New genetic traits in magnolias

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This article deals with several observations of genetic traits in magnolias that I find rather interesting, some unique to magnolias, and that are useful to hybridizers and others.

Trait One — "Sterile" plants as parents

The most interesting trait to me is the fact that many (or all?) clones of magnolias that are highly sterile as seed parents function very well when used as pollen parents. For example, M. 'Betty,' one of the "Little Girls" (so called because all eight have girls' names), is functionally sterile as a seed parent. It is not known to produce any seeds, either when open pollinated or hand crossed. Similar "sterile" clones have not been used as parents because it was assumed they were completely sterile even as pollen parents. This belief is only half true—they do function with perfection as pollen parents in magnolias.

Continuing with *M.* 'Betty;' it is a cross of *M. kobus* var. *stellata* 'Rosea' with *M. liliiflora* 'Nigra.' The kobus seed parent is a diploid and has 2 sets of chromosomes for a total of 38 chromosomes. The liliiflora pollen parent has 4 sets of chromosomes for a total of 76 chromosomes. Thus *M.* 'Betty' has 3 sets of chromosomes, 1 set contributed from kobus and 2 sets contributed from liliiflora, for a total of 57 chromosomes. Plants with 3 sets of chromosomes are called triploids, which translated means 3 fold. Triploids in most plant species are nearly 100% sterile both as seed parents and pollen parents. Thus, unlike magnolias, they do not function as either seed or pollen parents. For some unknown reason triploid magnolias, on the other hand, function readily as pollen parents. The same thing is true for pentaploids (5 fold sets of chromosomes) such as *M.* 'Elizabeth' or *M.* 'Sundance,' and all other plants with even higher uneven numbers of chromosome sets. As a result, these so-called sterile hybrids in magnolias function as pollen parents in contrast to most other plant species.

The functioning of triploids, pentaploids and similar plants with uneven numbers of chromosome sets results in dramatic effects in their offspring in subsequent generations. This is because the uneven numbers interfere with the subsequent, orderly division of cells involved with the production of egg and pollen cells.

Plants produce pollen and egg cells by means of a special cell division known as meiosis. In meiosis each of the chromosomes divide into two daughter chromosomes. In the next division, the two daughter chromosomes *do not divide*, but entire daughter chromosomes move to opposite poles of the dividing cell, one daughter cell of each pair to each opposite end. The meiotic process breaks down in most species of plants when there are not even numbers of daughter chromosomes, a situation found in triploids for example. This is why triploids in most species are nearly 100% sterile, both as seed parents and pollen parents. Importantly, in magnolias the uneven numbers are not a barrier to the meiotic process and meiosis continues beyond this usual barrier. However, there is no way that uneven numbers of daughter chromosomes can be distributed evenly to both poles of the new cells, and at this point in magnolias the distribution of the daughter chromosomes at each pole of the new cell is at random, a complete departure from the norm. Thus in triploid magnolias the numbers can range from 38 to 76 daughter chromosomes at the two poles. This means that the resulting pollen cells of such triploids can be highly variable in their final number of chromosomes. It follows that the offspring resulting from the recombination of such pollen cells will be extremely variable in their chromosome numbers and hence in their genetic traits. I have plants from the cross of *M.* x *soulangiana* 'Lennei' by *M.* 'Betty' that have huge sized leaves, almost as though 'Betty' acted as a tetraploid with a large number of chromosomes. Plants with such random chromosomes are called aneuploids because they have unbalanced and irregular chromosomes and cannot be classified as diploids, triploids, tetraploids, etc. Such aneuploids are genetically highly variable and produce offspring that are highly variable. Aneuploids are therefore a kind of mixing bowl that can result in entire chromosome deletions, duplications, and other abnormalities. For a hybridizer they provide a great range of different kinds of plants from which to make selections, along with many traits that are entirely new and unexpected. As such they give rise to entirely new hereditary characteristics. The Soulangiana hybrids are mainly aneuploids with chromosome numbers from 76 to 156 (Treseder 1978).

Trait Two—Insect preference

Insect feeding preference is a genetic trait of importance in plant hybridization. Many crop plants have been improved by manipulating insect feeding preference by breeding for high resistance to insect preference. In magnolias there is high resistance to feeding by Japanese beetles. In fact, these beetles almost completely avoid magnolias, even when there are huge populations of these insects.

However, in my plantings leaves of the cultivar *M.* 'Pink Goblet,' a Gresham hybrid, is badly eaten by Japanese beetles (*Popillia japonica* Newman). Great damage has been done consistently over a period of 6–7 years. It is the only clone in a planting to 500 of more trees on which these insects feed. Every year for the past several seasons this one plant is nearly denuded of its leaves. It is evident that although magnolias in general have innate chemical substances that discourage feeding by Japanese beetles, this one cultivar lacks that genetic character. The exact parentage of *M.* 'Pink Goblet' is unknown, so we cannot determine accurately the origin of the undesirable genetic trait. However, I would strongly recommend that hybridizers refrain completely from ever using this cultivar in their hybridizing programs. It would be tragic to have the genes for insect preference propagated widely. Hopefully, this will never happen.

Trait Three—Some unreported effects of polyploidy on magnolias

Many effects of polyploidy on magnolias have been reported (Kehr 1985, 1996). There are some effects that, to my knowledge, are entirely new. Thus, over a period of years I have noted that polypoid plants flower later in the growing season than do the plants with lower chromosome numbers. This characteristic is highly important in areas where frosts kill the flowers of early flowering plants. My plantings are in a frost pocket, and therefore it is essential to develop hybrids that flower late in the season. Polyploid plants fulfill this need. For example, in 1997 the last killing frost occurred on May 21, a date that must be a record in this area. Despite that late date, there were several polyploids that flowered normally. Thus in developing frost-proof magnolias, polyploidy is a very important and desirable characteristic.

A second effect of polyploidy is that the chronological age of flowering is delayed. This effect has no special value and may have just the opposite. I have a progression of related kobus hybrids ranging from diploid (*M.* 'Encore') to tetraploid (*M.* 'Two Stones') to octoploid (*M.* 'Edward A. Kehr'). As ploidy number increases, so does the date of flowering and the age of flowering. In fact *M.* 'Edward A. Kehr' is about 15 feet high and at least 8 years old but has not yet flowered. In contrast, *M.* 'Encore,' the diploid member of this trio, flowers at one year of age from cuttings.

A third effect was reported to me by Karl Flinck based on his 1997 results in his garden in Sweden. According to Karl, the 1997 growing season was exceedingly dry. He observed that it did very little good to water under drought conditions because the air relative humidity was so low that the plants still suffered from the dryness. As a result of the dry soil and the dry air, most of his plants on *M. sieboldii* suffered badly and were either unthrifty or even killed. He noted, however, that plants of the tetraploid sieboldii, *M. sieboldii* 'Genesis' grew very well and were not greatly affected by the severe dry soil and low relative humidity. He attributed the tolerance to the dry conditions to the very thick leaves of 'Genesis' preventing the loss of moisture from that source. The thicker leaves in turn resulted from the plant being a tetraploid.

I have recently named and registered a hexaploid form of sieboldii under the name *M. sieboldii* 'Colossus.' This plant was developed by crossing the tetraploid 'Genesis' with a diploid sieboldii to form hybrids that were triploids and finally treating the triploids with colchicine to produce hexaploids with 6 sets of chromosomes. 'Colossus' produces huge flowers and leaves. In fact, one extra large leaf measured 12 inches long and 6 inches wide. It is very vigorous and produces large quantities of open pollinated seed. One may wonder if this hexaploid is even more drought tolerant than 'Genesis.'

For many years I have sought to explain why so many of the native plants in the Arctic regions are polyploids, because polyploids are not more cold tolerant than the parental diploids. Thus a tetraploid of a given plant species is no more cold tolerant than the diploid of the same species. However, in an Arctic situation where air humidity is extremely low, the thicker leaves of the tetraploids are a critical factor in surviving the damaging low air humidity and thereby have greater survivability. Hence over a period of years the tetraploids gradually replaced the diploid forms with thinner leaves.

Trait Four—Other possible effects of polyploidy

In my plantings are two polyploid plants with unique characteristics. Both have unregistered names as yet. One, provisionally called 'Sleeping Beauty,' is not a beauty at all, but it certainly earns the sleeping part of the name. It remains totally dormant for over 3 weeks after all nearby magnolia plants have flowered and leafed out. In mid to late May it begins growth and leaves are formed. Because of this tardy awakening, it seldom forms full-sized flower buds in the fall. It most likely will never be of any ornamental value because of its tardiness to leaf out and flower normally. It is a polyploid of the cross of *M. cordata* 'Miss Honeybee' and 'Sundance' [*M. acuminata* hybrid × *M. denudata*]. Because of its nature toward dormancy it may best serve in crosses with magnolias such as forms of *M. campbellii* which do not ripen wood sufficiently in the fall to escape winter damage.

The other polyploid plant is a hybrid with the complex parentage of (*M. liliiflora* × *M. cylindrica*) × *M.* 'Pickard's Ruby.' This polyploid plant is very unusual in that it produces flower buds at the base of nearly all its leaves. Consequently, it has flower buds all up and down the branches. It seems to form flower buds before it produces leaf buds. The older flower buds start opening in March and there is a progression of flowers that open all season until the first frost in the fall. This plant has the tentative, but descriptive, name of 'March Till Frost.' The flowers are a deep purple color. The seed cones, which never have seeds in them, stand upright on the branches like candles on a Christmas tree. Although the plant is a polyploid, the polyploidy may have nothing to do with its unusual flowering condition. However, the parent, 'Pickard's Ruby,' being a soulangiana derivative is most probably an aneuploid and, as such, can have unknown chromosome deletions, duplications, *ad infinitum*, as pointed out above.

Trait Five—Chromosome substitution in a hybrid

Magnolia × *wieseneri* (formerly *M.* × *watsonii*) is a superb hybrid with many outstanding characteristics. It has large, beautiful, and highly fragrant flowers. It has one serious fault, however. It cannot be grown in the southeastern part of the United States.

I first saw this hybrid in a garden in Oregon and immediately decided to try to grow it. It is not easy to find plants in most nurseries, but after searching, I found a source and bought plants. These plants became established, but soon afterwards they began to retrogress and died. Another attempt gave the same results. It was eventually concluded that this hybrid could not be grown in the southeastern part of the United States.

The initial solution to that problem seemed to be to repeat the original cross, which was believed to be *M. obovata* [formerly *M. hypoleuca*: The TMS has recently learned that the Committee for Spermatophyta of the International Committee for Botanical Nomenclature has examined the publication of the name M. obovata and considers it validly published. It thus has precedence over the name M. hypoleuca.] crossed with *M. sieboldii*, and then make selections for plants adapted to this climate. The cross was made and a sizable population was grown out. Subsequently, as the plants grew to flowering size, individual plants began to show weakness and many died. They had inherited some kind of weakness from their parental species. Meanwhile the only plant in the garden of *M. obovata* began to show the same symptoms of dieback as found in it's hybrids. This suggested that the problems shown by *M.* x *wieseneri* had their origin in that species which had passed on its genetic traits for lack of adaptability to its offspring.

I already had a flowering plant of *M. tripetala* x *M. obovata* so it was easy to make the modified cross of *M. sieboldii* (seed parent) x [*M. tripetala* x *M. obovata*] (pollen parent). The species, *M. tripetala*, is a native of this area and hence well adapted to the vagaries of the local climate. The guess was that substitution of the tripetala chromosomes might overcome the detrimental genes on the chromosomes of a non-native species.

The seedlings grew well and developed into flowering plants. They were healthy and vigorous. When they flowered, the flower was large, white, and very fragrant. The growth habit, foliage, and habit looked identical to *M.* x *wieseneri*. They had all the characteristics of *M.* x *wieseneri* except they were vigorous in their growth. They remain strong growers and apparently are well adapted to the climate in this area. In brief, the substitution of 50% of the obovata chromosomes with an equal number of tripetala chromosomes resulted in a hybrid with all the fine qualities of the original hybrid but without the bad lack of climatic adaptability. Thus, chromosome substitution corrected the weaknesses inherent in the original hybrid. In summary, the modified wieseneri hybrid will permit the growing of these fine plants in the southeastern United States and probably in other areas where *M.* x *wieseneri* cannot presently be grown.

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