Use of Aerial Photography to Detect Diseases in Peanut Fields
I. Sclerotinia Blight[1]

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ABSTRACT
Aerial surveys were conducted over portions of Southampton County, Virginia, during the 1974 growing season. The flights were conducted to determine the spectral, spatial, and temporal characteristics of Sclerotinia blight in peanut (**Arachis hypogaea** L.) fields caused by the soil-borne fungus **Sclerotinia sclerotiorum.** Natural color and false color infrared imagery were used in the aerial surveys. Disease detection was best using false color infrared imagery. Sclerotinia blight, characterized by a unique spectral signature, can be detected on false color infrared imagery taken at 19,803 m above mean sea level. High altitude flights (19,803 m) were better for large area disease surveys. However, low altitude flights (3,504 m) gave better resolution for detailed study of individual fields. Aerial photography detected disease patterns which were difficult to observe from the ground. Early detection of the disease via aerial surveys could aid in minimizing disease severity. Imagery will also provide historical data that can be used in implementing control measures in subsequent growing seasons. Imagery evaluation indicates that Sclerotinia blight was widespread in the peanut growing region of Virginia during the 1974 growing season.

Additional index words: **Arachis hypogaea, Sclerotinia sclerotiorum, Whetzelinia sclerotiorum,** natural color imagery, false color infrared imagery, spectral signature, groundnut, soil-borne fungus, sclerotia.

Several researchers have used aerial photography to detect plant diseases. As early as 1929 (Taubenhaus *et al.*, 1929) aerial photography was used for locating plant diseases. Colwell (1956) used infrared sensitive film for detecting plant diseases among cereal crops. Norman and Fritz (1965), using infrared-sensitive color film, detected the presence of sick and declining citrus trees before they could be observed in the field. Meyer and French (1967) found that Kodak Ektachrome Infrared (false-color) film could be used as a practical means of disease detection in forest and shade trees. Manzer and Cooper (1967) demonstrated that aerial photography could be used as a tool for basic potato disease research. They demonstrated that with proper film-filter combinations late blight of potato could be detected prior to the development of visual field symptoms and estimates of damage could be obtained. Similar studies have been conducted in the United Kingdom (Bell, 1974; Brenchley, 1968). Hilty and Ausmus (1973) found that aerial infrared photography could be used in conjunction with ground information to detect plant diseases. Their studies indicated aerial photography reveals patterns of disease development and severity which cannot be detected on the ground.

Sclerotinia blight of peanuts (*Arachis hypogaea* L.), caused by the soil-borne fungus *S. sclerotiorum* (Lib.) Debary (*S. minor* Jagger), was first reported in the Virginia peanut growing areas in 1971 (Porter & Beute, 1974). This disease has since become widespread in Virginia and North Carolina. Under certain conditions, such as prolonged rainy periods, Sclerotinia blight is a very destructive peanut disease. All parts of the peanut plant, especially those in close proximity with the soil, are easily colonized by this fungus. Disease severity ranges from single or multiple branch infections to death of the plant. Foliage on infected plants is initially characterized by a pale yellow color. With time infected plant parts become brownish giving the plant a blighted appearance. Sclerotinia blight of peanuts is characterized by small, irregular-shaped, black sclerotia that are produced on and within infected plant tissue (Porter and Beute, 1974). Pod yields are greatly reduced under severe disease conditions (Porter *et al.*, 1975). Certain chemicals have also recently been shown to be effective against Sclerotinia blight (Beute *et al.*, 1975).

Sclerotinia blight poses a potential threat to the peanut growers of Virginia and North Carolina. It was for this reason that a preliminary study was undertaken during the 1974 growing season to determine if natural color and false color infrared aerial imagery could be used to detect and record the occurrence and spread of this disease. The objective of this research was to determine the spectral, spatial, and temporal characteristics of Sclerotinia blight in peanut fields by the use of natural color and false color infrared aerial imagery.

Materials and Methods

During the 1974 growing season two aerial flights were conducted by the National Aeronautics and Space Administration over parts of Southampton County, Virginia. The first flight was conducted September 10, 1974, at 19,803 m above mean sea level to collect false color infrared imagery of the area. The second flight was conducted September 18, 1974, at 3,504 meters above mean sea level and false color infrared and natural color imagery of the area was obtained. Table 1 gives a summary of the imagery collected. The quality of the imagery was rated good to excellent with no cloud cover in the region photographed.

Peanut fields known to have been infected by Sclerotinia blight during the 1974 growing season were identi-

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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

fied. Fields were then located on 7.5 minute topographic maps (Virginia Quadrangle Map Series, 1:24,000) and on the aerial imagery. The aerial imagery, consisting of positive transparencies, was viewed on a Richards Model GFL-940 Light Table[5] to detect infected peanut fields and to distinguish them from other fields of non-infected peanuts and such crops as soybeans. Once the spectral signature of Sclerotinia-infected peanut fields had been determined, other peanut fields in the photographed region were scanned to detect fields that were suspected of being infected but had not been reported.

Once Sclerotinia-infected fields and suspect-infected-fields had been located on maps and aerial imagery, selected fields were visited. During visitation, the existing peanut debris was examined for evidence of infection by **S. sclerotiorum.** Disease severity correlations of each field were made between suspect-Sclerotinia-infected and a field known to be severely infected with **S. sclerotiorum** during the growing seasons of 1973 and 1974. Possible disease severity ratings were made based upon the presence of Sclerotinia-like sclerotia found in the debris. When plated on a suitable substrate, sclerotia germinated and produced fungal growth typical of **S. sclerotiorum.**

Results and Discussion

A total of 14 fields was considered in this study. Photographs of three of the fields are presented in Fig. 1. Healthy and Sclerotinia-infected peanut areas are illustrated in Fig. 1A (taken September 18, 1974, from 3,504 m). Areas designated by (a) are healthy growing peanuts. The area designated by (b) is moderately infected by *S. sclerotiorum.* Area (c) is bare soil and area (d) is woodland. Areas with healthy plants are characterized by a uniform red color. Areas of infected plants are characterized by various shades of gray, thus indicating that the foliage had died or was dying at the time the photograph was taken.

A comparison of a Sclerotinia-infected peanut field on false color infrared and natural color photographs is given in Fig. 1A and 1B. The photographs of this area were taken at the same time under the same conditions. Sclerotinia blight symptoms are more difficult to detect on the natural color photograph (Fig. 1B) than on the false color infrared photograph (Fig. 1A). The diseased areas on the natural color photograph appear as a slight brownish discoloration indicating dead and/or dying plant parts. This is in contrast to the false color infrared photograph where the diseased plants are characterized by a distinct gray discoloration. This difference in spectral characteristics illustrated the importance of using false color infrared imagery instead of natural color imagery for studying Sclerotinia blight in peanut fields.

Fig. 1C and 1D are false color infrared pictures of the same field taken from different altitudes (Table 1). Fig. 1C was taken September 18, 1974, at 3,504 meters. Fig. 1D was taken September 10, 1974, at 19,803 meters. These photographs illustrate how Sclerotinia blight can be detected from very high altitudes. The disease symptoms in Fig. 1D were highly visible on a positive transparency viewed on a light table. Some of the detail has been lost in the process of enlarging the photograph for publication.

Fig. 1C and 1D also give some indication of how the severity of Sclerotinia blight may change with time. An evaluation of the imagery in Fig. 1C taken September 18, 1974, and imagery of the same field taken Septmeber 10, 1974 (Fig. 1D) indicates that during the eight day interval between flights, the disease appeared to intensify. The disease appeared to migrate down the rows but not laterally to adjacent rows. As an example, from the imagery it was noted in Fig. 1D the distance along the rows infected by the blight in two cases was 25 and 41 meters on September 10, 1974, but had spread to 35 and 64 meters, respectively, by September 18, 1974 (Fig. 1C). The area labeled by (e) in the figure (1C) was a mature corn field with an abundance of weeds.

Fig. 1C and 1D also illustrate the difficulty of making image distinctions between soybeans (f) and peanuts (b) at the time the imagery was obtained (September 10 and 18, 1974).

The possibility that water acts as a mechanism for the spread of *S. sclerotiorum* is illustrated in Fig. 1E. There was evidence that Sclerotinia blight moved laterally across rows with water movement

[5]Mention of a trademark, code name, or proprietary product is for identification purposes and does not constitute a guarantee or warranty of the product by the Virginia Polytechnic Institute and State University or the U. S. Department of Agriculture, nor imply its approval to the exclusion of other products that may be suitable.

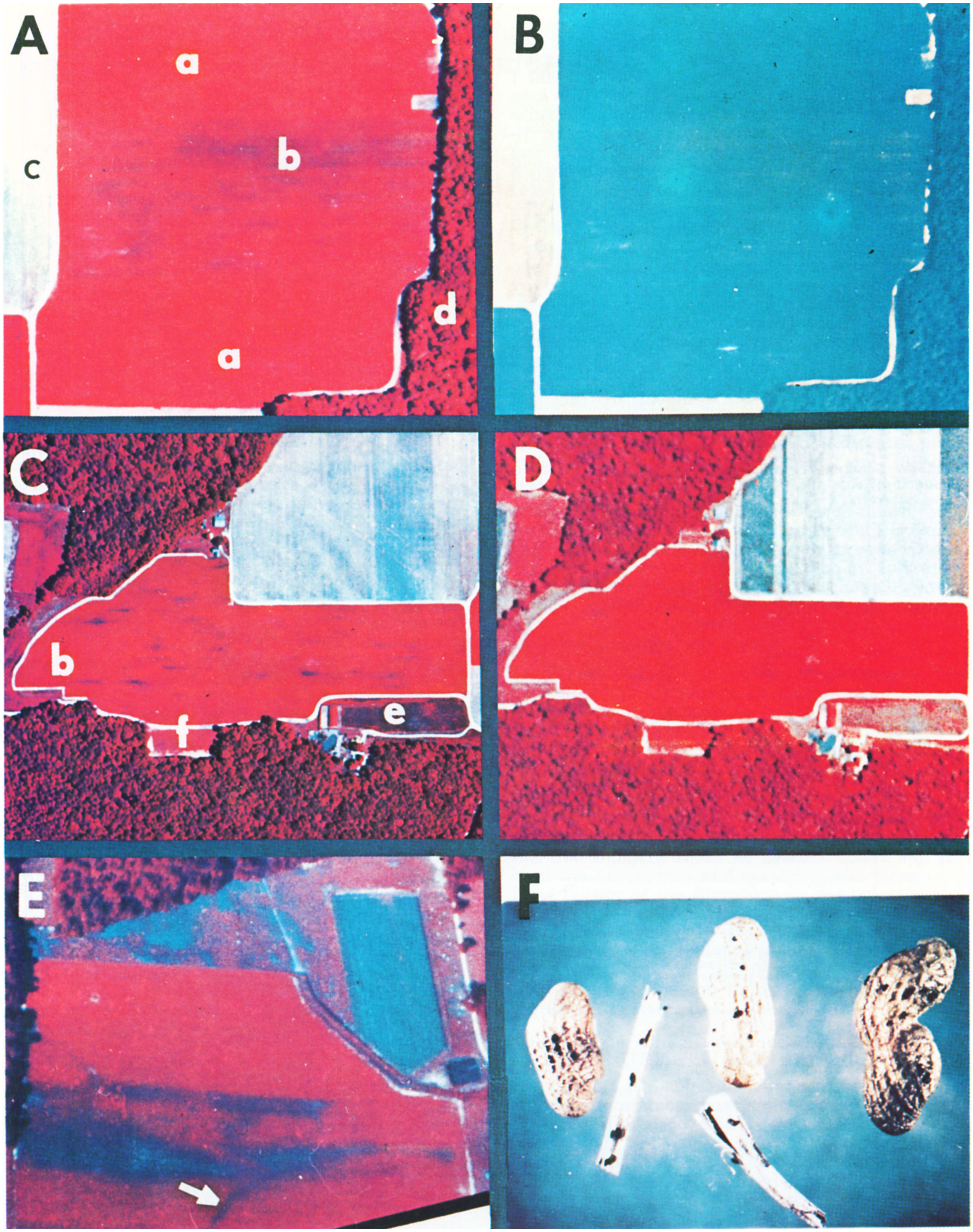

Fig. 1 (A through E) Aerial photographs of several Sclerotinia blight infested fields. (A, C through E) False color infrared photographs. (B) Natural color photograph. (A through C and E) Photographs taken September 18, 1974, at 3,504 m above mean sea level. (D) Photograph taken September 10, 1974, at 19,803 m above mean sea level. (F) Sclerotia produced by *Sclerotinia* **sp. on diseased plant tissue of peanut shells and branches.**

(arrow at bottom of figure).

Results of the on-site observations and the analysis of field debris are given in Table 2. Field 1 is a Sclerotinia blight research test site. This area was chosen for Sclerotinia research plots because it had a history of this disease. In some areas, disease development was severe in 1974 and pod yields were greatly reduced. Fields 2 through 4 and 7 through 9 were those reported by the local extension agent as being infected with Sclerotinia blight during the 1974 growing season. The remaining fields 5 and 6, and 10 through 14 were those which were located on the imagery as possibly being infected and were later verified by field inspection and an assay of field debris. Peanut pods and branches collected from Sclerotinia-infected fields were characterized by the presence of sclerotia as shown in Fig. 1E. Pod sclerotia within the intercellular spaces of the shell matrix were exposed following removal of the pod epidermis.

Table 2. Summary of on-site observations in Sclerotinia-infected fields and percent branches and pods containing sclerotia.

Field number	Date sampled	Disease severity[2/]	Field condition[3/]	Sclerotia (%)[4/] branches	pods
1[1/]	2/20/75	Severe		30	44
2	3/19/75	Severe		46	60
3	3/19/75	Severe		52	61
4	2/20/75	Severe		32	48
5	2/20/75	Moderate		20	29
6	2/20/75	Moderate		12	35
7	2/20/75	Severe	Grazed	26	16
8	2/20/75	Severe	Disked, rye Grazed	24	24
9	2/20/75	Severe	Disked, rye, Grazed	22	7
10	2/20/75	Severe		40	40
11	2/20/75	Severe	Grazed	20	9
12	2/20/75	Moderate		16	0[5/]
13	2/20/75	Severe	Grazed	30	28
14	2/20/75	Severe		30	44

[1/] A field severely infested with Sclerotina blight in 1973 and 1974.

[2/] Estimated by on-site observations on the sampling date.

[3/] A blank indicates the field was found as left immediately after harvest; grazed inciates the presence of swine feeding; disked and rye indicates the field had been disked and planted in rye by sampling date.

[4/] Indicates the percentage of branches and pods collected that contained sclerotia.

[5/] Grower attempted to control Sclerotinia blight with fungicides.

The moderately infected fields had a lower percentage of branches and pods containing sclerotia than did Field 1, a field severely infested with Sclerotinia blight (Table 2). Most of the severely infected fields observed in the post-harvest condition had a higher percentage of branches and pods containing sclerotia than did Field 1. The remaining severely infected fields, which had been disked, planted in rye, and grazed by swine, contained a lower percentage of branches and pods with sclerotia than did Field 1.

Summary and Conclusions

The spectral, spatial, and temporal characteristics of Sclerotinia blight can be detected by natural color and false color infrared photography. Aerial photography depicts disease patterns which are difficult to observe from the ground. Disease areas, characterized by a unique spectral signature, are best detected on false color infrared imagery. Moderate to severe disease infestations can be detected on false color infrared imagery photographed from 19,803 m above mean sea level. High altitude flights (19,803 m) are better for large area disease surveys, whereas low altitude flights (3,504 m) give better resolution for the detailed study of individual fields. Disease patterns that are difficult to observe from the ground and changes of the disease with time are easily detected by aerial photography. Imagery evaluation indicated that Sclerotinia blight was widespread in the Virginia peanut growing region during the 1974 growing season. Early detection of the disease via aerial surveys could permit prompt diagnosis and control measures to minimize spread of the disease if chemicals and/or other control measures are available. The imagery provides historical records of the disease. This study also provides a method of estimating the percentage of the field affected by this disease in instances where the disease is considered to be moderate to severe.

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