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The Formation and Development *of the* PISTILLATE FLOWERS of the Pecan

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Throughout history there have been a few outstanding revolutionary inventions which almost immediately brought great changes in industry. The majority of industrial developments, however, have been gradual and have been based on accumulated bits of new information. When taken alone these bits of information or researches are of little or no importance, but without them progress is hindered. Large industrial plants are now maintaining fully equipped research laboratories. They realize that without research their progress ceases.

And so it is with the pecan. "The Morphological Differentation of the Pistillate Flowers of the Pecan" is a research designed to tell the inside story of a pecan bud. Differentation is a scientific term which means the changing over of a bud from a leaf bud to a flower bud. Morphology is the study of the actual steps involved in making the change. This study is then concerned with fruit bud formation and development.

It has been known for a long time that the flower buds of most fruit trees are developed in the summer preceding the time of their blooming. Even as far back as 1812 Thomas Andrew Knight, the first president of the Royal Horticultural Society, mentioned that he had repeatedly ascertained that blossom buds developed in the season before their unfolding.

It has been in the United States, however, that the most complete work has been done in regard to the formation of blossom buds. Goff, of Wisconsin, was the leader in this country. He determined the time at which the flower buds of the cherry, apple, pear, plum, and strawberry were first starting to develop. Drinkard, of Virginia, contributed an extensive study of the fruit buds of the apple, pear, peach, plum, and cherry in his section. Bradford added similar information for the apple in Washington, McDaniels in New York worked on blackberries and raspberries, and recently Tufts and Morrow in California have added the apple, pear, peach, plum, cherry and almond. These studies have added much to the definite understanding of the growth and responses of fruit trees under various conditions. It has

*A non-technical summary of a technical paper by the author on the Morphological Differentation of the Pistillate Flowers of the Pecan.

paved the way for a better understanding of pruning, fertilizing, cultivation, and other orchard practices. The application of these studies has just begun.

The only work that had been published in this respect on the pecan is that of Woodruff in Georgia. Woodruff found that the lateral buds of the pecan contained small catkins a full year before the catkins unfolded in the spring. (Catkins in the pecan perform the same function as the tassels in corn). Woodruff did not ascertain the time at which the pistillate flowers began to develop. (The pistillate flowers bear the nuts.)

Three questions indicate the scope of this study:

1. Where are the pistillate flowers of the pecan borne?
2. When are the fruit buds formed?
3. How do they develop?

How, when, and where do the pistillate flowers of the pecan develop?

The first requirement for intelligent procedure in the collection of pistillate flower buds was to ascertain exactly where these flowers occurred. No record was found which set forth clearly and definitely the location of pistillate flower buds. Woodruff (1924) approached the subject by calling all lateral buds reproductory buds. It is quite true that all lateral buds normally contain catkins but the majority of lateral buds do not normally bear pistillate flowers. Abnormal conditions such as the removal of certain terminal buds or the killing of these terminal buds by cold may cause lateral buds, which normally would produce catkins only, to develop pistillate flowers. The forcing out of a lateral bud, however, may or may not be accompanied by the development of a pistillate flower. This condition seems to be controlled by some internal nutritive combination. It is most noticeable in the budding of pecan trees. Lateral buds, which by microscopic examination are known to contain catkins, when budded into a young stock or a vigorous sprout normally produce a vegetative shoot terminated by a strictly vegetative terminal. Rarely catkins develop along with the vegetative shoot. This has been observed even in the case of current season buds placed in August and forced out immediately. A pistillate terminal, however, is rarely formed from such buds.

Pistillate flowers are usually said to originate from terminal buds. Bearing pecan trees, however, were found to have four distinctly different types of terminal buds. The first type is strictly vegetative and is the only type to be found in a young unbearing tree. This terminal bud is distinctly different in size, shape, and structure from all other pecan buds. The second type is a terminal bud which is very similar in size, shape and structure to the lateral buds. A twig bearing such a terminal bud was terminated in the growing season by a full sized leaf. The third type is a terminal bud located at the base of the stem of the nut cluster. During its development this bud was accompanied by a full sized leaf. The fourth type is a terminal bud which seems to be borne on the stem of the nut cluster but it was not accompanied during the growing season by a fully developed leaf. As many as five such buds, fully developed but without accompanying leaves, have been found on a nut-cluster stem of the Schley.

The relative frequency of the four types of terminal buds, of the pecan tree used in this investigation, were found to be as shown in the following table:

Type	Description	Frequency	Percent
1	Vegetative terminal	184	46
2	Nonfruiting-branch terminal	76	29
3	Fr-branch terminal with leaf	58	14.5
4	Fr-branch terminal without leaf	82	20.5

It is quite evident that the type 2, 3 and 4 terminals are produced on shoots which bore pistillate flowers in the spring of their development. The type 2 terminal either failed to develop a flower or the flower was shed probably because of the lack of pollination. A study of the source of the pistillate flower buds, that is the shoots bearing type 2, 3 and4 terminals, indicated that these buds only rarely originate from type one terminals. No case was observed where a type 4 terminal gave rise to a pistillate flower. Type 2 terminals did not give rise to anything but pistillate terminals and the same was true of type 3 terminals. Normally type one terminals either give rise to type one terminals or fail to develop at all, shoots from lateral buds taking their places.

The most prolific source of pistillate flowers is from the lateral buds near the tips of the shoots bearing type 2, 3, and 4 terminals. Lateral buds do not normally develop into pistillate flowers unless they are located within approximately two inches of the terminal of the shoot. Half of the lateral buds on shoots bearing type 1 terminals gave rise to pistillate flower shoots while the other half gave rise to vegetative shoots.

Under abnormal conditions it seems that any bud of the pecan may develop into a pistillate flower. Even type 1 terminals may give rise to these flowers when conditions are highly favorable to flower bud development. The determination of the time at which the pistillate flowers began to form collections of buds extended through a full year.

The development of a special method for treating the buds, so that they could be cut in thin sections, was first necessary. This required several months of intensive study but resulted in a method which was used successfully. The method of procedure was very complicated but in general it consisted of soaking the buds in parafine then cutting them into fine sections by means of a microtome which is a delicate instrument, somewhat similar to an automatic bacon slicer. These sections were then mounted on glass slides and examined with a microscope. More than 25,000 sections were made and more than 8,000 were actually examined with a microscope in this study.

Practically no development, so far as the central tip of the bud is concerned, took place between the first of September and the last of December. During this time the buds contained an outer scale, two outer catkin groups, an inner scale, two inner catkin groups, four embryoic or rudimentary leaves, and a central point or growing tip. All of the parts of the bud are grouped around the growing point in a protecting manner. Enlargement of the bud through January, February, and early March, consists of the development of new embryonic leaves and the enlargement of the catkin groups. The embryonic leaves continue to develop from the sides of the central growing point until about twelve have formed. The actual development of the pistillate flowers does not take place until growth has begun in the spring. The formation of leaves is not completed until the bud has elongated to about three-eighths of an inch and the formation of the floral parts does not begin until twelve leaves—on the average—have developed.

The first indication of a pistillate flower is a small blister-like formation on the central growing point. Several of these, one for each nut in the cluster, develop. Soon after their appearance the center of the blister slows up in growth while the sides continue. This forms a cup the outside of which becomes the outer husk of the nut. A second depression in the center of the bottom of the cup forms a cavity in which the ovules develop and from which the stigma of the flower develops. Four points on the rim of the outer cup grow more rapidly than the remaining parts. These become the

small green leaf-like sepals which are found at the apex of each nut. These sepals fold over and protect the stigma when it is forming.

While these developments are taking place the entire shoot begins to grow. The unfolding is similar to the pulling out of a telescope with each part stopping at its appointed place.

Conclusions

It has long been known that flower bud formation is associated with some internal nutritive condition in which the food materials that are manufactured by the leaves are proportionately greater—so to speak—than the raw materials brought up from the soil. Arresting or hindering the downward flow of this manufactured sap, from the leaves to the roots—without interfering with the upward flow of water and raw materials from the soil—is known to bring about a heavy set of blossoms if it occurs at or before the time the blossoms begin to differentiate. The practices of slitting the bark for curing the so called "hide bound" condition of a tree, driving nails in the tree "to supply iron," bending down and tying the limbs of trees, cutting narrow rings through the bark, etc., are based on this principle of sap arrestation.

Nature brings about the same results by a drouthy condition of the soil, by bending limbs with the weight of fruit, by injury to the roots caused by insects or disease, etc.

Since the pecan does not differentiate until growth has started in the spring, it seems reasonable to believe that a drouthy condition which would prevent the rapid dilution of the sugar sap of the tree just previous to and during the time of flower bud differentiation would result in a heavy set of blossoms. If that droughty condition continues too far the blossoms may be shed due possibly to sterility. If, on the other hand, the droughty condition is broken by good rains which come after the flowers have formed the conditions for a heavy crop of pecans are ideal so far as the set of nuts is concernerd.

This indicates that the ideal time of the first irrigation for a young unbearing pecan grove should be in early spring before growth starts, while for a bearing grove it may be better to withhold water until the pistillate flowers have formed than irrigate heavily.

Since cultivation of the soil, especially the turning under of a cover crop in early spring, has an important effect on the moisture condition of the soil it seems that too early turning under may be practiced when there is an abundance of moisture in the soil. Much moisture in early spring followed by a drought later will probably be the most unfavorable conditions for a good pecan crop.

It has been a common belief among many leading pecan men that knocking off pecans with poles at harvest time injures the blossom buds for the following year. The location of the buds bearing pistillate flowers and differentiation of other buds under abnormal conditions show very clearly that injury to the terminal buds of the pecan by the common practice of "threshing" is not the cause of the short crop which often follows a heavy crop year. Shoots on several limbs of a tree were stripped of half of their buds from the terminal end. In each case just as many pistillate flowers differentiated from lateral buds, on the basal half of the shoot, as did differentiate on limbs not so treated. Within the bounds of reason pecans may be "threshed" from the trees without any injury to the tree or to the next years crop.

Summary

1. The pecan has four types of terminal buds.

2. The pistillate flowers of the pecan (those which develop into the nut clusters) are borne on the terminals of shoots which originate from some terminal buds more often from lateral buds near the terminals of the past season's growth.

3. Pecan pistillate flowers differentiate in the spring after growth has started.

4. The irrigation of bearing trees should probably be delayed in early spring until the pistillate flowers have formed.

5. In moist regions the turning under of a cover crop should probably be delayed in early spring until the pistillate flowers have formed.

6. Within the bounds of reason pecans may be "threshed" at harvest time without injury to the buds for the following season's crop.