future, more compact shrub mums that can fit more easily into the urban landscape will be released.

Although the cushion habit should continue to remain the most popular garden mum plant habit, other habits will begin to grow in popularity. Upright garden mums with larger



Figure 2. 'Mellow Moon', a 1983 University of Minnesota release, is a large-flowered mum (~4") that grows to ~2 feet tall and makes a great cut flower.

flowers and stems suitable for cutting is a plant habit large propagators have generally ignored and would be a great area for niche mum growers to pursue. Many of the program's earlier releases fit this category, and gardeners visiting our fields express a strong interest in these mums (Figure 2). A very different mum plant habit that the University of Minnesota floriculture breeding program is developing and should make available in a few years is prostrate or groundcover mums. Some of these mums grow only a few inches tall but spread over two feet! Prostrates have the potential to make exceptional hanging baskets, containers, and low-growing groundcovers in the landscape.

Flower Initiation and Development

Part of the widespread popularity of garden mums and mums in general is the ease of controlling flowering through photoperiod. Long day (short night) photoperiods promote vegetative growth and short day (long night) photoperiods promote flowering. Growers can manipulate the type of growth produced through photoperiod which aids in mum propagation, timing of flowering, and ultimate size

of the flowering plant. When the mum breeding program at the University of Minnesota began in 1920's, the objective was to develop garden-hardy mums that would flower under our relatively short growing season. Since cultivars on the market did not reliably flower in Minnesota, selection needed to occur for mums that would be able to respond more quickly to short days and have flowers that open sooner.

After generations of intermating diverse germplasm and selecting for early flowering, hybrids were obtained that reliably flowered in September. As the program progressed some hybrids began flowering in August, and now some start flowering at the end of June and July! Through selecting hybrids over the years that flower earlier and earlier, it was discovered that some of these hybrids are day neutral; they flower after reaching a critical size irrespective of photoperiod! Some selections are day neutral for flower bud initiation, flower bud development, or both. 'Snowscape™' (introduced in 1996) is a strongly day-neutral cultivar from the University of Minnesota breeding

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program. Overwintered, mature plants often start flowering the end of June and continue to produce new flowering stems above the spent flowers throughout the season. With the popularity of spring and summer flowering daisy-like plants such as agaranthemum, gerbera, and osteospermum for the spring bedding plant market, day-neutral mums may be a valuable addition to this niche.

Mum flower color

Almost every mum flower color can be attained through various combinations and concentrations of color pigments, with the notable exception of true blue. The flower color that we see in mums is due to a combination of both water soluble (anthocyanins and flavonols) and fat soluble pigments (carotenoids) and the interaction of those pigments with factors such as pH, various copigments, and metal ions. Carotenoids are yellow to orange in color and are located in cell organelles called plastids. Anthocyanins and flavonols are shades of red through purple and creamy white, respectively, and are found in the vacuole of cells. These color pigments are produced in defined areas of the petal. Anthocyanins and flavonols are found solely in the epidermal cells of mum petals (the outermost layer of cells), while carotenoids are located within cells throughout the petal. Carotenoids provide what is commonly referred to as the background color of the petal and can be either yellow (relatively high carotenoid pigment) or white (little to no carotenoid pigment). Anthocyanin and flavonol pigments in the epidermis provide the “overlying” color. If there is little to no anthocyanin pigments, the background color and flavonols will predominate and the flower will either be white or yellow.

Anthocyanins typically produce colors ranging from shades of red



Figure 3. This purple / white bicolor garden mum selection in the University of Minnesota mum breeding program obtained its bicolor effect from its grandparent, ‘Coccarde’, a red / yellow cut flower cultivar.

through purple and in combination with the background color produce the final mum color we see.

Anthocyanins, along with a yellow background, typically produce bronze, peach, and orange-red colored mums, and anthocyanins on a white background typically produce mums in shades of pink, red, and purple. Two popular University of Minnesota cultivars, ‘Centerpiece’ and its sport ‘Peach Centerpiece’, for instance, differ only in their background color. ‘Centerpiece’ has a white background with anthocyanins providing its purple color, while ‘Peach Centerpiece’ has a yellow background and in combination with the same anthocyanins has an overall peach color.

Anthocyanins can be produced in a variable manner across the petal due to environmental factors. For instance, warm temperatures can interfere with anthocyanin pigments and cause them to fade. This can be a significant problem, especially when richly colored red and bronze fall garden mums become pale in color due to being forced into flower under warm production temperatures. Cooler temperatures, however, can enhance anthocyanins. When nights begin dipping into the 50s F at the U of

Minnesota research fields, many of the mum hybrids experience temperature-induced anthocyanin production. We refer to this phenomenon as “purpling” because purple is the color typically produced by this response. With white and yellow mums, purpling is often unattractive because of uneven distribution over the flowers and a dulled, muddy overall appearance to the plant. Purpling can sometimes enhance the overall color, especially for bronze, red, and purple mums. During the selection process we consciously try to select clones that are less prone to environmentally-induced anthocyanin variability so that growers will have a more consistent product.

Spectacular color effects can be found in some cultivars as different sectors of the petal epidermis selectively produce anthocyanin pigment irregardless of environment. Most University of Minnesota mum cultivars, as well as most mum cultivars from private breeding programs, have a solid color throughout the petals. However, a growing trend among cut flower

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mums and potted, florist mums is uniquely patterned, multicolored flowers. Such coloration will soon be widely available in garden mums as well. For instance, there are cut flower and potted florist mums that produce anthocyanin pigment on the lower half of the petal, but not on the outer half. Some cultivars have red petal bases and white tips, red bases and yellow tips, or purple bases and white tips. Within the University of Minnesota mum breeding project, I have been working with this trait and have brought it into our lines from the cut flower mum, 'Coccarde' (Figure 3). Some mums in the breeding program also have the reverse effect with anthocyanins produced at the petal tips. In addition, there are mums in which the upper surface of

the petal contains anthocyanin pigment evenly throughout its length, but the lower surface produces little or none. This effect is particularly attractive on opening buds of double-flowered cultivars. The University of Minnesota release, 'Royal Knight', for instance, has this color pattern with a purple upper surface and white lower surface. In addition, there are mums in which anthocyanins are produced as a bar down the middle of the entire petal length. Greater diversity of colors and color patterns among garden mums will soon be available and can help growers develop unique, higher-value product lines.

Summary

Most Minnesota garden centers strategically offer inexpensive,

colorful garden mums to draw customers in during the fall season and include them in small pots for spring sales. As profit margins narrow for garden mums, in part due to low price points on mums sold by discount retailers, setting oneself apart with attractive and unique product lines that demand a premium price will be critical. Mums that have proven to be Minnesota-hardy, day-neutral, larger flowered, possess stems with lengths suitable for cutting, or have unique color patterns may provide your business with the competitive edge needed for a tightening garden mum market.

United States Department of Agriculture, 2003. Floriculture Crops 2002 Summary, Sp Cr 6-1 (03). <http://usda.mannlib.cornell.edu/report/s/nassr/other/zfc-bb/floran03.pdf>

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