The Pistillate Inflorescence of Sweetgum (Liquidambar styraciflua L.)

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(Received for publication July 15, 1965)

In 1905 Shoemaker reported on the morphology and anatomy of the sweetgum (Liquidambar styraciflua L.) inflorescence in relation to a more exhaustive study of floral development in witch-hazel (Hamamelis virginiana L.); more recently Flint (1959) wrote a detailed account of megasporogenesis in sweetgum. Because of the significance of floral structure and anatomy for phylogenetic studies and for practical breeding purposes some additional morphologic and anatomic details may be of interest.

The information reported here was obtained incidental to an attempt to follow pollen tube growth during an investigation of self-sterility in sweetgum. The pistillate inflorescences (heads) were sectioned at varying time intervals after pollination, thus affording an opportunity to observe the morphologic structure and anatomy of the heads in some detail as well as to locate the pollen tubes.

Methods

Two sweetgum trees, each in North Carolina forest populations separated by 40 miles, were used as seed parents for post-pollination analysis. Sixty heads from each tree were collected over a period of eight weeks following controlled pollination, and immediately after harvest the heads were quartered and dropped in a modified FAA solution (Flint, 1959). They subsequently were embedded in Tissuemat according to the TBA method of Johansen (1940) and sectioned at either 15 or 20 μ. The sections were stained with hematoxylin (Sass, 1958) followed by lacmoid (Chieable et al., 1953).

Results

Figure 1 shows the axile nature of the pistillate inflorescence. Its growth is determinate only in a qualified sense, since the interfascicular cambium which is confluent with that of the peduncle continues to function for several weeks after fertilization. It does so, however, as a secondary or marginal meristem, thus contributing to the globular shape of the head.

The bicarpellate capsules are appendicular. Three main bundles enter each carpel resulting in tri-lacunar gaps in the marginal meristem of the head. The bundles become ramiform in the receptacle. The initial peripheral branches develop acropetally to form the staminate traces, usually three – four per carpel. Subsequent branching produces a prominent dorsal bundle and several ventral bundles in each carpel. As the inflorescence grows in size, papillae form on the surface of the capsules. Within each papilla a vascular trace is initiated which differentiates basipetally towards the existing vascular net.

Before pollen release from the staminate inflorescence the bicarpellate capsules are nearly distinct, i.e. united only at the base. The sides of the capsules are covered by transversely oriented epidermal hairs. As the inflorescence continues growth the hairs of the adjacent capsules interlock (Fig. 2), thus firmly uniting the capsules almost to their summits.

The stamens arise from the sunken capsule edges, usually at a corner. The filaments are short and traversed by a vascular trace which extends into the connecting supportive tissue of the anthers. The germinal tissue of each anther, located in two initially discrete patches, develops normally producing plasmoidal tapetum and microsporocytes. The latter develop into polyporate pollen grains. In the two trees investigated some of the stamens from the nominally pistillate inflorescences produced functional pollen in the sense

Figure 1. — Cross section of the pistillate inflorescence of sweetgum four days after pollination. Arrow marked (A) indicates position of the interfascicular cambium delimiting axis of the inflorescence. (B) is a stamen (X10).

Figure 2. — Longitudinal section through two capsules showing elongated, transverse, hair-like cells (A) uniting the adjacent capsules (X80).

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that it was capable of germination (Fig. 3). Much of the pollen produced by these stamens, however, is small, wrinkled and probably abortive.

Pollen from the primarily female inflorescence is released by the rupture of a well developed endothecium (Fig. 3). However the maturation of the stamen and its pollen is not synchronized with the development of the rest of the pistillate inflorescence whereas pollen release from the staminate inflorescence coincides with stylar receptivity.

Discussion

The literature clearly indicates that both staminate and pistillate flowers lack corollas; the staminate flowers also definitely do not have calyces. On the other hand statements concerning the presence or absence of a calyx on the flowers of the pistillate inflorescence vary. The evidence advanced to support the presence of a calyx consists of a more or less convolute rim constituting the capsule edges. This rim was held to be a rudimentary calyx (Sargent, 1921). Other authors were noncommittal (c. g. Harms, 1936). The absence of a calyx was affirmed by Samorodova-Bianchi (cited in East, 1963) because of the marginal origin of the stamens. In my material there was no evidence of a distinct capsule rim, and, as previously noted, the peripheral vascular traces were all associated with the stamens. These observations tend to confirm the opinion that the pistillate flowers lack calyces as well as corollas.

The stamens on the female inflorescence are neither rudimentary nor, from the standpoint of pollen production, nonfunctional. Although it is possible that the two North Carolina trees were unique in this respect, this does not seem likely because Shumaker (1903) reported and illustrated pollen in the locules of anthers of a pistillate inflorescence from a sweetgum tree in New York (however in his judgement the pollen was abortive, and the stamens functioned as nectaries).

It is rather striking that in sweetgum neither pollen from the staminate inflorescence nor from the stamens of the pistillate inflorescence can effect prompt fertilization of the ovules. In the case of the pollen from the staminate inflorescence, the ovules lack egg apparatus during and for some time after pollen release. However the growth of the pollen tube is arrested in the chalaza until the ovule forms an egg apparatus, usually one to three weeks after pollination.

Asynchrony of pollen from the primarily pistillate inflorescence is of a different type. This pollen is released three to four weeks after the pollen from the staminate inflorescence has been released. By this time the styril tissue, particularly the stigmatic tissue and the extra-xylary fibrous sheath in the styles, and the internal parenchymatous tissues of the ovaries, have become sclerified. More important, the ovules have already been fertilized or else they have aborted (Schmitt and Perry, 1944).

Chalaza gamy, delayed fertilization, and the production by both types of inflorescence of functional pollen whose release is not synchronous with ovule development, are perhaps adaptations reflecting the as yet imperfect transition to monoecy in L. styaciflua. Because sweetgum achieves its optimum development in the southern region of the mixed mesophytic forest with which it has long been associated and whose climatic requirements are presumed to have changed little since Tertiary times (Baum, 1950), it is possible that structurally more primitive floral types (more nearly perfect) could be found in such populations. In this connection it is worth noting that investigations on the floral structure of sweetgum (including this one) were based on trees located in the northern part of its range or from trees of unknown origin in European botanic gardens.

Actually the pistillate flower of sweetgum has a number of features usually considered primitive, viz. several arche megaspores, polygonum type embryo sac, bitegmic anatropous ovules with a prominent nucelus, free nuclear endosperm, and an obviously phylloclarpous ovary. Thus, apart from the reduction in floral parts and the tend towards monoecy, neither of which is complete, the floral structure of sweetgum is relatively primitive. The wood anatomy is also primitive (Tippo, 1938). The evidence from wood anatomy and floral structure and anatomy lend support to Markova’s (1957) opinion, based on paleobotanics studies of leaf variation in the genus, that Liquidambar is an ancient angiosperm genus in the Hamamelidaeae, and that L. styaciflua was probably the stem species in this small genus.

Acknowledgements

The research was partly financed by National Science Foundation, Grant No. 10680 to Dr. Bruce Zobel, N. C. State University, to whom my thanks are also due for stimulating questions during the course of the investigations. I should also like to acknowledge the assistance and advice of Dr. T. O. Perry and Dr. Ernest Hall, N. C. State University, Raleigh; and to thank Drs. E. Bayne Snyder and J. R. Wilson of the Institute of Forest Genetics, U. S. Forest Service, Gulport, Miss. for reading the manuscript.

Summary

Examination of the pistillate inflorescence of sweetgum at varying intervals after pollination showed that the stamens on the capsules produced pollen capable of germination. But by the time this pollen was released, the tissues of the gynoecium had sclerified. Such pollen could conceivably function only in cross-pollination.

A previous Russian report, based on botanic garden material, that the pistillate flower of sweetgum lacked a calyx was confirmed.

Despite the reduction in floral parts, the sweetgum pistillate flower is relatively primitive.
Anatomische Beobachtungen zur Bewurzelung der Kurztriebe von Pinus radiata

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(Eingegangen am 30. 6. 1969)

Einleitung


In unseren Versuchen hatte sich wiederholt gezeigt, daß kräftig bewurzelte Kurztriebe, deren Knospen sich in 2–5 cm hohe Langtriebe verwandelten hatten (Abb. 3), sehr leicht vertrockneten, wenn sie aus der feuchtigkeitsgestützten Atmosphäre der Anzuchtstäbe in das Freiland verpflanzt wurden, wo sie recht häufig Bedingungen ausgesetzt waren, die eine hohe Transpiration erforderten. Wir vermuteten, daß anatomische Ursachen die ausreichende Wasserversorgung der jungen Triebe in Frage stellen. Im folgenden sollen die wichtigsten Resultate unserer diesbezüglichen Studien mitgeteilt werden.


Abb. 2: Graphische Darstellung einer im peripheren Kallusparenchym entstehenden Wurzel. p: Kallusparenchym, t: Tracheiden. m: Meristematische Zellen, welche sich zum Wurzelspitzenmeristem herausdifferenzieren. k: Der Kallus umhüllendes Korkgewebe. (Vergr. 60×)