# NOTES ON FRUITING OF STROPHANTHUS SARMENTOSUS IN SOUTH FLORIDA[1]

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It has been established since 1929 that the seeds of *Strophanthus sarmentosus* A. DC. were potentially rich in the cortisone precursors, sarmentocymarine and sarmentogenine (Callon et al., 1951; Euw et al., 1951; Reichstein, 1952). Work connected with bringing this plant under planned cultivation has been started some time ago. Methods for rapid vegetative propagation on a commercial scale have been worked out and numerous seedlings and cuttings from material selected for high precursor content by chromatographical means in its African habitat are presently growing in this country and abroad (Dijkman, 1950; Creech and Dowdle, 1952). The phase that will determine whether S. *sarmentosus* and other species can be developed into a crop plant of economic value is now being investigated. This phase is concerned with the possibilities of producing a cheap, consistent high yielding crop.

In connection herewith it was decided to start orientative experimental work on the points that are decisive for this phase, namely:

(a) The fruiting habit of S. *sarmentosus* and

(b) The cultural requirements of this plant.

The fruiting habit was studied on six mature S. *sarmentosus* vines growing in the estate of the late Col. Robert H. Montgomery, Coconut Grove, Florida and on two year old cuttings of one of these vines. The mature plants are all seedlings raised in 1927, 1928 by the U.S.D.A. Plant Introduction Center at Chapman Field, Florida (Loomis T, 1949). The cultural experiments were carried out on seedlings of S. *sarmentosus* No. 50 (Reichstein 1952) and are being reported separately. The observations reported here are from one season only. Still they are regarded important enough to be communicated, since they may aid in determining the directions in which research should be led.

## REVIEW OF FIELD NOTES AND LITERATURE

Wit (1941), De Visscher Smits (1951) and Douglas (1953) found self sterile as well as self fertile strains in S. *gratus* which were imported to Java, Indonesia. Cuttings from self fertile plants grown in East Java, where the climate has a pronounced wet and dry season and long hours of sunlight, fruited better than the mother plants at the Cultuurtuin, Bogor, West Java. At Bogor, the rainfall is high and more evenly distributed over the year and there are fewer hours of direct sunlight (Mohr, 1933). Reichstein (1952) also emphasizes full sunlight as a necessity for fruiting of all *Strophanthus* species. He based this conclusion on the observations that vines in their natural habitat fruit only on those portions of the plants exposed to the sun.

Meyer, a planter in Africa, found self fertility in individual plants of S. *preussii* and low fertility when these plants were intraspecifically crossed. Another farmer, working with Meyer with an unidentified species of *Strophanthus*, noticed that natural fruit setting was correlated with the presence of an unidentified species of red ant. A vine from which the ants were kept away did not fruit. The manner in which the ants were connected with the fruiting was not disclosed (Reichstein, 1952).

Reichstein noted great variation in fruit production of S. *sarmentosus* in different locations in Africa. He also mentioned that in certain African habitats, plants of S. *sarmentosus* had two blooming seasons. During the main blooming season the plants flowered profusely. During the secondary blooming season, lasting throughout the remainder of the year, only a few flowers at a time were produced. Self sterility was observed during the main blooming season but during the secondary blooming season there appeared to be much self fertility (Reichstein, 1952).

[1]/Main points of this article were communicated at the 17th Annual Meeting of the Florida Academy of Science at Gainesville, Florida in December 1952. The authors are indebted to: Mrs. Robt. H. Montgomery, Coconut Grove, Florida, for the privilege of using the Strophanthus sarmentosus vines on her estate; to Dr. Thadeus Reichstein, Organisch-Chemische Anstalt der Universitat Basel, Switzerland, and to Mr. Jos. Monachino of the New York Botanical Gardens, for their interest and for the data and materials they so kindly supplied. The authors are also grateful to Mr. Arnold Jordan, horticulturist for the Montgomery estate and for Fairchild Tropical Gardens.

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Of the plants grown from seed imported to the Americas in 1927, only sporadic, spontaneous fruiting has been reported from one vine in Cuba and one in south Florida (Loomis, 1949; Jordahn, 1953).

## Biological Notes on Strophanthus sarmentosus in South Florida

S. *sarmentosus* belongs to a group of vines which recently have been named "weavers" (Venning, 1953). This vine shows typical morphological dimorphism. It grows as a shrub without support but also climbs by means of dominating fast-growing shoots or leaders. When it finds support it twists and turns and weaves its way among its own branches or among the supporting structures. On the leaders, branching usually begins near the basal portions; however, they seldom branch during their first year. On some plants no branching has been observed within three years. The small branches are slender and restricted in terminal growth whereas the internodes of the leaders are two or more times longer than those of the small branches. Another type of shoot is distinguished from the leaders in that it develops into a diffused mass of thin, short-noded branchlets.

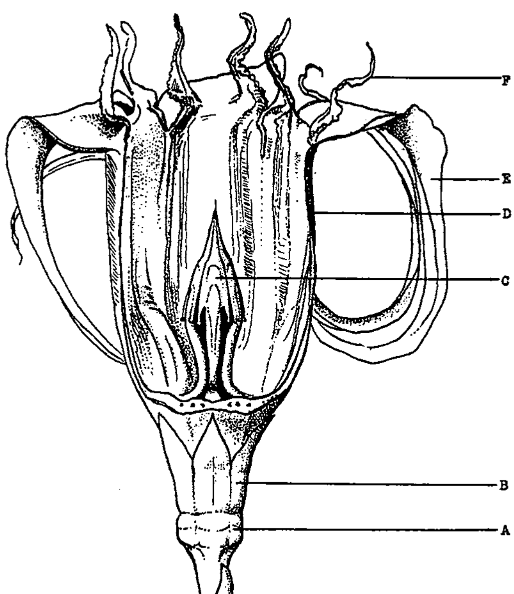


**Figure I. Flower of Strophanthus sarmentosus A. D.C. Part of the corolla tube removed to show anther cone. (Drawn by M. J. Dijkman). A.—Receptacle; B—Calyx; C—Anther cone enclosing pistil; D—Corolla tube; E—Corolla limb; F—Corona.**

Since the flower biology of S. *gratus* as published (Wit, 1941) closely resembles that of S. *sarmentosus*, only a brief presentation of the details concerning the technique of pollination will be given.

Apocynaceous plants have a characteristic anther cone which intimately encloses the upper portions of the pistil (Fig. 1) (Engler and Prantl, 1891; Monachino, 1952). Only the upper portion of the anther is polliniferous. The anthers open in the bud one to two days before the flower opens. The pollen does not ordinarily reach the receptive portion of the stigma because the entire upper portion of the stigma, which is non-receptive, is connected to the lower parts of the anthers by a mucous that is infiltrated between stiff hairs on the inner side of the lower part of the anthers. The receptive base of the stigma is an expanded ring which stands out from the narrower apical part (Fig. 2).

From the six vines studied, five (Nos. 1-3, 5, 6, Table 1) flowered from March through June, one (No. 4) from April to September. Cuttings from vine No. 2 at an age of two years flowered throughout the year 1952, with a main blooming period of January through April.

When flowering, the branches carrying flowers shed their leaves. The flowers on the branchlets open up first, those on the leaders last. Vegetative flush sets in immediately after the flowers have faded. Hence the branchlets are in new foliage as the leaders still bloom. The flowers arise in the axils of the leaves and are borne on short spurs.

## Experimental Material

In the spring of 1952, artificial pollinations were started on four of the six mature vines growing on the Montgomery Estate. It was one of these vines that had reportedly fruited spontaneously (Loomis, 1949; Jordahn, 1953). The other two vines were not accessible for pollination.

At the same time, artificial pollinations were made with two-year-old branch cuttings of the vine that was reported to have set fruit. All of these cuttings were grown in an experimental plot at the main campus of the University of Miami.

The pollinations were made with newly opened flowers. Some flowers were pretreated one or two days before they opened by cutting through the corolla-tube and re-

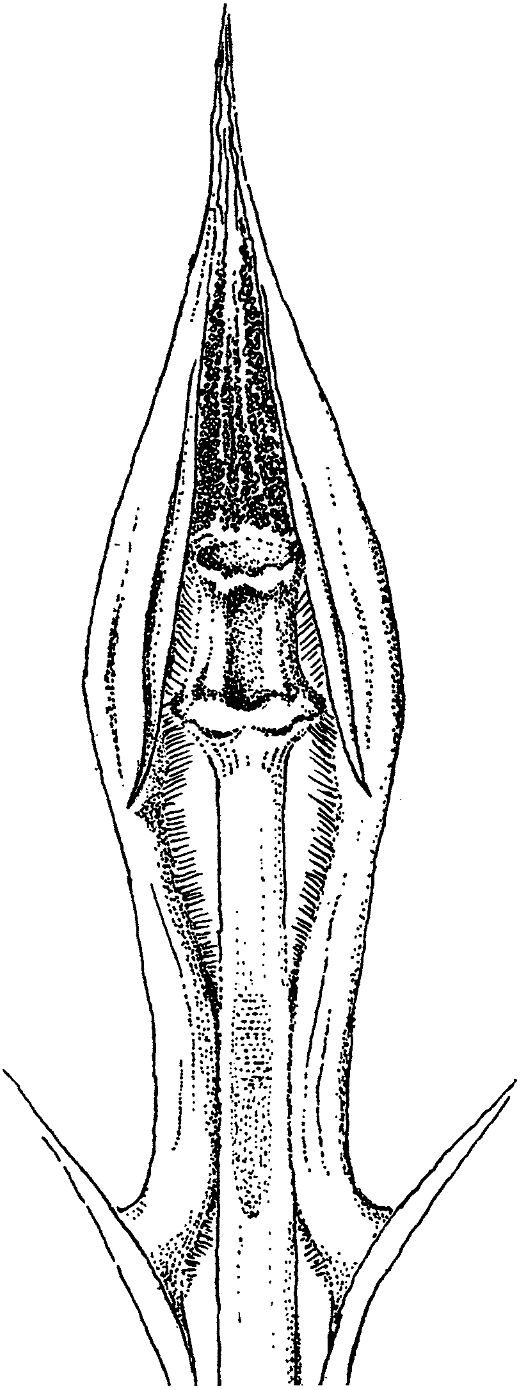

Figure 2. Anther-cone readied for pollination by removal of one anther. The remaining anthers show opened pollen sacks in upper half and stigma enclosing hairs on lower half of anther. Pollen should be brought on protruding ring at lower end of stigma for pollination. (Drawn by M. J. Dijkman).

moving one or two anthers. Anthers not pretreated were removed immediately prior to pollination. All pollinations were made by scraping the pollen out of the upper portions of the remaining anthers with forceps or othei sharp instrument and transferring the pollen to the sticky ringed base of the stigma. As in S. *gratus* it was more difficult to pollinate a flower that has just opened than a flower just prior to opening. With S. *sarmentosus* this point is not essential for the success of the pollination.

Hand pollinations were made throughout the entire flowering period at approximately one week intervals. Many of the flower-bearing branches grew out of reach over a slat house which would not hold the weight of a person, a fact which accounts for the limited number of hand pollinations made, even though the vines produced hundreds of flowers.

During the course of this study, observations were also made of natural fruit set. Preliminary surveys were made on June 9, 1952 and

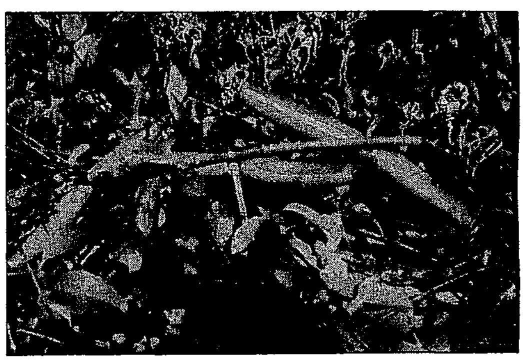

Figure 3. A—Fruit on mature vine self pollinated by hand February 1952. Note flowers of blooming season 1953. B—Fruit to the extreme right is the result of an intraspecific cross made April 1952. The other two were selfed by hand on same date. (Photographs by M. J. Dijkman, March 1953).

TABLE I

Summary of kinds of pollinations on six Strophanthus sarmentosus vines. The flowers self pollinated by hand and intraspecifically pollinated by hand were pollinated on various dates between February 24, 1952 and May 1, 1952. The flowers on vines 5 and 6 were not accessable for hand pollination.

| Kind of Pollination | 1 | 2 | 3 | 4 | 5 | 6 | Tot. | % |
|---|---|---|---|---|---|---|---|---|
| | Number of Vine | | | | | | | |
| Selfed by hand | 5 | 8 | 0 | 11 | 0 | 0 | 24 | |
| Intraspecifically crossed by hand | 33 | 15 | 10 | 19 | 0 | 0 | 77 | |
| Successful at first inspection | | | | | | | | |
| Selfed by hand | 2 | 6 | 0 | * | 0 | 0 | 8 | 33.0% |
| Intraspecifically crossed by hand | 3 | 3 | * | * | 0 | 0 | 6 | 7.9% |
| Successful at last inspection | | | | | | | | |
| Selfed by hand | * | 2 | 0 | 0 | 0 | 0 | 2 | 8.3% |
| Intraspecifically crossed by hand | * | 1 | 0 | 0 | 0 | 0 | 1 | 0.1% |
| Labeled flowers at first inspection | | | | | | | | |
| Naturally pollinated flowers | 17 | 11 | 1 | 0 | 0 | 0 | 29 | |
| Successful at last inspection | | | | | | | | |
| Naturally pollinated flowers | 2 | 3 | 1 | 0 | 0 | 0 | 6 | 20.6% |
| Fruit not labeled because of inaccessability | | | | | | | | |
| Naturally pollinated flowers | 0 | 6 | 0 | 0 | 5 | 3 | 14 | |

* Abscised or dead
The first inspection was on June 9, 1952, the last on January 9, 1953.

September 3, 1952. A final survey of the number of fruit set was made on January 9, 1953. During the initial surveys the naturally fertilized fruits were labeled. The results of these surveys are summarized in table 1.

### Observations and Discussion of Results

The characteristics significant in determining preliminary take after pollination are, (1) the rapid swelling and corking of the peduncle and, (2) the gradual growth of the two carpels until they are about one centimeter long and about one centimeter wide. While the carpels are still small they may undergo a rest period lasting for many months. On the other hand, they may continue to grow to maturity without this rest period. Seven months after pollination the fruits attained their ultimate size, but it takes five more months before they ripen and dehisce. Depending on the time of pollination, fruit development can extend into the following blooming period as shown by one fruit growing on a 3-yr.-old cutting and many fruit on full grown vines (Fig. 3). After twelve months the overall length of both carpels of the largest fruit was 50 cm. long and about 10 cm. in circumference at its thickest part. At this time the fruit develops numerous, prominently protruding lenticels composed of dark brown cells. These lenticels fall off when the fruit is handled.

All the fruit on the full grown vines were formed on leader branches which had southwest exposure. This orientation is obviously connected with fundamental physiological activities. We mentioned that *S. sarmentosus* sheds its leaves just prior to flowering. Plants which do this generally transfer foods from the leaves to the stems and branches. This accumulation of foods is especially true of the strong leaders and stems which appear to form the main food reservoirs in *S. sarmentosus.* Similar observations were made with *S. gratus* (Douglas T, 1953).

With the development of the buds, part of this nutritive material is used. After fertilization, when the fruits begin to grow, large amounts of these stored nutrients are again required. The channeling of the food to the developing fruit on the leaders is usually so vigorous, that it causes the leaders to grow in diameter up to the point where the fruit has set. Beyond that point the stems often remain entirely stagnant and at a much smaller diameter. This is very obvious when fruit development is at a great distance from the base of the leader. When the fruit develops close to the base of the leader there appears to be no difference between the diameters of the portion of the leader below the fruit and the portion above the fruit.

The fruit developing on the thin branchlets all aborted within three months' time. A possible explanation of this point might be that during their development, the flowers and young fruits on the branchlets soon use up the food stored in these organs and that they then lose the competition for food with the fruit developing on the leaders.

Under certain circumstances fruit also developed on the cuttings. These cuttings, made in 1950, had a main blooming season, but showed in addition flowers on isolated branches throughout the year. All the flowers on the cuttings were self pollinated by hand during the primary blooming period and during the secondary blooming periods. Up to July 1952 in many cases fruits developed but within one month they had all aborted. In July 1952 and successive months, 30 percent of the fruit started, began to develop; within four months five fruits on four shrubs were growing of which one is nearing maturity.

A factor which may have had a bearing on the fruiting success, may be mentioned here. Spurned by the results of pot cultures on pH and deficiency experiments (Azoff and Irvine, 1952), the cuttings were supplied in January and July with flour of sulfur, NPK and minor elements and with supplemental magnesium. Heavy mulching was also practiced.

The fertilizer experiment will have to be repeated with new material in randomized tests to make out this point definitely. The results, however, were suggestive of favourable general response.

After the treatment the plants, then two feet high and about two feet wide, became vigorous. Leaders sprouted and developed abundant healthy foliage.

Although branchlets on all sides flowered during the after season periods, only those exposed to the west and north-westerly directions succeeded. The shrubs are in a row running north-north-east by south-south-west growing between two rows of citrus which are about 150-200 cm. high. Development is close to the ground and primarily on the west and north-west exposure. The leaders tend to crawl over the citrus in a south-westerly direction which was also the general orientation of the main body of foliage of the mature vines on the Montgomery estate.

### Conclusions

Although further investigations must be made, the results to date do not indicate that *Strophanthus sarmentosus* in South Florida will be developed into an economically workable crop plant in the near future.

The response to hand pollination was successful from a breeding standpoint but not from a commercial standpoint. Breeding and selection of self-fertile, high-yielding plants is the only rational solution to the problem; then clone plantings will be the first commercial step. Such a program would require large areas to grow the numerous seedling generations and a long term breeding set-up.

### Summary

*One.* In accord with the results obtained with S. *gratus* in Indonesia, S. *sarmentosus* shows varying degrees of self compatibility, ranging from incompatibility to relative compatibility when individuals are mutually compared.

*Two.* Intraspecific cross-pollination is possible.

*Three.* Hand pollinations have increased the fruiting response, but not to an extent that is commercially feasible.

*Four.* The possibility of finding self-pollinating individuals exists as Table 1 indicates.

*Five.* On mature vines only one blooming period was observed.

*Six.* Fruit on mature vines developed only on strong leader shoots.

*Seven.* In South Florida the fruit requires one year to ripen.

*Eight.* Two-year-old cuttings of a self compatible plant could be brought to fruit by hand pollination.

*Nine.* Possible correlation with fertilizing with sulphur powder, NKP, minor elements with increased magnesium applications and heavy mulching is indicated.

*Ten.* Scattered flowering throughout the year was observed on cuttings.

*Eleven.* In general, the results of these orientative investigations are disappointing from a time element viewpoint. For commercial utilization self-compatible naturally-fruiting high-yielding strains will have to be bred, which requires a long term breeding selection program.

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# REVIEW OF INVESTIGATIONS ON THE ANNONA SPECIES

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The edible annonas, indigenous to the Western Hemisphere, are probably as widely distributed in the tropical parts of the world as any other New World fruit. Frost and extended cool weather are recognized as the