PIGEON PEA ANTHRACNOSE [1]

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INTRODUCTION

The pigeon pea, or gandul (*Cajan cajan* (L.) Millsp.) (*Cajanus indicus* Spreng.), is an important food crop in Porto Rico. The pods are picked before they mature, and the fresh, green seeds have a high nutritive value and may be found in the local markets almost throughout the year. The leaves and pods are eagerly eaten by all classes of livestock, and the crop is highly recommended as forage for cattle.

During the past three years pigeon peas at the station have been considerably damaged by a spotting of the pods, accompanied by molding and decay of the seeds. In general appearance the disease is strongly suggestive of bean anthracnose, and the term "anthracnose" was applied to it even before the causal organism was determined. Examination of the available literature failed to reveal any reference to a pod disease of pigeon peas, and the serious damage wrought by it seemed to warrant investigation to determine the cause.

The disease is rather generally distributed over the island, especially in the western section. Infected pods were received also from Fajardo, on the eastern coast, where the disease is said to have caused considerable loss.

SYMPTOMS OF THE DISEASE

Anthracnose of pigeon pea may be recognized by the appearance of spots or blotches on the leaflets, pods, and seeds. On mature leaflets the spots are dark brown, definite, somewhat angular, and usually delimited by veinlets. The spots are most conspicuous on the superior surface of the leaflet. With age the spots become reddish brown and often slightly zonate, sometimes coalescing and covering a large portion of the leaf surface. Single spots range in diameter from 2 to 7 millimeters. Infections occurring during the rainy season may cause spotting on any part of the leaf blade, whereas infections occurring during dry weather usually affect the midvein and extend into the leaf tissues on both sides. The spots are very similar to those caused by *Vellosiella cajani* (Henn.) Rangel (*Cerocspora cajani* Henn.), and a microscopic examination is often necessary to distinguish between them.

Infection of very young leaflets usually results in a blackening and shriveling of the veins, resembling lesions on *Phaseolus vulgaris* infected with *Colletotrichum lindemuthianum* (Sacc. and Magnus) B. and C. The leaves fall prematurely.

Circular to irregularly oval spots are formed on the pods. At first the spots are almost black, but later the center turns a dark brown and becomes surrounded by a narrow very dark purplish border.

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(Fig. 1.) When moisture is abundant the centers become salmon colored and mealy in appearance, owing to the formation of masses of conidia. The pod shows no cankering or pitting such as occurs with infection of garden beans by *Colletotrichum lindemuthianum*, probably because of the tough, chartaceous character of the pigeon pea. Infection of very young pods results in shriveling, twisting, and deformation, and in most cases the pods die and drop.

Injury of the seed varies often in the same pod from a shriveling caused by pod infection in the region of the placenta to complete decay resulting from direct invasion by the fungus. In the latter case white tufts or a covering of white cottony mycelium usually may be seen. (Fig. 2.)

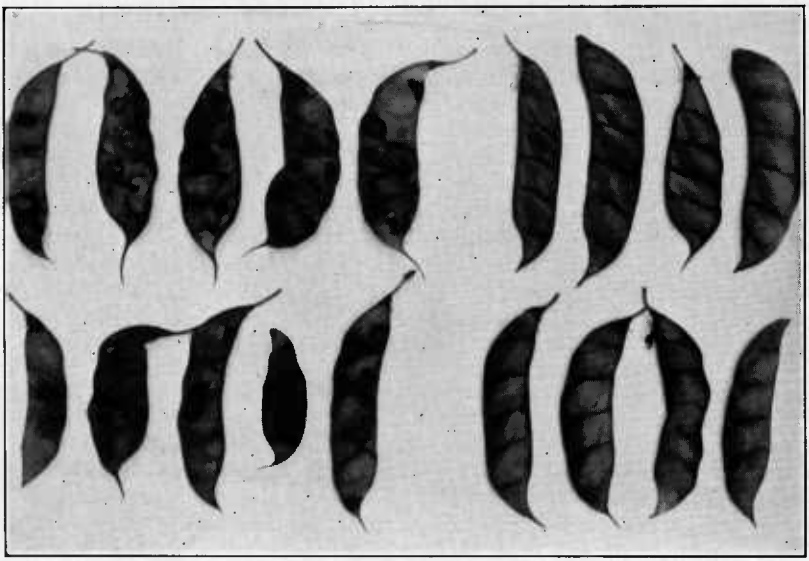

FIG. 1.—Left, pigeon-pea pods infected by anthracnose due to *Colletotrichum cajani*. The spotting and distortion of the pods is the most conspicuous symptom of the disease. Right, healthy pigeon pea pods

LOSSES CAUSED BY THE DISEASE

Damage attributable to anthracnose varies with the purpose for which the crop is to be harvested. When the pods are picked in the green stage the loss is much smaller than when they are allowed to ripen on the plant. Early in the dry season of January, 1925, 629 green pods were picked at random from plants in the station grounds. Of these 544, or 86.5 per cent, were found to be infected with anthracnose. The pods were mostly at the green-pea stage, at which time they are edible. The peas were shelled and graded as marketable or unmarketable; that is, discolored, moldy, decayed, or aborted. Table 1 shows the number of marketable seeds in diseased and healthy pods.

The 544 diseased pods yielded 1,342 marketable seeds; whereas, from the same number of healthy pods a yield of 2,118 seeds would be expected. The loss attributable to the fungus is 776 seeds, or 36.6 per cent.

In addition to the above easily calculated loss, there is the loss of young infected pods, which fall soon after the blossom drops. No exact data have been obtained on this kind of loss, but it is certainly considerable during the rainy season.

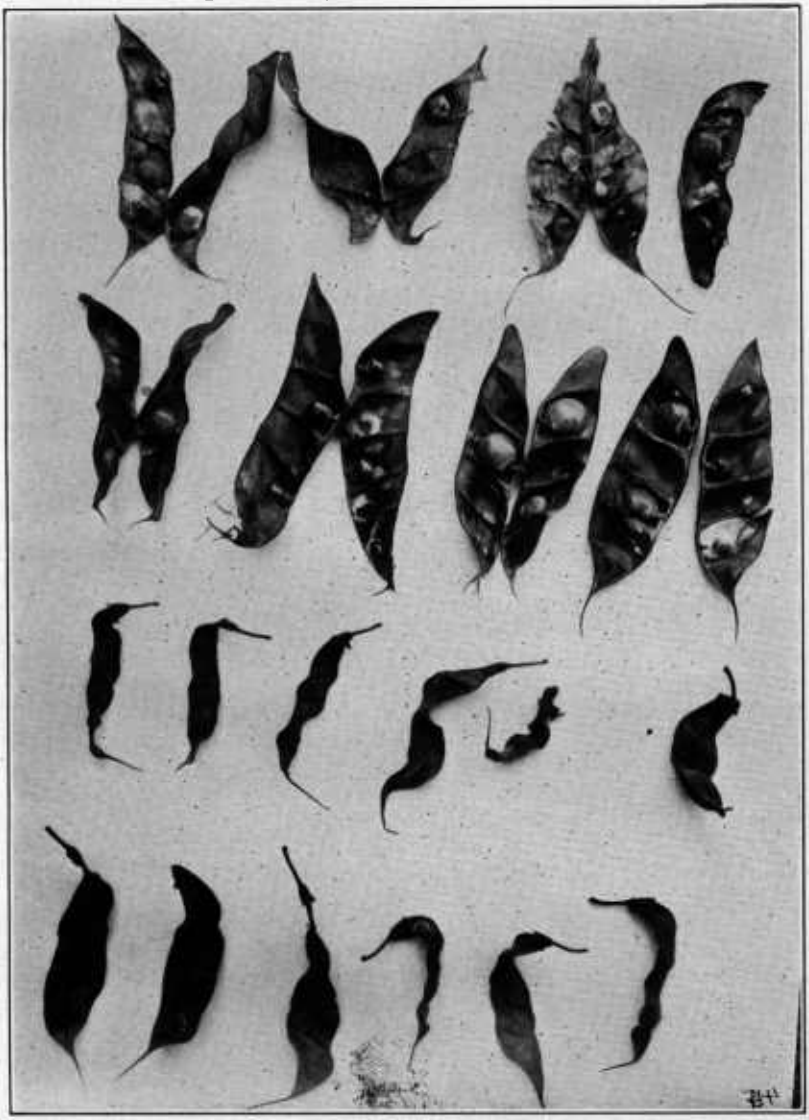

FIG. 2.—Above, split pigeon-pea pods bearing anthracnose spots. Note the white cottony mycelium. Some of the seed infection is confined to one or two dissepiments. Below, pods shriveled, distorted, and dead; the result of early infection by the anthracnose fungus

Probably the most important of the factors that determine the quantity of infection is rainfall. Pods which have formed during the rainy season show a much higher percentage of infection than those produced under dry conditions. Plants in sheltered situations produce a larger percentage of infected pods than plants to which the sunlight and breezes have free access.

TABLE 1.—*Marketable seeds in healthy and diseased pigeon-pea pods*

Marketable seeds per pod	Diseased pods in each class		Healthy pods in each class	
	Number	*Per cent*	*Number*	*Per cent*
0	66	12.1	0	0
1	84	15.4	0	0
2	101	18.5	0	0
3	144	26.5	21	24.7
4	121	22.3	52	61.2
5	28	5.2	12	14.1
Total	544	100.0	85	100.0

Although the pods may become infected during any green stage, the resulting damage is greatly affected by the age of the pod at the time of infection. Early infections before the pod is 1 inch long usually cause the death of the whole pod. Later infections may cause the loss of the seed in the infected dissepiments only. The dissepiments of the pod are closed by the constrictions, and usually the fungus invades the seed in dissepiments on which acervuli are borne, but does not pass the constrictions. Late infections produce dotlike acervuli which do not enlarge much, and usually the fungus fails to penetrate to the interior.

THE ORGANISM

Microscopic examination of diseased pods and leaflets reveals the presence of a fungus of the anthracnose group. Acervuli are borne on the pod spots and on the superior surface of the leaf spots.

The conidia from pod acervuli are cylindrical, broadly elliptical to irregular in shape, usually rounded at the ends, hyaline when very young, but later becoming densely granular, or few—guttulate, straight, or slightly curved. They are continuous or very rarely 1-septate, and are 12 to 17×3.5 to 7.2 microns, with an average of 13.6×5.6 microns. (Fig. 3, B.)

The conidia are borne in abundance on pod acervuli and in smaller numbers on the leaf acervuli.

The conidiophores are simple, hyaline, cylindrical or slightly swollen, usually septate near the base, rounded at the apex, and 15 to 25×3 to 5.5 microns. (Fig. 3, A.)

Setae are numerous on old pod spots, but occur only occasionally on the leaves. They are fasciculate, dark brown, cylindrical, usually somewhat curved or bent, rounded at the apex, 1 to 5 septate, and 70 to 120×3.3 to 4.2 microns, with an average of 100×3.5 microns. (Fig. 3, D.)

The above description of the fungus places it in the genus Colletotrichum. Two references to the occurrence of this genus on the pigeon pea have been found. Dash (*4, p. 38*) stated,[2] "A species of Colletotrichum was found on pigeon pea at Codrington [Barbados] which seemed to cause death to the branches attacked." Rangel (*6, p. 154–155*) in Brazil described and figured a Colletotrichum on leaf spots of the pigeon pea. His description follows:

[2] Reference is made by number (italic) to "Literature cited," p. 596.

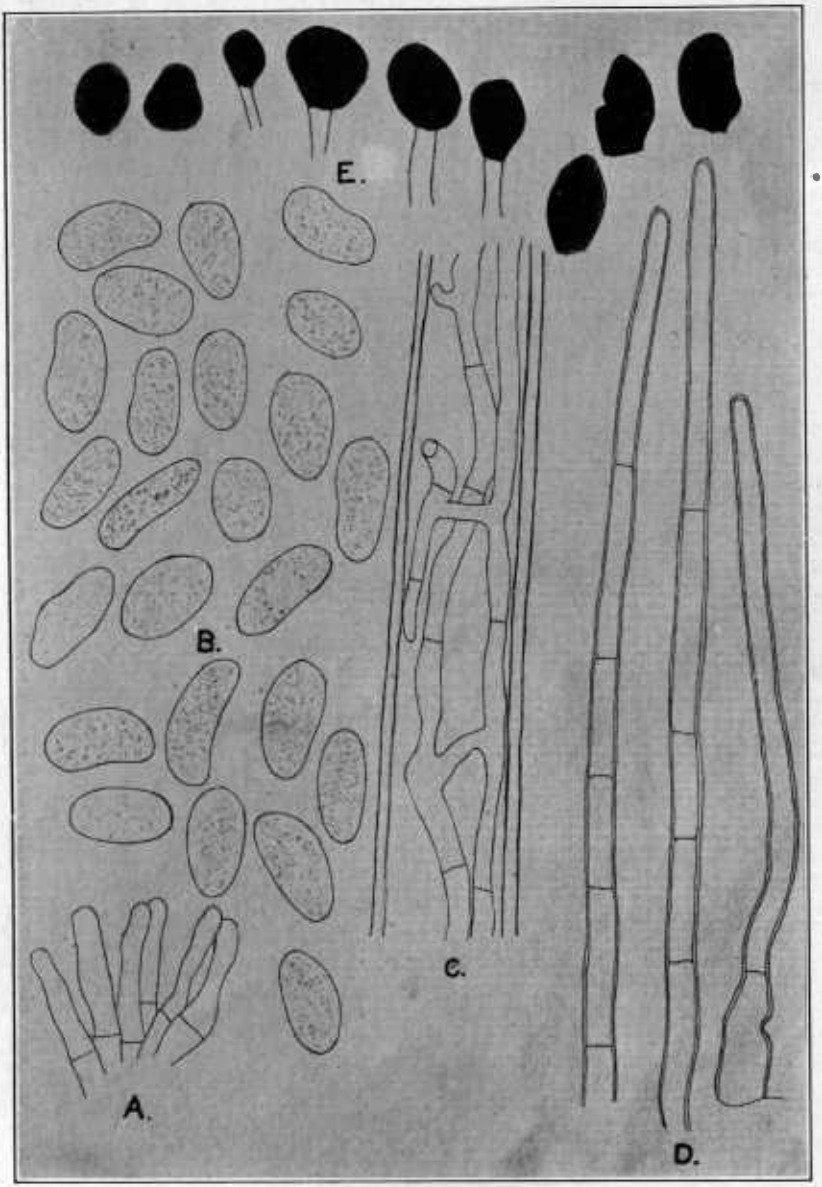

FIG. 3.—*Colletotrichum cajani*: A, conidiophores; B, conidia; C, section of a hair from an infected pigeon-pea pod, showing invasion by the mycelium of the fungus; D, setae from a pod acervulus; and E, appressoria from 2-months-old potato-dextrose agar culture. × 1175

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Colletotrichum cajani, Rangel (n. sp.).

Maculis majusculis, apicalibus, obscure ferrugineis, indeterminatis vel atro-brunneo marginatis; acervulis plerumque epiphyllis, minutis, olivaceis; conidiis cylindraceis, oblongis vel lato ellipsoideis, continuis, granulosis, hyalinis, 10—15=4—5μ setulis rectis vel curvulineis, septatis, brunneolis, 45—60=4—5μ. In foliis vivis *Cajani indici*. Niteroy. Brasiliae. (Exs. 723. Maio. 1913).

The fungus here described does not differ essentially from that under discussion. As to the differences in the size of conidia and setae, it should be remembered that Rangel's observations were made on material from leaf spots, whereas the writer used diseased pods on which the conidia and setae developed more profusely. The fungus under discussion is therefore referred to *Colletotrichum cajani* Rangel.

In culture the fungus grows rapidly on a variety of nutrient media. On potato-agar plates the growth is closely appressed, thin, white, spreading, regular, radiate and sliming from below. At 25° C. the mycelia after 72 hours average 22 millimeters in diameter, and after 120 hours, 37 millimeters. No spores were produced during one week.

On potato-dextrose agar plates the growth has the same characters as on potato agar except for a slight increase in density and in rapidity of growth. After 72 hours the mycelia average 25 millimeters in diameter, and after 120 hours, 46 millimeters. After one week no conidia were borne.

On oatmeal-agar plates the growth was intermediate in density and rapidity between that occurring on potato agar and potato-dextrose agar. After 72 hours the mycelia average 23 millimeters in diameter and after 120 hours, 43 millimeters. No conidia were borne in one week.

On steamed pigeon-pea pods a luxuriant growth of white cottony mycelium is made. Conidia are abundant after a week's growth. The conidia are very similar in size and shape to those borne on pods as the result of natural infection.

In 2-months-old cultures on potato-dextrose agar and pigeon-pea pods, appressoria, as described and figured by Edgerton (*5*) are abundant. They are dark brown in color and are formed by the swelling and thickening of the wall of an apical hyphal cell. They usually occur singly, but occasionally two to five apical cells become swollen, producing the appearance of a chain of chlamydospores. The appressoria are oval to irregular in shape and vary in size, ranging from 6.4 to 12 × 4.8 to 6.4 microns.

Edgerton (*5*) found appressoria occurring generally in the anthracnose fungi following the germination of conidia in a medium lacking nutrient material. In the writer's potato-dextrose agar cultures conidia were never numerous, yet appressoria appeared in large numbers, and observations indicate that at least a large majority were formed directly from hyphal cells. The resulting thick-walled cells or resting bodies seem in every respect to be analogous to chlamydospores.

INOCULATIONS

The fungus was grown on steamed pigeon-pea pods for two weeks, with profuse conidia production. A water suspension of conidia and mycelium was atomized on 107 pigeon-pea seedlings about 8 inches high. The seedlings were then watered daily by sprinkling and kept shaded for 48 hours. The earliest symptoms of infection appeared about five days later, when the veins in some of

the youngest leaves darkened. After 12 days infection was well advanced. Apparently the leaflets emerging from the bud during inoculation were most easily infected. Of 107 inoculated seedlings, 102 showed unmistakable symptoms of infection. In every case infection appeared on the veins of the leaflets, resulting in death in severely affected specimens. Deformed leaflets were borne by other seedlings as a result of the continued growth of the healthy portions and the arrested growth of infected veins. Infection of the older leaflets was not common. When infection did occur, the blades were spotted. The older leaflets showed no vein infection. Elongated narrow stem lesions were present on 54 seedlings. The lesions were as yet hardly more than a darkening of the epidermal cells. The woody character of the pigeon-pea stem prohibits the formation of cankers such as occur on anthracnose-infected garden beans. Petiole infections occured on 25 seedlings and usually caused the affected leaflets to yellow and fall.

The fungus was reisolated from vein, stem, and petiole lesions and was found to be identical morphologically and in cultures with the inoculating organism.

Thirty-eight seedlings were used as controls. These received the same treatment as was given the inoculated plants except that sterile water was substituted for the inoculating fungous suspension. Thirty-four seedlings remained healthy, two were doubtful, and two became slightly infected.

Garden-bean seedlings were inoculated like the pigeon-pea seedlings, the pigeon-pea seedlings being used for parallel inoculations as a check on the virulence of the inoculating cultures. The varieties of *Phaseolus vulgaris* used included Giant Stringless Green Pod, Valentine Pencil-Pod Black Wax, and Refugee (all bush beans). These varieties were selected because of their susceptibility to *Colletotrichum lindemuthianum*. Barrus (*1*) showed them to be susceptible to the alpha and beta strains, and Burkholder (*3*) demonstrated their susceptibility to the gamma strain.

No infection was obtained on the varieties named, although the parallel inoculations on pigeon peas produced abundant leaflet-vein infection.

The infection of varieties of *Phaseolus vulgaris* with a Colletotrichum from *Cajan cajan* could hardly be expected in view of the results obtained by Barrus (*2*). Summarizing the results of extensive inoculation experiments, he states: "There are evidently but few species outside the genus Phaseolus which are susceptible in any degree to anthracnose [*C. lindemuthianum*], and no plants except varieties of *Phaseolus vulgaris* are susceptible to such an extent that the disease becomes epiphytotic in regions where such plants are extensively grown."

SUMMARY

The pigeon pea (*Cajan cajan*) in Porto Rico is attacked by anthracnose, resulting in spotting of the pods and leaves and destruction of the seeds.

On young leaves infection occurs mostly on the veins and causes them to blacken and shrivel; on young pods infection causes distortion, abortion, and death.

The losses sustained are due to the destruction of young pods and the decay or discoloration of one to all the seeds in infected pods. Infection is most serious during periods of heavy rainfall.

The causal organism is referred to *Colletotrichum cajani* Rangel, which is now first recorded as the cause of a pod and seed disease.

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