Use of Aerial Photography to Detect Diseases in Peanut Fields
II. Cylindrocladium Black Rot[1]

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ABSTRACT

Aerial surveys were conducted over portions of the peanut (**Arachis hypogaea** L.) growing region of Virginia during September, 1974. The flights were conducted to determine the spectral, spatial, and temporal characteristics of Cylindrocladium black rot disease in peanut fields utilizing false color infrared and natural color imagery. The disease, caused by the soil-borne fungus **Cylindrocladium crotalariae** (Loos) Bell and Sobers, was detected on imagery obtained at 19,803 m above mean sea level. The disease was easily detectable on either false color infared or natural color imagery at 3,504 m above mean sea level. With its unique spectral/spatial signature, the disease was distinguishable from other diseases of peanuts such as Sclerotinia blight. Disease patterns that were difficult to observe from the ground were easily detected with aerial photography. Analysis of field soil samples for **C. crotalariae** microsclerotia confirmed results of imagery analysis. Detection of the disease by aerial surveys will permit prompt control measures to minimize spread of the disease. Information from this study will provide permanent records that can be used to monitor the change in extent and severity of the disease in future growing seasons.

Additional index words: **Arachis hypogaea, Cylindrocladium crotalariae,** false color infrared imagery, natural color imagery, soil-borne fungus, spectral signature, spatial, temporal, Sclerotinia blight.

In the United States, the Cylindrocladium black rot (CBR) disease of peanuts (*Arachis hypogaea* L.), caused by *Cylindrocladium crotalaria,* (Loos) Bell and Sobers, was first recognized as a problem in Georgia in 1965, and was later found in South Carolina in 1968 (Garren, *et al.,* 1972). In Virginia, CBR was first discovered in one peanut field in 1970 (Garren, *et al.,* 1971). In 1971, CBR was found in two fields in Virginia and several fields in the Williamston, N. C. area (Garren, *et al.* 1972). Garren (1973) reported that without a concerted survey, CBR was found to be severe in 10 fields in four counties in Virginia in 1972. North Caroina reported 40 infestations of CBR during the 1972 growing season (Rowe, *et al.,* 1973). In Virginia for 1973, there were 20-25 fields of CBR reported in Isle of Wight and Southampton Counties and the City of Suffolk.

The disease symptoms were described by Garren and Jackson (1973). The first symptoms of diseased plants in the field were chlorosis and wilting of the leaves on the main axis, followed by chlorosis and wilting of the remaining foliage and blighting of the leaf tips and margins. The main axis often was more extensively affected than the lateral branches. Hypocotyls and tap roots were necrotic and blackened, with necrosis usually terminating near the groundline. Frequently, the entire root system of a diseased plant was destroyed, leaving a blackened and fragmented hypocotyl.

Control practices for CBR were almost nonexistent during the 1974 growing season. No chemical or commercial Virginia type peanut variety provided adequate control. Detection and diagnosis of the disease is important. Infested areas of the disease need to be detected and isolated through proper management practices to minimize the spread of the fungus.

CBR is of major economic importance to the peanut growers in Virginia and North Carolina. This fungus also attacks soybeans (Misonou, 1973) and tobacco (Rowe and Beute, 1973) and, therefore, could be a major economic threat to Virginia and North Carolina agriculture.

Because of the serious threat posed by CBR, a study was conducted during the 1974 growing season to determine if natural color and false color infrared imagery could be used to detect and record the occurrence and spread of the disease. A brief review of the literature on the use of aerial photography to detect plant diseases in the field has been presented by Powell *et al.* (1976). The objective of this research was to determine the spectral, spatial, and temporal characteristics of CBR disease in peanut fields utilizing aerial photography.

Materials and Methods

Imagery used for this study was collected during the 1974 growing season in Southampton County and the City of Suffolk, Virginia by NASA air-craft from NASA Wallops Flight Center, Wallops Island, Virginia. A summary of the imagery used is reported in Table 1.

Ground information collected to correlate with the aerial imagery included locating fields that had known **Cylindrocladium** infestations during the 1974 growing season. This information was provided by the county or city agricultural extension agents. The fields were located on

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Table 1. Summary of aerial imagery used for this study collected by National Aeronautics and Space Administration.

Date	Time (EST)	Altitude (meters)	Aircraft	Camera/ Focal Length (mm)	Imagery
September 10, 1974	1056-1151	19,803 (65,000 feet)	U-2	RC 10/254	False color infrared Kodak Aerochrome 2443
September 18, 1974	1237-1436	3,504 (11,500 feet)	C-54	T 11/152	False color infrared Kodak Aerochrome 2443 and natural color Kodak Ektachrome EF Aero Graphic SO-397

*Flights originated through NASA Wallops Flight Center, Wallops Island, Virginia

7.5 minute topographic maps (Virginia Quadrangle Map series, 1:24,000) and the aerial imagery. The aerial imagery, consisting of positive transparencies, was viewed on a Richards Light Table Model GFL-940[6] to determine the spectral/spatial characteristics of known **Cylindrocladium**-infested peanut fields and to distinguish infested fields from fields of non-infested peanuts and other crops. Once the spectral/spatial signature of CBR-infested peanut fields had been determined, other peanut fields in the photographed region were scanned visually to detect unconfirmed fields suspected of being infested by **Cylindrocladium** but had not been reported.

After known and suspect **Cylindrocladium**-infested fields were located on the maps and the aerial imagery, the fields were visited and soil samples collected. The soil samples were obtained from the surface six inches in areas of known or suspected pathogen infestation after the peanuts were harvested. A procedure employing wet-sieving-of-soil and plating on a selective medium was used to determine the population of microsclerotia of **C. crotalariae** in the soil samples (Krigsvold and Griffin, 1975).

Results and Discussion

Photographs of four of the infested fields considered in this study are given in Fig. 1. The presence of *C. crotolariae* in these fields was verified by laboratory analysis of soil samples collected from the fields (Table 2). The appearance of non-infested or healthy and *Cylindrocladium*-infested areas is illustrated in Fig. 1A (photograph taken September 18, 1974, from 3,504 m). The areas labeled (a) are healthy peanuts. The area labeled by (b) is severely diseased with CBR. Area (c) is woodland. Areas with healthy plants are characterized by a uniform red color. Areas of infested plants are characterized by bare areas where the disease had killed the plants. These bare areas are usually surrounded by a ring of dead and/or dying plants and is seen on the imagery as a black margin. The bare areas also show a slight red color; possibly, because there is some green peanut foliage remaining and/or because of the presence of other vegetation (weeds, etc.) in the area.

There are two diseases which have severe effects on peanuts in Virginia and North Carolina. One is CBR and the other is Sclerotinia blight. In work by Powell *et al.* (1976), the spectral/spatial signature for Sclerotinia blight has been identified and it is different from CBR (see Fig. 1 of Powell *et al.,* 1976). Sclerotinia blight has dead or dying peanut foliage mixed with green peanut foliage to give a black to gray streaking appearance on the false color infrared photographs.

A comparison of a CBR diseased peanut field on false color infrared pictures taken from different altitudes is given in Fig. 1A and 1B (Table 1). Figure 1A is a photograph taken September 18, 1974, from 3,504 m. Figure 1B was taken September 10, 1974, from 19,803 m. These two photographs illustrate how CBR can be detected from very high altitudes. It appears from these two enlarged photographs that CBR is as easily detected from 19,803 m as it is from 3,504 m. This was true for several other fields studied.

Figures 1A and 1C give a comparison of a *Cylindrocladium*-infested peanut field on false color infrared and natural color photographs. The photographs of the area were taken at the same time under the same conditions. It appears that the CBR damage is as easily detected on the natural color photograph (Fig. 1C) as it is on the false color infrared photograph (Fig. 1A). This was true for several other fields studied. It was noted, however, that the natural color photograph was much darker and not as clear as the false color infrared photograph. This is primarily because haze absorbs part of the light in the visual range (natural color) and a sharp distinct picture from 3,504 m is difficult to obtain even with filters. The near infrared reflection (false color infrared) is not absorbed by the atmosphere and it is, therefore, possible to get clear and sharp pictures from very high altitudes (up to 19,803 m). This is in contrast to the Sclerotinia blight studies reported by Powell *et al.,* (1976). They found that it was very difficult to detect Sclerotinia blight on natural color photographs but the disease was easily detected on false color infrared photographs.

Figures 1A, 1D, 1E, and 1F give some idea of the spatial distribution of CBR in the fields. It was

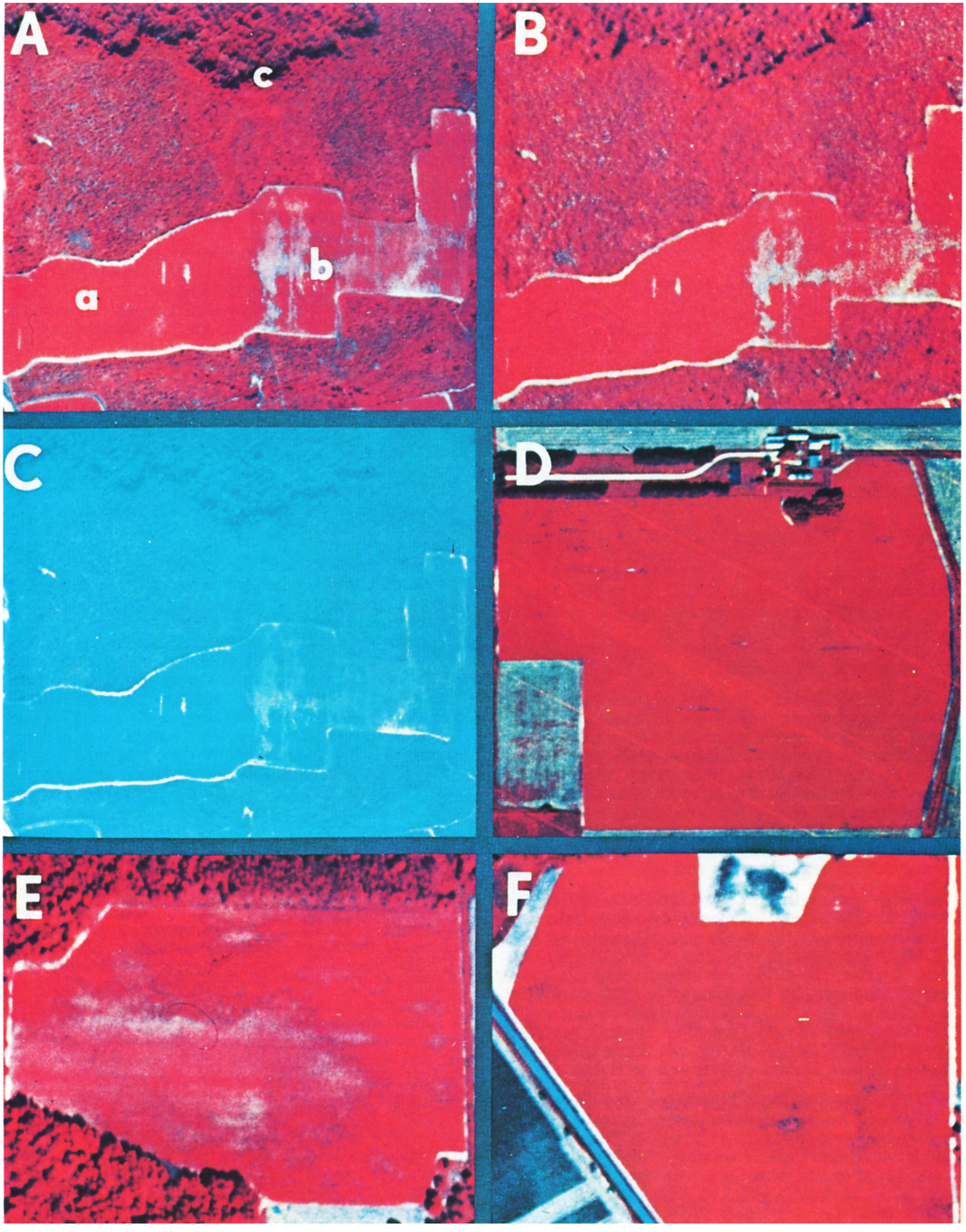

Fig. 1. (A to F) Aerial photographs of several Cylindrocladium-infested fields. A and B and D through F are false color infrared photographs. C is a natural color photograph. Photographs A, and C through F were taken September 18, 1974 at 3,504 m above sea level. Photograph B was taken September 10, 1974 at 19,803 m above mean sea level.

Table 2. Summary of laboratory analysis for Cylindrocladium crotolariae **microsclerotia in soil samples collected from known and suspected CBR-diseased peanut fields.**

Date field sampled	Field Number	Number of samples assayed	CBR diseased peanut fields: Known[a/]	CBR diseased peanut fields: Suspected	Microsclerotia/g soil: Range	Microsclerotia/g soil: Mean
Fields with typical CBR spectral signature						
2/21/75	20	1		+		2
1/9/75, 2/14/75, 4/7/75	25	9		+	6-55	27
2/21/75	27	1		+		7
11/7/74	29	1	+			1
11/7/74	29a	1	+			2
11/7/74	30	1	+			1
2/21/75	35	1		+		5
2/21/75	37a	1		+		1
2/21/75, 3/18/75	47	5	+		0-1	1
1/9/75	58	1		+		11
1/9/75	58a	1		+		1
2/21/75	59	1	+			54
1/10/75, 2/21/75	62	2		+	0-1	1
11/7/74	68	1		+		1
11/7/74	68a	1		+		5
11/7/74, 4/7/75	69	5		+	0-17	4
4/7/75	70	4		+	0-14	6
11/7/74	103	1	+			1
11/7/74	104	1	+			1
11/7/74, 3/17/75	105	3	+		0-14	8
Fields with atypical spectral signature						
1/9/75	39	1		+		0
1/9/75, 2/21/75, 4/7/75	50	4		+		0
1/9/75, 4/7/75	51	2		+		0
1/10/75, 2/21/75	60	2		+		0
1/10/75, 2/21/75	61	6		+		0
1/10/75, 2/21/75	63	2		+		0

a/ Based on extension agent reports.

noted that the disease completely destroys large portions of some fields (Fig. 1A and 1E), whereas it was confined to small areas and very spotty in other fields (Fig. 1D and 1F). It was noted especially in Fig. 1D that the disease has a tendency to follow the rows. This would indicate that cultivation practices may be important considerations in the spread of the disease.

The temporal characteristics of the disease, as it changed over an eight day period during one growing season, are illustrated in Fig. 1A and 1B. These two photographs were obtained eight days apart (September 10-18, 1974); however, it does not appear that the disease had spread to any new area in the field this late in the growing season during this time period. This was true for all fields studied where imagery of the same fields was available for September 10 and 18.

From viewing the imagery, and noting the size of the infested area it is possible to speculate that CBR has been in the fields shown in Fig. 1A and 1E for several years, even though the disease was first reported in 1974. The disease had probably been in the field of Fig. 1D one to two years (not reported previously) whereas this was probably the first year for the field in Fig. 1F (not reported previously). This speculation will have to be verified by future flights over the same fields.

Table 2 reports the results of the laboratory analysis of the soil samples taken from several of the fields considered in this study. Some of the fields were known to be infested with the pathogen prior to soil sampling, whereas others were suspected of being infested after reviewing the aerial imagery. All fields with the typical CBR spectral signature, described above, were found to contain microsclerotia of *C. crotalariae*. In contrast, soil samples from fields having a similar but not typical CBR spectral signature did not contain the fungus. Populations of microsclerotia varied considerably from field to field and from sample to sample for a given field. Part of this variation may have resulted from the small centers of *Cylindrocladium*-infested areas. Areas shown in Fig. 1D and 1F were difficult to locate in the fields because the peanut crop had been harvested prior to soil sampling. Low microsclerotial populations were found in these fields (Fields 27 and 20, respectively). Field 25, seen in Fig. 1A, and Field 59, seen in Fig. 1E, had high microsclerotial populations as well as large areas of infestation. High populations of microsclerotia were detected in some fields through mid-winter. This indicated that environmental factors, especially temperature, did not have any appreciable effect on the viability of the microsclerotia.

Several of the fields were sampled more than once. In some instances, this was because no microsclerotia were recovered from the soil sample collected on the first date. Therefore, the fields were sampled again taking two to four additional samples from each field on the second or third date. The first sample was taken by walking to the approximate location in the field following study of the imagery. This procedure was good in large areas of disease infestations (Fig. 1A and 1E and Fields 25 and 59 respectively). For small areas of *Cylindrocladium* infestation, a more accurate procedure was used for determining the exact location of the infested area in the field. This involved making measurements on the imagery with a Finescale magnifying comparator and then using a measuring chain in the field to find the exact location. This was the procedure used for Fields 47, 69 and 105. Fields 20 and 27 (Fig. 1F and 1D respectively) were sampled only once using the exact measurement technique. Field 25 in Fig. 1A was sampled many times because research plots for CBR will be established there during the 1975 growing season.

Summary and Conclusions

From aerial surveys conducted over portions of the peanut growing region of Virginia during September, 1974, the spectral, spatial and temporal characteristics of Cylindrocladium black rot (CBR) disease in peanut fields was determined. Imagery used for this study was false color infrared and natural color. The presence of *C. crotalariae* in known and suspected CBR-diseased peanut fields was verified by laboratory analysis of soil samples collected from the fields. It was found that CBR has a unique spectral/spatial signature and was easily distinguishable from Sclerotinia blight on the imagery. The CBR disease was easily detected on either false color infrared or natural color imagery taken at 3,504 m above sea level or on false color infrared imagery taken at 19,803 m above mean sea level. Spatial distribution of CBR in the fields indicated that the disease followed the rows suggesting that cultivation practices were important considerations in the spread of the disease. Image comparison indicated there was no spread of the disease to new areas of the fields during the eight day period between September 10-18, 1974. From viewing the imagery, it was speculated that the disease had been in several of the fields for several years although they were first reported to be CBR infested in 1974. Several *Cylindrocladium*-infested fields whch had not been previously reported were discovered. This illustrates how disease patterns which were difficult to observe from the ground can easily be detected on aerial photographs. The importance of using accurate measurements in locating, in the field, small *Cylindrocladium*-infested areas based on the aerial photographs was demonstrated. Early detection of CBR by aerial surveys will permit prompt control measures to minimize spread of the disease. Information from this study will provide permanent records which can be used to monitor the change in extent and severity of the disease in future growing seasons. These records also provide the researcher with a method of locating desirable areas for field studies of CBR of peanuts.

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