BULLETIN No. 180 DECEMBER, 1914

ALABAMA

Agricultural Experiment Station

OF THE

Alabama Polytechnic Institute

AUBURN

Leaf Spot and Some Fruit Rots of Peanut

By

DR. FREDERICK A. WOLF, Pathologist

1914
Post Publishing Company
Opelika, Ala.

STATION STAFF

C. C. THACH, President of the College.
J. F. DUGGAR, Director of Experiment Station and Extension.

AGRICULTURE:

J. F. Duggar, Agriculturist.
E. F. Cauthen, Associate.
M. J. Funchess, Associate.
J. T. Williamson, Field Agent.
D. J. Burleson, Assistant
O. H. Sellers, Assistant.
H. B. Tisdale, Assistant.

VETERINARY SCIENCE:

C. A. Cary, Veterinarian.
L. F. Pritchard, Assistant.

CHEMISTRY:

J. T. Anderson, Chemist, Soils and Crops.
C. L. Hare, Physiological Chemist.
S. Adler, Assistant.

JUNIOR AND HOME ECONOMICS EXTENSION:

* L. N. Duncan, Superintendent.
*Madge J. Reese, State Agent in Girls' Clubs.
* J. C. Ford, State Agent in Pig Clubs.
* I. B. Kerlin, Ass't. State Agent in Corn Clubs.
** Nellie M. Tappan, Home Economics.

BOTANY:

J. S. Caldwell, Botanist.
A. B. Massey, Assistant.

PLANT PATHOLOGY:

F. A. Wolf, Pathologist.

HORTICULTURE:

Ernest Walker, Horticulturist.
J. C. C. Price, Associate.
G. V. Stelzenmuller, Field Agent.

ENTOMOLOGY:

W. E. Hinds, Entomologist.
J. E. Buck, Assistant.
G. W. Ells, Field Agent.

ANIMAL INDUSTRY:

G. S. Templeton, Animal Husbandman.
E. S. Girton, Assistant.
N. A. Negley, Assistant. *
E. Gibbens, Assistant.

* In co-operation with United States Department of Agriculture.
** In co-operation with Alabama Girls' Technical Institute.

LEAF SPOT AND SOME FRUIT ROTS OF PEANUT.

(*Arachis hypogoea L.*).*

BY

FREDERICK A. WOLF.

The peanut is among the field crops whose culture throughout the Southern States is being especially emphasized at this time, when so many agencies are at work to promote the practice of diversified farming. It is only within the past fifty years that the peanut has been regarded as a commercial crop. While peanut growing was an industry of little significance at first, it has grown to such an extent that its products have a present valuation of more than ten million dollars annually. This increase is due in part to the fact that the peanut is a legume, as are the clovers, alfalfa, and cowpeas, all of which are invaluable in the enrichment of soil, in that they form nitrogen-gathering root nodules. Since legumes have a place in every rational system of rotation the peanut is being profitably employed in that place. Aside from this fact, there must also be taken into consideration the growing recognition of the many uses for this crop. While all kinds of live stock thrive on this plant, it is especially valuable in pork production. There are vast possibilities in the production of peanut oil for culinary purposes, especially by oil mills which cannot now operate throughout the entire year because of the shortage of cotton seed. There are many ways, aside from their consumption as roasted and salted peanuts, in which this crop is being utilized as a human food. Among these may be mentioned the use of peanuts in peanut flour, in peanut butter, in confections, and as a substitute for meat in vegetarian diets.

Because of the importance of the peanut, more or less attention has been given, during the past three years, to a study of some of the fungous diseases which affect it. None of the several troubles are to be regarded as a serious menace, within Alabama, to this growing industry; yet under certain conditions they may and sometimes do occasion considerable losses.

Among the organisms known to produce diseases of the peanut within the United States may be mentioned

---

* Report of investigations in progress under the Adams Fund.

Bacillus solanacearum, E. F. S., causing bacterial blight, *Phoma sp.*, stem rot, *Cercospora personata* (B. & C.) Ellis, leaf spot, *Neocosmospora vasinfecta* E. F. S., red rot, and *Sclerotium Rolfsii Sacc.*, sclerotial rot, Bacillus solanacearum is known to produce a wilt disease of potatoes, tomatoes, and egg plants and the Granville wilt of tobacco and has recently(1) been shown also to cause a disease of peanuts in North Carolina. The disease has thus far not been observed to occur within Alabama, however. It is not improbable that the same organism is concerned in a bacterial disease of peanuts, upon which studies looking toward control have been made in the Dutch East Indies(2). It might be noted that, according to the report on these studies, no benefit was derived from the addition of sulphur to the soil, and that water kept standing around the plants from one to four weeks had no preventive effect. Some little hope of success in control, however, attended the efforts at breeding a resistant variety.

A stem rot produced by a species of *Phoma* was observed at Auburn, Alabama, during May, 1912, upon the young plants which had developed from the peanuts left in the soil from the crop of the previous year. The outer tissues of the main stem become disintegrated near the ground level, extending some distance below, and small dark specks, the pycnidia or fruit bodies of the fungus, appear within these dead cortical tissues. The disease has not been observed subsequently and so no study has been made of it further than to isolate it in pure culture upon cowpea agar. Upon this medium it fruits abundantly and develops a loose smoky gray mycelium. It is possible that this *Phoma* has not been described, since no mention of *Phoma* on peanuts has been found in the literature of the diseases of this plant.

Cercospora personata causes the formation of brown spots on the foliage and stems. It is apparently co-extensive in distribution with the range of its host. Then too, it invariably occurs every year wherever this crop is grown, but the losses occasioned from it are not so serious as are those sustained from a leaf disease caused by *Septogloeum arachidis, Racib.*, which probably occurs in all parts of Asia and Africa where this crop is grown. This leaf disease is not known to occur, however, within the United States. Leaf spot is probably more serious than the rots of the peas themselves with which *Necosmospora vasinfecta* and *Sclerotium Rolfsii* are associated. Since *Cercospora personata* does not attack the peas its effect on them is indirect in consequence of the affected leaves. The three organisms last named and the diseases which they produce will be given further consideration in this report.

LEAF SPOT.

This disease of the peanut is very prominent within the United States and the West Indies(3&4)and is also known in India (5&6). It appears as small brown spots principally upon leaves, being especially noticeable upon mature plants, although young plants do not escape attack during wet seasons. It is caused by a parasitic fungus bearing the name, *Cercospora personata.* This fungus penetrates the tissues of the leaves and stems of the peanut plant and depends for its existence upon the material which the peanut has elaborated for its own growth and development. The affected leaves may be shed, thus decreasing the value of the hay crop. There can be no doubt that this shedding of the leaves and the presence of numerous spots on those which do not fall cause a considerable reduction in the yield of peas. The amount of injury done by the fungus will of course depend upon the stage of maturity of the peanut crop when the disease appears; and the severity of attack will, in turn, be governed by climatic factors. After the peanut has become infected with leaf spot there is no method of destroying the fungus and at the same time preserving the life of the peanut plant. It is evident therefore, that preventive rather than curative measures of control must be employed in combatting this disease.

Appearance of leat spot: Recognition of the symptoms of this disease are essential, first of all, to its successful prevention. The disease first appears as tiny, yellowish areas, indicating that the destruction of leaf tissue has begun. These increase in size more or less rapidly, dependent upon the conditions which influence the growth of the fungus, and become slightly elevated, chestnut-brown spots, evident on both leaf surfaces (Pl. 1). These spots are surrounded by yellow areas which pale out into the adjacent green tissue. They can be easily recognized at this stage even by a casual observer. The spots first appear on the older, lowermost leaves, and if conditions are favorable for their development, the infection spreads to adjacent leaves and plants. The number of spots on a single leaflet may be from one to twenty or more, and their mature size from one sixteenth to one quarter of an inch in diameter. Usually the original spots are circular in outline and remain distinct; the diseased areas on petioles and stems are elongated. However, the increase in size and number of spots may result in the formation of irregular areas, and the death and fall of the leaves in such quantities may occur as to make a considerable litter of leaves around the base of the plant. Plants have never been observed which were completely defoliated and killed by the disease, although, as is evident, the development of the peas may be seriously impaired. Plants of all ages are subject to attack at any time during the season of growth of the peanut. Young plants have been found to be affected as early as the middle of May, with new infections appearing until the plants were frozen late in October. As a rule the disease does not become severe under normal conditions until late summer. Greenhouse and field observations lead to the conclusion, when the spores of *Cercospora* are present on the leaves, that from five to seven days are required before the spots are evident to the eye. This is termed the incubation period of the fungus. Then after the disease has progressed twelve to fourteen days longer, the leaf spot organism reproduces itself.

Appearance of the fungus: Meanwhile the vegetative part of the fungus, which consists of a slender, branching network of filaments called the mycelium, has penetrated the leaf cells, withdrawn from them their contents and caused them to collapse and die, thus forming the brown spots. It is not known why the affected cells become brown, but it is very probable that the coloration is imparted as the result of an oxidation of the cell contents. A comparable brown coloration appears on peanut leaves as the result of the attacks of another leaf disease organism, *Septogloeum arachidis*, and from injuries inflicted mechanically or by insect punctures.

The reproductive structures consist in the beginning of dense aggregates of fungous filaments or hyphae below the epidermal cells. These aggregates become brown cellular structures, which by continued growth and the consequent pressure upon the epidermis rupture it and protrude cushion-like. Hence at this stage each brown spot is occupied by a number of tiny, yet prominently projecting, dark colored cushions or stromata, upon whose surfaces the spore bearing branches, the conidiophores, and the spores of conidia are borne (Pl. 5, Figs. 1 & 2.). The formation of a stroma such as is shown in Fig. 1, is not typical of Cercospora. Instead the portion of the fungus external to the host is typically merely a fascicle of conidiophores and conidia. These stromata may be as large as 100 microns in diameter, about twice the length of the conidia. They form for the most part on the lower surface of the leaves but it is not uncommon to find them on both surfaces of the diseased spot. The conidia are brown, club shaped bodies, divided into several cells by means of cross walls, as shown in Pl. 5, Figs 3 & 4. They vary in size from 30 to 50 by 5 to 6 microns and are sometimes twice this maximum length(7).

Germination of Conidia: Upon germination colorless hyphae arise from these cells not unlike those known to occur in other species of Cercospora, and in case this process occurs on the surface of a peanut leaf the hyphae penetrate into the interior of the leaf, producing infection and initiating a center for the development of a new spot. Thus if conditions for the growth of the fungus are favorable it may reproduce a new crop of conidia every three weeks. The cycle of development of the fungus may therefore be repeated many times during a growing season. Repeated attempts have been made to observe the entrance of the fungus into the leaf by using detached leaves placed in moist chambers. Unfortunately no cases of penetration have yet been seen.

Attempts to germinate the conidia in artificial media are not always successful as is quite generally the case with other species of the genus *Cercospora.* It is highly probable that the nature or composition of the media is not alone responsible for failure to secure germination, since it is even difficult to secure germination on detached leaves and on living plants. This inference is drawn from examples of this sort, only one of which is here given but it is typical of numerous tests which have been made. Healthy plants from the greenhouse were brought into the laboratory and placed in moist chambers on Sept. 3rd. at which time there was an abundance of leaf spot in the fields. Conidia from some of these leaf spots were placed in drops of water on the healthy leaves. Examinations of the contents of these drops at intervals during the next five days failed to reveal the germination of any of the conidia. No spots subsequently developed on the leaves. At the same time conidia from the field were placed in drops of water on potted peanut plants in the greenhouse. The plants were covered by bell jars about twenty-four hours to prevent the too rapid evaporation of the drops of water. No evidence of infection appeared in due course of time.

The fungus has several times been isolated in pure cultures upon artificial media by both the poured and planted plate methods. Among the different media upon which it has been grown are cowpea agar, sweet potato agar, oat meal agar, corn meal, sterilized peanut leaves and stems, and potato cylinders. Its habit of growth upon all culture media is essentially the same, resulting in the formation of small, compact, elevated colonies, a characteristic growth which seems to be very generally present in species of *Cercospora*. The colonies are smoky brown or olivaceous in color. The mycelium in old cultures consists of brown, thick-walled, oval cells with a densely granular content and with numerous oil droplets (Pl. 5, Fig 7). These cells are therefore chlamydospore-like in structure. Colonies in poured plates originating from single conidia will have attained a diameter of from one to three millimeters in twenty-one days. A new crop of conidia may be formed in these cultures within this length of time.

Infection experiments with *Cercospora personata*: Plants have been grown every season for three years in the greenhouse in benches and in pots for use in artificial inoculations. Pure cultures of the fungus and diseased leaves from the field have been used as the source of infective material. No injury was inflicted in making inoculations, contact of infective material and host alone being considered sufficient in case of truly parasitic forms. It may be said in regard to this work, omitting unnecessary and cumbersome details, that with few exceptions this work has all resulted in failure to secure infections. Plants grown under glass from September, 1912, to April, 1913, and around which a large number of badly diseased leaves had been worked into the top layer of soil at the time of planting, failed to develop any evidence of leaf spot. Investigations with species of *Cercospora* on other hosts have given comparable results. No adequate explanation, substantiated by experiments, of this failure to secure a reasonable number of successful inoculations is at hand. Apparently infection with *Cercospora* is in some manner correlated with certain moisture and temperature conditions. Townsend(8) says (*) in the case of *Cercospora beticola* on sugar beets that a uniform supply of moisture in the soil and a slight reduction of temperature retard the development of *Cercospora*. Heald and Wolf(7) have previously recorded a similar general observation upon the prevalence of leaf diseases caused by *Cercospora* as apparently correlated with drought and high temperatures. (**) South (4) finds that the vigor of attack of the peanut leaf spot organism in Dominica is probably due in part to excessive moisture and consequently he recommends good drainage as effective in its control. The ravages of *Cercospora personata* seem to attain their maximum severity after a dry period followed by excessively sultry weather, conditions which are very common in Alabama in August and continue into the early part of September.

---

* See page 16. "A constant and uniform supply of moisture in the soil has a beneficial effect in retarding an outbreak of leaf spot. Moisture reduces the temperature of the soil and of the atmosphere surrounding the beets and also prevents the leaves from wilting. It is noticeable that a slight reduction in temperature will retard the development of *Cercospora* and the production of spores."

** See page 23. "The excessive drought together with the high temperature produces a languid condition in the aerial parts of the vegetation and thus renders them more susceptible to the attacks of fungi of which the genus *Cercospora* is an abundant representative. While it is not known that any correlation exists between the presence of this genus and high temperatures yet it seems more than a coincidence since *Cercospora* diseases are not nearly so abundant in the Northern States even in arid places or during seasons of drought."

Spread of the Disease: *Cercospora personata* has thus far not been found to attack any other plant than peanut, so that its distribution cannot be accounted for by the presence of closely related hosts. The conidia, being light, are readily dislodged from the conidiophores as soon as they are mature. The distribution of these conidia from leaf to leaf on the same plant or to adjacent plants may therefore very readily be accomplished through the agency of the wind and rain or by the implements and animals used in the culture of the crop. All attempts to gain definite data showing that the wind is a carrier of the conidia have thus far been unsuccessful. Poured plates of sterile agar were exposed in the field near diseased peanuts, at different times of the day for varying lengths of time during August, 1913. Exposure was made by removing the cover from Petri dishes and placing them on the ground. Contrary to expectations no colonies of *Cercospora* developed in these plates. In spite of this negative evidence it seems reasonable to suppose that the conidia might be carried short distances by the wind. Further investigation of this point is necessary.

The spread of leaf spot to fields in which this crop has not previously been grown and to widely separated localities indicates that it has been introduced on the seed. The prevalence of leaf spot in lands not previously cultivated is not uncommon. No evidence has been gained that the seed themselves are diseased but the conidia may adhere to the surface of the shell or to the soil particles upon the shell. The method of curing peanuts commonly employed, by which they are stacked around a pole, makes it possible for the fungus to find lodgment on the peas. As a matter of fact conidia and conidiophores have been found in the centrifuged washings of peas. While it is not maintained that this is the principal means by which leaf spot is disseminated, yet it is an important practical point to be taken into consideration in control.

Hibernation or over-wintering of the fungus: In order to secure information as to the manner in which the leaf spot organism passes the winter, diseased leaves were collected during October and November, put into wire cages and allowed to remain out of doors. By May many of these leaves had become quite badly disintegrated; the diseased areas covered with minute cushion-like tufts of conidiophores seemed, however, to be more persistent than adjacent leaf tissues. When these leaves were kept moist as when placed in moist chambers, conidia were abjointed. Additional evidence that the fungus remains viable is to be found in the fact that leaf spots developed during May, on young plants, in a field which had grown a badly diseased crop the previous season. These plants developed from peanuts which had been left from the previous crop. This proves that the fungus remains alive in the decaying leaves and stems and affords indisputable evidence that infective material persists in the soil from one season until the next. The early attacks which reach the lower leaves from the soil presumably come from these conidia. Since many fungi possess, in addition to the conidial stage, a perfect or ascosporic stage which develops saprophytically during the winter and is of more or less importance in the hibernation of the fungus, careful searches have been made from time to time to discover a perfect stage in connection with *Cercospora personata.* Such a stage, which has been observed to be unnecessary in the over-wintering of this fungus, may rarely be found to occur, as indicated by certain structures which are now to be briefly described.

Spermagonia: If fallen peanut leaves are examined during November or December or subsequently during the winter, the diseased areas and immediately adjacent tissues will be found to be densely dotted with black bodies. Upon sectioning these bodies at different times throughout the entire winter it is found that some of them appear to remain as compact masses of sclerotia-like cells. From the diseased leaf material embedded in paraffin, sectioned and stained, it was observed that other of these apparently compact masses are thick-walled pycnidia. The pycnidia are commonly formed within the old stromata upon which the conidia were borne as evidenced by the presence of the old conidiophores Pl.5, Fig. 6. This is shown in Pl.3, Fig. 2, in which case two pycnidial cavities had formed within a single conidial stroma. They may also be formed anew within stromata which have not borne conidia as represented in Pl.5, Fig.8. In this case they are not to be confused with a saprophytic species of *Phyllosticta* not infrequently present and which is not genetically connected with *Cercospora personata.* The fact that these pycnidia occur within the old conidial stromata is taken as proof that the conidial stage, *Cercospora,* and the pycnidial are genetically connected.

Within this pycnidium are very minute, rod-like bodies, about one to two microns in diameter and about six times as great in length. They are formed on very slender, faintly staining branches, which arise from the deeply staining cells lining the inner wall of the pycnidium. The character of this pycnidium indicates that it is probably a spermagonium, and the minute size and method of formation of the pycnospores leads to the belief that they are to be regarded as spermatia. No evidence has yet been found, however, that they function as male cells. All efforts to germinate them have been unsuccessful. Nor is there evidence at hand that there are other stromata which develop into perithecia as is the case with *Mycosphaerella nigristigma*(9) on bird cherry. Higgins found in working with this form that there were two kinds of stromata from one of which the spermagonia and spermatia developed, and from the other the trichogyne-like structures within the developing perithecia. It is not improbable that there has been in *Cercospora personata* a complete degeneration of these corresponding female structures and that the ascosporic stage is evidenced only by the spermagonia as vestigial male parts. The truth of this conjecture can only be known after further investigation.

Identity of the Fungus: This fungus was first described by Berkeley(10) in 1875 from specimens collected by Ravenel along the Santee river in South Carolina. He named it *Cladosporium personatum* B. and C., and says that it "looks very much like a Puccinia." The conidial cushions might, to a casual observer, simulate rust sori. Ten years later Ellis(11) correctly identified it as a *Cercospora* and he named the organism *Cercospora personata* (B. and C.) Ellis. In 1902 Hennings(25) described another species, *Cercospora arachidis,* on peanut leaves, which differed(*) from *C. personata* as originally described by Ellis in that it formed elevated spots, the conidiophores were septate, and the conidia were shorter. It has been impossible to secure for comparison the type material of *Cercospora arachidis*

---

* Von *C. Personata* (B. & C.) durch die aufgeblasenen Flecke, septierten Hyphen, die kurzeren, 3-6-septierten Conidien der Beschriebung nach verschieden.

but in the light of the present studies there seems to be no reason for regarding it as distinct from *C. personata.* Ellis merely failed to mention the fact that the diseased areas caused by *Cercospora personata* are slightly elevated, and overlooked the fact that the conidiophores are not all continuous. The fact that dried specimens, which were consequently shrunken, were studied by Hennings may account for the smaller size of conidia. It is generally recognized too that the size of conidia of the same species may vary greatly under different conditions of growth, so that too much importance must not be attached to this diagnostic character especially in separating species of the same genus on the same or closely related hosts. *Cladosporium personatum* B. and C. and *Cercospora arachidis* P. Henn. are therefore regarded as synonymous with *Cercospora personata* (B. and C.) Ellis. This organism is not to be confused with *Septogloeum arachidis* Racib., which has not yet been reported to occur within the United States, but with which Chevallier (12) suggests that it is probably identical. *Septogloeum arachidis* is the cause of the "tikka" disease in India. This leaf disease, which singularly has been controlled by the introduction of exotic varieties, is frequently mistaken for the leaf spot (6) (*).

Control of leaf spot:

At least two rational points of attack in the control of leaf spot are suggested by the information at hand relative to the life history and development of *Cercospora personata.* The fact that it lives over on fallen leaves in the field from one season until the next as has been shown, and does not attack any other host plant except peanut suggests the observance of proper cultural practices. By this is meant (1) crop rotation, and (2) plowing under the decaying diseased material deeply, in case it is absolutely necessary to grow peanuts on the same land in successive years. No definite rotation system is laid down since disease control is only one of the ends to be attained in crop rotation. In order to facilitate their cultivation, however, peanuts should follow some crop which has been kept reasonably free from weeds. No observations are at hand

* l.c. Page 65. "At Surat there was no tikka, though a leaf spot caused by *Cercospora personata* (which is frequently confused with tikka but does little damage) was present.

showing how long a field infested with leaf spot should be in other crops in order that *Cercospora* may have perished through the lack of food. It is doubtless wise, however, to plant the land for at least two years in other crops before returning to a crop of peanuts.

If the infective material is plowed under deeply it should very greatly lessen the chances of infection to the succeeding crop. Experience has shown that fall plowing to a depth of fourteen inches very greatly reduces the amount of injury from sugar beet leaf spot(8) when successive crops are grown. For this reason deep plowing is recommended, but it is not considered that it will in any wise supplant crop rotation.

The fact that the organism adheres to the peas and that the seed may therefore serve as a means for its distribution suggests seed treatment. Seed treatment is also suggested by that fact that leaf spot has been observed to occur in fields not previously planted in peanuts. If the presence of the organism on the surface of the peas were the sole means of carrying it over from one season to the next and of introducing it into new localities, disinfection of seed would be entirely efficacious. For this purpose treatment by steeping the seed in copper sulphate or formaldehyde would be effective. One pound of copper sulphate or one pint of formaldehyde should be used to every twenty gallons of water, treating for fifteen minutes in the former case and for one hour in the latter. It is quite probable, however, that on any farm where the crop has been grown for several years all of the soil is more or less infested. In such cases it is very desirable that careful tests be made of the efficiency of seed disinfection. As an added protective precaution it would be well to shell treated seed before planting especially when the peanut is being grown in new localities.

Spraying: Since it is felt that the increased gains as the result of spraying would not sufficiently exceed the cost of labor and spraying materials, no experimental work along this line has been done. It is questionable whether spraying should be considered as a control measure even should it be found that one could secure perfect control. The extra labor and the difficulty of doing the work thoroughly and of making the applications at times when infection might be prevented would of themselves be prohibitive. It is doubtful if under the best of field practices one could get satisfactory results. Considerable experimentation with Bordeaux mixture and other fungicides resulted in failure to control the tikka leaf disease(13 & 14) of peanuts, which fact counterindicates spraying of *Cercospora*. South(4) reports little effect in peanut leaf spot control in Dominica from the use of Bordeaux mixture and lime sulphur preparations.

Refuse Disposal: As is the case with many other diseases it is advisable to give attention to the return of manure and other refuse to the field. When peanut hay has been fed to stock it is of course best as a precautionary measure to apply the manure to the field one or two years in advance of its being planted in peanuts. This should afford sufficient time for the fungus to perish in the decomposing refuse.

RED ROT.

This name is applied to a rot of the peas because of the presence on the surface of the shell of numerous red bodies. These red bodies are the perithecia or the fruits of a fungus, *Neocosmospora vasinfecta* E. F. S. The disease is not uncommon and was first noticed by the writer in the autumn of 1911. As far as can be learned there are no published accounts of the occurrence of this fungus on peanuts.

Historical: *Neocosmospora vasinfecta* was first described in 1899 by Smith(15)from a study of the wilt disease of cotton, okra, watermelon and cowpea. Since then the organism has been found by Butler(16) on the following crops in India: pigeon pea, cotton, indigo, gram (*Cicer arietinum*), sunn-hemp (*Crotalaria juncea*) and cowpea. The work of both Butler(16) and of Higgins(17) leaves little or no reason for believing that *Neocosmospora vasinfecta* is parasitic. The investigation of this organism therefore in connection with a rot of peanuts concerns itself with the microscopic characters and cultural behavior of the fungus in order to determine if it is identical with *Neocosmospora vasinfecta* or is a distinct species. The differences between the *Neocosmosporas* on all of the hosts before mentioned are so insignificant that they are all regarded as the same species.

Nature of the rot: There is no characteristic which will serve to identify this rot so well as the presence on the peas of the red perithecia. They may be formed both on the outer and on the inner surface of the shell. Commonly the tissues of the shell become brown and more or less disintegrated and collapsed as shown in Pl.2. When the decay of the shell has progressed sufficiently, the kernels themselves are also destroyed.

Pathogenicity of *Neocosmospora*: On Sept. 30. 1912, peanuts were found in the Experimental gardens of the Station which showed not the slightest trace of decay but were partially covered over with perithecia, as is illustrated by the peanut with the stem attached in Pl.2. Evidently the fungus had not obtained any of its nutriment from the peanuts upon which it was fruiting. This observation alone throws grave doubt on its parasitic nature. The fact, too, that it attacks only mature peas which cannot, strictly speaking, be regarded as living and that it has never been found on young peas indicates that it is not an active parasite. It is probably incapable of initiating decay in actively growing plant tissues, as is the case with many other organisms which occur in the soil and which decompose vegetable matter. Attempts at inoculating young peas on potted plants in the greenhouse have been unsuccessful. In making these inoculations pure cultures together with the media upon which the fungus was growing were introduced into the soil near young peas. It is of course realized that a large number of inoculation experiments should be carried out in order to furnish conclusive proof that the fungus is not parasitic, taking into account the fact that various races or strains of the same species may vary greatly in their capacity for producing infection, a criticism that is offered by Shear(18) in reference to the work by Butler(16) on the parasitism of *Neocosmospora*. In spite of the fact that the number of inoculations has been limited, when all additional evidence is taken into consideration there seems to be no reason for believing that *Neocosmospora* is parasitic on peanuts.

Identity of the peanut *Neocosmospora*: No difficulty is experienced in isolating the peanut organism in pure culture. Through the courtesy of Dr. H. W. Wollenweber, Washington, D. C., strain no. 1623 of *Neocosmospora vasinfecta* from cotton was obtained for comparison with the form isolated from peanuts. For the sake of brevity it may be said that the peanut fungus and strain no. 1623 are identical morphologically and in cultural characters and consequently it is maintained that the peanut rot organism should properly be referred to *Neocosmospora vasinfecta* E. F. S.

Something of the duration of the viability of *Neocosmospora* can be gained from the fact that the culture originally sent from Washington, D. C., February, 1913, was still alive September, 1914, as evidenced by growth in subculture from this original culture. This culture was being grown on a cotton stem and it was so old (the label bore no date) when it was received by the writer that the water had all evaporated. Dr. Wollenweber said in reference to it, at the time of dispatch, that he believed the fungus was still alive. Certainly at least two years must have elapsed since this culture was made.

Appearance of the fungus: It is not deemed necessary to repeat the descriptive accounts of the macroscopic and microscopic appearance and cultural characters of *Neocosmospora,* all of which are to be found in published accounts of Smith, Butler, and Higgins already referred to. No variation from these statements has been observed in the writer's studies except that he has never been able to demonstrate the presence of paraphyses. In Smith's original account(*) they are figured and described as about three times the diameter of the asci and attention is directed to the fact that they may be readily overlooked. Not infrequently, especially in young cultures, one finds large vacuolized asci, which simulate such paraphyses. Concerning these Wollenweber(**) says that the paraphyses cannot be mistaken for vacuolized asci, the latter of which have always in whole or in part a dense content. The paraphyses are very hyaline and very fragile and can best be observed directly from living material. They soon burst in water mounts, becoming invisible, and are destroyed in sectioning. He further adds that he has been able to demonstrate the presence of paraphyses in many Nectriaceous fungi which have been described as destitute of them. In order to overcome or at

* "Paraphyses present and often two or three times the diameter of the asci, each composed of several roundish, oblong, or irregular, thin-walled, loosely connected cells, nearly destitute of protoplasm and readily overlooked (unstained they are best seen by viewing the sections or crushed out material in water with a very narrow pencil of rays)."

** In litteris.

least to minimize this rapid disappearance of paraphyses in water mounts the writer attempted using solutions of different concentrations of cane sugar and of potassium nitrate. This too, has been without avail. A study from sectioned and stained material of the early development of the perithecia is still in progress and should determine the occurrence of paraphyses.

Control of red rot: Under normal conditions it is believed that red rot it not sufficiently severe to warrant special attention by the grower. When harvesting has been delayed, especially by rains, more or less red rot may be found to occur. For this reason, the peanuts should be harvested as soon as they are mature, as indicated to those familiar with the crop by a slight yellowing of the leaves and the drooping of the stems. Care must be taken to not dig them too early, for in this case many of the peas will not have become fully mature. The loss from red rot of a few of those which have matured early will by no means be equivalent to the loss in yield from failure to let the crop properly mature.

Any system of diversification or crop rotation which might be adopted upon the broad general principle that crop rotation, wisely planned, reduces fungous diseases below the point of causing serious losses, must take into consideration the fact that *Neocosmospora vasinfecta* is known to grow upon several of the field crops. It is also known to be capable of remaining dormant under laboratory conditions for at least two years.

SCLEROTIAL ROT.

A very considerable number of field and truck crops together with many cultivated flowers are subject to the ravages of one of the sclerotial fungi. This parasite, which is so omnivorous in its habit, bears the name, *Sclerotium Rolfsii* Sacc. The fungus was first described in 1893(19) as *Sclerotium sp.* and it was not until 1911(20) that the binomial *Sclerotium Rolfsii* Sacc. was established. Like *Rhizoctonia* it is capable of producing a damping off of seedlings. The character of the sclerotia themselves and of the mycelium of these two fungi renders impossible an error in the diagnosis Each, of course, is also capable of producing a condition known as root rot of adult plants. A species of

Rhizoctonia apparently *Rhizoctonia solani* Kuehn., attacks peanuts in India (21). This fungus is apparentlly identical, in that it agrees exactly in morphological features, with one growing also upon cotton in India. It might be added that thus far *Rhizoctonia* has not been observed on peanuts in the United States, although it is not unusual that cotton seedlings succumb to a damping off disease associated with *Rhizoctonia*.

Appearance of the Disease: This disease appears to confine its attacks to the roots and peas. Usually there is no indication of the disease in the appearance of the above-ground parts. When, however, the plants are dug a greater or less proportion of the peas will be found to have decayed. It is not uncommon for half of them to have been thus destroyed. There is nothing so characteristic of this rot as the presence of fine mycelial strands upon the surface of the shells and of numerous, hard, smooth, spherical bodies about as large as mustard seeds, which are formed on these strands. Some of these bodies will appear white, some fawn, and some shades of brown, depending upon their stage of maturity. These bodies are the sclerotia and it is by means of these sclerotia that the fungus is able to maintain itself during unfavorable conditions for growth such as cold weather and seasons of drought. Sclerotia may be formed on the outer surface of the shell but they are far more numerous within the shell. The kernel or embryo plant will have been prevented from developing or will have entirely been destroyed dependent upon the stage of growth of the pea at the time of attack. The vascular tissues of the shell are most resistant to decay and consequently are most persistent. The rot may be in the nature of a wet rot or a dry rot, apparently as other organisms of decay are associated with the *Sclerotium*.

Appearance of the fungus: No difficulty is experienced in obtaining this fungus in culture. The sclerotia need only be transferred to some nutrient substratum and a copious mycelial growth soon develops. Cultures upon media of widely different composition resulted in little difference in appearance of the fungal growth. Growth appeared to be much more vigorous on steamed oat meal and corn meal than upon nutrient agar (Pl. 4.) prepared with various vegetable extracts. There is a much more copious development of whitish mycelium and sclerotia are more numerous. Representative slant tube cultures of the same age on oatmeal and cowpea agar, produced by actual count 636 and 49 sclerotia respectively. Upon the former of these media a luxuriant growth of whitish mycelium occurs, and within a week the beginnings of the sclerotia are evident. They are at first visible as minute, white tufts. These gradually enlarge, becoming 500 to 800 microns in diameter, and change to brown spherical masses with smooth shiny exteriors. Upon desiccation this color deepens and the surface becomes wrinkled. The sclerotia develop singly although not infrequently they become united. In section young sclerotia appear to consist of fairly uniform plectenchymatous cells with a slight differentiation into cortex. In mature sclerotia there is a very apparent differentiation into cortical and medullary portions, Pl. 3, Fig. 1. The cell walls of the cortex are thick and brown in color, while the medulla consists of less compact, almost colorless cells.

There is nothing distinctive about the vegetative hyphae. The absence of the characteristic constrictions at the points of origin of the branches and of the characteristic transverse septa serves to distinguish it with certainty from Rhizoctonia. Old hyphae may contain numerous granules and oil globules, Pl. 5, Fig. 10.

Inoculation experiments: Since there is no doubt from field observations of the pathogenicity of *Sclerotium Rolfsii* on peanuts no special effort has been made to study the infection of this legume. Instead preliminary attempt has been made to learn if other legumes, more or less commonly grown and which might be substituted for peanuts in a rotation system, are equally subject to attack. For this purpose soil sterilized with formaldehyde, one part to fifty parts of water, was used. The seeds were inoculated at the time of planting by stirring them in a small quantity of water in which had been macerated vigorous cultures of *Sclerotium*. The sclerotia and mycelium were thus adhering to the surface of all seeds. Soy, Lyon, Yokohoma, and velvet beans, hairy vetch, crimson clover, and cowpeas of the varieties, New Era, Groit, Brabham, and Iron were subjected to this test. Within two weeks after the date of planting all of the crimson clover, velvet beans, and New Era and Groit cowpeas had succumbed to damping off, which on examination proved to be caused by *Sclerotium Rolfsii.* Many of the young plants of hairy vetch, Soy, Lyon, and Yokohoma beans perished in like manner, but a few of each of them grew to maturity. *The Brabham and Iron cowpeas remained to maturity apparently free from attack.* These results are considered only as indications and the tests should not only be repeated but should also be carefully conducted under field conditions.

Comparison with other forms: Some of the sclerotial fungi are known to have spore forms. Thus far, however, none have been observed in connection with *Sclerotium Rolfsii.* Cattaneo (22) reported from his studies of Sclerotium Oryzae on rice that spherical spores are formed within a large central cavity of the sclerotium. The later investigations of Shaw (24) upon the same organism do not bear out the correctness of this observation. His account and the microphotographs which accompany it show that these sclerotia are solid masses of fungous tissue, as are those of *Sclerotium Rolfsii* (Pl. 3, Fig. 1.). Stout (23) finds that *Sclerotium rhizodes* is actively parasitic on the aboveground parts of several common grasses, but is only slightly so on the roots, where it might be considered as entering into a symbiotic relationship. No such mycorhizal relationship exists in the case of the *Sclerotium* on peanuts.

Control: The fact that such a great variety of plants are subject to attack by this fungus must be taken into account in planning measures looking toward its control. Sclerotia exposed to desiccation in the laboratory from September to April were still viable, as shown by the formation of mycelium and new sclerotia when transferred to oat meal agar. How long these sclerotia can perennate in the soil where conditions are less rigorous is of course unknown. It is therefore to be expected from these two facts that all remedial measures will be unsuccessfully employed.

It might be possible on a small scale to sterilize the infested soil by the use of chemicals and heat. This is of course impractical under field conditions for a crop whose value is no greater than that of peanuts. Fortunately the disease is not at present to be regarded as the cause of much damage. In case it does become generally present and sufficiently severe, attention should be directed to the breeding of resistant varieties, in the hope that peanuts may be found which exhibit permanent resistance to the attack of this fungus.

SUMMARY.

Three fungous diseases of peanuts within Alabama are considered in this report, leaf spot, *Cercospora personata* (B. & C.) Ellis, red rot, *Neocosmospora vasinfecta* E. F. S., and sclerotial rot, *Sclerotium Rolfsii* Sacc.

The most striking symptom of the leaf spot disease is the presence of chestnut brown areas on leaves, petioles, and stems. Considerable defoliation results with consequent impairment of the hay crop and indirectly of the yield of peas. The fungus forms numerous, elevated, cushion-like stromata, most commonly on the lower leaf surface. No other legume seems to be attacked by this organism. Conidia have been found adhering to the surface of the shell and it is possible that the disease is introduced into new localities by this means. *Cercospora personata* has been found to hibernate in the conidial stage on diseased leaves left lying in the field, as evidenced by a new crop of conidia upon old stromata. The retention of viability in the diseased leaves is further shown by the presence of leaf spot in the spring upon the young plants growing in fields in which the disease was known to occur during the previous season. Climatic factors influence the severity of attack, hot dry weather followed by sultry humid weather being especially favorable to the production of leaf spot within Alabama. No ascosporic stage has yet been found. Spermagonia may form within conidial stromata, thus showing their genetic connection with the Cercospora. They may also be formed in stromata which have never borne conidia. The spermatia have not been observed to germinate or to function as male cells. A sexual stage may rarely occur, and the spermagonia are therefore regarded as vestigial.

Crop rotation and seed disinfection are recommended as preventive or palliative measures. Spraying is regarded as impractical. Attention may well be given to sanitary measures relative to the disposal of waste.

The presence of bright red bodies on the brown de-

caying shells serves to identify the red rot disease. The fungus has apparently not been reported on this crop previously. It is morphologically identical with and exhibits the same cultural appearance as *Neocosmospora vasinfecta* E. F. S., on cotton. It is not parasitic on peanuts as evidenced by the fact (1) that it has been found fruiting on mature peas with no invasion and decay of the tissues of the shell; (2) that it has never been observed on immature peas; and (3) that inoculations with pure cultures on young peas have thus far been unsuccessful. Digging the crop when the peas are mature, without delay, should aid in diminishing the amount of red rot, although the disease has never been observed to be the cause of any considerable losses. Consideration should be given in a diversification system to the occurrence of this organism on other hosts and to the fact that it is able to live in culture under laboratory conditions for at least two years.

Sclerotium Rolfsii Sacc. is a soil inhabitant which is actively parasitic on a great variety of cultivated plants. The sclerotial disease of peanuts caused by this fungus appears as small, brown bodies about the size of mustard seeds formed for the most part within the decaying peas. Shell and kernel are both destroyed, the fibrous part of the shell being most resistant to decay. The sclerotia are solid masses of fungous tissue. Tests of its parasitism upon other legumes shows that it will attack seedlings of crimson clover, hairy vetch, Soy beans, Yokohoma beans, Lyon beans, velvet beans, and Groit and New Era cowpeas. Brabham and Iron cowpeas escaped attack in the few tests made. Since no remedial or palliative measures are known it is fortunate that this disease is not known to cause widespread damage.

BIBLIOGRAPHY.

1. Fulton, H. R. and Winston, J. R. A disease of peanuts caused by Bacillus solanacearum. Abstract in Phytopath. 3: No. 1, 72-73, 1913.
2. deJong, A. W. K. Studies on bacterial disease of peanut. Dept. Landb., Nijv. en Handl. (Dutch East Indies) Meded. Agr. Chem. Lab. No. 3, 56-59, 1913.
3. South, F. W. Reports on some pests and diseases in the West Indies for the year 1909-1910. I. Fungous diseases. West Indian Bul. 11: No. 2, 73-85, 1911.
4. South, F. W. Fungous diseases of ground nuts in the West Indies. West Indian Bul. 11: No. 3, 157-160, 1911.
5. Barber, C. A. Report of the Government Botanist, Madras Dept. Agr. Rep't. 1905-1906, 43-48.
6. Butler, E. J. Tikka disease and the introduction of exotic ground nuts in the Bombay Presidency. Agr. Jour. India 9: No. 1, 59-70. P1. 1, 1914.
7. Heald, F. D. and Wolf, F. A. A plant disease survey in the vicinity of San Antonio, Texas. U. S. Dep't. Agr. B.P.I. Bul. 226: 1-129. Pls. 19, Fig. 2, 1912.
8. Townsend, C. O. Leaf spot, a disease of the sugar beet. U. S. Dep't. Agr. Farmers' Bul. 618: 1-18, Figs. 10, 1914.
9. Higgins, B. B. Life history of a new species of Sphaerella. Mycol. Centrb. 4: 187-193, Figs. 14, 1914.
10. Berkeley, M. J. Notices of North American fungi. Grevillea 3: 106, 1875.
11. Ellis, J. B. Journal of Mycology 1:63, 1885.
12. Chevallier, A. Diseases and enemies of the peanut. Jour. Agr. Trop. 13: No. 141, 72-76, 1913.
13. Butler, E. J. Experiments in treating ground nut leaf disease. Agr. Jour. India 3: No. 2, 171-172, 1908.
14. Kelkar, G. K. Ground nuts in Bombay Deccan. Bombay Dep't. Agr. Bul. 41: 1-17, 1911.
15. Smith, E. F. Wilt disease of cotton, watermelon, and cowpea. U. S. Dep't. Agr. Division of Vegetable Physiology and Pathology. Bul. 17: 1-53, Pls. 10, 1899.

16. Butler, E. J. The wilt disease of pigeon pea and the parasitism of Neocosmospora vasinfecta, Smith. Memoirs Dep't. Agr. India 2: No. 9, 1-64, Pls. 6, 1910.
17. Higgins, B. B. Is Neocosmospora vasinfecta (Atk.) Smith the perithecial stage of the Fusarium which causes cowpea wilt? N. C. Agr. Exp. Sta. Annual Rep't. 32: 100-116, Figs. 16, (1909), 1911.
18. Shear, C. L. and Wood, Anna K. Studies of fungous parasites belonging to the genus Glomerella. U. S. Dep't. Agr. B.P.I. Bul. 252: 1-110. Pls. 16, 1912.
19. Rolfs, P. H. Annual Report of the Florida Agr. Exp. Sta. for 1893.
20. Saccardo, P. A. Annales Mycol. 9: 257, 1911.
21. Shaw, F. J. F. Morphology and parasitism of Rhizoctonia. Memoirs Dep't. Agr. India 4: No. 6, 117-153, 1912.
22. Cattaneo, A. Sullo Sclerotium Oryzae, nuovo parassita vegetale. Archiv. d. Lab. Crittogamia d. Uavia. Vol. 2 and 3: 75, 1879.
23. Stout, A. B. Sclerotium disease of blue joint and other grasses. Wis. Agr. Exp. Sta. Research Bul. 18: 207-253, Pls. 8, 1911.
24. Shaw, F. J. F. A sclerotial disease of rice. Memoirs Dep't. Agr. India 6: No. 2, 11-23, Pls. 3, 1913.
25. Hennings, P. Fungi paraensis II. cl. Dr. Huber collecti. Hedwegia 41: (18) 1902.

EXPLANATION OF PLATES.

Plate 1—Leaf spot of peanuts. *Cercospora personata,* (B. & C.) Ellis, showing characteristic size, shape, and number of the diseased areas. Note also the numerous small spots.

Plate 2—Red rot of peanuts, *Neocosmospora vasinfecta,* E. F. S. The darkened portions of the shell are decayed and the perithecia or fruit bodies of the fungus are present on the decayed areas. They are most easily seen on the pea which is entirely dark. The pea with the stem attached is covered with perithecia at the distal end, but there is no decay of the shell.

Plate 3, Fig. 1—Photomicrograph of a section of *Sclerotium Rolfsii* Sacc. The cortical portion is denser than the medullary, with no evidence of a central cavity.

Fig. 2—Photomicrograph of spermagonial stroma of *Cercospora personata*. The conidiophores have persisted above, and two spermagonia are developed within the stroma.

Plate 4—*Sclerotium Rolfsii* in Petri dish, planted culture. Many sclerotia are formed attached to the cover of the dish as shown in the upper figure, especially when the fungal growth has been profuse.

Plate 5, Fig. 1—Conidial stroma of *Cercospora personata* of the projecting cushion-like type which bears numerous conidiophores, X 350.

Fig. 2—Conidial stroma of *Cercospora personata* which is more nearly like the typical condition for other species in which a small cluster of conidiophores project usually from a breathing pore, X 350.

Fig. 3—Conidia from leaves, X 350.

Fig. 4—Conidia from pure culture, X 350.

Fig. 5—Portions of the cortex and medulla of *Sclerotium Rolfsii*. The cortex consists of compact thick-walled cells, the medulla of densely woven filaments, X 350.

Fig. 6—Spermagonium of *Cercospora personata* borne in a conidial stroma. The conidiophores are still present. The spermamagonia are minute rod-like bodies borne on slender sterigmata, X 425.

Fig. 7—Mycelium of *Cercospora personata* in old cultures forming chlamydosphore-like cells, X 350.

Fig. 8—Spermagonium of *Cercospora personata* developed in a stroma which has not previously borne conidia, X 425.

Fig. 9—Germinating ascospores of *Neocosmospora vasinfecta*, twenty hours old, X 240.

Fig. 10—Mycelium of *Sclerotium Rolfsii*. Note that the hyphae are not Rhizoctonia-like, X 350.

Fig. 11—Ascus and ascopores of *Neocosmospora vasinfecta*. The spores are spherical to broadly elliptical with a thick wall, X 350.

Fig. 12—Perithecium of *Neocosmospora vasinfecta*, X 175.

PLATE I

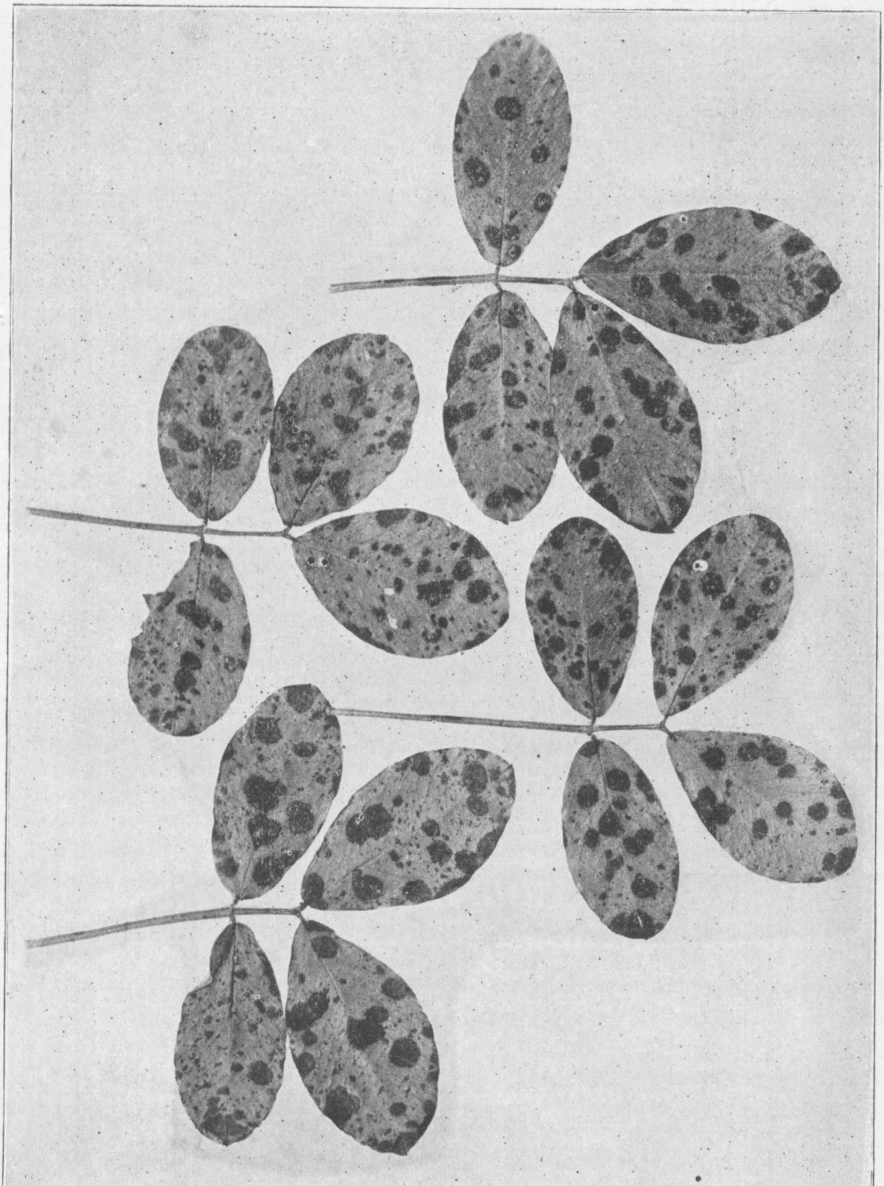


PLATE II

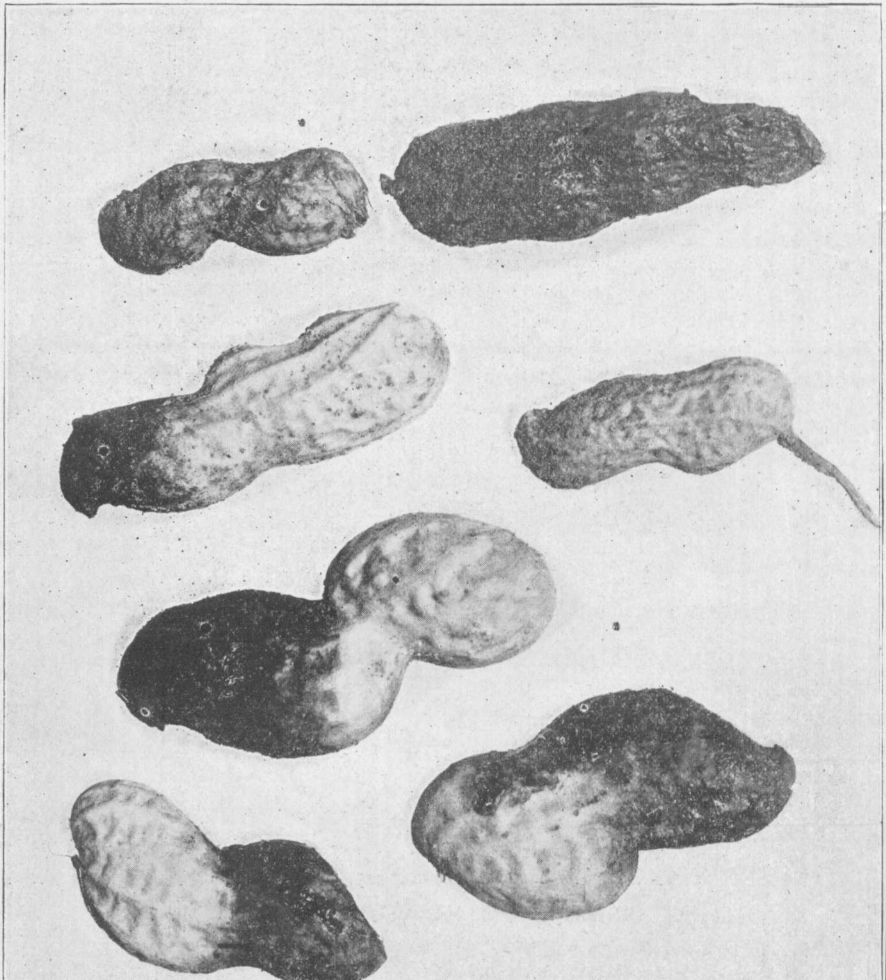
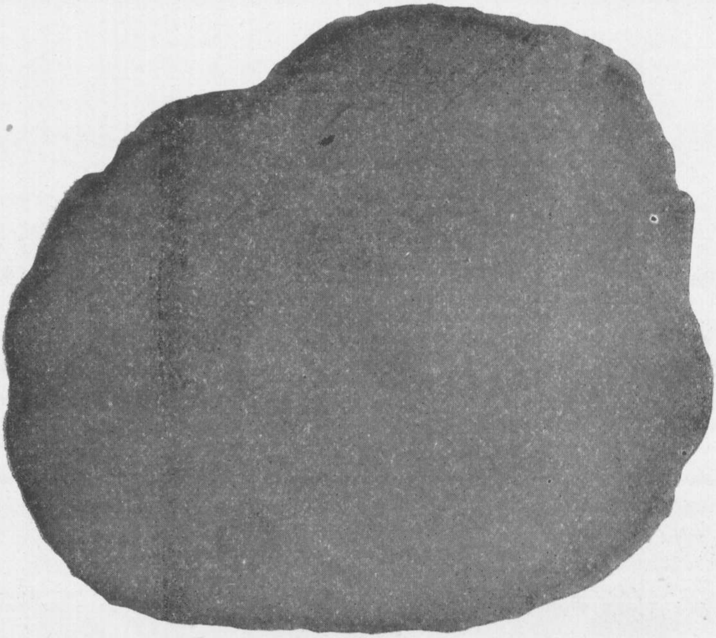
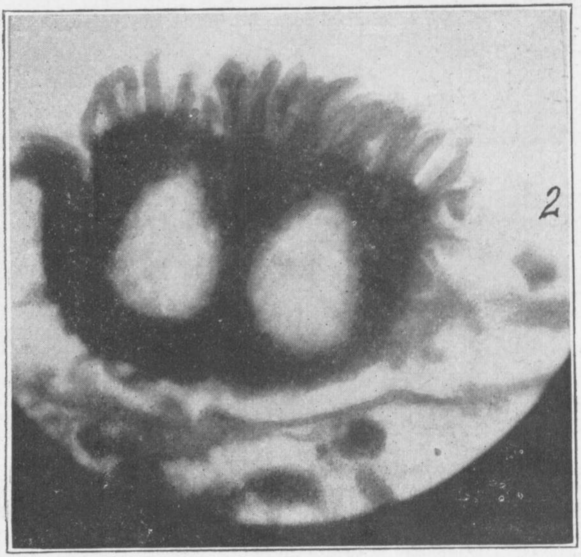


PLATE III



1



2

PLATE IV

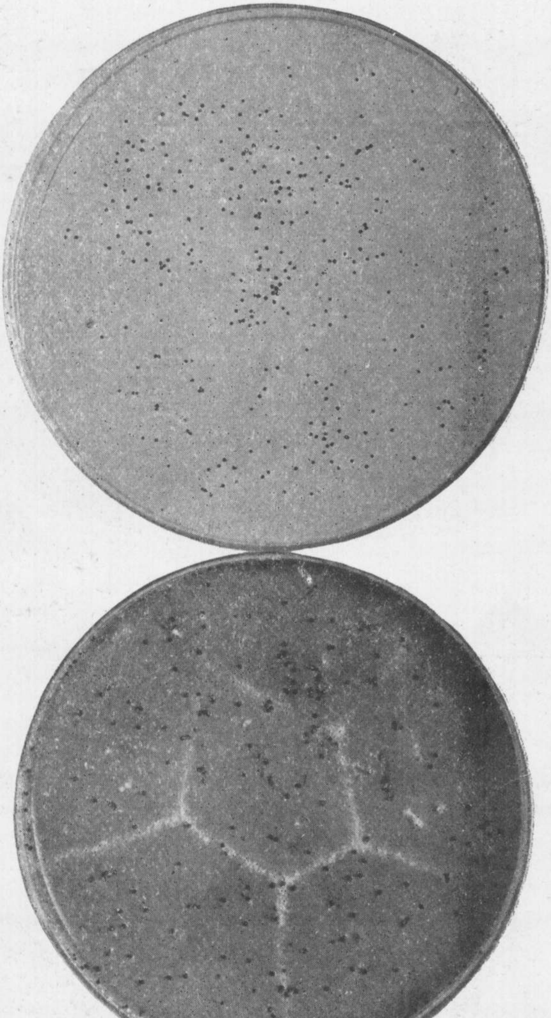


PLATE V