Breeding Maize as an Ornamental Annual Grass

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Ornamental grasses are firmly established as major components in the landscape and textbooks devoted exclusively to them are available (Grounds, 1989; Meyer, 1975). Perennial grasses are commonly used in mixed borders and as specimens, because of their attractive foliage, form, and/or ornamental inflorescences. Many are easily grown and reliably cold-hardy. They come in an assortment of heights, growth habits, and leaf shapes. Leaf color ranges from green [e.g. *Pennisetum alopecuroides* (fountain grass)], blue (e.g., *Festuca glauca* [blue fescue], red or purple (e.g., *Pennisetum setaceum* 'Rubrum' [red fountain grass], yellow (e.g., *Carex elata* 'Aurea' [yellow tufted sedge], brown (e.g., *Carex buchananii*, leather leaf sedge), and variegated (e.g., many *Miscanthus sinensis* [eulalia grass] cultivars and *Phalaris arundinacea* [ribbon grass] cultivars). With few exceptions, perennial grasses must be clonally propagated by division to maintain phenotypic integrity. Although many perennial grasses are quite cold-hardy, the red-leafed ones are not hardy above Zone 5 or 6, eliminating their use for a significant portion of the U.S. population. Some grasses (e.g., *Phalaris* and most bamboos) can be considered quite vegetatively invasive. There is also significant concern about the escape of non-native grasses via wind-blown seed (White et al., 1993).

In comparison to perennial grasses, annual ornamental grasses are not as impressive from a vegetative standpoint and are generally grown for their attractive seed heads which can be dried (sometimes dyed) and used in floral arrangements. Little selection has been done to improve annual grasses by developing cultivars with superior characteristics. Most can be considered species grasses. They include *Lagurus ovatus* (hare's tail), *Coix lacryma-jobi* (job's tears), and *Setaria italica* (foxtail millet).

Zea mays L. (maize) is an annual grass most commonly used as a food, forage, and seed oil crop. To date, its most popular use as an ornamental is its fruit (i.e., "ears") which can possess brightly colored seeds (i.e., kernels) in a variety of colors and patterns (see Vernon, 1997). When dried the ears are hung as an autumn ornamental. The use of maize as an ornamental landscape grass has not been fully exploited. There exist a few "heirloom" types developed decades, if not centuries, ago. A type called *Zea mays var. japonica* with white and green striped leaves is still listed in some seed catalogs. A cultivar called 'Quadricolor' is infrequently still available. We have field tested the plant and found it to possess leaves irregularly striped with cream, yellow and occasionally bright pink stripes, although the leaf surface is mostly green. In my trials, 'Quadricolor' was the type most susceptible to a fungal disease called smut. In addition, it grew over 7 ft tall, a height that limits its use in the home landscape. In the text *Variegated Leaves* (Conder, 1993), a maize cultivar called 'Gracillima Variegata' is pictured. The plant is short, well branched, and has wide white stripes on the leaves. We thoroughly investigated the source of this photograph (taken in England) and was informed that the photograph is decades old and the seed is apparently no longer available. If anyone knows otherwise, please inform me. In addition, Conder (1993) advises that with 'Gracillima Variegata' you

should select the most variegated seedlings as it has been reported that some seedlings never develop white strips and remain dull green. The *Index of Garden Plants* (Griffiths, 1994) also lists a 'Harlequin' maize described as having green and red striped leaves, but we could locate no source for seed. In addition, many of the described plants in the literature appear to be the same plant with different names. Meyer (1975) claims that 'Variegata', Quadricolor' and 'Versicolor' are the same plant.

The lack of cultivated maize cultivars suitable as ornamental grasses inspired me to initiate a program to investigate the potential of maize as an ornamental grass. Maize has several advantages over many other annual grasses. It is a highly adaptable rapidly growing plant that is grown worldwide. It has a tolerance to a number of soil conditions and, being an annual, can be grown in extremely northern climates. Although the seed can be attacked by corn ear worm, the foliage is generally pest free. From a sentimental standpoint, maize holds a significant role in the agricultural heritage of the United States. Thanksgiving Day is a celebration that is largely the result of a gift of corn seed from native Americans to the first European settlers — a gift that allowed their survival through their first winter (Vernon, 1997).

One fact that we have taken advantage of in the breeding program to my knowledge is that, during the assemblage of linkage maps for maize breeding, geneticists used chemical mutagens and other methods to generate hundreds of maize mutants (Neuffer et al., 1997). Although most of these mutants have no agronomic use, they assist geneticists trying to map agronomically important maize traits to specific locations on each of the maize chromosomes. Mutant stocks are available to researchers and are the source of the unique traits that we will describe. Most are nuclear genes, which are transmissible by seed. Some cause variegation that mimics that of periclinal chimeras (pictured in Marcotrigiano, 1997). In addition, there are dwarfs as small as 18 inches at maturity, multi-tillering types, leaf shape variants, and plant architecture mutants. There are leaf color mutants that make foliage either red, yellow, mottled, or brown, and stem color variants that make stems red or white. Table 1 lists some mutants that potentially could be combined to produce many different ornamental maize cultivars.

The positive aspects of breeding maize include the reproductive anatomy of maize, which allows hybridization with relative ease. Maize has imperfect flowers (i.e., individual flowers do not possess male and female organs). The plant is monoecious (i.e., male and female flower on the same plant) with the male flowers on the terminal inflorescence (i.e., the tassel). All male flowers can be removed by manually detasselling the plant. Ear shoots, which develop the female flowers, arise in the leaf axils, well separated from the male flowers. Paper bags can be placed over ear shoots to prevent random pollination and paper bags can be placed over the tassels to collect desired pollen. It is thereby possible to make deliberate crosses even in the presence of wind-blown pollen from undesirable plants. In most lines, one cross can yield about 300 seed. To develop ornamental lines that "breed true" some difficulties must be overcome. Inbreeding depression, which is caused by the necessity of either self-pollinating plants or crossing related plants in order to fix a series of desirable traits, can weaken plants or result in poor seed set. Unrelated background genes can also affect the expression of the genes of interest, sometimes reducing their expression. So, for example, in some stocks, genes that are suppose to make a plant yellow in

Table 1. Mutations in maize with possible use in the development of maize as an ornamental grass.[1]

Trait name	Gene symbol	General phenotypic effect
albescent plant	*al1*	*reduction in chlorophyll*
booster	b1	distribution of anthocyanin pigments
bronze	bz1	yields brown plant when combined with B1 and Pl1
corngrass	cg1	shorter, more tillered, reduced fertility
dwarf	d1 to d10	all mutants are very short plants
delayed flowering	dlf1	delays flowering
iojap striping	ij1	variable white stripes on leaves
japonica striping	j1	white stripes on leaf and sheath but not on seedlings
lax midrib	lxm1	flattened broad flexible midrib making leaves appear limp
liguleless	lg1	*leaves lack ligule and auricle and stand* upright wrapping around the culm
oil yellow	oy1	plant color yellow
piebald	pb1	leaves yellow-green with irregular white crossbands
purple plant	pl1	sunlight-independent purple pigment enhanced when other genes are present
tillered	tlr1	tillers on non-tillered stocks, extra tillers on others
red color	r1	controls kernel and plant coloration by regulating genes responsible for anthocyanin biosynthesis
teopod	tp1,2,3	reduces leaf width, increases tillering, can lead to male-sterility
white sheath	ws3	white leaf sheath and culm

[1]Descriptions modified from Neuffer et al., 1997.

color will make the plant light green instead. In addition, the phenomenon of "paramutation" at the R locus (the R locus causes the expression of red pigment) can permanently stop the expression of the genes responsible for the red pigment in maize. Yet, given these technical difficulties the first 4 years of the breeding program has yielded maize lines with significant ornamental appeal. By combining several mutations into one line, we have created dwarf variegated plants, large variegated plants with deep red stems, intensely red plants with upright habit, dwarf plants with yellow leaves, and many highly tillered plants which, unlike the familiar maize of commerce, produce plants with dozens of shoots rather than one or two. Preliminary results from a local trial garden indicated public excitement over these new maize plants.

Most of the lines that have been developed have not been inbred enough to result in uniform populations. Yet, with a few more years of work it will be possible to release some new cultivars of ornamental maize that will integrate well into informal perennial borders and even formal beds. Truly a-maize-ing.

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