Aglaonema Breeding

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Historically, the origin of *Aglaonema* cultivars has depended upon introduction of species collected in the wild or selection of mutations of commonly grown species observed by collectors or nurserymen. Breeding has played a small role in new cultivar development, although four important commercial cultivars have resulted from hybridization.

Aglaonema 'Silver Queen', 'Silver King', 'Parrot Jungle' and 'Franscher' are hybrids obtained from interspecific crosses (Table 1.). Mr. Nat DeLeon of Miami, Florida developed 'Silver King', 'Fransher' and 'Parrot Jungle' whereas the late Bob McColley of Bamboo Nursery in Orlando, Florida produced 'Silver Queen' (Jerris, 1980). *Aglaonema* 'Silver King' and 'Parrot Jungle' were reported selected from among 13 seedlings produced from a single pollination. It is not known how many seedlings Bob McColley screened before obtaining 'Silver Queen', although it probably was a small number because of the low number of flowers and seeds *Aglaonema* normally produced.

Although these four *Aglaonema* hybrids were developed during the 1960's, little breeding activity has occurred since then and no new hybrids have appeared. *Aglaonema* 'Abidjan' and 'Manila' are two reported hybrids, which have recently become commercial cultivars, but their true origin is not known. They are most likely natural hybrids introduced directly from the wild.

Table 1. The reported parents of four *Aglaonema* hybrids grown commercially in Florida.

Hybrid	Male Parent	Female Parent
'Fransher'	*A. cummutatum* 'Treubii'	*A. marantifolium* 'Tricolor'
'Silver Queen'	*A. commutatum* 'Treubii'	*A. nitidum* 'Curtisii'
'Silver King'	*A. pictum* 'Tricolor'[1]	*A. nitidum* 'Curtisii'
'Parrot Jungle'		

[1]It is doubtful that *Aglaonema pictum* 'Tricolor' is a parent of either 'Silver King' or 'Parrot Jungle'. This is because their leaf shape, growth habit and foliar variegation patterns are not normal for hybrids from such a cross. In addition, we have not been able to obtain seed from crosses of *A. nitidum* 'Curtisii' with *A. pictum* 'Tricolor.' Most likely, *A.* 'Silver King', *A.* 'Silver Queen' and *A.* 'Parrot Jungle' are all from the same cross, (*A. commutatum* 'Treubii' x *A. nitidum* 'Curtisii').

There are several reasons for the lack of breeding activity involving *Aglaonema*. Sterility, differences in chromosome number and sporadic flowering are all barriers to hybridization which are prevalent in the genus. In addition, seeds average 4-6 months to mature following pollination and seedlings require at least one year to reach a size suitable for evaluation and selection. On the other hand, diversity in types of foliar variegation patterns, plant size, leaf shape and size, growth habit and petiole coloration make *Aglaonema* well suited for breeding and genetic research. For these reasons *Aglaonema* was selected for study as part of the foliage

breeding program established at the Central Florida Research and Education Center, Apopka (CFREC-A), Florida in 1977.

Throughout the remainder of this chapter, results from researching various factors pertaining to *Aglaonema* breeding and genetics will be discussed. This will include reviewing techniques necessary to obtain predictable flowering and maximum seed production as well as what to expect from various crosses.

FLOWERING

Initial observations on the flowering habits of *Aglaonema* in the CFREC-A breeding collection during 1977-1980 indicated a sporadic flowering habit, i.e. plants of the same cultivar did not always flower simultaneously when grown under the same environmental conditions. Plants were grown under natural photoperiod in shaded greenhouses or slat houses with at least 75% of the sunlight eliminated by paint or shade cloth at our geographic location of 28 degrees latitude and 81 degrees longitude. Research on *Dieffenbachia* conducted during the same time period led to the discovery that flowers could be induced by treatment with gibberellic acid (Henny, 1983).

Similar studies with gibberellic acid (GA) were then conducted using *A. commutation* 'Treubii'. Uniform plants were given a single thorough foliar spray of GA at 0, 100, 200 or 400 ppm.[2] All plants sprayed with GA had at least one open inflorescence within 148 days after treatment (Table 2.) and there was no significant difference in mean number of days to flower among the 100, 200, and 400 ppm concentration of GA. One of 9 untreated control plants did produce 3 blooms during the same period, but none of the other controls showed any sign of flowering when the experiment was terminated. Plants receiving the 400 mg/liter GA treatment produced an average of 6.7 blooms per stem, which was significantly higher than the 4.7 or 5.3 produced at 100-and 200mg/liter treatments, respectively. Flowers were normal in appearance and produced viable pollen.

Table 2. Effect of a single foliar spray of gibberellic acid (GA) on number of days to flower and number of inflorescences per plant of *Aglaonema commutatum* 'Treubii'.

GA3 concn (ppm)	Average days to first bloom[3]	Average number of inflorescences
0	—	0.3
100	144	4.7
200	143	5.3
300	142	6.7

[3]Days after treatment until first inflorescence opened.

Following the results of this study several other *Aglaonema* species and cultivars were treated with a 250 ppm GA spray for the purposes of future pollination attempts. Within five months after treatment the plants flowered simultaneously and were able to attempt cross pollination for the first time (Fig. 1). This method is now routinely used to induce flowering of *Aglaonema* in the breeding program at CFREC-A.

FLOWER STRUCTURE and POLLINATION METHODS

Aglaonema have a typical aroid inflorescence consisting of a spadix subtended

[2]GA is the active ingredient in ProGibb which is sold as a liquid (3.91% w/w). One ounce of ProGibb per gallon of water produces a solution with 250 ppm GA.

Fig. 1. *Aglaonema* 'Emeralds-on-Ice', previously treated with GA to induce flowering, showing several inflorescences with seeds in various stages of development.

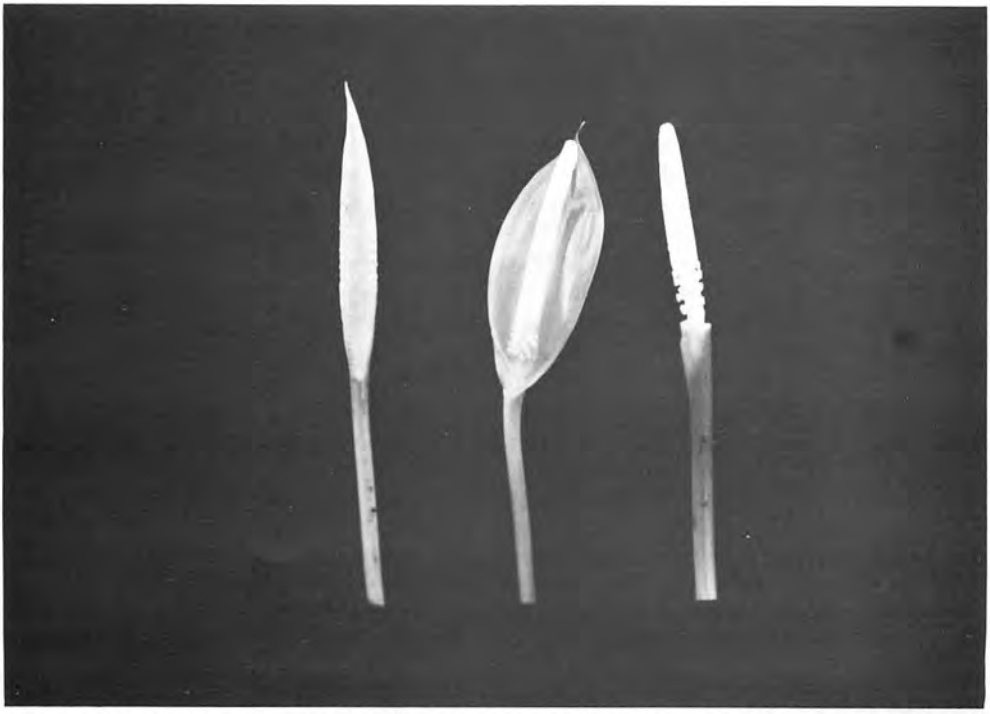

Fig. 2. *Aglaonema modestum* inflorescences: A. bud stage; B. anthesis with spathe unfurled; and C. with spathe removed for easier pollination.

by a spathe. The spadix consists of an upright central axis covered with minute naked flowers. Male (staminate) flowers cover the upper portion of the spadix and female (pistillate) flowers are located the base. Although the basic flower structure is the same for all *Aglaonema* there are some differences in the general shape of the spadix and spathe. The spadix may be relatively short and thick (e.g. *A. pictum* 'Tricolor', *A. rotundum*), long and thin (e.g. *A. modestum*) or long and thick (e.g. *A. nitidum* 'Curtisii'). There are also differences in the numnber of female flowers per spadix among cultivars. *Aglaonema modestum* generally has less than 10 female flowers per spadix among cultivars. *Aglaonema modestum* generally has less than 10 female flowers per spadix (Fig. 2) while *A. nitidum* 'Curtisii' frequently has more than 20; other cultivars normally produce a number within those two extremes.

The spathe remains tightly wrapped around immature inflorescences until the day of flower opening (anthesis). At this time a partial unfurling of the spathe indicates female flower receptivity, although not all spathes open to the same degree. For example, the spathe from *A. modestum* will totally unfurl to expose the entire spadix whereas the spathe from *A. nitidum* 'Curtisii' will open slightly allowing a glimpse at the male portion of the spadix. Cultivars with such a habit must be closely examined to determine the proper time for pollination.

Pollination requires the transfer of pollen from the male portion of a spadix to the stigmatic surface (identified by their golden yellow color) of female flowers. This procedure may be complicated by the fact that *Aglaonema* flowers are dichogamous. Dichogamy means that male and female flowers do not mature at the same time. Female flowers of *Aglaonema* are receptive at the day of anthesis while pollen, produced by male flowers, appears approximately two days later at which time the female flowers are no longer receptive. This mechanism is nature's way of promoting outcrossing. It also means that pollen must be obtained from an inflorescence other than the one to be pollinated. Dichogamy may be an advantage to anyone attempting *Aglaonema* hybridization because it eliminates the need for removal of male flowers to prevent unwanted pollinations. An *Aglaonema* inflorescence need not be pollinated within a few hours of the spathe unfurling to ensure seed set; in fact it may be successfully pollinated anytime during the same day or during the day after opening. Flowers pollinated at 2-days after anthesis, however, are unable to support pollen germination and do not yield seed.

When making a pollination, an artist's small brush is used to pick up pollen and transfer it to the stigmatic survace. The brush will pick up pollen more easily if it is first brushed lightly across the sticky stigmatic surface.

Knowledge of flower structure and how to induce flowering does not guarantee that pollination attempts will result in seed production and our initial attempts at hybridizing *Aglaonema* were largely unsuccessful. Subsequent research investigating factors affecting pollen germination revealed that high relative humidity was essential for optimum pollen germination. In one study *A. crispum* 'Chartreuse Halo', *A. pictum* and *A. commutatum* 'Treubii' inflorescences pollinated and then maintained at 100% relative humidity (RH) for 24 hours showed excellent pollen germination whereas inflorescences pollinated at 50% RH revealed poor germination. Inflorescences pollinated and then exposed for only 4 hours to 50% RH lost viability. Based on this information, newly pollinated inflorescences are always wrapped with moistened paper toweling and enclosed in small plastic bags for 24 hours following pollination (Figure 3). In addition, fresh pollen is collected early in the morning and used immediately or kept at high RH until used later the same day. Using these methods, seed production on *Aglaonama* stock plants increased dra-

matically, and seed set failures are now rare.

Aglaonema seed usually required 4-6 months to mature at which time the seed coats are bright red. The fleshy red seed coat should be removed at harvest and the seed planted before it dries (Henny & Fooshee, 1985). Seeds may be disinfested in 10% Clorox for 10 minutes before planting in small plastic trays in shallow depressions in the germination medium. Each container is enclosed with a plastic bag to maintain the high relative humidity around the seeds. The trays are placed under fluorescent lights which are on 12 hours daily in a growth room held at 80F. Any environment which keeps the seeds warm and moist and provides some light should yield excellent germination. Seeds begin to germinate immediately once planted, and within 8-10 weeks the first leaf may be developed. At this time the plastic cover is removed and seedlings are transferred to the greenhouse. Seedlings are transplanted to larger pots once they have developed 4-5 leaves.

INHERITANCE of FOLIAR VARIEGATION

The diversity in foliar variegation patterns present in *Aglaonema* make it a good subject for genetic research. Initial studies involved analyzing hybrid progenies obtained from self-pollination of *A. commutation* 'Treubii', *A. nitidum* 'Curtissii' and *A. crispum* 'Chartreuse Halo' (Henny, 1983). Data indicated that variegation was dominant to nonvariegation and that each of the three types of patterns was controlled by separate genetic factors (Table 4). Results from crosses of *A. n.* 'Curtisii' and *A. c.* 'Chartreuse Halo' showed that both plants transmitted their variegation patterns equally well when used as the male or female parent (Table 3.). Two types of variegation patterns were observed from this cross. One-half of the seedlings expressed only the 'Chartreuse Halo' pattern while the other half expressed a combination of the 'Chartreuse Halo' patterns and the 'Curtisii' pattern. These results indicated that a) 'Curtisii' was heterozygous for variegation while 'Chartreuse Halo' was homozygous; b) the genetic control of variegation was carried on nuclear chromosomes and not in the cytoplasm; and, c) that the genes for variegation were codominant which allowed expression of two variegation patterns in the same leaf. However, it was still not known if variegation was due to the action of one or several genetic loci.

Table 3. Segregation data for foliar variegation patterns from the reciprocal cross of *A. nitidum* 'Curtisii' and *A. crispum* 'Chartreuse Halo'.

P1 (female) x P2 (male)	Total # of seedlings	*Variegation classes*[4] P1	P2	P1+P2	Ratio
'Chartreuse Halo' x 'Curtisii'	25	14	—	11	1:1
'Curtisii' x 'Chartreuse Halo'	34	—	19	15	1:1

[4]Number of seedlings with each type of foliar variegation pattern whose P. = pattern identical to female parent; P2 = pattern identical to male parent and P1 + P2 = combination of both parental patterns superimposed on the same leaf.

A plant expressing two patterns of variegation was required to determine the number of genetic loci involved in its control. A hybrid (AREC-A #1502) from the cross of *A. tricolor* 'Tricolor' and *A. 'Manila'* was used for this purpose. Hybrid #1502 leaves contained a combination of the faint 'Tricolor' pattern and the bolder 'Manila' pattern. It was self-pollinated and reciprocally crossed to *A. n.* 'Curtisii'. Results from these crosses indicated that the genetic control of foliar variegation

Fig. 3. Newly pollinated *Aglaonema* flower wrapped in wet paper toweling and enclosed in a plastic bag to ensure high relative humidity and good pollen germination.

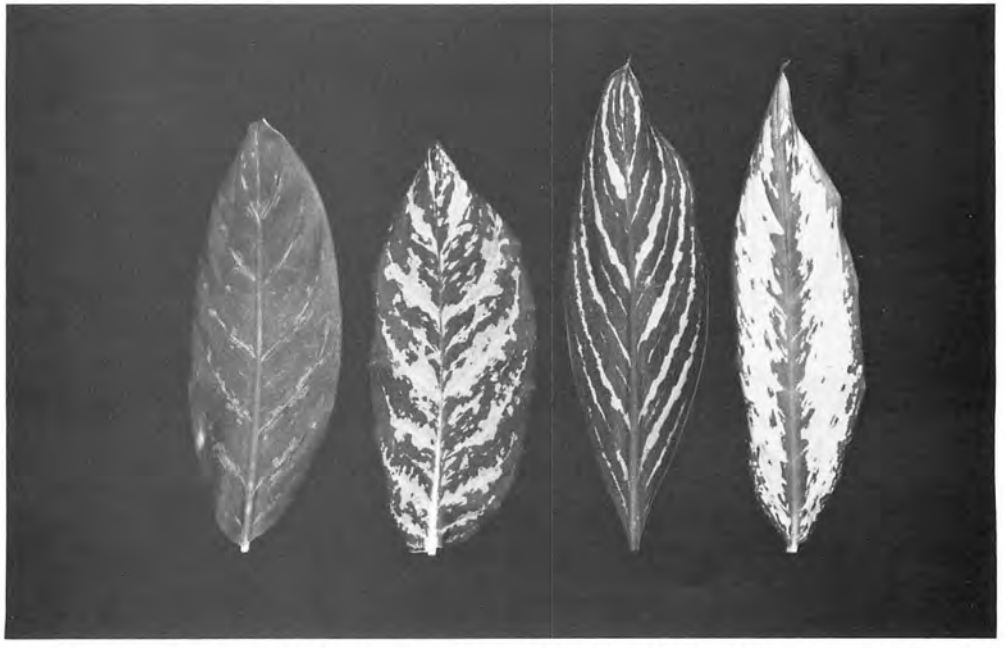

Fig. 4. Leaves from four *Aglaonema* cultivars (including their assigned genotype) used to study inheritance of foliar variegation patterns.

a. *Aglaonema tricolor* 'Tricolor' pattern (*VttVtt*)

b. *A.* X 'Manila' and AREC-A hybrid 1502 (identical patterns and genotypes) (*VmnVtt*) c. *A. nitidum* 'Curtisii' (*Vcv*)

d. *A. crispum* 'Emeralds-on-Ice' pattern (*VeiVei*)

was due to a single dominant gened with multiple alleles and each different variegation pattern was under control of a separate allele (Henny, 1986).

A summary of the proposed genotypes for the *Aglaonema* species, cultivars and hybrids studied to date is presented in Table 5. The gene determining the presence or absence of variegation has been labeled as *V*. plants with a *VV* or *Vv* genotype will be variegated while those with *vv* genotype will be nonvariegated (green). The type of variegation pattern observed depends on the form of the *V*-gene (or allele) present. For example, the Vt allele controls the *A. n.* 'Treubii' pattern. Leaves from four *Aglaonema* cultivars are shown in Figure 4 along with their corresponding genotype.

From a breeding standpoint the straightforward nature of *Aglaonema* variegation inheritance makes development of hybrids with unique combinations of variegation much easier. We are limited however by the fact that any one hybrid can contain only two different foliar variegation patterns. Still, the potentials are practically unlimited when one considers the diversity of patterns present throughout this genus. The potential is magnified when petiole coloration, leaf shape, plant size, growth habit and other factors such as growth rate or resistance to chilling are considered.

Table 4. Segration data for foliar variegation patterns following self-pollination of three *Aglaonema* species.

Species	Total # of seedlings	*Variegation classes*[5] P1	Green	Ratio
A. crispum 'Chartreuse Halo'	9	9	0	1:1
A. commutatum 'Treubii'	54	40	14	3:1
A. nitidum 'Curtisii'	16	11	5	3:1

[5]Number of seedlings with each type of foliar variegation pattern where P1 = pattern identical to parental plant and green = no variegation present.

Table 5. A summary of proposed genotypes for *Aglaonema* species, cultivars and hybrids studied for inheritance of foliar variegation.

Species/Cultivar/Hybrid	Proposed genotype
A. tricolor 'Tricolor'	*VttVtt*
A. crispum 'Emeralds-on-Ice'	*VeiVei*
A. x #1502	*VmnVtt*
A. 'Manila'	*VmnVtt*
A. nitidum 'Curtisii'	*Vcv*
A. commutatum 'Treubii'	*Vtv*

INHERITANCE of PETIOLE COLOR

Aglaonema petioles may be green, white, russet, or pink. A main goal of most people involved in *Aglaonema* breeding is to combine the bright pink petiole of *A. tricolor* 'Tricolor' with other showy types of foliar variegation. However, inheritance of petiole coloration has proven to be more complicated than foliar variegation. The genes controlling petiole color are carried on nuclear variegation. The genes controlling petiole color are carried on nuclear chromosomes as indicated by

reciprocal crosses which give similar types ofcolor segration. Data also indicate that at least two genes are involved in determining petiole coloration, however, the crosses needed to verify this proposal have only recently been made. Even so the following guidelines regarding inheritance of petiole color in *Aglaonema* seem to hold true. Pink petioled hybrids may be obtained only from crosses of pink x pink, pink x russet or pink x white petioled parents. No pink petioled seedlings are obtained from crosses involving green x pink petioled parents. These crosses result in green, white, or russet petioled offspring. The intensity of pink, white and russet coloration varies among seedlings indicated that other genes are active which modify the degree of expression of the main genes for petiole color.

Inheritance of other characteristics such as leaf shape, suckering, plant form and growth habit is controlled by several genes. Such traits show a gradual variation among hybrids rather than an all or none effect. For example, hybrids made by crossing a wide-leafed with a narrow-leafed can be expected to produce seedlings with leaf widths intermediate between the two parental extremes.

CONCLUDING REMARKS

Future *Aglaonema* hybrids will be vastly different from today's popular cultivars. Plants with pink or white and possibly yellow stems and petioles will be prevalent with many diverse growth habits and foliar variegation patterns. Utilization of the breeding techniques discussed in this chapter plus the introduction of new and varied plant types by plant explorers (Brown, 1980; 1982) makes development of unique hybrids a reasonable goal for any interested individual.

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