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KERNEL-SPOT OF THE PECAN AND ITS CAUSE.

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CONTENTS.

DISTRIBUTION AND HISTORY.

The pecan kernel-spot is found throughout the southern pecan belt, including North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, and Texas. This trouble is not evenly distributed over these States, but is more prevalent in restricted localities. Its appearance is more or less sporadic; that is, it may be abundant one season and almost absent the season following.

The first published record of an investigation of pecan kernel-spot was in 1914 by Rand (*5*).[1] As set forth in this preliminary account, the fungus *Coniothyrium caryogenum* Rand was isolated from affected pecan kernels. Rand reported that by subsequent inoculation in healthy kernels with this fungus he was able to produce in a series of laboratory experiments during 1912 and 1913 typical pecan kernel-spot symptoms. Laboratory inoculations with this fungus were so largely positive that it was considered by him to be the cause of the disease.

Since Rand made no observations or investigations in the field in reference to pecan kernel-spot, he was unable to determine the time and manner in which the infection of his isolated fungus took place

[1] Serial numbers (italic) in parentheses refer to "Literature cited" at the end of this bulletin.

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under natural conditions. He gave no method of possible means of control. However, he suggests in a footnote that affected nuts should be gathered and burned, in order to lessen the chances of further spread of the disease.

Turner (*6*) reports a severe outbreak of kernel-spot throughout central and southern Georgia during the season of 1916. He, as well as several growers, observed that orchards having an abundance of kernel-spot were planted to cowpeas; also that these same orchards had a severe infestation of the southern stinkbug (*Nezara viridula* L.). He at first considered this to be possibly only a coincidence.

However, Turner conducted a preliminary experiment the following season to test the possibility of an association of pecan kernel-spot with punctures of sucking insects. His work, though conducted on a small scale and apparently with no check except nuts growing upon the tree not confined with bugs, indicated very strongly that these bugs bore either a direct or an indirect causal relation to the disease. No attempt was made at that time to determine what part the fungus *Coniothyrium caryogenum* Rand played in the cause of pecan kernel-spot.

Since one of the investigators above cited conducted his work entirely in a laboratory and from a pathological standpoint and the other did field work only, and from an entomological standpoint, and the two results were in a way contradictory or, at least, not corroborative, the growers were considerably confused as to the true cause of the disease and, therefore, as to the adoption of possible remedial measures. Consequently, the writer was urged to conduct an experiment combining both field and laboratory work to definitely determine which of the above-named investigators arrived at the correct conclusion regarding the cause of pecan kernel-spot.

ECONOMIC IMPORTANCE.

It is difficult to estimate the amount of damage and the extent of the prevalence of kernel-spot, owing to the fact that the evidences of the disease are not discernible until the shells of the nuts are removed.

Pecans from planted orchards do not ordinarily go to cracking establishments, but are widely distributed in small quantities in the shells to consumers, adding greatly to the difficulty of accurately estimating the proportion of nuts affected. While the nuts in some orchards will be entirely free from the trouble, in other orchards such a large percentage of the nuts will be spotted that the crops will be unmarketable.

The most serious losses have been reported to the writer by growers in southern Georgia, northern Florida, and Texas. The trouble was of a serious economic importance in southern Georgia in 1916 and again in 1921. Some growers in northeastern Florida reported an entire loss of their Curtis nuts in 1919 and 1920, but these same Florida growers reported the loss to be slight in 1921.

DESCRIPTION OF KERNEL-SPOT.

The spots are found only upon the kernels of the pecan nuts. Ordinarily no evidence of the trouble is apparent until the shell is removed. The writer has observed that when nuts are punctured by the Nezara before or soon after the nuts have attained their full growth small sunken places will be formed in the shucks of the nuts. (Fig. 1.)

Punctures may also be seen in the shell if an examination is made while the nut is yet green. The pecan shell is greenish white until the maturing processes start, and during this stage punctures appear as small brown spots less than 1 millimeter in diameter. These spots can be followed through the shell by shaving or scraping with a knife, and a typical spot will usually be found on the kernel immediately beneath it. These spots are not evident on the shell after the nuts have matured and developed the nut-brown color.

FIG. 1.—A pecan nut of the Curtis variety, showing indentations caused by early punctures of *Nezara viridula.*

The centers of the spots are always found upon the ridges or the edge of the pecan kernels, and never in the creases or on the inside surface of the halves of the kernel. (Fig. 2.)

In almost all typical kernel-spots one will find a small papilla, or pimplelike structure, in approximately the center of the spot. A magnified cross section of a spot through this pimplelike structure shows the epidermal cells and those cells lying immediately beneath this point as being ruptured. (Fig. 3.) Undoubtedly this small elevated place marks the point of entrance of the seta of the insect. The kernel spots are usually but not always sunken below the surface of the adjacent healthy tissues. They vary in size from 2 to 5 millimeters in diameter.

In color, the surface of the spots ranges from brown to black. Internally the affected tissues extend in approximate hemisphere beneath the surface and are frequently separated from the healthy tissues by a distinct brown layer. The internal part of the spots is almost white, pithy and porous, and apparently is not discolored or disorganized until organisms of decomposition gain admittance. The spots are decidedly bitter, but this bitter taste is not imparted to the unaffected portions of the kernel.

PRESENT INVESTIGATIONS.

The object of the series of experiments herein reported was to determine, if possible, the true cause of pecan kernel-spot and its relation, if any, to certain sucking insects and parasitic fungi.

In preparation for this work, 250 small wire cages were made of No. 16 screen wire. The wire was cut in strips and two edges were

FIG. 2.—Kernel spots on Schley pecans. The upper six views show the location of the spots on the ridges and edges of the halves. The three lower views illustrate kernels cut through the spots, showing the depth and extent of the injured portions. (Enlarged about one-fourth.)

clamped and soldered together, thus forming a cylinder 6 inches long and 4 inches in diameter. Cheesecloth was sewed to each end of the cylindrical cage, with the ends open, so that the cloth at one end could be tied around the limbs just back of the cluster of nuts, thus holding the cage in a position around the cluster. (Fig. 4.) The cloth at the other end of the cage was tied during the experiment, so that insects could be placed in the cage conveniently and also for any necessary examination of the nuts during the test.

The Schley and Curtis varieties were selected on which to conduct the experiment, owing to their apparant susceptibility to spotting.

The cages were placed in position during the last week of August and the first week of September, 1921, in the vicinity of Thomasville, Ga. From three to seven adult southern stinkbugs (*Nezara viridula* L.) [2] taken principally from cowpeas and tomatoes, were placed in each cage between September 1 and 15, except those used as checks. This species of insect (Fig. 5) was used on account of its abundance in the pecan belt of southern Georgia and also because of its frequent appearance on pecan nuts. The writer has also observed a species of Leptoglossus feeding upon immature pecan nuts, but has made no attempt to determine its relation to pecan kernel-spot.

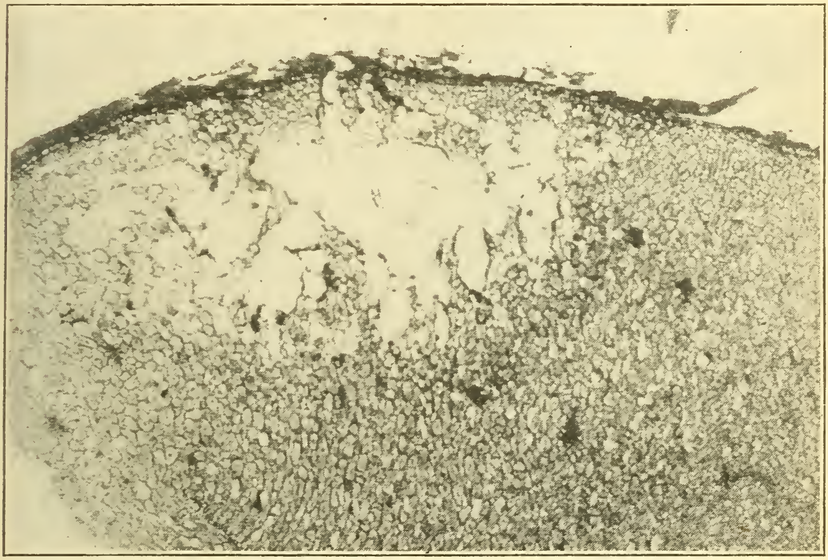

FIG. 3.—Highly magnified cross section of a kernel spot, showing the point of entrance of the insect's seta and also the greatly ruptured and collapsed cells caused by the extraction of the oil and other substances from the kernel.

At the time the bugs were placed in the cages the nuts of the Curtis variety were immature, but had possibly attained their full size. The Schley, being an earlier variety, was showing some evidence of maturing, as indicated by a harder shell and some slight discoloration of the shuck.

Since the only object of using the insects was to determine the relationship between insect punctures and kernel-spot, no attempt

[2] Determined by W. L. McAtee, acting custodian of Hemiptera, U. S. National Museum.

was made to determine at what period the spots may appear during the development of the pecan kernel. However, the bugs are found most abundantly on pecan nuts in September and October.

The experiment required no further attention until the nuts were harvested, except to replace with live bugs those that had died. The Schley nuts were harvested on October 16 and the Curtis nuts on November 19, and the results are shown in Table 1.

TABLE 1.—*Result of experiment showing number of pecan nuts spotted when caged with and without bugs.*

Variety.	Number of nuts.	Number with kernel-spot.	Percentage of kernels spotted.
Schley, without bugs (check)	36	0	0
Schley, with bugs	145	140	96.6
Curtis, without bugs (check)	55	0	0
Curtis, with bugs	168	166	98.8

In no case did the protected nuts, or checks, show any evidence of spotting, while a very large percentage of those confined with bugs were badly affected with typical kernel spots. Many of these individual nuts had 15 to 25 spots. In fact, some nuts were so badly spotted that almost the entire kernel was discolored and partially shriveled.

An attempt was made to produce kernel-spot artificially by puncturing the nuts with sterile needles. Several punctures were made in each of 12 nuts. This work was done during the first week in September at the time when most of the bugs were placed in the other cages. The shells of the nuts had hardened to such an extent by this time that several needles were broken while attempting to force them through to the kernels. It appears to be a remarkable feat that the bugs are able to pierce through the hardening pecan shells with their delicate mouth parts. These artificially punctured nuts were examined at harvest time as to the effect the punctures had upon the kernels. While these injuries were still evident as either open holes or holes partially healed over, they in no manner resembled the spots caused by the insect punctures.

In addition to the caged nuts, an examination was made of uncaged nuts growing upon the same trees. Of 375 Schley nuts thus examined, 9 per cent were spotted. Of 82 Curtis nuts examined, 8½ per cent had kernel spots.[3]

The result of the experiment recorded above demonstrates very conclusively that punctures by the southern stinkbug (*Nezara viridula*

[3] A smaller number of uncaged Curtis nuts were examined than the writer wished, as the crop that grew upon these trees was stolen soon after it was harvested. The nuts examined were gathered under the trees as a last resort.

L.) were in these cases either directly or indirectly the cause of kernel spots, with the evidence strongly favoring a direct causal relation. The southern stinkbug is a rather omnivorous feeder. Furthermore, it will feed upon any part of the plant, but shows a decided preference for fruit and seeds. Jones (*3*), Morrill (*4*), Watson (*7*), and Drake (*2*) have cited the insect as feeding on the following plants: Tomatoes, okra, mesquite, cowpeas, beans, most Cruciferæ, cotton, citrus, peach, grape, rattlebox, etc.

Turner reports that the southern stinkbug appears to attack cowpeas when these are present in preference to all other plants, either cultivated or wild. The writer and many growers have observed that the greatest prevalence of kernel-spot over large areas is found in or near orchards where cowpeas are growing.

It is a common practice of the pecan growers throughout the southern United States to plant cowpeas between the tree rows to be used either as hay or plowed under as a cover crop. When the hay is harvested or the pea vines die down naturally the bugs, if present, will migrate to the pecan nuts, often in great numbers.

Frequently kernel-spot will be found in great abundance on nuts that have grown in close proximity to gardens where tomatoes, okra, or other host plants are present. This is especially noticeable in orchards where some crop other than cowpeas has been planted.

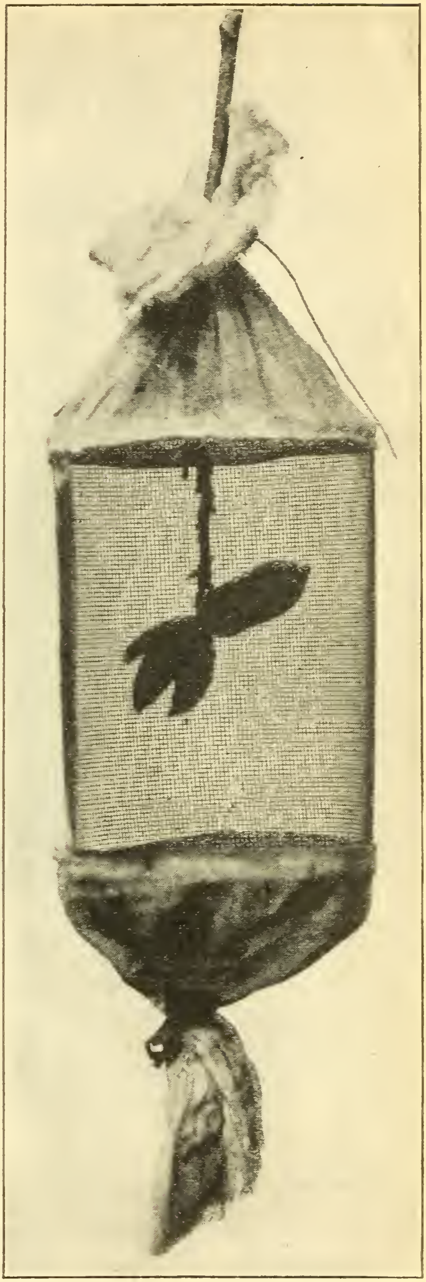

Fig. 4.—Type of cage used for confining insects with nuts.

SUPPLEMENTARY EXPERIMENT.

On September 15, 1921, 12 clusters of Curtis nuts were brought into the laboratory and placed in lantern-globe cages. Short stems were left on the clusters which were inserted in bottles containing water. Each cage had a strip of cheesecloth tied over its top.

From five to seven specimens of adult southern stinkbugs were placed in each of six of these cages. The other six clusters were reserved as checks, but were subjected to the same conditions, except that no bugs were confined with them.

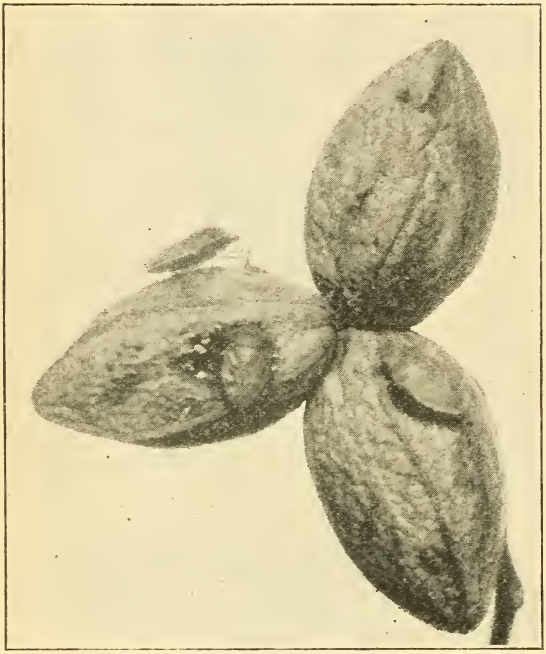

Fig. 5.—Southern stinkbugs (*Nezara viridula*) on pecan nuts of the Curtis variety. (Natural size.)

On September 18, or approximately 65 hours later, all the nuts were opened and examined. Of the 17 nuts confined with bugs, each had from 1 to 12 typical kernel spots. Of the checks, numbering 15, not the slightest evidence of kernel-spot was found on any. Cultures were made on beef agar from 10 spotted nuts of the first series. No growth of any kind was produced from these cultures.

This test alone would seem to prove that pecan kernel-spot is caused directly by the stinkbugs feeding upon the kernels or by injecting toxic substances into the tissues. It also indicates very strongly that the Nezara bugs do not regularly transmit parasitic microorganisms to the pecan kernels with their piercing mouth parts.

LABORATORY CULTURES OF KERNEL-SPOT.

Owing to the porous structure of the kernel-spots and their tendency to quickly absorb liquids, the method of soaking diseased plant tissues in a solution of mercuric chlorid in preparation for making cultures was found to be impracticable. The following method was used, giving very satisfactory results:

The surface of the kernels was wiped with absorbent cotton saturated with a 1 to 1,000 solution of mercuric chlorid. Then with a flamed scalpel the top of the spot was cut off. A section of the remaining spot with its adjacent healthy tissues was removed with the same scalpel. This was immediately transferred with a sterile needle to a Petri dish containing beef or corn-meal agar.

This method of technic eliminated the danger of killing by the absorption of mercuric chlorid any parasite or saprophyte that might happen to be in the affected tissues, and at the same time it reduced the chances of outside infection to a minimum. By employment of the above method numerous Petri dish cultures were made, in order to study the flora of the diseased spots.

The use of kernels having several spots whose internal structures were discolored very generally resulted in producing, in cultures, colonies of fungi and bacteria. This was to be expected, since several forms of saprophytic fungi and bacteria readily obtain entrance to plant tissues which have died from any cause. This is especially true of tissues which have died from mechanical injury, since they are not already inhabited with microorganisms. Eight forms of fungi and three of bacteria were quite constant, but no single one predominated except a bacterial form with a light-yellow color. This is possibly the same form referred to by Rand in his investigation previously cited.

Out of 58 spots taken from Curtis nuts that had been confined in cages with several specimens of *Nezara viridula* for a period of approximately two months, 35 produced colonies of bacteria, 19 grew fungi, and 4 remained sterile. It should be recorded here that the kernels of these nuts were so severely injured by the constant feeding of the bugs over an extended period that many blackened and internally discolored sunken spots resulted. The kernels were all dwarfed and shrunken, and the shucks of none of them opened normally. The check nuts and also uncaged nuts on the same trees were well filled, and their shucks opened at the normal time for the Curtis variety.

Cultures were made of 65 spots taken from moderately diseased Curtis nuts. Colonies of bacteria were formed in 28, 9 produced fungi, and 28 remained sterile.

Of spots taken from Schley pecans that were confined with bugs for a period of 4 or 5 weeks 111 were plated on corn-meal agar. Of these, 6 produced colonies of bacteria, 6 grew fungi, and 99 were sterile.

Of spots from Frotscher pecans, grown near Thomasville, Ga., 21 were cultured. Fungi grew on 9 of the spots, none produced bacterial colonies, and 12 were sterile.

Nuts were selected from the same Schley tree on which the cages were attached. Cultures were made of 48 separate spots. The result of this series was that 1 produced bacteria, 7 grew fungi, and 40 were sterile.

Curtis nuts sent to the writer from Blackshear, Ga., constituted the last series cultured. Of 88 spots that were plated, eight grew bacterial colonies, 20 grew fungi and 60 spots produced no growth. The record of these laboratory cultures is shown in Table 2.

TABLE 2.—*Record of laboratory cultures of the kernel spots of three varieties of pecans, in November and December, 1921.*

Date cultured, 1921.	Culture media.	Variety and source.	Number of cultures.	Number with bacteria.	Number with fungi.	Number sterile.	Date of final examination.
Nov. 30	Beef agar	Curtis from cages	17	14	1	2	Dec. 6.
Dec. 1	do	do	26	18	6	2	Do.
Dec. 2	Corn-meal agar	do	15	3	12	0	Dec. 7.
Do	Beef agar	Curtis not caged	65	28	9	28	Do.
Dec. 10	Corn-meal agar	Schley from cages	60	6	3	51	Dec. 20.
Dec. 12	do	do	51	0	3	48	Do.
Dec. 16	do	do	25	2	1	22	Do.
Dec. 20	do	Curtis, Blackshear, Ga.	25	2	3	20	Dec. 26.
Dec. 23	do	Frotscher, Thomasville, Ga.	21	0	9	12	Dec. 31.
Do	do	Schley, Thomasville, Ga.	48	1	7	40	Do.
Do	do	Curtis, Blackshear, Ga.	63	6	17	40	Do.
Total			416	80	71	265	

Table 2 indicates that of the 416 kernel spots cultured, 63.7 per cent produced neither fungus nor bacterial growth. The spots most generally producing growths in cultures were those taken from nuts badly injured by many insect punctures. Cultures made from spots that were only slightly or not at all discolored internally generally proved to be sterile.

Since no constant form appeared in the cases where organisms did develop, it was thought highly improbable that kernel-spot could be attributed to any of them, especially since most of the cultures remained sterile. Nevertheless, for the sake of completeness, from 25 to 50 inoculations were made in healthy pecan kernels, employing each of the different forms isolated.

After an interval of seven days, at a temperature of about 22° C., the kernels were all found to be softening more or less around the points of inoculation. None of the inoculations produced the mealy, dry spots which characterize pecan kernel-spot.

Since no form of Coniothyrium was developed from the cultures, an attempt was made to develop it from badly affected kernels by placing them for several days in a moist chamber. Only negative results were produced.

ANALYSIS OF RESULTS.

Of the 313 nuts confined with bugs in the field and 17 in the laboratory (a total of 330), 323 had typical kernel-spot and most of these, especially the Curtis, were very severely spotted. Of the 91 checks in the field and 15 in the laboratory, totaling 106 nuts, all were entirely free from any evidence of kernel-spot. The results reported seem to leave little doubt as to the association of pecan kernel-spot with sucking insects, therefore confirming the investigations of Turner (*6*).

It has been suggested that the insects involved may possibly transmit with their piercing mouth parts some microorganisms to the pecan kernels which cause the characteristic spotting effect. With this supposition in view, the cultural work in the laboratory was carried out. Of portions of over 400 separate spots that were planted on beef and corn-meal agar, more than half proved to be sterile. Rand's Coniothyrium was not observed in any of these cultures. If either a fungus or a bacterium was responsible for the spotting, it is logical to assume that a large percentage of cultured kernel spots would in suitable media develop the causal organism.

Cultures from affected kernels have shown that most of the spots are sterile, while among those developing fungus or bacterial growth no single type of organism has been found constantly associated with the diseased condition. Furthermore, typical kernel spots can be produced readily by confining stinkbugs with immature pecans. It is, therefore, also logical to conclude that pecan kernel-spot can be directly attributed to injuries inflicted by sucking insects, in this case to the southern stinkbug (*Nezara viridula*). The pathological result may be caused by the mechanical rupturing of the host cells, by the sucking up of plant juices, by injection of toxic substances into the tissues, or by the combined result of all three types of injury. No study was made to determine the pathological effect of the punctures, but Figure 5 would lead one to suspect that the injury is due to the extraction of juices from the tissues affected and to the mechanical injury of the cells.

CONTROL MEASURES.

The writer has done no work in view of demonstrating the practicability of controlling pecan kernel-spot. Dr. C. A. Van Duzee, an extensive pecan grower of Cairo, Ga., has been practicing clean cultivation in his orchard for several years. He reports that since this practice was adopted his nuts have been free from kernel-spot.

It is the writer's opinion that clean cultivation can not be recommended unless stable manure can be supplied to the orchard soil each year. Most southern soils are naturally deficient in organic matter, and unless supplied by means of growing cover crops for green manuring each year the trees will soon suffer.

The cowpea for many years has been the most popular cover crop with pecan growers. It is an easily cultivated legume and adds a large quantity of organic matter to the soil when plowed under. However, it has been observed by the writer, as well as by several growers, and also reported by Turner, that kernel-spot is almost always found more abundantly in orchards planted to cowpeas. This indicates that cowpeas may have to be discarded as a cover crop for pecan orchards and some other luxuriant-growing legume substituted. It appears at present that velvet beans, preferably the bunch variety, will largely take the place of cowpeas in bearing orchards. The velvet bean is a legume, a rank grower, and the writer's observations as well as other available information indicate that it is not a favored host for the stinkbugs. Kudzu and lespedeza are also possible substitutes for cowpeas as summer cover crops in pecan orchards.

The writer made a preliminary investigation during the pecan harvest during the season of 1921, attempting to learn in what section of the tree kernel-spot is most abundant. About 150 nuts were collected from each of five large Frotscher trees averaging from 30 to 40 feet high. The nuts were kept separate from the lower third, middle third, and upper third of the trees. The nuts were cracked and the kernels carefully examined for kernel-spot. Table 3 gives the results.

TABLE 3.—*Sections of pecan trees in which kernel-spot is most abundant.*

Tree.	Affected third (per cent).		
	Lower.	Middle.	Upper.
No. 1	54	46.6	24
No. 2	61.2	18.2	17
No. 3	49.9	19.8	7.6
No. 4	92	68.1	69.6
No. 5	47	0	2
Average	60.2	29.8	24

These results indicate that while the bugs are able to fly to the tops of comparatively high trees, they do most of their feeding on the lower limbs. The evidence procured in this study is not intended to be conclusive, but suggests that in case the growers have an abundance of kernel-spot they could possibly save a portion of their crop by first harvesting the lower part of their trees, keeping these nuts separate and cracking at home or selling to a cracking establishment, thus eliminating what may be a total loss.

It is logical to conclude that greater vigilance in protecting the pecan crop from kernel-spot will have to be observed during seasons following winters with no extremely low temperatures, as there will, no doubt, be a lower mortality of hibernating bugs.

While the information leading to an explanation of the irregular appearance of kernel-spot is meager, it is significant to record that two very severe occurrences of the trouble have followed winters with no extremely low temperatures.

There was a greater occurrence of kernel-spot during the seasons of 1916 and 1921 than during any other years on record for southern Georgia, while in this same region there was very little kernel-spot during the seasons of 1917, 1918, and 1919.

Table 4 shows the absolute minimum temperatures recorded by the United States Weather Bureau at Thomasville, Ga., covering the period from 1914 to 1921, inclusive, together with the prevalence of kernel-spot.

TABLE 4.—*Minimum temperatures and kernel-spot prevalence at Thomasville, Ga., 1914 to 1921, inclusive.*

Years.	Minimum temperature (°F.).	Prevalence of kernel-spot.	Years.	Minimum temperature (°F.).	Prevalence of kernel-spot.
1914–15	23	Abundant.	1918–19.	18	Small amount.
1915–16.	25	Do.	1919–20.	23	Abundant.
1916–17.	13	Small amount.	1920–21.	29	Do.
1917–18.	15	Do.			

The correlation of kernel-spot with temperatures may be only a coincidence. However, it is the writer's opinion that future observation will establish a record showing relationship of occurrence of kernel-spot with winters of no extreme low temperature.

While this investigation seems to clearly demonstrate that the inciting cause of pecan kernel-spot is due to insects, the pathological and physiological changes involved are apparently influenced by the condition of the nuts at the time the punctures are made. Bugs, confined in cages with mature pecan kernels that had been removed from the shells, were observed for several days by the writer. The bugs fed upon the kernels constantly, but produced no evident injuries or spots resembling kernel-spot. This suggested that spots can be produced by the bugs only when the tissues of the kernels are soft and the cell walls can easily be ruptured by the sucking effect of the insects involved.

The history of the investigation of pecan kernel-spot and its pathological effect upon the host plant is parallel in ways to the disease of carnation leaves that Woods (*8*) designated as stigmonose and proved by him to be caused by punctures of aphids, thrips, and red spiders. This carnation trouble had previously been studied by

Arthur and Bolley (*1*) who concluded that the disease was caused by a bacterium. In the case of pecan kernel-spot, Rand first concluded that the trouble was caused by a fungus, and it is now proved by the writer to be caused by insect punctures.

Since the initial cause of pecan kernel-spot is entomological and the result pathological, control measures can possibly best be worked out by considering both factors.

SUMMARY.

Pecan kernel-spot has been reported from North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, and Texas.

Owing to the fact that the spots can not be seen until the shells of the nuts are removed, and also because pecans from planted orchards are usually widely distributed in small quantities to consumers, the extent of the loss caused by kernel-spot is difficult to estimate. While the nuts in some orchards will be entirely free from this disease, in other orchards such a large percentage of the nuts will be spotted that the crop will be unmarketable.

Rand conducted a laboratory investigation of kernel-spot in 1912–13 and concluded that it was caused by *Coniothyrium caryogenum*.

The result of the work of Turner in 1917 indicated that the spots were caused by punctures of insects.

In the present investigation, 250 clusters of Schley and Curtis pecans were incased with wire cages. From five to seven specimens of southern stinkbugs (*Nezara viridula* L.) were confined in 200 cages during a period of approximately five weeks for the Schley nuts and two months for the Curtis. Fifty clusters were caged as the others, but no bugs were placed in them. These served as checks. At the end of the experiment none of the checks showed any signs of kernel-spot. Of those nuts caged with bugs, 97.6 were spotted with typical kernel spots.

Nuts with which bugs were confined in a laboratory developed typical kernel spots within 65 hours. No microorganism developed from these spots in Petri dish cultures.

Of 416 cultures made of kernel spots, 80 developed colonies of bacteria, 71 grew fungi, and 265 remained sterile.

No one organism was found constant in pecan kernels affected with kernel-spot. Eight species of fungi and three of bacteria were isolated in this experiment and considered to be saprophytic.

All 11 forms isolated from affected kernels were inoculated into healthy pecans. None produced spots resembling typical kernel-spot.

The cause of pecan kernel-spot is attributed entirely to the mechanical rupturing of the host cells, to the sucking of the plant juices, to the injection of toxic substances into the tissues, or to all three types of injury.

Possible control measures are suggested.

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