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Disease Assessment with IR-Color

Methodology is being applied to determine the percentage of blight in bean fields in Southwestern Ontario, Canada.

Introduction

In 1968 the authors used aerial color-IR photographs to detect bacterial blight of field beans in Southwestern Ontario. From these photographs it was possible to detect seed-borne foci of blight in infected fields (Philpotts and Wallen 1969). Detection of photography it is necessary to know three factors:

- The area of the field,
- The yield obtained from the field and
- The percentage of plants infected in the field.

This study describes the method that we have developed to obtain the percentage of

Abstract: *A method was developed to evaluate the percentage of diseased plants per field from aerial IR-color photography. The method requires the tracing of infected areas of a field onto a cellulose acetate sheet coated with Krylon. Finally autopositive copies of the field size and other copies of the infected areas are placed side by side on 4×4-foot paper. The 4×4-foot sheet is scanned on an IBM drum scanner originally designed for the Canadian Land Inventory and the information is recorded on magnetic tape. One square inch of area is subject to 62,500 recordings and, depending on the photographic scale, each 1.4 to 7.8 square feet of a given field is scanned with the technique. Yields of the fields were also recorded in an attempt to obtain a disease-yield loss evaluation.*

bean blight by aerial IR-color photographs is being used as the model in an attempt to develop a system to survey certain agricultural crops in Canada for disease. In addition, we are attempting to develop methodology for crop disease loss evaluation from the photographs. Our purpose is to be able to assess the percentage of plants affected with blight in a given bean field and relate this assessment to actual field yields in order to establish loss evaluation.

In order to develop methodology for crop disease loss evaluation from IR-color aerial plants infected in a bean field and the evaluation of disease-loss/disease-intensity relationships obtained from IR-color aerial photographs obtained in Southwestern Ontario, Canada.

Methods and Materials

The area of photography study from which yield data were obtained was located 5 miles immediately west of highway 8 and parallel to it near the town of Hensall, Ontario. The films and filters, camera, focal length, exposure and scale were as described previously (Philpotts and Wallen 1969).

In this area reliable yields were obtained by leaving postcards requesting yield information on the various farms. When yield figures were obtained later the cards were returned to us. The information consisted of the yields of the photographed bean fields on

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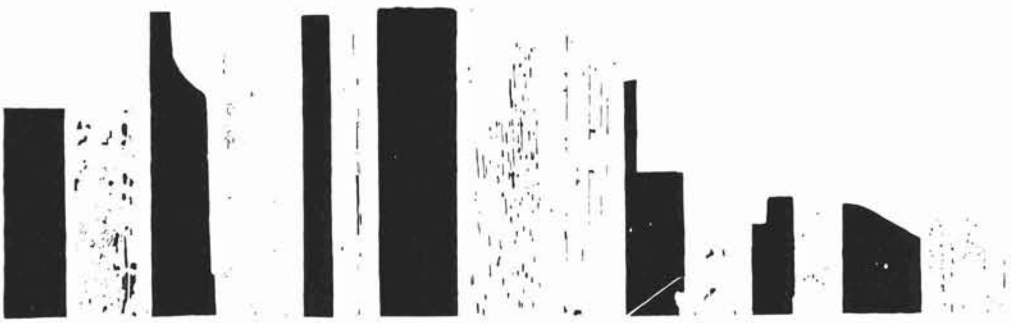

FIG. 1. A portion of a typical autopositive ready to be placed on the drum scanner. The totally black images on the left represent total field acreage, followed by bacterial blight acreages to the right of each field image. The field that is shown fourth from the left shows three categories, namely, total field acreage, blight acreage, and void acreage. The white areas (holes) found within three of the total field acreage images are permanent non-productive areas.

the various farms under study. In most cases, exact yields obtained in this manner are unreliable and are primarily estimates; however, in this area, beans are grown as a cash crop under contract and growers are paid to the pound of seed. All yields for individual fields are weighed and recorded by the seed merchant.

The size of each field was determined by knowing the photographic scale, reference points having been measured on the ground during the ground-truth study. For this study of 37 fields we obtained photographs from which the data on disease incidence were compiled. Yields were obtained from 20 of these fields.

The first step in determining the area of infection within a given field was to trace the infected areas from the photographs onto a cellulose acetate sheet coated with Krylon. Blight areas are readily recognized by plant pathologists because of their color, tone, and field patternization. From the original ink tracings, a camera-exposed high-contrast line negative was produced the same size as the original. From this, a vacuum-frame contact was exposed, again on high-contrast film to produce a film positive with the same tonal relationships as the original ink tracing but on a transparent base. These autopositive copies were cut and placed together in order from left to right on 4×4-foot paper showing the total areas of the field in black to the left followed by the infected areas of each field on the right (Figure 1). The final autopositive is produced and retouched eliminating any unnecessary smudges. The autopositive is placed on an IBM drum scanner that was designed for the Canada Land Inventory Geo-information System (Figure 2). The black images are placed on the drum of the scanning device and the proper length and width measurements are dialed on the instrument panel. Approximately 15 minutes is needed to scan a full 4×4-foot document and record the information on magnetic tape from a 2401 tape drive.

The scanning system consists of a scanning head device, its associated electronics and controls leading to the tape drive. The technique is to detect the intensity level of light reflected from the drawing and record this information as a series of binary bits written on magnetic tape. The scan head consists of an A-channel device utilizing fibre optics capable of scanning eight scan lines simultaneously. One record is produced for each 0.032 inches along the X-axis of the drawing and the height of each record area is 0.004 inches along the Y-axis. The 0.032-inch record represents one byte of computer storage and is divided into eight bits. The scan heads are such that if 50 percent of a spot impresses black data then a 1-bit is generated, other-

FIG. 2. IBM drum scanner (right) showing the 4-by-4-foot sheet preparatory to scanning, and the tape drive on the left.

wise a 0-bit is generated. The image is thus represented as a collection of bits.

To determine the percentage of the field diseased requires a simple comparison of the bits recorded for the diseased portions of the field against the bits recorded for the entire field.

Converting this figure to the area examined is done by knowing the photographic scale. In our photography we used two scales, 1:3600 and 1:8400. As the actual scan size of the instrument is 0.004×0.004 or 0.000016 inches; one square inch has therefore 62,500 recordings. At a scale of 1:3600, a square inch of photography represents 90,000 square feet, and at a scale of 1:8400, it represents 490,000 square feet. For the scale of 1:3600, then at 62,500 recordings per square inch, a scan would view a field area of 1.4 square feet and at a scale of 1:8400 a scan would represent approximately 7.8 square feet. This would mean that at a scale of 1:3600 the area of scan would be approximately that area occupied by one bean plant in a field.

Results and Discussion

Of the 20 fields which were photographed and subsequently scanned, 3 fields were free of blight and the remainder of the fields were infected from 0.17 to 51.20 percent (Table 1). Yields of these fields ranged from 1268.12 pounds per acre to 2271.73 per acre, excluding field 20 where poor management practices resulted in a very low yield. Although the 3

Table I. Percentage Field Infection of Bacterial Blight as Shown by Drum Scanner Method and Field of Scanned Fields

	Field Acreage	*Infection Acreage*	*Percent Field Infection*	*Yield (pounds per acre)*
	44.1111	0.4138	0.93	2,271.73
	10.9197	0	0	2,211.63
	7.1010	0	0	2,133.33
	19.9332	0	0	2,100.00
	26.6952	0.2790	1.04	2,059.50
	5.6617	0.0099	0.17	1,998.57
	23.9351	0.1767	0.73	1,920.00
	11.1821	0.1551	1.38	1,860.00
	13.6904	0.6094	4.45	1,814.39
	10.5433	1.5588	14.78	1,680.00
	19.6797	0.7950	4.04	1,679.50
	19.6513	0.4906	2.44	1,650.00
	8.6698	4.5171	52.10	1,600.00
	37.0614	0.3310	0.85	1,429.00
	2.4080	0.2485	10.32	1,423.72
	32.3362	7.3692	22.78	1,420.19
	12.9448	0.0932	0.72	1,380.65
	36.4172	2.6557	6.31	1,350.00
	53.8799	0.5419	1.00	1,268.12
	68.9659	4.4316	6.42	721.30
Total	465.7870	24.6665	130.46	33,980.63
Average	23.2893	1.2333	6.523	1,699.03

fields that were free of blight all yielded over 1 ton of beans per acre, field 5, which contained slightly over 1 percent infected plants, also yielded over 1 ton of beans per acre, and field 19 with percent 1 infection yielded only 1268.12 pounds per acre. Field 13 yielded 1600 pounds per acre even though over half of the plants were infected with blight.

Nine fields containing from 0 to 4.45 percent blight all yielded over 1800 pounds per acre and 5 fields within this range yielded lower than 1800 pounds. The remaining 6 fields, all containing over 6 percent infected plants per field, yielded less than 1800 pounds per acre.

Although a relationship seems to be evident between freedom or relatively low infection levels of blight and high yields, this statement cannot be generalized as many other factors are responsible for the various yields obtained. Good management practices, such as procuring disease-free or relatively disease-free seed, usually coincide with high fertility, good drainage and other good management practices and, conversely, poor management practices follow with lower quality seed, lower fertility and soil less adapted to high yields of beans.

Many of the fields containing a higher percentage of blight contained low areas where infection foci had coalesced to form large blight areas despite having initially no more original seed infections than many of the low-infection high-yielding fields.

The original objective of this study (Philpotts and Wallen 1969) was to ascertain if field infections of bacterial blight could be detected by IR-color aerial photography. Two further objectives emerged in this study from the terms of reference of our program on crop loss assessment. The first, to develop a method whereby field infections, i.e., the number of infected plants, could be determined in relation to field acreage is realistic. The method is now semi-automatic and requires manual interpretation of blight acreages by qualified plant pathologists followed by automatic scanning and read-out of blight percentages. When more sophisticated equipment becomes available we shall continue to automate the whole procedure. The second objective to relate field percentage infections to yield can only be accomplished if variables such as fertilizers, soil type, and other management practices can be controlled or eliminated, such as in field-plot studies. This fact was brought out in the present study where it was shown that these variables and blight all play an important role in total yield loss.

IR photographs followed by this method is now being used to determine the percentage infection of blight in bean fields in Southwestern Ontario. In controlled-plot experiments, preliminary disease intensity-loss relationships were established during the summer of 1970.

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REFERENCES

Philpotts, L. E. and V. R. Wallen. IR color for crop disease identification. *Photogrammetric Engineering* 35: (11) 1116–1125, 1969.

1972 International Congress

The quadrennial Congress of the International Society of Photogrammetry will convene in Ottawa July 23 to August 4, 1972. The Congress Director is Mr. S. G. Gamble, Surveys and Mapping Branch, 615 Booth St., Ottawa, Canada.

Virtually all the "invited" speakers and topics were selected during a joint meeting of the Council and the Commission Presidents in September 1970 in Paris, including the adoption of a "Procedures for Commission Activities and Publications".

"Presented" papers are also solicited. A 200-word abstract in one language needs to be in the hands of the Congress Director by February 1, 1972 in order to be included in a volume of abstracts, as well as in the hands of the Commission President in order to be considered for inclusion during a session. Twelve hundred copies of the complete paper must be delivered by June 1, 1972 so that they can be collated for distribution during the Congress. (See also page 504).