PRELIMINARY REPORT ON THE JUVENILE CHARACTERS AND HETEROSIS OF THE HYBRIDS BETWEEN *SWIETENIA MAHAGONI* × *S. MACROPHYLLA*

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INTRODUCTION

Although the common mahogany tree consists of only two species, *Swietenia mahagoni* Jacq. (small-leaved) and *S. macrophylla* King (big-leaved), a third form with medium leaflets has been found in mahogany plantations. In the mahogany forests of Taiwan, these so called "medium-leaved" mahogany trees grow more rapidly and possess higher resistance to canker disease.

For some years the foresters and tree breeders have wanted to know the origin of this good form in order to select it for planting. Briscoe and Lamb (1962) have supposed that this medium-leaved mahogany may be a hybrid between the big-leaf and the small-leaf, identified from the progenies of isolated parents and of those in mixed stands. In the same year, Briscoe and Nobles (1962) reported that the medium-leaved seedlings, either from the big-leaved or small-leaved parents, grew taller than either parent species. But all the seedlings studied by them were raised from open-pollinated seeds. Their conclusions are still questionable because they did not use controlled pollination. After the unisexual flowers (not hermaphrodite as mentioned by other taxonomists) were found by Lee (1967). Yang and his coworkers, including the author, have successfully made such controlled pollinations (Yang, 1965).

The present paper is aimed at an investigation of the differences between the one year old seedlings of selfed and crossed seeds of *S. mahagoni* with a check on open-pollinated seeds, which tends to justify the assumption of Briscoe and Lamb's report and to provide some valuable information for the breeding of mahogany trees.

MATERIAL

1. Parent Trees

The parent trees were selected from a sixteen year old mixed plantation in Chung-pu Branch Station, Taiwan Forestry Research Institude, by the leaflet size, stomata size and the lenticel distribution on young twigs. The ♀-parent tree of *S. mahagoni* (S_1) is about 18 m high with DBH about 25 cm. The ♂-parent tree of *S. macrophylla* (L_1) is about 25 m high with DBH about 40 cm. Another ♂-parent

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tree of *S. macrophylla* (L_2) is about 20 m high with a DBH about 30 cm. The morphological characters of these three parent trees are as follows:

Table 1. Characters of parent trees.

Tree No.	Leaflet size	Young twig	Stomata		
			Length	Width	Ratio
S_1	69.8± 6.8 mm	with lenticels	8.4 μ	2.6 μ	3.23
L_1	125.7±15.8	smooth	9.1	5.2	1.75
L_2	102.3±19.0	with lenticels	9.4	5.4	1.74

2. Hybridization

Owing to the different blooming times of these two species, Lee (1967) stated that reciprocal pollinations are impossible. The actual controlled pollinations are $L_1 \times S_1$, $S_1 \times L_2$, L_1 selfing and S_1 selfing. All the treated fruits on L_1 fell off as a result of a typhone before maturation. The seeds were harvested only from the small-leaved parent tree.

3. Seeds and seedlings

Seeds were harvested in April 1965 from selfed fruit and crossed fruit and sown in May 1965 in the seed bed at the Chung-pu Branch Station.

The following table shows results of this study.

Table 2. Percentage of seedlings alive after one year.

Fruit No.	Seeds harvested April 1965	Seedlings alive May 1966	% of living seedlings
CK*	50	24	48.0
No. 3, S_1 selfed	39	5	12.8
No. 8, $S_1 \times L_2$	16	7	43.7
No. 16, $S_1 \times L_2$	51	19	37.2
No. 31, $S_1 \times L_2$	47	17	36.1

*: Open-pollinated fruit of S_1.

METHOD

Leaflet size is not the only important character for identification of the small-leaved *S. mahagoni)* and the big-leaved (*S. macrophylla*) mahogany, especially in the seedling stage. Because leaflet size variation is greatly dependent upon the vigor, age and nutritional condition of the tree. The smallest leaflets of *S. macrophylla* are often smaller than the largest ones of *S. mahagoni.* Therefore the shape of leaflets, the size and shape of stomata and the distribution of lenticels are other important factors used to distinguish these two species (Lee, 1966). In 1-0 seedling stage, there are no lenticels present on the young stem of either species. Only the

size and shape of stomata can be used as genetic characters in these seedlings. In the present study the author has concentrated his attention on the stomata as well as the leaflets for distinguishing the big-leaved, small-leaved and medium-leaved seedlings.

RESULTS

1. Fertility in self and cross pollination

The results of pollination in 1964 were as follows:

Table 3. Result of pollination in 1964

Parent Tree	Inflorescences	♀ Flowers	Pollen	Fruit harvested
L_1	35	1,254	S_1	0
S_1	48	538	L_2	3
S_1	5	30	S_1	1
S_1 (CK)				1

The fruiting percentage cannot be computed from such few fruits. From the number of seeds in each fruit the percentage of fertilization in self-or cross-pollination can be calculated and compared with their fertility (Table 4).

Table 4. Comparison of the fertility of pollination.

Fruit No.	No. of ovule Theoretical*	No. of Seeds	Fertility %
Check	60	50	83
No. 3, $S_1 \times L_2$	60	39	65
No. 8, $S_1 \times L_2$	60	16	26
No. 16, $S_1 \times L_2$	60	51	85
No. 31, $S_1 \times L_2$	60	47	78

*: In the normal ovary of female flowers there are 12 ovules in each of the five carpels.

From these results the mahogany tree may be said to be a selffertile plant and with a considerable crossability between these two closely related species. This is an advantage in the breeding of this timber tree.

2. One year old seedling surviving percentage

Under the same conditions and age, the number of seedlings of these hybrids surviving after one year are different. See Table 2.

As in many crop plants the selfed progeny of the small-leaved mahogany has a lower surviving ability than that of the open- and cross-pollinated plants. The growth vigor may be decreased by inbreeding. Although the crossed progenies of No. 8, No. 16 and No. 31 have only a moderate survival percentage yet the cross-pollination can be proved as an important factor in maintaining the growth vigor

of this species. The unisexual flowers of this genus is an advantage in preventing inbreeding. Open-pollination, even intra specific, may maintain the normal growth vigor.

3. Size of stomata

The author has reported the stomata size on the mature trees of both species (Lee 1966). The stomata of *S. mahagoni* are always smaller and narrower than *S. macrophylla*. This may be also true on the juvenile leaves. The average size of stomata of seedlings are recorded in Table 5.

Table 5. The average size of stomata

Seedling No.	Length	Width	L/W
S_1 Parent tree	8.4 μ	2.6 μ	3.23
No. 3, S_1 selfed	8.1	2.9	2.83
CK	9.3	4.3	2.16
No. 16, $S_1 \times L_2$	9.1	4.5	2.02
No. 31, $S_1 \times L_2$	8.4	4.4	1.91
No. 8, $S_1 \times L_2$	9.1	4.9	1.85
L_2	9.4	5.4	1.74
L_1	9.1	5.2	1.75

In this data the variation of stomata lengths are less significant. But in stomata width, the parent trees are the lowest and highest. The small-leaved parent S_1 has the largest L/W ratio and the big-leaved parent tree L_2 has the lowest ratio. The ratios of open- and cross-pollinating progeny fall in between these two limits. They may be called the "medium-leaved" hybrids with the stomata nearer to *S. macrophylla*. The big-leaved parent L_2 itself is probably a hybrid because of the densely distributed lenticels on its young twigs is a character of *S. mahagoni*. (Table 1.)

4. Leaflet size of the hybrid seedling

The leaves of the seedlings are slightly different from those of the mature trees. The leaves of the seedlings are often oddly compound but on the mature trees they are always evenly compound. To compare the largest leaflets of every seedlings the size and shape are recorded in the following table.

Table 6. Characters of leaflets of seedlings

Seedling No.	Size	Shape variation	Thickness
No. 3, S_1 selfed	small	less variation	thick
CK	large	much variation	thin
No. 8, $S_1 \times L_2$	large	much variation	thin
No. 16, $S_1 \times L_2$	large	much variation	thin
No. 31, $S_1 \times L_2$	large	much variation	thin

The leaflets of No. 3 seedlings, selfed small-leaved mahogany, are like the parent tree. The leaflets of open-pollinated and crossed progenies are larger and have more variation in shape. It is supposed that the hybrids produce much thinner leaflets with wavely curved margins. (Plate I). They may be called the "medium-leaved" plants.

5. Stem growth

The average stem length of seedlings are tabulated as follows: (also see Plate II.)

Table 6. Average stem length of one year old seedlings

Seedling No.	Seedlings observed	Stem length (cm)
CK	24	18.5±5.25
No. 3, S_1 selfed	5	12.6±1.73
No. 8, $S_1 \times L_2$	7	20.3±5.61
No. 16, $S_1 \times L_2$	19	20.0±3.32
No. 31, $S_1 \times L_2$	27	18.7±6.92

As in the surviving ability, the stem growth of selfed progeny is also decreased by inbreeding. From the height growth of crossed progenies a prominent heterosis is clearly evident. If the good timber quality of *S. mahagoni* can be preserved in the hybrids, if these hybrids are truly the medium-leaved trees, and if the height growth and resistance to canker can be combined with good wood, these hybrids will be very ideal trees for foresters.

DISCUSSION

1. According to the differences between the crossed seedlings and the selfed small-leaved seedlings, the technique of controlled pollination developed by Yang (1965) can be believed very successful. The seedlings from crossed pollination are therefore the true hybrids, although the reciprocal pollination ($L_1 \times S_1$) resulted in no mature seed. It is regreted that the pollen parent tree (L_2) is not a typical *S. macrophylla*, so the comparison of the hybrid and the big-leaved mahogany is not reliable. Indeed, the genetic research on such a long-lived tree is a difficult and time-consuming work. But this result is still helpful for the future breeding of this genus.
2. From the heterosis in growth of the crossed progenies and open pollinated seedlings, the medium-leaved progeny may be a good hybrid line for forestry. In this respect, the present result coincides with Briscoe and Nobles' report of 1962. The natural cross-pollination in these two species is not uncommon in the mixed forests and even between two closely neighboring pure stands. These prominent taller seedlings are always found in the nurseries of both species

in Taiwan, and many intermediate trees are found in the big-leaved mahogany plantations. From the limited results of present paper, it is known that the hybrid medium-leaved seedlings are preferable to *S. macrophylla.*

3. The hybrids can be selected by their juvenile characters in the nursery of open-pollinated progenies. But for the pure line of these two species, the seeds must be collected from the isolated stands of each species or by selfing.

SUMMARY

From the seeds of three cross-pollinated fruits of *Swietenia mahagoni*×*S. macrophylla* in 1964, hybrid seedlings were raised in the nursery at the Chung-pu Branch Station, Forestry Research Institute. To compare the characteristics of these hybrid seedlings with the selfed and open-pollinated seedlings of the parent tree S_1 (*S. mahagoni*), the following results were obtained:

Table 7. Comparison of seedlings of parents and hybrids.

Tree or Fruit No.	No. of Seeds	No. of Seedlings	Stomata			Leaflets			Stem length
			Length	Width	L/W	size	shape	thickness	
S_1 parent tree	—	—	8.4 μ	2.6 μ	3.23	small	uniform	thick	—
No. 3, S_1 selfed	39	5	8.1	2.9	2.83	small	uniform	thick	12.6 cm
CK*	50	24	9.3	4.3	2.16	medium	variable	thin	18.5
No. 8, $S_1 \times L_2$	16	7	9.1	4.5	2.02	medium	variable	thin	20.3
No. 16, $S_1 \times L_2$	51	19	8.4	4.4	1.91	medium	variable	thin	20.0
No. 31, $S_1 \times L_2$	47	17	9.1	4.9	1.85	medium	variable	thin	18.7
L_1 parent tree	—	—	9.1	5.2	1.75	large	uniform	thin	—
L_2 parent tree	—	—	9.4	5.4	1.74	medium	variable	thin	—

* Check: Open-pollination of *S. mahagoni*

From these results the following conclusion are drawn:

1. From the comparison of some morphological characters, the seedlings of No. 8, No. 16, and No. 31 are the hybrids of *S. mahagoni*×*S. macrophylla.* The seedlings of No. 3 are the true selfed progeny of *S. mahagoni.*
2. From the success of controlled pollination, it is confirmed that the flowers of *Swietenia* are unisexual.
3. In this genus, outbreeding is a necessary mechanism of reproduction for maintaining the growth vigor and inbreeding is disadvantageous.
4. The genetic pattern of stomata and leaflet sizes may be quantitative inheritance which is controlled by additive genes but *S. macrophylla* possesses the strong influence.

ACKNOWLEGEMENT

The cotrol-pollinated seeds used in this work are from the treated fruits in the

experiment of hybridization of *Swietenia* conducted by Mr. B. Y. Yang, Senior Specialist Taiwan Forestry Research Institute in 1964. Special thanks are due Mr. W. C. Yang and Mr. T. C. Tsai, Junior Technicians in the same Institute, for their help in collecting seeds, planting of seedlings and measuring of plants.

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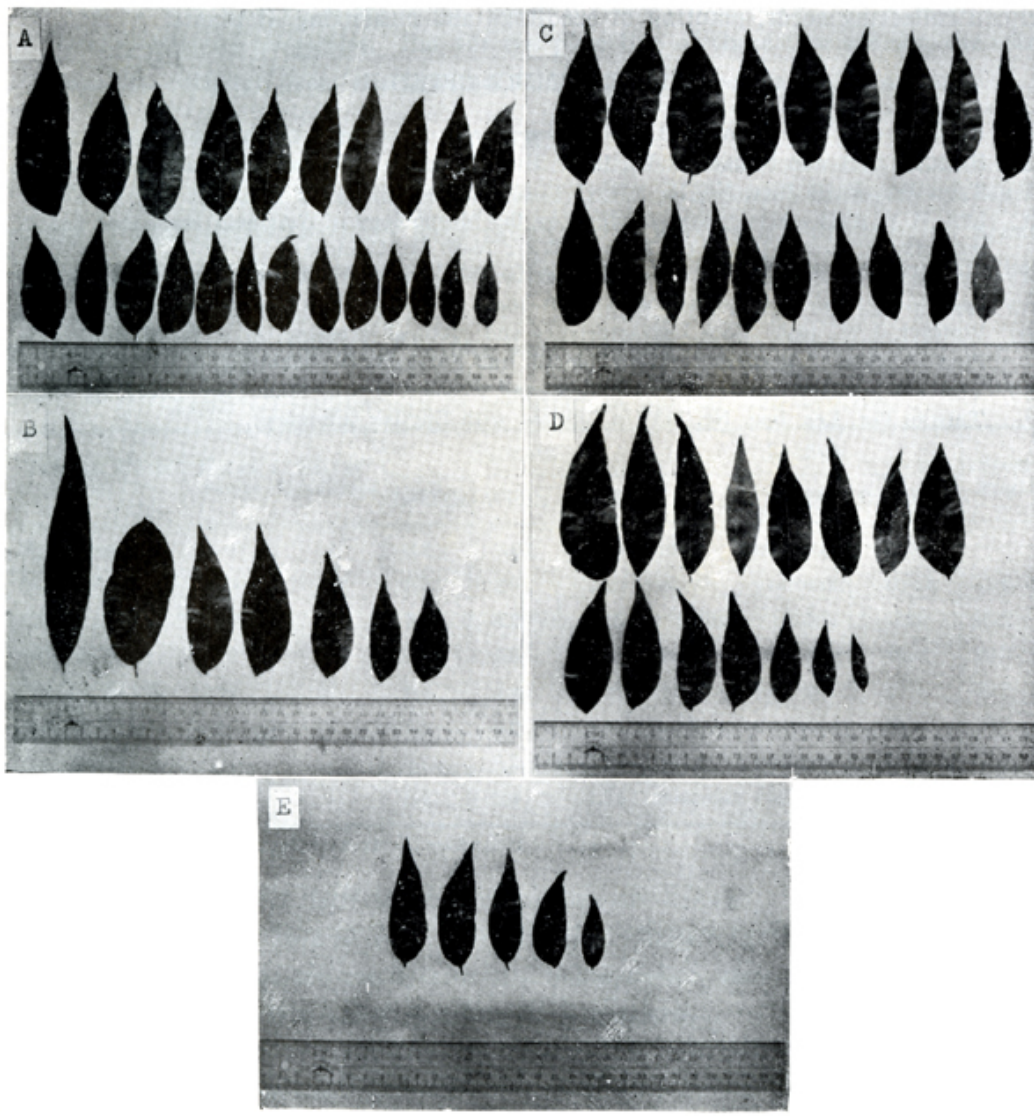

Plate I. Largest leaflet on each seedling of crossed and selfed seeds in *Swietenia*: (×1/1)

A. Seedlings of open-pollinated seeds of *Swietenia mahagoni* (S_1).

B. No. 8, seedlings of crossed seeds of $S_1 \times$ *Swietenia macrophylla* (L_2).

C. No. 16, seedlings of crossed seeds of $S_1 \times L_2$.

D. No. 31, seedlings of crossed seeds of $S_1 \times L_2$.

E. Seedlings of selfed S_1 seeds.

Plate II. Comparison of stem length of one-year old seedlings: ($\times \frac{1}{5}$).

A. Selfed S_1 seedling.
B. Open-pollinated seedling of S_1.
C. No. 8, crossed seedling of $S_1 \times L_2$.
D. No. 16, crossed seedling of $S_1 \times L_2$.
E. No. 31, crossed seedling of $S_1 \times L_2$.